METEOROLOGICAL SATELLITES

HEARINGS

BEFORE THE

SUBCOMMITTEE ON APPLICATIONS AND TRACKING AND DATA ACQUISITION

OF THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS U.S. HOUSE OF REPRESENTATIVES

EIGHTY-SEVENTH CONGRESS

SECOND SESSION

ON

PROGRESS OF METEOROLOGICAL SATELLITE DEVELOPMENT AND APPLICATIONS

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NOTE.—The chairman of the full committee and the ranking minority member, Hon. Joseph W. Martin, Jr., are ex officio members of all subcommittees.

METEROLOGICAL SATELLITES

TUESDAY, AUGUST 28, 1962

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE NO. 4,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Ken Hechler (chairman) presiding.

Mr. HECHLER. The subcommittee will come to order.

This morning the subcommittee is starting hearings on the progress being achieved in the development of weather satellites.

We shall also appraise the progress in research and development and examine some of the achievements of our weather satellite systems at home and abroad.

The United States I believe has achieved remarkable success in the launching and orbiting of Tiros weather satellites. Out of five attempts we have had five full orbiting flights with return to Earth of more than 150,000 photographs of weather from also every portion of the inhabited world.

We will examine the military interest in weather satellites, and so this morning we have as our first witness Lt. Col. Leslie W. Cowan of the U.S. Air Force, Chief of Intelligence Systems, Directorate, Systems Deputy Chief of Staff for Logistics.

Accompanying Colonel Cowan is Lt. Col. James B. Jones, Air Weather Liaison Officer, National Weather Satellite Center.

Before you begin your prepared statement, Colonel Cowan, I wonder if you would tell the subcommittee for the record whether you are representing the Air Force or the Department of Defense here at these hearings.

Colonel COWAN. Yes, sir. I have been asked to represent the Department of Defense as their witness at the hearings.

Mr. HECHLER. And you have a prepared statement?

Colonel COWAN. Yes, sir.

Mr. HECHLER. Does Colonel Jones have a prepared statement?

Colonel COWAN. No, sir.

Mr. HECHLER. Colonel Jones will be available for questioning?

Colonel COWAN. Yes, sir. Colonel Jones will be available. He is a support witness, as is Comdr. John Ploetz of the Navy.

Mr. HECHLER. Commander, will you identify yourself, please?

Commander PLOETZ. Yes, sir.

Comdr. John D. Ploetz, Office of the Chief of Naval Operations, Naval Weather Service Division, and I am Assistant for Technical Readiness and Requirements.

Mr. HECHLER. You may proceed, Colonel Cowan.

STATEMENT OF LT. COL. LESLIE W. COWAN, U.S. AIR FORCE, CHIEF, INTELLIGENCE SYSTEMS, DIRECTORATE SYSTEMS ACQUISITION, DEPUTY CHIEF OF STAFF FOR LOGISTICS; ACCOMPANIED BY LT. COL. JAMES B. JONES, AIR WEATHER LIAISON OFFICER, NATIONAL WEATHER SATELLITE CENTER, AND COMDR. J. D. PLOETZ, CHIEF OF NAVAL OPERATIONS, NAVAL WEATHER SERVICE DIVISION, ASSISTANT FOR TECHNICAL READINESS AND REQUIREMENTS

Colonel COWAN. Mr. Chairman and members of the subcommittee, it is a pleasure to appear before your committee today on the general subject of weather satellites.

While the national program is the primary responsibility of the Weather Bureau and the NASA, the Department of Defense and each of the military departments has participated actively for several years in numerous interdepartmental activities related to the program.

These interdepartmental activities have been concerned both with the development of Tiros and Nimbus satellites, with the formulation of the means for making full use of the important weather data derived from these and the establishment of mechanisms for using meteorological satellite data on an operational basis.

In my statement I will outline the principal organizational mechanisms which exist within the Department of Defense and between the Department of Defense and other agencies including NASA and the Weather Bureau for establishing requirements, coordinating development activities, and assisting in the formulation of plans for the accomplishment of early operational activities.

DOD REQUIREMENTS—JOINT METEOROLOGICAL GROUP (JMG/JCS)

A statement of requirements for an operational meteorological satellite program has been developed by the Joint Meteorological Group the Joint Chiefs of Staff.

This group is composed of representatives of the three military services and the U.S. Weather Bureau. These requirements are set forth in Joint Chiefs of Staff Paper 2283–129 and were approved by the Joint Chiefs of Staff on April 6, 1961.

The Director of Defense Research and Engineering forwarded these requirements to the Administrator, NASA, for guidance in the research and development of meteorological satellite systems.

Comparison of the observational requirements stated in Joint Chiefs of Staff 2283–129, and the capabilities of the National Meteorological Satellite Systems indicated that—

(*a*) The military requirements are included in the overall national requirements, and

(*b*) These requirements will be satisfied by the system when it becomes fully operational, insofar as basic data are concerned and within "state of the art" limitations.

COORDINATION OF DEVELOPMENT ACTIVITIES—JOINT METEOROLOGICAL SATELLITE ADVISORY COMMITTEE (JMSAC)

The initial Tiros development plan was prepared by the Air Force under the technical direction of ARPA during 1958.

The design and fabrication of initial payload and ground station equipment was accomplished by the Army Signal Corps, and pioneering work in processing and analysis of the satellite data was undertaken by the Air Force Cambridge Research Laboratory.

The first Tiros was launched for NASA by the Air Force. Subsequent Tiros launches have been accomplished under NASA contract by Douglas crews, still using the Air Force-developed Thor booster.

In getting this program underway, the Department of Defense had expended $11.7 million at the end of fiscal year 1959. The results of this program have been most successful as evidenced by the five Tiros launches.

The research and development program, including the interim operational use of data, is coordinated through the Joint Meteorological Satellite Advisory Committee (JMSAC).

The NASA member is Chairman; and representation includes OSD/DDR&E, USWB, and the three military services. Although the actual expenditure of funds by the Department of Defense has been nominal, the contributions through participation in various aspects of the program have been substantial.

Specifically, through coordination in JMSAC, joint participation has involved the following:

(*a*) Provision of facilities for command acquisition and data readout. This is accomplished at Wallops Station and the Pacific Missile Range. Personnel from U.S. Army, U.S. Navy, U.S. Air Force, NASA, and USWB participate in this activity.

(*b*) Processing of the master film for archives (Naval Photographic Interpretation Center).

(*c*) Collection of supplementary data for research and the development of interpretation techniques and procedures. Activities include photo meteorological reconnaissance flights, the collection of special surface weather observations, the collection of "in-flight" pilot reports, hurricane reconnaissance and ice reconnaissance. Agencies participating in these activities are: U.S. Navy, U.S. Air Force, U.S. Army, U.S. Weather Bureau, and Federal Aviation Agency.

(*d*) The interim operational use, application and evaluation of cloud analyses. These functions are performed by the U.S. Weather Bureau, U.S. Navy, and the U.S. Air Force.

PLANS FOR OPERATIONAL SATELLITE—NATIONAL COORDINATING COMMITTEE FOR AVIATION METEOROLOGY (NACCAM)

Under NACCAM a Panel on Operational Meterological Satellites (POMS) was formed to develop a plan for a meteorological satellite system that would satisfy civilian and military requirements.

Members of the three military services, the U.S. Weather Bureau, the Federal Aviation Agency, and NASA participated in the development of this plan.

The plan was completed in April 1961 and submitted to the 87th Congress. The funds to implement the plan were provided to the Weather Bureau by Public Law 87–332.

A new working committee on satellites was established under the National Coordinating Committee for Aviation Meteorology in June of this year, to continue on a permanent basis the planning, coordination, and evaluation of the National Operational Meteorological Satellite System.

The U.S. Weather Bureau member is Chairman; and representation includes NASA, FAA, and the three military services.

DOD CONSIDERATIONS

Our interests in this program are keen and continuing. There is a military requirement for data which can only be obtained through use of a meteorological satellite, but there is not a current requirement for a military owned and operated satellite as such.

The Department of Defense position is, and has been, that it is not essential that a military agency operate the system as long as its requirements can be met by the National Operational Meteorological Satellite System being developed jointly by the National Aeronautics and Space Administration and the U.S. Weather Bureau under the overall management of the U.S. Weather Bureau.

The Department of Defense considers that its basic requirements can be met by the national meteorological satellite program.

It is believed premature to speculate concerning reliability and effectiveness which are yet to be demonstrated in this program; however, if it becomes evident that the national program development cannot satisfy military requirements, appropriate expansion of the national effort will be requested.

If an urgent, unique military requirement for weather satellite observations could not be satisfied by the national program, consideration would naturally be given to incorporating it in a suitable military space program.

Notwithstanding our full support of the national program, there are some areas which concern us:

(*a*) The approved plan states that the NASA Nimbus research and development program will attain independent operational status by the beginning of 1964 with one satellite. This was based on an initial development Nimbus spacecraft in the second quarter of calendar year 1962.

We are now informed by the NASA that the launching of this initial satellite will slip 12 months to second quarter calendar year 1963. Although operational use will be made of the first Nimbus research and development satellite, military operational use of the complete Nimbus system will be delayed until 1965, or later, unless an intensive effort or modification in plans is initiated.

(*b*) The approved plan specified three ground stations for acquisition of satellite data. The station planned for the European area is still under study. Delay in this ground station is of particular significance to the military.

Also, a direct read-out subsystem is urgently required by the services. This is of concern because leadtime is required by the services

in order to adapt the equipment to the service environment and to provide maintenance, operator, training, and logistic support for the ground equipment.

Within the Department of Defense, the services are conducting research on the techniques for applying meteorological satellite data to their specialized military operations and studies concerning the uses and employment of weather satellites.

These are necessary activities because the national program may not be flexible, survivable, and secure in wartime as needed for support of military operations.

The specialized processing of these data for military purposes and their dissemination to military organizations are responsibilities which must also be accomplished by the military services. These activities will continue until an adequate operational military capability is achieved.

We will certainly continue to support the national program in every possible way, insuring that valid updated DOD requirements are maintained for guidance of NASA and the NSWB, coordinating our DOD activities, and providing assistance as feasible.

We are most anxious that the United States acquire an operational meteorological satellite program at the earliest possible date.

Mr. HECHLER. Thank you, Colonel Cowan.

Colonel COWAN. Thank you.

Mr. HECHLER. There has been a lot of talk, of course, since the latest cosmonaut flights of the Russians, about military interest in space and the protection of American military interests in space.

Are you concerned at the present time with the progress of our weather satellite program so far as it provides and meets the military requirements?

Colonel COWAN. Yes, sir. I think it is indicated in the statement.

Mr. HECHLER. Are you disturbed?

Colonel COWAN. I think all of the military services are disturbed. The capability we would like is lagging. The extent of this I can't state right now.

Mr. HECHLER. Is the slippage in the schedule for Nimbus the most serious thing, so far as the military is concerned?

Colonel COWAN. Yes, sir. Our operational program is tied to the Nimbus program.

While there is some small use being made of the Tiros data it really is a very limited application.

Mr. HECHLER. Is there anything in the organizational setup that you would recommend which would more nearly insure the satisfaction of military requirements in the weather satellite system?

Is the military adequately represented in terms of advanced planning?

Colonel COWAN. Yes, sir. We think that we have made an adequate statement of the requirements and we have the mechanism to keep these updated.

Mr. HECHLER. How much money is the Department of Defense now spending on weather satellites?

Colonel COWAN. In the Air Force there is a $400,000 program planned in existence for this fiscal year.

Actually, we probably will fund it at about a $300,000 level and today it is funded to the extent of $268,000.

These are in studies and research.

The Navy has a similar level of effort, of approximately $375,000 in research and studies in meteorological satellites.

Mr. HECHLER. This is the technique for applying meteorological satellite data to military operations?

Colonel COWAN. Yes, sir. As well as studies on the use of data.

Mr. HECHLER. In a sense this has to be a duplication in small part of what the Weather Bureau is doing, does it not?

Colonel COWAN. This is possibly true to a small degree but through in JMSAC in particular the efforts in research are very carefully coordinated.

The research programs of all the agencies are brought in there on a current basis. Whenever a new contract is let by any of the agencies voluntarily a copy of this is brought to the JMSAC and made available to the other people.

I think this is one of the finest examples of coordination of research effort very close to the grassroots that we have.

Mr. HECHLER. This subcommittee, of course, is disturbed and concerned, as you are, about the protection of any necessary military requirements in this field.

I wonder what recommendations you could offer the subcommittee that would insure that military requirements be met?

Colonel COWAN. We are not prepared to answer this for Department of Defense. There isn't any action contemplated that I know of at DOD level other than to insure that our requirements are updated and that we maintain active communications with the people involved so that we are certain that we know what they are doing and that they know what we want.

Mr. HECHLER. You just have the concern, without any definite recommendation as to how to proceed?

Colonel COWAN. Yes, sir.

Mr. HECHLER. You mention on page 5 of your statement a direct read-out subsystem is urgently required by the services.

What are you doing about it?

Colonel COWAN. Well, this is the requirement that we have, again, presented to NASA. I don't think that we are alone in wanting this. The U.S. Weather Bureau would like it very much, too.

I think it is fairly obvious that if you could have the data directly from the satellite in your weather forecasting office it would be much superior to having had it processed through a central facility and sent over communication lines, with the attendant delay in filtering of the information, and that sort of thing.

Mr. HECHLER. Mr. Roush?

Mr. ROUSH. Colonel, could you define a little more specifically the military requirement, especially in its practical aspects? You say there is a military requirement for a meteorological satellite. What is the requirement? How do you plan to use it from the practical standpoint—the tactical standpoint?

Colonel COWAN. There is, of course, a very detailed JCS statement, that is classified.

Aside from this, obvious applications I think may serve to answer what you mean: The Strategic Air Command in its mission is performing global flights and the weather is very important.

For instance, in refueling aircraft it is important to know areas that are cloud free. These might well be in the Arctic where there are no reporting stations.

There is a natural use of the meteorological satellite information for this.

In a small war situation in a part of the world where there is no weather observing network, if we could have the broad view of the weather seen from the satellite it would be immensely useful to the Navy in their operations. At sea there are no data.

Primarily these, I guess, are the data-sparse areas and the immediate application is most useful there.

Mr. ROUSH. You are confident that Nimbus would give you this information and that it would be good information?

Colonel COWAN. Well, Tiros has in our judgment proved what can be gotten from it. The early vehicles have surpassed our expectations. We rely on this. We think Nimbus will be better even.

Mr. ROUSH. Do you know whether any other country of the world is making similar efforts in this field—Russia, for example?

Colonel COWAN. We don't from a technical channel. I think I will defer to Colonel Jones. He is living with it.

Colonel JONES. I am not aware of any such program. As you may know, there is a program—at least in the formative stages—for the participation in a cooperative program between the several countries in the World Meteorological Organization.

However, as far the the development and launch and operation of the spacecraft, I am personally not aware of any such program in existence other than our own here in the United States.

This is from my own experience with the Weather Bureau Satellite Center.

Mr. ROUSH. We could quite readily then claim a first in this field.

Colonel JONES. Well, I think perhaps we have. I think it would be presumptuous to feel that other countries weren't capable of doing it.

We just aren't aware of any such program.

Mr. ROUSH. In the development of our program are we using the talents and information from other nations and scientists of other nations, to your knowledge?

Colonel JONES. Well, sir, I think as far as I have been able to tell the United States has been pretty much a leader in the area of meteorological satellites.

As you may know, the Department of Commerce and the NASA last November held an international meteorological satellite workshop to which meteorologists of the countries in the World Meteorological Organization were invited to send representatives—to participate in the workshop—using the data that had been acquired thus far from the Tiros satellite.

I believe France and perhaps England—perhaps some of the other countries—have been interested to the extent of proposing, at least informally, some experiments which might be added to a meteorological satellite.

Mr. ROUSH. That is all. Thank you, Mr. Chairman.

Mr. HECHLER. Mr. Davis?

Mr. DAVIS. Is it true that Japan has always been quite interested in meteorology and has some very able men in that field?

Colonel COWAN. Yes, sir.

Mr. DAVIS. Are they participating in this program?

Colonel JONES. I believe, sir, that they were not able to participate in this international meteorological satellite program.

However, they have been among the more enthusiastic receivers of Tiros cloud analyses which have been transmitted on a worldwide basis.

Among other things, the Weather Bureau prepares and transmits to pertinent locations the location and description of any tropical disturbances.

The Japanese Weather Service has been most enthusiastic in its reception of this information.

Mr. DAVIS. One other question: Of course, the old saying is that everybody talks about the weather and nobody does anything about it, which in a way would indicate that there is a lot of information about the weather. In other words, the Russians are competent in meteorological science.

Could you give us an idea where the line is, or should be drawn between classified weather information and unclassified weather information—information that it would be perfectly all right to share with any nation, or information that should be withheld, perhaps, in view of the military significance of the information?

Colonel COWAN. We, just as a general policy, have treated the weather as unclassified except when it is specifically related to something that we are doing militarily speaking.

This is more or less a traditional policy. But in wartime—I must admit in World War II we departed from this—and it is possible that we would again.

But this is the way we handle it now. Weather is only classified when it is related to something we are doing militarily speaking which is classified and as it is an indicator then to what is being done.

Mr. DAVIS. Now, of course, in World War II Japan was one of our enemies. We would have been interested in withholding weather information from them. But, in view of the present world situation, we could count on the assistance of Japan, of course. I am wondering if we have a sufficient network around the world to operate pretty well, to obtain a good knowledge of world weather, especially with the help of a weather satellite, even though the Iron Curtain countries did not cooperate in this way with us.

Could we still say we had a very good knowledge of the world weather? We do, as it stands now, depend on some reporting on their part, don't we? At least we use their data.

Colonel JONES. Yes; this is correct. We receive information of the conventional type. We feel, however, from the limited operational use that we have been able to make of the Tiros satellite data that over any data-sparse area regardless of the reason this information is better than no information at all certainly. And in many cases, for specific applications it provides a great wealth of information to us.

Colonel COWAN. Let me add one thing to this, sir: The exchange of weather information is a voluntary worldwide effort, and I doubt

if we could assume that it would continue as freely even in our side of the curtain let's say in a tense situation.

The only thing that we could probably expect to have would be what we could get from—depend on having—would be what came from a meteorological satellite or from our own forces wherever they might be disposed.

This is the only thing we could be absolutely sure of having. Then only if our communications would provide it.

Mr. DAVIS. Now a weather satellite could in no sense be said to constitute a substitute for ground observation, could it? You still need ground observation.

Colonel COWAN. Yes, sir; this is right.

Mr. DAVIS. It is just an adjunct to ground observation, is that correct?

Colonel COWAN. Yes, sir; it is only another geophysical sensor. It provides a certain type of information, you have a range of things taken down in the atmosphere and at the ground, specific types of measurements which all contribute to your knowledge of what is happening in this ocean of air.

Mr. DAVIS. If you had only the satellite you would be pretty deficient in such things as wind velocity, precipiation, and things of that kind, would you not?

Colonel COWAN. This is true as a generality, but in a short-term sense, if you have an information base to operate from you can bridge this sometimes with indicators that are available over a period of days, several days, you might be able to extrapolate from what you knew, and with indications, but in a long-term sense you would soon lose intimate knowledge of the structure of the atmosphere and the dynamics, and things which were occurring.

Mr. DAVIS. Isn't it also highly possible that as you gain more experience from interpreting your satellite pictures you could form more accurate conclusions as to what the local conditions were?

Colonel COWAN. We think this is true but there is, of course, a limit to the information that can be sensed by a satellite.

Mr. DAVIS. I believe that is all, Mr. Chairman.

Mr. HECHLER. Mrs. Weis?

Mrs. WEIS. You referred to data-sparse areas. Could you give us an idea of what percentage of the world globe is data sparse?

Is that a general condition or is it fairly well localized?

Colonel COWAN. For the committee I can give a statement. I think we talk of something like 90 percent to 95 percent or the globe as being data sparse.

Mrs. WEIS. So further development of Tiros or Nimbus would be very beneficial to that situation; wouldn't it?

Colonel COWAN. Yes, ma'am.

Mrs. WEIS. Thank you.

Mr. HECHLER. What is the limitation of the operational data that you can get now militarily from Tiros?

What limitations does Tiros impose that you feel Nimbus will solve?

Colonel COWAN. Nimbus, just the sensing vehicle, will be in essentially a polar-type orbit, and will give us information to 80° north, thereabouts, and around the world, whereas the Tiros orbits have been much lower, the first four, 48°, and the fifth one at 58°.

So, this is a substantial advancement, to have them in a polar orbit, because it gives a sweep around the world then.

Perhaps that is the biggest thing.

Mrs. WEIS. Would it have picked up that storm along the eastern seaboard that, apparently, Tiros missed last year? I refer to the storm that devastated the eastern coast.

Colonel JONES. I was about to say, I think we did see that storm, but I perhaps better not be too positive since there have been a great number of Tiroses.

We have seen a great number of storms along the eastern seaboard.

Perhaps the other change between Tiros and the Nimbus is, the Tiros satellite is a spin-stabilized vehicle, sees the earth only about 25 to 30 percent of each orbit and the area of view oscillates with time between the North and Southern Hemisphere. When looking south of the Equator it cannot observe north. These are limitations imposed by the stabilization and the inclination of the orbit.

The Nimbus satellite will be an earth orientated vehicle so that the sensory platform or cameras will always point to the Earth so that, provided the satellite works as it is supposed to, we will always be able to observe the Earth in the daylight portion—So we see the Earth once a day in daylight.

Mr. HECHLER. Colonel Cowan, you mentioned in your prepared statement, on page 5, "military operational use of the complete Nimbus system will be delayed until 1965, or later, unless an intensive effort or modification in plans is initiated."

Have you any ideas to exactly what we can do? What does this mean—"intensive effort and modification of plans"? What are you doing about it?

Colonel COWAN. We haven't seen any indication that it is planned to compress the schedule to try and make up for the delays that are encountered so far.

This is exactly what perhaps we would like to see attempted if it is feasible.

Mr. HECHLER. What I am trying to probe for is whether you have made such representations—Colonel Jones—through your liaison activity—of the military interest in the modification of the plans and whether you can sense any particular reason for delay that could be corrected?

Do you or Colonel Jones care to answer that?

Colonel COWAN. We have not pressed awfully hard directly with the NASA people on this.

Perhaps the next phase of our relationship will be to do this.

Mr. HECHLER. Would you say this is a matter of serious concern to the military?

Colonel COWAN. Very definitely. I would say that the Department of Defense hasn't yet taken a position on it.

It is my belief that the three services involved—this being the Army, Navy, and Air Force—are all very concerned about it, and will undoubtedly if it continues come to the Department of Defense with a request for some concerted action at that level.

Mr. HECHLER. Would you care to comment any on the delays and cause of the delays, whether these are purely technical considerations?

Colonel COWAN. Mr. Chairman, I think I will ask Colonel Jones again—he has perhaps a better idea than I do—to comment.

Colonel JONES. Well, if this doesn't seem as though I am trying to duck the issue completely, I would like to ask if it would be proper to defer this until the Weather Bureau and NASA have their day in court here?

Mr. HECHLER. Yes.

Colonel JONES. I believe actually they are more capable of answering these questions.

I have my own opinions, but these people are the executive agencies involved, and I would prefer to defer to them.

Mr. HECHLER. We are interested in protecting military requirements, of course, and making sure military requirements are fulfilled. That is the only purpose back of my question.

Colonel JONES. Right. Through our relationship with the NASA and Weather Bureau through the Joint Meteorological Satellite Advisory Committee and the working Committee on Satellites the several members, military members, have expressed a dissatisfaction with the lack of speed apparently with which we are going forward.

The response to this has essentially been that we are pushing the state of the art pretty hard and that, for technical reasons, that perhaps these are the overriding reasons for the slippages that have occurred in the program thus far.

Mr. ROUSH. May I be sure on this: You are saying that it is because of technical reasons that the slippage has occurred and not for reasons such as lack of funds?

Colonel JONES. Well, as far as I know it has not been the lack of funds.

Technical reasons or technical problems have been given as the primary reasons.

Mr. ROUSH. Thank you.

Mr. HECHLER. Commander Ploetz, I wonder if at this point you could outline the Navy's interest in the military weather satellite system?

Commander PLOETZ. I think on this, sir, because of security reasons, the exact requirements, and the materials involved, I can provide the committee with a statement at a later time, or present it in closed session.

Mr. HECHLER. About how much is the Navy spending in this area?

Commander PLOETZ. Around $350,000 to $400,000 in satellite application.

Mr. HECHLER. Are you satisfied with the administrative setup and the representation of the Navy's interest?

Commander PLOETZ. Yes, sir; we are represented in all of the various committees and joint groups that meet, such as the JMSAC, that was mentioned in the opening statement, the meteorological satellite activity group. We are well represented in the various coordinating committees.

Mr. HECHLER. Are you concerned or disturbed with the program?

Commander PLOETZ. Yes; we are concerned, as stated in the opening statement, on the time lag on it.

Mr. HECHLER. Do you have any suggestions or recommendations as to how the Navy, or the military interest, could be protected or enhanced?

Commander PLOETZ. No, sir; I do not.

Mr. HECHLER. Along this line, do any other members of the subcommittee have questions?

Mrs. WEIS. I would like to ask the commander if you mean there is only $300,000 to $400,000 involved in your share of the program?

Commander PLOETZ. Yes.

Mrs. WEIS. That seems like a small figure to present to any committee of Congress. I thought it would be millions. [Laughter.]

Commander PLOETZ. The management activities on this for the national system are the U.S. Weather Bureau and NASA.

Mr. HECHLER. This is largely research?

Commander PLOETZ. Research, design studies, applications, and so forth, yes.

Mr. HECHLER. Colonel Jones, I wonder if you could tell the subcommittee a little on the ways in which the military forces of our allies are benefiting or will benefit from the development of weather satellite systems?

Colonel JONES. I would think to the extent that these governments now benefit from the exchange of weather information of the conventional nature, that the benefits would also accrue from the meteorological satellite observations, and the degree to which our program succeeds, I think to the same degree—or the same benefits—then will accrue to these allied countries, because we will make the information available to them in the same manner as we have our other weather data.

Mr. HECHLER. Do you know if there are any units within NATO or SEATO that are working actively in this area?

Colonel JONES. Not to my knowledge, sir.

I do know that since about the third day after launch of the first Tiros satellite we have been transmitting the cloud analyses from pictures obtained from the Tiros satellites essentially on an international basis, so that those countries allied with us have been in receipt of the information and have been able to make whatever use they desired of it.

Mr. HECHLER. Would you or Colonel Cowan care to philosophize a little bit on how our military requirements for meteorological satellites could be worked in with and reconciled with a future system of international supervision and regulation?

Colonel COWAN. I find it very difficult to visualize how wartime satellite requirements could be completely compatible with something like this.

Our past experience in World War II indicated that there were some areas where weather was very critical. We preferred not to have others know of our interest in this weather and its possible use.

Mr. HECHLER. Aren't we in a situation now where we have to protect our own information for military reasons?

Colonel COWAN. Well, Mr. Chairman, I don't think that we are quite at that point, although I would concede we might arrive there.

The strictly military applications of the weather satellite data, these being unique and perhaps tailored ones, are something that we will get to when the national system or an international system is operating.

I would speculate here that we would supplement such a system with further capabilities in time after the basic system is created,

and I draw a parallel here between the U.S. Weather Bureau which exists and then the numerous things which are done by the military weather services, which are not to duplicate what is done by the U.S. Weather Bureau in any fashion, but to tailor the application of meteorology to the military forces.

Mr. HECHLER. I believe that it was either you or Colonel Jones that mentioned earlier the work with the World Meteorological Organization.

I wondered whether you could expand a little bit on the participation that we have in the World Meteorological Organization?

Colonel JONES. In the area of the satellite meteorology?

Mr. HECHLER. Yes.

Colonel JONES. To my knowledge, sir, the only two specific activities in which this Organization has been involved has been in the workshop, international met satellite workshop held here last November.

The other is the recent meeting, I believe the WMO, in Geneva, at which, among other things, an international met satellite program was at least discussed and basic outline was prepared.

Beyond that, I am not aware of any other activities in the met satellite area.

Colonel COWAN. Mr. Chairman, I think really the Weather Bureau could answer this quite adequately for you, sir.

Mr. HECHLER. I notice on page 5 of your statement, Colonel Cowan, you underline the interest in a station planned for the European area. You said it is under study.

By whom?

Colonel COWAN. This was included, Mr. Chairman, in the plan that the POMS committee provided and was indicated to be one of the initial phase activities and it still, as far as we know, is under study, and nothing concrete has been done.

Mr. HECHLER. Is this an urgent request?

Colonel COWAN. Let me explain it in this fashion—perhaps it is something I neglected a little bit.

One of the greatest difficulties in applying these data is to get them in the place where needed in the form they can use them. It is not just sensing the information in space. It is the process then of peeling it off from somewhere. Our forces in Europe I think would obviously be vitally interested in the information that the satellite could give them, but lacking a station in that area it must come back here to Washington and be digested and filtered and then communicated back to them again.

Mr. HECHLER. Have you any predictions as to how this is coming along?

Colonel COWAN. No, sir; I do not think so.

Mr. HECHLER. Any way we could help?

Colonel COWAN. I think one of the greatest problems that we face is to find a means of bringing the information quickly to the people who can use it. It is very difficult information to handle and to process and for the moment we have to be content to do it at the national meteorological satellite center here.

In due time we will perhaps acquire additional capabilities.

Mrs. WEIS. Could you say how long it takes, Colonel, to process this information and get it sent back?

Colonel COWAN. I would like to defer to Colonel Jones, because he has worked with it, and I think he has very definitive information.

Colonel JONES. In our current practices with the Tiros information we find on the average it requires approximately 6 hours from the time of observation until we are able to redistribute the information, in the form of a relatively crude cloud analysis, in which only the larger features are graphically depicted, along with a few amplifying remarks by way of interpretation as to what meteorological significance some of these cloud patterns appear to have.

We would hope by the time that the Nimbus system comes into being through a combination of machine and man analysis techniques we would be able to reduce this processing time to something on the order of 3 to 4 hours after observations were taken.

On top of this, of course, will be the time required to communicate this processed data to other centers to the European area in which we could have a military forecast center established.

The amount of data and the detail that we could send back is rather limited.

Colonel COWAN. Mr. Chairman, may I suggest that you might be interested in a Tiros NEPH which Colonel Jones was kind enough to bring along, showing the small storm you perhaps read about in today's paper?

Mr. HECHLER. Yes.

Colonel COWAN. Would you like to have this passed out to the committee?

Mr. HECHLER. Yes.

(Handing.)

Mr. HECHLER. Mr. Fulton?

Mr. FULTON. I would not want the record to show that there were talks in process or that there was progress being made at this time at the United Nations level on the peaceful uses of Outer Space Committee.

I could make a comment, although I am not a member of this committee. I was at the Geneva meetings as an adviser to the U.S. mission at the meeting of the U.N. Committee on the Peaceful Uses of Outer Space, specifically on the subcommittee on legal subjects.

My feeling was that a pure propaganda position was taken by Russia and no progress was made.

On the subcommittee on techanical aspects of space, as to communications, weather satellites, and others, there were proposals. But no action was taken at the United Nations Subcommittee level.

We will have to wait until September 18, when the General Assembly again reconvenes in New York and the work is again resumed, before there can be any progress—which is doubtful to me.

Another point is this: Under Dr. Hugh Dryden's leadership, I was one of those who sat in on the direct meetings with Russia, trying to work out some of these problems, with Dr. Blagonravov representing Russia.

At the technical level, between Dr. Dryden and Dr. Blagonravov, there was some indication of small progress. But when it came to decisions, it was my feeling and judgment that Dr. Blagonravov had no power to make basic additions nor did Russia show any willingness to make them.

So, that, as far as the communication satellites, the weather satellites, and the proposals by President Kennedy in his letter to the Premier of Russia, Mr. Khrushchev, it will have to wait for further negotiations. There has been nothing up to the present time that could be regarded as substantial development or progress.

I think Dr. Hugh Dryden made a good job of presentation. However, to me, the Russians, in view of the Berlin crisis and the disarmament crisis, are not willing at this time to work for progress in these fields.

To me, it is a case calling for patience. My only comment is to clear up the record specifically. I did not want it to appear as if there is progress being made, in these fields. We are just gradually approaching the implementation of policy through the adoption of methods by agreement.

That is not the case with either Russia directly, nor is it a result of negotiations through Dr. Hugh Dryden, nor is it the case with either one of the two subcommittees—that is, the technical subcommittee or the legal subcommittee on outer space of the Committee on the Peaceful Uses of Outer Space of the United Nations.

Mr. HECHLER. Mr. Fulton, I appreciate very much your updating us on these conversations and developments and, of course, the subcommittee will go into this a little more when we hear Department of State witnesses later on—but it is very useful to be brought up to date on all these international developments.

Mr. FULTON. Thank you.

Could I ask a question?

You are military officers. Do you have any reason to believe otherwise than the position I have just stated as to the current status of these negotiations, both at the United Nations level and on the direct conversations of our delegation headed by Dr. Dryden with the Russian delegation.

Colonel COWAN. No, sir.

Mr. FULTON. If you know anything different I would like to hear it. I just don't want the record to show that it is different.

Colonel COWAN. No, sir; there is nothing different.

Mr. FULTON. Do you?

Colonel JONES. No, sir.

Mr. FULTON. Do you?

Commander PLOETZ. No, sir.

Mr. FULTON. I thought the inference was the other way.

Colonel JONES. No, it was not intended.

Mr. FULTON. I thought you had made the inference that we were making progress.

Colonel JONES. No, sir; the meetings had just taken place and that was the sum and substance of it as far as I knew.

Mr. HECHLER. Colonel Jones, will you proceed?

Colonel JONES. I had essentially finished I believe as far as the time required for this particular activity.

This particular observation was made at about 11:35 yesterday morning (indicating the Tiros cloud analysis).

This is one of—a relatively crude depiction—of the more detailed information that is available in the actual pictures themselves.

The little storm is situated just to the west of this crossmark here [indicating], in the map which delineates the crossing of the 60° longitude and the 30° latitude.

The storm center is just off the east northeast of Jacksonville.

It is depicted by a small three-bladed propeller sort of symbol.

Colonel COWAN. How long was this after the observation that it was disseminated?

Colonel JONES. This was transmitted I would estimate within 4 to 5 hours after the observation was made.

Mr. HECHLER. Under what circumstances could you cut this time down?

Colonel JONES. Well, sir, the people actually in the read-out stations have the information in form where it can be used in meteorological analysis in this case within 5 to 10 minutes after the picture was taken and in most cases within 15 to 20 minutes after the pictures or data have been acquired at the ground station.

It is possible then to make some meteorological use of them. The only difficulty is that at the present time at our read-out stations we have no basic metorological capability or weather forecasting centers, so that it is necessary to analyze these pictures in some form which can then be transmitted by existing communications.

Mr. HECHLER. Not a case then of insufficient number of ground stations.

Colonel JONES. Well, for the fourth support of the Tiros program I think not. In this particular case, the question in point, of our concern, or interest, in a northwestern European read-out station, for example, is that the data from this area then would be available almost immediately after acquisition in the unprocessed form so that a greater flexibility could be exercised in the processing of data for that particular area, and it would be available to them in a much shorter time, which is perhaps the more significant consideration.

Mr. ROUSH. Is this what is transmitted? [Indicating map.]

Colonel JONES. Yes.

Mr. ROUSH. Does this tell us anything about the intensity of the storm, direction it is moving, or speed with which it is moving?

Colonel JONES. This is essentially a snapshot.

It tells very little in itself. If this is the only picture we have it tells very little of the intensity.

It gives an idea of the aerial extent of the storm, how many thousands of square miles perhaps are included in the cloud shield associated with the storm, and in some instances from weather models we can make some inferences as to the probable intensity.

If we can observe the same storm today and then tomorrow again, the changes in appearance of the storm will give some added information.

But this is all inferred information and not a direct measurement.

Mr. ROUSH. This does not purport to interpret the storm then?

Colonel JONES. No. This shows where it is, how much cloudiness is associated, how this cloudiness is distributed, and the type, the way in which it is organized, and from all of these things it is that we—particularly from the organization of the cloud—that we can draw inferences as to possible wind directions, and so forth.

From a single snapshot I think very little of a quantitative nature beyond the amount of cloud and the distribution of cloud can be told.

Colonel COWAN. One of the distinctions between the R. & D. system and the operational system is to have something more than one-a-day looks at this.

Whereas now the general planning is for something that will pass by around noon each day, in a later phase in Nimbus there would be, say, a 9 o'clock in the morning pass and then a 3 o'clock in the afternoon pass.

Actually there are two also at night but they do not see the clouds. They would just collect the infra red radiation. Having two 6 hours apart it becomes much more meaningful because you have a comparison of what has happened over this interval.

Mr. ROUSH. Does this top portion of this have any relationship to the bottom portion?

I believe the top portion covers Newfoundland.

Colonel JONES. The top portion covers essentially from the Delmarva area through Newfoundland and southern Labrador.

Mr. ROUSH. Is that related to the bottom portion?

Colonel JONES. Not directly. It follows on directly from this first pass. The pictures were acquired in two different modes of operation of the satellite. There was perhaps a few minutes between the observation time of the snapshots which compose this lower portion of the chart and the upper portion of the chart.

But essentially they were taken within 5 to 6 minutes of one another.

Mr. ROUSH. Thank you.

Mr. FULTON. Mr. Chairman?

Mr. HECHLER. Mr. Fulton.

Mr. FULTON. Tiros weather satellite information is open, isn't it, to all scientists?

Colonel JONES. Yes, sir.

Mr. FULTON. Congressmen are curious. Why is this about 4 square inches blacked out? [Laughter.]

Colonel JONES. If you look closely you can see there is a legend block—this is perhaps a rather shabby copy to hand out—it was made rather quickly this morning by a Brunnings process—and this particular legend block explains what these symbols mean.

Mr. FULTON. You thought we might find out what it was. [Laughter.]

You gave us everything but the symbols which will translate the map.

Colonel JONES. Yes, sir. That is essentially it.

That was what was blacked out. And it was certainly not intentional.

Mr. FULTON. Possibly for putting this in the record we could have that supplied to us.

Colonel JONES. We will be glad to supply the original copy.

Mr. HECHLER. Thank you, Mr. Fulton.

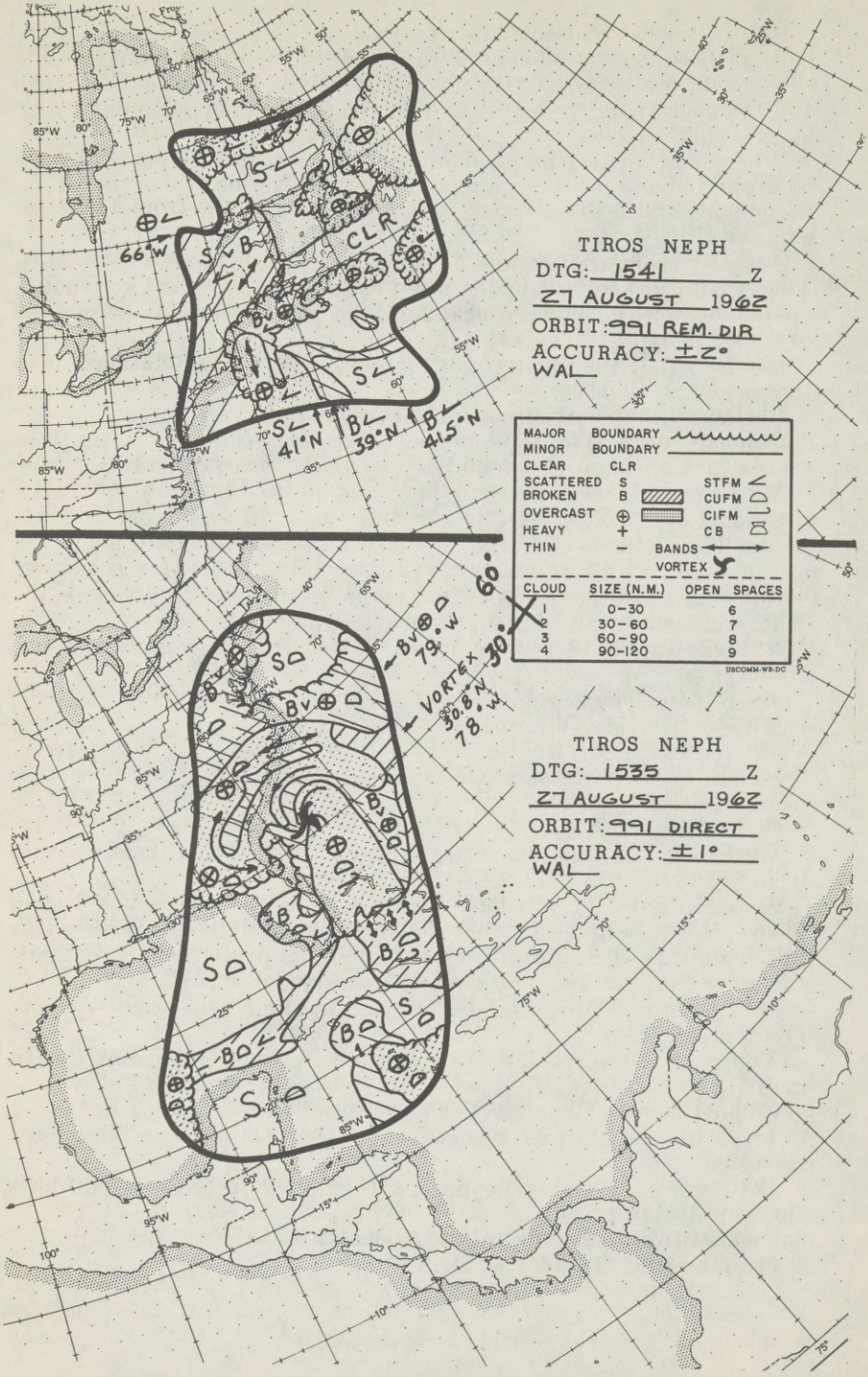


FIGURE 1.—Tiros cloud analysis.

Mr. HECHLER. Mr. Hines?

Mr. HINES. Under our present system of accumulating and disseminating weather information from satellites, weather data is distributed from one central point. In military operations would this be necessarily true? Would it be necessary to send back information to one central point and then distribute it broadly by other means?

Commander PLOETZ. It is to be used both ways, one from a central location and given out.

In the Navy we have our fleet facsimile broadcasts which can transmit the information such as you see here to units at sea.

Another mode would be to get it directly at the ship from the satellite.

Mr. HINES. This is part of your planning, I would assume?

Commander PLOETZ. Yes.

Mr. HINES. Direct reading from the satellite?

Commander PLOETZ. Yes.

Colonel COWAN. Mr. Hines, I would like to comment, I think from the strictly military point of view it is a very bad thing to overly centralizing anything we do, and we have a distinct preference to decentralize to operating units wherever we can.

It is in this particular case such a massive amount of data to handle and it is in comparatively youthful stage of development, we haven't yet gotten a basic system, so we find we are centralizing, it is the only way we know how to do it now, but from a military point of view we wouldn't like to have too many eggs in one basket.

Mr. HINES. Is this a problem that is causing some delay in your program?

Colonel COWAN. We don't have a program and the delay is not due to this at this stage.

I indicated my personal view that in perhaps 5 years, when things exist, the military will want to supplement and augment the things in some areas.

I can't predict what this would be just yet.

Mr. FULTON. Are you saying that it will be 5 years before the United States has an adequate Tiros weather satellite program and that thereafter the military will come in and get an adequate program?

From what you said it appears as if we have a 5-year civilian program and then the military comes next.

I think that should not be left on the record either?

Colonel COWAN. Congressman Fulton, I don't really mean that we won't have the satellites. The Nimbus program should surely be operational sooner than that; perhaps by 1966, the way it looks now, unless we could compress the latter part of the schedule.

I am concerned——

Mr. FULTON. Isn't it necessary for the security of the United States and for the protection of our economy, our ships, and our people against hurricanes, typhoons, and monsoons and ordinary storms, that we progress quicker than that?

You give me some concern when you speak of 1966–67. We will have landed on the moon, possibly, by then. And still we would not be able to tell what the weather is on the earth.

Colonel COWAN. Sir, we had discussed this earlier. The services are each concerned about the lag in the program. There hasn't been a Department of Defense position established on this.

I feel likely there will be this next year, let's say. We intend to certainly work with our civilian counterparts, with the people in the Weather Bureau and NASA, to see if there is anything we can do to help them accelerate the program, then knowing just where this can go and how quickly it can get there. I am sure we will make up our minds on the course of action. But this has not been done.

Mr. FULTON. Why aren't the decisions made in the Department of Defense, that there is a U.S. security interest in space, in space developments, and space research?

To me, to hear time after time, from the Department of Defense, and from the various services, that there is no specific military space mission, and no weaponry system, that at present can be justified, and that there is time—say 3 to 5 years—to develop an adequate weather system for the civilians first to me is begging the question.

We must get these decisions made. There are two chief factors in outer space; one is security and, second, the peaceful uses of outer space.

We must have decisions on both. And I must say to you that this committee seems to be much further advanced than either the military, the Department of Defense, or NASA, on recognizing a need for urgency on these problems.

Would you comment on that—with the chairman's permission?

Colonel COWAN. Congressman Fulton, I would like to express my agreement with you. I think that we have been in a honeymoon stage.

Mr. FULTON. When do we get the decisions? That is my point. When do we get Department of Defense decisions on these matters and how do we get them? It is the decisionmaking process that my comment is directed to.

Colonel COWAN. I think——

Mr. FULTON. I don't press it.

Colonel COWAN. I would like to reply. I think that the services have got to take their positions and bring them to the Department of Defense and——

Mr. FULTON. Glad to hear that.

Colonel COWAN. I feel that the onus is really on the Navy and the Air Force and the Army, in all honesty, to come back to the Department of Defense as soon as this concern is recognized and translated into something specific.

Mr. FULTON. I believe the services, Army, Navy, and the Air Force and Coast Guard and Marines, are much further ahead than the upper echelons of the Department of Defense on seeing the need, the urgency and the security interest of the United States. But the problem is we can't get the basic decisions made at these higher levels.

Mr. HECHLER. Will the gentleman yield?

Mr. FULTON. Yes.

Mr. HECHLER. Following up the questions Mr. Fulton asked, I would like to ask Colonel Cowan whether the individual services have underlined the necessity for an early decision in this field?

Is this a problem of waiting on something that is to be done at the higher level in the DOD or is it a problem of waiting until the individual services can represent their needs?

Colonel COWAN. Mr. Chairman, it is my opinion that the individual services need to take the initiative now, that a year ago when the decision was made to rest with the national system, that settled the question for the moment then, but now, a year later, when we say the program has slipped a year, I think that we are entitled to review our position and perhaps to make new recommendations, and to my knowledge this has not yet been done. I think it is overdue.

Mr. HECHLER. In other words, there is no laxity on the part of some higher echelon in DOD, the laxity may well be within the services?

Colonel COWAN. Mr. Chairman, I think I would be irresponsible if I blamed the DOD for the fact that we haven't gone to them, to my knowledge, specifically on this.

Mr. HECHLER. I just wanted to clear the record on this. I think it is important.

Mr. FULTON. Could I comment on that?

There is no charge of laxity. But there is the need to make prompt decisions on space where U.S. security affairs are involved.

When I see there has been a 1-year slippage on as important a program as the Nimbus weather satellite program, it does cause me concern.

When I hear that it may be 5 years before the civilian objectives are accomplished, and that then the military requirements will be met, I get further concerned.

Now my purpose is not place blame but to get decisions.

Further, my point is that when DOD witnesses have come up here—as recently as within the last 2 weeks—I have been unable to get the decision made on security matters in space. I am told that the armed services don't have specific military missions in space and they cannot justify particular weaponry systems.

My point of view is exactly the opposite. We must first make decisions and then decide how to implement them.

So that I am not looking for blame. I am trying to get action. I want to make that clear, Mr. Chairman.

Mr. HECHLER. I believe Colonel Cowan in his initial statement mentioned intensive effort for modification of plans needed to be initiated in order that military requirements be fulfilled.

In fairness to the witness I point that out.

Mr. FULTON. I think that is a good comment.

Mr. HECHLER. I wonder, Colonel Jones or Colonel Cowan, if you would care to elaborate on any technical considerations that in your opinion need to be solved in order to regain lost time?

Colonel JONES. I think, again, I would like to defer to the Weather Bureau, because I think primarily this has been in the realm of spacecraft and supporting equipment—NASA.

Mr. HECHLER. Anything further?

Mrs. Weis?

Mrs. WEIS. No, sir.

Mr. HECHLER. Any further observations that you gentlemen care to make?

Mr. FULTON. We have one I think.

Do you need more money for this research and development? This committee has jurisdiction of scientific research and development, wherever it is being carried out, particularly in the basic research area.

Colonel COWAN. Well——

Mr. FULTON. We have asked other witnesses that question and they are just as reluctant to answer. They back away from the word "m-o-n-e-y."

Colonel COWAN. I think the answer is that if we feel we must put something into a space program we would need considerable money, but the decision has not been made.

Mr. FULTON. My inference is this: It isn't budgetary limitations that are holding you back on these necessary security decisions and military decisions on operations in outer space, is it?

Colonel COWAN. Yes, sir, I think that is a fair statement. I believe that other considerations—to see if we can get the national program nearer to schedule and not to withdraw support from it which might undermine it—have been a factor, more so than money.

Mr. HECHLER. It is much more important to move the national program forward even then to make the military decisions; is that your point?

Colonel COWAN. Well, Mr. Chairman, I would like to say it has only been a year since this program, this national program, was laid on and was funded, and it is a time when we all hope that it can succeed, and we wouldn't want to do anything to undermine it.

Our thinking in the other areas perhaps has lagged a little, and I am sure that your comments today will be considered very carefully.

I think there has been some wonderful guidance for us in our thinking—particularly from Congressman Fulton.

Mr. HECHLER. We appreciate that.

Mr. FULTON. When I see a headline such as "If Space Becomes a Battlefield Will U.S. Be Ready?" and then hear that if the peacetime uses are taken care of in 5 years, then the military will be able to go ahead, it does give some of us a little concern.

Colonel COWAN. Yes, sir. I should qualify my 5 years.

I am a professional meteorologist at heart and by trade and my standards for what I want to see in the system are much higher I think than many others.

There are useful things being done now. I won't be satisfied with the system for 5 years, but this doesn't mean that it wouldn't be highly useful.

It will be just evolving to what we think it needs to get to for this period of time.

Mr. FULTON. Don't you think the military should be proceeding with a full-steam-ahead program and that, the peacetime uses of space through NASA should be developed with full steam ahead?

I don't see why the military has the attitude that "it will take time" and "we have got other things to do." Maybe on balance the other things are more important. But to me space is of top importance, both for peacetime purposes and military. We should quickly get the decision that that is the fact.

That is all, Mr. Chairman.

Mr. HECHLER. Thank you, Mr. Fulton.

Mr. Hines?

Mr. HINES. Colonel Jones, would you clarify your position with the National Weather Satellite Center?

Colonel JONES. I am the air weather service liaison officer with this organization, actually an active participtant in a good many phases of

the meteorological satellite work, primarily in the area of operational application of the satellite information and data as we acquire it from one satellite to the next and to keep the National Weather Satellite Center apprised of our air weather service requirements for data and keep the air weather service informed on the status of the progam on a more or less day-to-day basis.

Mr. HINES. Thank you.

Mr. HECHLER. I would only say, before concluding, I would hope that an early decision would be reached to make a clear-cut expression of the military requirements.

Mr. FULTON. May I join with you?

I think that is an excellent statement.

Mr. HECHLER. Any further questions?

If not, the subcommittee——

Mr. HINES. Colonel Cowan, do you have anything further?

Colonel COWAN. No, sir.

Mr. HECHLER. If not, the subcommittee stands adjourned until 10 a.m. tomorrow.

(Whereupon, at 11:20 a.m., the committee adjourned to reconvene at 10 a.m., on Wednesday, August 29, 1962.)

METEOROLOGICAL SATELLITES

WEDNESDAY, AUGUST 29, 1962

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE NO. 4,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Ken Hechler (chairman) presiding.

Mr. HECHLER. The committee will come to order.

This morning we are continuing our hearings on the progress being achieved in the development of our weather satellite program.

I would like to call attention that in the audience we are honored by the presence of Lt. Gen. Donald N. Yates, retired, U.S. Air Force, who was commanding general of the Air Weather Service from 1944 to 1950 and is currently vice president of the Raytheon Corp.

Yesterday the Department of Defense spokesman expressed grave concern over the 12-month slippage in the schedule for development of meteorological satellite Nimbus. This committee is also concerned, not only with the effect of this delay on military requirements, but also its effect on many other phases of our weather satellite program and the results we expect to achieve in other fields.

This committee intends to keep the heat on to find out what is delaying the Nimbus program, and to also press forward with the Nimbus program at all possible speed.

Despite the fact that we may not have proceeded as fast as we planned on Nimbus, I believe we have made highly successful breakthroughs by means of the Tiros series of weather satellites and the television cameras aboard the Tiros weather satellites have picked up cloud formations and other data which have enabled us to give early warnings of hurricanes and other storms, and more accurately to interpret a very wide range of weather phenomena.

I believe the economic implications of the improved weather predictions have great value for this country and for the entire world, and will also help lift the standard of living of people of underdeveloped areas all over the world, as we obtain weather information in areas hitherto blacked out as far as weather data is concerned.

So all in all the United States has scored many firsts in space with our meteorological satellites.

This morning we are very pleased to have with us the Chief of the U.S. Weather Bureau, Dr. Francis W. Reichelderfer, accompanied by Dr. S. Fred Singer, Director of the National Weather Satellite Center.

I might mention, incidentally, that Dr. Singer was consultant to the Select Committee on Astronautics and Space Exploration in 1958

when that committee laid the groundwork for establishment of the National Aeronautics and Space Administration.

Dr. Reichelderfer, do you have a prepared statement?

Dr. REICHELDERFER. I do have a statement, Mr. Chairman. Would you like me to go through the statement, or would you rather have me go directly into the questions?

Mr. HECHLER. Proceed in your own way.

Dr. REICHELDERFER. Thank you, sir.

STATEMENT OF DR. FRANCIS W. REICHELDERFER, CHIEF, U.S. WEATHER BUREAU; ACCOMPANIED BY DR. S. FRED SINGER, DIRECTOR, NATIONAL WEATHER SATELLITE CENTER

Dr. REICHELDERFER. Mr. Chairman and members of the committee, when the first Tiros (television infra-red observation satellite) carried its two television cameras into orbit on April 1, 1960, meteorologists were not certain what could be learned from the pictures it transmitted to earth or how they could be used in weather forecasting.

It was expected that months, and perhaps years, of study and development would be necessary before there would be tangible results.

Viewing the initial Tiros photographs, the weatherman saw for the first time the vast panorama of cloud systems over large sections of the earth. They saw, in the configurations of the clouds, the large-scale weather patterns that they had plotted on their charts.

The pictures revealed the many sizes and shapes of cloud systems. There were clouds in parallel rows, clouds in uniform sheets, and clouds in irregular broken patterns. In cloud-free areas, the surface features of the earth could be easily distinguished. Coastlines, snow-covered mountains, lakes, rivers, sand dunes, and ice in gulfs and bays were clearly visible.

Almost immediately, the new view of cloud systems provided by the satellite's television cameras was found to be of practical use in locating storms and in synoptic weather analysis, especially over ocean areas from which few, if any, reports are received.

Samples of the photographs and a review of progress during April, May, and June 1960, were presented to the Executive Committee of the World Meteorological Organization in Geneva in July 1960. It was my privilege as U.S. delegate to the WMO and member of the WMO Executive Committee to show the results of Tiros I to my colleagues and I shall never forget the immediate and enthusiastic response with which these results were received.

It is unusual for an experimental program to blossom out with practical applications as quickly as the weather satellite program has done. Indeed, this program has been one of the most successful in the U.S. space effort. In a period of slightly more than 2 years, we have seen the launching of five Tiros satellites. The performance of the satellite instruments has exceeded expectations. The information relayed to earth has been used to provide better forecasts and warnings. The satellites have opened new avenues of weather research by gathering data never before available. In the past year, Tiros satellites have been in operation on 260 days out of 365, sending to earth information that affects the safety, economy, and convenience of people all over the world.

Early warnings of devastating storms provide a dramatic example of the many practical uses of satellite photographs. The Tiros satellites have repeatedly demonstrated their effectiveness in identifying and tracking such storms.

Year after year destructive storms have developed at sea and struck the coasts of Australia, Japan, India, Pakistan, and Latin America with little or no advance warning. Few nations can afford to pay the very high cost of maintaining conventional weather observing and reporting stations in ocean areas.

A glance at the map shows how difficult it is for nations in the Southern Hemisphere to establish and maintain an adequate network of weather reporting stations. In the Northern Hemisphere, ocean traffic and air commerce across the North Atlantic and North Pacific provide means for obtaining weather data. But the shipping and air traffic over the great expanses of ocean in the Southern Hemisphere are very small in comparison to those in the Northern Hemisphere.

As a result, the Tiros satellites now provide on a current basis several hundred times more information on weather in the Southern Hemisphere than was ever available before.

In 1961, Tiros III photographed tropical storms on more than 50 occasions and discovered Hurricane Esther. Tiros V, the present satellite, has already discovered a typhoon—subsequently named Sarah—in the western Pacific Ocean.

Since the launching of Tiros I, we have made a special effort to share the benefits of the weather satellite programs with all nations. Cloud analyses are distributed internationally in coded form by radioteletypwriter. During the operation of Tiros IV, the Weather Bureau used radiofacsimile for international dissemination of the actual cloud maps, giving meteorologists in Europe, South America, Africa, the Far East, and the Southwest Pacific a clear and immediate picture of the cloud patterns seen by the satellite. This program was experimental—we hope to resume it in the future.

When satellites detect significant weather developments, such as storms, hurricanes, and typhoons, special international bulletins are issued to nations that might be affected. We have, in the past year, sent 433 such messages to foreign governments and to remotely located weather bureau and military weather facilities.

Argentina, Australia, Brazil, Chile, the Republic of China, Great Britain, Hong Kong, Iceland, Ireland, Japan, Malagasy, Mauritius, Mexico, New Zealand, Nicaragua, Nigeria, the Philippines, Senegal, South Africa, Surinam, Uruguay, Venezuela, and the British East African Territories of Kenya, Uganda, and Tanganyika—all have received warnings of weather conditions detected or more definitely located by Tiros.

These advisories have been well received, and the numerous complimentary acknowledgments are evidence of the usefulness of the information.

On July 12 of this year, the Chilean weather service was warned of a well-developed storm system in the South Pacific. On July 13, we received a message from Chile:

> Received via Transradio your message dated 12th, 1837Z. Information very useful our forecasting section. Please send any other information related with our area.

After Tiros V discovered Typhoon Sarah, the Weather Bureau warned endangered nations. On August 17, 1962, we heard from the Taiwan Weather Bureau:

> Your radiogram dated 14th giving us the first position of Typhoon Sarah has been duly received with high appreciation. Typhoon Sarah is still in her way to hit the east coast of Taiwan probably tomorrow morning. The satellite information was so important to us that we wish to have your assistance at any time when such information is available.

The ability to detect and track storms is certainly the most dramatic and most publicized accomplishment of the Tiros satellites. But satellite photographs of other weather phenomena have been used on many occasions to improve more routine weather analyses. Research is continuing on the meaning of various features in the cloud pictures in observing weather fronts, relatively small severe storm situations such as those which produce tornadoes wave clouds which occur to the lee of mountain chains, and so on.

Other applications that are not of a strictly meteorological nature are being developed. It has been demonstrated that snow and ice can be distinguished in satellite photographs, and as these techniques improve, the information will be of great value to shipping and to agencies responsible for water supply and flood forecasting.

The meteorological services of more than 100 nations have been invited to undertake their own research programs using Tiros data and to conduct special observing programs coinciding with the passage of the satellite overhead. Many nations are doing so. This is another facet of our international cooperation.

Last November, the Weather Bureau and the National Aeronautics and Space Administration sponsored an international meteorological satellite workshop in which representatives of foreign weather services were given the opportunity to acquire a working knowledge of the use of satellite data in daily forecasting operations and in research.

After the success of the Tiros program became evident, the Congress in September 1961 appropriated $48 million to the Weather Bureau to "establish and operate an Operational Meteorological Satellite System" (Public Law 87–332).

In response to this legislation, the Weather Bureau has established the National Weather Satellite Center which is the responsible entity in the Bureau for research in satellite meteorology, for management of the operational system, for participation in planning future systems, and for liaison with NASA in arranging those portions of the system appropriate to that agency. The center is now proceeding with the development of the operational system.

The core of the operational system will be the Nimbus satellite. Nimbus will be so oriented that its cameras always point toward the earth. It will travel in an essentially polar orbit, providing global coverage of the weather.

Thus, more complete and more continuous information will be available to weathermen all over the world. This satellite will also have nonmeteorological applications, which we will pursue. For example, it is expected that Nimbus will detect forest fires in their early stages, thereby permitting early control and saving millions of dollars annually. It is also expected that locust swarms, which act essentially as clouds, will be seen by Nimbus, and early advice can be given to agencies concerned with locust control.

In some parts of the world, the locust is responsible for millions of dollars of damage each year.

This Nation's weather satellite program has provided the most concrete demonstration of the real benefits to all mankind of the peaceful use of outer space. But it has done more than that. The weather satellite program has, in effect, harnessed the universal interest in weather to promote better understanding and closer cooperation among nations. It has generated new enthusiasm and activity within the scientific community in this Nation and abroad.

With the close collaboration of the President's Science Advisory Committee, the National Academy of Sciences, the American Meteorological Society, the American Geophysical Union, and other scientific bodies, planning groups are now at work formulating suitable programs for 5 or 10 years in the future.

A special committee, known as the Committee on International Planning in Atmospheric Sciences and Hydrology (CIPASH), has been formed and is hard at work. More than 100 scientists from various parts of the scientific community have been brought together with a view to developing the best possible proposals. Seldom have scientific opportunities been so swiftly recognized and acted upon.

On an international level, the United Nations recognized the benefits of the weather satellite program when it passed Resolution 1721 in December 1961, calling upon the World Meteorological Organization to take certain actions in the further development of satellite meteorology and in the improvement of weather services and atmospheric sciences in general.

The United States has taken an active part in the work of the United Nations on this subject, as well as in that of the U.N. Combittee on Outer Space and its technical subcommittee.

We have provided expert assistance to the World Meteorological Organization in the development of its plan for improving worldwide weather service.

This plan proposes the establishment of a world weather watch, including satellite observations of the world's weather and the development of world weather centers in such locations as Washington and Moscow, with the understanding that complete exchange of information will be accomplished.

The WMO report outlines in a preliminary way the possibilities for research in the atmospheric sciences. To develop these possibilities, a collaborative effort is needed among WMO, UNESCO, ICSU, and other bodies representing the scientific community. ICSU is the International Council of Scientific Unions. The cost of both the service and the research programs required will be small in comparison to their potential benefits.

The WMO report has now been endorsed by the Executive Committee of the World Meteorological Organization. considered by ECOSOC, and will soon be considered by the United Nations Committee on Outer Space and the U.N. General Assembly. Next spring, the Quadrennial Congress of the World Meteorological Organization will examine in detail the practical aspects of implementation of the plan by the various countries concerned.

Finally, weather satellites were a major item in the bilateral discussions on outer space between Dr. Hugh Dryden of NASA and

Academician Blagonravov of the Soviet Union. Preliminary arrangements are being made for complete exchange of information on weather satellite programs, and for eventual coordinated launchings to achieve optimum coverage.

I have confined my remarks primarily to the technical aspects of the international benefits to be gained through weather satellites. Further information on the plans of the United States under United Nations Resolution 1721 of December 20, 1961, and on other budgetary and diplomatic aspects will be taken up in due course by the departments of government that are primarily responsible—principally the State Department, with whom the Department of Commerce Weather Bureau, the National Aeronautics and Space Administration, and other agencies are working in close cooperation.

Mr. Chairman, I mentioned a moment ago the world weather watch. I would like to take just a moment to refer to the work of Dr. Harry Wexler, especially while he was working with the WMO in Geneva. Dr. Wexler, Dr. Singer and others, were among the first to foresee the value of satellites. Dr. Wexler presented a paper at the Hayden Planetarium in New York in 1954 which depicted how he thought cloud systems over North America would look from a satellite, and when we actually obtained the real views from the satellite the picture was a faithful preview.

Dr. Wexler has been a very prominent contributor to advancement of the science and it was a tragedy that he suffered a fatal heart attack about 2 weeks ago. It was a great loss to science and to the Weather Bureau.

Mr. Chairman, in your opening remarks you mentioned the Nimbus program. We have been working closely with NASA. I believe Dr. Singer will have more to say later about time schedules. He is close to this situation. We are very much aware of the urgency expressed in your remarks of the dependence not only of the public and of the meteorological services on the early achievement of an operational satellite program that will give full-time coverage, such as visualized in Nimbus, not only this, we realize also there are potentially important military uses and we have been interested in doing everything possible to expedite action.

We know that NASA and the contractors who are working for NASA have bent every effort to speed up the work, and I believe you will be interested in further information on this aspect that Dr. Singer will give.

I have one other point that I would like to mention in connection with my general statement.

The importance of satellite observations in early discovery, in tracking and warning of hurricanes, and hopefully later the detection of such more localized and more transitory destructive storms as tornadoes, but certainly for hurricanes right now, can hardly be overemphasized.

I think this is generally appreciated, but I would like to refer to an article that appears in the September issue—September 1962—of Reader's Digest. It is dramatically entitled "Hurricane Coming, Get Out or Be Drowned."

The author has traced the importance of the warnings in this case very dramatically. This hurricane caused the greatest mass evacuation that ever occurred in history in order to escape a storm. A con-

servative estimate is if it had not been for the warnings the drownings in the storm would have run into the thousands, perhaps the tens of thousands.

Tiros was not wholly responsible. In this particular case the action was a good illustration of how much cooperation is involved in adequate meteorological services.

We had aircraft reconnaissance from the military forces, which is an essential part of hurricane warnings. We also had the radar networks which after the hurricane came close to the coast gave fixes to enable us to estimate quite definitely just when the high waters would come.

But Tiros also had a part because at a time when Carla's position was uncertain in the gulf, we had photographs from Tiros and these helped in locating and keeping track of the storm, much more accurately than ever had been done before in history.

I will quote two sentences:

Thousands of persons who might well have lost their lives were given ample time to escape, however, for on the 9th and 10th of September, sheriffs in Texas coastal communities, urged to action by the U.S. Weather Bureau forecasts, warned "Get out or drown."

Mr. HECHLER. Doctor, without objection, we will incorporate the entire article in the record.

Dr. REICHELDERFER. I believe it will be necessary for the committee to get permission from the Reader's Digest. I will be glad to request that if you would like.

Colonel PEACOCK. We will check it out before it is placed in the record. Without objection, we will place it in the record if there are no restraints on it.

(The article referred to is as follows:)

HURRICANE COMING—GET OUT OR DROWN

(By Thomas Gallagher)

It was just a year ago, on September 11, 1961, that one of the biggest (350 miles in diameter) and most violent (90 times as much energy as Soviet Russia's 50-megaton bomb) hurricanes in recorded weather history whirled in from the Gulf of Mexico to blast the coast of Texas. Pushing 40 billion tons of water before her, Hurricane Carla left 30,000 Texans homeless and destroyed hundreds of millions of dollars' worth of property.

Thousands of persons who might well have lost their lives were given ample time to escape, however. For on the 9th and 10th of September, sheriffs, in Texas coastal communities, urged to action by U.S. Weather Bureau forecasts, warned: "Get out or drown."

As a result more than 500,000 persons, in the greatest mass exodus in U.S. history, boarded up their homes, packed their cars, and headed upstate to Red Cross shelters or to the homes of relatives or friends.

When Carla struck the Texas coastline, her fullest force was aimed directly at the little town of Port O'Connor. As luck would have it, not quite everyone had fled Port O'Connor. What follows is the almost incredible story told by 11 who remained behind—and saw 98 percent of their town swallowed up before their eyes.

Port O'Connor, on a neck of land between Galveston and Corpus Christi, lay waiting tensely. An old fishing town, it was a summer resort as well, with imported palm trees, a marina, a motel, a trailer camp, and many cottages whose lawns were matted with fine white sand from the beach. Devastated by hurricanes four times since the turn of the century, it was a town where there were as many barometers as coffeepots.

On Saturday, September 9, when the U.S. Air Force ordered its planes and personnel evacuated from the base on Matagorda Island, only 6 miles away, the residents of Port O'Connor began to leave. Chris Clarich, an old merchant seaman and shrimp fisherman, whose house was a quarter-mile from the beach, would have left with them if he had not promised to look after the six Almanzar children while their mother visited her doctor in nearby Port Lavaca.

"I don't think the storm will come here," he said to his 77-year-old wife, who had the youngest child, a 5-month-old infant, in her arms. "But there's still time. We'll all leave as soon as Mrs. Almanzar returns." What Chris Clarich didn't know was that Mrs. Almanzar was at that moment undergoing an emergency appendectomy in Port Lavaca.

Ten blocks further inland from the beach were three brothers—Edgar, Whip, and William Munsch—who had no intention of leaving Port O'Connor. For half a century they had never left to escape a hurricane. "You don't leave a place," they said. "You take precautions, but you don't leave."

In 1950, after experiencing half a dozen hurricanes, Edgar Munsch had taken every precaution by building a house the like of which had never before been seen in Port O'Connor. "There are more struts and braces in this house than in any three other houses put together," Whip said to me afterward. "Edgar used extra-long nails, too, and bent each one over at the end. Why, you couldn't pull this house apart."

In honor of his 25 years in the U.S. Coast Guard, Edgar had also constructed a glassed-in, 5-foot-square lookout at the apex of the roof, with a view in every direction. In front of the house lay a field of live-oak thickets, a tight mass of woden arms strong enough to catch and hold the uprooted trees, piles, and telephone poles that could become battering rams against houses during a hurricane. Whip, the Port O'Connor weatherman, had always advised his fellow townsmen to allow the thickets on their property to grow, but most people had had them uprooted and replaced by lawns or summer rental cottages. Now the only house in Port O'Connor protected by thickets was Edgar Munsch's.

It was in this house that the three brothers, no more aware of Chris Clarich's presence in town than he was of theirs, awaited developments.

Water began to trickle into the Clarich yard that evening. Chris watched patch after patch of sand "melt like sugar" round his doorstep. When the electricity went off, he decided to leave town with his wife and six children without waiting longer for Mrs. Almanzar.

After putting on hip boots and carrying his wife and the infant to the car, he drove to the Port O'Connor schoolhouse, four blocks away, where the older children were playing. He left his motor running and sloshed through the yard to the auditorium where the children had said they'd be. In less than 10 minutes he rounded them up—but in that time the water had risen to cover the car's exhaust. Was the road to Port Lavaca already washed out?

"Children, go back to the auditorium," he said. "Hurry!"

When all were safely inside the sturdy brick building, he ran to the principal's office to telephone for help. The line was dead.

The next morning, Sunday, the Munsch brothers saw from their lookout that the water was advancing on the town from three directions—from Matagorda Bay, San Antonio Bay, and the Intracoastal Waterway. It came inquiringly, over roads that might have been the decks of a slowly sinking ship.

"I began to feel small and humble," William Munsch, a yacht captain, told me later. "The air became tense, and felt almost too heavy and wet to breathe. And the sky turned hazy and yellow in a way that made everything look unreal."

Birds and animals seemed alive to what was happening, too, for the brothers could see black skimmers and Caspian terns hugging windbreakers in an effort to rest before flying inland. At one point Whip saw a possum rushing so frantically up a telephone pole that when it reached the top it kept right on going—up into the air and then down into the water again.

In the evening the wind increased with steady persistence. This was the rim of the hurricane and, as it blew through the town, electric and telephone wires ripped like cat-o'-nine-tails through air already filled with broken glass, car license plates, pails, clothing, and bits of lumber.

"When the storm struck, it was the worst thing I've ever experienced," Chris Clarich said. "The tide had to be at least 20 feet above normal for the town (7 to 12 feet above sea level) to be that covered. The auditorium looked like a swimming pool."

The night before, after trying in vain to phone for help, Clarich had rushed home for mattresses, blankets, food, water, and oil lamp, and a single-burner

stove. Now, out of piled tables, benches, and chairs, he built an island on the auditorium stage. As the water reached the stage, even the oldest, 11-year-old child began whimpering with fear. Chris piled the bedding and equipment on top of the island and lifted his wife and the children up.

There was a square opening in the ceiling above the stage, leading to the attic, and as Chris worked he kept scanning it. If things got much worse, he planned to pile one table on top of another, climb through the opening to the attic and, with a knotted blanket, pull his wife and the children to safety.

Meanwhile, from a backstage window to which he kept running, he could see the piled-up masses of water rushing past, the twisted and broken spines of boats, and sometimes the swollen bodies of dead cattle. There were terrible impacts of debris and jarrings of air, vicious rushes of wind in which all the atmosphere seemed concentrated, and then, above the steady roar, rending shrieks like air-raid sirens.

During hurricanes at sea, Chris recalled, there had been a monstrous kind of harmony between the raging waves and the struggling ship. Here on land everything that happened was unlike what it happened to. Sedentary household things like sofas and TV sets flew by like grotesque things with wings. Chris saw a trailer, emptied of its furnishings, its metal skin ribboning off the framework in the wind, sail by looking like an open and discarded sardine tin.

"By Monday morning," Chris said later, "I wanted to stop what I was doing and just listen, because I couldn't believe my ears anymore. If 10 jet planes had been in the auditorium with us, they could not have made more noise than that wind."

As dawn was coming up, Chris's eyes wandered to the auditorium windows high above the water level on the lee side, and what he saw suddenly made cereal of his body's fiber. The glass was smashed, and coiled in and around the narrow sashes were more than a dozen rattlesnakes and water moccasins. The wind and water had chased them from their lairs on Matagorda Island, swept them across the bay, and thrown them against the trees and buildings of Port O'Connor.

Chris knew that the storm had torn shingles and even planks and rafters off the roof, leaving gaping holes through which snakes could crawl into the attic. Were there rattlers and moccasins coiled in the darkness above them, in the only place left for them to go? This terrifying possibility haunted him as the water rose and he tried to distract and calm the children and make their island of safety higher.

At the Munsch house, Whip was urging his brothers to follow his example and put on life preservers. Whip's car in the garage, like the others parked in the yard, had disappeared under the churning waters. On the first floor, the piano, refrigerator, sofa and chairs were all either covered or afloat.

Yet the destruction of their belongings shrank to insignificance beside the sheer vastness of the destruction they could see from the lookout. They saw the whole roof of a house poised on a blast of air, then tossed half a block as one might toss a book. They saw trees, trucks, butane tanks rising and rolling with the masses of water rushing past. If it had not been for the live-oak thicket directly in front of them, this wreckage would have ripped their house to pieces.

"The barn's moving!" Whips shouted suddenly to his brothers. He had gone to a bedroom to fetch something and was passing through the hallway when he noticed that the view from the hall window had changed. He wasn't supposed to be able to see the barn through this window, but there it was—and it was moving! Even more astounding, it was moving against the wind.

"I was taking a barometric reading at the time," Edgar said later. "The reading was 27.68, I remember. Just then there was a rumble through the house, and I could hear the branches being ripped off the mulberry tree in the yard and the windows crashing on that side of the house. 'That ain't the barn moving!' I shouted to Whip. 'It's us!' You see, the bottom of the house is sealed with marine plywood and rests on concrete blocks four feet from the ground. When the water and wind came in a rush like that, the whole house just pulled loose from the blocks and became a boat."

Broad and solid, the house floated serenely backward to where trees, 150 feet away, brought it to a halt.

The storm had now reached its height. In the school auditorium, Chris and his seven were all up on the island in the middle of the stage, praying on their knees. Mrs. Clarich had a crucifix in one hand and the infant in the other.

"I knew that if the wind kept up there would not be a brick left in the building," Chris said. "But when I prayed I began to hope. After a few minutes I

remember standing up and shouting, 'God has answered our prayers!' It was like a dream. The wind stopped all of a sudden, and the water started going down just like when the stopper is pulled in a bathtub. Not only that, the snakes disappeared."

At the Munsch house, just before this calm, the brothers saw a 4-by-10 foot workbench of Edgars come floating out of the garage. Loaded with tools, nails and boxes of screws, it passed beyond them out of sight to be destroyed, they thought, and become part of the storm's debris. No sooner did the water begin to recede, however, than the bench reappeared, minus the tools, nails, and screws, and headed straight back toward the garage from which it had come.

"If it had made the trip all the way back," Whip said, "I think I would have given up. Hurricanes do funny things, but that would have taken the cake."

The "eye" or calm center of Hurricane Carla, 25 miles in diameter, came at 2:40 p.m. on Monday, September 11, and remained until 4 p.m. Outside the eye, the winds were still tearing along at more than 150 miles an hour, but in Port O'Connor itself five candles could have been lighted in the open air with a single match. As the water receded to below the motor level of Edgar Munsch's pickup truck, a short circuit developed in the wires connected to the horn. Suddenly the horn started to blow, in the absolute silence of the calm.

"You couldn't even have heard the noise during the storm," Edgar said. "But with the eye over the town it was more than I could stand. I waded out and disconnected the wires."

The Clariches and Munsches knew that the wind was going to return suddenly from the opposite direction, so no one ventured far out of doors. "While we were in the eye, the auditorium was almost dry for about 40 minutes," Chris said. "Then, when the wind shifted, the auditorium filled up again, and the water began rushing past even faster than it had the first time. It was going downhill now, back into the gulf. Things flew by so fast you couldn't even identify them." Indeed, the second phase was perhaps even more destructive than the first.

When, on Tuesday morning, the hurricane had passed, more than 98 percent of Port O'Connor had been destroyed. A terrible stench filled the air, mostly from the mud and muck and seaweed. The carcasses of hundreds of snakes and cattle lay caught in barbed-wire fences or hidden under debris and seaweed in fields. In front of the Munsch house, a boat that had been blown from a town 35 miles away stood tilted on its keel in mud.

The Clarich house, completely destroyed, has today been replaced by the Red Cross. The Munsch house has been moved back onto its blocks. And all of Port O'Connor is alive with the hammering and sawing of new lumber.

At lunchtime these days, carpenters and masons listen to the jukebox at either the new Stryker's Cafe (of Stryker's old place all that had been left was a beer can opener) or Hurricane Junction, a totally new restaurant. Ed Payne's Fishing Headquarters and Tourist Courts, completely rebuilt, are today doing a better business than ever, with fishermen from all over Texas coming to compete for the sailfish, tarpon, and other game fish for which the gulf is famous.

Did Carla leave any benefits in her wake? Well, ragweed and marsh-elder plants were so badly damaged that the pollen count dropped below sneezing level. Hayfever sufferers had their least annoying season in years.

Beyond this, Chris Clarich and the Munsch brothers discovered an interesting thing. When the evacuees returned, they stood weeping on the ground where their houses had once been, their bereavement unalleviated by the fact that their lives had been spared—since their lives were never threatened. The evacuees concentrated on their loss, whereas Chris and the Munsches, though also losers, concentrated on their gain and were thankful—they were still alive.

Dr. REICHELDERFER. Thank you, sir. That covers my statement.

Mr. HECHLER. You have given us a number of very dramatic illustrations of the practical uses of the information we receive from weather satellites. I appreciate also the way that you have put in perspective our achievements and cooperation with other nations.

Do members of the committee have questions?

Mr. ROUSH. I have none, Mr. Chairman.

Mr. HECHLER. I wonder if you would review the management structure of the development of meterological satellites and clarify the

relationship with NASA, and also indicate the way in which military requirements are given importance.

Dr. REICHELDERFER. I will be glad to make a few remarks.

I would like for Dr. Singer, who is directly responsible now, to amplify what I say.

As is obvious from the remarks I have made, Tiros right from the beginning was so successful and carried such great possibilities in filling the gaps in atmospheric knowledge, at least some of the gaps, which have plagued meterologists in trying to meet the day-to-day requirements of the public, of business and industry, of the military, and so on, that all interested agencies, all agencies concerned with weather, and there are many, immediately looked ahead to see what can be done to get hold of this new system just as soon as possible.

Through the interest and cooperation of the Defense Department—and in this Lieutenant General Yates was a party—and of NASA, of FAA and certain other agencies cooperating with the Weather Bureau, we formed an interdepartmental committee which came out with a proposed plan.

This was accepted and adopted by the departments concerned and the plan agreed that while NASA is clearly responsible for the basic research——

Colonel PEACOCK. Is this the POMS report?

Dr. REICHELDERFER. Yes.

We discussed this with the committee last year.

Colonel PEACOCK. Yes, sir.

Dr. REICHELDERFER. While NASA is clearly responsible for the basic research, it was felt that the Weather Bureau, as the agency responsible for the national meteorological service of the United States, might well be the agency responsible for the operational satellite, and that is the way it has worked out, with the concurrence of the executive departments concerned, and with the assistance of Congress in appropriations, and so on.

The Weather Bureau now is responsible for the operational aspects.

We have developed, and are developing further good management arrangements and we feel that the working relationships are unusually good and unusually thorough.

If you would like more details, may I refer to Dr. Singer.

Mr. HECHLER. What do you estimate is the amount of loss in schedule now so far as Nimbus is concerned?

Dr. REICHELDERFER. It is quite definite that there will be 6 months postponement.

Mr. HECHLER. You think 12 months, as was brought out in the hearings yesterday, is too long an estimate?

Dr. REICHELDERFER. Certainly this is quite possible, but just as there are unforeseeable technical difficulties in designing and developing something new, and engineering it—and the difficulty has been primarily with the new aspects—the orientation system—just as there can be delays, sometimes there are windfalls and progress is speeded up.

So I think it is only fair to say that the 6 months seemed to be quite definite.

It may be as much as 12 months. We are hoping, and I think everybody concerned is working just as hard as they can, to keep it closer to the 6 months.

Mr. HECHLER. I just wanted to clarify it. You are as much interested as the military in making sure we get an operational meteorological satellite at the earliest possible time?

Dr. REICHELDERFER. We are very vitally interested in it.

Mr. HECHLER. I wonder if you or Dr. Singer would care to elaborate on the technical difficulties that you mentioned with respect to stabilization?

Dr. REICHELDERFER. Yes. I am familiar with them but not as directly in contact as Dr. Singer.

Dr. SINGER. I will be glad to answer to the fullest extent I can.

I think, however, that the particular technical difficulties are really the major concern of NASA. They would be most competent to answer your questions.

I would like to make a very general statement here, which is that the Nimbus satellite, in my considered judgment, represents a major technical advance in satellite technology, a real step forward, and I think it is being handled by an unusually competent group of people, in which we have fullest confidence.

Therefore, as far as any technical aspects of the present Nimbus program are concerned, we feel that NASA is doing as well as can be expected and, in fact, better in some respects, remembering that there are real advances that have to be made in the state of the art.

Mr. HECHLER. What is the approximate life of Tiros V predicted?

Dr. SINGER. Sir, the predicted life for Tiros V is 4 months.

Mr. HECHLER. Four months from now?

Dr. SINGER. Four months from the date of launch.

Mr. HECHLER. The date of launch was when?

Dr. SINGER. It was June 19.

This does not mean that it will stop operating on that date. It may last very much longer.

Mr. HECHLER. Will we have a gap then in the information that we get from weather satellites for weather prediction, or is it planned to fill in any hiatus before the development of Nimbus?

Dr. SINGER. If I may, I would like to preface my answer with a very brief statement, because we are getting into a discussion of operational problems and it would be well for us to have a clear view of what we understand by "operational."

Mr. HECHLER. Surely.

Dr. SINGER. The word means many things to different people.

Mr. HECHLER. Yes.

Colonel PEACOCK. Before you give us that, Doctor, would you include the management structure by which the Weather Bureau influences NASA's activities for funding and scheduling the military requirement input and for future user requirements.

Dr. SINGER. I am prepared to discuss this here.

Colonel PEACOCK. Let us know how the Weather Bureau exercised jurisdiction over this operational meteorological satellite system from a management standpoint in these particular areas, so if there is a schedule slippage, say, due to technical difficulties, how do you influence changing this schedule and how does the military incorporate

their future requirements; who determines whether you put a meteorological satellite on the shelf and have it ready to meet military requirements in case of an emergency?

There has been criticism that the military are being left out of the picture. Are they being left out of the meteorological program?

Dr. SINGER. I am prepared to answer all these questions, and I would like to. I hope if I omit any you will remind me and ask them again.

There were a lot of them.

Colonel PEACOCK. Sir, we will.

Dr. SINGER. I would like to amplify certain remarks made by Dr. Reichelderfer concerning how this system was set up.

The legislation which went with the appropriation last September, September 1961, Public Law 87–332, I believe, is a very historic piece of legislation. It is historic for several reasons: (1) It is the first time that an operational system has been set up legislatively, so to speak, based on space technology.

It is historic (2) because it views the fact that space technology is coming of age and will be integrated into the general economy of the Nation.

That is to say that people who need to use space for particular reasons will make use of it just as they use the air, the ocean, or any other part of the earth's environment.

It also sets a very important precedent in the fact that operational applications of space technology are assigned to those agencies that have a primary need for this operational use, in this case the weather satellites are assigned to the Weather Bureau.

Now, our concern is primarily an operational one. We want to provide the best operational cover consistent with the state of the art at all times. Of course, the Weather Bureau is doing this through its conventional services and is trying to improve these services all the time. These include ground observations, balloon, airplane observations, radar observations, and now rocket observations.

We realize that meteorological satellites give us an advantage which the other observing methods do not have, and that is the advantage of worldwide coverage.

Once you set up a satellite system it covers the whole world, and it does not cost any more to cover the whole world than it does to cover a small part of it.

On the other hand, the satellites do not give you the kind of information that the ground observations do, the more conventional observations, and as a result it is necessary to combine the satellite observations and the more conventional observations.

Therefore, what we want to provide at all times is a proper mixture of these which satisfies as well as possible, consistent with the state of the art, any requirements of any user.

Now, we are very pleased about the fact that the present Tiros satellites, as Dr. Reichelderfer has pointed out, which were conceived and are still operated essentially as an R. & D. program by NASA, are paying off economically, they are paying off from the operational point of view, and they are certainly paying off from the point of view of international prestige.

I think this is a good omen, a precursor of what the real operational system will be able to accomplish. Please consider the fact Tiros was not sent up to be an operational satellite and it is accomplishing all of the things that have been discussed here.

We therefore expect great things from the operational system, and I hope I will have a chance this morning to discuss with you some of the more unusual things that will come out of such a satellite system which will have real economic benefits, operational benefits, and will certainly enhance the prestige of the United States and establish our leadership in this particular area even more firmly.

We all realize that in this particular area at least we are very far ahead of any other nation, very far ahead of the Russians certainly, that in order to stay ahead we must continue to be leaders in the operational accomplishments of weather satellites, and this is our purpose.

Now I mentioned before that the weather satellites do not look at the weather in the same way as the conventional weather observations do. In fact, what we see are essentially a bunch of the clouds and the question comes up, for example, if you have a picture of white and black areas what does it all mean?

It is very hard to interpret these things unless you have experience. We are in the process now of gaining this experience through our research activities in the meteorological satellite laboratory.

I will hand these to you [handing].

Cloud Picture Interpretation

Satellite photography has enabled cloud forms and patterns to be observed from a perspective and to an extent never previously possible. Their correct analysis and interpretation constitute one of the major challenges of meteorology.

Below are three photographs, taken by Tiros, showing how significantly cloud patterns can differ in appearance and how difficult can be their correct interpretation in terms of the weather which lies below.

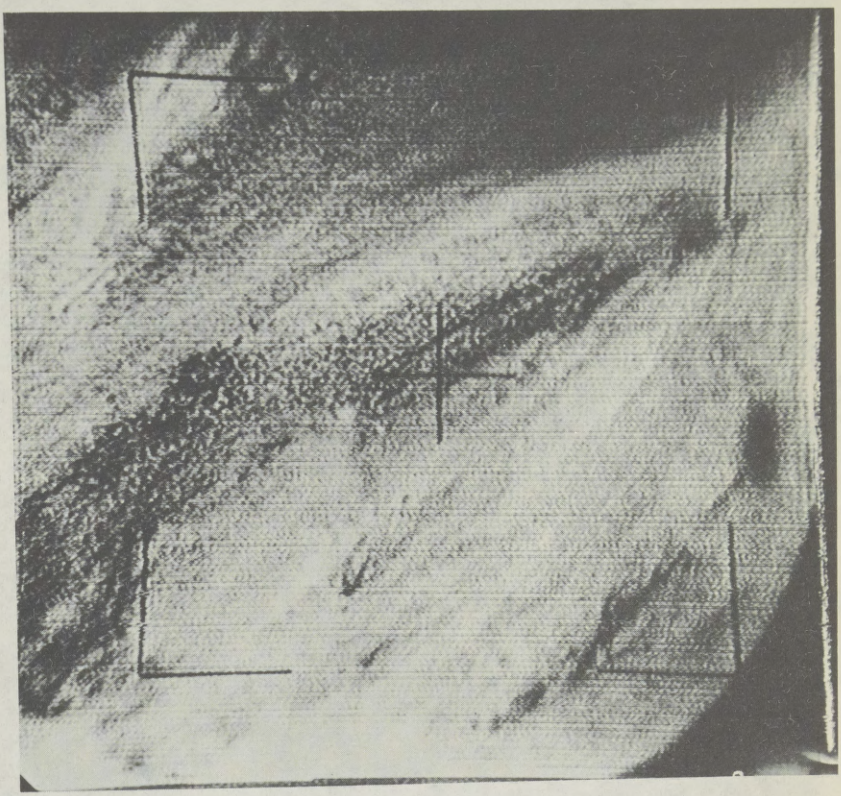


FIGURE 2.—Convective cells.

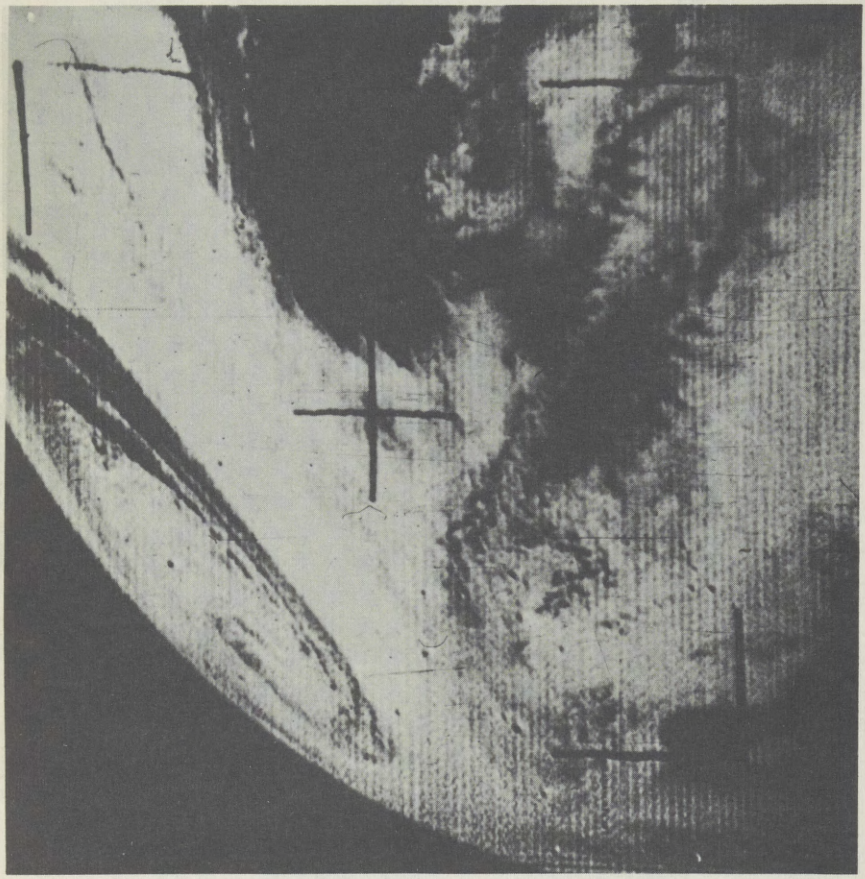


FIGURE 3.—Southern Hemisphere cyclone (taken over South Indian Ocean).

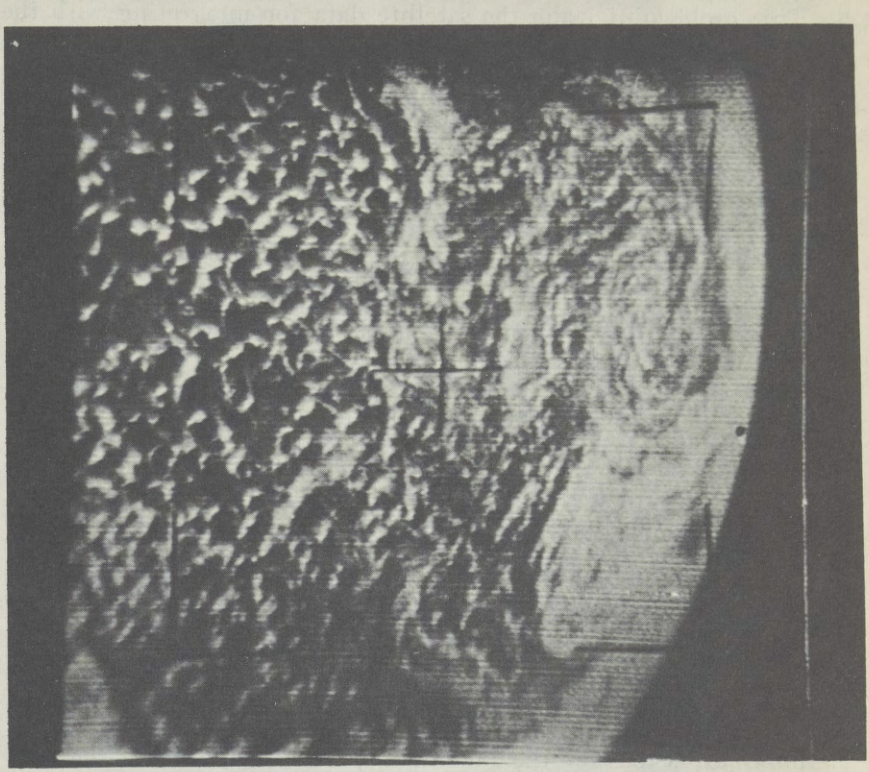


FIGURE 4.—Convective cells with cyclonic center.

Dr. SINGER. This gives typical cloud patterns. You might ask yourself, what can you tell about the weather from these cloud patterns; they don't do anything that a conventional weather map does for you, they do not measure the sea level pressure, temperature, or the winds.

This problem of using the satellite data for integrating with the conventional data and coming up with a forecast is the central problem that occupies our research laboratory.

Our operational people are gaining experience too, because they are learning how to interpret these pictures in terms of what we call cloud analyses, neph analyses. To indicate how this experience is paying off, we now approximately have doubled the number of neph analyses we had on previous satellites and our averages are improving, becoming more accurate.

As a matter of fact, our read-out station meteorological personnel is now training the Defense Department personnel.

We have a regular system whereby Air Force people are rotated in and stay for 90 days at our read-out stations to learn the technique and go back out into the military service. In this way we are diffusing the experience of dealing with satellite data very widely.

Also, as you know, NASA and the Weather Bureau arranged a workshop last year for international purposes which was very successful, and there we tried to spread the techniques of how to use satellite information to other nations in anticipation of the day when satellite pictures will be widely distributed to meteorological services throughout the world.

Now, I would like to say just a few things about what "operational" means to us, and then I would go directly into answering the questions that you have put to us.

Colonel PEACOCK. Give us your operational date, too, if you will.

Dr. SINGER. Yes.

"Operational" means primarily "dependability." It is like the telephone. If you put a dime in the slot you want to get a connection. I think our customers—the Defense Department, the FAA, the Foreign Weather Services, even NASA is our customer because they have now a need for worldwide weather information, in connection with the Mercury program, Gemini program, and Apollo program, all of these people are looking for dependability.

They want to be sure that they will have operational cover at all times.

And this is a primary definition of an operational system. It must be continuous in time. There should be no gaps. The system must have backups. There should be at least two satellites in orbit at all times. If one satellite fails the other will be available. As soon as one satellite fails another one will be put on the launching stand and put in orbit.

The system must be secure. The system should have backups also in the matter of launching——

Mr. HECHLER. What do you mean by secure?

Dr. SINGER. Secure from a military standpoint, and from every other point of view, too. I will be glad to amplify this in a separate statement.

The eventual operational system should also have more than one launching capability. At the present time we only have one launch

pad available for the Tiros satellite at Cape Canaveral. There should be another for the national operational meteorological satellite system and this should be provided for.

There must be——

Mr. FULTON. Where should that be?

Dr. SINGER. This could be at PMR. It could be at sea. It could be on an island. It could be a mobile launch site at sea.

For example, if Europeans take up meteorological satellites we would like to see them have this launching station.

Mr. FULTON. Is there any optimum location, from your point of view?

Dr. SINGER. For launching stations?

Mr. FULTON. Yes.

Dr. SINGER. It should allow you to launch a satellite into any desirable orbit. There are certain restrictions at Cape Canaveral which do not allow us to produce a polar launch.

Mr. FULTON. You need a polar orbit next. You need an equatorial, or some inclination?

Dr. SINGER. As you know, in Nimbus we are getting a polar orbit, which provides worldwide coverage.

We also need more intensive coverage in the equatorial regions.

If I may amplify this particular point: Shortly after I came into the Weather Bureau organization and assumed my present position, which was June 1, I was briefed on the status of Nimbus and was given the launch date.

The announced launch date is still the second quarter of calendar year 1963. This represents a 1-year delay from the date given in the POMS report, it represents a 6 months delay from an announced date given at a later time.

I think I would prefer to not talk about slippage in terms of months or years, but simply give the antiicpated launch date of the first Nimbus, which is now the second quarter of calendar year 1963.

Mr. FULTON. Where did the slippage occur?

Was it in manufacturing, or where?

Dr. SINGER. We were informed there were severe technical difficulties connected primarily with the attitude control system. These difficulties have now been overcome and NASA is now confident of meeting the announced date.

Mr. FULTON. Was it engineering or was it research that caused the delay?

Dr. SINGER. Development. I would put it there under the research phase, therefore, rather than engineering.

Mr. FULTON. Could I ask you about Christmas Island?

Several years ago I had spoken about the possibility of using that island in the Pacific for a launch base. We have the island of Nauru in the Southwest Pacific, where the inhabitants have nothing to do, as their mineral wealth is running out. We have the islands of the Pacific that are under the United Nations, called the Trust Territories.

Could we use those territories, where we are often having to subsidize them to keep the people alive?

Dr. SINGER. I am not competent to speak to this point.

Of course, there are many technical considerations involved in picking a suitable launching site. I can tell you, however—this is cer-

tainly public knowledge—that the AEC have launched a Thor rocket from Johnston Island.

So that it is possible, in principle at least, to set up a launching station on a Pacific island; yes.

Mr. FULTON. This is an unusual committee. How much money do you need for this extra launch installation or for weather satellites to keep the program moving fast?

And when do you need the money?

Dr. SINGER. I would like to supply the answer to this question in a separate statement, because I cannot give this at the moment.

Mr. FULTON. There is a new generation of Government witnesses that shy away from money, Mr. Chairman. I am amazed this year. That is all.

Mr. HECHLER. Dr. Singer was in the process of leading into a discussion of the various matters of responsibilities.

Would you continue, please?

The House will be in session at 11 o'clock.

Dr. SINGER. I would like to get very quickly on the operational aspects and how we view our management responsibilities.

To continue, I was informed of the launch date. The three questions that come to mind are the following: What if Nimbus slips further; secondly the question, what if upon launch it fails; the third question is, what if upon launch it has a lifetime which is very short, let's say, 1 month instead of 6 months as anticipated.

These are questions that we have to ask ourselves.

I am sure they are being asked by NASA as well. But we have a particular urgency to ask these questions, we have to decide what we ought to do and how we ought to plan to keep an operational cover on the people who have come to depend on us for operational weather services.

That is our job.

As I say, this only took place in June—we have made a very intensive in-house study.

This study is just about completed. We are coming out with a proposal—which we will, of course, pass to the suitable group, and I will explain in a moment—with a proposal that we go in for an operational version of the Tiros satellite until such time as we have an operational Nimbus in orbit.

Now after having worked out such a proposal, using in-house experts and consultants, we then present this proposal to a working group, on which are represented Army, Navy, and Air Force, NASA, FAA, Coast Guard, and the Weather Bureau.

Colonel PEACOCK. All the users?

Dr. SINGER. All the users. They will tell us whether they think this system meets their requirements. If they say no, we scrap it and go out and try something else.

But we must keep on coming up with alternatives in case something fails.

If they like it, then we in turn get a concurrence from NASA as to technical feasibility, and since it represents in this case an operational version of a vehicle which NASA has developed successfully, I think we will have no difficulty in establishing its feasibility.

Colonel PEACOCK. Do you have a technical staff of your own that can advise you, or do you accept carte blanche the NASA determination in the technical field?

Dr. SINGER. In which field?

Colonel PEACOCK. In the technical field.

Do you submit a request to NASA based on your requirements and they come back and give you a technical read-out?

Do you evaluate this from a technical standpoint, or do you accept their technical judgment?

Dr. SINGER. In this case we will ask them for an evaluation whether the satellite is technically feasible. We think they will say, "Yes," in which case we won't question it. If they say "No"—I don't think they will, because it is really a version of the Tiros satellite—I think we will have to see what other experts tell us.

Colonel PEACOCK. In the satellite field you rely wholly on NASA to provide the technical information necessary?

Dr. SINGER. Yes, sir; we do.

Colonel PEACOCK. Thank you.

Dr. SINGER. Although we have access to consultants, we have experts of our own, particularly, of course, in the area of the operational use of the data, and more particularly in data processing—this is our special concern and our specialty—technical specialty.

But on questions such as attitude stabilization, solar power supplies, things that have to do in detail with the spacecraft, things that have to do in detail with the launching rocket, we rely on NASA.

Now, we have a chart which really shows how these management responsibilities are divided [indicating].

This accords with the way it reads in the congressional records of last year and also with the interagency agreement between the Department of Commerce and NASA. This agreement was made in January 1962.

It is our job on the operational satellites now to coordinate the requirements of users. We do more than this.

We go out and beat the bushes. We go out and find users. I think it is our job to do this. We should act, you might say, as people who are anxious to sell this system to potential users, because we want to make sure the Nation gets the fullest use out of the system once it is established.

Colonel PEACOCK. When you say "coordinate," I understand that you go out and talk to people.

What happens if an agency places a requirement on you to do a certain job in this area?

Are you required to be responsive to them?

Say the Navy comes to you and says, "Here is the requirement; we want you to comply with it." Are you required to be responsive to that, or do you take that under advisement and determine whether you should or should not meet it?

Dr. SINGER. We would discuss it with them.

It is my opinion that we cannot meet all of the requirements of the military services, therefore the military services should take care of their own requirements that are not met by the national system.

Colonel PEACOCK. So it is on a request basis?

Dr. SINGER. Yes; but the national system should be bent in such a direction as to meet as many of the requirements as possible, to make it truly a national system.

Mr. HECHLER. Do you think of any significant examples of where requirements were not met that were requested?

Dr. SINGER. I think the Navy, let's say, particularly, has certain very specialized requirements, which come about because they have mobility.

What we would like to do is give them as much as we can out of the operational satellite system but then encourage them to meet their specialized requirements in their own way, help them in a technical way if they need the help, and encourage them to budget for it themselves.

Dr. REICHELDERFER. If I might say, with respect to some of the events before Dr. Singer came to the Weather Bureau: Of course the whole reason that the interested agencies got together and came out with the POMS report was the recognition that there is just not enough money to do everything that everybody wants, so while there may be no statutory or regulatory directive that requires the Weather Bureau to comply with requests, we do have the very strong motivation that we have been given the responsibility to try to meet all common needs and therefore we do everything we can to accommodate on anything that can be included in this common system.

Dr. SINGER. I would like to cite this analogy. The Defense Department has a problem of coming up with a fighter which meets the needs of all the military services. Each military service has its own special needs. Our job is easier because the area of common needs is perhaps greater, and I think I can speak from practical experience now in this working committee on satellites, which is under the parent committee on which representatives of all the weather service user departments are present.

There have been no particular problems there.

Our main problem has been to squeeze the requirements out of people. We must sit people down and tell them—"Let's think 5 to 10 years ahead, what will you need."

This system is a long-range system, we must plan now for something you will need 5 to 10 years from now.

Mr. HECHLER. I gather you do not then foresee the necessity for the military setting up its own satellite if it failed to get the requirements it needed; would that be your conclusion?

Dr. SINGER. I like to think this question will be academic because I think this national system will meet the military requirements, and the military feels the same way.

Mr. HECHLER. I agree.

Colonel PEACOCK. The committee would be interested in knowing whether there would be a possibility of duplication in the meteorological satellite program because of military requirements which are peculiar to the military.

Dr. SINGER. I think our system will meet all the basic needs of the military and I think that their specialized needs will not require satellites but will rather require auxiliary processing equipment, and seeing to what should be done with the data to squeeze out certain types of information.

Mr. HECHLER. Going to the other extreme, do you feel there is any tendency to duplication on the part of the military in their research and development of special processing of the data which you produce?

Dr. SINGER. No, I don't think so.

I would like to mention one military requirement to which we are really quite responsive as a prime example.

This is the requirement for direct read-out.

I would like to explain why this requirement is so important to the military and why we want to put this particular requirement even into an operational version of Tiros, and it is actually incorporated in this study that we are making.

Let's take the case of the Navy as an example and consider the commander of a task force who is making a carrier strike. When he launches his planes he wants to have no clouds overhead, over his carrier.

After the planes are launched he wants to have the carrier under a cloud so that it will be hidden. When the planes come back he wants no clouds over the carrier. This is a complex military requirement. This requirement can only be met by the task force commander having direct knowledge of the cloud systems in his immediate area—by this I mean say 500 miles from the central point of the task group.

Mr. FULTON. There is one added thing that is very important: The task force commander wants that information; he does not want his enemy to know about it.

Now, then, with regard to the communications systems, how do we keep them inviolate for the military and at the same time have them open for all the countries of the world in an open peacetime weather system?

Don't you need a different kind of communication system then?

Dr. SINGER. That is a tough problem. We will try to face this after we have further experience with the operation of the system.

Mr. FULTON. Is there communications equipment that cannot be jammed, that cannot be intercepted or broken?

Dr. REICHELDERFER. Well, I think in the absolute sense——

Dr. SINGER. There is communication equipment that would be secure in that sense.

Mr. FULTON. And can be used on a regular weather satellite on a national system?

Dr. SINGER. Yes, sir.

Mr. FULTON. That is all.

Dr. SINGER. I would like to illustrate how we coordinate these requirements.

Mr. HECHLER. We had better speed up in view of our limitation of time.

Dr. SINGER. Yes, sir.

We come up with a specification of what is to be measured and what is to go into the satellite.

We transmit the specifications to NASA. Of course there will be a lot of give and take here. They will tell us what can or cannot be done. We know too what can or cannot be done.

They are in the same committee so they can tell us, as the requirements are listed, whether these things can or cannot be done. And

the military have their experts, they know what can or cannot be done.

We in the Weather Bureau are like architects; we have clients and a builder, but the clients know as much about building as the builder sometimes, and give us requirements which they know can be met.

NASA supplies us the spacecraft, launch vehicle, supplies the command and data acquisition station, conducts the launch, tracks the spacecraft. We work in agreement with NASA on how to program and command the satellite, depending on what is of meteorological interests We control this in conjunction with NASA.

We recover and communicate the data back to the central processing station in conjunction with NASA. Then we take over again and process the data, disseminate it, and archive it.

In the processing of data, in the use of it, we really learn how to set the requirements.

It is only through the actual use of data that we learn how to set sensible requirements on a national system.

I am through.

Mr. HECHLER. Thank you, Dr. Singer.

In view of the fact that we have some more questions, and the fact that there is a quorum call, if you and Dr. Reichelderfer could come back tomorrow at 10, we would like to continue the hearings with you.

Yesterday I was up in the Press Gallery and one of my friends there mentioned that the tops of the heads of Members look a little bit different from up in the Press Gallery. So the press gets used to recognizing Members from the tops of their heads, and I suppose that is somewhat the same problem that you have using your information from weather satellites as compared to ground-operated stations. [Laughter.]

We are very pleased that you could come up this morning.

The committee stands adjourned until 10 a.m. tomorrow.

(Whereupon, at 11:07 a.m., the subcommittee was adjourned, to reconvene at 10 a.m., Thursday, August 30, 1962.)

METEOROLOGICAL SATELLITES

THURSDAY, AUGUST 30, 1962

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE NO. 4,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C.

The subcommittee met at 10 a.m., the Honorable Ken Hechler (chairman) presiding.

Mr. HECHLER. The committee will come to order.

This morning we are resuming our hearings continuing the testimony of the Weather Bureau on meteorological satellite development, following which we will hear from Dr. Morris Tepper, Director of the Office of Meteorological Systems, of the National Aeronautics and Space Administration, at about 11 o'clock.

STATEMENT OF DR. FRANCIS W. REICHELDERFER, CHIEF, U.S. WEATHER BUREAU; ACCOMPANIED BY DR. S. FRED SINGER, DIRECTOR, NATIONAL WEATHER SATELLITE CENTER—Resumed

Mr. HECHLER. Dr. Reichelderfer and Dr. Singer, we are pleased to welcome you back this morning.

I wonder, Dr. Reichelderfer, if you or Dr. Singer would care to elaborate any on the material brought up at yesterday's hearing?

Dr. REICHELDERFER. Thank you, Mr. Chairman; I believe we both would like to make remarks.

I will lead off with a résumé of policy and general management considerations that came up before Dr. Singer joined us in June, and then I believe from the questions brought out yesterday that the committee might be interested in somewhat more specific information about management and about schedule and the problems that confront us.

As we said yesterday, there has been almost phenomenal, miraculous success in the information and performance that we have from the Tiros satellites.

The interest is very widespread. Many departments are interested. We are quite conscious in the Weather Bureau of the importance of meeting the requirements of the several interested departments.

We naturally have to work very closely with NASA and in the Weather Bureau this is a necessity that we have kept in mind at all times.

Obviously, the Weather Bureau, it would not be economical for us to attempt, as an operating agency, to build up complete and independent competency in the launching and production and operation of satellites.

It is quite necessary, economically and logically, for us to work very closely with NASA.

Now, in an operation of this kind, it is quite obvious that it is not as simple to set up management and to keep schedules as if direction and management were vested in one completely totalitarian authority.

Cooperation is very essential, and this is what we have pursued.

In general there have been agreements between NASA and the Weather Bureau on those things which are of paramount importance operationally—user importance—belonging to the Weather Bureau; those which pertain primarily to the basic satellite research and developing of satellites in general are clearly the responsibility of NASA.

Our management and organization then have been set up with these two facts in mind.

In the questioning yesterday it was brought out that there has been, necessarily, a delay in the schedules for Nimbus because of unforeseen and unforeseeable technical difficulties.

We try to keep in perspective the fact that perhaps the success of the Tiros series has led us to expect altogether too much in performance.

That is one view.

On the other hand, we are aware of the very urgent needs, the insistent requirements from various departments as well as from the public, and we are pushing as rapidly as we can, and cooperating to the fullest extent that we can, in expediting the operational phases of Nimbus.

One other point I would like to make clear and then I would like Dr. Singer to speak, or for the committee to question on particular points.

As for the delay, it has been—in launching of Nimbus—it has been announced by NASA that the technical difficulties that were brought out yesterday will give a delay of about 6 months. It is recognized that it may be more than that, but at the present stage we do not have enough facts to be sure, nor does NASA, I believe, at the present stage.

We have, of course, because of the great importance of this program, thought of alternative possibilities.

Dr. Singer mentioned one of those yesterday; namely, the possibility that additional Tiros satellites might be launched to maintain at least a partial competency in operational satellites during the period of delay of the Nimbus.

Mr. HECHLER. Would you care, Doctor, to make that more definite? The way you couch that this morning it sounds like a possibility.

Is that only because it still has to go through the regular process for approval, or is this fairly clearly set in your own mind as a distinct direction that you would recommend?

Dr. REICHELDERFER. No. The point that I wanted to make quite definite is that the plan at the present time is still in the thinking stage.

Mr. HECHLER. Yes.

Dr. REICHELDERFER. And that we do not yet have enough facts to give any schedule of additional Tiros satellites, or even to know with certainty that this is the solution.

We brought this out yesterday primarily to show that we are not without alternative possibilities in case it is necessary to have an alternative.

This point I wanted to make quite clear.

As the facts develop within the next few weeks we will know, with the cooperation of NASA, what is the best policy to push this program with all of the speed and competency, in which this committee is very much interested, and in which the public is interested.

Thank you, Mr. Chairman. I believe that concludes the preliminary remarks that I wanted to make.

Mr. HECHLER. Dr. Singer, would you care to add anything?

Dr. SINGER. Mr. Chairman and gentlemen, I am very pleased to have a chance to amplify some of the remarks I made yesterday.

I would like to first discuss the way we see our role as the managers of a National Operational Meteorological Satellite System—NOMSS for short—and secondly, I would like to discuss some of the applications that we can now foresee which are not strictly meteorological but which are so exciting, and so useful, and so rewarding, economically speaking, that I think you would like to be made aware of them at this early date.

The only reason for the existence of our organization—the National Weather Satellite Center—is to provide at the earliest possible time the best operational system that we can, and this is our aim.

We have to ask ourselves at all times—and we do—what can be done at the present time, consistent with the state of the art, to provide operational cover, what will the state of the art be some time from now, what should be our plans at that time, where should the state of the art be advanced?

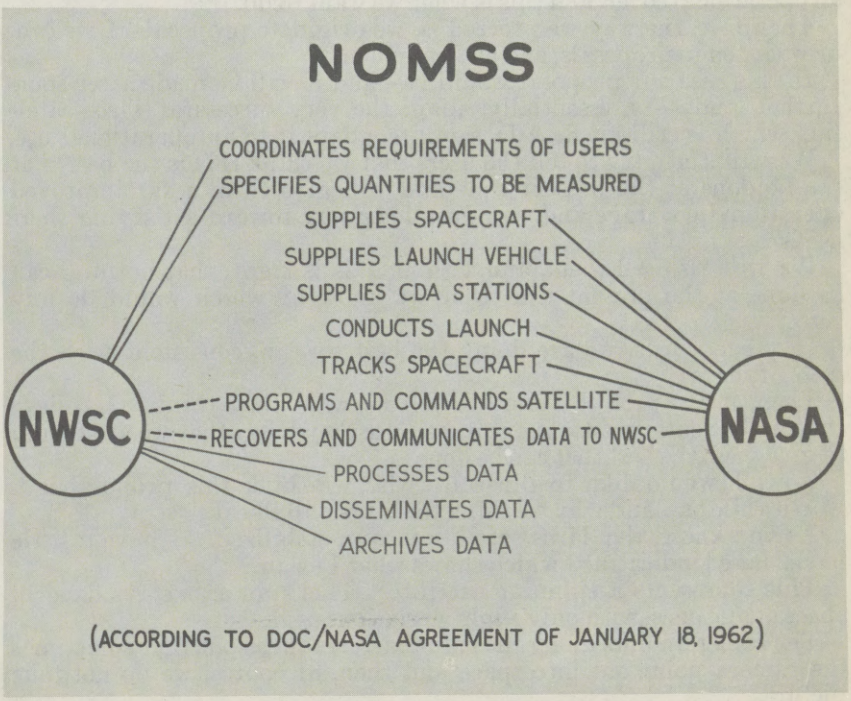


FIGURE 5

We are able to do this because we act as the agency in the Government—in fact we have been set up for this purpose explicitly by the Congress—to accept the user requirements as far as meteorological satellite needs are concerned.

Now, when the initial appropriation was made for NOMSS it was conceived that the Nimbus satellite would be developed at an early date, the Nimbus R. & D. satellite would be launched by NASA and after this initial R. & D. launching, our Nimbus satellites, called Nimbus operational satellites would be launched. Their primary purpose would be to provide the operational cover that we really desire.

The Nimbus satellite represents a great deal of advanced thinking and incorporates, many new steps forward.

It is at the present time—and this should be clearly understood—a research satellite.

The schedule that has been set up for it cannot and should not be construed as an operational schedule.

When we are engaged in research projects—I ought to interpolate, this is not our project, I am speaking about a NASA project, but I would like to make some general remarks—when one is engaged in a research project the schedule one sets up is essentially a guide, and in a research project you run into unforeseen, unforeseeable, difficulties, as Dr. Reichelderfer has pointed out.

In view of these you must make adjustments to the schedule.

Therefore, we do see the problems that NASA has.

On the other hand, we also see the problems that exist among the users who would like to see us proceed faster in providing them with an operational cover, and this is what we want to do.

Therefore, the way we proceed is, we originate proposals if we can, or we listen to proposals, and evaluate them.

In this case our proposal would be—and it will be made after some further study—to, essentially, adapt the very successful Tiros satellite, which is still an R. & D. satellite, adapt it to an operational use.

We will, then, try to tell the users that we think this is the best that can be done at the present time and will give them a far improved operational coverage and will go a long way toward satisfying their needs.

We will also tell them, and I think this is right, that nothing can be done at the present time that we know of which would do any better.

In other words, we are doing the best we can, consistent with the state of the art.

Then, it is up to the users to tell us what they think. I believe they will be enthusiastic about it, because they know that we are trying to give them the best that can be done.

Now, I would like to illustrate why we think this proposal is a worthwhile one, and why we think the users will like it.

As you know, the Tiros satellite is spin stabilized. I have a little model here [indicating] which shows what I mean.

This represents a spinning satellite. This spin axis stays fixed in space at all times, with only slight variations of it.

The camera points along the spin axis. It turns out that sometimes the camera point out into space and then, of course, we do not take pictures.

MAP 1602

PSBL VORTEX 16N 153°E

1010%1010
2320Z

1009%1009
2142Z

180°
10°

CLR

VORTEX 14.5°N 119.5°W

1006%1005
1634Z

100°W
10°

60°W
10°

1005%1003
1140Z

1008%1007
1956Z

20°S
165°W

1011%1010
0100Z

15°S
115°E

1010%1010
2320Z

1009%1009
2142Z

1008%1007
1956Z

1007%1006
1703Z

1008%1007
1954Z

1007%1006
1820Z

1006%1005
1634Z

1008%1007
2019Z

1012%1012
0255Z

1005%1003
1140Z

1005%1005
1500Z

MAJOR BOUNDARY			
MINOR BOUNDARY			
CLEAR	CLR		
SCATTERED	S		STFM
BROKEN	B		CUFM
OVERCAST	⊕		CIFM
HEAVY	+		CB
THIN	–	BANDS	
		VORTEX	

CLOUD	SIZE (N.M.)	OPEN SPACES
1	0–30	6
2	30–60	7
3	60–90	8
4	90–120	9

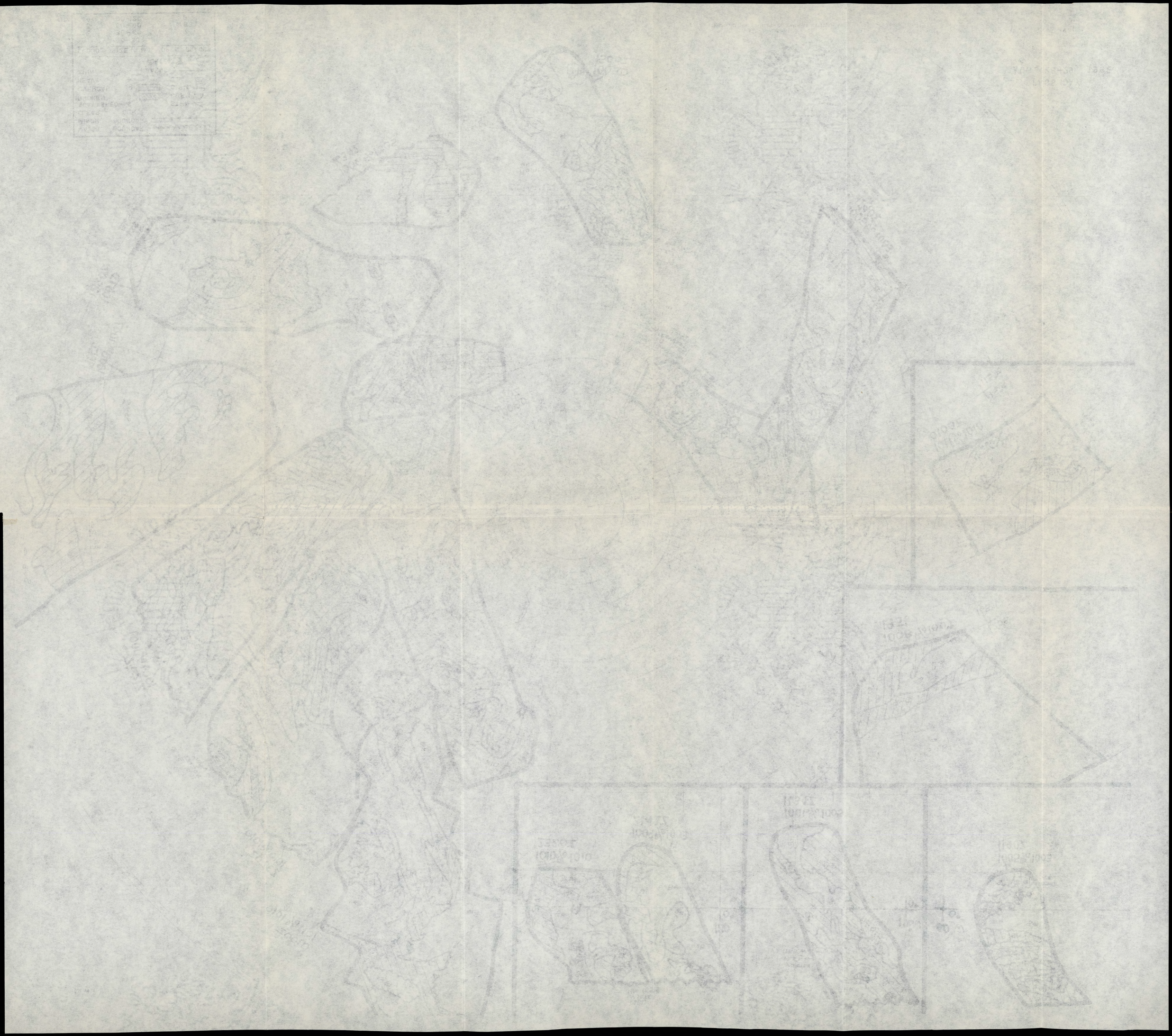
USCOMM-WB-DC

PASS DAY
AUG. 28-29, 1962

SCALE 1:30 000 000
POLAR STEREOGRAPHIC PROJECTION, TRUE AT LATITUDE 60°

MAY 1601

90360 O - 62 (Face p. 52)



We only take pictures when the camera and the spin axis happen to point to the earth.

The way this system works, it turns out that something like 15 to 20 percent of the earth's surface can be seen every day.

I have here a chart—the latest chart. It is a chart which shows the Northern Hemisphere and gives the pictures taken during the last day.

You will see lots of holes. These are areas not covered in the picture-taking operation. There is one great big hole you cannot see, and that is the Southern Hemisphere, because this is a map of the Northern Hemisphere. It turns out the present satellite can take pictures effectively only in one hemisphere at one time.

Mr. HECHLER. How many of these other holes will you be able to plug if you proceed?

Dr. SINGER. If we put up two Tiros vehicles we think—this is presently under study—we should be able to double the coverage and go to from 20 percent to roughly 40 percent.

Mr. HECHLER. You mean two at one time?

Dr. SINGER. Yes. But there is another reason for wanting to put up two satellites. Please consider the present situation.

Tiros V is now in orbit. It was launched June 19. It was launched in such a way that we would be observing the Northern Hemisphere during the hurricane season. That was the purpose of timing the launching.

Mr. FULTON. Now that the Northern Hemisphere hurricane season is starting early, are you going to move up your November launch?

Dr. SINGER. The launch has been moved up.

Mr. FULTON. To when?

Dr. SINGER. It will be some time in September.

I want to point out that 3 weeks after launch, one camera on Tiros V went out. A filament burned out. We are now hanging on with just one camera. There is no way of predicting how long this camera will last.

This filament may burn out any time. Something else may go wrong. If it does, we will be completely without satellite cover.

This is why we think that the first approach to an operational system must be one in which you have at least one satellite in orbit at all times.

As I put it, you must have dependability as with a telephone, every time you put your dime in the slot you want to get a connection—we want to know there is a satellite available which can be programed to look at places on the earth to aid the other meteorological services and supplement and extend their observations.

Mr. FULTON. To me, with the camera going out, that does not sound like a research and development failure, but an equipment failure.

Dr. SINGER. It is an equipment failure.

Mr. FULTON. Why do you have equipment and component failures on items that are standard and the reliability must be high?

Why don't you have a bond to make these companies come up to your standard? We are getting failures that are failures of merchantability and reliability.

Dr. SINGER. We have looked into this point.

Mr. FULTON. I can accept R. & D. failures on new equipment. But to have you say to me that one camera is already out on a Tiros operating satellite and the other one may go out any time, is to me, a failure to require adequate standards.

That, to me, is a failure of inspection.

Dr. SINGER. I would like to reply to your point.

It is a point well taken.

However, the Tiros satellite is an R. & D. satellite. There has been no program funded to build reliability into it, as far as I am aware.

This is one of the things we want to do, because we are after reliability.

Mr. FULTON. My point is that the particular component is not an R. & D. item. We just cannot afford to put up satellites and the payload failing soon after because a standard component ceases to function.

It is a metal failure, or a component or a manufacturing failure or a merchantability failure.

If components do not meet the proper standards there is no use of us spending the money. When we talk of economy in space, the only economy you can achieve is a successful payload and a successful booster.

Dr. SINGER. I think at this stage I should point out this is really a question that concerns NASA very much, and I think you will find them very responsive to this argument.

They would like to improve the reliability, of course.

I would like to point out that out of five Tiros launchings every launching was successful, which is a remarkable record and speaks well for the program in relation to other programs. We are very impressed and this is one reason why we would like to see this particular program expanded and add along with the R. & D. Tiros a concurrent operational version, so that one Tiros, either R. & D. or operational, is in orbit at all times.

Dr. REICHELDERFER. Mr. Chairman, if I may interject here with respect to the reliability of filament, in dealing with satellites there are many factors that are beyond the normal scope of inspection.

If I understand correctly, it is impossible for the technicians to know whether the filament failed because of poor material, which might be the assumption, and which could be determined if the filament were here on earth to inspect, or whether due to something associated with the launching and the forces that are involved when a satellite is launched.

Mr. FULTON. We can also tell whether there is an unusual happenstance at the time of launch. The question is on this particular Tiros: was there such an unusual occurrence at launch?

Dr. SINGER. I believe not, sir.

Mr. FULTON. Then it comes down to the point whether the component has a reliability that measures up to NASA's specifications and requirements.

We who are helping get the money for these programs are tremendously discouraged when we witness successful launches of Tiros satellites and then find that a camera mechanism does not work because of a filament failure.

Mr. HECHLER. Will the gentleman yield?

Mr. FULTON. Yes.

Mr. HECHLER. Could the high altitude nuclear shots have any effect on camera failure?

Dr. SINGER. Apparently there has been no effect on Tiros V. No discernible effect on its performance. But of course there are many things going on beyond our control. Sudden bursts of radiation from natural sources, which could damage solar cells, or other delicate components of the satellite, micrometeorites hitting the satellite, and so on.

I think the general point is well taken.

One way in which one improves reliability is to double up on components. This has been the design philosophy adopted in Nimbus by NASA.

We approve of it. It means that if one system goes out there will be, essentially, another system in the same satellite which is backing it up.

Mr. HECHLER. Would you proceed with your general introductory statements and we will get to questions?

Mr. FULTON. Could I just finish on your September shot?

Mr. HECHLER. Yes.

Mr. FULTON. You have three R. & D. Tiros on the shelf, one of which will be used for your September shot.

What backup will you have in case of the September shot failing?

Dr. SINGER. I should explain this is still the Tiros R. & D. program and——

Mr. FULTON. Are you planning a backup? We will have nothing in orbit if the current Tiros satellite fails, and your September shot is unsuccessful. You would have no coverage?

Dr. SINGER. This is exactly the point that concerns us, and this is why we think that our plan to have backups will be well received, both by the users and by NASA, because I am sure they will feel this constitutes endorsement of a very successful program, that they have a successful R. & D. program they have carried out.

Mr. FULTON. What is your backup in case of the September Tiros failure then?

Dr. SINGER. There is no immediate backup for this, and we are concerned.

Mr. FULTON. That is all. Thank you.

Mr. HECHLER. Proceed.

Dr. SINGER. I would like to quickly explain now what we see as far as the applications of this system are concerned.

The meterological applications were discussed in some detail before this committee several times. They were touched on again yesterday in the testimony that Dr. Reichelderfer gave.

I would like to expand on some applications which we find particularly exciting which are essentially nonmeteorological.

I think some will be relatively new, and we will be very pleased if we have a chance to expand on it here.

Mr. HECHLER. You may proceed.

Dr. SINGER. Very soon after the launch of Tiros I white areas were noticed and it was believed at first these would be clouds, but then on closer inspection it was found they did not go away, they stayed around, and the identification was made they were ice.

FIGURE 7

We have now gained a great deal of experience in our laboratory on how to distinguish clouds from ice, and we can tell not only whether it is ice but also what kind of ice it is. We can tell pack ice from sea ice, we can tell young ice, we can tell polar ice. We can tell when ice is about to break up.

We can use this for forecasting. We are developing better methods of being able to predict the breakup of ice. We have made a study to indicate how much money is being saved by these ice forecasts alone.

It comes to $1.7 million per year, just for the work in the St. Lawrence Seaway and the Gulf of St. Lawrence.

You see [indicating] the pictures taken in the Gulf of St. Lawrence. These are pictures taken by a satellite.

You can determine the floes of ice if you look closely.

We think this a wonderful way of getting more use out of the system, because it involves no additional cost in the system itself, except a little more care in the data processing. That is to say, in the large data processing complex that we have for the satellite data, we add a little box, essentially, which will print out ice forecasts and ice cover.

The saving comes about because you can save roughly 10 percent on the cost of ice breakers by directing them to the proper places, and save roughly 40 percent on the cost of ice reconnaissance aircraft.

Nine hundred and sixty thousand dollars in the first item, and around 700-some-thousand dollars in the second item, adding to $1.7 million.

In the early satellite pictures we saw other white areas. They turned out to be snow. We can tell snow from clouds, and also from ice, although there the distinction is not always very clear.

We see now a method of being able to tell how extensive the snow cover is, for example, in this case [indicating], in the Rockies, this picture covers the areas from Minnesota right up to Puget Sound.

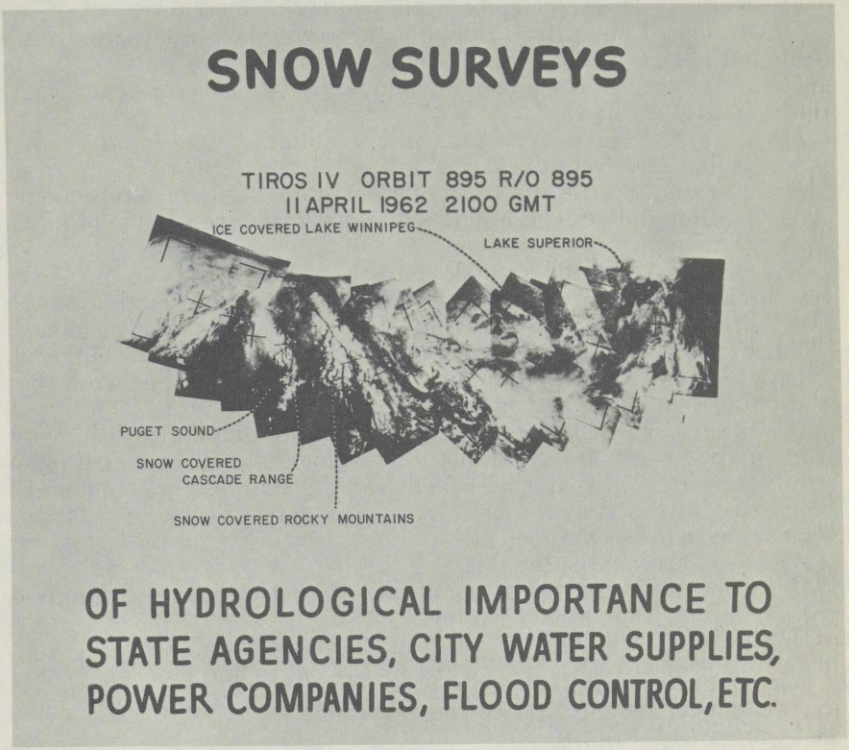


FIGURE 8

This is a very important application. It will enable us to make better hydrological forecasts. This information is vital to people who manage water supplies, dams, hydroelectric plants, irrigation systems.

The reason it is vital is the following: If you manage a dam what you want to do is to use all the water economically. If you think you are going to have a lot of runoff you must get rid of some of the water in the dam before the runoff comes, otherwise you have a flood.

On the other hand, if the runoff does not come, you have wasted your water. Water costs $15 per acre-foot.

There is 107 million acre-feet used yearly in the Western States alone. Waste of water is a big economic item.

We are really working very hard now on methods of being able to do more than just measuring the snow cover.

We would like to be able to measure the depth of snow and the water content of the snow.

Snow does not always have the same water content, as you know.

At the present time the system is to send out people who have long tubes and push them into the ground and to measure the depth of snow and take a core sample and melt it down and weigh the water.

I don't think we will be able to dispense with them, but we will be able to use them much more effectively and be able to improve our present hydrological forecasts.

Mr. FULTON. How much money are you saving on that?

Dr. SINGER. I don't like to predict the saving because it is very difficult, but I can tell you the total amount of money involved.

In the Western States alone it amounts to $1½ billion a year.

Mr. HINES. Billion?

Dr. SINGER. I am sorry—yes, billion dollars. One hundred and seven million acre-feet at $15.

Mr. FULTON. So the use of it efficiently does add to the economy about a billion dollars and a half while inefficient use would cut down the total amount.

Mr. SINGER. It would be a little conservative.

I think the more efficient use would save a certain fraction of the $1½ billion, perhaps a few percent—but even that is a lot of money.

Mr. FULTON. So that you can really say it might run into a hundred, or several hundred million dollars, for our hydrological control, that we would be saving by getting more efficient use of water?

Dr. SINGER. The important point that I would like to bring out from my point of view—I am not a hydrologist but I am managing a satellite system—is that this benefit can be achieved without additional cost to the system—again by clever data processing. This is what we have to become good at.

We have to become better at it.

Mr. FULTON. The area of magnitude of probably several hundred million dollars is not a small saving.

Dr. SINGER. I would say so. It is not a small saving.

As I mentioned yesterday, we are always out to find more customers for the system. That is our job, to sell the system to people who have never thought of using satellites before.

The fact that satellites are expensive is not their concern. They can get the use of the existing system or of the system soon in existence at essentially no cost, and therefore they should be interested in it.

We have had conferences with the Forest Service in the Department of Agriculture and they have supplied us with these figures [indicating].

The annual loss from the forest fires in the United States amounts to $300 million, according to our source. The annual cost of fighting forest fires amounts to about $140 million a year. This is in the continental United States. It does not include Alaska; in Alaska, in 1957, 5½ million acres burned out.

It turns out—this is a very interesting fact—that 95 percent of the loss comes from only 3 percent of fires. Those are the fires which get out of control.

So the emphasis must be on early detection.

This is a difficult problem. At the present time the Forest Service has people who are posted at certain intervals—they are spotters, looking for smoke. They also use aircraft.

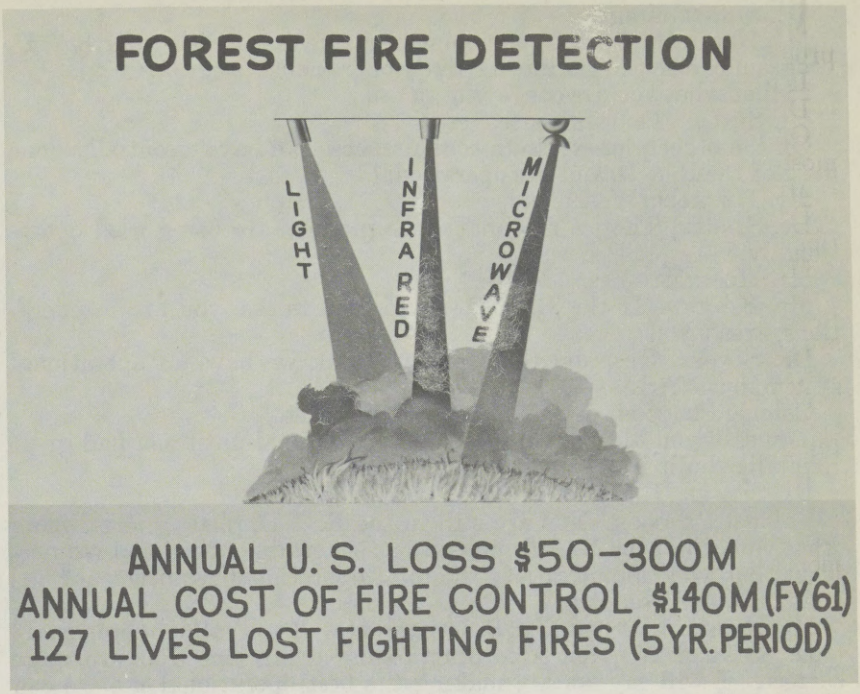


FIGURE 9

What we want to be able to do is to use a satellite to be able to spot forest fires. We think this can be done by incorporating the proper instrumentation.

We cannot spot forest fires as yet using the television cameras that are on Tiros. We have tried.

We have examined many pictures and compared them with locations of fires. This is because the visible radiation stops here [indicating]. It does not get through. We may be able to do better with infrared. We know, however, we will be able to do it with microwaves.

Again, the point is, once the system is in existence, the additional cost of processing the data to look for hot spots is minute, but the economic benefit is certainly very great.

Mr. FULTON. So we are losing economic ground in sustaining losses every day that the next Tiros are not in orbit?

Mr. SINGER. That is a fair statement, I think. It does not apply to forest fires yet.

Mr. FULTON. If we had adequate equipment——

Dr. SINGER. It does apply to meteorological data.

Mr. FULTON [continuing].—In orbit, and if Tiros satellites could be equipped with this added equipment, we could look ahead to savings.

My point is that if we are having these losses in the hundreds of millions of dollars in various fields, it would actually pay us in the United States, economically, to get on with the job—and to do it faster—of orbiting Tiros satellites?

Dr. SINGER. I agree.

Mr. HECHLER. Isn't it your point you have to complete your R. & D. program before you get into a strictly operational program?

Is that what you are conveying to us?

Dr. SINGER. On this phase, yes, sir.

On the other phases—ice reconnaissance—we have essentially done most of the R. & D. and are operational.

Mr. HECHLER. Yes.

Dr. SINGER. The ice reconnaissance pictures are being used operationally.

Mr. HECHLER. Yes.

Mr. FULTON. If the R. & D. equipment works, you are in operations, aren't you?

Dr. SINGER. Yes, sir; therefore we think we have an operational system, but NASA——

Colonel PEACOCK. By your definition it is not.

You said you did not consider this operational until you had great reliability built in.

Dr. SINGER. I stand corrected.

Colonel PEACOCK. You are still in the R. & D. phase and utilizing what you can of the R. & D. phase to meet certain operational requirements but you cannot satisfy the total operational requirement?

Dr. SINGER. No.

Mr. HECHLER. When R. & D. works real well you call it operational?

Dr. SINGER. No; not according to my definition—you are quite correct. I will say we are making the best operational use we can of anything that is available.

I would like to show another application. We have not done the R. & D. on it. We cannot guarantee it but we hope we will be able to detect and spot locust clouds in Africa and Asia. We are looking at this possibility.

While it will not benefit the continental United States directly, it will benefit us as far as international prestige is concerned.

I have written down the countries involved. There are 60 countries involved. All of these new African and Asian nations—they spend $15 million a year on spotting and controlling these locust swarms. The big job is to spot them.

Mr. FULTON. As a former member of the Foreign Affairs Committee, may I point out a penny earned is a penny saved. On the foreign aid program we will save the money we are otherwise spending for locust eradication.

Dr. SINGER. You are quite right.

Mr. HINES. $15 million each or the total?

Dr. SINGER. This is a total.

I would like to point to some particular economic losses we have got from statistics prepared by the United Nations.

About $10 million in Morocco in 1954; $10 million crop loss in Ethiopia in 1958.

The problem again is early detection, so that planes can go out and fight these locusts with chemicals.

Detection and communication in Africa is a very real problem.

Locust clouds may look very much like ordinary clouds and it will be up to us to learn to distinguish them from ordinary clouds. We

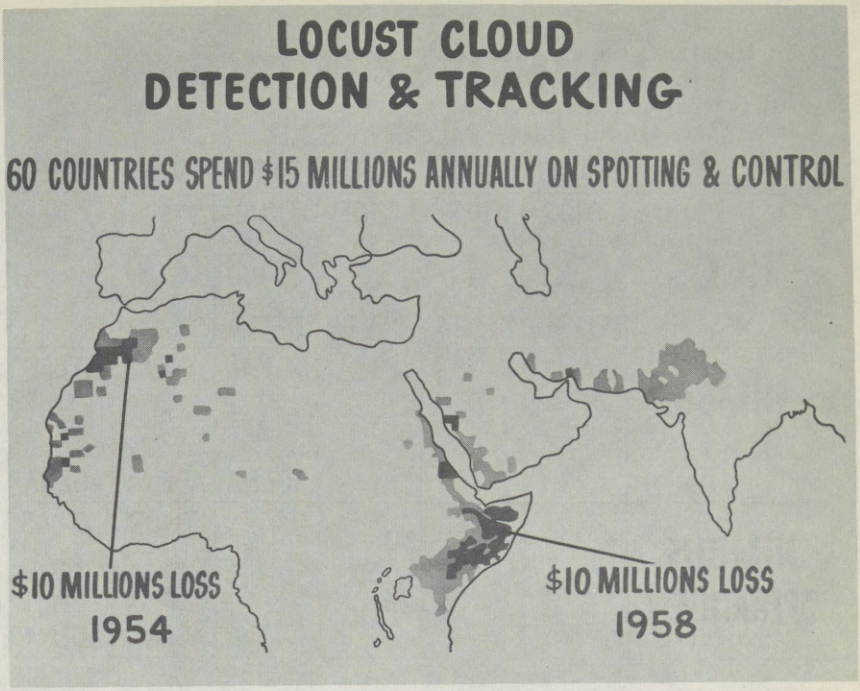


FIGURE 10

think once we see locust clouds we should be able to learn how to distinguish locusts from water droplets.

This more or less completes my presentation. I would like to emphasize that we are always searching for other applications of this system, meteorological or nonmeteorological. Every application we can find, every new customer adds to the total value of the system.

Mr. HECHLER. Dr. Singer, I wonder if for the record you could give us your specific schedule, recommended and contemplated, for the future Tiros shots?

Dr. SINGER. I would like to show the present schedule.

These [indicating] are the NASA R. & D. vehicles. The first one was fired April 1, 1960. Two in 1960. One in 1961. There will be a third soon to be fired in 1962. These are calendar years. We put question marks here [indicating], but I think, and hope, NASA will continue to use the Tiros satellite as an R. & D. satellite, while we will continue to use it as an operational satellite.

We are very happy with the fact they will continue to launch them, and encourage them to do this.

This [indicating] indicates the NASA Nimbus R. & D. launchings. Here [indicating] finally is where our operational Nimbus launchings come in.

You understand, the procurement process has to be 2 years ahead of launching. It takes fairly long leadtime to procure items.

You are aware of the budget process, I am sure. We have been budgeted in fiscal 1962 to procure these satellites that will be launched in 1964.

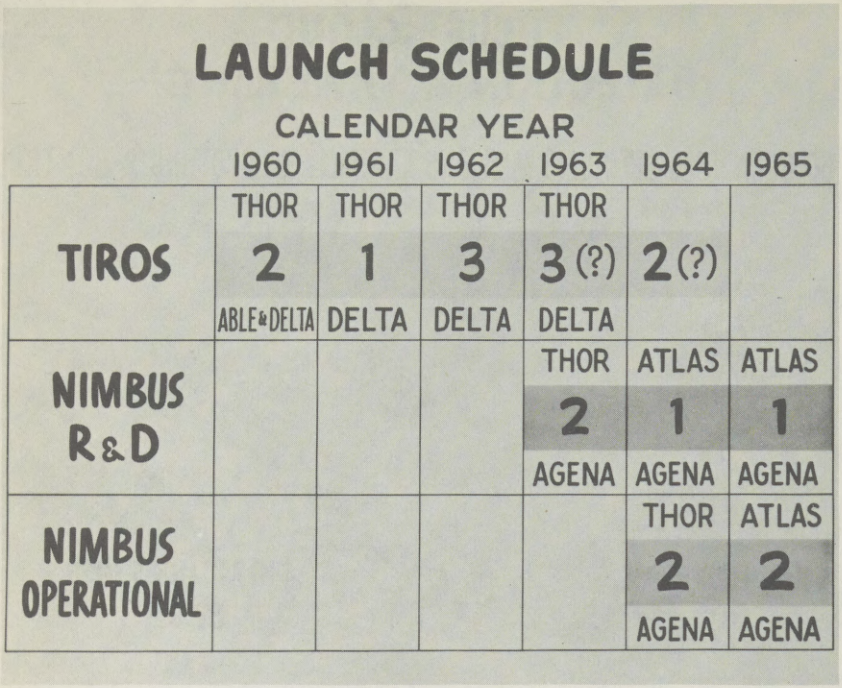


FIGURE 11

What we will recommend depends greatly on what happens to Nimbus R. & D. If there is an additional slip, and we do feel an urgency, we would like to recommend an expanded Tiros program, which we will call an operational version of the Tiros, and we would like to launch as many as we can in this area here, starting here [indicating], in early 1963, to make sure that the operational requirements are fulfilled to the best of our ability.

Mr. HECHLER. What additional funding will this require?

Dr. REICHELDERFER. This is uncertain.

Dr. SINGER. This is uncertain.

Dr. REICHELDERFER. We don't have enough facts.

Dr. SINGER. If we need additional funds we would like the privilege of coming back and asking for them.

Mr. HECHLER. Can you sketch the long future that follows your chart?

What do you really plan to do in looking toward the next decade? What do you hope to accomplish? What kinds of changes do you hope to make in the development of your weather satellite system?

Dr. SINGER. We plan to work very closely with NASA on the Nimbus satellite. We will continue to use the Nimbus R. & D. satellite to try out new experimental schemes—infrared, microwaves, radar, spherics detection, and other types of measurements.

We have found NASA very responsive to any suggestions for new experiments. They are interested in doing research and development. We will take advantage of anyone else who does research and development in this area.

Mr. FULTON. I would like to comment: Do you take advantage of anyone else?

Dr. SINGER. We will take advantage of anyone else's research. At the present time the Air Force is doing some very exciting atmospheric experiments on the Discoverer satellites.

We will take advantage of these. We will examine the data operationally and determine whether they have an operational application and if they do well, incorporate the experiments in the operational Nimbus satellite.

Mr. HECHLER. You can't be more specific then as to what some of your dreams are for the end of this decade?

Dr. SINGER. We look to the Nimbus satellite to provide the worldwide coverage which comes from a polar orbit. We will, however, look toward another satellite system based essentially on Tiros.

Essentially this type of satellite [indicating], is a spinning satellite, to cover the equatorial regions. We want to cover the equatorial regions particularly because this is where much of the weather is made. This is where the solar energy is received, where all the tropical storms are spawned.

It is a vital and important region to the military, especially to the Navy. It is a vital and important region to the many underdeveloped countries. We want to be able to present them and ourselves with a system which will give a good operational capability in these regions that have seldom been explored meteorologically.

Mr. HECHLER. I think it has exciting possibilities.

Mr. Roush?

Mr. ROUSH. With Nimbus will it be possible to detect temperature changes, and to measure temperatures, and possibly predict seasonal changes which do vary sometimes for a matter of weeks. Could you comment on that?

Dr. SINGER. Yes, sir.

This is one of the most exciting applications of a meteorological satellite system. By putting all of the world under surveillance and measuring what amounts to the total heat balance of the atmosphere.

Mr. ROUSH. This is not done by television camera?

Dr. SINGER. This will be done with infrared equipment and the television camera. Both of them to be combined. The television camera tells you how much of the solar light is reflected back out into space.

The energy input comes from the sun. If the earth is covered with clouds, then roughly 70 percent of this energy is reflected back out into space. If the earth is not covered with clouds, then practically all of the energy of the sun is absorbed in the ground.

Therefore, we must measure both cloud cover and infrared emission. But we will have this capability. We will therefore be able to study the heat input through the earth all over the globe, and we are confident that this will lead to improved long-range forecasts.

As you know, people are now working with numerical methods for long-range forecasting, making very successful use of conventional meteorological data.

We think the additional input of the satellite data will make possible a tremendous increase in precision.

We look forward to being able to predict the weather not only weeks ahead but perhaps seasons.

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Mr. ROUSH. Before we reach the place where we can accurately predict weather, will you be able to detect the seasonal changes I spoke of?

It seems to me this would be of great value to such people as farmers and sportsmen.

Dr. SINGER. Yes, sir; I think we will.

Mr. ROUSH. Thank you.

Mr. HECHLER. Mr. Davis?

Mr. DAVIS. Dr. Singer, I would like to ask what may be a silly question. Can you tell from a photograph of cloud cover whether or not it is raining underneath the clouds, whether or not precipitation is occurring?

Dr. SINGER. This is a good question. The answer is, "Not always." To be able to do this, this is the purpose of our Meteorological Satellite Laboratory. We are doing research which relates the type of cloud structure to the question of precipitation.

However, we think a radar placed on the satellite will be able to detect precipitation.

As you realize, this is a much more difficult technical problem than putting a television camera aboard. Therefore, in the beginning we will only use a television camera.

As I explained yesterday, unfortunately the satellite does not yet measure the sort of things we measure from the ground, like pressure, temperature, rain—it measures something completely different—just cloud cover right now.

Our job is to make sense out of the pictures, to give them a meteorological interpretation, and I feel that we have been quite successful.

Mr. DAVIS. Suppose a picture was taken on Monday and compared to a picture of the same area taken on Tuesday. Could you from that comparison gain a lot of information as to the wind velocities?

Dr. SINGER. Yes, sir. Our information about winds, as far as satellites are concerned, is indirect. However, I can show you a picture here which I think is unmistakable. I want to illustrate the point I made before.

Mr. DAVIS. Yes.

Dr. SINGER. This cloud picture here [indicating] is the most beautiful I have ever seen. It represents a typhoon—Typhoon Ruth. This almost hit the coast of Japan. It stopped short 50 miles of Tokyo. The winds were 200 knots at maximum. It was a tremendous storm. We call it a hurricane in the Atlantic, but it is the same beast.

There is no doubt, of course, that it is raining under there. We know this because we have the experience with this type of cloud picture. Unfortunately, not all cloud pictures can be interpreted in such a simple way.

I think as we gain experience and do meteorological research we will be able to determine from the cloud picture what is going on.

We can tell the winds from the shapes of the cloud bands.

Mr. ROUSH. Did you measure this typhoon on successive days to know how fast it was going?

Dr. SINGER. Yes, sir; we did. It was tracked three times with Tiros and, of course, it was tracked by radar from Japan, by the Japanese Weather Bureau, it was tracked by aircraft.

Mr. DAVIS. Only one other question. Would it be possible for you to furnish for the record copies reduced in size of the charts that you have used today in your testimony?

Dr. SINGER. We will be very happy to do this, sir.

Mr. DAVIS. That is all.

Mr. HECHLER. Dr. Singer, we have had several private conversations about interesting young people in this field. When Dr. Reichelderfer appeared before the committee last year I believe I asked him whether the salary structure of the Weather Bureau was such as to attract and keep outstanding people after they develop, and we had a little discussion about the fact that the glamor agencies of Government frequently can justify and receive a lot higher salary structure.

Does the Weather Bureau have any difficulties at the present time, or do you have any recommendations for the future, as to how we can attract and keep able and outstanding people in the field, which I believe is gaining more and more in importance?

Dr. REICHELDERFER. Mr. Chairman, there is still great competition, not only within Government departments, but between Government and industry for competent scientific talent, and we still have our difficulties.

We are sure that we will profit by action on the salary proposals that now are before the Congress.

Your question, Mr. Chairman, is timely, because it gives me an opportunity to mention that this afternoon we are giving prizes of $100 each to four students in the Weather Bureau summer student course.

I have here the number of students. I believe it is 235 that we have this summer, either college students or high school seniors who have been accepted for college.

This program has been going on for several years.

I was really surprised this morning to have the latest figure. We have 60 percent of those summer students who come to the Weather Bureau for jobs after they graduate. I think this is a very fine performance.

So I can only say that I think in this competition for talent, scientific talent, there must be a sufficient appeal in the mysteries of the weather to attract a rather larger percentage of these students than one would expect under the present salary restriction circumstances.

The Weather Bureau as one of the old line agencies has not been able to get its grades up to the level of some of the newer agencies. We are hoping this will be corrected.

Mr. ROUSH. May I ask what these four students did to win the hundred dollars?

Dr. REICHELDERFER. They did different things. One of them made a mesoscale meteorological analysis under the supervision of an expert in this field in Chicago and this was sufficiently outstanding as a summer course product—paper—that it was worth meritorious recognition.

Another man—whose name I will not announce, I don't want to jump the gun on the ceremony this afternoon—was selected as a student of the year. His selection was based on exceptional assistance in the development of a research project. His research relates radar precipitation echoes to winds, at the 1500 meter level over Miami.

Another was assigned the preparation of isohyet—rainfall—maps, for the State of Arizona.

He became proficient in the various techniques and because of his excellent working capabilities was able to finish the entire project somewhat beyond the expectation of the leader.

Mr. ROUSH. I did not think it rained in Arizona.

Dr. REICHELDERFER. We are working on that, sir.

This will take a little longer.

Mr. FULTON. What does isohyet mean?

Dr. REICHELDERFER. Rainfall.

We have to follow the medical doctors now and then and use great words.

Mr. FULTON. Please bring it down to the congressional level.

Mr. HECHLER. This committee is deeply interested in enriching the wellsprings of our talent to strengthen the program for the future.

Mr. Fulton?

Mr. FULTON. My question is on the programing of the Tiros and the Nimbus R. & D. and the operational Nimbus.

Part of the programing is dependent on funding. Suppose that you had an increase of funding. Could you tell us how much you could move up the operational program if you had extra money?

Can you speed those programs up? It looks to me as if both the security of the United States and the economic savings would be worth more than the price of the programs.

We have had other testimony that these programs cannot be speeded up one year. Then they were moved up by somebody outside the NASA agency.

Then the witnesses all came back in here and said, "Yes, they could meet the new schedule." That was 30 days after they said they could not.

Mr. HECHLER. Many things are done with the stimulus of Presidential leadership.

Mr. FULTON. And with the stimulus of m-o-n-e-y. I think that helps too.

My point is this, I believe that the Tiros and the Nimbus programs are necessary, both for U.S. security on a military basis, and for the economy and for the security of our country against floods, typhoons, and hurricanes.

So can you speed up the program if you get added funding? If so, how much can you hurry the programs, in the various aspects? Can you give some idea, an area of magnitude, of the money?

Dr. REICHELDERFER. We have to deal here with a matter of priorities. I think the answer has been given to some extent, Mr. Fulton, by your remark that if one were to concentrate wholly on this program, which is an urgent program, then certainly it could be speeded up.

Mr. FULTON. How much then?

Dr. REICHELDERFER. I think we would have to study that. Could we look into this further and supply it to you?

Mr. FULTON. It could be substantially speeded up if we laid emphasis on this weather program?

Dr. REICHELDERFER. This I think is obvious, if some of the other programs were curtailed.

Mr. FULTON. No. I meant not to curtail any other program. But if emphasis were placed on the Tiros and Nimbus programs, could these programs be speeded up substantially?

Dr. REICHELDERFER. Our limitations have not been so much money. This has been gone into rather thoroughly in preparation with the 1964 estimates. The limitation is not money. The limitation is technical personnel and other facilities, and it would take some study to give a definite answer to your question, Mr. Congressman.

Mr. FULTON. But the inference from what you say is that we are not going full speed ahead because of certain items.

One is facilities, another is technical personnel, and another is funding. I am taking the converse of your statement. So that, you are really saying we are not moving as fast as we could because of three points.

Dr. SINGER. On this point, the Tiros and the Nimbus satellites are somewhat different. The Tiros is essentially a developed satellite and here the problem is simply procurement. It is not quite as simple but it is almost as simple.

Mr. FULTON. When we have three on the shelf in R. & D. status of Tiros, how fast can we launch them?

Is it the Atlas-Agena you need?

Dr. SINGER. No. The Thor Delta. Procurement in the Tiros vehicle spacecraft itself is a matter of months. We have not yet got the procurement information on the vehicle. We are getting it.

Procurement on Nimbus, of course, is much too early to discuss, because the R. & D. vehicle has not yet been flown.

Mr. FULTON. What have you on the shelf now of the Tiros vehicles? What can you take off the shelf and launch quickly?

Dr. SINGER. I believe——

Mr. FULTON. I thought you had three R. & D. Tiros on the shelf now.

Dr. SINGER. This is really NASA's question—you must ask it of the NASA people—because the Tiros vehicles are theirs.

We would expect to order an operational version of the Tiros vehicle. They would be somewhat streamlined, but basically the same type of spinning vehicle with television cameras on it.

We will try to use very much the same type of equipment to be sure there is no delay in development and the only delay then will be in checkout of the equipment before launch.

Mr. FULTON. My point is this, that if there are Tiros R. & D. vehicles on the shelf which with some modification could be put into active use, with this hurricane season coming up, why don't we do it? To me, it is sort of an obvious question.

Dr. REICHELDERFER. I think it boils down to this: In the original plans, even if we take into consideration the full capabilities of Tiros—it is not the ideal answer.

We had expected Nimbus would be a very much of an advance and we had counted on this being in operation. It seemed on balance that rather than continuing with Tiros beyond the projected schedule we should place our bets on Nimbus.

Now, as has been brought out in the questions and testimony here, we are at the stage where we have to reevaluate this.

This is what we propose to do in the light of the probable delay in the Nimbus schedule.

So up to the present time it has not been obvious that we should turn to Tiros as our operational satellite rather than go ahead with the Nimbus program.

Nor do I think we have enought facts to make that decision this week. It should be made in the next few weeks.

Mr. FULTON. But if we have the R. & D. Tiros on the shelf, why don't we go ahead and use them, regardless of any decision between Tiros and Nimbus?

Dr. SINGER. I am not sure they are really sitting on the shelf in the sense that you mean it.

Mr. FULTON. You have to do some modifications. But if you know what to do to get a reasonable performance, although not perfect or up to Nimbus performance, why not do it?

Dr. SINGER. I can assure you that as soon as we have our recommendation accepted by the users—we must get the approval of this interagency working committee—we will move with all possible speed.

Mr. FULTON. Really, it is the decision of the users, then, that has not been made?

Dr. SINGER. To some extent. We have to make a proposal to them, and are making it to them in the next few days.

Mr. HECHLER. The United States has scored a number of firsts in space weather satellites.

I think you have both demonstrated here this morning the practical applications and economic values.

I think this is a great weapon of freedom in our relations with the underdeveloped nations of the world.

And I believe all members of the committee would agree that we should press forward with the utmost urgency in this field, where we have already demonstrated our capability.

Any further questions by members of the committee or staff?

Colonel PEACOCK. I would like to summarize what you said, Doctor, and if I am incorrect, please correct me.

What you state is, you still retain, from a management standpoint, the control over the absolute funding, the administration management, and the technical management over the meteorological satellite program as a whole; is that correct?

Dr. REICHELDERFER. Operational satellite.

Colonel PEACOCK. Of the operational satellite.

You stated Tiros has gone through the R. & D. phase and you are ready, if you use Tiros, to enter an operational phase.

Dr. REICHELDERFER. Yes.

Colonel PEACOCK. But in former plans you indicated you would not go into a Tiros operational phase, you would go directly into the Nimbus R. & D. phase, utilizing the operational fallout of both of these systems to meet what requirements you can.

Now you are reevaluating to determine, due to the delay in the Nimbus R. & D. project, an interim operational capability utilizing the Tiros satellites; is that correct, sir?

Dr. REICHELDERFER. That is correct.

Colonel PEACOCK. If you have complete management control over the meteorological operation satellite program, would not this decision be yours instead of the user's?

You are the Weather Bureau, you put this information out, so this decision, it seems to me, would be yours to make at this particular time—would it not?

Dr. SINGER. We do not make unilateral decisions. We hope——

Colonel PEACOCK. You have the authority to make it, don't you?

Dr. SINGER. We have the authority to do this.

I think we would want to have the best judgment of the other users.

Colonel PEACOCK. So you are consulting with them to get their opinion, but you have the authority——

Dr. SINGER. Yes.

Colonel PEACOCK. To make this decision, if necessary, without their advice, or without their concurrence; is that correct?

Dr. REICHELDERFER. The man who has the money has the power to decide.

Colonel PEACOCK. That is my next question.

You have authority to make the decision and then it is a question of the funding, and this funding has not been provided as yet?

Dr. SINGER. Not specifically.

Colonel PEACOCK. For an interim operational Tiros system, therefore, it is not only a decision to actually establish this system but it is also a method of funding for it.

In your plans do you contemplate coming back to Congress for a supplemental authorization to meet this requirement and modify these three satellites that Mr. Fulton has been pointing to?

How do you propose to try and fund this if you made the decision to go ahead?

Dr. REICHELDERFER. There are at least two possibilities. There can be reprograming. The question of supplemental funding could not be answered until we see what the magnitude of the problem, of the alternative program, would be.

But supplementing my remarks of a moment ago about the power of decision, I think Dr. Singer has said, quite appropriately, that we would not be doing our job if we were inclined to make decisions unilaterally.

While we have the power of decision over those things for which money is appropriated to the Weather Bureau, I must say, in all honesty, that this is a cooperative program, and I am sure we must have the concurrence and support of NASA for any of these programs that we go in for.

Colonel PEACOCK. Dr. Reichelderfer, I was not questioning your wisdom. I was trying to determine whether the Weather Bureau had relinquished any of its responsibility or authority.

Dr. REICHELDERFER. No.

Colonel PEACOCK. You have not relinquished that authority?

Dr. REICHELDERFER. No; in no way.

Colonel PEACOCK. One other question: I would like to go back to scheduling.

It is my understanding the schedules up to this time have been R. & D. schedules, not operational schedules, for your satellite system. Is that correct? Both for Tiros and Nimbus?

Dr. SINGER. Yes.

Colonel PEACOCK. These dates you have set up really are milestones in an R. & D. program, which you try to pass but due to the R. & D. activities they may shift, vis-a-vis an operational schedule, where you place great reliability on the date not changing, there is a different connotation between these two types of programs is there not?

I want to ask you, in the case of your Tiros program to date, you have not placed the operational connotation on your schedule, have you?

Dr. SINGER. We have to some extent.

We have found NASA very responsive to our request. This is a request that they schedule the satellites in such a way as to get maximum operational benefit, particularly during the hurricane season.

Colonel PEACOCK. But this slippage we talked about in Nimbus was just a milestone date?

Dr. SINGER. Yes.

Colonel PEACOCK. It could drop back from 6 months, a year, to 18 months as far as the R. & D. effort is concerned, is that true?

Dr. SINGER. That is correct; yes.

Mr. HECHLER. Mr. Fulton?

Mr. FULTON. The point on whether you need money or not has come up.

From my previous questions it had looked as if the limiting factor were not money. From the questions of Colonel Peacock it would now seem that the limiting factor is essentially money. You have the power and authority to make the decision in the Weather Bureau to go ahead with the modification of the three R. & D. Tiros.

My question is this: With this Congress adjourning sometime in the next few weeks, there is October, November, December, with no Congress in session. The new Congress, the 88th, comes into being in January, and will be preoccupied with organization requirements.

My point is this: If you need money, and don't say now, as I have suggested, what magnitude of money you might need, you will run into a required 5-month hiatus in Congress alone, let alone the delay of planning and programing in the various agencies.

So that you should consider the need for immediately presenting fund requirements and immediate decisions.

To me it would be intolerable to have the Tiros program, on any sort of a partial operational basis, delayed for 5 months merely because the Government agencies are not coming to decisions that can often be made quickly.

Dr. SINGER. I would like to reassure you on this point, Mr. Fulton.

I think we can make sure that there is no delay in any operational use of Tiros arising from the lack of funds.

I will study this question very carefully.

Mr. FULTON. But, obviously, when you say "reprograming," you must take from one program and give to another. The other R. & D. programs or operational programs in the Weather Bureau obviously must suffer. Now the quick decision and the quick application would eliminate all that.

Dr. SINGER. Could I explain this point in some detail?

I think you will be satisfied with this explanation.

We have been budgeted in fiscal year 1962 and have committed the funds for two operational Nimbus vehicles which were to be launched in fiscal year 1964.

The slip in the schedule——

Mr. FULTON. In 1964?

Dr. SINGER. Yes. This is fiscal year 1962 funds.

When we get our fiscal year 1963 funds we will have money to issue procurement of these two Nimbus vehicles to be launched in 1965.

If there is any further slip in the program we do not need to commit these funds during fiscal year 1963 for this purpose and will have funds available to do the best job we can on meeting the operational requirements.

Mr. FULTON. Do you intend to make a quick decision to use the available R. & D. Tiros and then to put them into partial operational use? I feel it is necessary.

Dr. SINGER. Yes, sir; we will.

We have worked very fast. This whole study has only taken us a very short time. We have done it on a "crash" basis. We only started a few weeks ago and we will have the study completed by next week.

Mr. HECHLER. One final question: Would it speed the programing any to transfer any of this from in-house to private industry?

Dr. SINGER. Sir, I think private industry is essentially doing the building job.

Mr. HECHLER. Nothing further could be done?

Dr. SINGER. I am not sure that anything further can be done. We think the NASA management of Tiros has been extremely successful and our inclination would be to stick with a successful management team.

Mr. HECHLER. This committee will follow the development with sympathetic understanding and at the same time will be breathing down your necks.

The committee will take a 2-minute recess before calling Dr. Tepper.

(Short recess.)

Mr. HECHLER. The committee will come to order.

Continuing our hearings on meteorological satellites we will hear now from Dr. Morris Tepper, Director of Meteorological Systems in the National Aeronautics and Space Administration.

Dr. Tepper, you may proceed.

STATEMENT OF DR. MORRIS TEPPER, DIRECTOR, METEOROLOGICAL SYSTEMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. TEPPER. Thank you, Mr. Chairman.

As you know, I have a statement, which I shall be glad to submit for the record, but if I may have a few moments, I would like to point out some of the highlights that the statement contains.

In essence it reviews the development of the meteorological satellite program of this country historically and managementwise, and indicates how we in NASA organized ourselves in order to cope with some of its problems.

The primary interagency coordination function has been vested in the Joint Meteorological Satellite Advisory Committee (JMSAC), a coordinating committee consisting of representatives of the Department of Defense, Weather Bureau, and NASA. The initial primary

purpose of this Committee has been to receive the military requirements officially and to comment on them with regard to how well the NASA program is meeting these requirements.

This is being done, and the Department of Defense is apprised of how well the NASA program meets the military requirements.

Then the statement describes the growth of the program from the Tiros project into the Nimbus project, including the current state of affairs you have been discussing here in the past few days; namely, the Nimbus operational system (NOS) phase.

This is the phase prior to the full operational period wherein the R. & D. satellites are augmented in number by additional but duplicate satellites in order to provide a meteorological capability continuously.

I was not aware that there had been a discussion of the word "operational," when I conducted my own definition, and not surprisingly, I don't think the definitions are dissimilar.

I indicate the three R's that characterize operational systems: First, reliability; second, the fact they have to be regularly scheduled; and third, that they have to be routine. In addition, they have to satisfy certain minimum requirements.

We indicate that in a sense the Tiros program is already operational; it is reliable; we are programing additional Tiros satellites on a regularly scheduled basis; it appears to involve a routine operation. Certainly Tiros satisfies operational requirements to a degree.

The phase we are in now including the Nimbus operational system spacecraft, must also be in a sense operationally oriented.

Nimbus spacecraft are going to be regularly scheduled, and they certainly will meet minimum requirements.

Their reliability can be established only in time and they will become routine only with experience.

I then discuss the concept behind the sequence of the individual Nimbus satellites and why we feel a certain period of the R. & D. development is necessary before we reach the phase where we think we can provide to the weather data users a proper satellite for an operational system.

I conclude with the fact that we have had our share of usual difficulties attending an R. & D. program in this development of the Nimbus system. However, the availability of actual hardware at the contractor's plant present convincing evidence that the process is a converging one and that we can look to our current schedule with greater confidence.

Our program objective in Nimbus has been to develop a long-term benefit satellite program—one that has a potential for growth and one that could be adapted to operational purposes as soon as possible.

We have been very fortunate that Tiros has served so well as an interim meteorological satellite, and we are confident that with the development of a Nimbus spacecraft, this country will have taken a major step forward, not only in space technology, but also in the providing to this country and to other countries, a most useful meteorological observational tool.

(Dr. Tepper's statement in full is as follows:)

STATEMENT OF DR. MORRIS TEPPER

I am pleased to have the opportunity of appearing before this committee in order to present and discuss with you the progress of the NASA meteorological satellite program. During the last few days, you have heard testimony from representatives from other agencies that have a vital interest in meteorological satellites, primarily, as users.

I am happy to state that our relationships with these agencies have been most amicable and the contacts among the working-level scientists both cordial and fruitful. I feel confident that this cooperation among us has contributed, to a large measure, to the success of the program to date. We need only to add the efforts of our contractors in industry in order to complete this picture of close and efficient team effort.

Perhaps it would be of interest to this committee if I reviewed the background and development of the meteorological satellite program in this country.

You will recall that this program originated in the Department of Defense. Based upon the recommendations of a special committee established under the auspices of ARPA, the Tiros project was instituted, and its basic configuration was more or less determined at that time. It was decided then, that cloud picture data and certain type of infrared radiation measurements lent themselves most easily to satellite applications, and that these observations would probably prove to be useful to the meteorologists.

I might point out that prior to that date, approximately 1958, we already had some information as to how the atmosphere might appear from above, from photographs taken by cameras in recovered missile nose cones. Although these photographs showed interesting weather configurations, the full impact of the potential from satellites was yet to come.

In April 1959, the cognizance for the Tiros project was transferred from the Department of Defense to the National Aeronautics and Space Administration (NASA), and I might add that it was during this very same month that I joined NASA and became connected with this program.

NASA vested the responsibility for executing the Tiros project in its Goddard Space Flight Center, and contracted with the Weather Bureau for its services in analyzing and utilizing these data. At that time, NASA transferred money to the Weather Bureau to organize its Meteorological Satellite Laboratory to handle the meteorological analysis and archiving of the data. Since fiscal year 1962 the Weather Bureau has been funding these activities directly.

Primarily, due to the foresight of the scientists at the Air Force Geophysics Research Directorate and their contractors, Allied Research Corp., the possibility of using the Tiros data in real time was recommended and implemented early in the project.

NASA arranged to have meteorological teams, consisting of Weather Bureau and the Department of Defense representatives present at the readout stations in order to use these data in real time. This arrangement bore fruit almost immediately with the launch of Tiros I and the receipt of its data.

A most important step was taken by NASA shortly after the cognizance of Tiros was transferred to it. Because of our arrangements with the Weather Bureau, we felt that the coordination between us was adequate and needed no additional strengthening.

However, in order to insure that the Department of Defense's requirements were met as the program evolved, NASA invited the DOD to participate in a newly established Joint Meteorological Satellite Advisory Committee (JMSAC).

The Weather Bureau was a member of this same group. JMSAC meets every month regularly, and during its meetings, NASA briefs the Department of Defense and the Weather Bureau concerning the current status of the program and its plans for future activity; and invites comments and reactions from the members. For example, a current problem before JMSAC is the advisability and feasibility of launching a Tiros satellite into a highly eccentric orbit.

You have already heard the testimony that the coordination activities of JMSAC are considered quite satisfactory by the participating members.

In line with the objectives of JMSAC, the Department of Defense has submitted to us a list of requirements relative to the meteorological satellite program. These requirements had been coordinated with the Weather Bureau in the Joint Meteorological Group of the Joint Chiefs of Staff.

JMSAC has analyzed these requirements with a view toward evaluating how they are being met in the program; and submitted its findings to the NASA Administrator who forwarded this analysis to the Department of Defense. The actual transmission of this information to the Department of Defense, however, more or less formalizes information that had been discussed in JMSAC previously and as such is information readily available to the Department of Defense through its JMSAC representatives. I might mention that the Nimbus satellite has been designed specifically to meet as many of these requirements as possible.

NASA recognized from the outset that the Tiros was a simplified satellite system and only a stopgap measure, and that the ultimate system would have to be much more complex. For example, the basic observational requirements for operational data to be provided in an initial operational program consists of—

1. Daily global cloud cover observations; and
2. Twice daily global mean temperature of radiating surfaces.

Required data for future operational programs include:

(1) Global cloud cover in pictorial form at a minimum daily frequency of once during darkness.
(2) Winds throughout the operational environment of weapons systems.
(3) Height of cloud bases and tops.
(4) Aerial extent and approximate intensity of precipitation.
(5) Vertical temperature, moisture, and density structure of the atmosphere.
(6) Index of refraction.
(7) Height of tropopause and inospheric layers.
(8) Surface pressure.
(9) Ground cover (e.g., snow, ice, vegetation, etc.).

In order to design such a system, several features are required that are not contained in the original Tiros configuration. The satellite must have Earth stabilization in order to view the Earth continuously. The satellite must be in a polar orbit in order to be able to view the entire globe. The satellite design must allow for growth, in order to permit the inclusion of other sensors as they become developed, without necessitating a costly redesign each time.

Well, that is essentially the configuration of Nimbus.

It will be Earth stabilized; it will be launched into polar orbit; it is designed on a modular concept to accept new and improved sensors.

While we were engaged in designing and formalizing our concept of Nimbus, some remarkable events took place—namely Tiros I and Tiros II had successfully launched.

As you know, they provided extremely useful cloud-cover data—data that exceeded the expectation of anyone, including those of us very close to the program.

Of course, we were delighted, the Weather Bureau was delighted, the Department of Defense was delighted, the meterological community was delighted—I am sure the entire country was delighted—with this excellent performance of the Tiros satellites.

As continued use was made of these photographs, the potential for an operational system became more and more recognized and the desire for planning for an operational system became stronger and stronger.

In the fall of 1960, NASA called a meeting to discuss with the Weather Bureau and the Department of Defense, the problems involved in implementing an operational system.

These discussions culminated in the establishment of the POMS Committee (Panel on Operational Meteorological Satellites) under the auspices of NACCAM (National Coordinating Committee for Aviation Meteorology), which studied the problem of how to proceed with an operational system.

The POMS report was issued in the spring of 1961, almost 1½ years ago. The POMS report recognized the rationale of the R. & D. program that NASA was engaged in—in developing the Nimbus system, but stressed the importance of filling in between the R. & D. spacecraft launches with additional spacecraft launches, in order to improve our ability to give continuous satellite coverage during this research and development period. This augmentation of the R. & D. program we refer to as the Nimbus Operational System (NOS).

Perhaps the word operational requires some definition here. I would like to suggest one. I think that for a system to be operational it should be reliable, it

should be routine, it should be regularly scheduled, and it should satisfy certain minimum requirements.

Consequently, in a sense, the Tiros program is operational. Certainly, it is reliable. We are programing additional Tiros satellites on a regular scheduled basis to provide a continuous satellite capability in space. It appears to involve a routine operation. Certainly, Tiros satisfies operational requirements to a degree.

To increase this operational capability we have launched Tiros V into a higher inclination orbit so that it views more of the earth. If Tiros V is still operating when the next Tiros is launched we will be gaining experience with two satellites aloft at once.

With the flight of the first Nimbus, it too will be operational in the sense that it will be regularly scheduled and will meet minimum requirements. Its reliability however, can be established only with time. It will become routine only with experience.

Our plans are that we will probably need four Nimbus R. & D. satellites before we have a reliable satellite, capable of providing to the weather data user, the minimum data that he requires. The first two research and development satellites will be, essentially, minimum satellites, launched for test purposes, to test out the basic system and the basic configurations.

The third Nimbus satellite will include sensor redundancy in an elementary form, by having duplicate systems, and finally, the fourth research and development satellite will be an integrated redundant system, where individual parts of systems can be interchanged in order to provide a system with longer life.

Since it is recognized that failures may take place during this period which will prevent continuity between R. & D. launches, Congress has provided the Weather Bureau funds for five additional satellite launches—the NOS satellites—to be interleaved with the R. & D. satellites.

This period, we feel, will last through about 1965.

However, during this period, we intend to have operational use made of all the Nimbus satellites.

After we have completed this Nimbus R. & D. series and have developed the basic operational satellite, we shall procure and launch on a routine, regular basis additional satellites of this kind as part of our responsibility under the National Operational Meteorological Satellite System.

At the same time, we will continue our research and development programs in order to improve the satellites, simplify them, reduce their costs, and in order to develop and fly additional useful sensors.

We have had our share of usual difficulties attending an R. & D. program in this development of the Nimbus system. However, the availability of actual hardware at the contractor's plant presents convincing evidence that the process is a converging one and that we can look to our current schedule with greater confidence.

Our program objective in Nimbus has been to develop a long term benefit satellite program—one that has a potential for growth and one that could be adapted to operational purposes as soon as possible.

We have been very fortunate that Tiros has served so well an interim meteorological satellite, and we are confident that with the development of a Nimbus spacecraft, this country will have taken a major step forward, not only in space technology, but also in the providing to this country and to other countries, a most useful meteorological observational tool.

Mr. HECHLER. What is your management responsibility, Dr. Tepper, for the R. & D. program, and secondly, who establishes the schedule for the R. & D. flight program?

Dr. TEPPER. My title is Director of Meteorological Systems, within the Office of Applications of NASA.

The schedules are determined in NASA at top management level in the Administrator's and associate Administrator's office, where the schedule requirements of all the national flight programs are taken into consideration, and the interplay between the various launches that are required are considered.

The Administrator's office makes the final decision, based on our recommendation, from the program point of view. The scheduling

from a program point of view is the responsibility of the Office of Applications, and more specifically, my office, the Office of Meteorological Systems.

The determination of the schedule that is recommended by my office is made on the basis of the technical evaluation of the progress of the work as compared with our original objectives.

So we have a house of cards, so to speak, as to how this schedule comes about.

Mr. HECHLER. Would you elaborate a little on why the Nimbus schedule has slipped and what needs to be done now in order to speed up the completion and operation of Nimbus?

Dr. TEPPER. If I may be permitted a few moments to discuss this matter of Nimbus slip. I have heard it mentioned quite frequently here this morning—I guess it has been mentioned yesterday and the day before.

I think Colonel Peacock indicated a few moments ago in more concise terms what I will say. When I came here this morning I noticed the new House building being constructed across the street and I think, without having definite knowledge about the matter, that you are under some impression concerning the date of completion or occupancy of this building.

I suspect that this building schedule is similar to that of the house that I bought recently—the date of completion changed from time to time.

In the case of the house that I bought, I saw the house that I was going to buy, it was standing there, it was just going to be built in another location.

The number of nails required was practically known, the number of boards required was practically known, all the variable here practically known, yet I got my house several months after the builder promised it to me.

This is one type of procurement. This is the type of procurement where you know what you are getting and go out to buy it. We see we have difficulties there, too.

In an R. & D. program we have another matter. We start with a program plan based on certain requirements. We develop a system design. We develop the system, subsystem specifications, we select contractors.

There is contract negotiation, agreeements on work statements. I could go on. There is development of a breadboard model which tests the principles of what we are trying to develop.

There is testing of the individual subsystems, and of the entire spacecraft.

In each of these steps that I have mentioned we get a better hold on our understanding of where we are going. This is because we have never seen the final product before.

A house we have seen before. Perhaps we have never seen exactly this building that is coming up across the street, but have seen buildings like it before.

The spacecraft we are talking about we have never seen before. We have to estimate what the schedule would be for the developments. How is the schedule made?

Mr. FULTON. May I make a point?

Dr. TEPPER. Yes, sir.

Mr. FULTON. Could you tell us how it has slipped?

Some of us have had experience in these fields, and have been on committees for some years.

So we don't need a lesson on contracts and agencies.

Answer the chairman on why this Nimbus program has slipped. Just address yourself to that.

I would like to hear that.

Dr. TEPPER. Well, I apologize——

Mr. FULTON. No need to apologize——.

Dr. TEPPER. For being lengthy, Mr. Fulton.

Mr. FULTON. I would like to hear directly the answer to the chairman's question.

Dr. TEPPER. Well, Mr. Chairman, I will defer to your guidance.

Mr. HECHLER. Just proceed, Dr. Tepper.

Dr. TEPPER. Thank you, sir.

What I was getting at is that in each one of these steps the manager has to make some sort of decision. He can either put the expected date of fulfillment, at an early date, in which case he may be faced with a situation where he may have to slip the schedule because as he learns more about the system he finds it will take longer.

Other than that, he can push the date down and leave himself enough leeway and then he may never slip.

Here too is a danger because the work always fills the amount of time allotted for it.

In each one of these steps we have to consider some sort of compromise.

Where are we now in the Nimbus development?

I would like to go through a chronology of what happened during the period of development.

From August 1959 to October 1960, we were developing the specifications for system and subsystem. This means we started before Tiros I was launched.

From October 1960 to February 1961 we were in the process of selecting major contractors. It was prior to this period in mid-1960 that we established the second quarter of calendar year 1962 as our schedule.

I might indicate that it was during this period in early 1961 that the POMS group met and discussed the development of an operational system.

This POMS figure was based on the information available at the time that the date of the Nimbus, first Nimbus launch, was the second quarter of calendar year 1962.

Mr. HECHLER. Doctor, may I interrupt? Maybe we could compromise a little here.

If you could submit for the record a historical review and then perhaps our time could best be spent on discussing your recommendations for what can be done now and in the future to speed this program up.

Historical Review of Nimbus Development

	Program Chronology	Nimbus System Development	Nimbus Official Schedule	Remarks
1959 J				
F				
M				
A	- TIROS transferred to NASA from ARPA			
M				
J		Initial general planning for Nimbus		
J				
A				
S				
O				
N		More detailed study		
D				
1960 J		and development of		
F			General program planning	
M		specifications for		
A	- TIROS I	the overall Nimbus		
M			General program planning	
J		system and subsystems		
J				
A			2 Quarter 1962	About August 1960 in connection with writing and issuing specifications for bids by industry on subsystems it was necessary to estimate a launch date. The best estimate by GSFC at that time for the launch of the first Nimbus was then the 2nd Quarter of 1962.
S				
O				
N	- TIROS II			
D		Selection of Major Nimbus Contractors		
1961 J				
F				
M		Definitize contracts and work statements for Nimbus subsystems and integration & testing.		
A	- POMS Report			
M				
J				
J	- TIROS III		4 Quarter 1962	After the contractors had been selected and the contract negotiations completed, we had a better grip on the nature of the work required. This analysis indicated that a more realistic date would be in the 4th Quarter of 1962.
A				
S				
O				
N				
D				
1962 J				
F	- TIROS IV		2 Quarter 1963	The slip of six months to the 2nd Quarter of 1963 was due to difficulties with the Nimbus attitude control system.
M	- House Hearings	Problems with subsystem development, in particular, failure in basic control system design and analysis of problem		
A				
M				
J	- Senate Hearings TIROS V			

FIGURE 12

Dr. TEPPER. In this regard I would like to refer to one word I have heard in the testimony this morning, and I suspect it was in yesterday's, and that of the day before—the word "urgency."

I have tried to recall in the many meetings we had with the data users and with the Department of Defense whether this word "urgency" was used with regard to a date for an operational system. I cannot remember any such word.

And so it has come to me somewhat as a surprise that there is this urgency involved with regard to a specific date for this system.

Colonel PEACOCK. I think the committee's main concern, Doctor, is, in the R. & D. field, in which you have the management and funding responsibility. How best can we expedite and push the R. & D. effort in the meteorological satellite area, and can this program be accelerated.

If it can't, why not; what are the limiting factors such as people, funds, in-house capability versus industry, etc.

The main concern of the committee is the feeling of an urgent need to provide, as soon as possible, an operational meteorological satellite system. Forgetting for the moment that the Weather Bureau is proposing an interim solution with an operational Tiros and addressing

ourselves to the Nimbus and Aeros program; what is your best estimate on how to get on with this job as fast as possible?

Dr. TEPPER. The first requirement for producing a speeded-up program is to establish the level of the urgency of the program as given by the user.

I repeat, the user has not indicated this urgency with regard to any date.

Colonel PEACOCK. You feel you do not have an urgent need for such a system?

Dr. TEPPER. We have not been notified, have not been informed, this urgency exists with regard to any date.

Colonel PEACOCK. Where do you have to get this requirement; who has to establish it?

Mr. HECHLER. Weather Bureau and military?

Dr. TEPPER. Yes.

Colonel PEACOCK. You have received it?

Dr. TEPPER. We have not had, to my recollection, any communication that there is an urgency on the part of developing the system with regard to any particular date.

My opening statement indicates that the data user agencies have been with us at our elbows in this committee of JMSAC from the beginning and have known what we have been doing and the rate we are going and never did we have a recommendation from the representatives they wished to meet any deadline with regard to the program.

Colonel PEACOCK. What is your understanding, as to the program priority?

Dr. TEPPER. As soon as possible.

Colonel PEACOCK. As soon as possible?

Dr. TEPPER. Yes, consistent with the development of a reliable satellite but with no urgency.

Colonel PEACOCK. No urgency?

Dr. TEPPER. That is correct, and consistent with the general objectives and schedules of the national flight program.

Colonel PEACOCK. Let's take a hypothetical case, that you have a directive which indicates the program is to be carried out as soon as possible with great urgency, the highest national priority, to meet all the users' requirements. What could you do now to the existing program as it is planned and being executed to expedite it and accomplish this mission as soon as possible in your area of responsibility?

Dr. TEPPER. F.D.R. said once he hesitated to answer an "iffy" question and this is really an "iffy" question.

Colonel PEACOCK. You restate it then.

Dr. TEPPER. I will try. In view of the approach that we took to the program, which was to make it part of a national space program, with proper emphasis, and since we have no recommendation for urgency with regard to any date, we went along in this R. & D. with what seemed to be a natural evolution in the R. & D. development program.

However, in an urgent situation, as you know, there is another approach and this approach is to duplicate the R. & D., both in terms of the number of contractors involved having more than one con-

tract or doing the same job, or in the number of difficult approaches that are possible——

Colonel PEACOCK. You are referring to a crash program?

Dr. TEPPER. Yes, sir; a crash program.

Colonel PEACOCK. All right.

Dr. TEPPER. This we have not done. Frankly, we have not even considered this.

We have not had this kind of urgency as a requirement. But this would be one way that the program could be accelerated.

Colonel PEACOCK. Dual approach under a crash program?

Dr. TEPPER. This would certainly be one way of doing it.

Colonel PEACOCK. How would you do it that way?

Dr. TEPPER. I think you are asking me to plan a program off the top of my head sitting here.

Colonel PEACOCK. How does that program differ from this program?

Dr. TEPPER. How does it differ now?

Colonel PEACOCK. Yes.

Dr. TEPPER. We have laid out for ourselves a stepwise R. & D. program. We have one integration contractor, General Electric, that is assembling the various subsystems from the various contractors that are manufacturing and producing these subsystems.

This one contractor is integrating these subsystems into one satellite. We could accelerate the program, if this is duplicated in two or three places, if the approaches to solving difficult and critical problems are tried in different places at the same time.

Colonel PEACOCK. How can you accelerate this program short of a crash program—the one that you have now—how can it be accelerated without major changes?

Dr. TEPPER. Even if it is considered desirable or necessary that we proceed with maximum urgency, I seriously doubt that we can—I seriously doubt we can improve on the date that we have for the launch of the first Nimbus, and I repeat, with regard to that date, it is based on the state of the development as of now, wherein we are collecting the subsystem prototypes and trying to integrate them into one satellite.

Mr. HECHLER. What is the limitation, Doctor Tepper? Why couldn't it be speeded up?

Dr. TEPPER. There are certain stepwise functions that have to be taken—individual pieces have to be fabricated, individual pieces have to be tested for definite periods of time. They have to be tested together as a system for a certain length of time. This is in order to provide the type of the reliability we would have to have.

We have to test it in a hot chamber, in a cold chamber, in a vacuum. All this takes time.

If you add the stepwise functions required to come out with the full system you come up with a certain date. That is where we are.

It represents the earliest date we can meet.

The only way you can speed the process is if you reduce any of these steps. If you reduce any of these steps in time, then you are jeopardizing the reliability, because the time that has been allotted to any of the individual steps has been based on engineering judgments with regard to what is necessary to produce a piece of hardware that will

work for a desired design period. For Nimbus, this is between 6 months and a year.

Mr. HECHLER. Am I correct in concluding that if you had additional funding or better availability of technical personnel, this would not speed up the process?

Dr. TEPPER. We are talking about the launch of the first Nimbus?

Mr. HECHLER. Yes.

Dr. TEPPER. I seriously doubt whether it would materially be affected, that additional money or additional personnel will materially affect it.

Mr. HECHLER. Mr. Davis?

Mr. DAVIS. No questions.

Mr. HECHLER. Mr. Fulton?

Mr. FULTON. Dr. Reichelderfer and Dr. Singer of the Weather Bureau each have given their judgment this morning that the R. & D. program of Tiros and Nimbus could be speeded up. From your comment we get a direct difference in point of view between NASA and the Weather Bureau.

What is the difference of opinion between these two Government agencies? I can't understand why NASA says it can't be speeded up and the Weather Bureau says it can. What is the difference between them?

Dr. TEPPER. I do not know specifically to what Dr. Reichelderfer or Dr. Singer were referring when they said they believed it could be speeded up.

The comment that I made was based on our review of the existing development of the Nimbus satellite and referred only to the availability and launch of the first Nimbus satellite, which is now scheduled no earlier than the second quarter of next year.

Mr. FULTON. When you are working on an 8-hour day, 40-hour week, that is one rate of production. But if you work at a higher workweek, or hours per day, you could speed up the program, couldn't you?

I am just making this a simple suggestion. I don't want to leave you in the position where you have a general "can't."

Dr. TEPPER. I was at the General Electric plant about 2 weeks ago and they pointed out to me that several of their engineers had been on the job for almost 36 consecutive hours to complete a certain aspect of the control system development.

I believe the effort being put into this job by the contractors and people at Goddard is a good effort.

Whether it could be accelerated by having individuals or people work still longer hours—one should never categorically say "no" to such a suggestion, but it probably could be accelerated only slightly and at some price.

However, the testing of the satellite could not be speeded materially without serious damage because this is a matter of time, and time cannot be compressed. When you have to spend a certain amount of time in the test chamber you just have to do it.

Mr. FULTON. Why have you not received statements of urgency from the Government users of this weather satellite equipment? Why is it that you haven't received these statements? You state you haven't.

Dr. TEPPER. I believe the question should be directed at the people that preceded me—because I don't know.

Mr. FULTON. Have you asked them to submit requests in order to meet what you in NASA consider immediate requirements? Have you shown them what you could do on your own research and development, management, to cooperate in moving these schedules up?

I am trying to determine what degree of cooperation there is among the various Government agencies as a factor in the development of these programs?

Dr. TEPPER. I refer to the Joint Meteorological Satellite Advisory Committee, and I believe Colonel Cowan who testified here, and who is a member, paid the compliment to this committee that is one of the best working coordinating committee that he knows of in Government service.

Mr. FULTON. Yes, they may be good on coordinating, but the question is on results. That is what this committee is testing this morning, whether we are taking the right managerial steps to get prompt, efficient and lowest cost results.

You must always remember that some of the best committees turn out some very strange animals.

I love the definition of a camel as a horse that was manufactured by a committee. [Laughter.]

I think coordination and getting together may be fine. The question is, why haven't we been getting the results.

Dr. TEPPER. I have referred to this committee to indicate that a forum exists, a vehicle exists for these requirements or any requirements to be directed to us.

More specifically, we developed a project development plan for the Nimbus operational system, which was coordinated with the Weather Bureau, and allows for or indicates specifically how requirements of the users would be fed into the Nimbus program.

Mr. FULTON. You are then saying the committee and the staffing is adequate at that level if the requirements are fed into it?

Dr. TEPPER. This is correct.

Mr. FULTON. You seem to infer that the requirements are not coming into the committee?

Dr. TEPPER. Requirements have been forwarded to the committee by document from the Joint Meteorological Group and this statement of requirement was coordinated with the Weather Bureau. We have indicated in our reply the extent to which we are meeting these requirements, we have informed the users of the situation, so to speak, as it exists, and had no indication from the users that we should proceed in any other way than we are proceeding now.

Mr. FULTON. When this committee hears there has been a slippage of a year in the weather satellite program and that it might go to 18 months, we would like to hear specifically what suggestions and recommendations there have been made to make up the slippage and to get on with the program efficiently. That is all, Mr. Chairman.

Mr. HECHLER. Earlier, Dr. Tepper, you made a remark about F.D.R. what he thought of "iffy" questions.

I recall he also made another remark in considering the construction of 50,000 planes a year.

Some of the industrial representatives indicated that they just couldn't do that, and he said, "Go back and sharpen your pencils, we need 50,000 planes a year," and eventually we got 100,000 a year, as I recall.

Mr. FULTON. I say some of us Republicans helped the President to do that, too.

Mr. HECHLER. We appreciate the cooperation.

Mr. FULTON. Didn't want it all to be Democratic.

Mr. HECHLER. In the usual process of committee hearings we call representatives of one agency and then another, but I would like this committee to try to do something unique this morning, and recall Dr. Singer to sit with you so that perhaps we could resolve some of these problems right on the spot.

If Dr. Singer would come up, please, and share the witness table with you, perhaps we could arrive at some conclusions, or at least get some advice as to how we could speed not only the Nimbus program but also possibly speed along the interim operation program of Tiros.

Dr. SINGER. Mr. Chairman, I am pleased you have given me the opportunity to be up here, because it gives me a chance to state for the record that we did not discuss any methods of speeding up the R. & D. program this morning.

If this was so interpreted it must be based on misunderstanding.

I think the record will show that we said—and I can quote—that we were well satisfied with the way NASA has been handling the R. & D. phase of the program.

We think that their technical competence is extremely high.

I did try to explain, if I recall, why one runs into problems in an R. & D. program, and stated that dates in an R. & D. program are more milestones which one tries to reach if one can, but I also stated yesterday that the operational requirement on Nimbus was put upon NASA after they had started an R. & D. program, and I felt this was a great burden for them, and was very sympathetic to their problems.

Mr. FULTON. The methods were not discussed, that is correct, but Dr. Reichelderfer is going to submit to us a program, in writing, of how it will be speeded up. The opportunity of speeding it up has been testified to—but not the methods.

And the difference is, NASA says it cannot be speeded up, and the Weather Bureau, to its great credit, feels that, with certain planning, that it can be speeded up.

Dr. SINGER. I think we want to see the operational aspect of the program speeded up.

We want to start moving at 16 knots instead of 8.

Mr. FULTON. That is right.

I think that is a fine approach.

Mr. HECHLER. Have you expressed this sense of urgency?

Dr. SINGER. I personally have not expressed it in these committees, because I have recently joined the Weather Bureau as Director of this Center.

However, the military has expressed a sense of urgency in committee meetings, and I am informed of this by Mr. Arthur Johnson, who is assistant director of operations in our center.

This was stated in the working committee on satellites.

Mr. FULTON. This shows a great difference of opinion.

Dr. SINGER. However, the requirement of urgency may have been stated only recently.

Colonel PEACOCK. The word hasn't gotten to NASA from this committee? Is NASA a member?

Mr. SINGER. NASA are members.

Colonel PEACOCK. That brings up a point. How do you receive your sense of urgency or priority?

Do you receive it from this committee as the guiding light or get it directly from the Weather Bureau?

Who tells you how urgent it is?

Dr. TEPPER. This committee referred to by Dr. Singer is just about getting organized, so that it is difficult to discuss its operational procedures.

However, we look to the established organization of JMSAC to continue to be the vehicle for receiving the requirements of user agencies as it has in the past.

I have referred to the document by the Joint Meteorological Group of Joint Chiefs of Staff that came to JMSAC, and to which we responded.

We look for continued use of this committee and the representatives of user agencies on this committee to furnish us with the guidance that we need to continue with the development of the program.

Colonel PEACOCK. How are you responsive to Weather Bureau's requirements. How does the Weather Bureau influence you on priorities, scheduling, technical management for the components that go into the spacecraft and must be responsive to their ground data reduction system?

Dr. TEPPER. They do that at various levels. They do it at the working levels where there is very close contact, and they do it at JMSAC.

I might indicate the choice of a lense, on one of the two Tiros cameras, was as a result of a suggestion by the Weather Bureau. We incorporated it in to the satellite as a result of that suggestion.

Colonel PEACOCK. Do you receive your requirements as suggestions or directives?

I am trying to see who has the authority to direct you or to place requirements on you which you must be responsive to.

Are these suggestions and then you evaluate and respond as you see fit?

Dr. TEPPER. I think we see it this way, that the meteorological requirements—what the meteorological output of the system must be we consider as a directive.

This is what the data users tell us they must have.

Colonel PEACOCK. Being the Weather Bureau.

Dr. TEPPER. Yes, together with the service organizations of the Department of Defense.

They tell us what they must have.

Colonel PEACOCK. You have a number of agencies placing requirements on you.

Dr. TEPPER. Perhaps sources is a clearer description.

Mr. HECHLER. May I ask if there are any representatives of the Department of Defense, who could speak for the Department of Defense on military requirements, in the audience?

I would like to get everybody together here.

Mr. FULTON. We will soon have the whole committee here.

Mr. HECHLER. Evidently not.

Dr. Singer?

Dr. SINGER. Mr. Arthur Johnson, Assistant Director for Operations of our Center, he sits on the committee which considers operational requirements for the operational satellites, he is aware and it is his job to be aware of military requirements.

Mr. HECHLER. Mr. Johnson, pull up a chair.

Glad to have you.

Would you answer that one?

Dr. TEPPER. May I finish that thought, please.

I repeat that the development of the requirements, the meteorological requirements, that the system must have, is the responsibility of and has always been the responsibility of the weather data users, Weather Bureau, and the Department of Defense.

How these requirements are to be met through the development of a satellite and through the development of an associated ground complex together with the satellite we feel is the responsibility of NASA, given to it as the civilian space agency.

This is our responsibility as the civilian agency.

Colonel PEACOCK. Dr. Singer?

Dr. SINGER. I would like to answer your question very directly.

We advise NASA on most programs which NASA funds. We have the authority to direct a program where we fund it ourselves.

This means we can only advise on the Tiros R. & D. program. We can advise on what lens to use, or when to schedule the launching.

I would say NASA has been very cooperative in taking our advice whenever it seemed sensible to them. But they reserve the right to make that decision for themselves.

Colonel PEACOCK. We are not questioning the relationship. We are just trying to define where the authority is vested.

What you said is, for the R. & D. programs NASA is responsible.

Dr. SINGER. There is a committee called JMSAC which advises NASA on how to handle those satellites, what to put on them, and to schedule them, and so on.

It gives helpful hints, you might say.

Colonel PEACOCK. The operational program is the sole responsibility of the Weather Bureau.

Dr. SINGER. That is our understanding, consistent with an interagency agreement between NASA and the Department of Commerce, which specifies precisely what portions of each program each agency is responsible for. We are responsible for getting the meteorological requirements, getting all the user requirements together, and for the processing of all the data and dissemination of it.

Colonel PEACOCK. You don't enter into it until the data is disseminated as an operational activity?

Dr. SINGER. Yes.

Colonel PEACOCK. Up to that time you are in an advisory capacity.

Dr. SINGER. That is correct.

Colonel PEACOCK. Up to this time it is NASA's responsibility to produce the system, based on the requirements they receive from the Weather Bureau, the Department of Defense, and other users, is that correct, Dr. Tepper?

Dr. TEPPER. That is correct.

Mr. HECHLER. Mr. Johnson, would you care to add anything on the procedure and the way in which the Department of Defense has ex-

pressed the urgency of its requirements and any recommendations that you would have, either about the procedure or anything else brought up this morning?

This committee is interested in examining this process, not in order to make any criticisms, but to be helpful and to try to move the program forward.

Mr. JOHNSON. Thank you, Mr. Chairman.

I would agree with essentially everything Dr. Tepper has said, that the user agencies have had the opportunity to present a collective requirement upon NASA.

This was done through the Joint Chiefs of Staff and a subgroup of it, of which the Weather Bureau is also a member.

The civilian and military requirements for the operational system were collected in a single document introduced into JMSAC and accepted by JMSAC.

These have then been returned by Mr. Webb to the Department of Defense as the study by JMSAC of the capability of meeting these requirements.

We have another committee——

Dr. TEPPER. Mr. Johnson was the Chairman of the JMSAC Subcommittee that made this analysis for JMSAC as to how well the program was meeting the requirements of the Department of Defense.

Mr. HECHLER. Yet in Tuesday's testimony before this committee, Colonel Cowan was critical of what he alleged, that the military requirements were not being met, and that what he termed slippage in the Nimbus schedule provided a great burden on the military and caused the military to wonder whether or not there should be some additional steps taken in order to satisfy the military requirements.

If I am misinterpreting Colonel Cowan's testimony, I hope you will correct me.

Mr. JOHNSON. Mr. Chairman, I have heard about Colonel Cowan's testimony but I was not present.

I should say we have another committee concerned with the operational system. This is the Working Committee on Satellites, to which reference has been made elsewhere.

This is a subcommittee of the National Coordinating Committee on Aviation Meteorology, which is a committee chaired by the Chief of the Weather Bureau with representation from NASA, the military agencies, FAA, and other interterested departments. In that committee we are concerned with operations, and we now have as a directive from that committee the responsibility to define the output of the Nimbus system.

This we must do by early October, indicating what the output will be, and then where it will be available.

We hope during September in the meetings of that committee to be able to reach these conclusions.

Meetings are going on right now on the computer and photographic techniques required in data processing in the new system.

These requirements go back to NASA for the engineering to carry them out.

Mr. HECHLER. I am glad you don't refer to these committees as boards, because I understand the definition of a board is something which is long and narrow and wooden.

I am glad they are committees. But I hope the committees can get together to——

Mr. FULTON. I am sorry they are committees. Obviously we are not getting action. It is being passed around here from one hearing to another as to who should come up with requirements, who should do the scheduling, and who has the responsibility of management.

For example, Dr. Singer said that the JMSAC gives NASA the scheduling. I will quote exactly, "the scheduling perhaps."

That doesn't present good managerial balance, to me. JMSAC can tell NASA "the scheduling, perhaps."

You see, it makes fuzzy edges on management. The various witnesses from different Government agencies, Mr. Chairman, are taking various points of view. It looks as if part of the problem of speeding up the program is by centralizing management and exercising the power to have decisions made.

That is all.

Colonel PEACOCK. Yes, Mr. Fulton, I think you are entirely right. It is the same problem we faced with the Advent program, where we had a double-headed monster and nobody on the top to make timely decisions and to take action.

I would like to direct this next question to you, Dr. Singer:

It appears that the Weather Bureau does not have control from a management standpoint over any of NASA activities in the field of R. & D., but still they must use the product that NASA produces to meet their operational requirements.

Tell me how in the world you will do this, providing they are not responsible to your requests?

I know they are not hostile, but say they were. How would you insure you would receive a system that would be responsive to your needs and capable of carrying out the Weather Bureau's missions on a worldwide basis where U.S. prestige is hanging on the success of this satellite program?

How can you assure the Congress that you can carry out your assignment?

Mr. HECHLER. What kind of administrative arrangement would produce it?

Dr. SINGER. I am not a member of any of these committees, I spend full time on management.

Mr. FULTON. You are a lucky man.

Dr. SINGER. The Chief asked me yesterday if I wanted to be a member of one of these committees and I declined with thanks.

Mr. FULTON. You are a wise man.

Dr. SINGER. In order to plan the operational system I must first have information on the R. & D. systems.

I have found NASA responsive and I think we will get all of the information that we need in order to be able to plan far ahead for operational systems, not only from the budget point of view but also from the technical point of view.

We must also have access to other types of information, and we are getting, or will soon get it, from NASA.

Colonel PEACOCK. In your personal opinion, Doctor—I realize you are a Johnny-come-late in the program and are just picking up the

reins—if you were starting from scratch, how would you set this up to operate this program?

Would you split the responsibility for R. & D. and operations as far as the management is concerned?

Dr. SINGER. No, sir. I think that the R. & D. responsibility belongs primarily to NASA and is being handled in about as good a way as I think we would like to see it.

As I mentioned before, NASA is not the only agency in the Government that is doing R. & D. on atmospheric experiments.

It is our job in the Weather Bureau to be aware of what is being done and evaluate every experiment to see if it fits into an operational system.

If the Air Force is doing an outstanding job it is our job to see to it that this information can be evaluated to see if it will produce an operationally useful result, and we are doing it.

Colonel PEACOCK. Don't you think it would enhance your capability to provide a system in a shorter period of time if you at least had jurisdiction over the design of the components that have to be placed in the spacecraft that must be responsive to your ground data reduction and dissemination system?

You don't have that now, do you?

Dr. SINGER. We have control over the operational satellite.

Colonel PEACOCK. I am talking about the R. & D. system components that go into the spacecraft that have to be responsive to the system that you are designing, to reduce the data?

Dr. SINGER. We do not.

Colonel PEACOCK. Don't you think it would enhance your capability if you had control over the specifications of these particular units that must go in the spacecraft to work with your system on the ground?

Dr. SINGER. In a theoretical sense it might.

If I feel at any time that these specifications on the R. & D. satellites are set in such way as to make the product useless and incompatible——

Colonel PEACOCK. With your ground data reduction system?

Dr. SINGER (continuing). We will complain and complain strongly.

Colonel PEACOCK. Who is your last court of appeals, who do you complaint to to get a decision?

Dr. SINGER. There are various courts of appeals within the administration.

In fact, between the Weather Bureau and NASA.

Colonel PEACOCK. What is the first one? It is the President, is it not, or the President's space council?

Dr. SINGER. I would like to work these things out on the working level.

Colonel PEACOCK. Say you had to go to court. Who is the judge you would go to to get the decision if you were in disagreement with NASA?

Dr. SINGER. I would get sound legal advice—that is the first thing I would do.

Mr. HECHLER. Dr. Tepper?

Dr. TEPPER. May I talk to this point too, please?

You raise a very important question. That is, how can we in NASA design and develop an R. & D. system and yet insure the end product?

Colonel PEACOCK. I am not being critical.

I am taking a hypothetical case.

Dr. TEPPER. You ask the question which we asked ourselves immediately when we started this program, "How can we develop a satellite system and insure that we have the responsiveness to the requirements of the forecaster?"

The way this was done was through the organization of the Nimbus project.

I have mentioned that the responsibility for the execution of the program lies with the Goddard Space Flight Center. There we have a Nimbus project directed by a manager and his staff.

Here we established something unique in Government service, I think.

The Nimbus project manager has four subsystem managers, four chiefs to assist him in the execution of this program.

One is for spacecraft development, one for launch vehicles, one for data acquisition.

Each one of these three men is a NASA employee.

The fourth man is for data utilization. This subsystem manager within the NASA structure is a Weather Bureau employee.

The reason this was done is to insure we don't get into the type of difficulty that you suggested might occur.

This Weather Bureau man meets with the other three chiefs and the program manager regularly, and they discuss and work out the development of the program. He is aware of all of the things that are going on in development of this program, and any time anything is happening which endangers the situation, or, rather, presents a situation of the kind you make reference to, he blows a whistle.

The question was raised, to whom?

He first does it within the project, to the project manager. If the question cannot be resolved, if no decision can be reached there, and this is clearly spelled out in the interagency agreement between NASA and the Weather Bureau——

Colonel PEACOCK. Could we make that document a part of the record?

Dr. TEPPER. I have no objection.

Mr. HECHLER. Without objection, we would like to make that part of the record.

Colonel PEACOCK. After you scan it to make sure there isn't any security violation.

Mr. HECHLER. The only security is the official use?

Dr. TEPPER. The only security is the "For Official Use Only."

(The material referred to follows:)

PROJECT DEVELOPMENT PLAN

NIMBUS

GODDARD SPACE FLIGHT CENTER

GREENBELT, MARYLAND

PROJECT DEVELOPMENT PLAN

NIMBUS

PROJECT MANAGER
Harry Press

This Project Development Plan will be released to contractors ONLY with the approval of the project manager. All funding and manpower data MUST be removed prior to release.

For the purposes of satisfying the above note and to remove the Official Use Only marking, Part VII Resource Requirements has been removed from this copy.

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

PUBLICATION AND APPROVAL RECORD

NIMBUS

Issue	Issued by GSFC		Approved by Headquarters		Remarks
	Date	Releasing Official	Date	Releasing Official	
Orig	MAY 16 1962	Harry J. Goett			

LIST OF EFFECTIVE PAGES

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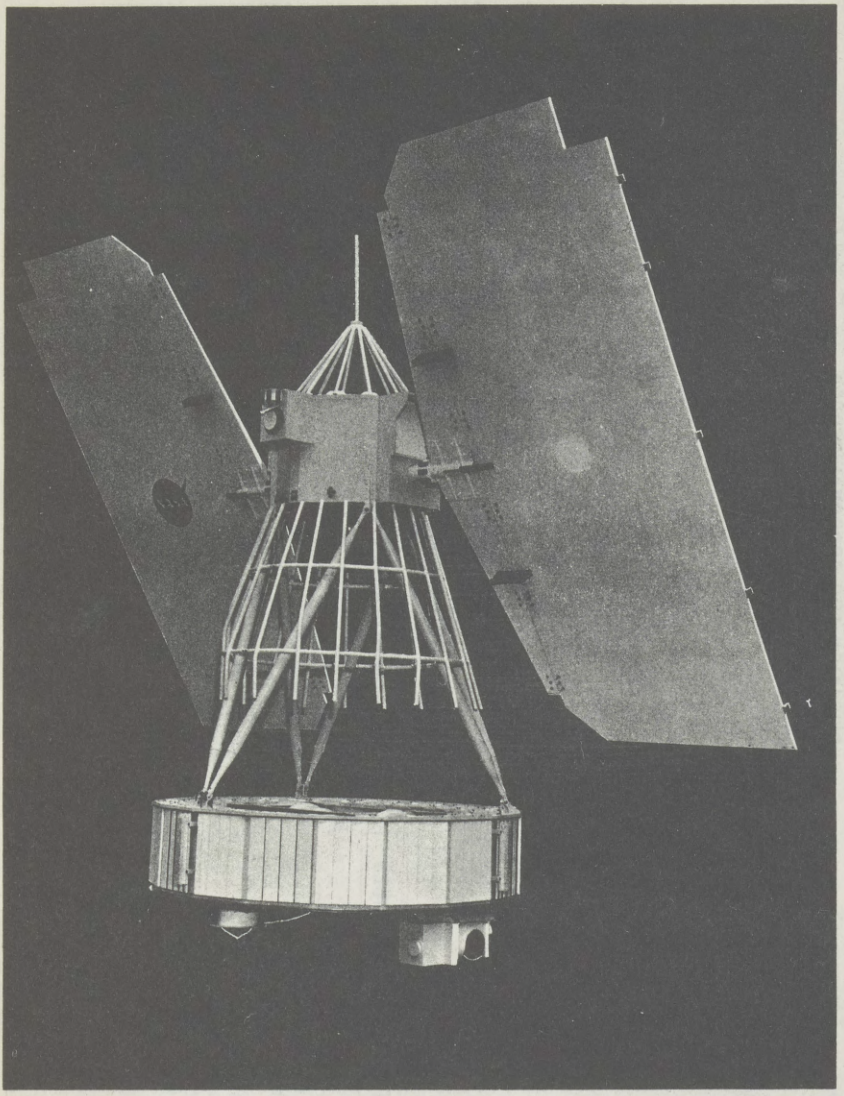

Frontispiece – Nimbus Spacecraft Model

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROJECT DEVELOPMENT PLAN

NIMBUS

FOREWORD

This Project Development Plan for the Nimbus project has been prepared in accordance with NASA Management Instruction 4-1-1 dated January 18, 1961. All inquiries regarding the plan should be addressed to the project manager, Harry Press, Goddard Space Flight Center.

Changes and revisions will be issued to holders of this Project Development Plan as required. This does not include the Program Management Plan included in Part V, which is updated at frequent intervals and widely distributed through a separate system. The latest Program Management Plan should be consulted for up-to-date schedule information.

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LIST OF TABLES

PART I

PROJECT SUMMARY

1. SCOPE

This Project Development Plan, dealing with technical and management aspects of the meteorological satellite system designated Nimbus, considers the spacecraft, launch vehicle, data-acquisition, and data-utilization subsystems for the project.

This plan complements and supplements the Nimbus Operational System (NOS) PDP, since, for managerial and technical reasons, the research and development and the operational efforts are merged in a single project, Nimbus.

2. OBJECTIVES

The overall objective of the Nimbus research and development project is to meet NASA responsibilities for conducting a research and development program leading to establishment of an operational meteorological satellite system.

The immediate objective of the Nimbus research and development project is television coverage of the daytime cloud cover of the entire earth, as well as infrared radiation pictures of nighttime cloud cover, reflected radiation, and the heat budget of the earth.

A secondary objective will be to gain information on certain earth-sun relationships and on results of several engineering tests of the satellites.

3. PROJECT APPROACH

The Nimbus spacecraft are a family of second-generation research and development meteorological satellites evolving from the TIROS experiments, and capable of performing numerous and diversified geophysical experiments. The Nimbus satellites, weighing approximately 650 pounds, will be earth-oriented in a polar orbit inclined approximately 80 degrees retrograde, whose plane will precess at a rate equal to that at which the earth circles the sun, and will always include the earth-sun line. The satellites will be stabilized within 1 degree. Proper launch time will permit the satellites to pass over selected areas at local noon.

Other capabilities of the satellite family will be tested in four successive launchings.

The research and development phases of the program will include operational testing and evaluation of the performance of the stabilization and control subsystem, the thermal control, and various types of instruments and power sources of the spacecraft.

4. FUNDING REQUIREMENTS

Estimated funding requirements for the approved four-launch Nimbus project are as follows:

(thousands of dollars)

	FY 60	FY 61	FY 62	FY 63	FY 64	TOTALS
GSFC	1802.00	8818.6	16662.7	26700.0	32250.0	86233.3
MSFC		300.0	7200.0	9100.0	9000.0	25600.0
TOTAL	1802.00	9118.6	23862.7	35800.0	41250.0	111833.3

5. MANPOWER REQUIREMENTS

Estimated NASA manpower requirements for the approved Nimbus project are as follows:

(man-years)

	FY 61	FY 62	FY 63	FY 64	TOTALS
GSFC	13.0	48.0	58.0	58.0	177.0
MSFC	6.0	9.0	14.0	14.0	43.0
TOTAL	19.0	57.0	72.0	72.0	220.0

6. SCHEDULE

Engineering design on the Nimbus project started in August 1959. The first launching is scheduled to take place during the second quarter of 1963. A series of four satellites will be launched in succession from the Pacific Missile Range at intervals from 1963 through 1965.

DATA SHEET
NIMBUS SPACECRAFT

SPACECRAFT

Weight: 650 pounds

Form factor: Overall dimension, 10 ft. high x 10 ft. wide; sensory ring, 54 in. x 13 in.; control housing, 17.25 in. x 33.28 in.; truss separator, 48 in.; solar paddles (each), 3 ft. x 8 ft.

Power Subsystems--

Required: 200 watts average power (continuous)

Supply: 10,988 solar cells and 8 nickel-cadmium storage-battery modules (23 modified F cells)

Transmission System--

Tracking and telemetry:	13 Mc (nom); PCM/AM 350 mw
AVCS/HRIR	1705 Mc (nom); FM 5 watt
MRIR	136 Mc (nom); AM 1.5 watt

Antenna Subsystem --

Tracking and telemetry	4 phased quadraloop antennas
AVCS/HRIR	1 conical spiral antenna
MRIR	1 quadraloop antenna
Interrogation	120 Mc (nom) folded ground plane on top of control housing

TELEMETRY STATIONS

Station	Type	Station	Type
Fairbanks, Alaska	Data-acquisition center	Lima, Peru	Minitrack
E. Grand Forks, N.D.	Minitrack	Blossom Point, Maryland	Minitrack
Mojave (Goldstone Lake)	Minitrack	Santiago, Chile	Minitrack
Fort Myers, Florida	Minitrack	Winkfield, England	Minitrack
Quito, Ecuador	Minitrack	Johannesburg, S. Africa	Minitrack
Antofagasta, Chile	Minitrack	Woomera, Australia	Minitrack
St. Johns, Newfoundland	Minitrack		

LAUNCH PHASE

Launch facility:	Pacific Missile Range
Launch vehicle:	Thor-Agena B
Orbital plan:	Circular, 80 degrees retrograde, 500-nautical-mile polar orbit
Stabilization:	± 1°, 3-axis, earth-oriented
Satellite life:	Six months
Launch period:	1963, 1964, and 1965

PART II

JUSTIFICATION

The design and development of the Nimbus project will extend our knowledge and understanding of atmospheric processes and provide a basis for the development of an operational weather satellite system. This will fill the need for complete global coverage of atmospheric processes, and will also provide meteorological information which can be used in real-time weather analysis and forecasting.

The project will encompass a variety of additional new developments and extensions to current technology. They are as follows:

- A larger spacecraft to permit expansion of the number, kind, and quality of meteorological sensors employed.
- An earth-oriented stabilization and control system to permit a continuous earth view, and reduce photographic distortion.
- Use of polar orbit to permit complete daily global coverage of the entire earth, particularly the polar regions, which have high meteorological significance.
- Development and use of both new and improved sensors.
- Direct readout of data to users.
- Extended life capability.

The Nimbus project will make a significant contribution in advancing the scientific mission of NASA by providing a new method of data collection for extending knowledge and understanding of atmospheric processes, as well as a basis for an operational meteorological satellite system.

PART III

HISTORY AND RELATED WORK

1. PROJECT HISTORY

The TIROS satellite flight program has demonstrated that a weather satellite system can extend knowledge and understanding of atmospheric processes. A spacecraft and ground data-acquisition system was developed which provided televised cloud photographs and infrared radiation measurements with adequate fidelity and resolution. Useful meteorological information was transmitted to the weather services to facilitate weather analysis and forecasting.

2. CURRENT EFFORTS

The NASA meteorological satellite program is a part of the long-range national space sciences program. Specifically, the meteorological satellite will be used (a) to study the basic laws of the atmosphere of the earth as planetary phenomena, (b) to develop techniques for making observations, and (c) to provide the basis for an operational satellite system. The techniques and knowledge obtained will be applied to the exploration of other planetary atmospheres.

NASA is currently conducting and supporting research and development programs in physical measurements, instrumentation techniques, and the storage, transmission, and analysis of data.

The Nimbus family of spacecraft will carry an integrated combination of meteorological experiments into a prescribed orbit. Use of a modular design will permit the introduction of new and improved sensors and auxiliary subsystems.

TV cameras will provide complete global mapping of the earth's cloud cover for real-time evaluation and forecasting. Infrared radiation studies of the earth and atmosphere will determine the attenuating effects of the atmosphere, clouds, and water vapor, and will provide information on cloud structure and movement.

3. FUTURE EFFORTS

The AEROS spacecraft system will make meteorological observations of the earth on a 24-hour global basis. The planned 24-hour synchronous orbit will provide hemispheric coverage to augment and back up meteorological data received from the Nimbus polar orbiting satellites. Primary sensory instrumentation will be televised on cameras or infrared sensors designed to produce continuous day or cloud photographs.

PART IV

TECHNICAL PLAN

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PART IV

TECHNICAL PLAN

1. GENERAL

1.1 OBJECTIVES

The overall objective of the Nimbus research and development project is to meet NASA responsibilities for conducting a research and development program leading to the establishment and operation of an operational meteorological satellite system.

The immediate objective of the Nimbus R&D project is to provide television coverage of the daytime cloud cover of the entire earth, as well as infrared radiation pictures of nighttime cloud cover, reflected radiation, and the heat budget of the earth. Provision will be made for real-time use of the relevant meteorological data. A secondary objective will be to gain information on certain earth-sun relationships and to provide results of engineering tests of the spacecraft subsystems.

1.2 APPROACH

To achieve the objectives of the Nimbus project, a spacecraft will carry TV cameras and infrared sensors to photograph global cloud cover from above, and will transmit these pictures to a ground station.

Four launchings (Nimbus A-4, A-5, A-6, and A-7) will carry the meteorological satellite program through calendar years 1963, 1964, and 1965.

Initial design will provide the capability of placing an earth-oriented and stabilized spacecraft weighing 650 pounds into a slightly retrograde 600-mile polar orbit. However, due to increased spacecraft weight and limitations of the launch vehicle, the initial flights are planned for 500-nautical-mile orbits.

The Nimbus program will provide information for the following:

- Preparation of radiation maps
- Preparation of nephanalysis charts
- Calculation of the earth's heat budget
- Basic data for investigating the composition of the atmosphere

- Interaction between solar radiation and portions of the atmosphere

The Nimbus satellites will be launched from the Pacific Missile Range into a polar and circular orbit inclined approximately 80 degrees retrograde, so that the plane of the orbit will precess and will always include the earth-sun line. Satellite attitude will be stabilized within one degree. Proper launch time will permit the satellites to pass over the earth's surface near local noon and local midnight.

2. SPACECRAFT

2.1 DESIGN REQUIREMENTS

General design requirements applicable to the Nimbus family of spacecraft are:

- Outgassing and the escape of gas from sealed compartments and/or materials will be minimized. The initial design provides that, after an initial period of 3 days, the gas cloud induced by the spacecraft (during the period of time when the attitude-control gas jets are not active) will diminish to a pressure of 10^{-7} mm Hg or less on surfaces where sensors are mounted.

- The use of permeable materials will be minimized.

- All designs will be as simple and as economical as possible, consistent with their performance requirements.

- All design and performance requirements are aimed at interchangeability and growth potential.

- Weights of all elements will be kept to a minimum. Flexibility of the design concept will assure compatibility with the growth missions of the succeeding family of satellites.

2.2 ALIGNMENT OF SPACECRAFT WITH LAUNCH VEHICLE

The Agena B, second stage of the launch vehicle, will support the spacecraft so that the reference positions and separation points are as shown in Figure IV-1. The spacecraft and vehicle geometric axes will be aligned within 1 degree.

2.3 REFERENCE AXES

Four sets of axes will define the spacecraft:

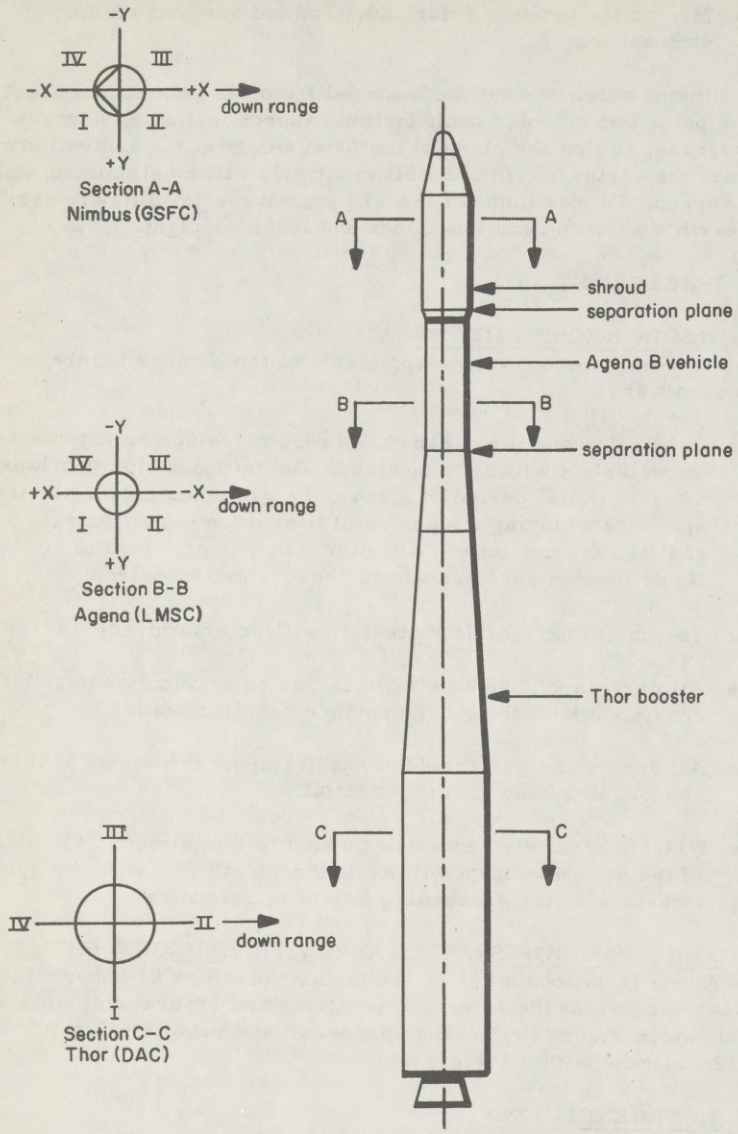

Figure IV-1 – Nimbus-Agena B-Thor Coordinate Axis System

- The orbit axes, defined by the earth's local vertical and the velocity vector
- The body axes, defined by the location of scanners and inertial sensors used for axis orientation
- Principal moment axes, defined by the principal moment of inertia axes of the assembled spacecraft
- Geometric axes, defined by the alignment reference in the spacecraft

The orbit-axis system is a set of three axes at the center of mass of the satellite, rotating in space so that one axis (coinciding with the earth's local vertical) is positive downward; the second axis (orthogonal to the vertical axis) lies in the instantaneous orbital plane with the positive sense in the direction of the velocity; and the third plane (orthogonal to both the local vertical and the instantaneous orbital planes) is positive to the right when looking in the direction of the velocity vector.

The second set of axes -- body axes defined by the sensory elements of the control system -- also is a set of three orthogonal axes having the same sense and center as the orbit-axis system, but fixed in the vehicle. Of the body-axis system, the earth-pointing axis is referred to as the yaw axis; the orthogonal axis nominally pointed in the direction of the velocity vector, the roll axis; and the third axis, the pitch axis.

The principal-moment axes are a set of three axes centered at the center of mass of the satellite so that one axis coincides with the principal moment of inertia axis nearest the body yaw axis. The second and third axes coincide with the principal moment of inertia axes nearest the roll and pitch body axes, respectively.

The geometric axes are defined by the layout of the spacecraft. The general location of these axes is defined by a line perpendicular to, and centered on, the separation ring; a line parallel to the solar-platform shaft center; and a line perpendicular to the plane defined by the above lines. Specific locations of the geometric axes are defined by a specific index placed on the base at the time of assembly and referenced to a jig supporting the spacecraft during assembly.

2.4 STRUCTURE

2.4.1 PAYLOAD

The planned payload, weighing 650 pounds, will connect to the Agena B stage by an adapter with a Marman clamp, equipped with pyrotechnic devices to assure separation after orbit injection (Figure IV-2). The shroud and nosecone covering the entire spacecraft are detached immediately after Agena B first ignition. An electrical separation switch and associated telemetry channels inside the Agena B/spacecraft adapter will indicate that separation has been achieved. The shroud and spacecraft with the solar array folded in the stored position are shown in Figure IV-3. After ejection into orbit, the solar array unfolds and rotates to face the sun continually.

The basic structure of the satellite consists of two primary sections: the upper housing, containing the stabilization and control section, and the base, containing the sensor section. The two housings are rigidly interconnected by means of a truss structure as shown in Figure IV-2.

2.4.2 BASE

The base consists of four machined rings and eighteen V-shaped separators, forming a series of eighteen rectangular modular pockets 8 inches by 6 inches by 13 inches. The modular pockets support the electronic equipment and battery packages whose dimensions are multiples of 2 by 6 by 6 1/2-inch basic packages.

A box (truss) beam structure, fastened to the sides of the inner surfaces of the base structure, provides lateral stiffening and areas for mounting the following equipments:

- Television cameras
- TV recorders
- High-resolution IR tape recorder
- Electronics for 1700-Mc antenna

The detailed design of the supports, sizes, and locations of these equipments is integrated with the structural design (Figures IV-2 and IV-4).

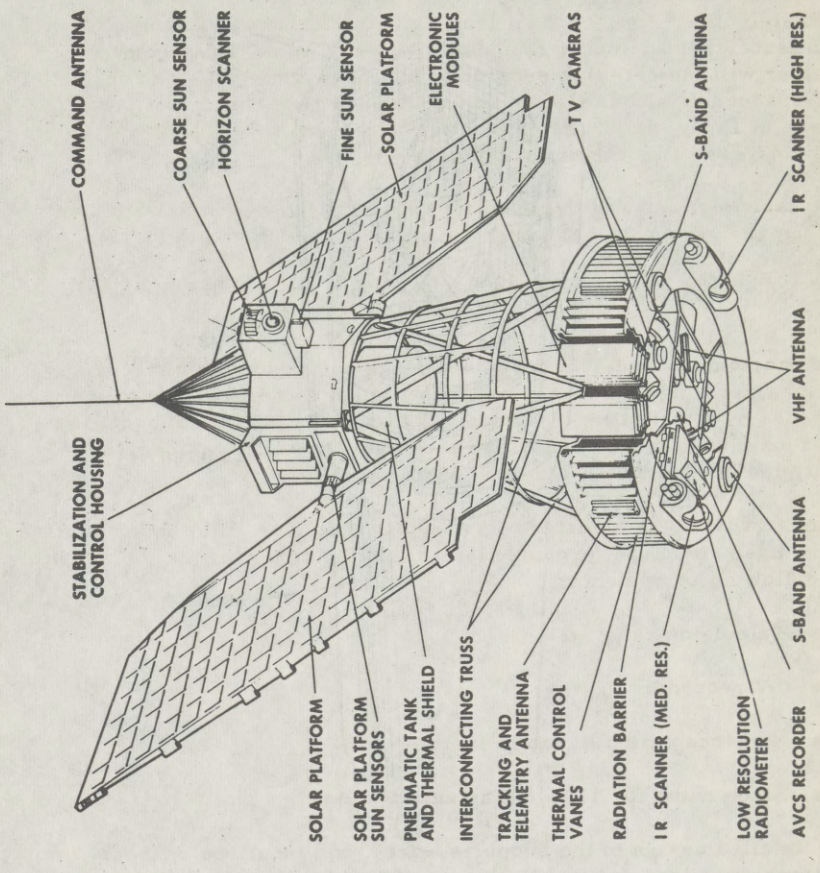

Figure IV-2 – Nimbus Deployed Configuration

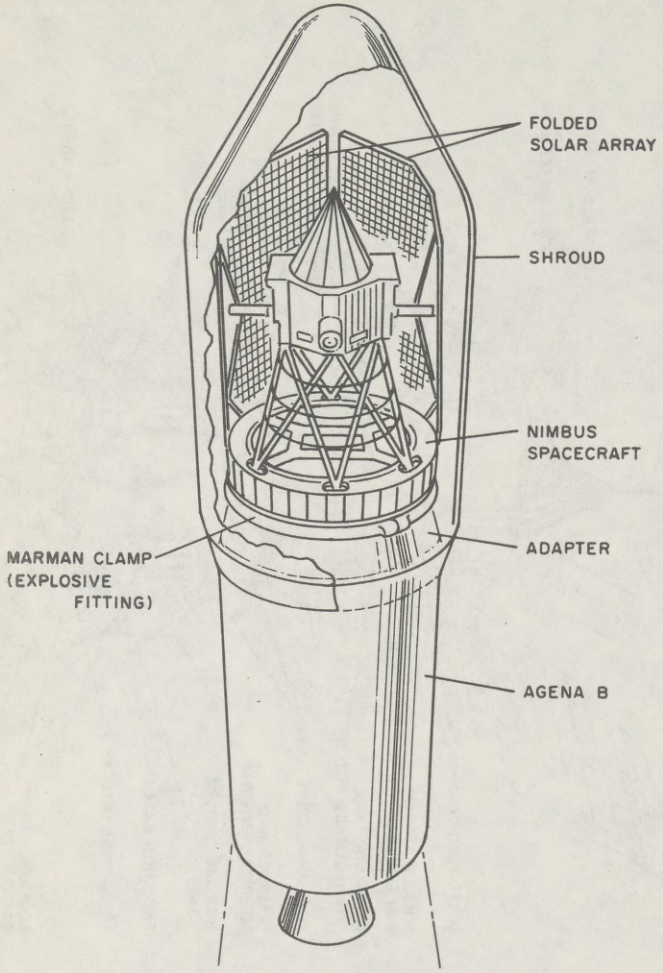

Figure IV-3 – Nimbus Folded Configuration

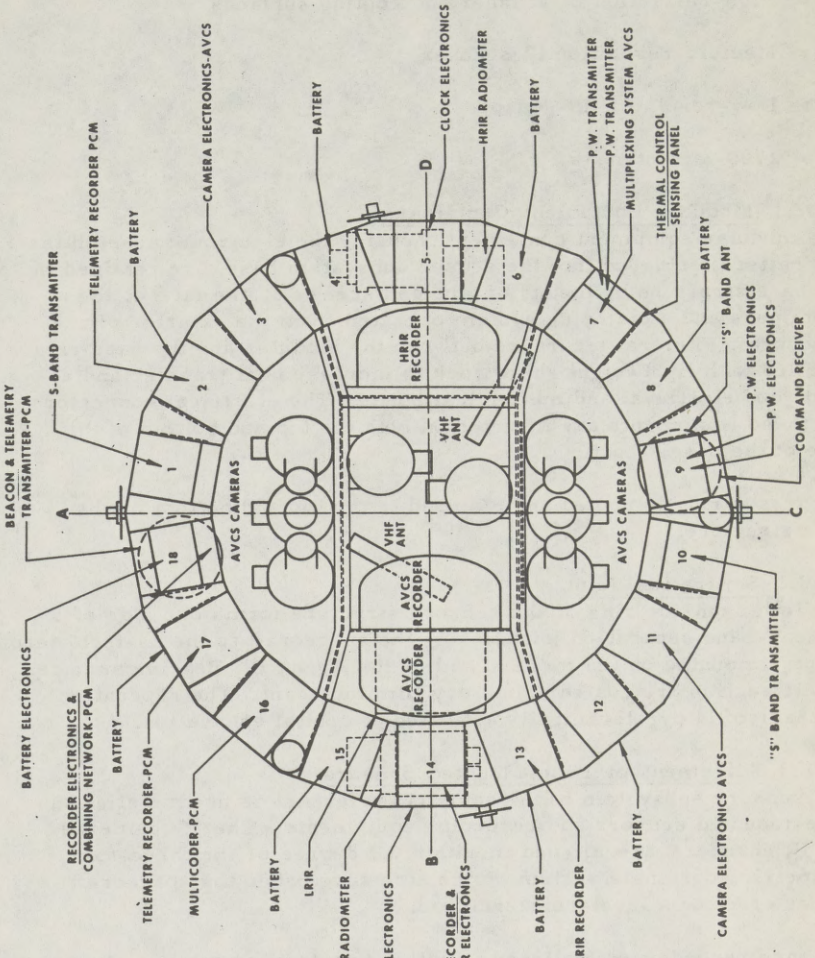

Figure IV-4 – Nimbus Module Layout, Top View

The following additional equipments are supported on the bottom (earth-oriented base) of the sensor structure:

- High-resolution IR scanner and cooling surfaces
- Medium-resolution IR scanner
- Low-resolution IR sensors
- 1700-Mc antennas

2.4.2.1 Modular Equipment Containers

The modular equipment containers, housing the electronic assemblies and batteries plugged into the sensor subsystem base, are retained in the base structure by means of tabs and screws at the face of the containers and a clamping system operated from the exterior of the spacecraft. Lateral clearance between the modules and the base ring is filled with lightweight shim stock to increase heat transfer and afford good electrical and mechanical bonds. The electrical connectors for these equipments are mounted on both the top and bottom of the face of the base structure.

Harness wiring is routed and clamped to the top and bottom of the base structure.

2.4.2.2 Separation Joint

The lower outside ring of the sensory structure forms one side of a large V-band separation joint linking the spacecraft to the 24-inch-deep adapter mounted on the forward end of the Agena B. Bearing surfaces of this section are coated with a dry film lubricant. The separation mechanism is pyrotechnically activated at orbital separation.

2.4.2.3 Alignment of Base-Mounted Sensors

The sensory subsystem base geometric reference is used to align the base-mounted sensors and recording equipments. The TV cameras and IR scanners are aligned to within 0.1 degree of the three-axis geometric coordinate system on the structure, when the spacecraft stands erect on a level-reference pad.

The tape recorders are aligned to within two degrees between their rotation axis and the spacecraft geometric axis.

2.4.3 TRUSS STRUCTURE

A truss attached at three points on the upper housing and three points on the lower housing connects the upper stabilization and control subsystem to the lower sensory structure. Figure IV-2 shows the method of attachment. Each of the six truss members is knee-mounted in upper socket joints adjustable laterally to provide correct alignment between the control subsystem and the base-mounted sensors.

The bottom sockets can be removed to mount an air-bearing support for ground testing of the spacecraft. Alignment between the control subsystem and the sensory base structure is critical. Reference points on both the control subsystem housing and the sensory base structure assure correct alignment.

2.4.4 UPPER HOUSING

The upper housing contains the solar array and attitude control subsystems. The solar array subsystem consists of the following:

- Solar array controls
- Drive mechanism
- Alignment sensors

The attitude control subsystem consists of the following:

- Horizon scanners to indicate proper satellite orientation with respect to earth.
- Pneumatic jets for initial stabilization in pitch, roll, and yaw.
- Reaction wheels to stabilize the spacecraft after initial stabilization.

2.4.5 SOLAR ARRAY

When the spacecraft is in the launch phase, the solar-array platforms are locked in the folded position and supported at the lower edge by the latch mechanism. At the proper time in the launch phase, this mechanism releases (unlatches) the platforms and they unfold (Figure IV-2). The platforms are fixed on a shaft supported by bearings in the control subsystem; when the spacecraft is in orbit, the shaft rotates continuously by a motor drive so that the solar array always faces the sun.

The outside edges of the solar platforms contain a line of tapped holes for the latching mechanism. The mechanism which unfolds the platforms is part of the power supply subsystem. On command, the unlatch-actuating mechanism releases the solar platforms from the base and from each other. The unlatch-actuating system must be operated without leaving any fragments. The system must demonstrate high reliability, therefore redundancy will be provided. The solar platform support and unlatching mechanism restrains the solar platform along the pitch and yaw axes to eliminate the possibility of excessive weight-load on the platform structures during the launch phase.

2.5 POWER SUPPLY

A single primary supply delivering -24.5 volts dc regulated ±2% has been developed to meet the requirements of the spacecraft subsystem. The Nimbus power supply is shown in Figure IV-5. The power supply consists of solar cells mounted on sun-oriented arrays, storage batteries, charging regulators, and protective devices. Two hundred watts nominal average power has been allocated for all subsystems.

The number of solar cells and the capacity of the storage batteries required in the power supply design were based on the following considerations: (a) variations in load that occur during the sunlit and dark periods of the orbit, (b) varying demands of the experiments, and (c) varying period of coincidence of illumination time versus interrogation time.

The primary source of power for the Nimbus satellite is derived from silicon solar cell arrays arranged on two honeycomb platforms which rotate continuously to face the sun (Figure IV-2). Each platform is nominally 3 feet x 8 feet and is covered by 5494 (2 cm x 2 cm) solar cells. The cells are interconnected in a series-parallel arrangement based on the voltage and current requirement and on statistical analysis of the probable failure mode of the cells. The anticipated efficiency of each solar cell is 11.9 percent at 30°C. Since efficiency decreases with increasing temperature, a blue-red coating is applied to a glass cover and bonded to each solar cell to reject that portion of the spectrum to which the cells are insensitive. This will lower the operating temperature of the paddles. The expected average operating temperature of the paddles will be approximately 20°C with extremes reaching -80°C and 44°C.

The storage batteries are packaged into eight parallel-connected modules, each consisting of 23 series-connected nickel cadmium cells.

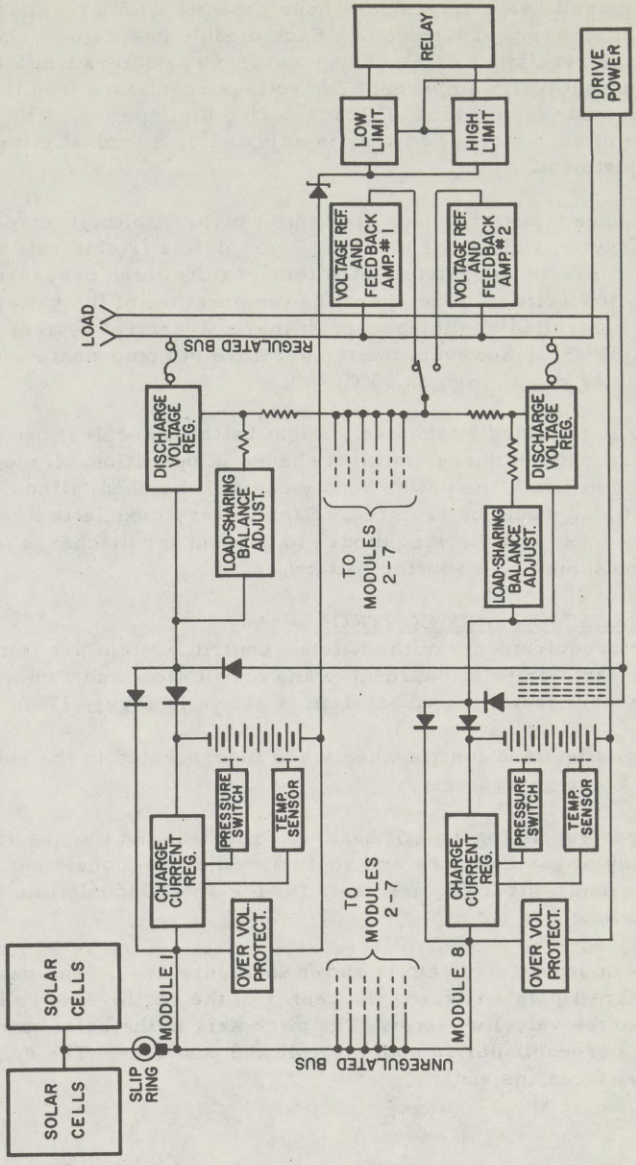

Figure IV-5 – Nimbus Power Supply, Block Diagram

Each storage cell has a 4.5-ampere hour capacity with a terminal voltage, at discharge, of 1.15 volts. Each module has its own charge and discharge regulators. The charge current regulators limit the charging current to 1.5 amperes. The voltage regulators feed the regulated bus bar from which all loads derive their power. The discharge rate of each storage battery is adjusted by a load-sharing balance adjustment.

There are three types of sensor elements which, with their associated feedback circuits, reduce the charging current to a trickle rate when activated. These sensors detect high temperature, high pressures, and excessively low voltage. The operating temperature of the battery modules is controlled by the spacecraft thermal-control system to approximately 25°C; however, the temperature of components within the module may run as high as 55°C.

Redundancy is provided by the use of eight battery modules, two of which can fail without necessitating a change in operation. If more than two modules fail, the power supply can still be used, although a reduction of load would be required. Each battery module is internally protected by fuses and blocking diodes to prevent the discharge of the remaining batteries by a shorted battery.

2.6 STABILIZATION AND CONTROL

The primary requirements of the Nimbus control system are initial acquisition, earth orientation, orbit-plane orientation, and sun orientation. The attitude-control subsystem is shown in Figure IV-6.

Pneumatic gas jets and inertia wheels are incorporated in the subsystem as torque generators.

A reserve gas supply (pneumatic tank) is provided, and the quantity and frequency of gas ejections are kept to a minimum consistent with stabilization and control requirements for the specified lifetime of the orbiting satellite.

The Nimbus coordinate system is shown in Figure IV-7. The yaw axis of the spacecraft points toward the center of the earth. The roll axis is parallel to the velocity vector. The pitch axis is the solar-array axis, and is perpendicular to both the roll and yaw axes. The solar array always faces the sun.

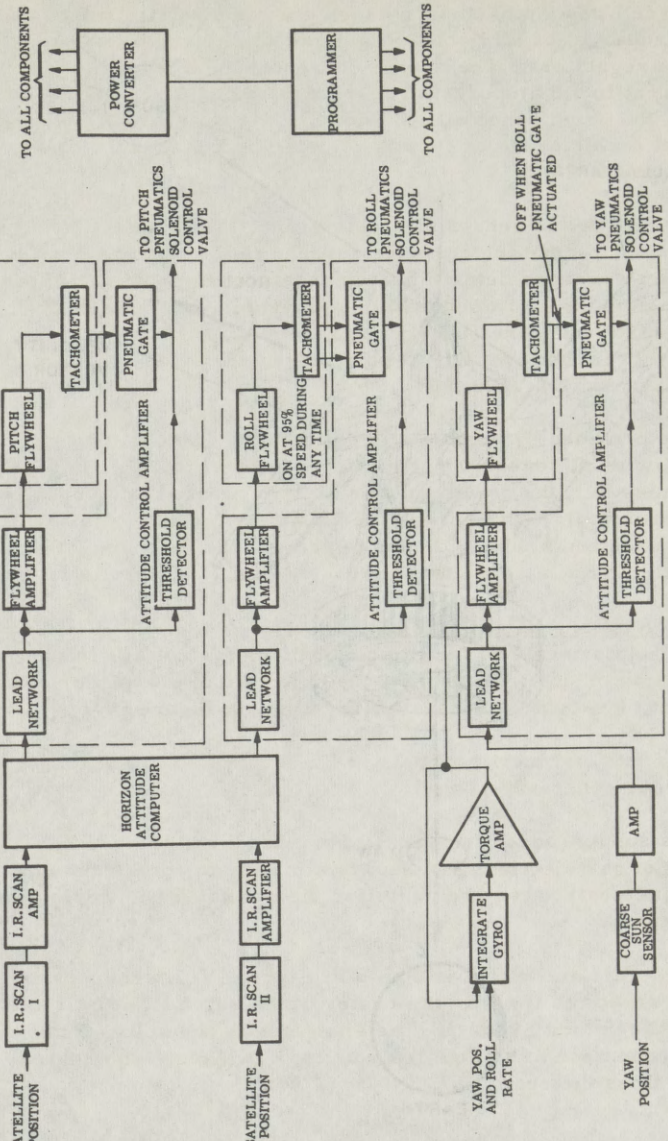

Figure IV-6 – Nimbus Attitude Control and Pneumatic Subsystem, Block Diagram

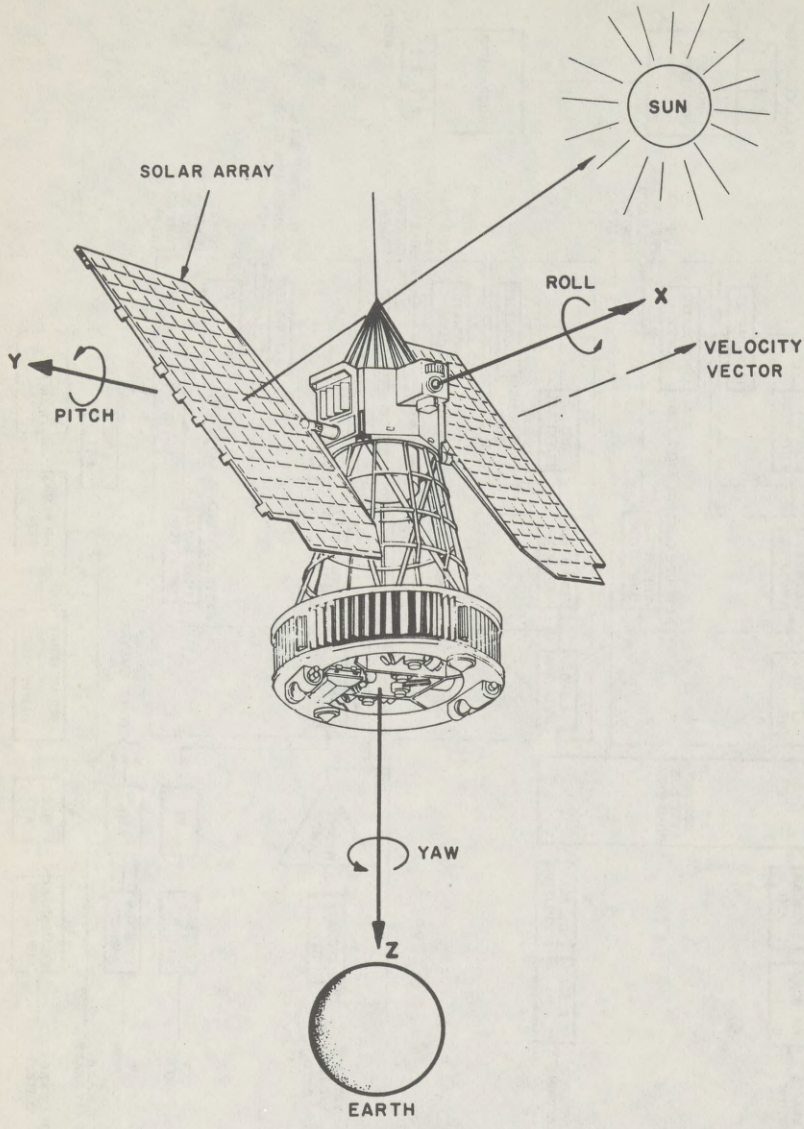

Figure IV-7 – Nimbus Coordinate System

2.6.1 FAILURE MODES

Should the yaw or pitch flywheels located in the control system fail, failure modes of operation would automatically maintain stabilization at reduced accuracy levels through the use of the gas jets. However, the gas supply would be quickly exhausted.

2.6.2 EARTH POINTING

The earth-pointing capability of Nimbus aims at stabilizing the satellite's reference axis within one degree of a line from the earth's instantaneous geometric center (local vertical). The instantaneous angular rate of the satellite body axes is less than 0.05 degree/second relative to the reference axis. Torque-producing gas jets provide initial attitude-alignment of the satellite along the reference axis. Initial stabilization and orientation from any attitude will occur within the first two orbits.

2.6.3 ACTIVE CONTROL METHODS

After the satellite has been injected into orbit and separated from the Agena B, its longitudinal axis is expected to be approximately 90 degrees from the desired operational mode of stabilization (Figures IV-8 and IV-9). Pitch-up to the operational mode and stabilization in this mode will be automatic. After initial stabilization, three orthogonally mounted reaction wheels provide control through an exchange of angular momentum between the wheels and the satellite.

2.6.3.1 Control Features

On command from the ground, the Nimbus control system is designed to program a yaw bias angle of ±30 degrees (in six-degree steps) from its normal yaw position during the sunlit portion of its orbit. This design permits reorientation of the satellite if orbit-injection errors are large or if the cumulative effects of minor injection errors are large. A fine sun-seeker mounted on the body of the control package transmits to the ground accurate information concerning the yaw-error. This information may be utilized to reorient the satellite. A rate gyro having its input axis aligned essentially along the roll axis of the satellite also aids in yaw control. The fine sun-seeker has a minimum accuracy of 0.1°, and the minimum detectable rate of the roll rate gyro is no greater than 0.35 degrees per hour.

2.6.3.2 Sun Pointing

The solar array, with a single degree of freedom about an axis parallel to the vehicle's pitch axis, will be oriented toward the sun by using sun-seekers and a simple drive system. The solar array will acquire the

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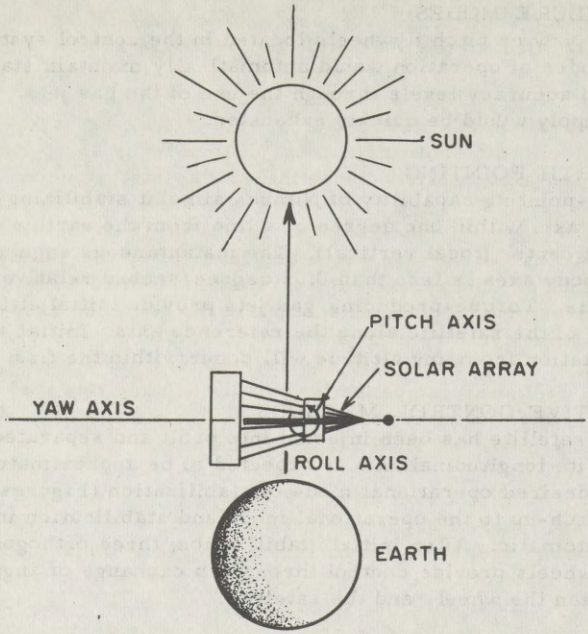


Figure IV-8 – Satellite Orbit Orientation after Separation from Launch Vehicle

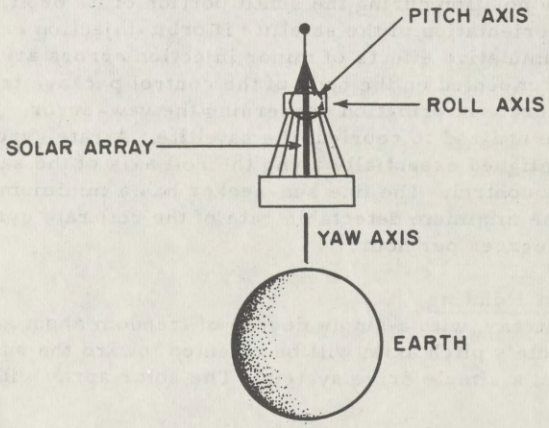


Figure IV-9 – Satellite Orbit Operation Mode after Stabilization

sun within one orbit after it separates from the launch vehicle, maintaining alignment to the sun within ten degrees of the earth-sun line.

2.6.4 DISTURBANCES IN ORBIT

The spacecraft is injected into orbit with its yaw or earth-pointing axis coincident with the orbit trajectory. It then turns about its pitch axis until the yaw axis is aligned with the earth's instantaneous geometric center and is in this position within one degree. During the pitch-up period, torque jets operate to place the satellite in the proper attitude, inducing a limit cycle rate which continues after the satellite achieves earth-pointing. The three reaction wheels oriented with the yaw, pitch, and roll axes provide angular momentum in all three axes to absorb the expected limit cycle rate from the gas-expulsion system. The reaction wheels have been designed to assure stabilization over a lifetime of 6 months, including compensation for disturbances caused by rotating parts. Flywheel moment-of-inertia and speed have been selected to provide capability for absorbing such disturbances.

The satellite control system acquires correct orientation within two orbits after separation. Reorientation must be assured even if earth and sun references are lost during the initial attitude acquisition. The three-axis reaction wheels must absorb disturbing moments caused by external as well as internal forces if the satellite is to achieve and maintain proper orientation for the entire 6-month orbit. The gas jets provide coarse orientation and, in addition, provide a means of "dumping" the integrated momentum accumulated by the wheels. The wheels alone furnish a means of torquing the spacecraft through small variations from the desired attitude.

2.6.4.1 Disturbing Moments Due to External Forces

The stabilization and control system is designed to maintain the specified accuracy in the presence of the following external disturbances: earth gravitational gradient, solar pressure, earth magnetic field, meteoroid impact, aerodynamic drag, radiation pressure, sun and moon gravitational fields, and cosmic rays.

2.6.4.2 Disturbing Moments Due to Internal Forces

The longevity and reliability expected of satellite earth-pointing accuracy over a period of six months govern the consideration of internal forces requiring compensation. Therefore, the stabilization and control system is designed to compensate for the effects of internal forces such as the expected gas-expulsion system limit-cycle rate, solar-array rotation, rotating parts, and rotating angular-momentum vectors of gyros induced by the orbital rate.

2.6.5 SUN SENSORS

Sun sensors for Nimbus consist of boron-doped silicon cells producing a photovoltaic response to solar illumination. As these sensors are photovoltaic they have no bias or power-supply requirements, and do not need auxiliary circuits.

The Nimbus satellite has three sun sensors: the coarse yaw-axis sun sensor, the fine yaw-axis sun sensor, and the solar-array sun sensor. Similar in geometrical configuration, the coarse sun sensor and the solar-array sensor have the solar cells mounted in an arc pattern so that solar rays cannot be normal to more than one cell at a time. Total response, therefore, is the sum of individual cell responses modified by the cosine effect of each cell's deployment with respect to the sun's rays. The sun-position sensors perform three functions:

- Solar array sun sensor senses the angle about the array axis between the line to the sun and the line normal to the solar array's active surface.
- Coarse sun sensor senses the angle about the yaw axis between the line to the sun and the vehicle's roll-yaw plane over 360 degrees of yaw motion.
- Fine sun sensor accurately senses the angle about the yaw axis between the line to the sun and the vehicle's roll axis over a limited orbital position, in order to supplement directional information from the rate gyro.

The desired transfer function of the solar array sun sensor is obtained by mounting the individual solar cells in a specific geometrical pattern and electrically interconnecting them to provide an output zero null. When the cells are illuminated along the zero angle, output is at zero (null); if the cells are illuminated along any other angle within the angular field of coverage, the output is of such polarity and level as to indicate the angular error in a proportional band.

2.6.5.1 Pitch and Roll Sensors

Two horizon scanners perform pitch and roll sensing, scanning a 90-degree field of view after initial satellite pitch-up is achieved. Positioning of the spacecraft in the earth-pointing attitude begins automatically after the programmed pitch-up, as soon as either sensor produces an error signal by reacting to cold black space or to earth radiation. The error voltage furnishes the impulse necessary to provide roll or pitch control of the spacecraft.

When the satellite reaches the earth-pointing position, an on-board computing circuit compares the error output from each horizon sensor's earth pulse with a known reference pulse to provide roll-axis attitude information. Comparison of pulse-width differences of the two scanners provides pitch-attitude information.

2.6.5.2 Coarse Yaw-Axis Sun Sensor

For initial orientation, or after a disturbance causing loss of sensor references, the satellite aligns first to the local vertical (earth-pointing attitude). The coarse yaw-axis sun sensor produces position information for aligning the satellite relative to the sun about the yaw axis. Eight silicon cells are mounted above the horizon sensor so that one of the sensors always faces the sun when the satellite is in the local-vertical position. These sensors provide error information to the control system, causing the gas-jet system or the reaction wheels to torque the satellite about its yaw axis.

2.6.5.3 Fine Yaw-Axis Sun Sensor

The fine yaw-axis sun sensor provides precision indication of the sun-satellite line. It consists of a silicon-cell complex mounted in a box on the forward horizon sensor structure. A slit aperture in the box permits illumination of the cell complex, providing voltage from which the satellite-to-sun line can be computed with an accuracy of .1 degree.

2.6.5.4 Solar-Array Sun Sensors

The solar-array sun sensors are twelve simple silicon cells encircling the solar-array driveshaft near the inside edge of the solar platforms; the advantage of this location is that the cells are not affected by the folding of the solar platforms nor by reflections from the stabilization subsystem.

2.6.5.5 Sun-Pointing Capabilities

During the initial phase of operation, the solar array will unfold, the satellite will pitch up to the earth-pointing attitude, and the array sun sensors on each shaft will detect solar radiation. The sensors are positioned so that the sun position can be acquired by the solar platforms regardless of the attitude of the spacecraft or the position of the solar platforms in respect to the sun-satellite line. If the power output of the sensors on one platform is greater than the output of those on the other platform (that is, if the gross error is large), then by command signal, the satellite may be torqued about the yaw axis to a more favorable sun-satellite position in steps of six degrees, through 30 degrees.

If, at this point, the power outputs from the pairs of cells on each shaft are still unbalanced in the roll vector of the array, then the platforms must be turned about the shaft axis. The platform drive motor will rotate the platforms until the voltages are optimum for sun pointing and a null occurs. After the sun is acquired, the array will track the sun with the sun sensors while maintaining earth-pointing accuracy (Figures IV-8 and IV-9).

2.6.5.6 Satellite Daylight Operation

During the time that the satellite is in daylight, the solar-array sun-sensors supply control power to operate the solar-array drive motor. The array is driven by an ac servo motor through a large gear reduction. Power for nighttime operation is through a potentiometer and satellite battery power. When the satellite is on the dark side of the earth, the speed of rotation of the array is increased and the array stops when it reaches the position for sunrise acquisition. Solar radiation energizes the solar-array sun sensors and their output overrides the potentiometer-coupled battery power during the satellite day.

2.6.6 PNEUMATIC SYSTEM

The pneumatic subsystem is designed to provide a nominal torque to moment of inertia ratio (T/I) of $.1°/sec^2$ in all three axes. The torque about the yaw axis is provided by two nozzle couples, one couple serving to accelerate the satellite in the positive direction, the other in the negative direction.

Torque about the roll and pitch axes is supplied by two nozzles; one accelerates the satellite in the positive direction, the other in the negative direction.

The actuating gas is nitrogen stored in a titanium tank. The tank is attached by strap fasteners in a well at the bottom of the control subsystem housing. Through operation of solenoid valves, gas is discharged through nozzles, providing thrust to change the spacecraft attitude as required. Control of the solenoid is through automatic programming and ground command signal. Figure IV-6 shows the Nimbus attitude control and pneumatic subsystem.

The pneumatic storage tank will be charged with a nominal pressure of 2500 psia at 75°F. It will be thermally protected to insure against excessive gas pressure. A high-pressure valve prevents tank rupture.

2.6.7 REACTION FLYWHEEL SUBSYSTEM

The momentum package contains the necessary flywheel and associated drive motor and speed-sensing devices to provide fine attitude control of the Nimbus spacecraft. All rotating parts and technical design features have been considered with reference to longevity and reliability. The unit will be thermally protected within the controls subsystem housing, and will be monitored through the mission by means of PCM telemetry. Figure IV-8 shows the satellite attitude before stabilization; Figure IV-9 shows the attitude of the Nimbus satellite after initial stabilization is acquired. Figure IV-10 shows the location of the pneumatic nozzles.

2.7 PCM TELEMETRY

2.7.1 GENERAL

Sensing transducers throughout the structure and equipments provide a means of monitoring spacecraft temperatures, performance of electronic and electrical systems, and earth-pointing characteristics. The telemetry subsystem will accept information from all subsystems for "housekeeping" purposes and from a number of sensors through low-rate data channels. The information stored and transmitted will be both digital yes-no data and analog signals. Two subsystems, each electrically independent of the other, will have the capability of handling stored telemetry or direct telemetry data. This permits the ground station to acquire data from up to two orbit passes before transmission, or to acquire data on a real-time basis for direct readout. These two systems have been designated "A" for stored telemetry data and "B" for real-time transmission.

The PCM telemetry system collects data from the transducers distributed throughout the spacecraft and transmits this data to ground stations where it is processed to indicate measurements of spacecraft parameters.

2.7.1.1 PCM "A" Telemetry System

The output of the "A" system will be recorded on tape and transmitted on command. The PCM "A" signal is a frame consisting of 64 words and each word of 7 bits plus a word sync bit. The sync word is all ones and the word sync bit is a zero. As shown in Table IV-1, the first 32 words are not commutated. Word numbers 33 to 48 are each subcommutated into 16 subframes so that 256 channels are available at a data rate of one per 16 seconds. The remaining 16 channels of the first row are subcommutated into 16 subframes also having a sampling rate of one per 16 seconds. Arrangements will also be included for some further subcommutation for the latter 16 channels. Thus, a total of 544

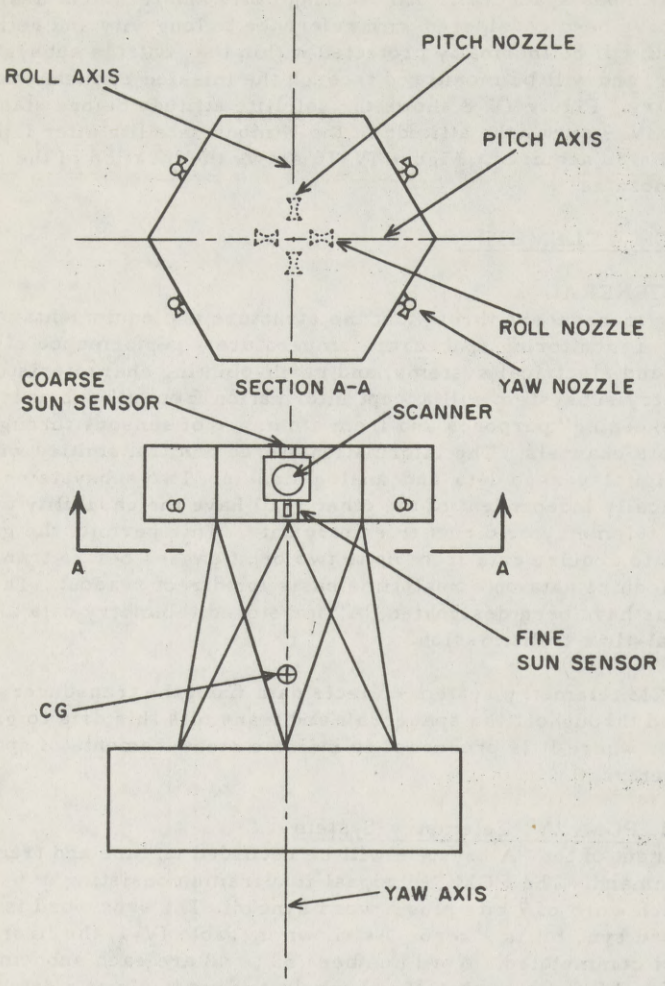
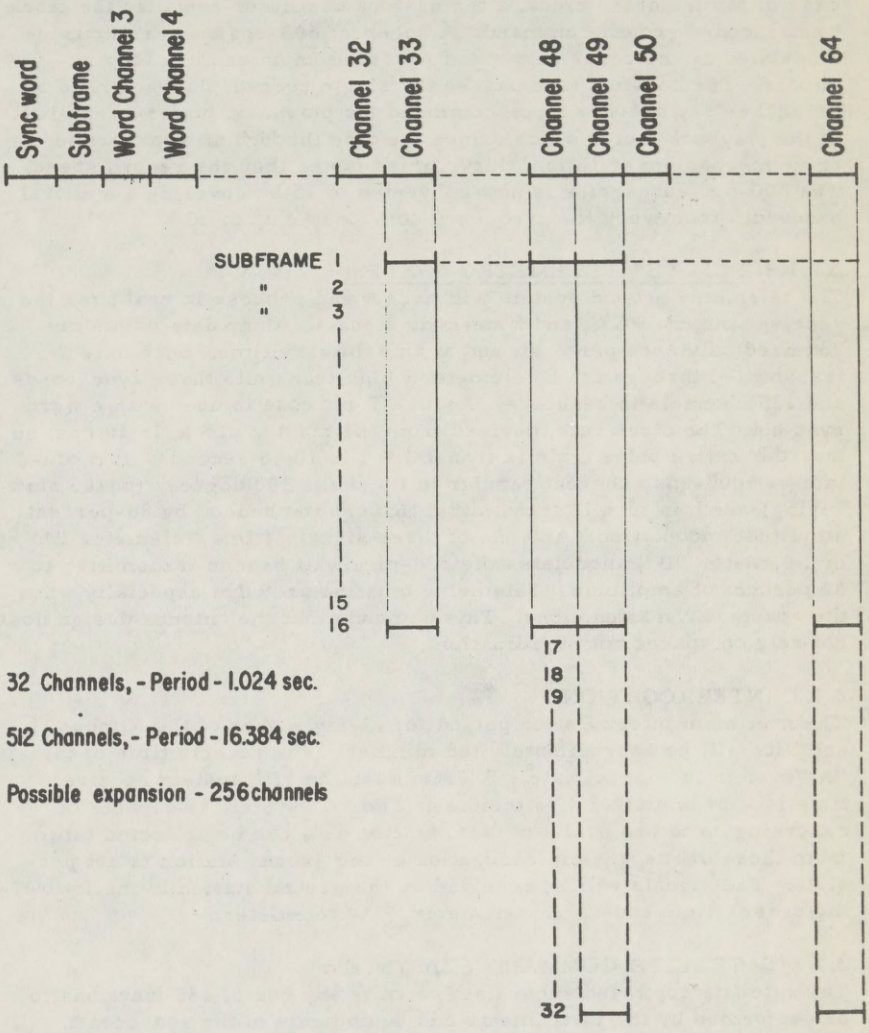


Figure IV-10 – Nimbus Control Subsystem Box Configuration

Table IV-1

FRAME DISTRIBUTION--NIMBUS TELEMETRY SUBSYSTEM



channels will be available with facility for some extension. Two of the channels are required for frame sync and subcommutation sync. A 500-pulse-per-second bit rate will be supplied by the master clock. In case of failure of the clock, a tuning-fork oscillator replaces the clock by unencoded ground command. A coherent 500-cps subcarrier is modulated by the coder output and recorded on an endless loop recorder. The 240-foot tape passes the single record/playback head at 0.4 inches per second. Upon command for playback, power is applied to the playback motor which drives the tape through an appropriate drive mechanism at 12 ips, thirty times faster than the record speed. The 500-cps subcarrier is now converted to 15 kc covering a spectral bandwidth from very low frequency components up to 30 kc.

2.7.1.2 PCM "B" TELEMETRY SYSTEM

The telemetry ground system will accept and process in real time the receiver output, PCM, and time-code signals. Many data points are required only once per orbit and at an arbitrary time. Such data are transmitted through the B telemeter which transmits three sync words and 125 channels in sequence. Again a 7-bit code is used with a word sync bit. The clock rate, derived from the master clock, is 10 cps; so that the entire pulse train is transmitted in 104.8 seconds. It modulates a 5000-cps coherent carrier in its phase 180 degrees (phase shift keying) which in turn is transmitted through the beacon by 80-percent amplitude modulation. Any one of three signals (time, telemeter "A", or telemeter "B") modulates the 300-milliwatt beacon transmitter to 80 percent of amplitude. Telemetry must be provided especially when the spacecraft malfunctions. This demands that the antenna design does not rely on spacecraft stabilization.

2.7.2 INTERROGATION

The maximum interrogation period for a single pass of the Nimbus satellite will be approximately ten minutes. The receive time of the "A" system is approximately 3.6 minutes; the "B" system receive time is approximately 1.75 minutes. The "A" system is capable of recording up to two orbits of data, so that data can be collected later from those orbits when interrogation by the ground station is not possible. The signals will be received by the ground station in the following order: time code, "B" telemeter, "A" telemeter.

2.7.3 SATELLITE COMMAND SUBSYSTEM

The satellite command subsystem permits any one of 128 functions to be performed by the instruments and equipments in the spacecraft. These functions are commanded by the ground station in the form of

binary code. The basic signal pulses for interrogation are received from the ground station and are interpreted by the clock subsystem in the satellite.

The clock subsystem is able to store commands and will accept one verified command per second. Each command message contains the time at which the command is to be initiated. The clock executes commands by applying a 12-volt 65-millisecond pulse output to latching relays or other switching devices. The command turns on the tape recorders and transmitters, which turn themselves off automatically at the end of playback. The commands also control the telemetry and other sensor subsystems.

2.7.4 GROUND COMMAND SUBSYSTEM

The ground command subsystem will be a part of the command and data-acquisition station at Fairbanks, Alaska. The site will have a disk-on-rod antenna array, permitting command interrogation to continue as long as the satellite is within range of the station. The ground station operator determines the sequence of functions for interrogation of the satellite subsystems. The ground station formulates and transmits the binary coded information for the execution of the command functions in the satellite.

2.7.5 S-BAND TRANSMITTERS

The S-band transmitters are packaged in standard Nimbus modules and will transmit the combined video and high-resolution infrared data on 1702.5 Mc and 1707.5 Mc.

Frequency-multiplexed subcarriers are combined and frequency-modulate the S-band transmitter carrier with a total deviation of 3 Mc.

The transmitter weighs 18.5 pounds and has a power output of 5 watts.

2.7.6 ANTENNAS

The Nimbus antenna subsystem is composed of nine antennas. They consist of two conical spiral-cavity antennas, six quadraloop antennas, and a single ground-plane antenna. Figure IV-2 shows the location of the antennas, and Figure IV-11 shows the Nimbus electronic payload.

The two conical spiral-cavity antennas are located on the bottom edge of the sensor structure. Their transmitting areas face the earth when the spacecraft is in the operational mode. They transmit all of the S-band TV and HRIR signals. Upon command, the antennas are driven

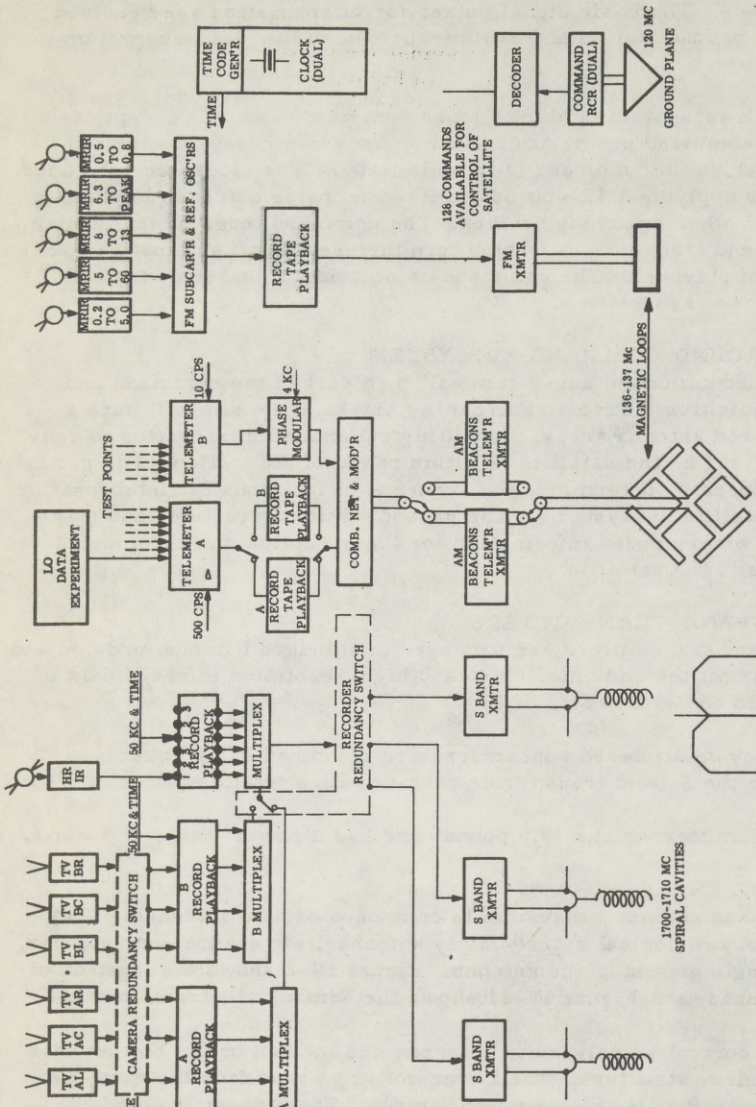


Figure IV-11 – Nimbus Electronic Payload

by two S-band transmitters with a nominal frequency of 1705 Mc. They gather information from two channels of high-resolution infrared information and a timing channel. Two television camera channels and a clock time-coding channel supply additional channels, which are the 1705-Mc outputs from the spacecraft.

Four quadraloop antennas, composing the beacon system, are mounted on the sides of the sensor structure. These antennas transmit telemetry information through the AM beacon transmitter. They also transmit information gathered by the medium-resolution infrared electronics (tape recorders, etc.) on nominal subcarrier frequencies of 136 Mc.

Two quadraloop antennas are mounted on the bottom of the sensor structure. These antennas resonate at a nominal frequency of 136 Mc and are located so that the main lobes will be oriented for maximum acquisition by the ground station.

The ground-plane antenna, mounted on top of the stabilization and control housing, receives nominal 122-Mc ground command signals.

2.7.7. SPACECRAFT TRANSMISSION

The following chart tabulates Nimbus spacecraft frequency assignments and transmission parameters. Figure IV-11 indicates the location of the transmission equipment in the spacecraft.

SUBSYSTEM	FREQUENCY (Nominal)	MODULATION	POWER OUTPUT
Beacon	136 Mc	AM	0.5 w
MRIR	136 Mc	FM	1.5 w
AVCS & HRIR	1702 Mc	FM	5.0 w
	1705.5 Mc	FM	5.0 w

The beacon transmitter is completely transistorized, and is contained in the PCM telemetry modular housing. Redundancy is employed to permit continuous operation in the event of failure.

The MRIR transmitter is transistorized, with exception of the output stage, and is contained in the MRIR electronics modular housing.

The AVCS & HRIR transmitters are transistorized except for the output stages, and are contained in their own modular housing.

2.8 THERMAL CONTROL

2.8.1 GENERAL

The spacecraft thermal control is achieved by designing the spacecraft structure as an isothermal mass with controllable heat leaks to the environment, thus maintaining an average equilibrium temperature of approximately 25°C, with the exception of the solar platform.

Independent thermal control has been established for three segments of the Nimbus spacecraft to provide individual thermal control for maximum growth and control capabilities. These are as follows:

- The solar platforms
- The sensor structure
- The control structure

2.8.2 SOLAR PLATFORMS

Absorptivity and emissivity of the front and rear surfaces have been carefully chosen and are expected to yield an average equilibrium temperature for the solar platforms of approximately 20°C. In addition, the honeycomb structure of the platforms provides excellent thermal conductivity in that the side of the structure away from the sun tends to cool the heated side, thus minimizing temperature gradients.

2.8.3 SENSOR STRUCTURE

The base ring of the sensor structure will serve as a heat sink for the electronics modules. The modules are mounted to achieve maximum heat transfer to this ring structure through conduction and radiation. Conduction paths to the ring are also provided for the heat generated by the equipment mounted on the cross-webs within the ring structure. Temperature control is achieved by a simple, reliable, active system of variable controlled shutters located around the peripheral surface of the sensor structure between the upper and lower rings. These open to expose a radiating plate of high emissivity made of heat-conductive material. The shutters are moved from any position between fully-closed and fully-opened by bellows filled with freon and by actuating links, which operate between 12° and 27°C to provide a high-gain self-regulating thermal control system. The bellows system is designed so that the shutters will return to mid-range position if the bellows fail.

2.8.4 CONTROL STRUCTURE

Both passive and active thermal controls maintain an equilibrium temperature of 25°C(±10°C) in the control structure.

The bottom surface is insulated primarily to avoid heat conduction to the attitude-control gas reservoir. This gas tank must be kept within specified limits of pressure; too high a temperature could cause the pressure to rise beyond desired limits.

The active thermal control system for the control subsystem consists of two panels, each located above the solar paddle drive shaft. Each panel has a freon bellows actuator and sensor tube. The sensor tube is snaked across the radiating panel, directly behind the shutters, so that the temperature across the total area of radiation can be sensed and controlled by opening and closing the shutters.

2.9 OPTICAL SYSTEM

2.9.1 ADVANCED VIDICON CAMERA SUBSYSTEM (AVCS)

The AVCS consists of two independent TV-camera and magnetic-tape-recorder components which can be operated interchangeably.

Each camera component contains three TV cameras, identical except for their mounting positions in the satellite, synchronized by a common camera-control unit which provides the shutter pulse and the vertical and horizontal sync pulses.

Each recorder component contains a four-track magnetic tape to store the video outputs from the three cameras and the pilot tone, containing satellite time information. Heterodyne oscillators are also included to translate the recorder playback outputs for frequency-multiplexing a single transmitter. The complete camera system can be commanded to operate with either recorder component, as shown in Figure IV-12, by appropriate control of the primary power.

The AVCS provides cloud-cover pictures during the satellite orbit day. The subsystem consists of three TV cameras, FM modulators, a tape recorder, a multiplexer, and a transmitter. The three cameras are mounted so that one camera looks straight down with a 37° field of view. The second camera is rotated 37° to the right with a 2° overlap. The third camera is similarly rotated to the left.

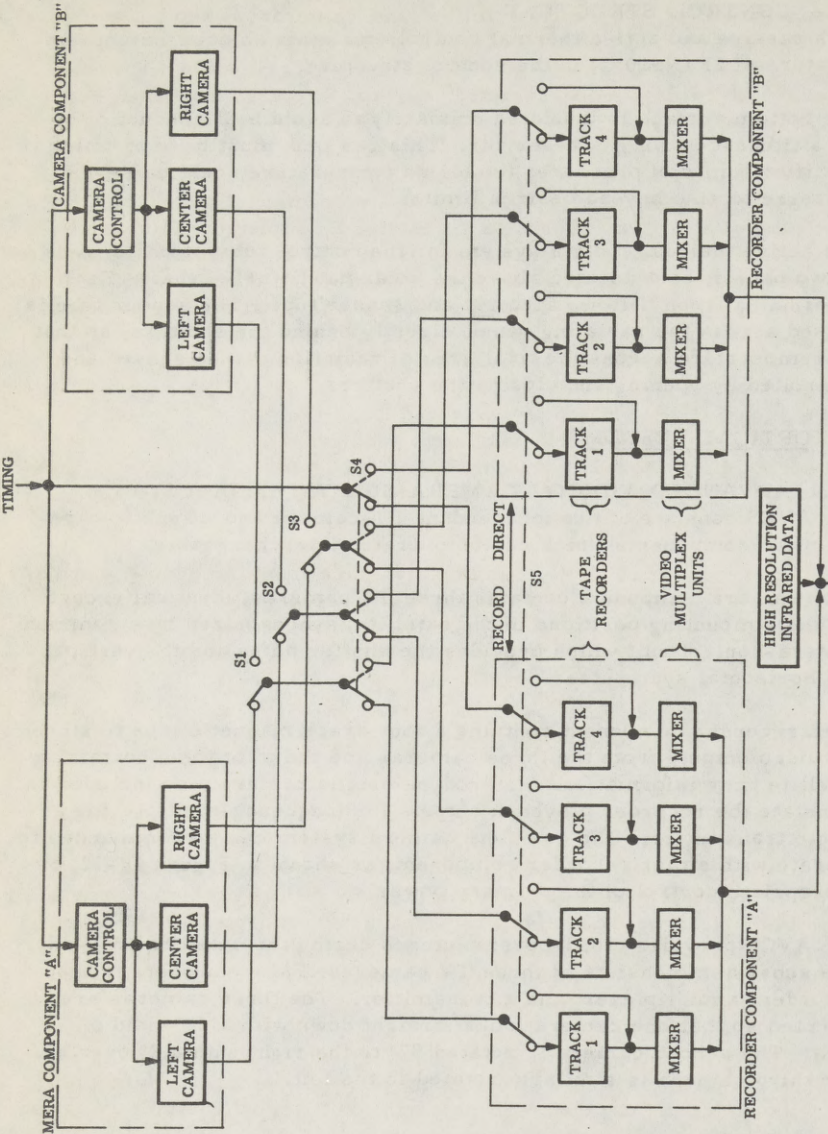


Figure IV-12 – Nimbus Advanced Vidicon Camera Subsystem

At an altitude of 600 nautical miles, the cameras sweep out a path which gives adjacent picture coverage at the equator on successive orbits. The central camera takes a picture approximately 400 miles square with a five-percent forward overlap. Pictures are taken every 108 seconds.

The TV tube is a one-inch vidicon with 800 lines and a resolution of one mile. The vidicon is exposed by an electromagnetic shutter for 40 milliseconds. The camera lens contains an adjustable iris which automatically controls the lens speed from f/16 at 90° solar illumination at the equator to f/4 at 4° solar illumination which occurs at 86° latitude. The iris opening is servo-controlled and is varied according to solar paddle position. The cameras cover a brightness ratio of 50 to 1 or 12 grey scales. A grey scale calibration is included at the edge of each picture frame.

After vidicon exposure, information is read out electronically every 108 seconds and stored on a tape recorder. The tape recorder is capable of storing 64 picture frames or 2 orbits. Satellite time is also stored on the tape recorder.

The tape recorder is played back on command from the ground station. The three TV pictures plus time are multiplexed and transmitted simultaneously over an S-band transmitter. Information is displayed on a quick-look kinescope for engineering evaluation, and on a facsimile recorder for high-quality pictures.

2.10 INFRARED RADIOMETER SUBSYSTEMS

2.10.1 GENERAL

The radiometer subsystems will perform a series of radiation measurements in a variety of spectral regions. Scan measurements will lead to the generation of synoptic analysis and nephanalysis data and maps of the distribution of radiation in many different regions, since water vapor, ozone, and carbon dioxide in the atmosphere have strong attenuating effects on portions of the infrared spectrum. Three types of radiometers will be mounted on the sensor structure of the Nimbus satellite. They will consist of:

- High-resolution infrared radiometer, sensitive in the 3.5 to 4.2 micron region, will detect the thermal radiation of the cloud cover on the dark side of the earth. A filter will inhibit radiation interference from the water vapor and CO_2 absorption band.

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- A medium-resolution infrared radiometer, sensitive to radiation in five channels, will measure the emitted and reflected radiation of the earth and its atmosphere.

- A low-resolution infrared radiometer will measure the thermal radiation and albedo of the earth and its atmosphere.

The following table gives the spectral regions, together with the spatial resolution and objectives, for these equipments:

	Spectral Region	Spatial Resolution	Objectives
HRIR	3.5 to 4.2 microns	1.74 x 1.74 miles	Night clouds
MRIR			
Channel 1	6.7 ± 0.05 microns	30 x 30 miles	Water vapor absorption
Channel 2	10.00 to 10.6 microns	30 x 30 miles	Atmospheric window
Channel 3	0.55 to 0.80 microns	30 x 30 miles	Red and near infrared
Channel 4	0.25 to 4.00 microns	30 x 30 miles	Albedo
Channel 5	5.00 to 30 microns	30 x 30 miles	Terrestrial radiation
LRIR	0.25 to 40 microns (black)	400 x 400 miles	Albedo
	4 to 40 microns (white)	400 x 400 miles	Albedo

2.10.2 HIGH-RESOLUTION INFRARED RADIOMETER SUBSYSTEM

The high-resolution infrared radiometer is an instrument capable of providing high-resolution nighttime cloud-cover pictures from a stable exploratory, meteorological satellite at an altitude of approximately 600 nautical miles (1000 km) in a near-polar orbit. The resolution of the radiometer is 2.8 milliradians, which is equivalent to approximately 1.74 miles on the ground. The radiometer is sensitive in the 3.4 to 4.2 micron atmospheric window and incorporates a filter designed so that minimum interference occurs from the water vapor and the CO_2 absorption bands. The radiometer consists of an optical system, a detector, associated electronics, and mechanical drive, all enclosed in a suitable housing.

The optical system consists of a single-sided flat mirror that will scan the earth as the satellite advances in its orbit. This mirror reflects the received energy into a Cassegrain ion-type telescope which will in turn focus this energy on a chopper. The chopper, a metallic disc with closely spaced teeth cut in its periphery, will provide the necessary modulation of the video signal. An optical relay system is located behind the chopper teeth in order to refocus the infrared energy on the detector.

The detector is a lead-selenide photoconductive cell which is radiation-cooled to -80° in order to provide the required sensitivity for detecting radiation in the desired spectral region.

The output of the detector is fed into appropriate electronics which will amplify and modify the video signal to a higher level so that it can be stored on tape and played back upon ground command.

2.10.3 MEDIUM-RESOLUTION INFRARED RADIOMETER SUBSYSTEM

The medium-resolution radiometer system measures infrared and reflected solar radiation from the earth and its atmosphere in five spectral bands. A rotating mirror sweeps out the viewed area of about 30 miles square. Data is recorded continuously and the last recorded orbit is transmitted upon ground command in time-compressed form. The five spectral bands are:

- Channel 1, Water-vapor absorption band -- This band, at 6.7 microns, will provide information on atmospheric structure and water-vapor distribution. Water-vapor absorption measurements are important in determining the absorption and radiation of solar energy by the earth and its atmosphere.

- Channel 2, Atmosphere window -- Measurements in the spectral band between 10 to 10.7 microns will provide information on the surface, cloud, and lower atmosphere radiation. This information will supplement information from Channel 4 to determine the upward heat loss from the atmosphere.

- Channel 3, Visible radiation -- Measurements in the visible spectrum between 0.55 and 0.8 microns will provide support for the vidicon cloud pictures and other radiometer data correlation.

- Channel 4, Albedo radiation -- Measurements in the visible and near infrared between 0.2 and 4 microns will be used to compute

the albedo of the earth or the radiant energy absorbed and reflected by the earth and its atmosphere.

- Channel 5, Terrestrial radiation -- Measurements of the spectral band from 7 to 30 microns will provide information on the earth's total longwave infrared radiation.

2.10.4 LOW-RESOLUTION INFRARED RADIOMETER SUBSYSTEM

The geometrical and spectral resolution of the low-resolution radiometer subsystem is considerably broader than that of either of the other Nimbus radiometer subsystems. This subsystem is designed to provide gross measurements of the earth's overall heat budget. This is accomplished by a pair of thermistor detectors, each of which is placed at the base of a highly reflecting conical cavity. The spectral sensitivities of each detector are different. One is painted black to absorb the total radiation leaving the earth (.2 μ to 40μ); the other is painted white so that only the thermal emission from the earth is absorbed. Each of the detectors is suspended at the base of the cone by a grid of low-conductivity fibers to minimize thermal coupling of the detectors with the radiometer housing structure. By considering the thermal balance of each detector and monitoring its response while the instrument views the earth, the apparent blackbody temperature and albedo of the area viewed on the earth can be inferred. However, this requires extensive calibration prior to orbiting the instrument.

The field of view of each detector is defined by the aperture of the conical cavity and is approximately 35°. The area covered from the altitude of the Nimbus spacecraft is approximately 400 miles in diameter. The three pairs of detectors described above are actually used in the experiment. One pair views the subsatellite point, and the optical axes of the other two pairs are displaced symmetrically 35° from the first, thus providing a net coverage of approximately 1200 miles in the direction transverse to the satellite motion. The orbital motion of the spacecraft provides the forward scan of the instrument, while the unchopped dc signal of each detector is processed, stored, and transmitted by auxiliary equipment located on the Nimbus spacecraft.

2.11 SOLAR CONSTANT MEASUREMENT

The solar constant (the total radiant-energy flux per unit area from the sun at the mean distance of the earth) is fundamentally important to geophysics and meteorology, as well as in understanding the solar-energy budget. A numerical value of 1.94 cal min^{-1} cm^{-2} or 1350 wm^{-2} is generally accepted today, although a more recent survey indicated that

2 cal min^{-1} cm^{-2} is a better estimate; these values were derived from measurements made from the earth's surface in recent decades. Atmospheric interference, however, necessitates considerable correction of experimental results; the atmosphere is completely opaque to large portions of the ultraviolet and infrared. Rockets and satellites now present the opportunity to determine the solar constant directly, without the interference of the atmosphere. At present, the solar constant is known to about ±2 percent. A satellite-borne heliometer must be one order of magnitude more accurate than this to advance the knowledge significantly. Thus, in developing the satellite-borne heliometer proposed herein, the goal has been an error of not more than ±0.2 percent, which would also permit observation of variations in the solar output. Minor changes in the radiant flux are expected during periods of enhanced solar activity.

The Nimbus satellite will carry a heliometer having a blackbody to receive direct solar radiation. The temperature of the blackbody will be monitored and telemetered to ground stations, giving meteorologists and geophysicists an accurate reference constant from which measurements of solar energy can be obtained. Consequently, a comparison of the solar energy with the measurements of radiated and reflected energy generated by the infrared sensors in the Nimbus satellite should produce a measurement of the earth's heat budget.

3. TEST AND EVALUATION

3.1 PHILOSOPHY OF ENVIRONMENTAL TEST PROGRAMS

The programs specified in the following pages are intended to provide the project management with a high level of confidence in the reliability of the spacecraft and the success of the mission. The test program is based on the fact that, almost without exception, the project is limited to very small system samples and thus statistical concepts have highly limited applicability. The prototype test program is intended to demonstrate a sufficiently conservative margin of design safety in the complete spacecraft and all its subsystems. Therefore, all tests and test levels are more severe for the prototype than are anticipated in flight.

The flight acceptance test program is intended to demonstrate the successful reproduction of the complete spacecraft and all its subsystems. Test levels are the best possible simulations of those anticipated in flight.

3.2 ENVIRONMENTAL TEST COMMITTEE

The GSFC project manager will establish a Spacecraft Environmental Test Committee, with the responsibility and authority to accept or reject the results of the prototype and flight environment tests of the spacecraft. In addition, the committee will review the test program periodically and recommend to the project manager changes in the program or test levels dictated by experience and/or new information. The committee will not concern itself with component or subassembly environmental testing, unless it affects overall spacecraft test philosophy. However, a qualification sheet of each environmentally tested subassembly and subsystem for the prototype and flight model will be submitted to the committee. The committee will also determine the disposition or additional testing of prototype or flight spacecraft models that fail to qualify under environmental tests.

The committee consists of four members, chaired by the Aeronomy and Meteorology Division, GSFC. One member is the test coordinator from the Test and Evaluation Division, GSFC; a senior electronic engineer and a senior mechanical engineer from the systems integration contractor's plant are the other two members.

3.2.1 TEST SUPPORT BY GSFC

The Test and Evaluation Division, through the Test and Evaluation Coordinator, provides facilities and technical services to perform various phases of testing at GSFC as scheduled, or to solve special problems as the project develops. The division also provides technical services to review and interpret GSFC's test requirements for the contractor.

3.3 REQUIREMENTS AND PROCEDURES

3.3.1 PREPARATION FOR TEST PROGRAM

Each spacecraft submitted for test will be clearly and permanently identified by suitable markings in a manner that will distinguish it from any other spacecraft.

When a spacecraft becomes qualified either as a prototype or as a flight model, additional identification will be added so that it may be distinguished readily from unqualified spacecraft.

Flight model spacecraft submitted for acceptance testing will be exact replicas of the qualified prototype.

Exposure to the various environments will be in the following order:

Prototype Test Program	Acceptance Test Program
1. Humidity	1. Vibration
2. Vibration	2. Pre-vacuum thermal temperature tests
3. Acceleration	3. Thermal vacuum
4. Pre-vacuum thermal temperature test	
5. Thermal vacuum	

A chronological log kept throughout prototype and acceptance tests will contain all test-program data, identification, procedure descriptions, and a record of all pertinent events during the test program. These reports will be submitted to the project manager's environmental test committee, and to others as appropriate. The project manager, with the advice of the environmental committee, will decide the final acceptance or rejection of the spacecraft.

3.3.2 PROTOTYPE TEST PROGRAM

3.3.2.1 Exposure to Humidity

While nonoperative, the major spacecraft subsystems will be subjected to a test chamber temperature of 40°C with a relative humidity of 95 percent for 50 hours elapsed time.

3.3.2.2 Exposure to Vibration

The spacecraft will be attached to a mounting adapter in a manner which will simulate the actual mounting of the spacecraft on the launch vehicle where the spacecraft yaw axis is vertical. The mounting adapter will be attached to the vibration equipment so that the spacecraft can be vibrated in each of three orthogonal directions, one of which will be parallel to the thrust axis.

Procedures and Levels. --- The spacecraft will be subjected to vibration under the following conditions:

Sinusoidal:

Frequency Range cps	Amplitude - g 0-peak	
	Thrust Axis	Transverse Axes
5-14	1/4" 0-peak	1/4" 0-peak
14-400	5	1.5
400-2000	10	3

Sweep rate

5-14 cycles 2-min sweep (3 times)

14-2000 cycles - one 40-min sweep

Random:

Direction	Frequency Band cps	Spectral Density g^2/cps	g-RMS
Thrust axis	20-2000	0.07	11.5
Transverse axes	20-2000	0.07	11.5

The duration of the test will be 4 minutes in each direction, 12 minutes total.

3.3.2.3 Exposure to Acceleration

Exposure Conditions. -- The spacecraft will be attached to a mounting adapter in a manner which simulates the actual mounting of the payload to the launch vehicle. The mounting adapter will be capable of attachment to the centrifuge so that the payload can be accelerated in three orthogonal directions, one of which shall be parallel to the thrust axis.

The spacecraft will be in an operational condition normal to powered flight during the exposure to acceleration.

Procedures and Levels. -- The spacecraft will be subjected to the following accelerations:

Direction	Acceleration	Duration
Thrust axis	15G	5 min.
Transverse axes	3G	5 min.

3.3.3 PRE-VACUUM THERMAL TEST

In order to ensure that the spacecraft has no obvious temperature deficiencies before being subjected to the vacuum-thermal test program, the following test is specified:

Exposure Conditions. -- A thermocouple to indicate the stabilization of the spacecraft's temperature should be mounted at the spacecraft's most massive non-heat-producing section. The temperatures indicated will be used to satisfy the temperatures herein specified.

Procedures and Levels. -- While operative, the spacecraft will be subjected to a test chamber temperature of +5°C for 6 hours after temperature stabilization. The chamber temperature will then be raised to 45°C, and the temperature stabilized and held for 6 hours. The spacecraft will be operated with bi-hourly interrogation during this test.

During the course of this test, any detectable change that can be interpreted as leading to failure or harmful degradation of the spacecraft within its expected operational life, or any change in its operation beyond the tolerance specified in the applicable performance specification, will be cause for rejection. Provisions will be made to ensure that dew-point condensation does not occur in the spacecraft or in small cavities of the spacecraft when the temperature is reduced.

3.3.4 VACUUM THERMAL TESTS

The spacecraft, attached to a mounting adapter, will be heated and cooled during this test by essentially radiant transfer. Thermocouples will be attached to the spacecraft in numbers and at locations sufficient to measure the highest and lowest spacecraft temperature. It will then be mounted in a thermal-vacuum chamber.

3.3.4.1 Test I

With the spacecraft in the operational condition normal to flight, the exposure chamber will be evacuated to a pressure of 10^{-5} mm Hg or

less at a rate not exceeding that of the pressure-time profile of actual flights. The temperature of the spacecraft will be raised and lowered by radiant heat sources until the temperature is stabilized as shown in Test I of Figure IV-13. The performance of the spacecraft will be checked bi-hourly.

3.3.4.2 Test II

With the spacecraft in the operational condition normal to space flight, the temperature of the spacecraft will be raised and lowered by radiant heat sources until the temperature is stabilized as shown in Test II of Figure IV-13. This test will begin at the crossover point between it and Test I. When stable conditions have been achieved, the exposure chamber pressure and the spacecraft temperature will be maintained at the required levels indicated. During the exposure period, the performance of the spacecraft will be interrogated bi-hourly throughout the duration of the test. Any detectable change which can be interpreted as leading to failure or harmful degradation of the spacecraft within its expected operational life, or any change in the operation of the spacecraft beyond the tolerance specified in the applicable performance specification, will be cause for rejection. The cycle indicated in Test II of Figure IV-13 will be repeated for 60 days or for as long as required to demonstrate the reliability of the spacecraft to the NASA/GSFC project manager.

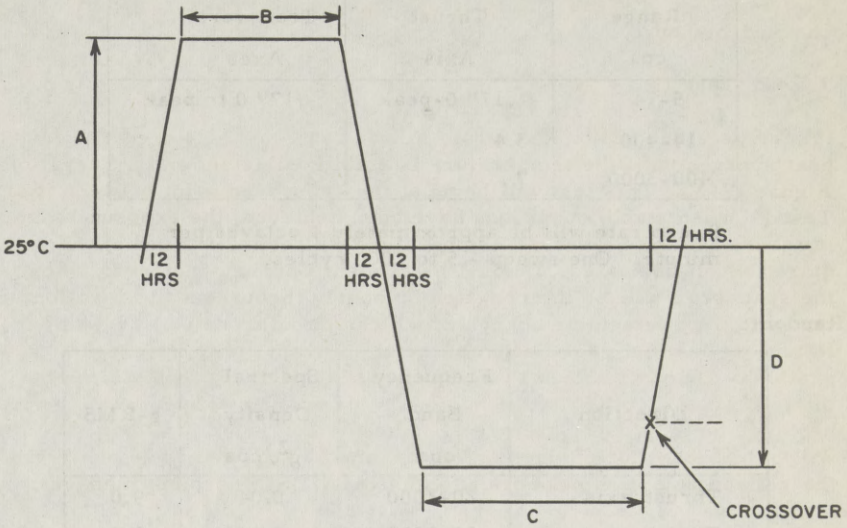
Any detectable change during any interrogation that can be interpreted as leading to failure or harmful degradation of the spacecraft within its expected operational life, or any change in the operation of the spacecraft beyond the tolerance specified in the applicable performance specification, will be cause for rejection.

Rejection and Retest. -- If a spacecraft is rejected before, during, or after an exposure, the exposure sequence will be discontinued, the cause of the rejection (including any design defects) corrected, and the complete prototype test program repeated until successful, starting at the event, timing, and temperature where failure occurred.

3.3.5 FLIGHT ACCEPTANCE TEST PROGRAM

3.3.5.1 Vibration Test

The flight spacecraft will be subjected to the exposures and tests as follows:



TEST	A	B	C	D	REMARKS
I	+50° C	1 DAY	1 DAY	+0° C	1 CYCLE
II	+5° C	4 DAYS	4 DAYS	+45° C	BEGIN AT CROSSOVER
III	+45° C	1 DAY	1 DAY	+5° C	1 CYCLE
IV	+10° C	4 DAYS	4 DAYS	+40° C	BEGIN AT CROSSOVER

Figure IV-13 – Vacuum Thermal Cycles

Sinusoidal:

Frequency Range cps	Amplitude - g-0 to peak	
	Thrust Axis	Transverse Axes
5-14	.17" 0-peak	.17" 0 to peak
14-400	3.4	1
400-3000	7	2

Sweep rate will be approximately 4 octaves per minute. One sweep - 5 to 2000 cycles.

Random:

Direction	Frequency Band cps	Spectral Density g^2/cps	g-RMS
Thrust axis	20-2000	0.04	9.0
Transverse axes	20-2000	0.04	9.0

Duration of test, 2 minutes each direction.

3.3.5.2 Exposure to Thermal Vacuum
The flight spacecraft will be subjected to the exposures and tests as outlined in Tests III and IV of Figure IV-13.

3.3.5.3 Rejection and Retest
If a payload is rejected before, during, or after an exposure, the exposure sequence will be discontinued, the cause of the rejection corrected, and the complete acceptance test program repeated until successful starting at the event, time, and temperature where the failure occurred.

4. GROUND SYSTEMS

4.1 TRACKING AND ORBIT DETERMINATION

Tracking operations will consist of two phases, trajectory tracking during the launch phase and orbit tracking during the post-launch phase.

4.1.1 TRAJECTORY TRACKING

The Nimbus spacecraft will be injected into an approximately 80° retrograde polar orbit from the Pacific Missile Range (PMR). PMR launch support facilities will perform the trajectory tracking function. Data obtained from the PMR launch tracking network will be transmitted to the NASA Computing Center, GSFC, in as near real time as possible for use in orbit refinement computations.

4.1.2 ORBIT TRACKING

Orbital tracking for the Nimbus spacecraft will be performed by the worldwide Minitrack network shown in Figure IV-14. During the launch phase, the Minitrack stations will acquire and track the spacecraft, using nominal predictions supplied by the GSFC. As additional tracking data becomes available, these predictions will be continually updated and transmitted to the Minitrack stations and to the Nimbus CDA station.

When the orbit has been accurately established, the tracking stations will enter the normal tracking phase. During this phase, the stations will track the Nimbus spacecraft utilizing the predictions prepared by the Data Systems Division, GSFC, in accordance with the procedures established by the Operations and Support Division, GSFC.

4.2 DATA ACQUISITION AND PROCESSING

The command and data acquisition (CDA) station for the Nimbus program is located on Gilmore Creek, twelve miles north of the city of Fairbanks, Alaska. This single station will be able to provide coverage for nearly 70% of the Nimbus orbital passes. The site has a horizon of ten degrees north and south, decreasing to approximately 2.5 degrees in the west and approximately 5 degrees in the east, which effectively shields the antenna from interference generated by radar or communications equipment.

The CDA station may be considered as performing three separate but obviously related functions: (a) acquiring the data, (b) performing the on-site processing required to present the data in usable form, and (c) transmitting it to NMC and GSFC. Figure IV-15 is a system block diagram of that portion of the Gilmore Creek CDA station most directly involved with the data acquisition function.

4.2.1 DATA ACQUISITION FACILITIES

4.2.1.1 Antenna

The main antenna for the Fairbanks, Alaska CDA station is an 85-foot-diameter paraboloid with a focal length of 36 feet. The surface,

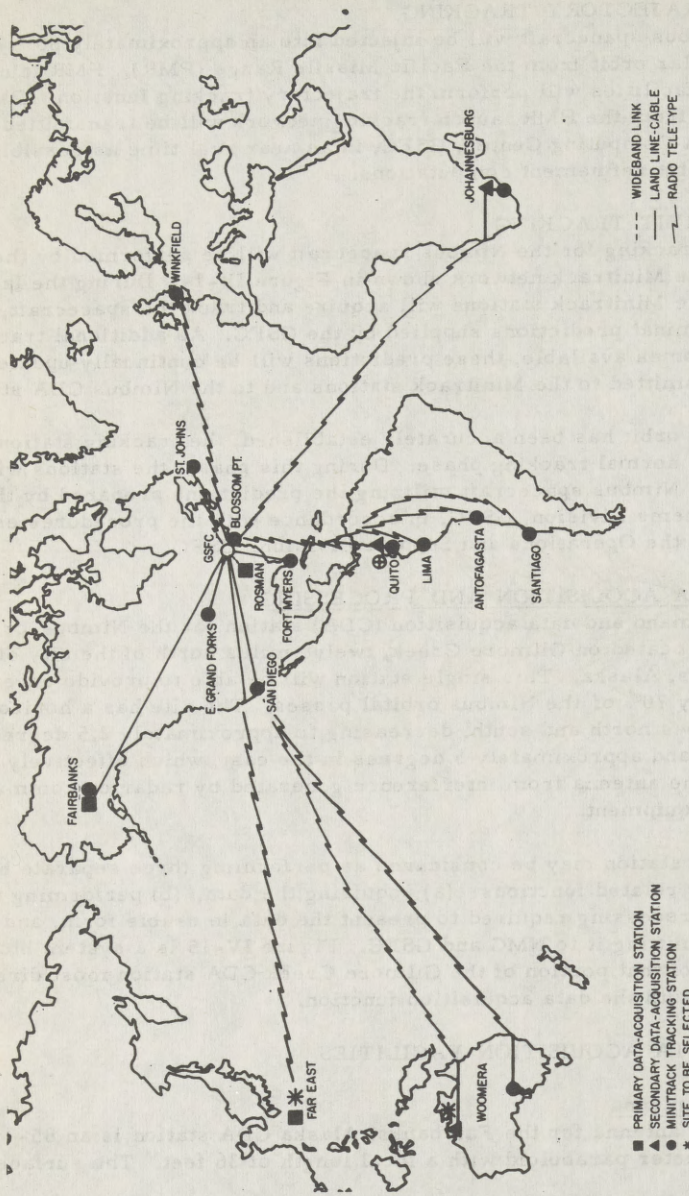


Figure IV-14 – Worldwide Tracking and Communications Network

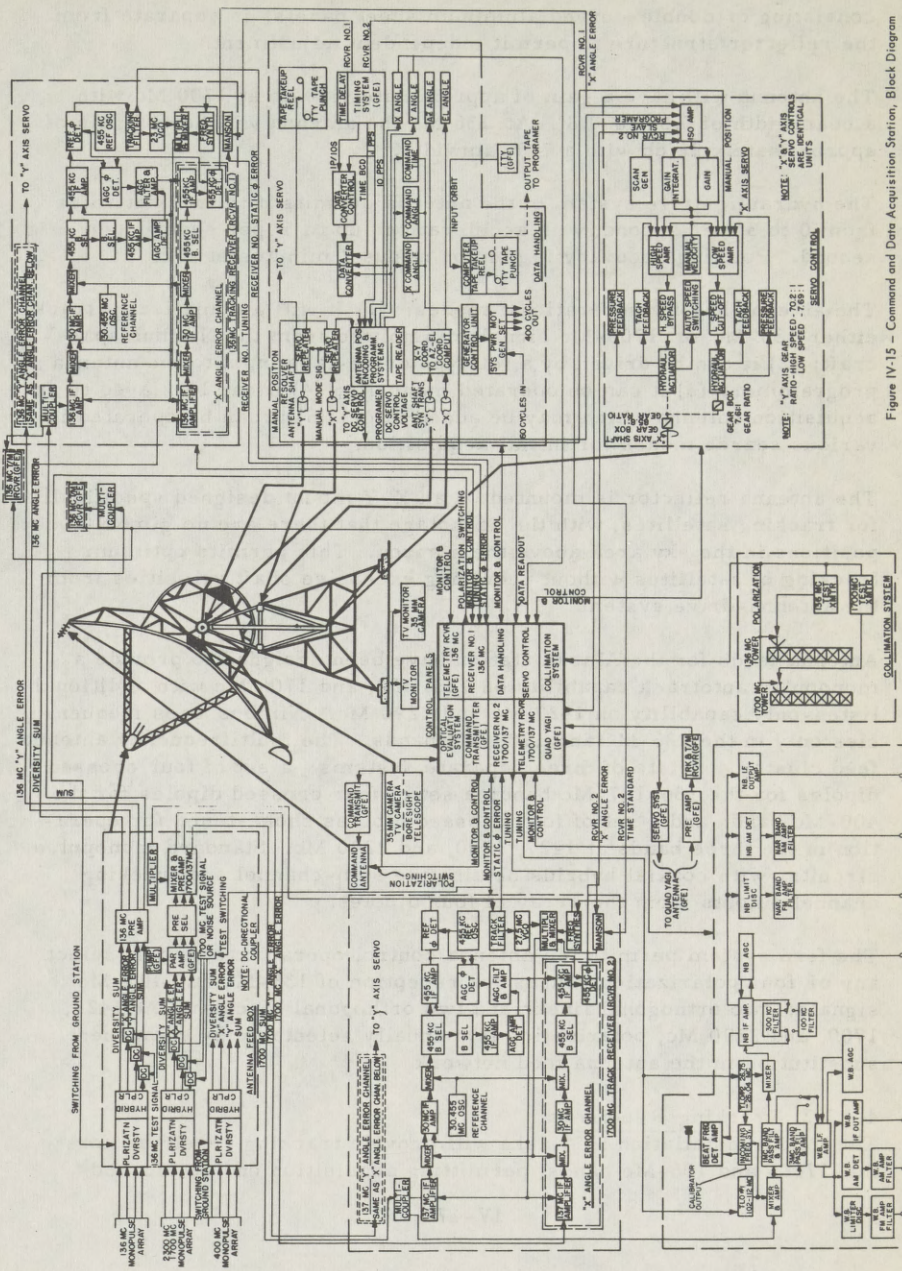


Figure IV-15 – Command and Data Acquisition Station, Block Diagram

consisting of double-curved aluminum sheet panels, is separate from the reflector structure to permit independent adjustment.

The antenna will have a gain of approximately 50 db at 1700 Mc with a beamwidth of 0.6° to 0.8°. At 136 Mc the antenna will have a gain of approximately 26 db with a 7° beamwidth.

The hydraulic drive system of the antenna permits it to track at rates from 0 to 3° per second, with accelerations up to 5° per second per second. Pointing accuracy is plus or minus 2 minutes of arc.

The antenna has five operational modes: (1) It will automatically track either 136-Mc or 1700-Mc signal transmitted from the Nimbus spacecraft; (2) it can be driven by a teletype drive-tape input to the antenna programmer; (3) it can be operated manually; (4) it can be slaved to an acquisition antenna which may be added later; (5) it can be operated in various search modes for initial acquisition.

The antenna reflector is mounted on an X-Y mount designed specifically for tracking satellites, with the advantage that there are no gimbal-lock positions in the sky area above the horizon. This permits optimum tracking of satellites without requiring excessive shaft velocities from the antenna-drive system.

Antenna feeds for the Alaska station have been designed to provide a monopulse autotrack capability on 136, 400, and 1700 Mc with additional listen-only capability on 1427 Mc and 2290 Mc. Nimbus uses frequencies only in the 136-Mc and 1700-Mc bands. The multifrequency antenna feed cluster consists of three separate systems: a set of four crossed dipoles for the 136-137-Mc band; a set of four crossed dipoles for the 400-Mc band; and a set of four crossed dipoles choke-tuned for operation in the three bands at 1427, 1700, and 2290 Mc. Standard monopulse circuitry with coaxial hybrids obtains the sum-channel and tracking channel outputs from the array of four dipoles.

The feed system permits the antenna control operator to switch-select any of four polarization senses for reception of 136-Mc and 400-Mc signals: two orthogonal linear and two orthogonal circular. At 1427, 1700, and 2290 Mc, polarization is manually selectable by component substitution in the antenna feed network.

4.2.1.2 Tracking Receivers

The initial installation in Alaska will provide tracking receivers for the 1700- and 136-Mc bands, permitting acquisition on 136 Mc and

more precise tracking when the 1700-Mc Nimbus transmitter is commanded on. The 1700-Mc receiver has two modes of operation: a narrowband phase-lock mode for high-sensitivity tracking, and an open-loop mode having a wide 100-kc bandwidth for tracking signals with an unstable carrier. The three RF preamplifiers (low-noise beam-type parametric amplifiers) are located on the antenna.

The tracking receiver actually consists of three sections: a reference-channel receiver, an X-axis error-signal receiver, and a Y-axis error-signal receiver. Local oscillators for the two error-signal receivers are derived from the reference-channel receiver's local oscillators. In the phase-lock mode, the IF bandwidth is 2 kc and the phase-lock loop bandwidth is 10, 30, 100, or 300 cps at the operator's selection. The frequency range of the received signal about the receiver-center frequency for which the receiver can maintain lock is at least ±55 kc. The receiver is capable of functioning properly with an input signal level between -50 dbm and threshold. The crystal-controlled tracking receiver is tunable over the 1700-1710-Mc band in tuning steps of 10 kc. A multicoupler for feeding three 1700-Mc receivers is located in the first IF of the reference channel of the tracking receiver.

The 136-Mc phase-lock tracking receiver is very similar to the 1700-Mc tracking receiver. The main difference is that the first mixer is located in the antenna control room rather than on the antenna. Low-noise RF amplifiers are located in the receiver box behind the feed on the antenna, and the amplified 136-Mc signals are brought down by means of coaxial cables into the control room. The receiver is tunable over the 136-137 Mc band in 1-kc steps. In the open-loop mode of operation, there are four selectable predetection bandwidths of 2, 10, and 100 kc; in the closed-loop mode of operation, the 136-Mc tracking receiver has a predetection bandwidth of 2 kc and selectable loop bandwidth of 10, 30, and 100 cps. The reference tracking receiver has a 136-Mc multicoupler, following the RF preamplifier, which provides four outputs feeding a set of 136-Mc Mod I telemetry receivers. Isolation between channels is greater than 30 db.

4.2.1.3 Telemetry Receivers

The 1700-Mc telemetry receivers use the reference-channel first mixer and parametric amplifier in common with the 1700-Mc tracking receiver. The 1700-1710-Mc signals are converted to 132-142-Mc signals by means of a fixed tuned oscillator. The bandwidth of the 137-Mc IF preamplifier and multicoupler is 13 Mc. The multicoupler drives three telemetry receivers, independently tuned over the frequency

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range of 132.0-142.0 Mc. Nimbus A will utilize only one 1700-Mc frequency, so that only one operational receiver will be required, the other two receivers acting as spares. Polarization diversity is not required.

Eight standard Minitrack Mod I receivers will acquire the data transmitted by Nimbus in the 136-137-Mc band. The eight receivers are represented in the block labeled "136-Mc T/M RCVR (GFE)" shown at the top of Figure IV-15. Reception is on two orthogonal polarizations. Consequently, there are four sets of receivers operating in polarization diversity: one set for receiving timing, PCM "A", and PCM "B"; one set for receiving MRIR; and two spare sets.

The RF preamplifier is common with the tracking receiver and the telemetry receiver. The multicoupler following the preamplifier supplies four channels to the Mod I telemetry receivers. The Mod I telemetry receivers are tunable in 1-kc steps, and have selectable predetection bandwidths of 10 kc, 30 kc, 100 kc, 300 kc, and 1 Mc. Each bandwidth has an FM discriminator output, an AM detected output, a translated IF output, and a straight IF output.

4.2.1.4 Data System

That portion of the system block diagram labeled "Data Handling" provides for the measurement, digital encoding, and readout of the antenna shaft angles for feeding into the servo system, visual readout, and teletype punch (Figure IV-15). These position-data and data-quality codes are punched on paper tape in five-level teletype code and can be transmitted to GSFC for orbital computation purposes. The data system includes a small computer with associated electronics which accepts the antenna drive tape one-minute-interval predictions received from GSFC via teletype, corrects the received data, and generates one-second-interval predictions by interpolation. The data system then compares the one-second predictions to the actual antenna positions and generates a velocity error signal for the servo system.

4.2.1.5 Auxiliary Systems

The Fairbanks data acquisition station has two collimation towers for calibration of the antenna tracking and for calibration of the telemetry receivers. One tower contains a 1700-Mc transmitter and antenna system; the second has the transmitter and the antenna system for 136 Mc. These towers are located at a sufficient range for proper evaluation of antenna performance, and at an elevation angle high enough so that the ground reflections do not appreciably deteriorate the calibration with the towers.

In connection with the calibration of the station with the boresight tower, the antenna is equipped with an optical evaluation system. This system presents a visual display by closed-circuit television to assist the antenna operator with electrical alignment on the collimation tower, and in tracking aircraft carrying test-transmitting equipment.

The command system at the data acquisition station consists of a 2.5-kw transmitter for the 122-Mc band and a 12-db gain antenna. The command antenna is a disk-on-rod type with selectable polarization. It is attached to the rim of the 85-foot antenna and collimated with the large antenna.

An antenna control room approximately 50 by 30 feet in size contains all the electronics described above for operating the antenna and receiving the telemetry signals. A second room of equal size contains the electronic equipment associated with the on-site processing of the Nimbus data.

4.2.2 ON-SITE PROCESSING

Figure IV-16 is a system block diagram showing the major equipments involved in the on-site processing of Nimbus data. A portion of the system shown in Figure IV-15 is duplicated to show the tie-in with the data acquisition system.

Equipment for on-site processing of the Nimbus data may be considered to fall into the following major subsystems:

1. Command
2. PCM telemetry
3. Television
4. IR

4.2.2.1 Command Subsystem

Commands can be sent by automatically transmitting the code previously punched on a paper tape, or the operator can assume manual control. An RF demodulator samples the command transmitter output, and a record is printed of the actual signal transmitted. Visual comparison is made to determine whether or not errors occurred. The command display system is also used to record the time difference between the spacecraft time clock and the station time clock which is synchronized with WWV absolute time.

4.2.2.2 PCM Telemetry

PCM "A" and "B" are commanded ON when the spacecraft is within range of the CDA station. The outputs of the Mod I receivers are

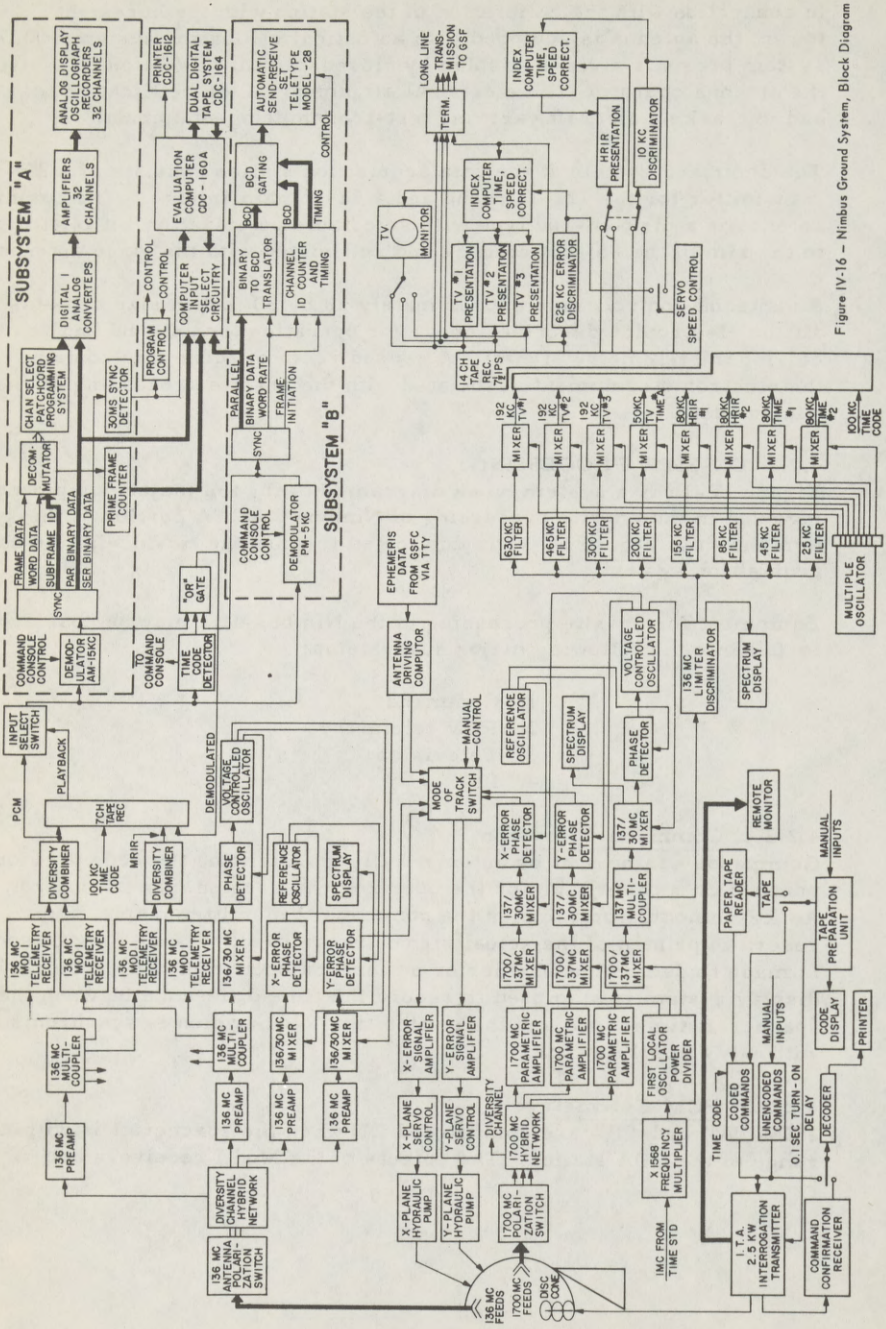

Figure IV-16 – Nimbus Ground System, Block Diagram

diversity-combined and the signals are recorded on a Mincom 7 channel tape recorder. During the time signals are being recorded on tape they can also be processed, and/or the tape can be played back after the spacecraft pass for processing and analysis.

The PCM "A" data is fed through a 15-kc demodulator and into a sync detector for frame and sync bit detection. The outputs of the sync detector feed a decommutator which decommutates all channels including subcommutation words. The serial pulse train is suppressed by a squelch until the first frame sync is acquired so that channel identification is positive. Each word is stored in a seven-bit shift register which is emptied in parallel into a CDC-160A computer. A magnetic-tape storage unit operating in conjunction with the CDC-160A computer stores each word in a standard digital tape format. The computer inserts frame number received and word number in each frame, thus serving a primary filing function. Analysis of individual channels over one orbit is achieved simply with calibration functions being stored as sub-routines.

There are 6420 frames of PCM "A" data per orbit with 60 words in each frame. These 385,200 words would require 200 feet of paper for printout on the computer-associated CDC-1612 high-speed printer, and it would take about 45 minutes to complete the operation at the print rate of 1000 lines per minute. It is evident that real-time printout of all channels is impossible, and that it would be impossible to inspect them in real time. Therefore, the CDC-160A will be programmed to print out only those words which are out of specified limits or tolerance as well as those words which are of significance from orbit to orbit.

In many instances, a selected printout of PCM "A" data will not be the optimum form of presentation: for example, the battery charge-discharge cycle for one whole orbit is best presented in analog form; also certain temperatures need only a gross analog presentation. The patchboard associated with the decommutator permits selection of up to 32 channels and connection to 32 D/A converters, the output of which is fed to a 32-channel galvanometer-type recorder. Since the entire orbit appears highly compressed (but less accurate), correlation of data can be established rapidly.

The PCM "B" telemetry is demodulated and fed to a sync detector. When sync is acquired, a decommutator is synchronized so that individual channel signals can be analyzed if so desired. For most cases the serial code will be converted by a code-converter and read out

into a tape punch for a permanent record. The relatively low data rate of the PCM "B" telemetry allows a tape punch to operate on a real-time basis. The tape can be fed into a conventional teleprinter to display channel number and measurement value.

4.2.2.3 Television Subsystem

The composite group of subcarriers received from the output of the 1700/137-Mc receiver-discriminator is fed to a set of filters for demultiplexing. The three separate FM subcarriers representing the output of the three spacecraft TV cameras are then converted to a nominal center frequency of 192 kc and recorded on three tracks of a Mincom 14-track tape recorder at 60 ips. The timing channel is converted to 50 kc and recorded on another track of the tape recorder.

During the time the TV signals are being recorded, a monitor can be connected to any one of the three channels. The kinescope technique is used for display and the CRT will be photographed by a camera. A control unit generates orbit number, date, time, camera designation, etc., so that this information is photographed simultaneously with the TV picture. The camera film is then rapidly processed for analysis shortly after exposure.

After recording the TV at 60 ips, the tape recorder is slowed to 1/8 speed (7.5 ips) for playback. Since 32 or 33 sets of pictures (representing one orbit of stored pictures) are recorded at the CDA station in about 3.8 minutes, it requires about 30 minutes for playback.

During playback, the signals on the three TV tracks are fed to three discriminators which in turn drive facsimile recorders. These recorders function like mirror-galvanometer recorders and produce a very stable scan pattern which requires much less frequent adjustment than electronic scanners. Pictures generated by these recorders will serve for quality control monitoring and for meteorological backup. The archival masters will be produced at MSA.

During tape-recorder playback, the three TV FM subcarriers and the timing channel also feed the data terminal equipment. Because of the tape-recorder slowdown for playback, the three TV FM subcarriers recorded at a nominal center frequency of 192 kc are accepted by the data terminal equipment at a 24-kc $\left(\frac{192}{8}\right)$ subcarrier center frequency and the timing channel is accepted at 6.25 kc. The data terminal equipment then converts the three TV subcarriers and the timing

subcarrier to appropriate locations within the 60- to 108-kc spectrum, which represents an unchannelized "L" carrier group. The data terminal equipment also includes the necessary filters for multiplexing the three TV subcarriers, and the timing channel for transmission by means of 48-kc bandwidth data circuit.

The TV subsystem includes equipment for accurately presenting the time that a particular picture was taken by the spacecraft, as well as means for correcting for ground and spacecraft tape-recorder speed variations.

4.2.2.4 IR Subsystem

The HRIR information is transmitted from the spacecraft on the same RF carrier as the TV and timing information. The HRIR is demultiplexed and recorded on separate tracks of the 14-channel Mincom recorder in a manner similar to that previously described. During tape-recorder playback, the HRIR information will be recorded on a facsimile recorder which will provide for real-time readout of nighttime cloud-cover pictures. It will also be fed to wideband terminal equipment.

The MRIR information is transmitted on a separate spacecraft transmitter operating in the 136-137-Mc band. Output signals from the diversity combiner associated with the Mod I receivers are recorded on one channel of the Mincom tape recorder, which is also used for the PCM telemetry. The CDA station will mail the tapes to the Aeronomy and Meteorology Division, GSFC, for further processing. Channel 2 will be transmitted over wideband link.

4.2.3 COMMUNICATIONS SYSTEM

A 48-kc bandwidth data circuit will be provided between the Gilmore Creek site and the AT&T Toll Center in Washington, D.C., where the circuit will be split to feed the National Meteorological Center at Suitland, Maryland, and the Nimbus Technical Control Center at GSFC simultaneously. Galvanometer recorders similar to those used at the CDA station will be provided at the Meteorological Satellite Activity and at GSFC for quality reproduction of the TV pictures.

A 4-kc bandwidth facsimile circuit will be provided between the Gilmore Creek station and Washington, D.C., for transmission of HRIR pictures. The circuit will be equipped for non-simultaneous voice operation.

One teletype circuit will be provided between the Gilmore Creek site, the Geophysical Institute at the University of Alaska, the Minitrack station at College, Alaska, and the Communications Center at GSFC. This circuit will be used primarily for administrative purposes. A second circuit will be established between the Gilmore Creek site and the Communications Center at GSFC, with MSA as a drop, for operational traffic use.

4.2.4 NIMBUS TECHNICAL CONTROL CENTER (NTC)

A Nimbus Technical Control Center will be established in 800 square feet of floor space reserved in Building 3 of GSFC. The functions of NTC will include:

- Determining what passes will be visible from the Gilmore Creek CDA site and preparing the general command program to be used during the pass.
- In the event of subsystem malfunctions within the spacecraft, instructing the CDA station on what corrective actions are to be taken.
- Plotting and analyzing key items contained in PCM A and B telemetry that will be transmitted via teletype from the CDA station to NTC.
- Evaluating CDA station performance by noting quality of TV pictures, HRIR data, PCM telemetry data, etc.
- Functioning as the contact point with MSA to determine which areas in the world have particular meteorological significance when there is a choice as to where TV pictures will be taken.

5. DATA UTILIZATION

5.1 GENERAL

The Nimbus satellite represents a major advance in the meteorological satellite program, by virtue of its capability to provide certain observational data on a global basis. This capability alone increases the potential value of the data to both operations and research. In particular, studies of the earth's heat budget and general circulation will benefit from this capability.

The information acquired from the satellite will be utilized in real time as well as in research and archival activities. Primarily, the TV pictures of daytime cloud cover will be displayed for pictorial study in real time, so that meteorologists and scientists may view the pictures of cloud cover, study them, and make determinations as to their relative meteorological significance. Included will be pictures taken in the "direct" mode, i.e., the TV cameras feeding the transmitter directly, and pictures taken earlier in each orbit and stored on a tape recorder.

The nighttime cloud cover provided by the HRIR will be utilized in real time in a manner similar to that for the TV pictures. Initially, only a portion of the data provided by the 5-channel MRIR will be utilized in real time. The Channel 2 data in the atmospheric window of 10.0 to 10.7 microns will provide both daytime and nighttime cloud-cover patterns as well as data which can be related to cloud-top temperatures. The other channels of the MRIR will provide data for use in research and development programs.

In addition to the immediate operational use of the Nimbus data, a sample of the data will be utilized in real time at the command and data acquisition (CDA) station by the meteorological team to (a) exercise quality control and (b) provide analysis backup in the event that the data cannot be received in a normal manner at MSA.

5.1.1 UTILIZATION OF AVCS DATA

The meteorological team at the CDA will use the pictures from the AVCS produced by the "quick-look" kinescope monitor for quality control evaluation. They will utilize the pictures produced by the high-quality light beam galvanometer facsimile recorder to produce a TIROS-type manual rectification for backup analysis. Each picture will be projected on the proper member of a library of generalized latitude-longitude grids prepared in advance. These grids will be properly positioned with respect to the image, using the latitude-longitude data computed by the CDC-160A ground-station computer. The resulting nephanalyses will be transmitted by documentary facsimile over the 3-kc communications link to the NMC.

In addition to the above, the meteorological team will also monitor the extraction of the attitude error data from the PCM "A" by the CDC-160A computer and the transmission of this data together with the picture times to the MSA and to Nimbus Technical Control. They will also monitor the transmission of the AVCS video data over the 48-kc communications link to the MSA.

The AVCS video data will be transmitted from the CDA to the MSA and will be recorded on 70-mm film by a galvanometer facsimile. Prior to the transmission of the video data, the attitude error data and the picture times which have been extracted at the CDA will have been transmitted to the MSA. The MSA 7090 computer will then compute the geographical grids for each picture, utilizing the above data together with the orbital ephemeris provided by the computer facility at GSFC. Then, as the video data is recorded on the galvanometer facsimile, the geographical grid data will also be recorded in its proper relationship to the picture. These gridded 70-mm pictures will be used by professional meteorologists to examine details of the flow pattern as evidenced by cloud structure. The pictures will be examined to determine the mesoscale structure in specific geographical areas of continuing interest. This data will be of great value, for example, in short-range forecasting for air routes and terminals, in military applications for refueling and target areas, and in severe-weather warning services. It is likely that ice reconnaissance for shipping-route safety will be greatly aided through the use of the AVCS picture data. When, for any reason, video signals cannot be transmitted from the CDA to the MSA, the TIROS-type nephanalyses prepared by the CDA station meteorological teams will be used by the MSA meteorologists to provide data for incorporation into the standard analyses, prognoses and forecasts. The addition of the Nimbus data is expected to improve significantly the reliability of this material.

MSA is acquiring a second IBM 7094 computer intended primarily for satellite data usage. This computer, with large disk files and direct data-channel communication, make feasible the rectification and digestion of vast amounts of digitized scan-spot data. Such procedures offer the ultimate possibility of complete automation of the data-processing system. The computer will be utilized to produce a rectified mosaic of several orbits of picture data. These data would then be in a form which could be utilized to a much fuller extent by the meteorologist, and would also be in a form which could be further processed by the computer for direct input to the NMC computer program for analyses and prognoses on a hemispheric or global basis.

5.1.2 UTILIZATION OF HRIR DATA

The nighttime cloud cover as observed by the HRIR system and recorded as a picture will be utilized in real time by meteorologists in much the same manner as the AVCS pictures. These data will supplement the coverage obtained during the daytime by the AVCS pictures.

The meteorologists at the CDA will monitor the HRIR data for quality control and, when the MSA cannot receive the data, will produce a TIROS-type nephanalysis for transmission to the MSA by the documentary facsimile equipment over the 3-kc communications link.

The HRIR data will be utilized by the professional meteorologists to supplement the data normally used in preparation of analyses, prognoses and forecasts. The CDA-produced nephanalyses will be used in like manner during emergencies. In addition, the data will be digitalized and incorporated into the MSA computer program. For example, cloud-top temperatures derived from the HRIR data and the vertical motions derived from the cloud-cover patterns could be incorporated directly into the NMC computer analysis and prognosis programs.

5.1.3 UTILIZATION OF MRIR DATA

Channel 2 of the MRIR, the atmospheric window at 10.0 to 10.7 microns, will provide data on cloud cover, both day and night, as well as cloud-top temperatures. The other channels will provide data for use in studies of the atmospheric heat balance and of the general circulation of the atmosphere. These data will be used in further development of computer programs for hemispheric or global weather analysis and prognosis.

The Channel 2 data will be transmitted via the communications link for processing by the MSA 7090 computer for operational use in analysis and prognosis programs. The data from the remaining channels, on magnetic tape, will be shipped for later computer processing by GSFC and MSA for use in conducting research, both basic and applied, to probe basic mechanisms of the atmosphere and to develop further techniques for operational use.

Under consideration is a system whereby the Channel 2 MRIR data would be displayed on a cathode-ray tube at the CDA station for use by the meteorological team for quality control. A 70-mm camera would photograph this display to produce a film for use by the meteorological team in preparing nephanalyses.

5.2 DATA ARCHIVING

The Weather Bureau will maintain two permanent stores of Nimbus cloud pictures; a file at the MSA primarily for in-house research, and the true archives in the National Weather Records Center at Asheville, North Carolina, constituting a data source for outside users. A proposed program, picture format, and other details of the archives are discussed in MSL Report #6.

Pictures for the archives will be produced at the MSA. The magnetic tapes containing picture data and the tapes containing complete attitude-error information for each pass will be sent promptly from the CDA station to MSA. The attitude-error tape, and the orbital ephemeris tape provided by GSFC, will be fed through tape recorders into the MSA computer. The computer will identify picture times, extract error signals appropriate for particular pictures, and compute geographical grids. When the grids have been computed, the video tape will be played into the archival galvanometer facsimile system along with the output of the computer, as in the real-time gridding process. Since time scheduling is not critical in archive production, slight modification in the real-time procedure may be made to achieve greater gridding accuracy.

The three 70-mm films from the galvanometer facsimile will be processed and then passed through a merger-printer which converts the pictures to the archival format. In this format, as presently planned, the three simultaneous pictures from the three cameras will be placed side by side along a single 35-mm film strip. Consecutive sets of three pictures will be arranged chronologically along the strip.

The archival master produced by the merger-printer must be of sufficient quality to preserve the maximum possible resolution and tonal quality in later-generation products available to users.

On the 70-mm film, a human-readable legend will appear beneath all frames. A machine-readable identification number will also be inserted beneath each frame of one of the oblique cameras, perhaps replacing part of the legend repeated on other frames of the set. The number will include time and location information, and will permit automatic search by viewing and reproducing equipment where this capability is desired. The search and retrieval system requires equipment to place the number on the film, as well as 35-mm viewers and reproducers with proper search capability.

In addition to equipment specifically mentioned, the archive production system will require high-quality rapid processors for 70-mm and 35-mm film, and a high-quality automatic printer for making contact copies of 35-mm film. A capability for contact-printing 70-mm film would be highly desirable.

A punchcard file containing full documentation information will be used for catalog listings, for sorting, and for retrieving pictures on the basis of meteorological content or other criteria. Standard punchcard-handling equipment is required.

In addition to the AVCS pictures, the digitalized picture data will also be archived. The exact format for these data has not yet been determined. The HRIR and the MRIR data will be archived in a manner similar to that previously described for the AVCS picture digitalized data.

6. LAUNCH VEHICLE

6.1 BOOSTERS

It was originally planned that the Thor-Agena B would be the basic launch vehicle for the Nimbus series of spacecraft. Recent events have resulted in an incompatibility between the performance capability of the Thor-Agena B and the Nimbus spacecraft, because of weight increases in the launch vehicle, orbit changes, and weight increases in the spacecraft.

Current plans are to fly a spacecraft with reduced instrumentation or fewer experiments for the Nimbus A-4 and probably A-5 launch using the present Thor-Agena B. Proposals are being considered for modifying the Thor-Agena B system to produce boosters with substantially greater capability.

6.1.1 THOR

Thor boosters, Douglas Models DM21, Mod. II will be used in modified form for the Nimbus flight. The Thor booster is powered by a Rocketdyne engine. The propellants are liquid oxygen and RP-1. For final adjustment and roll control, two smaller Rocketdyne vernier engines are used.

Guidance will be by means of BTL guidance systems, series 400. Booster requirements are further described in Douglas Specification DS-2110, "Performance Specification for Space Research First Stage Vehicle, Douglas Model DM-21," dated July 28, 1960.

6.1.2 AGENA B

6.1.2.1 General

The Agena B, a second-stage vehicle designed for use with a Thor or an Atlas booster, was originally developed by and is presently being produced by the Lockheed Missiles and Space Company, Sunnyvale, California. It will be used by NASA for a variety of orbital and space missions. The Agena B is approximately 23 feet long by 5 feet in diameter without payload and booster. The forward section, called the forward equipment rack, contains the electronic and guidance equipment, including the battery, horizon sensor, velocity meter, inertial reference package, etc. The center section of the vehicle contains the fuel and

oxidizer tanks, while the aft section contains the rocket engine, vehicle control equipment, and interface attachments for the booster.

The Agena is attached to the booster by an adapter which encloses the aft section of the Agena vehicle. The adapter stays with the booster upon separation and contains the booster retro rockets and the Agena destruct system. Adapter detachment is accomplished by explosive bolts blown by a discrete signal from the booster.

6.1.2.2 Propulsion

The liquid propulsion engine uses UDMH (unsymmetrical dimethyl-hydrazine) as fuel and IRFNA (inhibited red fuming nitric acid) as the oxidizer. The engine, a Bell type 8096 with a hydraulically controlled swiveling arrangement, generates a thrust of 16,000 pounds with a burning time of 240 seconds in one continuous firing or two separate firings. The fuel system is pressurized from a 3000-psi helium source tank through a pressure-regulating system. Two pairs of ullage rockets give the vehicle the necessary acceleration to collect fuel and oxidizer at the pump inlets during zero-g conditions. Figure IV-17 illustrates the Agena B propulsion system.

6.1.2.3 Guidance and Control

The vehicle guidance system consists of four basic components: inertial reference package, velocity meter, horizon sensor, and sequence timer. A diagram of the guidance and control system is shown in Figure IV-18.

The inertial reference package consists of three body-mounted gyros which sense motion in the pitch, roll, and yaw axes of the Agena B. Preamplifiers, power amplifiers, and associated circuitry complete the package which furnishes displacement signals to the flight control system.

The velocity meter consists of an accelerometer which produces pulses proportional to the acceleration, and a digital counter which integrates these pulses and initiates engine cutoff when the vehicle has attained the programmed velocity.

The horizon sensor detects the horizon of the earth by the difference in heat signal between the earth and surrounding space. An error signal is then generated, fed into a mixer box, and converted to torque signals to the gyros furnishing pitch and roll correction to the guidance system.

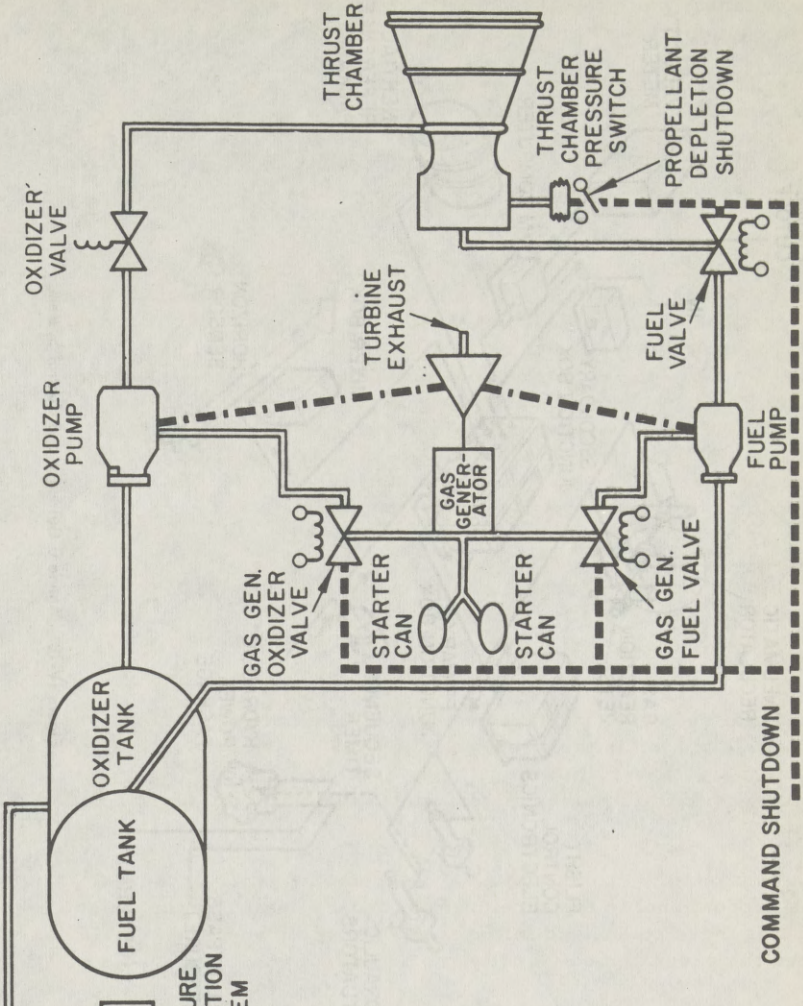

Figure IV-17 – Agena B Propulsion System, Flow Diagram

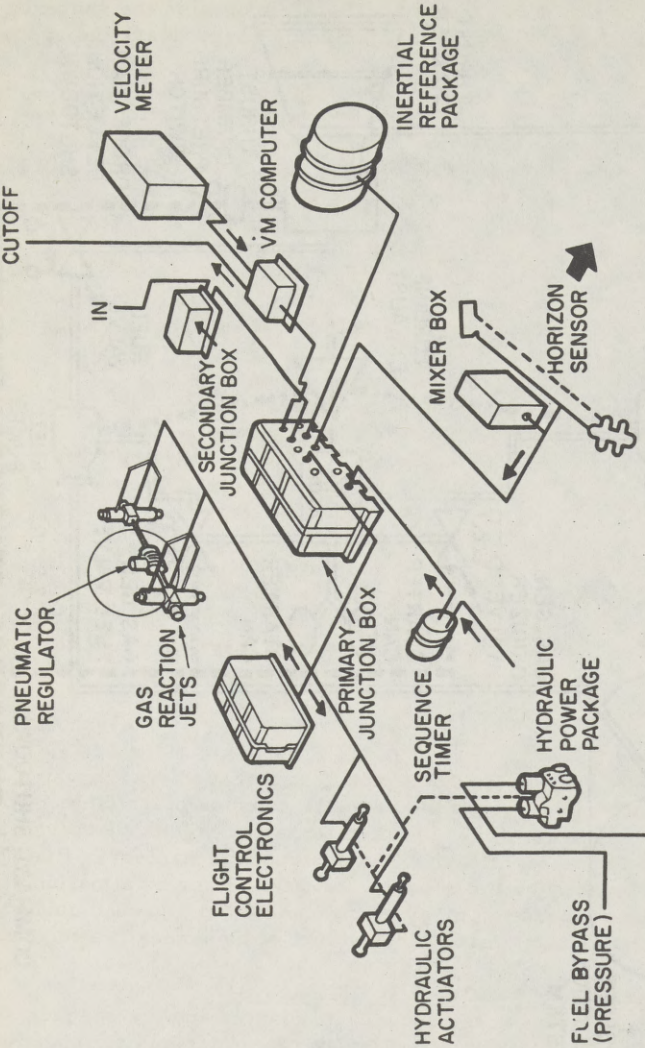

Figure IV-18 – Agena B Guidance and Control System

The sequence timer is started at lift-off, programs the sequence of events of the Agena flight phase, including engine start and spacecraft separation.

During powered flight, the vehicle is controlled in pitch and yaw by a hydraulic servo system which gimbals the main engine. Roll attitude is controlled by gas jets. In the coast phase, yaw, pitch, and roll are controlled by the gas jets.

6.1.2.4 Auxiliary Power System

The basic source of electrical energy for the Agena vehicle is a 70-ampere-hour silver peroxide/zinc battery with an output of 28vdc. This power is regulated, converted, and inverted into the following forms:

28 vdc, unregulated
28 vdc, regulated
Minus 28 vdc, regulated
400-cycle, 115v, three-phase ac
200-cycle, 115v, single-phase ac

6.1.2.5 Communications and Tracking

The communication subsystem monitors functional and environmental conditions in the Agena B and the payload section, and telemeters this data to the ground monitoring station through the UHF FM/FM unitized telemetry equipment. A C-band beacon transponder which transmits a radar beacon in response to radar interrogation is used for tracking purposes.

6.1.2.6 Destruct System

The destruct system for the Agena B is a shaped charge which fires directly into and ruptures the propellant and oxidizer tanks. The actual destruct mechanism, mounted on the booster-Agena adapter, stays with the booster upon separation. The destruct mechanism is fired by a discrete signal from the booster, initiated either by a malfunction such as improper separation or by a command from a ground-initiated signal. No provision is made for destruct of the Agena B after separation.

6.2 SPACECRAFT -- AGENA B INTERFACE

The interface between the spacecraft adapter and the spacecraft will consist of an explosive bolt-cutter actuated Marman clamp. Since a transition is required from the spacecraft to the 60-inch diameter Agena forward midbody, consideration has been given to a circular Marman clamp design. Figure IV-19 shows the shroud and Agena B Nimbus interface and the location of the separation indication switches.

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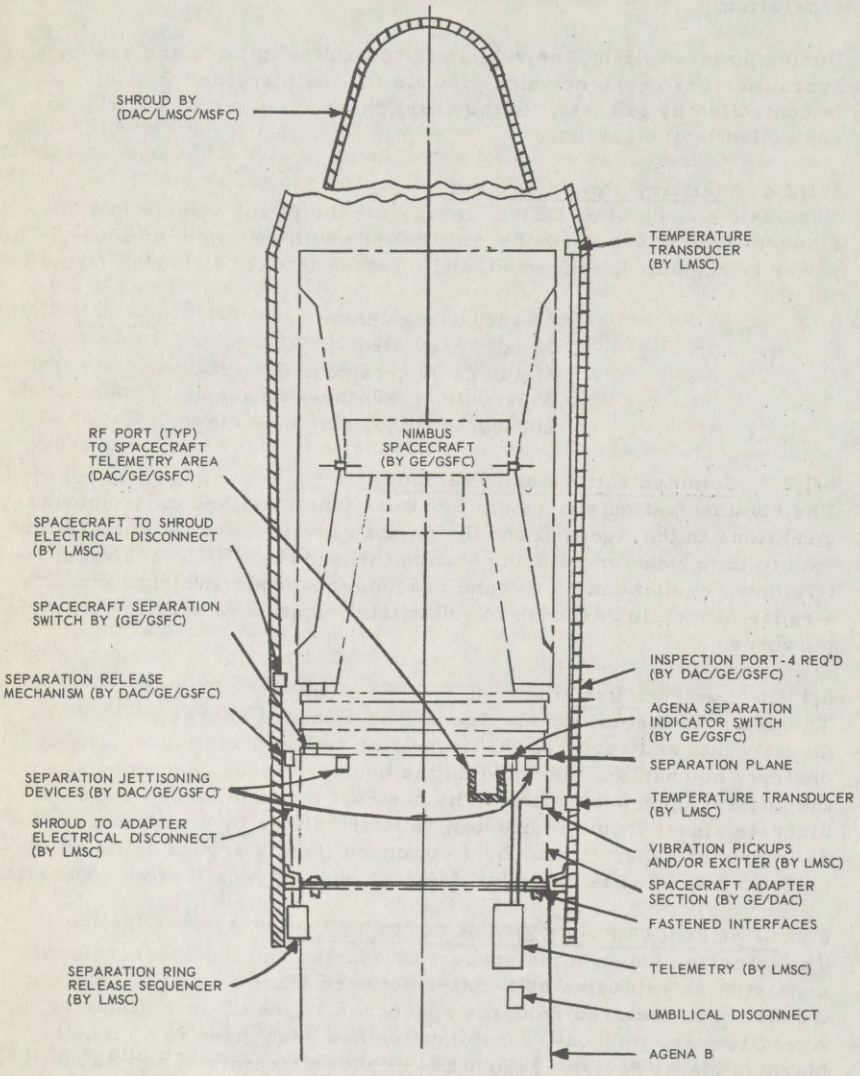

Figure IV-19 – Spacecraft to Agena B Interface Equipment Requirements

Upon actuation of the separation-system Marman clamp, a separation velocity of approximately five feet per second will be imparted to the spacecraft by compression springs.

6.3 LAUNCH SEQUENCE

6.3.1 THOR FLIGHT PHASE

Upon launch, the vehicle rises vertically for the first 10 seconds during which time the vehicle is rolled as required to give it the proper azimuth. For about the first 100 seconds of flight, the vehicle is maintained on the programmed trajectory by autopilot. At the end of this period, the BTL guidance system takes control of the vehicle. Thor shutdown will be initiated by the propellant utilization system upon indication of depletion of one of the propellants. The BTL ground RF link will then set the timer in the second stage (Agena B) to assure that the required velocity gain will be provided by the Agena B for achieving the desired orbit. The powered phase of the flight lasts approximately 156 seconds from launch. From this point, the vehicle continues on its flight under control of the vernier engines which position the vehicle according to continued signals received from the guidance system. When the correct attitude is achieved, the guidance system generates a signal to cut off the vernier engines.

6.3.2 BOOSTER SEPARATION

The separation of the Agena B from the first-stage Thor begins with the actuation of the separation-pin pullers and booster retrorocket firing. Separation is accomplished when the Agena B is in free and independent flight. The separation sequence is controlled by a programmer in the Agena B. Operation of the programmer is initiated by command signal from the booster guidance. The separation program is as follows:

- Disarm the destruct system
- Cut off the vernier engines on booster
- Uncage the gyros in Agena B
- Pin-pullers and retrorockets in the booster adapter ignited
- Agena B draws free of retarded booster

6.3.3 AGENA FIRST BURN AND TRANSFER ELLIPSE

At the conclusion of the post-separation coast phase, two ullage rockets on the Agena B will be ignited to provide an impulse sufficient to place

the propellants at the propellant pump inlets. Simultaneously, the velocity meter is armed for integrating the velocity gained by the Agena B during the first-burn period, to determine the engine cutoff point. The hydraulic pitch and yaw attitude are activated to position the thrust angle of the engine during operation. The engine is ignited to provide the impulse needed to place the Agena B/spacecraft combination in a transfer ellipse. The velocity meter causes engine cutoff when the required velocity is reached; the Agena B/spacecraft combination then coasts to apogee of the transfer ellipse.

6.3.4 AGENA SECOND BURN

In preparation for the Agena B second-burn operation, the remaining two ullage rockets are fired to place the propellants properly for engine ignition; the velocity meter is armed for integration, and the engine ignites. When the required orbital velocity is gained, the engine thrust is terminated.

6.3.5 SPACECRAFT SEPARATION

The explosive bolts on the Marman clamp securing the spacecraft to the payload adapter are ignited 90 seconds after the second burn, and the spacecraft is separated from the Agena B. A delay in separation is provided to eliminate possible thrust impulse due to boil-off of residual propellants in the Agena B propulsion system. Figure IV-20 illustrates the Nimbus launch sequence.

6.3.6 POST-SEPARATION AGENA B MANEUVER

After the spacecraft has been separated, the Agena B is programmed through a yaw maneuver at about 3 degrees per second. The yaw maneuver, 90-second separation delay, and a 5-feet-per-second separation velocity will preclude an Agena B-spacecraft collision.

6.4 LAUNCH-TO-INJECTION TRACKING AND COMMUNICATION

A ground instrumentation plan has not been developed at this time. In general, however, full launch vehicle telemetry and tracking coverage will be required from lift-off through Agena B first burn, and from 10 seconds prior to Agena B second burn through spacecraft injection and separation. No tracking or telemetry is planned during the Agena B coast phase; however, the coverage outlined above will furnish spacecraft acquisition data to the tracking net and, in addition, will permit post-flight determination of launch vehicle system performance.

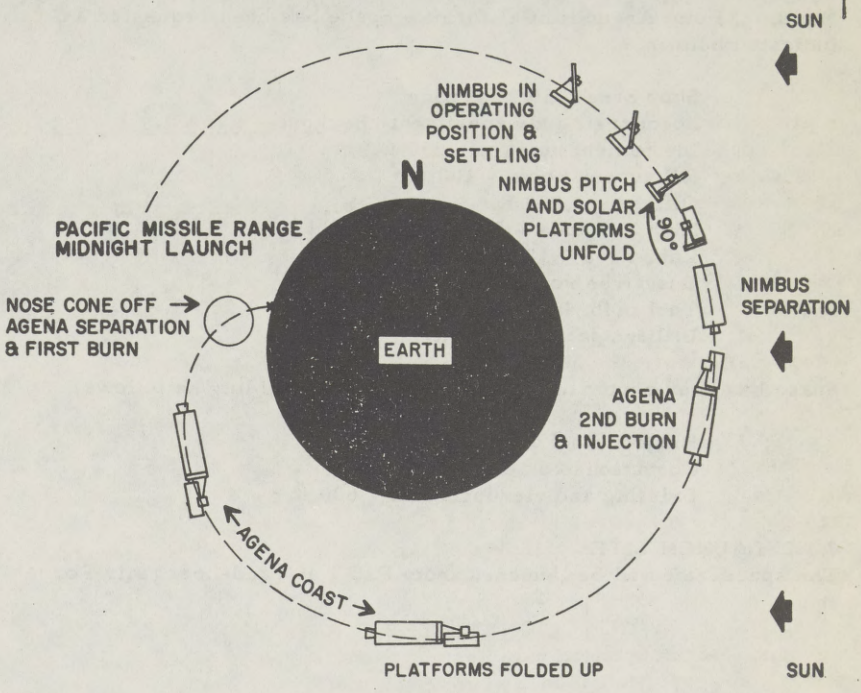

Figure IV-20 – Nimbus Launch Sequence

7. LAUNCH FACILITIES

7.1 PACIFIC MISSILE RANGE

7.1.1 SPACECRAFT CHECKOUT

The Nimbus spacecraft will be checked out in the Missile Assembly Building, Point Arguello, California. Space has been requested as indicated below.

Shop area - 20 ft. ceiling
Spacecraft and experiment checkout - 4,750 ft.^{2}
Instrument storage - 350 ft.^{2}
RF screen room - 100 ft.^{2}
Offices - 1,000 ft.^{2}
High bay area - 30 ft. hook height
Lab. area - 18 ft. hook height
Dust-free room - 480 ft.^{2}
Tool crib, jigs, and fixture storage - 1,250 ft.^{2}
Utility space - 3,000 ft.^{2}

Space has been requested in the range users' building as follows:

Project staff offices - 1,600 ft.^{2}
Operations center - 450 ft.^{2}
Briefing and viewing room - 600 ft.^{2}

7.1.2 LAUNCH SITE

The spacecraft will be launched from Pad 1 at Vandenberg Air Force Base.

PART V

MANAGEMENT PLAN

PART V

MANAGEMENT PLAN

1. APPROACH

1.1 ASSIGNMENT OF MANAGEMENT RESPONSIBILITY

Goddard Space Flight Center has been assigned project management responsibility for the Nimbus meteorological satellite project. In addition to project management responsibility, GSFC has been assigned systems management responsibility for the Nimbus spacecraft, tracking and data acquisition system, and data utilization system.

Marshall Space Flight Center has been assigned system management responsibility for the Nimbus launch vehicle system.

Specific responsibilities, authorities, and functions for the management of the Nimbus project are set forth in the attachments and this part of the Project Development Plan.

1.2 MANAGEMENT ORGANIZATION

Mr. Harry Press is project manager for the Nimbus project. In this capacity, Mr. Press represents the Director, GSFC, in all matters pertaining to the project. He is responsible for assuring the performance of all functions necessary for management of the Nimbus project. In particular, he is responsible for project-wide planning and evaluation, systems integration, systems engineering, scheduling, budgetary and financial planning and management, technical monitoring of contracts, and project reporting as set forth in Attachment 2.

The project manager has full authority to carry out these functions subject to limitations established by the Director, GSFC, in the interest of coordinating Nimbus requirements with other activities of the center.

The Nimbus project management organization is shown in Figure V-1. This chart indicates the project is being carried out through a special project-oriented organization which is integrated with the formal, functional GSFC organization (Figure V-2).

The Nimbus project management organization is composed of personnel of the Aeronomy and Meteorology Division, other GSFC divisions, Marshall Space Flight Center, other government agencies, and contractors. In addition to the project manager, the project coordinator

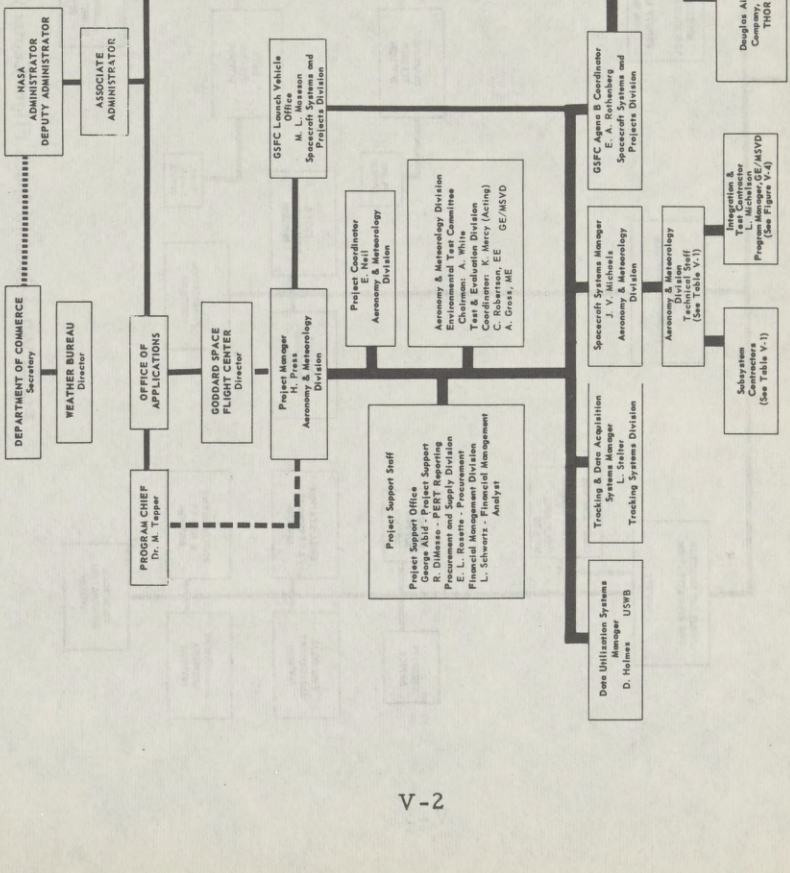

Figure V-1– Nimbus Project Management Organization Chart

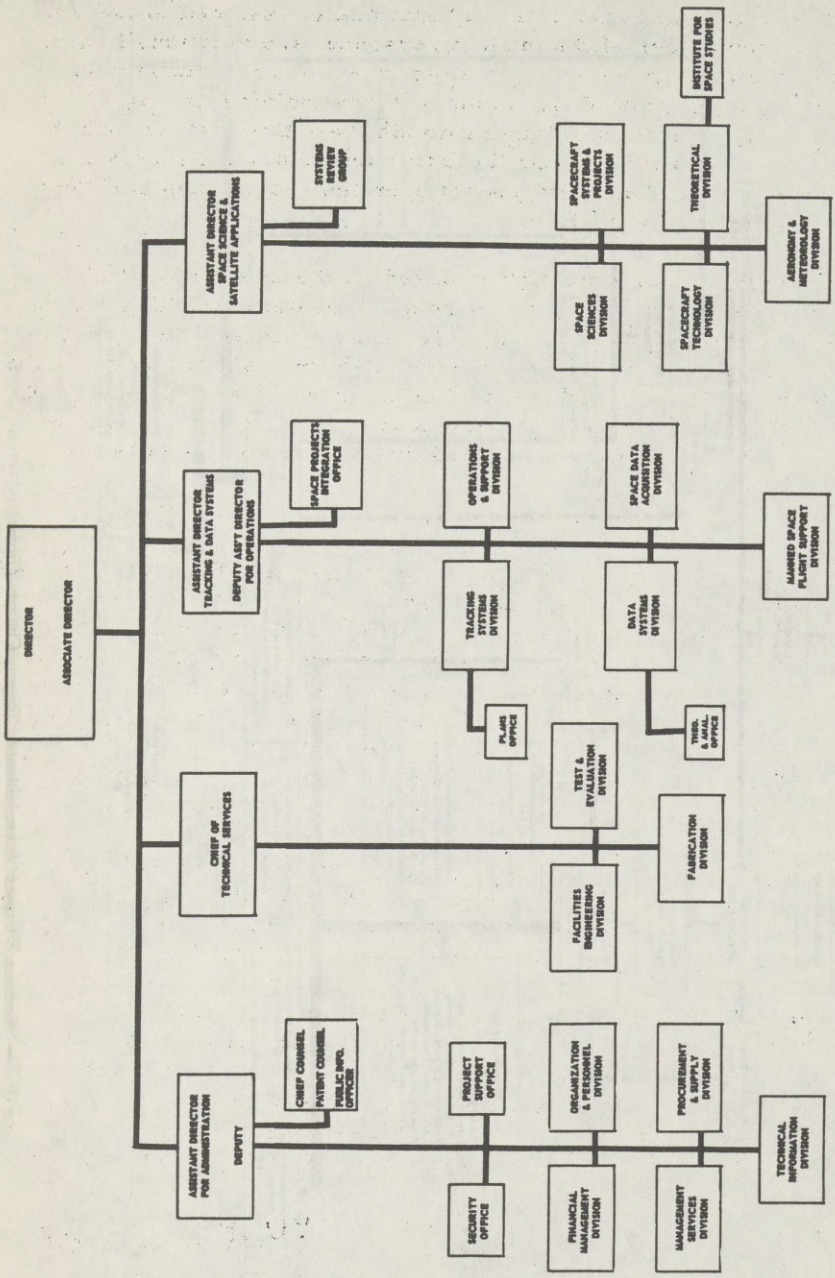

Figure V-2 – Goddard Space Flight Center Organization Chart

and several technical assistants are functionally assigned to the project office. The remainder of the project personnel are functionally assigned to other organizations, including the branches of the Aeronomy and Meteorology Division (Figure V-3). Some of these individuals work full time on the Nimbus project, while others divide their time between Nimbus and other responsibilities. For the latter individuals, the amount of effort expended on Nimbus is dependent upon the requirements of the project during any particular phase.

The Nimbus project organization is based on the four major systems which compose the total project: spacecraft system; tracking and data acquisition system; data utilization system; and launch vehicle system. The management organizations for each of these systems are described in subsequent pages. In addition to support from these elements of the Nimbus project organization, the project manager is assisted in his overall project management responsibilities by his immediate project management staff.

1.2.1 PROJECT MANAGEMENT STAFF

Mr. E. Neil is the project coordinator with responsibility for coordinating the activities of all organizations associated with the project. He acts as a point of contact between the project manager, contractors, and other government agencies. He assists the project manager in establishing schedules, implements required actions, monitors progress in meeting schedules, and initiates schedule modifications. Mr. Neil is responsible for keeping the project manager informed at all times of the progress of the overall project. He directs the activities of the Nimbus technical control group.

Within GSFC, certain individuals in the Office of Administration have been designated to provide business management support for the Nimbus project. Mr. E. Rosette, assistant chief of Negotiation Section D, Procurement and Supply Division, has been designated project support staff procurement officer for the project. He is responsible to the project manager for assuring timely accomplishment of procurement actions. His specific responsibilities include: advising the project manager in the planning of future and the status of present procurement actions relating to the project; advising the project manager in planning procurement actions involving other NASA activities; and coordinating project procurement actions between the GSFC and the Department of Defense.

Mr. Leon Schwartz of the Financial Management Division is the financial management analyst for the project. He is responsible for assuring adequate financial support and for keeping the project manager informed on financial matters.

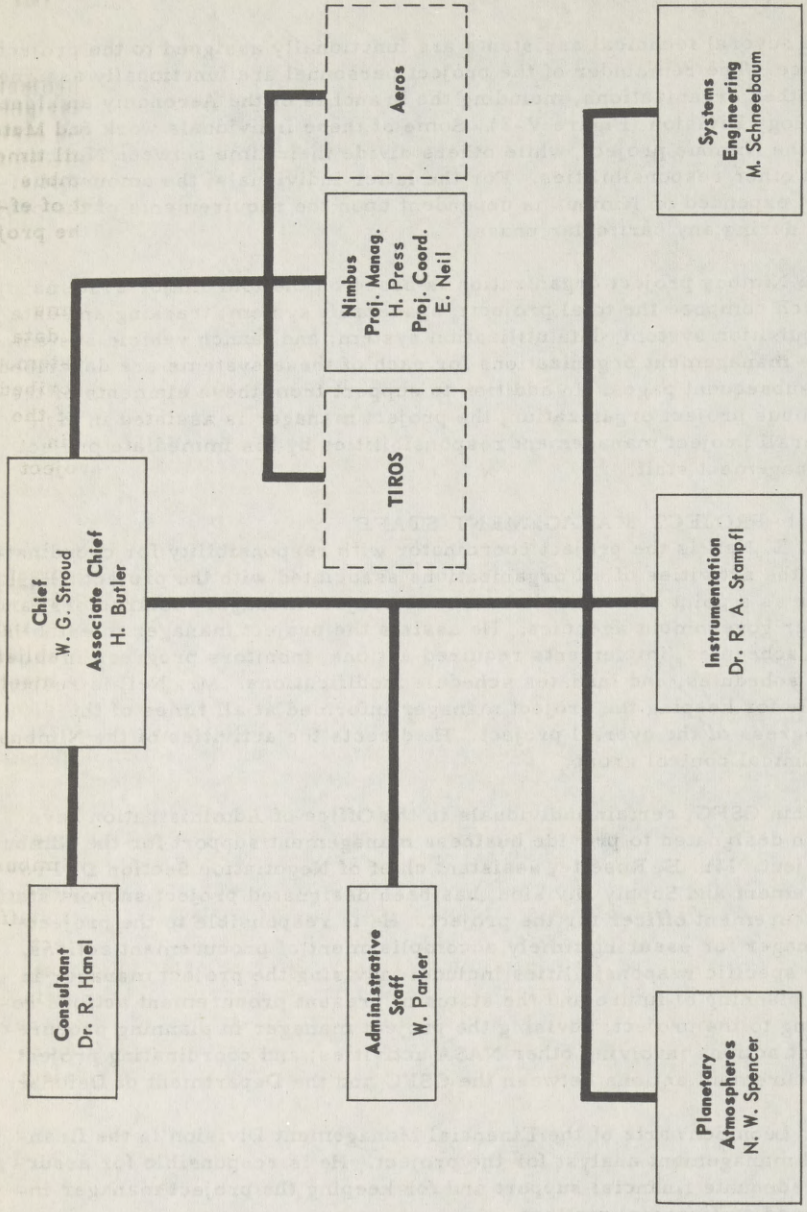

Figure V-3 – Aeronomy and Meteorology Division Organization Chart

Mr. George Abid of the Project Support Office serves as a focal point to the Project Manager for coordinating overall support for the Office of Administration.

Mr. Rino DiMasso of the Project Support Office assists the project manager in project monitoring and evaluation by means of the NASA PERT system. Information generated by the NASA PERT system is disseminated to cognizant technical officers and NASA Headquarters in accordance with Management Instruction 4-1-5.

1.2.2 GSFC SYSTEMS MANAGEMENT

1.2.2.1 Spacecraft System

Mr. J. V. Michaels is the system manager for the Nimbus spacecraft. In this capacity he is responsible for ensuring timely accomplishment of such technical, procurement, budgetary, planning and other actions as are necessary to design, develop, fabricate, integrate, test and deliver the spacecraft in accordance with the approved Nimbus schedule.

The spacecraft system manager carries out his responsibilities through a technical staff composed of engineers and physicists in the branches of the Aeronomy and Meteorology Division, a number of subsystem and equipment contractors, and a test and integration contractor (Figure V-1 and Table V-1).

Each technical officer develops specifications covering his area of responsibility for purposes of soliciting contractor proposals. He assists in evaluation of proposals which are submitted and in selection of the contractor best qualified to assure achievement of project objectives. After contracts are awarded, the technical officer directs the progress of the contractor to assure that the design, development, fabrication, test and qualification of subsystems and equipment are in accordance with specifications, and that the contractor's schedules are compatible with the achievement of specific milestones of the project.

Table V-1 indicates the contractors who have been selected to provide the subsystems and equipment for the Nimbus spacecraft. These items are accepted by GSFC and provided as government-furnished equipment to the Missile and Space Vehicle Division of the General Electric Company (GE/MSVD), which has been selected as the test and integration contractor.

Table V-1

Nimbus Technical Staff and Contractors

Subsystem or Equipment	Technical Officer	Contractor
Camera systems	M. Schneebaum	Radio Corporation of America
Antennas	J. V. Michaels	University of New Mexico
High-resolution infrared tape recorders	M. Schneebaum	Radio Corporation of America
High-resolution infrared radiometer	G. Alvarez	International Telephone & Telegraph Corp.
High-resolution infrared radiometer ground presentation equipment	S. Kant	To be selected
Medium-resolution infrared radiometer	C. Catoe	Santa Barbara Research Corporation
Medium-resolution infrared electronics & ground support equipment	M. Townsend	Aero-Geo-Astro
Medium-resolution infrared tape recorder-PCM tape recorder	R. Gibson	Raymond Engineering
Low-resolution infrared radiometer	F. Bartko	Barnes Engineering
PCM telemetry	R. Golden	Radiation Inc.
Command subsystem	S. Kant	California Computer Products
Command receivers	S. Kant	Radio Corporation of America
Transmitters		
S-band	G. Hogan	General Electronics
FM 136-Mc	G. Hogan	Hughes Aircraft
AM 136-Mc	G. Hogan	Texas Instruments
Solar power supply	M. Weinreb	Radio Corporation of America
Motor (rotating equipment)	R. Gibson	Rotors Inc.
Stabilization and control	W. Raskin	General Electric

Under terms of the contract, GE/MSVD is responsible for:

- Preparation of preliminary studies and the design and fabrication of a full-scale mockup.
- Design, development, construction, and testing of the Nimbus spacecraft structure and the integration of the structure with the controls subsystem, the solar power subsystem, and all electronic and sensory subsystems required for the Nimbus mission and supplied by GSFC as government-furnished equipment (GFE).
- Integration, mounting, testing, and alignment of the GFE check-of-calibration equipment and the go-no-go equipments to be located in the adapter sections.
- Performance, on an integrated systems basis, of the alignment and check-of-calibration of the sensory experiments of the prototype and flight spacecraft under the supervision of GSFC personnel.
- Fabrication, assembly, integration, and test of two sets of spacecraft checkout equipments, one to be used at the contractor's plant and the other for van mounting and transporting to the launch site.
- Furnishing of engineering and technical personnel and services at the launch site for the handling, preparation, and checkout of the spacecraft during the launch preparation. The launch site preparation of the satellite will be under the supervision of GSFC personnel.

The integration and test contractor is responsible for the design, development, fabrication, and test of the preliminary spacecraft-to-Agena B adapter and separation mechanism. The results of this phase of work will be furnished to GSFC and the launch vehicle system manager. After approval of the design by GSFC and the launch vehicle system manager of MSFC, the integration and test contractor will be authorized to proceed with work on the prototype and flight model adapters and separation mechanisms.

The launch vehicle system contractor will be given access to design, development, and test information related to the adapter and separation mechanism, as deemed necessary by MSFC, in order for the launch vehicle system contractor to carry out his responsibilities in the area of structural and compatibility integrity.

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Mr. L. Michelson is the GE/MSVD program manager for the Nimbus project. His responsibilities are carried out through the management organization outlined in Figure V-4.

Performance of work on the Nimbus integration and test contract is subject to the technical direction of the spacecraft system manager. Mr. Michaels will review and pass on the prototype and flight model, designs, drawings, and specifications prepared by GE/MSVD. Design drawings, specifications, and prototype and flight model instruments and sensors from other subsystem contractors, as well as all technical documentation, are also subject to the approval of the Nimbus spacecraft manager. These subsystems are supplied to GE/MSVD as government-furnished equipment after approval by the spacecraft manager. The prototype and final flight models of the spacecraft and their qualification by environmental test are subject to the approval of the spacecraft manager.

1.2.2.2 Tracking and Data Acquisition System

Mr. L. Stelter is the tracking and data acquisition system manager for the Nimbus project. In this capacity, he is responsible for assuring accomplishment of technical, procurement, budgetary, and other actions necessary to design, develop, fabricate, test and operate the Nimbus tracking and data acquisition system.

Mr. Stelter confers with and works in cooperation with the data utilization systems manager, the spacecraft systems manager, the launch vehicle representative, and other responsible parties, to assure that project objectives are achieved and that any problems that arise or limitations that exist are resolved. In particular, he is responsible for assuring that an adequate and effective ground complex is available at the time of spacecraft launch, and that the adequacy of the station equipment, adequacy of communication and data transmission links, the competence of the station staff, and the data being forwarded to the Nimbus Technical Control Center and the USWB/MSA will meet with the project requirements. In this latter responsibility he confers with the data utilization system manager and the project coordinator to resolve any interface problems that may arise in the transmission of data and in the preparation and transmission of satellite program commands over the communications link between the tracking and data acquisition station at Fairbanks, Alaska; the Nimbus Technical Control Center, Greenbelt, Maryland; and the Meteorological Satellite Activity, Suitland, Maryland.

The physical station facilities of the Nimbus Technical Control Center are the responsibility of the Tracking and Data Systems Directorate of

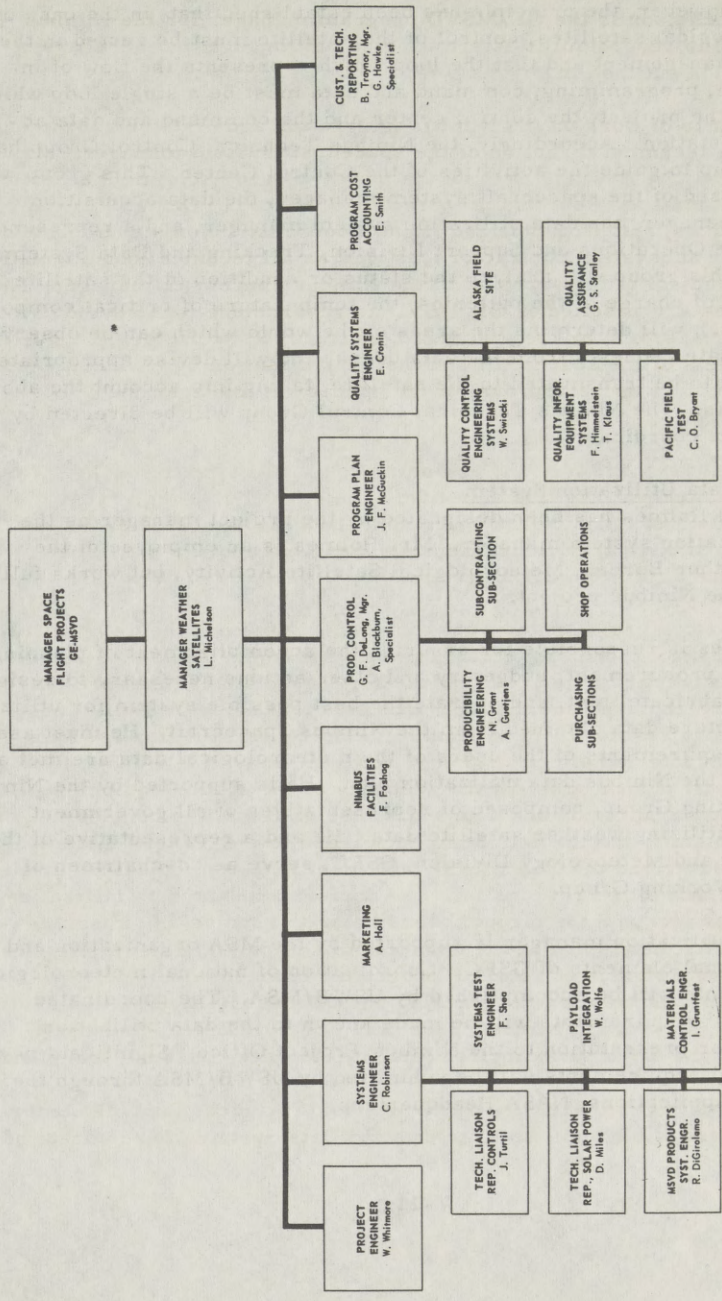

Figure V-4 – GE/MSVD Nimbus Integration and Test Contractor Organization Chart

GSFC. However, the principle has been established that, in the case of meteorological satellites, control of the satellite must be vested in the project management and that the loop which represents the flow of information, programming, command and data must be a single loop which includes the project, the control center and the command and data acquisition station. Accordingly, the Nimbus Technical Control Group has been set up to guide the activities of the Control Center. This group will be composed of the spacecraft system manager, the data acquisition system manager, the data utilization system manager, and a representative of the Operations and Support Division, Tracking and Data Systems, GSFC. This group will analyze the status or condition of the satellite (the state of charge of the batteries, the temperature of critical components, etc.), will determine the areas of the world which can be observed, will evaluate requests from the data users, and will devise appropriate programs to be transmitted to the satellite, taking into account the above constraints. The Nimbus Technical Control Group will be directed by the project coordinator.

1.2.2.3 Data Utilization System

Mr. David Holmes has been designated by the project manager as the data utilization system manager. Mr. Holmes is an employee of the U. S. Weather Bureau, Meteorological Satellite Activity, but works full time on the Nimbus project.

Mr. Holmes is responsible for assuring the accomplishment of planning, technical, procurement, budgetary and other actions necessary to design, develop, fabricate, test, and operate the best possible system for utilizing the TV picture data obtained from the Nimbus spacecraft. He must assure that the requirements of the users of the meteorological data are met as defined in the Nimbus data utilization plan. He is supported by the Nimbus Data Working Group, composed of representatives of all government agencies utilizing weather satellite data. He and a representative of the Aeronomy and Meteorology Division, GSFC, serve as co-chairmen of the Data Working Group.

The data utilization manager is supported by the MSA organization and the functional elements of GSFC. Coordination of national meteorological requirements will be accomplished by USWB/MSA. The coordinated data-users' requirements will be made known to the data utilization manager for presentation to the Nimbus Project Office. Significant new operational requirements will be submitted by USWB/MSA through the Office of Applications, NASA Headquarters.

1.2.3 MARSHALL SPACE FLIGHT CENTER

The George C. Marshall Space Flight Center is assigned responsibility for the overall management and conduct of the launch vehicle portion of the Nimbus project. In particular, this assignment includes administrative and technical responsibility from vehicle procurement through launch and tracking to spacecraft injection.

1.2.3.1 Vehicle System Responsibility

The Director, MSFC, in order to assume management cognizance of the Agena B and Centaur projects, has established as his principal agent a Light and Medium Vehicles Office, directed by Mr. Hans Hueter. It is his responsibility to assure proper launch vehicle support to the several space projects, including Nimbus, which use these vehicles, along with procurement and proper coordination with Air Force boost vehicles, such as Thor. In order to support the Nimbus project, as well as others utilizing the Agena B vehicle, an Agena B launch vehicle system manager, Mr. Friedrich Duerr, has been appointed within this organization (Figure V-5). Mr. Duerr is responsible for launch vehicle procurement, modification, GSE, planning and implementation of launch-to-injection, tracking, instrumentation, and certification of performance and reliability analysis. The assigned responsibility includes launch vehicle systems engineering, which consists of assuring: the integrity of the launch vehicle; the engineering compatibility of the launch vehicle and the spacecraft; and the proper matching of those interrelated systems necessary for the successful injection of the spacecraft into orbit.

This includes facilities and ground support equipment for the launch vehicle during the various phases of manufacturing, testing and launch preparation. The activities of the prime and subcontractors are directed by Mr. Duerr through the Air Force Space Systems Division.

1.2.3.2 Launch Operations Responsibility

Within Marshall Space Flight Center, the Launch Operations Division (LOD) has been assigned responsibility for NASA launches. For the projects assigned to the Light and Medium Vehicles Office, LOD will perform launch operations in response to program requirements and objectives specified by the project manager, through the Agena B launch vehicle system manager.

1.2.3.3 Launch Vehicle Procurement

NASA Agena B launch vehicles, including those for the Nimbus project, are procured through the Air Force Space Systems Division (AFSSD). Responsibility for procurement together with logistic and management

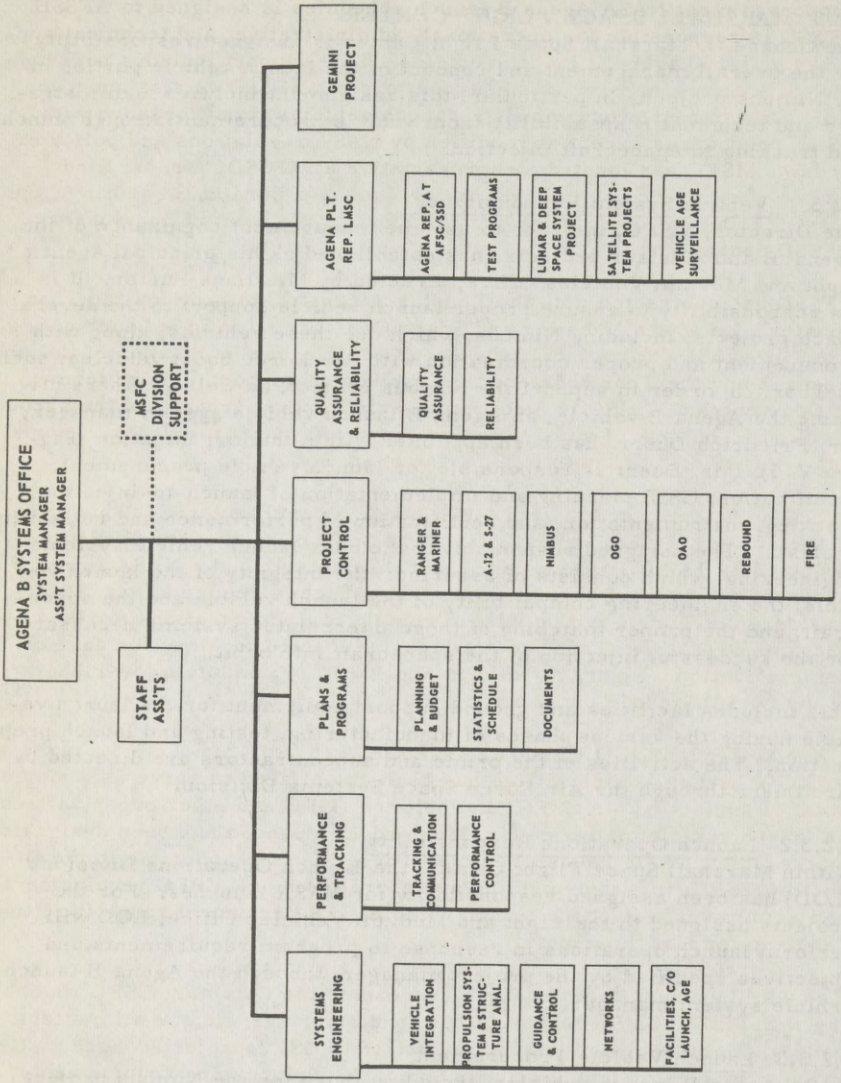

Figure V-5 – Agena B Launch Vehicle System Organization Chart

support to meet NASA Agena B launch schedules is assigned to AFSSD. AFSSD is responsible for operational, administrative, and technical support for NASA Agena B launch vehicles. This support includes personnel and facilities in support of launch operations. AFSSD acts as agent for MSFC in contract procurement of launch vehicles, in accordance with USAF procedures except as modified by NASA regulations and policy or by law. MSFC has located a representative at AFSSD, Mr. W. Kindt, for the routine accomplishment of the Nimbus program. In addition, the Air Force has established Major J. Albert as the point of contact for AFSSD operations.

AFSSD has contracted with the Douglas Aircraft Company for the Thor booster. Lockheed Missiles and Space Company (LMSC) is under contract to AFSSD for providing the Agena vehicle, for integration of the Agena B and the Thor boosters, and for launch support. Under terms of this contract, LMSC is also responsible for the shroud, and the shroud ejection. The task of supplying the shroud and accompanying hardware has been subcontracted to Douglas Aircraft Company.

MSFC has established a West Coast office located at LMSC. This office, headed by Mr. D. E. Forney, will be the point of contact for operations required by LMSC. In addition, LMSC has established a NASA Agena B program within their organization. This office is headed by Mr. H. T. Luskin. Mr. Luskin is the point of contact for all operations for the program by LMSC. These two offices are located together for ease of communication. Figure V-6 shows the LMSC organization for support of the NASA Agena B program.

1.2.4 GSFC LAUNCH VEHICLE OFFICE

A GSFC Launch Vehicle Office has been established to serve as a single point of contact within GSFC, and between GSFC and other organizations, on launch vehicle matters. Mr. Merland L. Moseson has been designated as the Chief, GSFC Launch Vehicle Office. He is responsible to the Director, GSFC, for implementing and coordinating all GSFC requirements and actions that affect the launch vehicles and permanent range facilities required for GSFC projects.

The GSFC Launch Vehicle Office represents the Director, GSFC, in dealing with MSFC, NASA Headquarters, and other agencies on all matters concerning launch vehicles as they relate to GSFC projects. Such matters include the establishment of launch vehicle performance requirements, the resolution of interface design and engineering problems between launch vehicles and spacecraft with MSFC, the establishment and revision of schedules, financial planning and management, and project reporting.

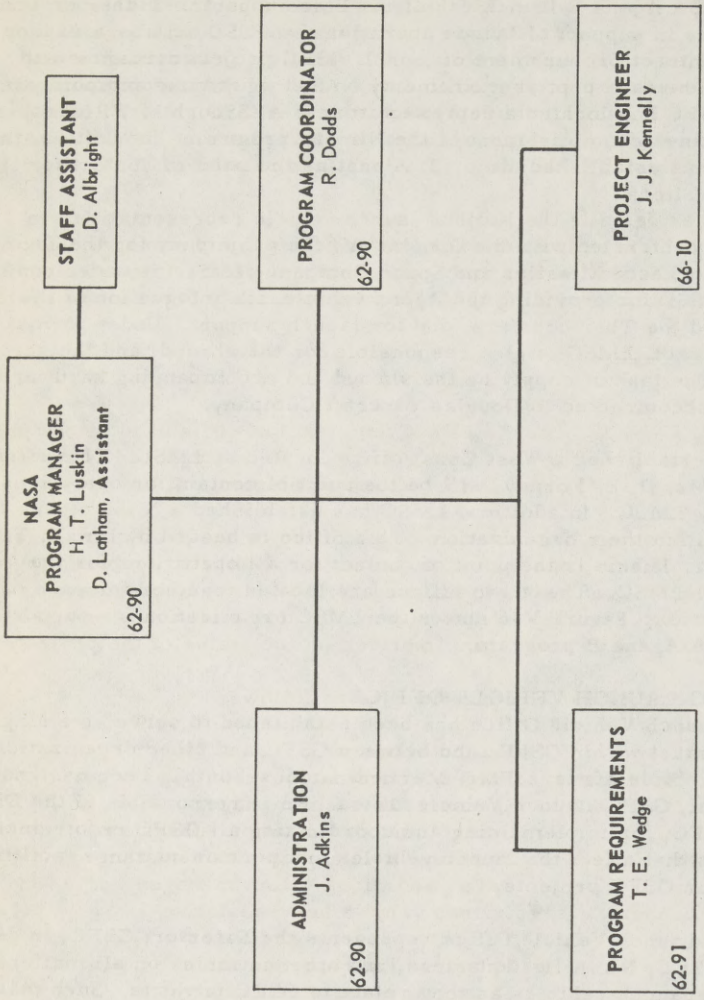

Figure V-6 – Lockheed Missiles and Space Company Project Organization Chart

Figure V-7 depicts the organization of the GSFC Launch Vehicle Office. Mr. E. A. Rothenberg is the GSFC Agena B coordinator. In this capacity, Mr. Rothenberg is responsible for the functions indicated above as they relate to the Agena B launch vehicle. All GSFC project managers and other personnel will place requirements on and otherwise communicate with the Agena B launch vehicle system manager through Mr. Rothenberg. Similarly, the Agena B system manager and members of his organization will confer with Mr. Rothenberg on all matters related to GSFC projects.

Mr. Rothenberg also is the Nimbus launch vehicle representative. In this capacity, he is responsible for keeping the project manager informed at all times of activities and problems concerning either the spacecraft or the launch vehicle which might affect compatibility between the systems.

1.3 COMMITTEES

1.3.1 NIMBUS WORKING GROUP

The Nimbus Working Group is one of the principal tools used by the project manager in managing the Nimbus project. It is composed of the key personnel who are responsible for the major elements of the project.

The working group meets biweekly or as called by the project manager. The purpose of these meetings is to promote coordination between the various technical, contractual, planning, scheduling, and budgetary activities, to resolve problems that have implications involving several areas, and to keep all concerned informed on the status of the project.

The membership of the working group is as follows:

Harry Press	Project manager
Ernest Neil (Secretary)	Project coordinator
J. V. Michaels	Spacecraft system manager
Walter Raskin	Control and stabilization subsystem
Vern Stelter	Tracking & data acquisition system manager
David Holmes	Data utilization system manager
Edward Rothenberg	Launch vehicle representative
George Abid	Project support coordinator
Ed Rosette	Procurement representative
Leon Schwartz	Financial management analyst
L. Michelson	GE/MSVD program manager (observer)
W. K. Widger	NASA Headquarters (observer)
Rino DiMasso	PERT specialist

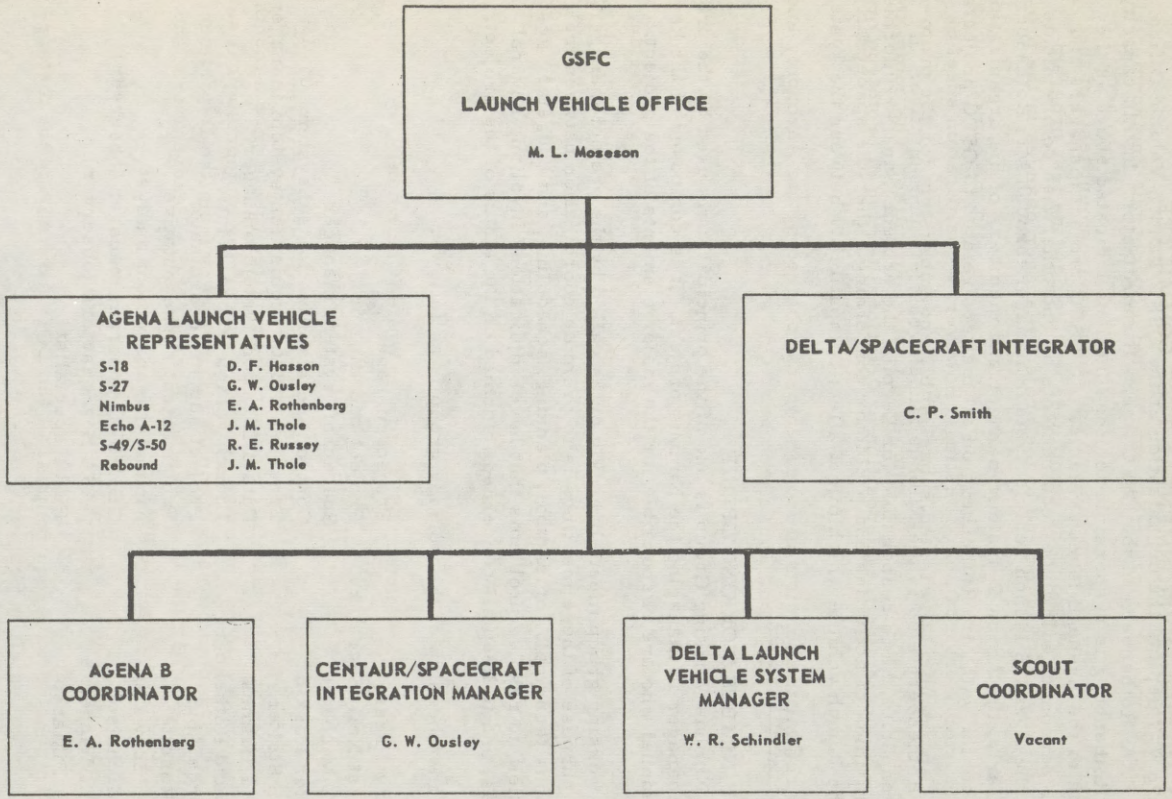

Figure V-7 – GSFC Launch Vehicle Office Organization Chart

1.3.2 NIMBUS ENVIRONMENTAL TEST COMMITTEE

The GSFC project manager has established a Spacecraft Environmental Test Committee which has the responsibility and authority to accept or reject the results of the prototype and flight environment tests of the spacecraft. In addition, the committee will review the test program periodically and recommend to the project manager changes in the program or test levels that may be dictated by experience and/or new information. The committee will not be concerned with the component and subassembly environmental testing. However, a qualification sheet of each environmentally tested subassembly and subsystem for the prototype and flight model will be submitted to the committee. The committee will also determine the disposition or additional testing of prototype or flight models that fail to qualify under environmental tests.

The committee consists of four members, chaired by the Aeronomy and Meteorology Division, GSFC, member. One member is the test coordinator from the Test and Evaluation Division, GSFC. A senior electronics engineer and a senior mechanical engineer from the systems integration contractor, GE/MSVD, are the other two members.

Mr. A. White, an engineer in the Aeronomy and Meteorology Division, GSFC, is chairman of the Nimbus Environmental Test Committee. Mr. K. Mercy (acting) is the test coordinator representing the Test and Evaluation Division, GSFC. Mr. C. Robinson, GE/MSVD contractor project engineer, is the mechanical engineer on the committee, and Mr. A. Gross of GE/MSVD is the electronics engineer on the committee.

Alternates for the above personnel are:

M. Weinreb, GSFC, for A. White (Chairman)
E. DeGraff, GSFC, for K. Mercy
W. Wolfe, GE/MSVD, for A. Gross

1.3.3 JOINT METEOROLOGY SATELLITE ADVISORY COMMITTEE

A Joint Meteorology Satellite Advisory Committee meets once a month to discuss problems and make decisions concerning meteorological satellites. The committee is composed of members from the Department of Defense (DOD), the U. S. Weather Bureau, NASA Headquarters, and Goddard Space Flight Center.

The objectives of the JMSAC committee are:

- To consider the requirements of the DOD and NASA in the meteorological satellite program

- To serve as a medium for the interchange of information among DOD and NASA members

- To assist wherever possible and appropriate in operating programs

The following members compose the committee:

Dr. M. Tepper, NASA Headquarters, Chairman
Dr. W. K. Widger, Jr., NASA Headquarters, Secretary

Members and Alternates

Lt. Col. A. W. Bostick	Headquarters Air Force Cambridge Research Center
Dr. J. F. Clark	NASA Code S
E. F. Corwin (Alternate)	Bureau of Naval Weapons
Lt. Col. L. Cowan	AFSSD-CS
W. B. Foster (Alternate)	Navy OSD RNEI
S. H. Hubbard (Alternate)	Bureau of Naval Weapons
D. S. Johnson	U. S. Weather Bureau, Deputy Director MSA
A. W. Magnitzky (Alternate)	Office Chief Naval Operations
Maj. L. Mittenthal (Alternate)	Army Office Chief R & D
Cdr. R. W. Sanborn	Naval Weather Station
Lt. Col. D. E. Simon	Army Office Chief R & D
Col. Arthur E. Smith	Navy OSD RNEI
W. G. Stroud	GSFC

1.3.4 AGENA B COORDINATION BOARD

The Agena B Coordination Board was established February 19, 1960 to provide the means for effective coordination between GSFC and MSFC to ensure that policy and program determinations are implemented in a timely and effective manner. Members of the Board are:

D. Forsythe, NASA Headquarters, Chairman
J. B. Mahon, Secretary
L. I. Baird, NASA Headquarters
F. Duerr, MSFC
J. Burke, JPL
J. James, JPL
M. L. Moseson, GSFC

In the past, the principal concern of the Board has been the resolution of problems arising at the interface between the launch vehicle and the spacecraft on individual projects. Under the provisions of NASA Management Instruction 4-1-1, these problems are to be resolved between the project manager (GSFC Launch Vehicle Office, Agena B coordinator) and the MSFC launch vehicle system manager.

The principal function of the Agena B Coordination Board will be to coordinate activities between projects using Agena B launch vehicles. Coordination functions will include:

- Maintaining standardization of those subsystems or subsystem components common to two or more projects
- Providing Headquarters assistance and advice on policy and planning
- Insuring the adequacy and coordination of project facilities, support, and funding common to two or more projects
- Providing ready access to Headquarters for resolution of interproject and intraproject problems that cannot be resolved in the field
- Providing Headquarters assistance in establishing interagency agreements and coordination that cannot be readily carried out by project management

During previous resolutions of interface problems, the Agena B Coordination Board established certain technical panels to assist it. Under the new arrangement, these groups will continue to advise and assist the Agena B launch vehicle system manager, project managers, and the GSFC Launch Vehicle Office.

1.3.5 AGENA B PANELS

The Agena B panels are composed of representatives from MSFC, GSFC, AFSSD, and LMSC. Representatives from Convair Astronautics Division, Douglas Aircraft Company, the Atlantic Missile Range, and the Pacific Missile Range attend as required.

1.3.5.1 Vehicle Integration Panel
R. E. Pace, MSFC, Chairman

This group continually monitors and evaluates structural, network, and configuration problems relating to the interface between the spacecraft and launch vehicle with shroud.

1.3.5.2 Performance, Trajectories, Guidance and Control, and Flight Dynamics Panel
R. E. Russey, GSFC, Chairman

This group continually monitors, compiles, evaluates, and coordinates data relating to performance, trajectories, guidance and control, and flight dynamics as they interact with the launch vehicle (with shroud) and the spacecraft interface.

1.3.5.3 Tracking and Data-Acquisition Panel
W. J. Bodin, Jr., GSFC, Chairman

The function of this group will be to:

- Ensure that adequate tracking of both the vehicle and spacecraft is available for determination of the injection parameters
- Ensure that adequate telemetry coverage of the spacecraft is available during the launch phase
- Specify vehicle instrumentation required to verify operation of vehicle/spacecraft related functions (e.g., shroud separation, spacecraft separation) and to determine environmental conditions affecting the spacecraft
- Resolve interface or interference problems between the launch vehicle and the spacecraft involving the tracking and data acquisition systems

1.3.5.4 Agena B Firing Operations, Logistics, Facilities and GSE for PMR Panel
J. H. Bell, Chairman (PMR) - MSFC (LOD)

This group continually monitors, compiles, and evaluates firing operations, logistics, facilities, and GSE, as they relate to the interface

between the spacecraft and vehicle with shroud. All elements of this interaction area, including schedules, will be considered. This group will cease to function when the Flight Test Working Group is formed.

1.3.5.5 Thor-Agena B Flight Test Working Group

Approximately one year prior to launch, the Flight Test Working Group will be formed. A representative of the Department of the Air Force, AFSSD, will be chairman. This group will continue the activities of the panel described immediately above. It will act as the prime mechanism for coordinating flight preparations. Members of this group will participate in vehicle and range readiness meetings, culminating at T minus 1 day, at which time the Launch Operations Directorate assumes control with AFSSD assistance.

1.3.5.6 Safe Systems Operations Group

The Marshall Space Flight Center, by virtue of the assignment to provide Agena B launch vehicle system management, has the responsibility for assuring the safe operation of the Agena B launch vehicle as an integrated system and the provision of a launch vehicle-compatible spacecraft. In order to accomplish the assigned task, the Marshall Space Flight Center will establish the Safe Systems Operations Group.

The Safe Systems Operations Group will be established to assure the integrity of the launch vehicle system; the engineering compatibility of the space vehicle (including spacecraft); and the matching of the interrelated systems necessary for the successful injection of the spacecraft.

Operations to assure these requirements will be conducted independently of all presently existing organizations to eliminate the influence of other responsibilities. This group will also review and evaluate the efforts of vehicle manufacturers and the design criteria and detailed specifications (including test specification) of the spacecraft.

The responsibilities outlined are to ensure the prevention of disasters or problems due to oversight or lack of coordination of individual design groups. This group will be cognizant of such details as interactions of the electrical, mechanical, pneumatic, RF, etc., systems which might cause unacceptable conditions during testing, checkout, countdown, and flight.

The Agena B Launch Vehicle System Manager, Mr. F. Duerr, as chairman of the Safe Systems Operations Group, is charged with the responsibility for fulfilling the stated objectives of the group. For his support, three working groups will be established:

- The Electrical Systems Working Group
- The Structural Systems Working Group
- The Radio Frequency Systems Working Group

These groups will have a technical capability consistent with the requirements of the particular working group.

The chairmen of the Electrical Systems and Structural Systems Working Groups will report directly to Mr. Duerr concerning their problems, results, and recommended solutions. The chairman of the Radio Frequency System Working Group will report to the Agena B Tracking and Data Acquisition Working Group. The chairman of this latter group will report the findings and recommended solutions to Mr. Duerr.

The chairmen of the working groups will establish operating procedures for their groups consistent with the objectives stated above. These procedures will be submitted to Mr. Duerr for coordination among the affected project systems and for final approval.

1.4. PROCEDURES AND REPORTS

1.4.1 PROJECT REPORTS

1.4.1.1 Project Development Plan (PDP)

The project manager is responsible for the prompt submission of changes or modifications required for maintaining the currency and adequacy of the Project Development Plan. The plan is designed to be flexible as to format, correction, additions, or other alterations. Fulfillment of the expected functions of the plan is largely dependent upon the timeliness and exactness of pertinent changes.

1.4.1.2 Program Management Plans (PMP) and Program Evaluation and Review Technique (PERT)

Program Management Plans, showing the major milestones to be accomplished in carrying out the Nimbus project, have been established in accordance with NASA Instruction 6-2-3. A copy of this document is a part of the Project Development Plan.

Reports indicating progress in accomplishing the milestones set forth in the Program Management Plans and summarizing the status of the project are furnished to Headquarters biweekly or less frequently as required by NASA Instruction 6-2-3.

The Program Evaluation and Review Technique will be used to record and report the progress on the Nimbus project. The PERT system provides the selected information required for monitoring the project and for coordinating the Nimbus work by Goddard and the contractors. The PERT reporting system includes network charts, computer printouts, and narrative analyses.

1.4.1.3 Internal GSFC Reports

The project manager submits to the Director on Friday of each week a written report which discusses significant events that have occurred on the project, highlights problem areas, and indicates any assistance that is required.

Periodic presentations on the projects are made to the Goddard Space Flight Center Executive Council. This group, chaired by the Director, is composed of top management officials of Goddard. The presentations cover all significant aspects of the project including technical progress and such management areas as funding, procurement, etc. Emphasis is placed on defining problem areas and applying necessary measures to resolve them.

1.4.1.4 Administrator's Progress Report

The project manager makes monthly submission of data for the Administrator's Progress Report, including progress made during the current month and plans for the coming month.

1.4.1.5 Budget Reports and Reviews

The project manager is responsible for the preparation of semiannual budget reports on his project, due on the 15th of May and the end of November, when recommendations for any formal changes to the currently authorized budget will be made.

The regularly scheduled budget report and reviews do not preclude submission by the project manager of recommendations for budget changes at any time when he feels that budgetary provisions are inconsistent or incompatible with the planned progress or ultimate success of the project.

1.4.1.6 Contractor Progress Report

Under provisions of the contract, the subcontractors submit a monthly progress report to GSFC Aeronomy and Meteorology Division. This report reviews technical status and indicates progress in achieving scheduled project milestones.

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1.4.2 FLIGHT TEST DOCUMENTATION

Under the provisions of Letter Contract AF 04(647)-592, Lockheed Missiles and Space Company (LMSC) prepares the following documents:

1.4.2.1 Program Requirements Document (PRD)

This document covers the support requirements of the PMR as applicable for the launch and tracking of the vehicles. The document consists of information fill-in of a series of standard forms furnished by the range.

One document will be required for the launch at PMR to cover requirements of GSFC, LMSC, and Douglas.

The program requirements document was submitted to PMR on December 1, 1961. Revisions will be performed as the requirements dictate. Signoff of the document will be by AFSSD and MSFC.

1.4.2.2 Systems Operation Plan (SOP)

This document presents the general overall operations for a series of flights which are directed toward the completion of a particular mission or program. Major portions of the document consist of mission and objectives, configuration, command organization and control for the test, launch operations, space operations, and test evaluation.

Coordination between LMSC and NASA will be required for preparation of the documents.

A preliminary release of the document is scheduled 8 months before the launch in each program; the final release is 6 months before the launch. Major changes will require revisions to the document; however, the DTO mentioned below will be the primary reference for current test information.

LMSC will supply an outline to participating organizations for preparation of this document. Signoff will be by GSFC (project manager), MSFC (Agena B launch vehicle manager), and AFSSD.

1.4.2.3 Preliminary Countdown Manual

The coordinated preparation of a countdown sequence chart is started early in the program and presents the sequence of events on a time and noninterference basis. This chart furnishes the basis for the detailed written countdown which represents all operations for the launch. The Preliminary Countdown Manual is prepared early in the program to evaluate the vehicle, ground support, facilities and launch control equipment, and to instigate a team concept for the launch.

Preliminary manuals will be required. The release date is 6 months before the first launch. The final countdown manuals, which are prepared by launch base personnel, will be prepared and revised for each flight for final release 10 days before the launch.

Format and contents of the countdown will be determined by discussion with AFSSD and NASA personnel, and DAC and NASA contractor operations personnel. LMSC will send a notice of intent and requirements before preparation of the chart and manuals.

Signoff of the preliminary manual will be by GSFC (project manager), MSFC (LOD), and AFSSD. The final countdown will be signed by designated members of the Flight Test Working Group at the launch base.

1.4.2.4 Flight Termination System

This document presents a description of the equipment, checkout, and control of the Range Safety subsystem installed on the vehicles. It is a requirement of the PMR Range Safety Office. This document is the first of the Range Safety reports; a second report, which covers trajectory and vehicle performance, is described below.

Flight Termination System reports will be required. The final release will be 6 months before each launch. Preparation of the report, as well as the system design, will require coordination between LMSC and DAC. LMSC will contact the associated contractor concerned for the information required for the report.

1.4.2.5 Detailed Test Objectives (DTO)

This document is prepared for each flight, although revisions will often satisfy the requirement when succeeding flights are similar. The DTO is the basic flight test operations document and, as such, is the governing reference for each flight test including launch and space operations. Deviations cannot be made from DTO requirements without authorization from the GSFC project manager. Major contents of the document include test objectives, system configuration, launch and space operations and control, and test evaluation requirements.

The DTO will require the close coordination of all contractors involved in the test, not only for the initial preparation but also for subsequent revisions, which must remain current at all times.

LMSC will submit an outline to participating organizations for preparation of this document. Final release is 90 days before launch, with a preliminary release scheduled 4-1/2 months before launch.

Signoff of this document will be by GSFC (project manager), MSFC (Agena B launch vehicle system manager), and AFSSD.

1.4.2.6 Range Safety Report

This document is the Range Safety trajectory and analysis report which is required by PMR Range Safety offices. The document includes plots and tabular data on trajectories, locus of impacts, dispersion, turning rates, etc.

A revision or reissue of this document is required for each flight. LMSC will prepare the document from basic weight and performance figures of the Agena B spacecraft, and Thor boosters.

The document is released 60 days before the first flight for each vehicle configuration, and approximately 45 days before succeeding flights for similar vehicles.

Signoff of the document will be by MSFC (LOD) and AFSSD.

1.4.2.7 Flight Test Directive (FTD)

This document is a detailed directive for conducting the launch and general range operations. It follows the general plan as written in the DTO but presents the operations in greater detail and coordinates all range functions.

The FTD is prepared for each flight by the launch operations personnel at the PMR launch base.

The document final release date is 30 days before the launch. Signoff will be by the flight test working group members representing GSFC, MSFC, and AFSSD.

1.4.2.8 System Test Directive (STD)

The STD is a detailed directive for conducting the spacecraft tracking, command, control, and data-acquisition procedures. The document follows the general direction of the DTO but presents the operation in much greater detail. The document must be reissued or revised for each flight.

Since the greater portion of the STD is concerned with the spacecraft post-injection operations, GSFC will supply the basic information for the report.

Release of the document is 30 days before the launch. Signoff will be by the GSFC project manager.

1.4.2.9 Pad Safety Report

This report is a range requirement and is furnished to describe the hazards associated with the vehicles. This includes pyrotechnics, propellants, pneumatics, and the control of these items as applicable on the launch pad.

Generally, each contractor will submit a report for his particular vehicle not later than 30 days before launch; however, the range may request this information much sooner. One document will be required at PMR. Revisions must be furnished when design changes occur.

The LMSC report will be prepared by the launch base personnel and will be signed off by MSFC (LOD) and AFSSD.

Other flight test documentation includes the test evaluation and analysis reports which are prepared after the launch. The details for preparation of these reports will be outlined in the SOP and DTO documents.

2. SCHEDULES

Key milestones for accomplishment of the Nimbus project are shown in the Program Management Plan (PMP). An unclassified version of the PMP for May 2, 1962, is shown in the following pages. Changes to this section of the PDP will not be issued. Therefore, the latest PMP should be consulted for up-to-date schedule information.

NIMBUS

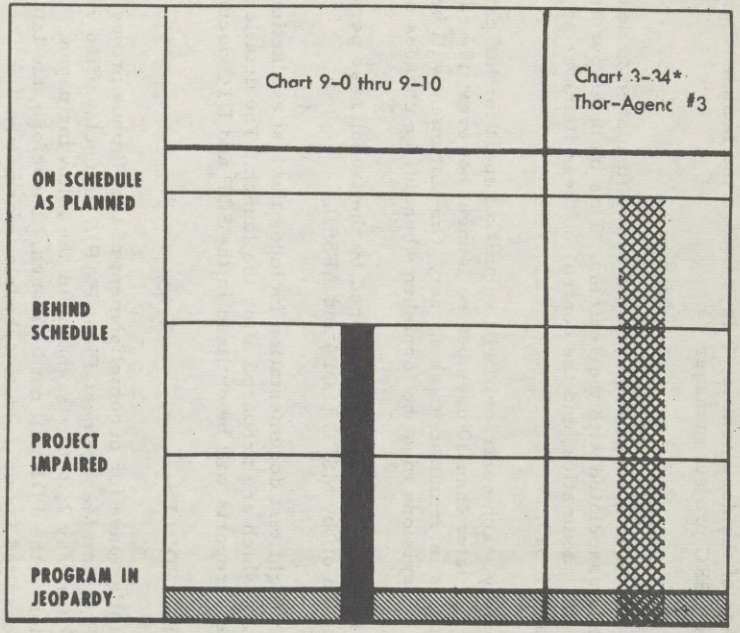
STATUS OF MAJOR SYSTEMS

May 2, 1962

HIGHLIGHTS

As of May 2, 1962

Control Subsystem, Camera Subsystems remain critical as determined from Project PERT. Vehicle and data acquisition programs on schedule. Project is actively reappraising present prototype and flight schedule.



*Reported by Project Agena

Program Chief: Dr. M. Tepper (FM)
Project Manager: Mr. Press (GSFC)

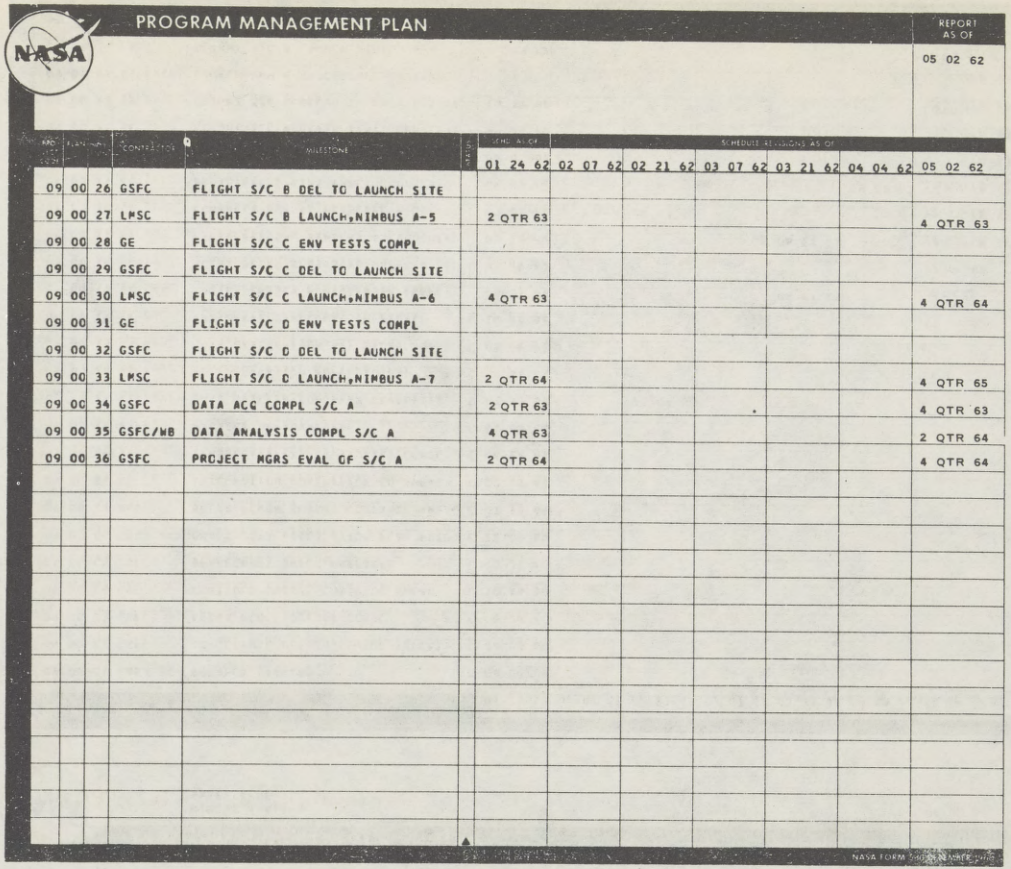
PROGRAM MANAGEMENT PLAN

NIMBUS A-4, A-5
SHEET 1 OF 2

REPORT AS OF: 05 02 62

PROJECT CODE	PLAN	ITEM	CONTRACTOR	MILESTONE	STATUS	BASE PLAN 01 24 62	SCHEDULE REVISIONS AS OF 02 07 62	02 21 62	03 07 62	03 21 62	04 04 62	05 02 62
09	00	01	NASA HQ	PROJECT STARTED	C	08 00 59						
09	00	02	GSFC	CONCEPTUAL DESIGN, SENSOR SELECT	C	04 00 60						
09	00	03	GSFC	AGENA MOD REQUESTS COMPL	C	06 20 60						
09	00	04	GE	CONTROLS SUBSYS CONTR GO AHEAD	C	10 15 60						
09	00	05	GSFC	SPACECRAFT SPECS PREPARED	C	10 31 60						
09	00	06	DATA WRK	DRAFT DATA UTILIZATION PLAN PREP	C	12 08 60						
09	00	07	RCA	SOLAR POWER SUBSYS CONTR GO AHEAD	C	02 13 61						
09	00	08	GE	INTEGRATION CONTRACTOR GO AHEAD	C	02 15 61						
09	00	09	GE	SPACECRAFT DESIGN STUDIES COMPL	C	06 24 61						
09	00	10	GSFC	PROJECT APPROVAL PDP	C	11 03 61						
09	00	11	GSFC/USW	DATA UTILIZATION PLAN COMPLETED	C	02 30 62		03 09 62				
09	00	12	GE	DEL SEPARATION MODEL TO DAC	C	08 31 61						
09	00	13	GSFC	DATA UTILIZATION ADV STUDY AWARD	C	01 02 62						
09	00	14	GE	PROTOTYPE STRUCTURE COMPLETED	C	10 15 61						06 15 62
09	00	15	GE	PROTO SENSORY SUBSYS ASSY COMPL		03 31 62				06 01 62		08 04 62
09	00	16	RCA	SOLAR POWER SUBSYS FL MODEL A DEL		05 29 62						07 07 62
09	00	17	GE	FIRST FLT S/C SENSORY ASSY COMPL		02 18 62				06 22 62		09 22 62
09	00	18	GE	CONTROLS SUBSYS FL MODEL A DELVD		03 01 62		07 07 62				12 15 62
09	00	19	GE	PROTOTYPE S/C ASSEMBLY COMPLETED		04 05 62					09 02 62	11 03 62
09	00	20	GSFC	ALASKA DATA STATION OPERATIONAL		06 00 62						
09	00	21	GE	FLIGHT S/C A ENVIR TESTS COMPLETE		09 26 62						04 15 63
09	00	22	GE	FLIGHT S/C A DELVD TO LAUNCH SITE		10 15 62						2QTR 63
09	00	23	GSFC/LaS	LAUNCH VEH & SPACECRAFT ON STAND								
09	00	24	LMSC	FLIGHT S/C A LAUNCH, NIMBUS A-4		4 QTR 62						2QTR 63
09	00	25	GE	FLIGHT S/C B ENVIR TESTS COMPLETE	▲							

NASA FORM 451 (DECEMBER 1962)



PROGRAM MANAGEMENT PLAN

REPORT AS OF: 05 02 62

PROJECT	FLIGHT	MILESTONE	CONTRACTOR	MILESTONE	STATUS	CHG. AS OF 01 24 62	SCHEDULE REVISIONS AS OF 02 07 62	02 21 62	03 07 62	03 21 62	04 04 62	05 02 62
09	00	26	GSFC	FLIGHT S/C B DEL TO LAUNCH SITE								
09	00	27	LMSC	FLIGHT S/C B LAUNCH,NIMBUS A-5		2 QTR 63						4 QTR 63
09	00	28	GE	FLIGHT S/C C ENV TESTS COMPL								
09	00	29	GSFC	FLIGHT S/C C DEL TO LAUNCH SITE								
09	00	30	LMSC	FLIGHT S/C C LAUNCH,NIMBUS A-6		4 QTR 63						4 QTR 64
09	00	31	GE	FLIGHT S/C D ENV TESTS COMPL								
09	00	32	GSFC	FLIGHT S/C D DEL TO LAUNCH SITE								
09	00	33	LMSC	FLIGHT S/C D LAUNCH,NIMBUS A-7		2 QTR 64						4 QTR 65
09	00	34	GSFC	DATA ACQ COMPL S/C A		2 QTR 63						4 QTR 63
09	00	35	GSFC/WB	DATA ANALYSIS COMPL S/C A		4 QTR 63						2 QTR 64
09	00	36	GSFC	PROJECT MGRS EVAL OF S/C A		2 QTR 64						4 QTR 64

NASA FORM

PROGRAM MANAGEMENT PLAN

THOR AGENA 4-FOR BACK UP
/AGENA #6102/

REPORT AS OF: 05 02 62

PROJECT CODE	PLAN	MILE STONE	CONTRACTOR	MILESTONE	STATUS	SCHD AS OF 01 24 62	SCHEDULE REVISIONS AS OF 02 07 62	02 21 62	03 07 62	03 21 62	04 04 62	05 02 62
03	33	01	GSFC	PRLLIM S/C INTER SPEC TO LMSC	C	12 30 60						
03	33	02	GSFC	SPACECRAFT INTER SPEC TO LMSC	C	12 30 60						
03	33	03	LMSC	AGENA ENGINEERING RELEASES COMP	C	02 12 62	09 01 61					
03	33	04	LMSC	FINAL ASSEMBLY INITIATED		03 12 62	08 06 62				07 28 62	
03	33	05	LMSC	FINAL ASSEMBLY COMP		05 01 62	09 26 62					
03	33	06	LMSC	AGENA SYSTEMS TEST INITIATED		05 02 62	10 03 62					
03	33	07	GSFC	SPACECRAFT ASSEMBLY COMP	Q							
03	33	08	LMSC	AGENA SYSTEMS TEST COMP		07 27 62	12 20 62					
03	33	09	LMSC	AGENA/SPACECRAFT COMP TEST COMP	Q							
03	33	10	LMSC	AGENA STATIC FIRING TEST COMP	Q							
03	33	11	LMSC	AGENA FINAL SYS TEST INITIATED								
03	33	12	LMSC	AGENA FINAL SYSTEMS TEST COMP								
03	33	13	LMSC	AGENA DELIVERY TO RANGE		07 29 62	12 21 62				12 22 62	
03	33	14	DAC	BOOSTER DELIVERY TO RANGE		06 26 62			11 28 62			
03	33	15	GSFC	SPACECRAFT DELIVERY TO RANGE	Q							
03	33	16	PMR	RANGE SUPPORT READY		08 06 62		12 30 62				
03	33	17	DAC	BOOSTER ON PAD		3 QTR 62			1 QTR 63			3 QTR 63
03	33	18	LMSC	AGENA MAB PREPARATION COMP		3 QTR 62	1 QTR 63					3 QTR 63
03	33	19	LMSC	AGENA ON PAD		3 QTR 62		1 QTR 63				3 QTR 63
03	33	20	GSFC	SPACECRAFT ON PAD		2 QTR 62				1 QTR 63		3 QTR 63
03	33	21	LMSC	JOINT COMPOSITE TEST COMP		3 QTR 62				1 QTR 63		3 QTR 63
03	33	22	LMSC	FRD COMPLETED		3 QTR 62				1 QTR 63		3 QTR 63
03	33	23	LMSC	LAUNCH		1 QTR 63	1 QTR 63					3 QTR 63

C MILESTONE COMPLETED
Q MILESTONE DATE IN QUESTION

NASA FORM 530 DECEMBER 1960

PROGRAM MANAGEMENT PLAN

NASA

THOR-AGENA 3-FOR NIMBUS A-4
/AGENA #6201/

REPORT AS OF: 05 02 62

PROJECT CODE	PLAN	MILESTONE	CONTRACTOR	MILESTONE	STATUS	SCHD AS OF 01 24 62	SCHEDULE REVISIONS AS OF 02 07 62	02 21 62	03 07 62	03 21 62	04 04 62	05 02 62
03	34	01	GSFC	PRELIM S/C INTER SPEC TO LMSC	C	06 23 60						
03	34	02	GSFC	SPACECRAFT INTER SPEC TO LMSC	C	08 05 60						
03	34	03	LMSC	AGENA ENGINEERING RELEASES COMP	C	03 13 62			04 07 62		03 07 62	
03	34	04	LMSC	FINAL ASSEMBLY INITIATED		04 13 62					04 05 62	D
03	34	05	LMSC	FINAL ASSEMBLY COMP		06 06 62						
03	34	06	LMSC	AGENA SYSTEMS TEST INITIATED		06 07 62						
03	34	07	GSFC	SPACECRAFT ASSEMBLY COMP					05 23 62			
03	34	08	LMSC	AGENA SYSTEMS TEST COMP		08 17 62						
03	34	09	LMSC	AGENA/SPACECRAFT COMP TEST COMP								
03	34	10	LMSC	AGENA STATIC FIRING TEST COMP		09 18 62						
03	34	11	LMSC	AGENA FINAL SYS TEST INITIATED		09 19 62						
03	34	12	LMSC	AGENA FINAL SYSTEMS TEST COMP		10 12 62					10 30 62	
03	34	13	LMSC	AGENA DELIVERY TO RANGE		10 14 62					11 01 62	
03	34	14	DAC	BOOSTER DELIVERY TO RANGE		09 00 62			09 23 62			
03	34	15	GSFC	SPACECRAFT DELIVERY TO RANGE				10 15 62				
03	34	16	PMR	RANGE SUPPORT READY		10 23 62	10 15 62	10 23 62				
03	34	17	DAC	BOOSTER ON PAD		4 QTR 62			4 QTR 62			
03	34	18	LMSC	AGENA MAB PREPARATION COMP		4 QTR 62					4 QTR 62	2 QTR 63
03	34	19	LMSC	AGENA ON PAD		4 QTR 62					4 QTR 62	2 QTR 63
03	34	20	GSFC	SPACECRAFT ON PAD		3 QTR 62					4 QTR 62	2 QTR 63
03	34	21	LMSC	JOINT COMPOSITE TEST COMP		4 QTR 62					4 QTR 62	2 QTR 63
03	34	22	LMSC	FRD COMPLETED		4 QTR 62					4 QTR 62	2 QTR 63
03	34	23	LMSC	LAUNCH		4 QTR 62					4 QTR 62	2 QTR 63

▲ MILESTONE SCHEDULE / MILESTONE DATE

NASA FORM 5.10 DECEMBER 1963

PROGRAM MANAGEMENT PLAN

THOR AGENA 5-FOR NIMBUS A-5
/AGENA #6202/

REPORT AS OF: 05 02 62

PROJECT CODE	PLAN		CONTRACTOR	MILESTONE	SCHEDULE REVISIONS AS OF						
					01 24 62	02 07 62	02 21 62	03 07 62	03 21 62	04 04 62	05 02 62
03	35	01	GSFC	PRELIM S/C INTERFACE SPE TO LMSC							
03	35	02	GSFC	SPACECRAFT INTERFACE SPE TO LMSC							
03	35	03	LMSC	AGENA ENGINEERING RELEASES COMP			10 05 62				
03	35	04	LMSC	FINAL ASSEMBLY INITIATED			11 06 62			12 08 62	
03	35	05	LMSC	FINAL ASSEMBLY COMP			02 08 63				
03	35	06	LMSC	AGENA SYSTEMS TEST INITIATED			02 09 63			02 15 63	
03	35	07	GSFC	SPACECRAFT ASSEMBLY COMP							
03	35	08	LMSC	AGENA SYSTEMS TEST COMP			04 19 63				
03	35	09	LMSC	AGENA/SPACECRAFT COMP TEST COMP							
03	35	10	LMSC	AGENA STATIC FIRING TEST COMP							
03	35	11	LMSC	AGENA FINAL SYS TESY INITIATED							
03	35	12	LMSC	AGENA FINAL SYSTEMS TEST COMP							
03	35	13	LMSC	AGENA DELIVERY TO RANGE			04 21 63				
03	35	14	DAC	BOOSTER DELIVERY TO RANGE				03 23 63			
03	35	15	GSFC	SPACECRAFT DELIVERY TO RANGE							
03	35	16	PMR	RANGE SUPPORT READY			04 23 63				
03	35	17	DAC	BOOSTER ON PAD				2 QTR 63			4 QTR 63
03	35	18	LMSC	AGENA MAB PREPARATION COMP			2 QTR 63				4 QTR 63
03	35	19	LMSC	AGENA ON PAD			2 QTR 63				4 QTR 63
03	35	20	GSFC	SPACECRAFT ON PAD							
03	35	21	LMSC	JOINT COMPOSITE TEST COMP						2 QTR 63	4 QTR 63
03	35	22	LMSC	FRO COMP						2 QTR 63	4 QTR 63
03	35	23	LMSC	LAUNCH	2 QTR 63						4 QTR 63

NASA FORM 5-10 DECEMBER 1960

PROGRAM MANAGEMENT PLAN

AS OF: 05 02 62

THOR-AGENA 9 FOR NIMBUS A-6
/AGENA #6203/

PROJECT CODE	PLAN	TASK	CONTRACTOR	MILESTONE	STATUS	SCHD AS OF 01 24 62	SCHEDULE REVISIONS AS OF 02 07 62	02 21 62	03 07 62	03 21 62	04 04 62	05 02 62
03	36	01	GSFC	PRELIM S/C INTERFACE SPE TO LMSC								
03	36	02	GSFC	SPACECRAFT INTERFACE SPL TO LMSC								
03	36	03	LMSC	AGENA ENGINEERING RELEASES COMP				04 19 63				
03	36	04	LMSC	FINAL ASSEMBLY INITIATED				05 21 63				
03	36	05	LMSC	FINAL ASSEMBLY COMP				07 17 63				
03	36	06	LMSC	AGENA SYSTEMS TEST INITIATED				07 18 63				
03	36	07	GSFC	SPACECRAFT ASSEMBLY COMP								
03	36	08	LMSC	AGENA SYSTEMS TEST COMP				10 14 63				
03	36	09	LMSC	AGENA/SPACECRAFT COMP TEST COMP								
03	36	10	LMSC	AGENA STATIC FIRING TEST COMP								
03	36	11	LMSC	AGENA FINAL SYS TEST INITIATED								
03	36	12	LMSC	AGENA FINAL SYSTEMS TEST COMP								
03	36	13	LMSC	AGENA DELIVERY TO RANGE				10 16 63				
03	36	14	DAC	BOOSTER DELIVERY TO RANGE								
03	36	15	GSFC	SPACECRAFT DELIVERY TO RANGE								
03	36	16	PMR	RANGE SUPPORT READY				10 15 63				
03	36	17	DAC	BOOSTER ON PAD								
03	36	18	LMSC	AGENA MAB PREPARATION COMP				4 QTR 63				4 QTR 64
03	36	19	LMSC	AGENA ON PAD				4 QTR 63				4 QTR 64
03	36	20	GSFC	SPACECRAFT ON PAD								
03	36	21	LMSC	JOINT COMPOSITE TEST COMP				4 QTR 63				4 QTR 64
03	36	22	LMSC	FRD COMP								
03	36	23	LMSC	LAUNCH		4 QTR 63			2 QTR 64			4 QTR 64

NASA FORM 530 DEC 62

PROGRAM MANAGEMENT PLAN

ALASKAN WIDE BAND DATA ACQUISITIO
& COMMAND STATION

REVISED AS OF: 05 02 62

WBS ITEM	CONTRACTOR	MILESTONE		BASELINE 01 24 62	SCHEDULE REVISIONS AS OF 02 07 62	02 21 62	03 07 62	03 21 62	04 04 62	05 02 62
45 20 01	BLAW-KNO	CONTRACT FOR ANTENNA FAB & INST	C	10 01 60						
45 20 02	GEO INST	SITE SELECTION SURVEY & TEST CONT	C	05 24 60						
45 20 03	BLAW-KNO	BEGIN ENGINEERING MODIFICATION	C	05 25 60						
45 20 04	NASA HQ	APPROVAL FOR LAND ACQUISITION	C	06 24 60						
45 20 05	NASA HQ	LAND ACQUIRED	C	07 02 60						
45 20 06	GEO INST	BEGIN CONSTRUCTION	C	07 15 60						
45 20 07	GEO INST	CONTRACT SUPPLEMENT FOR A&E CONST	C	08 01 60						
45 20 08	ALFA COR	CONTRACT FOR ELECTRONICS DESIGN	C	10 01 60						
45 20 09	GEO INST	COMPLETE OUTSIDE CONSTRUCTION	C	11 01 60						
45 20 10	GEO INST	ALL CONSTRUCTION COMPLETED	C	04 01 61						
45 20 11	BLAW-KNO	STEEL DELIVERIES COMPLETE	C	05 01 61						
45 20 12	BLAW-KNO	SPEED REDUCER SHIPPING COMPLETE	C	07 15 61						
45 20 13	ALFA COR	HYDRAULIC SYSTEM SHIPPING COMPLET	C	07 15 61						
45 20 14	BLAW-KNO	ANTENNA FABRICATION COMPLETE	C	07 26 61						
45 20 15	BLAW-KNO	BEGIN ANTENNA ERECTION	C	08 11 61						
45 20 16	ALFA COR	ELECTRONICS SHIPPING COMPLETE		03 25 62						
45 20 17	BLAW-KNO	ANTENNA ERECTION COMPLETE	C	11 20 61						
45 20 18	ALFA COR	ELECTRONICS INSTALLATION COMPL		04 02 62						05 15 62
45 20 19	GSFC	BEGIN CALIBRATION	C	02 15 62						
45 20 20	GSFC	BEGIN FINAL C/O&ALIGNMENT OF ANT		04 15 62						D 05 15 62
45 20 21	GSFC	COMPL FINAL C/O&ALIGNMENT OF ANT		05 15 62						06 15 62

NASA FORM 530 (9-62)

PROGRAM MANAGEMENT PLAN

NIMBUS
DATA UTILIZATION SYSTEM
1 OF 2

REPORT AS OF: 05 02 62

						SCHEDULE REVISIONS AS OF						
						01 24 62	02 07 62	02 21 62	03 07 62	03 21 62	04 04 62	05 02 62
09	03	01		ADVANCED VIDICON CAMERAS								
09	03	02	GSFC/USN	UTILIZATION PLAN COMPLETED	C	02 30 62		03 09 62				
09	03	03	GSFC/USN	EQUIPMENT SPECIFIED		02 15 62			04 01 62	04 15 62	04 20 62	D 05 15 62
09	03	04	GSFC/USN	CONTRACT PLACED		03 15 62		04 25 62				D 06 15 62
09	03	05	GSFC/USN	SYSTEM IN OPERATION		11 30 62						
09	03	06										
09	03	07			C							
09	03	08										D
09	03	09										D
09	03	10										
09	03	11		HIGH RESOLUTION IR RADIOMETER								
09	03	13	GSFC/USN	EQUIPMENT SPECIFIED	C	08 01 61						05 15 62
09	03	14	GSFC/USN	CONTRACT PLACED		02 01 62			04 25 62			D 06 15 62
09	03	15	GSFC/USN	SYSTEM IN OPERATION		02 00 63						03 15 63
09	03	16		MEDIUM RESOLUTION RADIOMETER								
09	03	18	GSFC/USN	EQUIPMENT SPECIFIED	C	06 28 61						05 15 62
09	03	19	GSFC/USN	CONTRACT PLACED	C	06 28 61						06 15 62
09	03	20	GSFC/USN	SYSTEM IN OPERATION		12 00 62						03 15 63
09	03	21		USNB ARCHIVAL EQUIPMENT								
09	03	22	GSFC	DATA UTILIZATION CONT AWARDED		02 30 62		03 30 62			04 20 62	D 05 15 62
09	03	28	GSFC	ARCHIVAL EQUIP CONTRACT AWARDED		03 15 62			04 25 62			D 06 15 62
09	03	29	GSFC	STUDY CONTRACT FINAL REPORT		07 00 62						
09	03	30	GSFC	ARCHIVAL EQUIPMENT DELIVERED		09 00 62						
09	03	31	GSFC	EQUIPMENT OPERATIONAL		10 00 62						
09	03	32		ADVANCED STUDIES	▲							

NASA TERMS, DEFINITIONS (1962)

PROGRAM MANAGEMENT PLAN

REPORT AS OF: 05 02 62

PROJECT	PLAN	WORK AREA	CONTRACTOR	DESCRIPTION		SCHEDULE REVISIONS AS OF: 01 24 62	02 07 62	02 21 62	03 07 62	03 21 62	04 04 62	04 18 62
09	03	33	GSFC	SPECIFICATIONS PREPARED	C	05 01 61						
09	03	34	GSFC	CONTRACTS PLACED	C	01 02 62						
09	03	35	GSFC	STUDY CONTRACT FINAL REPORT		12 15 62						

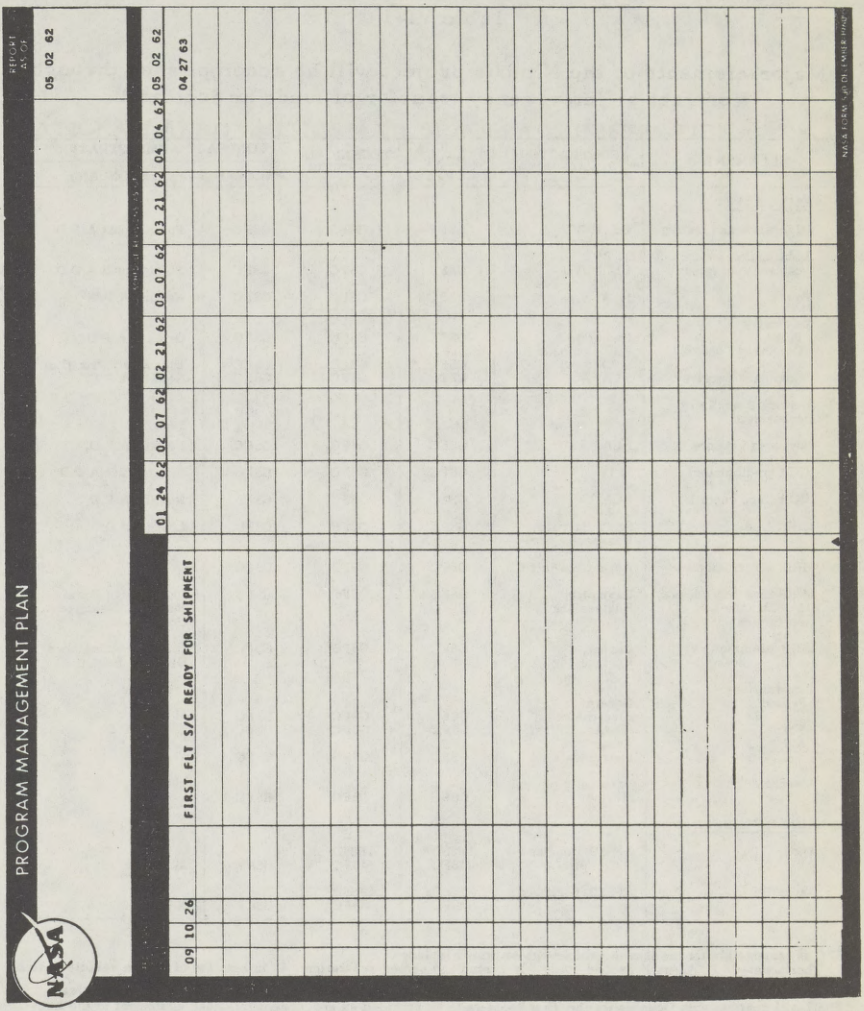
PROGRAM MANAGEMENT PLAN

NIMBUS SPACECRAFT
INTEGRATION & TEST
SHEET 1 OF 2
SHEET 2 OF 2

AS OF 05 02 62

WBS			CONTRACTOR	MILESTONE		SCHEDULE REVISIONS AS OF 01 24 62	02 07 62	02 21 62	03 07 62	03 21 62	04 04 62	05 02 62
09	10	01	GSFC	SPECIFICATIONS PREPARED	C	10 31 60						
09	10	02	GE	CONTRACT INITIATED	C	02 15 61						
09	10	03	GE	MODEL ANALYSIS COMPLETED	C	06 15 61						
09	10	04	GE	MODEL STUDIES COMPLETED		02 08 62			03 26 62	04 15 62	06 01 62	
09	10	05	GE	PROTOTYPE STRUCTURE COMPLETED		10 15 61					06 15 62	
09	10	06	GE	PROTO SENSORY SUBSYS ASSY COMPL		03 31 62				06 01 62		08 04 62
09	10	07	GE	FIRST FL S/C SENSORY ASSY COMPL		02 15 62						09 22 62
09	10	08	GE	PROTO SENSORY SUBSYS TESTS COMPL		02 18 62						08 18 62
09	10	09	GE	FIRST FL S/C SENSORY TESTS COMPL		02 20 62						10 06 62
09	10	10	GE	PROTO SENS SUBSYS V/T TESTS COMPL		03 12 62			08 01 62			09 22 62
09	10	11	GE	FIRST FL S/C SENS V/C TESTS COMPL		03 27 62			09 01 62			11 10 62
09	10	12	GE	PROTO S/C ASSEMBLY COMPLETED		04 05 62					09 02 62	11 03 62
09	10	13	GE	PROTO S/C TESTS COMPLETED		04 20 62						D 11 17 62
09	10	14	GE	PROTO S/C ACCEL TESTS COMPL		04 28 62						D 12 01 62
09	10	15	GE	PROTO S/C VIBRATION TESTS COMPL		05 12 62						12 15 62
09	10	16	GE	FIRST FLT S/C ASSEMBLY COMPLETED		05 23 62						12 22 62
09	10	17	GE	FIRST FLT S/C TESTS COMPLETED		06 12 62						01 05 63
09	10	18	GE	PROTO S/C V/T CALIBR COMPL		06 18 62						01 19 63
09	10	19	GE	FIRST FLT S/C VIBRATION TEST COMP		06 19 62						01 26 63
09	10	20	GE	PROTO S/C V/T TESTS COMPLETED		07 15 62						02 09 63
09	10	21	GE	PROTO S/C V/T CALIBRATION COMPL		07 23 62						02 16 63
09	10	22	GE	PROTO S/C READY FOR SHIPMENT		08 01 62						03 02 63
09	10	23	GE	FIRST FLT S/C V/T CALIBR COMPL		08 20 62						03 16 63
09	10	24	GE	FIRST FLT S/C V/T TESTS COMPLETED		09 18 62						04 06 63
09	10	25	GE	FIRST FLT S/C V/T CAL CHECKS COMP	A	09 26 62						04 13 63

NASA FORM 5 [illegible]


PROGRAM MANAGEMENT PLAN
05 02 62
09 10 26
FIRST FLT S/C READY FOR SHIPMENT
01 24 62
04 07 62
02 21 62
03 07 62
03 21 62
04 04 62
05 02 62
04 27 63

V-40

PART VI

PROCUREMENT MANAGEMENT ARRANGEMENTS

Table VI-1

Major elements of the Nimbus project will be accomplished through contract or interagency transfer of funds as indicated.

ELEMENT	CONTRACTOR OR AGENCY	PROCUREMENT CENTER	TECHNICAL DIRECTION	CONTRACT ADMINISTRATION	
				PRIMARY	SECONDARY
SPACECRAFT					
Integration and testing	GE/MSVD	GSFC	GSFC	GSFC	Philadelphia A.P.D.
Stabilization and control subsystem	GE/MSVD	GSFC	GSFC	GSFC	Philadelphia A.P.D.
Power	RCA	GSFC	GSFC	GSFC	Newark A.P.D.
Telemetry					
PCM	Radiation Inc.	GSFC	GSFC	GSFC	Orlando A.P.D.
Command	Cal. Computer				
	PDTS	GSFC	GSFC	GSFC	L.A. Army Ord. Dist.
Command receivers	RCA	GSFC	GSFC	GSFC	Newark A.P.D.
Sensory & auxiliary subsystem					
Advanced vidicons	RCA	GSFC	GSFC	GSFC	Newark A.P.D.
HRIR (radiometer)	ITT	GSFC	GSFC	GSFC	Indianapolis A.P.D.
HRIR (tape recorder)	RCA	GSFC	GSFC	GSFC	Newark A.P.D.
MRIR (radiometers)	Santa Barbara Research Corp.	GSFC	GSFC	GSFC	L. A. A.P.D.
MRIR electronics	Aero-Geo-Astro	GSFC	GSFC	GSFC	-------
MRIR tape recorders & PCM tape recorders	Raymond Engineering	GSFC	GSFC	GSFC	Inspector of Naval Material, Bridgeport, Connecticut.
LRIR radiometers	Barnes Engineering	GSFC	GSFC	GSFC	U.S. Army Ordnance District, Boston
Transmitters					
S-band	General Electronics	GSFC	GSFC	GSFC	-------
FM	Hughes Aircraft	GSFC	GSFC	GSFC	L. A. A.P.D.
AM	Texas Instruments	GSFC	GSFC	GSFC	-------
Antennas	University of Mexico	GSFC	GSFC	GSFC	-------
LAUNCH VEHICLE					
Thor	AFSSD/Douglas	AFSSD/ MSFC	AFSSD/ MSFC	USAF	MSFC
Agena B	AFSSD/Lockheed	AFSSD/ MSFC	AFSSD/ MSFC	USAF	MSFC

MSFC is responsible for the launch vehicle system which includes:
1. Thor booster 2. Agena B second stage 3. Shroud and shroud separation 4. Integration of launch vehicle system

NOTE: MSFC will place an order on the Air Force Space Systems Division for the Thor/Agena B launch vehicles. AFSSD will contract with Douglas for the Thor boosters to be provided as government-furnished equipment to the Lockheed Missiles and Space Company. Lockheed, under contract to AFSSD, will provide the Agena B second stage and shroud, integrate the stages, and furnish launch support services. Douglas Aircraft Company, under subcontract to Lockheed, will supply the shroud and install it on the prototype at the Space Simulator test facility and on the flight model at the launch pad.

For the purposes of satisfying the above note and to remove the Official Use Only marking, Part VII Resource Requirements has been removed from this copy.

PART VIII

COORDINATED OPERATIONS PLANS

The coordinated operations plan will be available June 1, 1962.

PART IX

PROJECT RESULTS

The current plan for the flow of Nimbus data is shown in Figure IX-1.

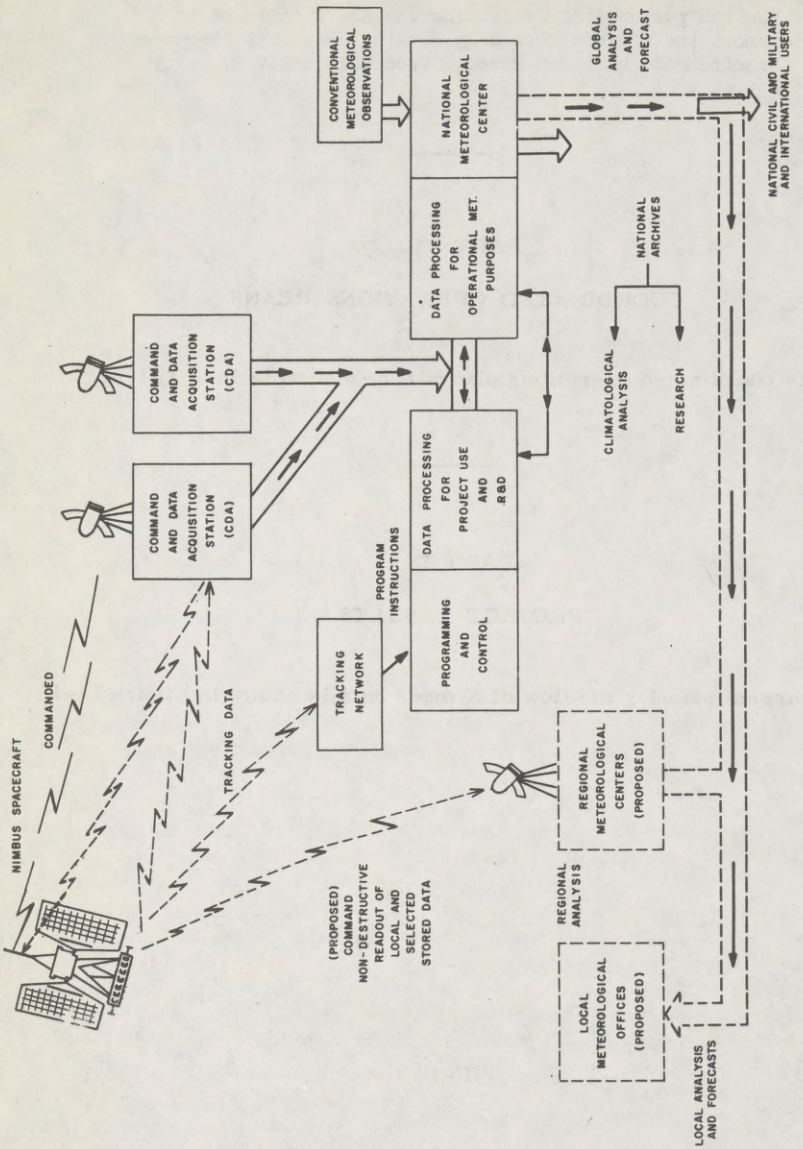


Figure IX-1 – Tracking and Data Acquisition and Data Utilization

MANAGEMENT ASSIGNMENTS

ATTACHMENT 1

STATEMENT OF RESPONSIBILITIES, AUTHORITIES, AND FUNCTIONS FOR THE MANAGEMENT OF THE NIMBUS PROJECT

OVERALL

PURPOSE

This statement assigns responsibilities, authorities, and functions for the accomplishment of the Nimbus project in accordance with the Nimbus Project Development Plan.

MANAGEMENT

Management responsibility for Project Nimbus is assigned as follows:

Project Management. The Goddard Space Flight Center is assigned project management responsibilities for the Nimbus project.

Spacecraft System Management. The GSFC is assigned system management responsibilities for the Nimbus spacecraft system.

Tracking and Data System Management. The GSFC is assigned system management responsibilities for the Nimbus tracking and data acquisition system.

Data Utilization System Management. The GSFC is assigned system management responsibilities for the Nimbus data utilization system.

Launch Vehicle System Management. The Marshall Space Flight Center is assigned system management responsibilities for the launch vehicle system.

Attachments 2 and 3 establish the responsibilities, authorities, and functions of the two centers concerned with the Nimbus project.

MANAGEMENT ASSIGNMENTS

ATTACHMENT 2

STATEMENT OF RESPONSIBILITIES, AUTHORITIES, AND FUNCTIONS FOR THE NIMBUS PROJECT AND SYSTEMS MANAGEMENT

GODDARD SPACE FLIGHT CENTER

GENERAL RESPONSIBILITIES

The GSFC is responsible for the accomplishment of the Nimbus project. In accordance with the approved Nimbus Project Development Plan, it will serve as the Project Management Center with the following broad responsibilities:

For Project Management:

- Integrating the several systems of the Nimbus project, carrying out overall systems engineering activities as necessary.
- Ensuring that oversights and omissions in any aspect of the project are detected and corrected in time to minimize cost overruns, schedule delays, and technical failures.
- Identifying project requirements which have not been anticipated in the Nimbus Project Development Plan, and actively taking steps to obtain solutions to these needs.
- Giving appropriate consideration to the responsibility and authority of the Director, MSFC, for the procurement and modification of the launch vehicle, and for the launch of the Nimbus space vehicle.

For Systems Management:

- Undertaking and completing the technical design, development, fabrication, testing, and operation of the following Nimbus systems:

  Spacecraft system
  Tracking and data acquisition system
  Data utilization system

SPECIFIC FUNCTIONS AND AUTHORITIES AS SYSTEMS MANAGER

The Director, GSFC, within his delegated authority to conduct the activities of his center, will designate a project manager to carry out the following functions for the overall management of the Nimbus project.

Project-wide Planning and Evaluation:

- Initiating and submitting for Headquarters approval Project Development Plan changes necessary to revise the technical parameters, the system assignments to the several field centers, or the scheduled dates of accomplishment for the Nimbus project.

- Maintaining continuous surveillance of schedule milestones for all systems in terms of programmed costs, technical reliability, and completion dates.

- Maintaining a current awareness of all activities inside or outside NASA which may affect the Nimbus project accomplishment.

- Devising technical or procedural changes in areas within his own authority, or recommending such changes to higher authority.

The MSFC, as the launch vehicle system manager for Nimbus, will grant access and information to the Nimbus project manager through the GSFC Agena B coordinator to ensure effective performance of the foregoing functions.

Systems Integration, Project-wide Systems Engineering, and Scheduling:

- Maintaining surveillance over the quality of systems engineering for any of the project's systems to ensure a maximum probability that the several systems will effectively perform their part of the project assignment.

- Deciding interface questions concerning any question of the interrelationships of the several systems which make up the Nimbus project.

- Assigning tasks through the GSFC Agena B coordinator to MSFC for successful incorporation of the launch vehicle system into the project.

- Assigning tasks within GSFC for successful integration of its systems into the project.

- Modifying the schedule of spacecraft and tracking and data system activities without affecting major milestones in the Nimbus Project Development Plan.

- Recommending to MSFC through the GSFC Agena B Coordinator changes in the schedules for launch vehicle system milestones in order to ensure scheduling compatibility among all systems.

- Submitting for Headquarters approval proposed changes in scientific or technical scope of scheduling which go beyond the currently approved Project Development Plan.

MSFC, as launch vehicle system manager, will consider interface decisions by the project manager received through the GSFC Agena B coordinator as conclusive, unless promptly referred to higher authority. The MSFC may refer to higher authority for decision requests to undertake systems engineering and integration assignments when compliance with such requests will result in exceeding MSFC's commitment of resources to the project, as set forth in the Project Development Plan.

Technical Consultation and Advice:

- Establishing ad hoc advisory bodies as appropriate.

- Requesting from appropriate parts of NASA special technical information as required.

- Chairing the Nimbus Working Group as established in the Project Development Plan.

- Participate as a member of the Meteorological Programs Committee.

MSFC will provide participation and information necessary to the effective execution of the foregoing functions.

Budget Requirements and Financial Operating Plans:

- Submitting initial budget recommendations for the project or any of its systems to the Director, GSFC, as part of the annual GSFC

budget preparation, and revisions on a case-by-case basis as requested.

- Obtaining information from MSFC, through the GSFC Agena B coordinator, on its budgetary requirements for Nimbus launch vehicles and manpower or funding needed in overall systems engineering or integration.

- Developing and recommending financial operating plans for the systems assigned to GSFC, and ensuring that MSFC's proposed financial operating plans for the launch vehicle system are in phase with the overall project schedule.

MSFC will furnish the project manager, through the GSFC Agena B coordinator, complete information concerning its budgets and financial operating plans for the launch vehicle system.

Financial Management:

- Making decisions, within the approved financial operating plans or other limitations by Headquarters or the GSFC Director, to commit or to reprogram funds as necessary for the prosecution of project assignments within GSFC.

- Arranging with the approval of the Director, GSFC, for the financing of special unbudgeted requirements and studies concerned with overall systems integration, systems engineering, or reliability.

Contracting Activities:

- Ensuring that GSFC or other NASA elements maintain appropriate technical monitoring over the quality, timing, and costs of work placed with outside contractors or other government agencies.

- Providing close liaison with, and assistance to, procurement officials in their negotiation and administration of contracts for the project.

- Requesting through the GSFC Agena B coordinator status reports as appropriate from MSFC for all launch vehicle system contracts.

MSFC will furnish through the GSFC Agena B coordinator specific information as requested by the project manager with respect to its launch vehicle system contracting activities.

Reports:

- Developing and initiating project reports required by NASA or by project circumstances to keep the project manager, the system managers, and higher authorities informed of project progress.

- Furnishing project reports to Headquarters and the field centers, as established in the Project Development Plan. (In particular, ensuring that MSFC is fully and currently informed of Nimbus spacecraft and tracking system activities.)

- Ensuring that data resulting from the project are disseminated in accordance with the provisions of the Project Development Plan.

MSFC will meet the reporting requirements established by the Nimbus Project Development Plan and those determined by the Nimbus project manager and the GSFC Agena B coordinator.

INTERNAL ORGANIZATIONAL ASSIGNMENTS

The Director, GSFC, will retain overall responsibility for the performance of project and systems assignments entrusted to his center. He will assign the immediate responsibility for the foregoing functions and responsibilities to an appropriate project management and system management staff as established within GSFC by the Nimbus Project Development Plan.

AUTHORITY LIMITATIONS

Authority delegated herein will be exercised in accordance with applicable laws and regulations.

MANAGEMENT ASSIGNMENTS

ATTACHMENT 3

STATEMENT OF RESPONSIBILITIES, AUTHORITIES, AND FUNCTIONS OF THE LAUNCH VEHICLE SYSTEM MANAGER FOR THE NIMBUS PROJECT

MARSHALL SPACE FLIGHT CENTER

GENERAL RESPONSIBILITIES

The MSFC is responsible for successful procurement, modification and operation of the Nimbus launch vehicle system. In accordance with the approved Nimbus Project Development Plan it will serve as the launch vehicle system management center with the following broad responsibilities:

- Undertaking and completing the technical design, development, fabrication, testing, and operation of the Nimbus launch vehicle system.
- Coordinating vehicle system procurement and modification with the requirements of other systems and the project as a whole, as established in the Nimbus Project Development Plan and as determined by the Nimbus project manager and the GSFC Agena B coordinator.
- Ensuring that requested launch vehicle modifications do not compromise the launch vehicle's minimum requirements for reliable performance.
- Undertaking the launch of the Nimbus space vehicle.

In carrying out the foregoing responsibilities, the Marshall Space Flight Center will:

- Ensure that oversights and omissions within the system are detected and corrected in time to minimize cost overruns, schedule delays, and technical failure.
- Identify system requirements which go beyond the provisions of the Nimbus Project Development Plan and, in consultation with

the project manager and the GSFC Agena B coordinator, initiate or seek solutions to these needs.

SPECIFIC FUNCTIONS AND AUTHORITIES FOR VEHICLE SYSTEM MANAGEMENT

The Director, MSFC, in accordance with his delegated authority to conduct the activities of his center and with recognition of his obligations to support the GSFC in its overall management of the Nimbus project, will undertake all technical, procurement, budgetary, and other actions necessary to successful development and operation of the launch vehicle system established in the Nimbus Project Development Plan. The Director, MSFC, will designate a Nimbus launch vehicle system manager to undertake the following functions:

System Engineering and Scheduling:

- Directing all system engineering on the launch vehicle necessary to meet Nimbus project requirements.
- Deciding interface questions among subsystems within the launch vehicle.
- Requesting other parts of NASA to undertake work on contract monitoring, testing, reliability studies, or other activities as appropriate to achieve the technical compatibility of subsystems.
- Determining and recommending for project manager, GSFC Agena B coordinator, and Headquarters approval, the schedule (and changes in the schedule) affecting the launch vehicle system.

Participation in Overall Systems Integration:

- The MSFC will consider interface decisions and task assignments made by the Nimbus project manager, the GSFC Agena B coordinator, or the Director, GSFC, concerning overall systems integration to be conclusive until (or unless) reversed by higher authority.
- Task assignments from the Nimbus project manager or the GSFC Agena B coordinator may be referred for decision by higher authority when acceptance would overtax MSFC's resources beyond the agreed commitments as specified in the Nimbus Project Development Plan.

- The MSFC will participate fully in reporting, information, advisory, and other procedures designed to provide the Nimbus project manager and the GSFC Agena B coordinator with optimum cognizance of all project systems. These procedures may be either those established in the Nimbus Project Development Plan, or special requests and procedures made by the project manager or the GSFC Agena B coordinator, pursuant to Goddard Space Flight Center's project management authority.

Technical Consultation and Advice:

- Establishing ad hoc advisory bodies as required by the launch vehicle system.

- Requesting from appropriate parts of NASA special technical information as required by the launch vehicle system.

- Chairing and participating in Agena B Panels and Working Groups as established in Part V of the Project Development Plan.

Budget Requirements and Financial Operating Plans:

- Submitting to the Nimbus project manager, through the GSFC Agena B coordinator, initial budget recommendations for Nimbus launch vehicle procurement as part of the total project estimates for the annual NASA budget preparation and revisions on a case-by-case basis as requested.

- Developing and recommending to the Director, MSFC, financial operating plans for the launch vehicle system (or changes in such plans) which are in phase with the overall Nimbus project schedules.

- Furnishing to the Nimbus project manager and the GSFC Agena B coordinator financial information on the launch vehicle system as requested.

Financial Management:

- Making decisions, within approved financial operating plans or other limitations by Headquarters or the Director, MSFC, to commit or to reprogram funds as necessary within allocations for the specific class of vehicles used by the Nimbus project.

Contracting Activities:

- Ensuring appropriate technical monitoring over the quality, timing, and costs of launch vehicle work placed with contractors or other government agencies.

- Providing close liaison with, and assistance to, MSFC procurement officials in their negotiation and administration of launch vehicle system contracts.

Reports:

- Furnishing launch vehicle system reports to Headquarters, the Nimbus project manager, the GSFC Agena B coordinator, and other parts of NASA, as indicated in the Nimbus Project Development Plan, or furnishing additional information as requested by the Nimbus project manager or GSFC Agena B coordinator.

INTERNAL ORGANIZATIONAL ASSIGNMENTS

The Director, MSFC, will retain overall responsibility for the performance of systems assignments entrusted to his center. He will assign the foregoing functions and responsibilities to an appropriate system management staff as established within the MSFC by the Nimbus Project Development Plan.

AUTHORITY LIMITATIONS

Authority delegated herein will be exercised in accordance with applicable laws and regulations.

Dr. TEPPER. In this document we spell out what happens if there is no agreement on these problems within the project.

The question then goes to the next echelon in both organizations. In the Weather Bureau it goes to Mr. Dave Johnson, deputy to Dr. Singer.

In NASA organization it goes to the Chief of the A. & M. Division in Goddard Space Flight Center.

The next level beyond that consists of Dr. Singer and myself as the managers of the programs in our respective organizations.

Colonel PEACOCK. Where do you go from there?

Dr. TEPPER. We didn't spell out where we go from there.

As of yet we have had no problems of this kind that we have had to discuss, and on which we had agreement or disagreement.

Dr. Singer is still quite new on the program and I suspect I will be hearing from him as these problem areas develop in the execution of the program.

Colonel PEACOCK. I think you are to be commended for such a fine job of coordination.

The point I wish to make is, this is very fine, but it looks as if this system is a substitute for a better management system because somebody did not clearly define overall program responsibility.

As Mr. Fulton pointed out, why not place it on one individual?

Who is going to blow the whistle? I can see, if you weren't such good friends and working in such close harmony together, he could sit down and blow the whistle all day and nothing would happen.

There may be a future case where you would have to go to a court of final appeals.

We have seen other very fine satellite programs bite the dust, Advent being one, because of this very same breakdown on sound management.

The committee just can't understand why this split has been made.

Can either one of you address yourselves to why this split was made this way and why one person was not vested with overall program authority?

Mr. HECHLER. Responsibility means leadership, too.

Mr. FULTON. We could point out two more perhaps that have difficulties on management.

One is the Centaur engine program and the second one is the nuclear power program in space.

Dr. TEPPER. I would request that first, the organization structure, or this court of appeals structure I just described, be given an opportunity to work, before we worry about its breaking down.

As I said, we have not as yet reached a point where it has broken down.

Colonel PEACOCK. We waited on one program and it cost the taxpayers an additional $76.5 million.

Mr. HECHLER. One of the jobs is to anticipate the difficulties before they arise and take such steps as necessary.

Mr. TEPPER. Yes, sir.

Mr. FULTON. When we have a year's slippage already stated on the Nimbus program I would say that the midget is already on Morgan's lap; it is here. [Laughter.]

Mr. HECHLER. I am not old enough to remember that.

Dr. TEPPER. Thank you, Mr. Chairman.

Now, with regard to the overall responsibility point that you raise, I repeat my request that the existing structure be given an opportunity to function, I am not saying to fail but at least to function, to see whether we need to have another court of appeals or another level to go to.

Colonel PEACOCK. You already experienced a breakdown in the case of sense of urgency. We find some of the users feel their sense of urgency is not being met and now are standing on what they think is shaky ground. They would like to have their own satellite because you are not going to be able to hold to your schedule.

So we feel that somewhere within this committee structure the communications system is breaking down.

Do you have any fears that this will get worse, or do you think this is just a minor problem that can be rectified without changing the management structure and vesting the authority in one agency, either Weather Bureau or NASA, for overall program responsibility?

Dr. TEPPER. I think perhaps the difficulty discussed is one of semantics and I will investigate and try to find out where this sense of urgency with regard to a specific launch date has been expressed in the past, and what is the nature of the current sense of urgency that has been indicated timewise.

Mr. HECHLER. I would say that far more important is what we do in the future than in reviewing what may have happened in the past.

Dr. TEPPER. I understand that, sir.

Mr. FULTON. How we make up this time that has been lost.

Mr. HECHLER. Dr. Singer.

Dr. SINGER. I will try to give a summary answer if I can to your question, Colonel Peacock.

We do have the authority and responsibility on the operational meteorological satellite system.

Colonel PEACOCK. We feel there is no question there.

The question is basically within the R. & D. program.

Dr. SINGER. We have the funds. You have asked where does the authority seem to be divided.

The reason this is so is because we recognize the competency of NASA in the spacecraft and space vehicle area and we do not wish to duplicate this competency elsewhere in the U.S. Government structure.

Therefore, we have given NASA a purchase order—it is the largest purchase order NASA has from any group—and we have set up an interagency agreement.

Colonel PEACOCK. You didn't give away the management responsibility when you gave NASA the purchase order, did you?

Dr. SINGER. Yes.

I would say as long as we have proper fiscal reporting, proper technical reporting, and adherence to the interagency agreement, which means free access to all the data from the satellite and the processing of the data, then we shall have no complaint whatsoever in any aspect, or any phase, of this interagency management relationship.

Colonel PEACOCK. For operational satellite?

Dr. SINGER. Yes, sir.

Colonel PEACOCK. Do you feel in your opinion vesting the authority for the overall program management both R. & D. and operational, in

one agency, would accelerate, or enhance the program in any way at this particular time or in the future?

Dr. SINGER. I don't think it would at this particular stage of game; no, sir.

Colonel PEACOCK. In the future, do you think it could?

Dr. SINGER. That is a very difficult question.

Mr. HECHLER. I think it would be helpful if representatives of each agency here would give some serious thought to the questions that the committee has brought up and to submit for the record any recommendations on the administrative arrangements and any suggestions on how to improve on the administrative arrangements, with particular attention to the future without trying to defend the past, or talk about what has happened in the past.

Colonel PEACOCK. If you would submit any recommendations that you feel may be warranted on future management relationships the committee would be more than happy to have them for the record.

Mr. HECHLER. Both members of the committee and staff will also be in touch with you on any additional questions that we have for the record.

I think this hearing, if nothing else, might provide some valuable material for Ph. D. dissertations, and I think that we have provided a very useful formula here for the representatives of the interested agencies to express their opinion.

I only say this in conclusion, that I am certain that you gentlemen share with the committee the feeling of the sense of urgency of this program which has already indicated such rich rewards to us in our space efforts.

Any further comments by members of the committee, questions or comments by witnesses?

The committee will stand adjourned.

Thank you very much, gentlemen.

(Whereupon, at 12:17 p.m., the committee adjourned to reconvene at 10 a.m., Tuesday, September 4, 1962.)

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METEOROLOGICAL SATELLITES

TUESDAY, SEPTEMBER 4, 1962

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE NO. 4,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Ken Hechler (chairman) presiding.

Mr. HECHLER. The committee will come to order.

This morning we are continuing our hearings on the development of weather satellites.

The committee has already heard—last week—from representatives of the Department of Defense, Weather Bureau, and NASA, in that order.

The success of the Tiros weather satellites is outstanding. These successes, along with delay in the development of Nimbus, have prompted the Weather Bureau to recommend the launching of additional modified Tiros satellites as an interim operational system until the Nimbus program is ready.

One of the items that was brought out in last Thursday's testimony from NASA was that NASA had received no statements of urgency from the users regarding the development of Nimbus system, yet the Weather Bureau indicates that the Air Force has stated an urgent need for Nimbus.

There are some inferences also in the testimony developed last week that the Air Force feels that it may be necessary to initiate a separate meteorological satellite system to meet military requirements due to the delays in the Nimbus program.

I think one of the things that has concerned me and the members of this committee in these hearings is that there appears to be no single overall manager for both the research and development and the operational meteorological satellite system. NASA is responsible for the R. & D. program while the Weather Bureau is responsible for the operational program.

I would feel that perhaps a better administrative arrangement could be devised and whether we should expect the President to step in and resolve conflicts as they arise. That appears to be the only level that the conflicts could be resolved on, and that is one of the things I think that the committee would like to examine this morning with representatives of all three agencies.

I am somewhat confused by the large number of coordinating agencies that are involved in this highly important program, because of the indication that such coordination does not appear to be completely effective.

I believe, for example, the testimony of the military representatives might seem to indicate that such a coordination has not been completely effective.

Also there ought to be a greater sense of national urgency established for the weather satellite program.

The committee is also concerned that the necessary technical personnel be assigned to speed up the program, and that sufficient funds be provided to insure that there is no lag or delay in the program.

Weather satellites, as was brought out before this committee, are not only providing great practical results, for our own Nation, but they are a great weapon of freedom with reference to underdeveloped nations all over the world.

This morning we have before the committee, Dr. Robert C. Seamans, Associate Administrator of the NASA, Dr. S. Fred Singer, Director of the National Weather Satellite Center, and John H. Rubel, Assistant Secretary of Defense and Deputy Director of Defense Research and Engineering.

With us today, also, is Dr. Francis W. Reichelderfer, the Chief of the U.S. Weather Bureau.

STATEMENTS OF DR. ROBERT C. SEAMANS, ASSOCIATE ADMINISTRATOR, NASA; HON. JOHN H. RUBEL, ASSISTANT SECRETARY OF DEFENSE AND DEPUTY DIRECTOR, DEFENSE RESEARCH AND ENGINEERING; HON. FRANCIS W. REICHELDERFER, CHIEF, U.S. WEATHER BUREAU; AND DR. S. FRED SINGER, DIRECTOR, NATIONAL WEATHER SATELLITE CENTER

Mr. HECHLER. Dr. Seamans, I wonder if you would review, for the committee, the general procedure for establishing requirements for the meteorological satellite program and indicating the management and decisionmaking structure within NASA for establishing schedules and program priorities within the whole program.

Dr. SEAMANS. Mr. Chairman, I would be very happy to discuss management aspects of the weather satellite program.

I wonder if I might start in by just saying a word or two about the matter of urgency, that I know is of concern to you and your committee.

I would like to stress, at the start, this is also of concern to NASA, as it is to the Weather Bureau and the Department of Defense.

I believe that the discussion of last week may have given the impression that NASA did not feel that it was important to carry out an aggressive R. & D. program and implement an operational system at the earliest possible time.

This is not the case.

As of about a year and a half ago, we were reviewing plans for an operational system. It was clear that it was in the national interest to implement such a system at the earliest possible time. This was the basis for request for additional funds that the President made in May of 1961.

This funding served to increase the number of Tiros firings so that we would have interim capability until the Nimbus became available.

I have a letter from Mr. Rubel, dated in July of 1961. He says, in part:

Of particular significance is our requirement for some early operational meteorological satellite capability for providing continuous global coverage on a daily basis.

So that we are pressing forward with a project that is involving people on an overtime basis, that is in some cases, where practical, on a double-shift basis.

The question comes as to whether it is a crash program or not, and it is not a crash program in the sense that we have backed up every subsystem with an ultimate subsystem, and we feel that it would not be wise to carry out the development on that basis.

We feel that we have a good concept for the Nimbus system in the design. It takes extensive testing, and the right kind of quality control, before it pays to launch such a satellite, even the first time, and we do not propose to hold a date unwisely.

When we launch something, we want to have reasonable assurance that the satellite will operate as specified.

Coming now to the matter of organization, I did bring along two charts that I would like to use in my discussion. The first one shows the NASA organization. Using these two charts I would like to have the committee differentiate between the R. & D. effort and the implementation of an operational system.

I would like to first talk about the R. & D. effort. It is clear that NASA has the responsibility for the R. & D. development, but that this development cannot be carried out without giving due consideration to the eventual requirements, and consequently a mechanism was needed that would permit us to work back and forth with the Department of Defense and the Weather Bureau on the R. & D. objectives. That is what this chart shows.

It shows a committee, JMSAC—Joint Meteorological Advisory Committee. This committee is chaired by Dr. Tepper, and it has on it, in addition to the Weather Bureau, representatives from each of the services, as well as from the DOD.

It is our intent, through this mechanism, to receive inputs from the eventual user; namely, the Weather Bureau, as well as from an agency that has many important requirements, DOD, and, at the same time, to inform them with progress on the R. & D. effort.

Within NASA, we have, in headquarters, a program office, the Office of Application, headed by Mr. Stoller, and he has, working for him, Dr. Tepper.

Dr. Tepper is the Director of Meteorological Systems. He is responsible for programing the funds, for establishing the schedules, for the overall technical review of all of our meteorological effort.

The center that is most heavily involved in our meteorological program is at Goddard Space Center at Greenbelt, Md. Within the center there is a division of Aerology and Meteorology, headed by Mr. Stroud, and in this division you will find both the Tiros and the Nimbus projects.

We have, at NASA, a management arrangement in which we delegate to the centers the responsibility for managing specific clearly defined projects.

So it is in line with our management procedure to delegate to the field the running of specific projects, like Tiros and Nimbus.

If I could have the next chart——

Colonel PEACOCK. What is the significance between the dotted and solid lines?

Dr. SEAMANS. I should have explained that.

Thank you very much, Colonel Peacock.

We wanted to show the Weather Bureau is not only represented on the Joint Meteorological Advisory Committee, but that they also have access to headquarters, for discussion with the Application Office, as well as for discussion with Mr. Webb, Dr. Dryden, and myself, and we also feel it is important that the Weather Bureau have a direct communication line with the division out at Goddard responsible for this type effort as well as the project people.

However, the overall inputs that could involve reprograming, reprograming funds, and matters of that sort, must come through NASA headquarters.

NASA centers do not have the authority for reprograming between major projects.

Colonel PEACOCK. The solid line is a command line and the dotted lines are coordinating lines?

Dr. SEAMANS. Yes, you could say that is so.

The chairman of that committee is also the Director of Meteorological Sytems in headquarters, so one and the same man is involved. That is the reason for that solid line between the committee and headquarters.

Colonel PEACOCK. Once this committee establishes the requirements, they become firm requirements as far as NASA is concerned?

Dr. SEAMANS. Yes. We feel it is important that the Weather Bureau be fully informed of the project, and this cannot be done by going just up through the command line in NASA, that they must have free access to information at Goddard.

I might say this is also true of the Department of Defense. They are welcome to visit our installation and review the progress of the program, but also to visit GE and other contractors any time they wish for a full accounting of what we are doing on Nimbus or on Tiros.

Mr. HECHLER. Would you illustrate by means of that chart the development of Nimbus, for example?

When it became apparent that there would be a delay in the development of Nimbus, how and when was that information communicated to the Weather Bureau and the DOD?

Dr. SEAMANS. There are really two times that this matter of schedules was reviewed. Originally in about the middle of calendar year 1960 we planned to have the first Nimbus firing in the second quarter of 1962.

This date was indicated in the original planning document of the so-called POMS report.

At the time this plan was put together we had not had an opportunity, obviously, for detailed planning with the contractors, and this always must be done before you can have a real target date. Until then it is a planning date.

Following negotiations with the contractors, it was apparent this date was not realistic and that a fourth quarter date in calendar year 1962 was the best that could be realized.

This matter was reviewed in the JMSAC Committee to be sure that all participants were thoroughly aware not only of the scheduled dates but the reason for the dates.

Since then we have experienced a number of technical difficulties. In particular we have experienced one in connection with the stabilization system. This gets back to the problem of holding the Nimbus satellite along the local vertical as it travels around in orbit.

In order to do this, it is necessary to have a sensor, an IR scanner, that will measure at all times the direction of the horizon. We have found, as a result of Tiros and other measurements that we have made in orbit, that at the shorter IR wavelength we will get into trouble discriminating between the clouds and the sky. Consequently, we have had to change the IR scanner and go to a longer wavelength.

This change takes time, not only to develop the new scanner, but the circuitry that goes with it.

We have also had difficulty in the new TV vidicon, which is different from the vidicon we have used on Tiros.

RCA has had difficulties. This would have caused a slip had not one arisen in the stabilization development.

We have kept all interested parties informed of these types of technical problems, as well as the resulting slippages or delays, through the mechanism of that committee, and through our close working relationships day by day in the Nimbus project.

Mr. HECHLER. So far as the timing of that information, you do not have any immediate information here this morning?

Dr. SEAMANS. I do not. If you would like to pursue it further, Dr. Tepper may.

(To Dr. Tepper:) Do you have any specific information on when the potential users were informed of what slippage there was in the program?

Mr. HECHLER. You can submit that for the record.

Dr. SEAMANS. Yes, we will.

(The document is as follows:)

Paragraph 1: "On June 22, 1961, at a JMSAC meeting, the members were notified of the Nimbus slip from the second quarter to the fourth quarter of calendar year 1962."

Paragraph 2: "On May 1, 1962, at a JMSAC meeting, the members were notified of the probable Nimbus slip from the fourth quarter of calendar year 1962 to the second quarter of calendar year 1963."

Mr. HECHLER. Will you proceed?

Dr. SEAMANS. Yes, sir.

I have another chart, which shows the Nimbus project office [indicating].

Mr. Press, who is here with us this morning, is the project manager, and he has an office which has four functions: One, the design and development of spacecraft; second, the launch vehicle; third, the data acquisition techniques; and final data utilization.

Data utilization is a direct responsibility of the Weather Bureau, and they have an individual who is assigned to this project office and reports to Mr. Press on a full-time basis so that we can insure continuous input to the project with respect to the ultimate needs of the Weather Bureau.

We also have in the project office other Weather Bureau personnel who have been assigned for the duration of this project.

Mr. HECHLER. The Department of Defense then is not directly represented on this chart?

Dr. SEAMANS. The DOD as far as I know, does not have any of its technical people assigned to this project office. We have them, as you know, assigned to other projects throughout the NASA.

Mr. HECHLER. Before we leave this, I wonder, Dr. Seamans, if you would indicate whether there has been any additional—I don't like to use the word "slippage"—but what is the current estimate on Nimbus?

Dr. SEAMANS. I might just say a word about management aspects related to the scheduled dates.

You ask how we run our programs. We have in headquarters a monthly review of the status of all approved projects. That is a review that I run in headquarters with the program directors and any of the people that they wish to bring to the meeting.

At that time we review all of our principal milestones, not just the target dates, but the dates that must precede launch dates.

The official date that we have for the Nimbus, as approved at our last NASA project status review meeting, which was about 2 weeks ago, was the second quarter of calendar year 1963.

I understand that there is concern in the project office with regard to this date and that there may be a recommendation at the next project status review for a change in the date.

We would not change the date without a very careful review, both with the Goddard personnel as well as with the other agencies involved in the weather satellites, namely, the DOD and the Weather Bureau.

So I am not prepared at this time to say whether this is a date that we can hold and should hold. We will do everything we can to hold the date.

Mr. HECHLER. When you say "concern," you mean concern about technical progress?

Dr. SEAMANS. Yes. I should have said "interested," perhaps.

Mr. HECHLER. Yes.

Mr. Rubel, last week, when we had testimony from the Department of Defense representatives, there was an indication that the DOD requirements for a meteorological satellite system will not be met in a timely manner by the Nimbus project, and there was an inference that the Department of Defense might decide to develop its own military meteorological system; is this correct?

Mr. RUBEL. Mr. Chairman, I have read the testimony that Colonel Cowan gave in that regard, and I think that one certainly could infer that from reading his testimony, namely, at least one of the services might contemplate coming forward with such a proposal.

Colonel PEACOCK. Have they, Mr. Rubel?

Mr. RUBEL. No.

Colonel PEACOCK. Do you anticipate there would be such a requirement from the DOD?

Mr. RUBEL. I think my personal view would go as follows, that, in the first place, the requirements for the meteorological satellite, the military requirements imposed upon the meteorological satellite program, have been specified by the Joint Chiefs of Staff and sent forward as of April 1961, as I testified to here last year.

Those requirements have been reviewed on at least one occasion—probably more than one—and the finding is still the same as it was before, namely, that the Nimbus program will meet the military requirements as presently planned.

The NACCAM—I always have trouble remembering what all the initials stand for, but I guess it is the National Committee for the Coordination of Aviation Meteorology——

Dr. SEAMANS. That is pretty close. It is the National Coordinating Committee for Aviation Meteorology.

Mr. RUBEL. Set up the POMS Panel on Meteorological Satellites and the classified section of the POM report stated the view of the Department of Defense to the effect that the Nimbus program as contemplated would fill the military requirements, and we transmitted that classified paper to the committee last year.

Since last year the Nimbus development project has run into delays and these, of course, affect the time at which the capabilities that are planned will actually become available to us, both from a military and from a nonmilitary point of view.

I would say, however, that there are only two bases on which the Department of Defense would undertake a new R. & D. project in view of this development.

No. 1 would be that we would be convinced that while the satellite, if it worked, would meet our requirements, that we would have lost confidence in the ability of the NASA to do a good development job and felt that even though they might have a delay on their project, we would not have corresponding delays in ours, or that we could invent some better solution than the NASA could—but we don't believe that.

Secondly, that the requirements have changed in some way so that it really was not necessary to wait for Nimbus any more, but that there was some quick and dirty solution to the problem that we could convince ourselves could be put into development and brought into operation more rapidly than by following the orderly programs that we have laid out for ourselves—and we do not believe that either.

Therefore, I would say that it would be highly doubtful that we would find ourselves undertaking, or proposing to undertake, a new satellite development project at this time in this area.

Mr. HECHLER. There is some indication that the Navy might have a design for its own meteorological satellite system to meet its own needs, and I wonder if you care to comment on whether the Navy might be put in such a position that it would be interested in developing a separate system.

Mr. RUBEL. Well, they probably would, or at least might very well be, interested in that.

The Navy has a substantial number of small study programs going on, many of them involving only three or four or half a dozen man-years worth of effort, looking into the possibility of utilizing space technology for a variety of applications that would be of potential value to the fleet in time of war, or even in time of peace, and among these are probable type of devices that would in some cases, according to the present thinking, as I understand it, utilize even Nimbus-type sensors to discern, or to depict, the weather in a relatively local area, where the fleet might be deployed, and where Nimbus- or Tiros-type data would not be available in a timely way.

There is no program to develop devices of this sort. There are these relatively small study efforts to investigate the implications of these different approaches.

Mr. HECHLER. Can you figure out any way to improve this system? I have a feeling that it is rather cumbersome administratively.

Do you think of any way it could be improved, in the national interest?

Mr. RUBEL. Mr. Chairman, I don't think the system is as cumbersome as it looks on paper. It is true that there are an awful lot of initials that stand for various groups, but it is not a simple problem either.

There are a lot of groups interested in weather. It is a subject of great interest to not only organizations but people everywhere.

For that reason the Joint Chiefs fo Staff had found it desirable to establish a group to review and provide a basis for the establishment of requirements—JMG—but that is actually an orderly way to evolve requirements.

The NASA has the responsibility for developing this device. If they did not have it presumably the DOD would. I doubt very much that we would want to see duplication of these programs. No matter which agency had the development responsibility, the other would take an interest in it.

NASA has established JMSAC to make sure there is coordination. DOD, D.D.R. & E., and the three military departments, are represented on JMSAC. I think that is a good way to accomplish coordination without interfering with NASA's authority or responsibility.

NASA has an open-door policy. I have talked to Dr. Seamans on this often, as recently as last week. If any people in the DOD want further information they only have to ask. They are free to visit NASA, or the contractor's facilities. There are no secrets. There are no closed doors.

I think that is a good way to run a program, clearly recognizing one agency, in this case NASA, has the full development responsibility.

Somebody in the Government needs to accept responsibility for the operation of the meteorological system employing these devices, and that logically is the Weather Bureau. I think everybody has fully accepted that. The Weather Bureau in an effort to coordinate their plans in this area has established various groups, including POMS and a committee for specific ad hoc reports.

Again this enables all to be represented here and see what the plans are and influence them. I think that is an orderly way to proceed. I believe that, personally, the existence of these groups reflects a will to make sure none of the operational planned R. & D. or formulation of requirements are conducted in a vacuum, but rather will insure that all interested parties understand what is going on and participate in it to the proper degree.

Mr. HECHLER. I gather from what the witnesses last week said, the military perhaps did not have sufficient opportunity to present the urgency of the requirement to NASA.

Mr. RUBEL. Well, I don't know how to comment on that except to say the following: Mr. Chairman, I first talked to Colonel Cowan after that meeting; we had a session together, and discussed some of his testimony and some of his views.

The JMSAC meets every month. The military representative is Colonel Cowan.

The Air Force representatives are free to ask any questions or state any views—every month. In between meetings nothing stops them from picking up the telephone. They are free to go to NASA, free to go to NASA contractors.

Perhaps Dr. Seamans would like to testify to that, but that is certainly my understanding of the relationship we enjoy with NASA in this regard.

I know of no letter hinderance that has been imposed on any military representative with respect to understanding the program and voicing his views with respect to it.

I did not mention the fact, but I know you are very familiar with it, as is the rest of the committee, that the Unmanned Spacecraft Panel of the Aeronautics and Spacecraft Coordinating Board receives periodic reports on the status of Tiros and Nimbus projects.

There are military and civilian and NASA representatives alike on the Unmanned Spacecraft Panel. They, too, are quite familiar with the program and its progress and its problems.

So I am not aware of any problem of communication or expression between the military folks on the one side and the NASA or DOD on the other.

Colonel PEACOCK. Dr. Rubel, when you were referring to the former testimony on military requirements you stated that you had perfect confidence in NASA's ability, from a technical standpoint, to perform in the Nimbus project, and also stated that the Nimbus project, if successful, would meet the military requirements.

The testimony of former witnesses was not directed toward the technical capabilities of the program or requirements established by JMSAC. They were concerned with the scheduling and the timely production of data that could be utilized for weather forecasting by the military.

This is where there was an inference that maybe there was an internal solution needed to meet military requirements until NASA established a completely operational system.

Would you address a comment to the schedule slippage as it affects the military requirements in this field?

Mr. RUBEL. Yes.

I think that there is a requirement to utilize the Tiros satellites to fill in the gap.

We have discussed this with the NASA people too. The Tiros was originally intended to be an R. & D. satellite, of course, but it is much more useful operationally than I think any of us had probably anticipated.

As a result, although it does not have all the features that will eventually be avilable in the Nimbus, it has enough so that by filling in the gap caused by the delay in the Nimbus development schedules we can tide ourselves over at far less cost and with far more certainty of success than by inaugurating a new program.

This is what we would recommend. I have discussed these schedules with Dr. Seamans and Dr. Tepper and it is my understanding from what they have told me that their plans and our requirements are completely consistent.

Colonel PEACOCK. So the interim operational capability of Tiros would meet the military requirements until the Nimbus system could fill the total requirements; is that correct?

Mr. RUBEL. That is correct; yes.

Mr. HECHLER. Dr. Singer, would you comment a little on how this system can be improved?

I will give you a rather broad question there.

This committee is very deeply interested in seeing that this program moves forward with greater speed and with perhaps more sensible administrative arrangements.

Dr. SINGER. Mr. Chairman, the matter is of such vital concern to the Weather Bureau that I would like to defer to the Chief of the Weather Bureau to make an introductory statement.

Mr. HECHLER. Dr. Reichelderfer?

Dr. REICHELDERFER. Mr. Chairman, your question has to do with how the system can be improved?

Mr. HECHLER. I mean the administrative system now, not the technical system.

Dr. REICHELDERFER. Thank you.

Well, as Dr. Rubel has pointed out, when you deal with weather you are dealing with what everybody is interested in, and if you are going to have coordination, then you have to have representatives from many different organizations.

If you bring those together in committees, with due regard to the necessity for command channels, in order to get things done, then, it seems to me, that you have about the best means for coordination.

Mr. HECHLER. Yet if you overemphasize coordination you may lose leadership, don't you, and responsibility?

Dr. REICHELDERFER. This is a matter of good judgment.

You are quite right, sir. This is a matter of judgment.

And I think loss in leadership is a possibility that has to be watched all the time. I don't see any evidence of the loss of leadership. It is well known and accepted by all the agencies concerned that NASA is the general space agency, that it has the authority, the responsibility and the authority, to see that programs are done effectively, are carried out effectively, and without delay, and, as has been brought out before the committee, there is a sense of responsibility and a recognition of the urgency in getting the Nimbus program going.

The problems were technical problems that were unforeseeable. I remarked in my comments last week that it seems to me the surprising thing is not the relatively small delay but the remarkable dispatch with which this whole program has gotten on the road.

I would guess, as of our expectations on March 31, 1960, the day just before Tiros was launched, I would guess that we now are a year or 2, even 5 years, ahead of where we expected to be in operational achievements with Tiros.

Later on, I believe Dr. Singer plans to bring out a chart—which he just showed me a few minutes ago—about the number of hurricanes that have been discovered initially by the Tiros satellite, and this really is a remarkable achievement.

Usually operations lag behind expectations, but here operations have in fact gone way ahead of schedule—the applications of R. & D.

Further, with respect to organization, the present setup has had frequent review, it has had a great deal of internal scrutiny and constructive criticism, and I have come to the conclusion, which is the same that Dr. Rubel expressed, that although this arrangement, when you set it down on a chart, looks a bit involved, it seems to me it is the most direct and the best arrangement that can be devised as a compromise between straightline command administration and the use of committees to coordinate.

We do have to keep watch constantly as to whether one gets ahead of the other. I don't believe there is loss in management leadership at the present time.

Mr. HECHLER. On that point, I wonder, Dr. Reichelderfer, if you would submit for the record all of the relevant documentation on any joint agreements or directives which delineate the various responsibilities of the Weather Bureau and NASA and the other agencies and uses of Government regarding the meteorological satellite program?

Dr. REICHELDERFER. Be very glad to do so, sir.

(The documentation is as follows:)

AGREEMENT BETWEEN NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND DEPARTMENT OF COMMERCE-U.S. WEATHER BUREAU CONCERNING IMPLEMENTATION OF NIMBUS OPERATIONAL SYSTEM (NOS)

The Supplemental Appropriation Act, 1962, provides the first increment of funds to the Department of Commerce-U.S. Weather Bureau for the joint NASA–USWB implementation of the first phase of a national operational meteorological satellite system.

This phase is to be designated as the Nimbus operational system (NOS), and will correspond to the time period coincident with the NASA Nimbus R. & D. program, and thus is expected to extend approximately through 1965.

It is the purpose of this joint agreement to set forth the functional responsibilities and operating procedures under which NASA and USWB will conduct their respective parts of the NOS Program.

A. RESPONSIBILITIES

The functional responsibilities of the USWB and the NASA under NOS will be as follows:

1. U.S. Weather Bureau:
   - (*a*) Determination of the overall meteorological requirements;
   - (*b*) Specification of quantities to be measured by the satellite meteorological instruments;
   - (*c*) Processing of data for operational meteorological purposes;
   - (*d*) Integration of data into weather analyses;
   - (*e*) Use of data and analyses for forecasts;
   - (*f*) Dissemination of data, analyses, and forecasts;
   - (*g*) Archives (processing, storage, retrieval);
   - (*h*) Research and climatological use of data.
2. National Aeronautics and Space Administration:
   - (*a*) Design, fabrication, and test of the spacecraft;
   - (*b*) Procurement of the launch vehicle;
   - (*c*) Maintenance of launch sites;
   - (*d*) Construction of command and data acquisition stations;
   - (*e*) Prelaunch preparation of spacecraft and vehicle;
   - (*f*) Launch operations, including scheduling;
   - (*g*) Tracking and orbit determination;
   - (*h*) Programing and command to satellite;
   - (*i*) Data recovery at command and data acquisition stations;
   - (*j*) Communication of data to National Weather Satellite Center.

Summarizing the replies to questions about management arrangements during the hearings August 29 and 30, and September 4, it is clearly understood that

the direct responsibility for research and development of new types of meteorological satellites rests with NASA but that responsibility for satellites for regular service operations funded by the Weather Bureau is placed in the Weather Bureau. Thus, there is single management for the R. & D. stages in NASA and single management for the service or operational satellites in the Weather Bureau to the extent that Congress provides funds to the Weather Bureau for this purpose.

In one of the charts discussed during the hearings, reference was made to JM/SAC (Joint Meteorological/Satellite Advisory Committee) and to NOS (Nimbus Operational Satellite). It is our understanding that JM/SAC as its name implies, is advisory and that it has no command authority as might be inferred from the solid line joining JM/SAC with NASA in the chart. Also, this chart does not represent the management relationship with reference to NOS since the operational satellite is the responsibility of the Weather Bureau. JM/SAC is a means for exchange of views and coordination of recommendations relating primarily to technical and scientific aspects of meteorological satellites. It is advisory, not authoritative.

The user requirements or operational characteristics of meteorological satellites have been brought together originally by POMS (Panel on Operational Meteorological Satellites). All Government agencies directly interested in data from meteorological satellites were represented on this panel. The panel has now been superseded by a standing subcommittee on satellites under the general organization of NACCAM (the National Coordinating Committee on Aviation Meteorology) whose activities encompass meteorology in general since aviation meteorology is in fact concerned with practically all phases of the subject in one way or another. This subcommittee is the continuing means for bringing together the views of interested departments at the working level. User requirements are summarized when appropriate in letters from the respective departments to the Secretary of Commerce or the Chief of the Weather Bureau.

In any large operation like the meteorological satellite program, the plans and program are in a more or less continuous process of evolution. New ideas and technological developments call for frequent review and suitable changes. Accordingly, the Weather Bureau as the responsible agent for operational meteorological satellites places much emphasis on close working relationships with NASA and other interested departments and bureaus. Many of the requirements are shaped up through informal conferences with representatives from user agencies. When the proposals reach a stage where they are ready for group discussion by representatives of the interested agencies, they are brought up in JM/SAC or NACCAM/WC/SAT, depending upon whether the subject has to do primarily with R. & D. design questions (JM/SAC) or with operational uses and service requirements (NACCAM/WC/SAT). In some cases the members from the respective departments on JM/SAC are not the same as those on NACCAM/WC/SAT. When necessary for consideration of subject relating importantly to both research and development on the one hand and services on the other hand, the two committees or representatives from the two committees meet in joint sessions.

As stated earlier, these committees are advisory and do not have management authority. When questions arise involving differences in recommendations from various sources, they are settled, if necessary, by the Administrator of NASA if the subject refers to research and development of new satellites and by the Department of Commerce-Weather Bureau if the question refers solely to the operational satellite program.

Since the output of the R. & D. NIMBUS vehicles will be used by the Weather Bureau in the operational system, the interagency agreement for the National Operational Satellite (NOS) applies to R. & D. vehicles insofar as data utilization is concerned. These interfaces in meteorological satellite programing are subjects of continuous coordination between NASA and the Weather Bureau. Insofar as the R. & D. satellites are precursors or development models for NOMSS (the National Operational Meteorological Satellite System), the Weather Bureau needs to express its requirements regarding design and to obtain complete information on progress in development, not only from the technical point of view but also for fiscal purposes and programing schedules. This coordination is provided in a number of ways, both at the working level and at the top management level. One of the ways of effecting close cooperation is the assignment of a Weather Bureau employee as manager of the NIMBUS Data Utilization Systems Office in NASA where he works directly with and is responsible to

the general NIMBUS Project Manager. This link does not however replace the single management organization under which NASA is responsible for R. & D. of new satellites while the DOC–WB is responsible for operational meteorological satellites,

COORDINATING OR ADVISORY COMMITTEES INVOLVED IN WEATHER SATELLITE PROGRAMS

Working-level coordination of the weather satellite requirements and activities of interested Government agencies and departments is carried out mainly via the following committees:

Joint Meteorological Group (JMG) of the Joint Chiefs of Staff.
Joint Meteorological Satellite Advisory Committee (JMSAC).
Working Committee/Satellites (WC/SAT).

JMG, comprised of representatives of the Army, Navy, Air Force, and Weather Bureau, is the formal mechanism for coordinating civilian and military activities.

JMSAC, composed of representatives from the Army, Navy, Air Force, Defense Department (D.D.R. & E.), Weather Bureau, and NASA, was organized by NASA to (*a*) consider requirements of the DOD, Weather Bureau, and NASA in the meteorological satellite program; (*b*) serve as a medium for technical information exchange; and (*c*) assist wherever possible or appropriate in the operating program.

WC/SAT operates under the auspices of the National Coordinating Committee for Aviation Meteorology (NACCAM) and replaces the Panel on Operational Meteorological Satellites (POMS) which preceded it. The Army, Navy, Air Force, Weather Bureau, Federal Aviation Agency, and NASA are represented. WC/SAT: (*a*) conducts and consolidates user requirements for the National Operational Meteorological Satellite System (NOMSS); (*b*) examines the characteristics of NOMSS as they apply to the meeting of these requirements; and (*c*) reports to NACCAM on the plans, status, and progress toward the implementation of NOMSS and the extent to which these satisfy the requirements of the meteoroligcal users.

The essential difference, it would be pointed out, between JMSAC and WC/SAT is the former's prime concern with the research and development of weather satellite systems and the latter's preoccupation with NOMSS. This division of interest is reflected in the fact that JMSAC is chaired by a NASA representative, WC/SAT by a Weather Bureau representative.

Mr. HECHLER. This committee acknowledges and congratulates those responsible for the tremendous strides of progress. The only thing we are concerned about is that further progress will not be crippled by administrative arrangements.

Dr. REICHELDERFER. If I may say so, Mr. Congressman, it seems to me this committee is doing a real service in bringing up these questions and making sure that we have had a careful look at them.

Mr. HECHLER. I would like to ask you, Dr. Reichelderfer and also Dr. Singer, your reaction to having a single manager that would have complete jurisdiction and control over both R. & D. and operational aspects of the meteorological satellite system?

What would be your reaction to that?

Dr. REICHELDERFER. I would like Dr. Singer to comment independently of my remarks.

I will say in the beginning, however, that as a general principle this is a suggestion that is open to constant review and will never be settled.

Some organizations, some very large organizations—I believe this is true in part of the Department of Defense—keep their research and development quite separate from operations, and they have very good reasons for doing so.

Smaller organizations may have them all under one management, one director.

I do not see how, unless by setting up what, in my opinion, would be a superfluous management structure at the top, I don't see how the R. & D. functions of NASA and the operational functions of the Weather Bureau can be placed wholly under single management. The Weather Bureau has some R. & D., too, in this field—but to keep it simple, we do have this general distinction—the R. & D. in satellites is under NASA, but the operational functions of the Weather Bureau and the operational functions of other agencies—geodetic satellites, perhaps communications satellites, and so on—all of these user requirements, which certainly will develop, blossom out manifold in the future, are the responsibilities of the users. It seems to me the prototype organization that we have set up in meteorological satellites is the best solution.

Mr. HECHLER. Dr. Singer, wouldn't such a system as I mentioned clarify responsibility and insure a greater degree of leadership, move the program forward with greater urgency, and also command the necessary technical personnel that we might make greater forward strides in our whole weather satellite program?

Dr. SINGER. I think there are essentially two ways to run a program. One way is to have a single man in charge.

The second way—and this is the way we are proceeding at the present time—is to recognize the competence of NASA in the spacecraft field and the competence of the Weather Bureau in the weather field, and, therefore, we divide the project roughly along those lines.

Now the success of any operation of this type I think depends on having a good, tight, interagency agreement and seeing to it that the people stick with it—and that is our job.

The agreement exists; we are reasonably satisfied with it; it divides roughly along the lines we have indicated, where in the operational system the Weather Bureau is responsible for setting meteorological requirements, after determining these from the users, where NASA then takes over, designs the spacecraft, procures the spacecraft, procures the vehicle, launches the vehicle, commands the satellite, and the Weather Bureau takes over when the data come back to the ground, processes them, and analyzes them, and disseminates them to the users.

This basically is the interagency agreement.

NASA and the Department of Commerce are parties to this agreement. Both agencies still stick to this agreement, and we will try to make it just as tight as we can, so there can be very little latitude, for the more latitude you have the more friction you may develop.

No friction has really developed to speak of, but such possibilities do exist, and I think by defining our responsibilities closely, and seeing to it that the agencies stick to their respective responsibilities we will make a better management success of it.

Mr. HECHLER. This is a rather unique idea, to get representatives of all the agencies involved before the committee, and I believe we are making a greater progress that way.

We are all letting our hair down now. Isn't there some way this could be improved, in the way to pinpoint and clarify the decision-making process?

Dr. SINGER. Dr. Seamans has already explained the setup.

The first chart he showed, according to my understanding, applies to the Nimbus R. & D. vehicle. JMSAC is a committee which advises

NASA but does not command NASA; it brings to NASA the suggestions of various other groups as to how the Nimbus R. & D. vehicle ought to be developed.

Then as I mentioned before, the interagency agreement specifies that the Weather Bureau has the responsibility to coordinate the requirements of users and set the meteorological requirements for the operational vehicles.

We could do this unilaterally. We have the authority to do this. We do not act unilaterally. Therefore, we have, again, a committee which brings us the requirements of the users, and we make sure we have taken all the requirements into account as far as we can before we write a set of specifications which we then transmit to NASA.

Colonel PEACOCK. You say there are two methods of management, one by a single manager, the second by the joint agreement or committee.

Dr. SINGER. The committee does not manage—the committee advises.

Colonel PEACOCK. In this particular case there are at the present time, according to Dr. Rubel's testimony this morning and former testimony before the committee during the NASA authorization hearings, there are five committees in this program—the Joint Meteorological Group, the JMG; the Joint Meteorological Satellite Advisory Committee, JMSAC; there is NACCAM, the National Committee for Coordination of Aviation Meteorology; POMS Group; and the AACB.

There are three large agencies, the Department of Defense and NASA and the Weather Bureau, that are parties to this agreement.

There are two programs: the R. & D. program, which also puts out an operational capability, and is an operational program.

The Weather Bureau has the operational program. NASA has the R. & D. program.

We have seen conflicts regarding schedules, slippages, et cetera, where the users have become concerned. How do you feel these questions will be resolved when you actually come up against an impasse?

Mr. HECHLER. What will happen if conflicts or disagreements between the heads of the Weather Bureau and NASA should arise?

Who resolves them?

Dr. SINGER. This situation has not come up and may not arise.

Mr. HECHLER. This is what the committee is concerned about, looking toward the future, to insure this program moves forward with all possible speed.

Dr. SINGER. I find that if the matter gets beyond my immediate competence and jurisdiction I must then call on the Chief of the Weather Bureau and ask him to handle it with his opposite number in NASA.

Mr. HECHLER. Who has the ball?

This is the question that confuses the committee a little bit.

Dr. SINGER. Well, we essentially have the ball to provide an operational system—because it says so in the congressional legislation.

Colonel PEACOCK. You are so charged by law.

Dr. SINGER. We have to establish an operational system.

Colonel PEACOCK. Yes.

Dr. SINGER. We do want to draw on the competence of NASA, and this is generally recognized.

We have therefore this cooperative type of agreement. We are anxious to keep this cooperation because the success of any system can only be as good as the technical inputs.

We want to be sure that we can get such technical inputs.

Colonel PEACOCK. By "technical inputs" you mean to NASA?

Dr. SINGER. From NASA. In the spacecraft field, in the development of some of the sensors, in the launch vehicle, and in the operation of the launch.

Colonel PEACOCK. How are you assured that the R. & D. system being developed is going to meet your operational requirements?

What authority do you have to see that NASA carries out their R. & D. program to meet your needs?

Dr. SINGER. We have no authority to tell NASA how to build their R. & D.

Mr. HECHLER. We are not interested in asking you to make any critical comments. We are merely interested in trying to develop a better administrative system.

Colonel PEACOCK. We understand at the present time there is no conflict between the Weather Bureau and NASA.

Dr. SINGER. We do not have the authority, but we have so far found no cause to object to any substantial decision made in the R. & D. Nimbus vehicle.

Colonel PEACOCK. In case you did, what would be the next course of action?

Dr. SINGER. We would go to the committee set up by NASA to advise it on how to develop Nimbus; namely, JMSAC, and would make our complaints there, if we have any complaints, and I have a feeling if our complaints are justified they would be listened to and taken into account.

Colonel PEACOCK. So this would be a committee solution, then, on resolving the problem?

Dr. SINGER. Yes.

Colonel PEACOCK. It may not be the Weather Bureau's solution; it would be the committee's solution?

Dr. SINGER. Yes.

Colonel PEACOCK. If you had to start from scratch would you choose this system or a single management system?

Dr. SINGER. The system was set up originally in the DOD and transferred to NASA and most of the development of the meteorological satellite system was done within NASA. Now the realization that there is an operational application came only quite recently, so that the Weather Bureau really was brought in fairly recently.

However, it is generally recognized that the operational responsibility is ours.

To answer your question directly, I think as long as the present system works, I would stay with it, since any change in an existing system would cause delays.

Mr. HECHLER. Dr. Reichelderfer?

Dr. REICHELDERFER. The management responsibility really is clean cut as regards these two fields.

The research and development responsibility is clearly with NASA. The DOD is an important user. The Weather Bureau is an important user. There will be others.

Now it would be impossible to set up any single direction, any single management, in any one of these agencies without having the other interested departments dependent on that management to satisfy their requirements.

This is the relationship with NASA.

Even in the operational satellites our relationships there are every bit as strong, perhaps stronger, than the relationship between a Government agency and a contractor.

NASA in effect carries out the requirements, specifications, we lay down for operational satellites.

So that the management arrangement is really much more clean cut than perhaps the charts or discussion might lead one to believe.

A moment ago reference was made to five committees. It is not quite that complex. POMS has been superseded by the NACCAM Subcommittee on Meteorological Satellites and NACCAM itself is in this not as a satellite committee, but as the parent body to the Subcommittee on Meteorological Satellites.

JMSAC is included for those things which cannot be taken up in a general government committee—that is the classified things only.

So that if we sort these out you will find there is a good reason for each one of the bodies and that the job cannot very well be done by abolishing any one of them.

Mr. HECHLER. That certainly represents substantial progress, if there are only four committees instead of five.

Dr. REICHELDERFER. Really there are only three, because one is a subordinate.

Mr. HECHLER. That is better yet.

Dr. REICHELDERFER. So this management subject has had a great deal of study, and my impression—of course, I am an interested party, because I am in the—I have been in the middle of most of it—but my impression is that it has been reviewed frequently with the idea of constructive criticism and that is a well-streamlined administrative structure.

Mr. HECHLER. When you mention being in the middle, it occurred to me maybe we ought to have somebody at the head as well as in the middle.

Dr. SINGER. Mr. Chairman, we do take our responsibility for operational satellites quite seriously, and do exercise initiative in the program.

For the last 3 months we have been making a very intensive in-house study, which, as I indicated last week, would be completed this week, and it is completed now, because we worked over the week-end.

Colonel PEACOCK. Dr. Singer, what is wrong with the single-management concept?

It has been used in the Department of Defense in the field of transportation. The Deputy Secretary of Defense, the Honorable Roswell Gilpatric, has been up to see our chairman and has pointed out very strongly the advantage to the single-management concept in the operation of the Atlantic Missile Range by the U.S. Air Force.

Is there something wrong with the single-management concept, so that it would not apply to this program?

Every program we have reviewed that has a single manager in charge seems to be very successful such as Transit, Polaris, Mercury, and Apollo. Those programs that follow the joint agreement type solution are the ones that seem to be in trouble—like Centaur, Advent, and others.

Each time the single manager is in charge the program seems to move along very well.

Is there something wrong with this concept that we do not want to use it?

Mr. RUBEL. Colonel Peacock, the single managers that you refer to are not engaged in R. & D.

Any proposal to put all R. & D. in the DOD under the single manager of an R. & D. supply agency would probably be met with some resistance in a number of quarters.

The single manager for defense supplies is a logistics organization. Single management of the ranges, which in fact are not under single management, but under coordinated management, is again a service-type function, not a development function.

As I think somebody pointed out earlier—Dr. Reichelderfer, I believe—in none of the services, to my knowledge at least, is the research and development actually performed by the operating agency?

The Strategic Air Command does not develop bomber planes. The unified and specified commanders who have charge of Polaris submarines do not develop Polaris submarines. And so forth.

So I don't really think that the single-manager concept in the sense that the word is being applied here really applies in the Department of Defense either.

Where very large and separate R. & D. organizations, albeit under military department supervision, are responsible for the R. & D. phase and other organizations the operational phase of every major project they have.

Colonel PEACOCK. Mr. Gilpatric was talking to Chairman Miller about the Atlantic Missile Range, which is an R. & D. range. He was alluding to the principle of operating this range under the single-manager concept through the U.S. Air Force doing work for NASA and other agencies.

In many of these areas where you have the overall program responsibility being carried under one agency the research and development is being done by other agencies. The point I wish to make is that one person is responsible, one decisionmaking authority, even though the particular activities may be carried out by R. & D. agencies vis-a-vis operating agencies.

At this particular point in time it may be advisable to have NASA in charge—but later when the program is designated as an operational program, then the overall management should shift to the Weather Bureau as the single manager.

It appears there is no one man responsible now unless you go to the President for the Space Council. Is there something wrong with this particular basic principle of a simple manager?

Mr. RUBEL. I think there is, yes, something wrong with it, and I think that what you have just said about the single-manager principle requiring the President of the United States to coordinate this project would be true of every other project, too, and if applied to your

analogy of the Atlantic Missile Range, as an example, it would mean that the Atlantic Missile Range would have to be responsible for the development of all projects tested there—at least that is the way I would interpret the analogy.

The Weather Bureau would be responsible for utilizing the output of operational satellites for weather purposes. That is the meaning, as I understand it, of operational responsibility.

NASA is responsible for development. The only way you could alter that arrangement to be conformal with the principle of single management would be to transfer the development responsibility to the Weather Bureau or operational responsibility to the NASA, but in either case you would be duplicating a Government function in a manner which would very importantly alter the existing allocation of responsibilities.

Colonel PEACOCK. You would not have to do this if you designated one agency as a single manager for the whole program, even though NASA was still responsible for the development and the Weather Bureau was still responsible for the operational phase, would you?

Mr. RUBEL. Then I guess I would fail to understand what was meant by single management, because if NASA is responsible for development, NASA must be responsible for development, period.

Just can't be any other way.

Colonel PEACOCK. In the development of spacecraft, yes, but the R. & D. for the ground data reduction system is still being carried out by the Weather Bureau. They are therefore carrying out R. & D. in the program as well as running the operational end. The only thing NASA is doing in the overall program is R. & D. on the spacecraft. R. & D. for data reduction rests with the Weather Bureau as well as all the operational activities.

So both NASA and the Weather Bureau have R. & D. and operations activities within their portion of this program. The reason I say one person should be designated as overall manager is to make timely decisions in the case of conflicts. Eventually the responsibility rests with the Weather Bureau by law to come up with a completely operational system.

So in essence the R. & D. by NASA is being performed for the Weather Bureau to give them this operational capability. The reason I mention the President, that is the first unified authority which could make a decision in case of an impasse.

If you had a designated single manager he could relieve the President of this responsibility.

Mr. RUBEL. Without wanting to prolong this, I think the committee's interest in insuring there is management efficiency is an excellent interest. I agree with you, Mr. Chairman and Colonel Peacock, that if you look at the initials of all of these committees it is very confusing.

None of us believe in managing projects by committee. On the other hand, all of us do believe that if you have assigned the responsibility for the operation and for the development of items as important as the Nimbus satellite and the operational system that will flow therefrom, some mechanism has got to exist to make sure that the requirements are properly reflected to and by the other interested agencies of the Government.

That is what these committees do. They do not run the projects.

I do not contemplate a major difference of view or opinion among any of the principals involved. It has never arisen. There is no reason to think it will. If it did, I don't think it would have to go to the President of the United States.

In practice, that hypothetical situation between the DOD and NASA on programs totaling $5½ billion rather than a few tens of millions of dollars has never arisen.

I don't expect that it will. So that although these committees, the management committees, would represent a cumbersome and unsatisfactory arrangement, are not in fact management committees, and represent a necessary coordinating mechanism.

Mr. HECHLER. Mr. Hines?

Mr. HINES. Dr. Singer, considering your operational responsibilities, what is the process by which you maintain a flow of information from NASA on the progress they are making?

Is there a continual flow of information coming to you, or is it responsive only to your requests?

Dr. SINGER. This is spelled out in the interagency agreement which specifies that continuous reporting is to be made, both fiscal reporting and technical reporting, on the satellites which are funded by the Weather Bureau.

Now, of course, to fulfill our responsibility properly, we ask NASA to give us corresponding information to the best of their ability on the R. & D. Nimbus vehicle, because we must know its status and its problems, both fiscal and technical, to intelligently plan and program the operational vehicles.

We have been able to get the information that we want and I have all the information I need at the present time to manage the program intelligently.

Mr. HINES. Is this reporting system a periodic one, on certain dates, or is it a continuous flow of information, Doctor?

Dr. SINGER. It is more a continuous flow of information. It has not been formalized in a normal reporting procedure as yet.

The program is still very new. The interagency agreement was only drawn up last January and the formalized relationships which must be carried on of course on the lower levels are just being drawn up now.

In the meantime, however, the informal arrangements are doing a satisfactory job of keeping us abreast of what is going on.

Mr. HINES. Then you are continually apprised of the progress being made, are you not?

Dr. SINGER. I make sure that I am continually apprised, yes.

Mr. HINES. Then, because of your recent association with the Weather Bureau, Dr. Reichelderfer could perhaps tell us at what time the Weather Bureau became aware that Nimbus would be delayed?

Dr. REICHELDERFER. Certainly we had an indication of this early this year, perhaps even before.

There have been so many things going on in the space field of that development that I am not sure, but I recall that even before the POMS report—April 1961—there was a discussion about the possibilities of technical difficulties that would mean some delay. But the

definite time, of course NASA informs agencies concerned as soon as it has definitely reached the conclusion that there has to be a change in date, and the official date was as of the date of notification by NASA, although one knows beforehand that there is a possibility of this kind of a thing and it is discussed.

Mr. HINES. Has the estimate of delay progressively increased?

Was it initially a small estimate and then did it grow to 6 months and so on?

Dr. REICHELDERFER. Yes.

Mr. HINES. This is what has happened?

Dr. REICHELDERFER. That is right; yes.

Mr. HINES. At that time did the Weather Bureau discuss—perhaps I am repeating previous testimony, but perhaps to best orient this now—did you discuss this situation with your opposite numbers in NASA and the DOD?

Dr. REICHELDERFER. Yes. Most of these discussions were at the working level. I have had some discussions with Dr. Dryden and Dr. Seamans on this subject and certainly with the DOD representatives, principally in the Joint Meteorological Committee—the Joint Meteorological Group, it is called now.

Mr. HINES. May I ask, at what time did the Weather Bureau decide on the use of additional Tiros satellites to take care of any hiatus?

Dr. REICHELDERFER. This was only recently. Specifically, planning has only been within the last several weeks.

Dr. SINGER. If I may speak to this: When I came aboard June 1, I was apprised of the delay in Nimbus.

I studied the situation and reached some of my own conclusions. I became concerned about things that may go wrong that we cannot anticipate, cannot foresee.

Any R. & D. program may develop problems, even after the satellite is launched. It may turn out that the lifetime is not quite what we would like it to be.

These things are not really quite under our control, or, of course, under NASA's control. Therefore, we wanted to develop alternatives. We must have alternatives, because it is our responsibility to provide that best operational cover that we can, consistent with the state of the art.

The state of the art at the moment is essentially the Tiros satellite and its subsystems, which have functioned extremely well.

I keep coming back to this because it seems that the Tiros satellite, even though it is an R. & D. satellite, has demonstrated a capability to be used operationally, which is quite astounding.

I would like to show to the committee the chart that Dr. Reichelderfer referred to earlier. [Indicating.]

This chart shows the tropical storms, hurricanes and typhoons, observed by Tiros V during the last month.

Of these 10 storms 50 percent were discovered by Tiros V.

This is an enviable record.

This does not mean that if Tiros V were not there, these storms would not have been discovered, but they might have been discovered too late.

They are always discovered when they hit the land and cause damage, of course.

The point is that the satellite discovered these storms at an early stage and therefore aided in their tracking and aided in making preparations to avoid damage.

Therefore, since Tiros is the state of the art, we began these in-house studies to develop an operational version of the Tiros satellite, basically the same spinning satellite with a television camera, but changed in certain respects to give it, first of all, more reliability, secondly, to eliminate those aspects which are not of direct operational use.

We have then tried to meet what we call the operational definition, that is to have two satellites in orbit so that at least one satellite will be available at all times; as soon as one goes out another one is launched.

Mr. HINES. Doctor, you are approaching the time for an administrative decision, a management decision?

Dr. SINGER. The management decision would be the following: we use our available funds to set up an operational system based on the existing Tiros satellite which would run in parallel and be complementary to the R. & D. Tiros satellites which NASA plans to launch in the coming years.

Mr. HINES. Would that be your decision?

Dr. SINGER. I cannot make the decision because it will involve reprograming of funds, but I will see to it that a decision would be made at the earliest time.

Mr. HINES. Who would you look to for decisions?

Dr. SINGER. First the Chief, then in the Department of Commerce.

Dr. REICHELDERFER. This has to be checked with not only Commerce but the Bureau of the Budget. It may be necessary to consult with committees of Congress concerning it.

Mr. HECHLER. We view this with great sypmathy.

Mr. HINES. These are points where decisions would be made?

Dr. REICHELDERFER. Yes.

I believe, sir, your question illustrates the number of agencies and persons and officials involved and explains somewhat our views on the earlier question about single management. I would not want my previous remarks about committees to dilute the statement that in the last analysis, by virtue of congressional action in giving the operational meteorological satellite responsibility to the Weather Bureau, there is a single manager, and it is the Chief of the Weather Bureau, but he has to consult with many people to get the job done.

Dr. SINGER. I should like to add, too, first we would present our plan to this meteorological satellite committee of NACCAM. The users would then tell us whether they like the scheme. If they do not like it, it is scrapped and we try something else. But we must keep coming up with alternatives.

We would also at an early stage want to get the complete and full concurrence of the NASA.

We think that they probably would go along with us because it represents the successful application of a vehicle which they developed.

Mr. HINES. Dr. Seamans, if the Weather Bureau does decide they will go ahead with additional Tiros satellites, and get the concurrence of all the people involved, would this impose an unusual or difficult in-house problem for you technically so far as your resources, talents, and so forth are concerned?

Dr. SEAMANS. No; it would not. We have a team of people at Goddard responsible for Tiros. That team is working side by side with a Nimbus project group. And we have always planned—I say "always"—since approximately a year and a quarter ago—to maintain Tiros satellites in orbit until such time as the Nimbus provides the type information the Weather Bureau wants.

So we have been planning on this basis and will if this is the recommendation of the Weather Bureau.

Mr. HINES. Thank you, Mr. Chairman.

Mr. HECHLER. Dr. Seamans, if the national meteorological program were accorded a DX priority by the President, given the highest national priority, would this in itself accelerate and expedite the program?

Dr. SEAMANS. A DX priority on R. & D. problems we have described here does not necessarily speed up the launch schedule. We are faced with fundamental technological problems. We are working up against the threshold of what Mother Nature will permit us to do.

It is only when delays result from, say, unavailability of standard launch vehicles, that a DX priority helps speed up the program.

Mr. HECHLER. I was under the impression that some of the delay was caused by unavailability or inability to get technical personnel.

I wondered if this would have any effect on the speed with which you could move forward with this program?

Dr. SEAMANS. First, let me make it clear, a DX priority does not make scientific and technical people available for a program. The DX priority only relates to getting on the head of an assembly line where they are making motors, valves, or engines or boosters.

Mr. HECHLER. This is not your problem?

Dr. SEAMANS. Which is not our problem.

As to the desirability of having additional technical and scientific personnel on the program, when you are faced with specific problems only so many people can work on the problem at one time.

It is very difficult to bring in additional people and proceed more rapidly. So I would question whether additional technical personnel would assist us in solving the kind of technical problems I have mentioned earlier in the hearing.

Mr. HECHLER. Dr. Seamans, would you like to add anything following the discussion we have had this morning about administrative arrangements?

Dr. SEAMANS. Yes; I would be happy to make a few remarks, if I may.

I would agree with Mr. Rubel and Dr. Reichelderfer that it is very appropriate to consider these matters in a hearing of this sort, that there is always a question of the manner in which research and development should be transferred over into an operational system. For example, should this be a complete cradle to grave operation, where the same organizational unit takes the project all the way through.

I personally think that the arrangement we have here gives us the advantage of continuity of effort inasmuch as the project office under the people at Goddard is continuing all the way from the R. & D. through to the development of the prototypes to types which will make up the operational system.

In addition, we have recognized at NASA that we have a very great responsibility to see that, wherever possible, this new technology is utilized in operational systems that are of benefit to this country and to mankind.

This is often one very excellent example of the use of this technology in something that is new, has tremendous benefit, and is terribly exciting. It is for this reason that we set up a program office in headquarters specifically devoted to these kinds of applications where there is the real problem of how the technology can be passed over to the ultimate user, and in this case it is the Weather Bureau.

They do have responsibility for the operational system. They are the single management; they have the absolute authority to turn the operational program in NASA on and off as they wish. They can eliminate the funding if they wish on the operational system and turn to other methods of weather forecasting.

From what I have heard, they feel, and we all feel, that satellites give us information that cannot otherwise be obtained, and I do not see this actually happening but it is their prerogative.

However, we are their agents to supply them with the kinds of hardware that are required and we will be using the very same people—coming back to my first point, supplying this hardware—who were used in the initial research and advanced technology projects.

Colonel PEACOCK. Are you running a joint program right now, operational and research, in which the Weather Bureau is funding a portion and NASA is funding a portion?

Dr. SEAMANS. First of all, within NASA we have one program office in headquarters, Office of Application, that, as far as NASA is concerned, is responsible for all the funding, scheduling, and technical review of the program, at Goddard, we are doing the in-house Government work on the hardware as well as managing the contract effort at General Electric, RCA, and other contractors.

This office must take the responsibility for the research and development decisions and must be responsive to the Weather Bureau on the decisions that relate to the operational system.

But when we move into the operational system the program in effect is larger, it involves more than just space technology, it involves the total weather community of this country and the world, giving the best possible service to all users.

NASA is not in position to satisfy this type function.

Colonel PEACOCK. Is any of the Tiros program being funded by the Weather Bureau?

Dr. SEAMANS. No. The Tiros program to date is funded by NASA and is a R. & D. program.

Colonel PEACOCK. How about Nimbus?

Dr. SEAMANS. Nimbus is split. The R. & D. portion is NASA funded and the decisions that NASA makes relate to the use of that funding.

The operational Nimbus system, which is further downstream, has funding from the Congress to the Department of Commerce, and the decisions in the operational system relate to the use of those funds.

Colonel PEACOCK. In other words, one office is spending all the money?

Dr. SEAMANS. Within NASA the funding control, both for the R. & D. and the operational system, goes through our Office of Application.

We are holding them accountable for both the funds we are authorized by the Congress directly to NASA as well as for those funds that are transferred to us by the Weather Bureau.

Colonel PEACOCK. So in essence the Nimbus program has a single manager within NASA?

Dr. SEAMANS. Within NASA we have a single manager. In the sense that we are managing all of our projects.

Colonel PEACOCK. In the case of Nimbus for even the Weather Bureau portion?

Dr. SEAMANS. Yes; we have in NASA headquarters a single office for programing the funds, reviewing the schedules, and technical progress. We have at Goddard a single technical management team both for the in-house work as well as for the contract effort.

Colonel PEACOCK. That is the area where the Weather Bureau have their section integrated within the NASA organization? Is this the same section you are talking about, the one in red [indicating]?

Dr. SEAMANS. No; the reason that shows red is that there is a Weather Bureau man who has been assigned to this project office and reports in to the project manager at Goddard.

Colonel PEACOCK. Who decides how the funds will be split, who determines what portion the Weather Bureau picks up and what portion NASA picks up within the Nimbus project?

Dr. SEAMANS. It is not an either-or proposition.

We are pressing forward on the development of Nimbus and all the funds that are used for the R. & D. are allocated by headquarters to Goddard and are the responsibility of this project manager.

The funds for the implementation of the operational system are transferred to NASA, NASA serving as agent for the Weather Bureau, and those funds also allocated to Goddard and are the responsibility of this project manager.

Colonel PEACOCK. Right through the same NASA channel?

Dr. SEAMANS. Yes.

Mr. HECHLER. Dr. Singer?

Dr. SINGER. On this matter of funds, if I could add, the Weather Bureau funds were transferred to NASA in the form of a purchase order and it specifies what the funds are to be spent for.

They include two spacecraft, two launch vehicles, two command and data acquisition stations, and a certain amount of technical management.

Mr. HECHLER. Have you ever had any difficulty in connection with getting the funding you needed?

Dr. SINGER. We only received one funding so far for fiscal year 1962 and have had no difficulties.

Mr. HECHLER. Do you anticipate any difficulties under this procedure?

Dr. SINGER. Getting funds from Congress?

Mr. HECHLER. Do you have any recommendations to make about the procedures, sir?

Dr. SINGER. As far as our funding is concerned from Congress, no, sir, I do not. I only hope you will keep your interest in seeing to it that the Nation gets an operational satellite program as soon as possible.

Mr. HECHLER. That is the purpose of these hearings.

Colonel PEACOCK. How do you determine how much money you are going to transfer to NASA on these purchase orders.

Dr. SINGER. The way it works is as follows:

That is a bit technical, but I have made it my business to find out how it works.

NASA works on incremental funding; the Weather Bureau, on the other hand, has project funding. Therefore we have been funded for the total of these two spacecraft by Congress.

A purchase order was written to NASA February 1 covering two spacecraft, two data acquisition stations, and a certain amount of technical management. This purchase order now rests with NASA.

This does not mean our responsibility is over.

It is our job now to find out how the money is being spent, insure it is spent as we agreed, and be accountable for it at all times.

In my case I must be accountable to the Chief and to the Department of Commerce, and ultimately to the Bureau of the Budget and to Congress for every penny.

Colonel PEACOCK. Do you have any technical input along with this?

Dr. SINGER. Yes. NASA bills us and we reimburse them as they bill us.

They bill us for funds expended. We verify the billing. If we agree with it we reimburse them.

Colonel PEACOCK. Your vertification includes a technical review?

Dr. SINGER. This is really how we exercise technical review. It is through the billings. If we did not have this feature built in we would have to rely completely on good will.

This way we have a legal responsibility.

Colonel PEACOCK. Do you know where your dollars go?

Dr. SINGER. Yes. There is part of an interagency agreement also.

Colonel PEACOCK. This agreement does not give all the technical details we have referred to, does it?

Dr. SINGER. No.

Colonel PEACOCK. Does it spell out each activity?

Dr. SINGER. No.

Colonel PEACOCK. Just general areas?

Dr. SINGER. Yes.

Colonel PEACOCK. In essence, for the Nimbus project you have a single manager—it is NASA. They are carrying out your operational responsibility in addition to exercising jurisdiction over the whole project, even though you are funding the operational portion.

Dr. SINGER. NASA does have a single manager essentially for their phases of the program, which include construction of the spacecraft, launching, construction of the CDA station.

Colonel PEACOCK. Who will determine when the project will pass from the R. & D. phase to the operational phase?

Dr. SINGER. This is somewhat a matter of semantics, but in essence I would view it as follows: As soon as Congress gave us the funds to

establish the operational system, we have thereby an operational system.

It is not the ultimate operational system, it is not a real operational system in the sense I defined it last week, but it is an operational system of sorts.

Colonel PEACOCK. What I am trying to determine is when will the major responsibility pass from NASA to the Weather Bureau?

Dr. SINGER. NASA has the major responsibility during the R. & D. phase. At some date in the future the Weather Bureau will have it. But, I don't see NASA getting out of the act.

Colonel PEACOCK. It looks to me like NASA will never get out of the act.

Dr. SINGER. Right. We have full confidence in their technical competence in the development of the Nimbus spacecraft. We view the fact that there has been delay with some concern but we understand it, we are very sympathetic, we realize that in an R. & D. project dates are more like milestones and cannot be adhered to absolutely.

I think perhaps some of the trouble with the Advent program—and we made our management study of it by now—was that there was a strict insistence that artificial launch dates be adhered to.

We do not propose to do this here. But as I did explain before, it is our responsibility if there is a delay which is serious as far as the users are concerned, that we come up with alternatives.

We have funds and we should use these funds for the purpose intended. The general purpose intended for the use of these funds is to povide operational cover for such Weather Bureau customers.

Dr. PEACOCK. Sir, what is your anticipated date when the operational system would be turned over to you; and, second, if the interim operational Tiros system, is approved, will you have complete jurisdiction over it?

Dr. SINGER. To answer question No. 1, we do not ever anticipate doing the complete job ourselves, in the following sense, that even, let's say, 5 years from now, when Nimbus is what we might call fully operational, we will still work with NASA in asking them to procure for us the Nimbus spacecraft, see to it that it is checked out, certify to the fact that it is worthy to be shot up into orbit, and see to it that it goes into orbit.

Colonel PEACOCK. Will this be a happy marriage of long standing?

Dr. SINGER. We look forward to a very long marriage and want to be sure this stays so.

On the operational Tiros, our feeling is that the Tiros satellite has proved itself and that the R. & D. on the Tiros satellite is essentially complete.

That is not to say that more cannot be done, but as far as certain operational applications are concerned, the Tiros satellite is adequate.

We have, therefore, made a study to see how the existing Tiros satellite could be put into active operational use.

The results are very encouraging. I would like to, perhaps, show you one chart, which comes out of this study that we have made in the past few weeks, which shows the type of coverage we get with two Tiros satellites in orbit at the same time, which would be, we would hope, the situation, let's say, 90 percent of the time—two satellites in orbit.

When one satellite fails some time would, of course, elapse before it is replaced, so it may be that 10 percent of the time you would have only one satellite in orbit, which gives the minimum satellite cover.

Colonel PEACOCK. Would you fund this completely and manage it?

Dr. SINGER. We would try to use the same system we have indicated for Nimbus, we would work with NASA but we would fund it.

Colonel PEACOCK. Booster and spacecraft?

Dr. SINGER. Turn over the funds to them and ask them to procure the spacecraft and procure the boosters. Essentially we would like to act with NASA on the Tiros satellite now as we would like to act with Nimbus 5 to 10 years from now.

Colonel PEACOCK. Are you going to draw up a separate agreement or use the existing agreement?

Dr. SINGER. Use the existing agreement and determine whether any changes are necessary.

Mr. PEACOCK. If everyone approves it when do you think you can launch your first satellite?

Dr. SINGER. June 1, 1963.

The chart, by the way, is right here [indicating].

Mr. HECHLER. Without objection, I think we should put the chart in the record.

Dr. SINGER. Because of the way the satellite orbit changes, and because of the way the day and night situation changes, and because of the spin axis of the coverage, the earth does change slowly, but this is a typical chart [indicating], which shows what can be done.

The green shows the coverage obtained with one Tiros satellite, the orange the coverage obtained with the other.

The area in between is not covered continuously but one quarter of the area can be covered during any one day.

The amazing thing that comes out of this study is that we get essentially worldwide cover with two Tiros satellites.

Colonel PEACOCK. Critical areas are covered?

Dr. SINGER. Yes.

Mr. HECHLER. Would you do better with three?

Dr. SINGER. Somewhat better but not better enough to justify the additional expense.

Mr. HECHLER. Yes.

Dr. SINGER. The system as it stands now would definitely favor the North American Continent, and it would provide cover there at all times. In fact under one condition it would cover the North American Continent twice a day.

This is because the present readout stations for Tiros are located in California and on the east coast.

Mr. HECHLER. Mr. Davis, do you have any questions?

Mr. DAVIS. I would like to ask one question.

There has been some testimony to the effect that the word "urgency" has not cropped up in any of the agreements or correspondence or conversations.

I would like to ask if this possibly is not true with a program which has such obvious advantages to the human race as this weather program does—the savings in life, limb, and property, crops, navigation, and other things? Isn't it possible that it would be rather silly to go around talking about urgency? Isn't it more or less like the dis-

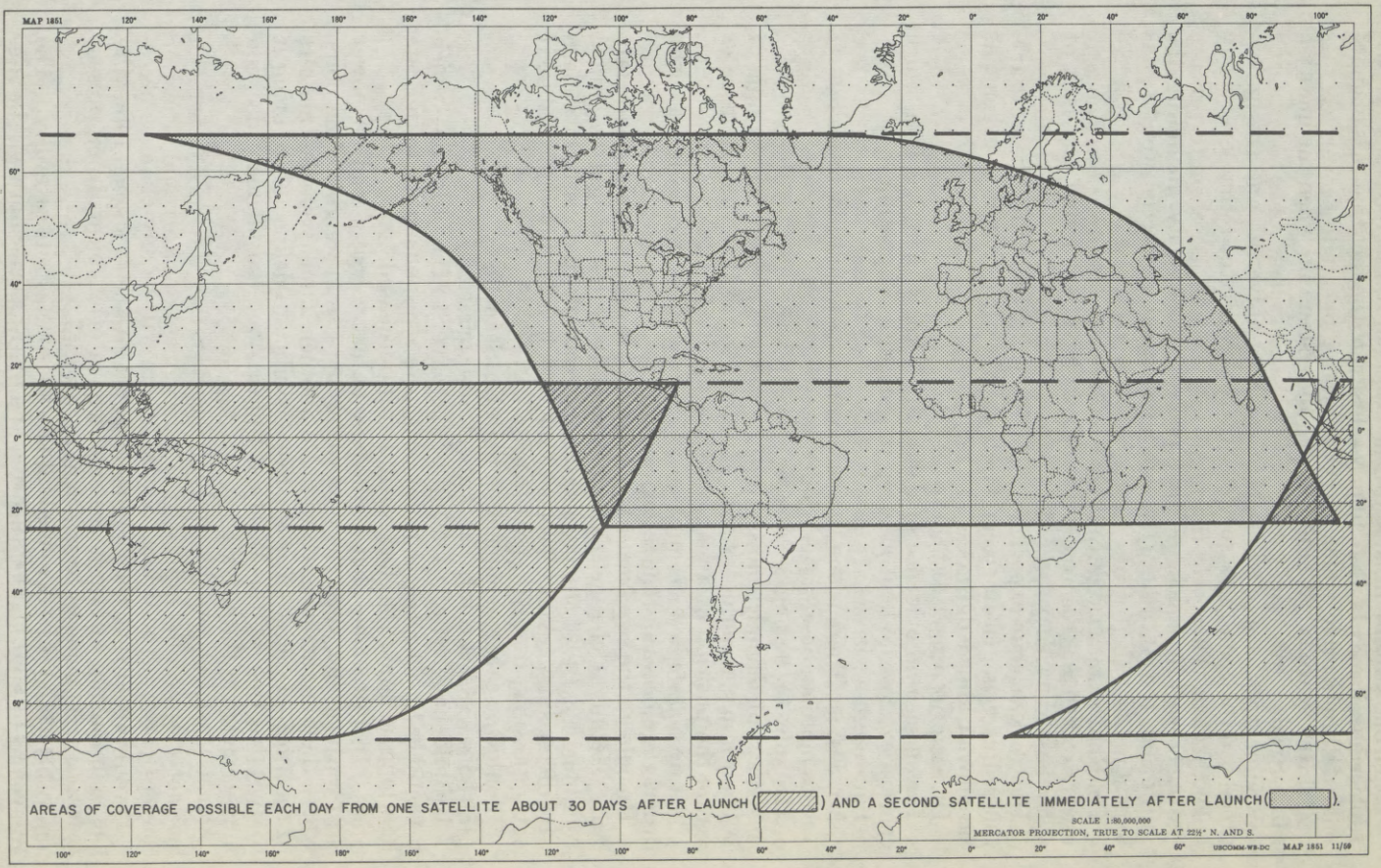
MAP 1851
AREAS OF COVERAGE POSSIBLE EACH DAY FROM ONE SATELLITE ABOUT 30 DAYS AFTER LAUNCH ( ) AND A SECOND SATELLITE IMMEDIATELY AFTER LAUNCH ( ).
SCALE 1:80,000,000
MERCATOR PROJECTION, TRUE TO SCALE AT 22½° N. AND S.
USCOMM-WB-DC
MAP 1851 11/59

FIGURE 13

covery of penicillin, or the Salk vaccine; that it is so obvious that possibly people have just left out any allusion to the fact that it is urgent?

Would you care to comment on that, sir?

Dr. REICHELDERFER. This was my understanding when the question came up last week.

The urgency is so obvious, the benefit so universal, and the importance internationally is so clear that I understood that everybody knew that it was urgent.

Mr. DAVIS. It struck me that probably everybody, including the janitor at the Weather Bureau, understood perfectly well it was urgent.

Dr. REICHELDERFER. I think that is true.

Mr. DAVIS. And I would like to ask, have you found any lack of awareness of urgency?

Has it been your experience that everyone, including the military, the people engaged in research, all fully realize that it is urgent, as far as your knowledge goes?

Dr. REICHELDERFER. I believe they do.

I have seen no evidence of delay and I know there has been much concern expressed about meeting the schedule, if possible.

I quite agree with what you say, sir.

Mr. DAVIS. There is one further comment I would like to make.

It is more an observation than a question.

It alludes to the single-manager concept.

My imagination, let me say, refuses to come up with an example of how an impasse could develop. It seems to me that you are more or less in the position of a man ordering a suit of clothes from a tailor. I just do not see how an impasse could come up between the man who orders the clothes and the tailor.

He puts up the requirements, let's say. He orders a suit of a certain size. He might change his requirement if he lost weight or gained weight. But I just cannot imagine any example of an issue or a clash of wills arising. And it seems to me that it is highly improbable, if not impossible, for an impasse to arise.

Would you care to comment on that, Dr. Seamans?

Dr. SEAMANS. I think that is essentially correct.

I think that in a relationship of the buyer to the tailor or—which it would be to NASA—the tailor does have a responsibility to indicate how long he thinks the clothes will last if purchased.

So to requirements that could pose an extra heavy load on power supplies, or could cause the payload to increase in weight to the point where they might have to switch to another launch vehicle—matters of that sort—I believe it is our responsibility to define and to bring it to the attention of the Weather Bureau, but the ultimate decision must be made by the buyer.

Mr. DAVIS. I believe that is all.

Mr. HECHLER. Mr. Pelly?

Mr. PELLY. I would like to ask if there will be any changes necessary in the contract for the management of the tracking, following the maintenance of two Tiros satellites in orbit, or will our present tracking arrangements be sufficient to cover it?

Dr. SINGER. We have looked into these aspects quite carefully. The present CDA stations at California and the Eastern Shore will be ade-

quate. We will miss some passes of the satellite, however, as we are now, and we may wish to recommend setting up of a third CDA station for Tiros in the Western Pacific but I would rather keep this as a preliminary type of recommendation before we really go out with it.

Mr. PELLY. Thank you.

Mr. HECHLER. Following up Mr. Pelly's question, when Nimbus becomes operational, will this necessitate any additional data acquisition stations?

Dr. SINGER. No, sir. I believe the plans have been made for the Nimbus program.

I can report briefly on the progress but I must refer details to NASA since they are handling for us the procurement and construction of the CDA stations.

Colonel PEACOCK. You may have answered this question the other day, Dr. Singer, but for the record I would like to ask you this question again.

Would it be possible to meet the additional funding requirements for the fiscal year 1963 for the interim operational Tiros program from the existing Weather Bureau budget by reprograming, or are you going to need additional funds?

Dr. SINGER. As we see it now, we should be able to meet all costs arising from this interim program.

Mr. HECHLER. This committee, of course, is concerned with money and time. We are concerned with moving the program forward in the way that will save money, money which we feel has been lost by bad administrative arrangements and poor planning in some other programs.

We are trying to learn and apply the lessons of history in the development of these and future programs.

We are deeply interested in time, in pushing this program forward with all possible urgency.

Even though the janitor at the Weather Bureau may understand, I think it is healthy and useful to focus national public attention on the value of the meteorological satellite program, the tremendous strides that we have made by means of Tiros, and the maintenance of that forward progress which we hope to achieve.

Thank you, gentlemen, for being here this morning.

The committee stands adjourned.

(Whereupon, at 11:45 a.m., the committee was adjourned.)

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METEOROLOGICAL SATELLITES

TUESDAY, SEPTEMBER 11, 1962

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE NO. 4,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Ken Hechler (chairman) presiding.

Mr. HECHLER. The committee will come to order.

We are continuing our hearings this morning on the national meteorological satellite program, and today we will hear from Dr. Richard N. Gardner, Deputy Assistant Secretary of State for International Organization Affairs, Department of State, and Mr. T. H. E. Nesbitt, Deputy Chief of Staff for Outer Space Matters, Office of the Science Adviser, Department of State.

The committee is concerned with the participation by other countries and also the effective use of the data acquired from meteorological satellites by the world community.

We are concerned with the effectiveness of this program in assisting the underdeveloped countries to help themselves.

We are very pleased, Dr. Gardner, and Mr. Nesbitt, that you are with us this morning, and if you care, at the opening, Dr. Gardner, to identify any other assistants that you have with you, for the record, we would appreciate it.

STATEMENT OF RICHARD D. GARDNER, DEPUTY ASSISTANT SECRETARY OF STATE FOR INTERNATIONAL ORGANIZATION AFFAIRS; ACCOMPANIED BY T. H. E. NESBITT, DEPUTY CHIEF OF SECTION FOR OUTER SPACE MATTERS, OFFICE OF SCIENTIFIC ADVISER; J. SIMSARIAN, OFFICER IN CHARGE, INTERNATIONAL SCIENTIFIC ORGANIZATIONS, BUREAU OF INTERNATIONAL ORGANIZATION AFFAIRS; G. D. CARTWRIGHT, CHIEF, OFFICE OF INTERNATIONAL METEOROLOGICAL PLANS, U.S. WEATHER BUREAU; AND A. W. JOHNSON, ASSISTANT DIRECTOR, OPERATIONS NATIONAL WEATHER SATELLITE CENTER, U.S. WEATHER BUREAU

Dr. GARDNER. Thank you, Mr. Chairman.

I am accompanied today, on my right, by Mr. T. H. E. Nesbitt, who is in the Outer Space Section of the Science Adviser's Office of the State Department; on my left, by Mr. Gordon Cartwright, Chief of the Office of International Meteorological Plans of the U.S. Weather

Bureau; by Mr. Arthur W. Johnson, Assistant Director for Operations of the National Weather Satellite Center; and by Mr. James Simsarian, officer in charge for International Scientific Organization of our Bureau of International Organizations in the Department of State.

With your permission, Mr. Chairman, I would like to read a prepared statement, copies of which will be available to the members of the committee shortly from the Department.

The Department of State is pleased to be invited to make a statement before this subcommittee on the relationship of the U.S. meteorological satellite program to our foreign relations with other countries.

U.S. leadership in the launching of Tiros I through V has fired the imagination of people throughout the world with respect to the possibilities of further developments relating to weather forecasting and the atmospheric sciences on a global scale.

The meteorological satellites are a leading example of how outer space can be used to benefit mankind. Under both the Eisenhower and Kennedy administrations, special attention has been given to this aspect of outer space.

In his state of the Union message, of January 30, 1961, President Kennedy extended an invitation to other countries to join with the United States in invoking "the wonders of science instead of its terrors."

"Specifically," he said:

> I now invite all nations—including the Soviet Union—to join with us in developing a weather-prediction program, in a new communications satellite program, and in preparation for probing the distant planets of Mars and Venus, probes which may some day unlock the deepest secrets of the universe.

On September 25, 1961, President Kennedy laid before the United Nations a four-point program of space cooperation under United Nations auspices. The program called for a regime of law and order in outer space, the promotion of scientific cooperation and the exchange of information, a worldwide undertaking in weather forecasting and weather research, and international cooperation in the establishment of a global system of communication satellites.

A resolution embodying the President's program was unanimously approved by the U.N. General Assembly on December 20. This resolution emphasized the four principal areas of space cooperation outlined by the President:

First, it urged a program of space cooperation on the basis of two basic principles: (*a*) international law, including the Charter of the United Nations, applies to outer space and celestial bodies; and (*b*) outer space and celestial bodies are free for exploration and use by all states in conformity with international law and are not subject to national appropriation.

Mr. HECHLER. Could you supply, for the record, Doctor, the complete text of the United Nations resolution?

Dr. GARDNER. I will be glad to do so. I have that here.

With your permission, I will put that in the record.

Mr. HECHLER. As well as the complete text of the Presidential statements to which you referred.

Dr. GARDNER. I will supply that for the record as well.

Mr. HECHLER. Thank you.

(The resolution referred to follows:)

[Text of resolution]

A

The General Assembly,

Recognizing the common interest of mankind in furthering the peaceful uses of outer space and the urgent need to strengthen international co-operation in this important field,

Believing that the exploration and use of outer space should be only for the betterment of mankind and to the benefit of States irrespective of the stage of their economic or scientific development,

1. Commends to States for their guidance in the exploration and use of outer space the following principles:

(a) International law, including the Charter of the United Nations, applies to outer space and celestial bodies;

(b) Outer space and celestial bodies are free for exploration and use by all States in conformity with international law and are not subject to national appropriation;

2. Invites the Committee on the Peaceful Uses of Outer Space to study and report on the legal problems which may arise from the exploration and use of outer space.

B

The General Assembly,

Believing that the United Nations should provide a focal point for international co-operation in the peaceful exploration and use of outer space,

1. Calls upon States launching objects into orbit or beyond to furnish information promptly to the Committee on the Peaceful Uses of Outer Space, through the Secretary-General, for the registration of launchings;

2. Requests the Secretary-General to maintain a public registry of the information furnished in accordance with paragraph 1 above;

3. Requests the Committee on the Peaceful Uses of Outer Space, in co-operation with the Secretary-General and making full use of the functions and resources of the Secretariat:

(a) To maintain close contact with governmental and non-governmental organizations concerned with outer space matters;

(b) To provide for the exchange of such information relating to outer space activities as Governments may supply on a voluntary basis, supplementing but not duplicating existing technical and scientific exchanges;

(c) To assist in the study of measures for the promotion of international co-operation in outer space activities;

4. Further requests the Committee on the Peaceful Uses of Outer Space to report to the General Assembly on the arrangements undertaken for the performance of those functions and on such developments relating to the peaceful uses of outer space as it considers significant.

C

The General Assembly,

Noting with gratification the marked progress for meteorological science and technology opened up by the advances in outer space,

Convinced of the world-wide benefits to be derived from international co-operation in weather research and analysis,

1. Recommends to all Member States and to the World Meteorological Organization and other appropriate specialized agencies the early and comprehensive study, in the light of developments in outer space, of measures:

(a) To advance the state of atmospheric science and technology so as to provide greater knowledge of basic physical forces affecting climate and the possibility of large-scale weather modification;

(b) To develop existing weather forecasting capabilities and to help Member States make effective use of such capabilities through regional meteorological centres;

2. Requests the World Meteorological Organization, consulting as appropriate with the United Nations Educational, Scientific and Cultural Organization and other speicalized agencies and governmental and non-governmental organizations, such as the International Council of Scientific Unions, to submit a report to its member Governments and to the Economic and Social Council at its thirty-fourth session regarding appropriate organizational and financial arrangements

to achieve those ends, with a view to their further consideration by the General Assembly at its seventeenth session;

3. Requests the Committee on the Peaceful Uses of Outer Space, as it deems appropriate, to review that report and submit its comments and recommendations to the Economic and Social Council and to the General Assembly.

D

The General Assembly,

Believing that communication by means of satellites should be available to the nations of the world as soon as practicable on a global and non-discriminatory basis,

Convinced of the need to prepare the way for the establishment of effective operational satellite communication,

1. Notes with satisfaction that the International Telecommunication Union plans to call a special conference in 1963 to make allocations of radio frequency bands for outer space activities;

2. Recommends that the International Telecommunication Union consider at that conference those aspects of space communication in which international cooperation will be required;

3. Notes the potential importance of communication satellites for use by the United Nations and its principal organs and specialized agencies for both operational and informational requirements;

4. Invites the Special Fund and the Expanded Programme of Technical Assistance, in consultation with the International Telecommunication Union, to give sympathetic consideration to requests from Member States for technical and other assistance for the survey of their communication needs and for the development of their domestic communication facilities so that they may make effective use of space communication;

5. Requests the Internatonal Telecommunication Union, consulting as appriate with Member States, the United Nations Educational, Scientific and Cultural Organization and other specialized agencies and governmental and non-governmental organizations, such as the Committee on Space Research of the International Council of Scientific Unions, to submit a report on the implementation of those proposals to the Economic and Social Council at its thirty-fourth session and to the General Assembly at its seventeenth session;

6. Requests the Committee on the Peaceful Uses of Outer Space, as it deems appropriate, to review that report and submit its comments and recommendations to the Economic and Social Council and to the General Assembly.

The General Assembly,

Recalling its resolution 1472(XIV) of 12 December 1959.

Noting that the terms of office of the members of the Committee on the Peaceful Uses of Outer Space expire at the end of 1961,

Noting the report of the Committee on the Peaceful Uses of Outer Space.

1. Decides to continue the membership of the Committee on the Peaceful Uses of Outer Space as set forth in General Assembly resolution 1472(XIV) and to add Chad, Mongolia, Morocco and Sierra Leone to its membership in recognition of the increased membership of the United Nations since the Committee was established;

2. Requests the Committee to meet not later than 31 March 1962 to carry out its mandate as contained in General Assembly resolution 1472(XIV), to review the activities provided for in the present resolution and to make such reports as it may consider appropriate.

(The complete text of the Presidential statements referred to above follow:)

[From Office of the White House Press Secretary, the White House, Jan. 29, 1961]

STATE OF THE UNION MESSAGE OF PRESIDENT JOHN F. KENNEDY

Mr. Speaker, Mr. Vice President, Members of the Congress, it is a pleasure to return from whence I came. You are my oldest friends in Washington—and this House is my oldest home. It was here, more than 14 years ago, that I first took the oath of Federal office. It was here, for 14 years, that I gained both knowledge and inspiration from members of both parties in both Houses—from your wise and generous leaders—and from the pronouncements which I can vividly recall, sitting where you now sit—including the programs of two great

Presidents, the undimmed eloquence of Churchill, the soaring idealism of Nehru, the steadfast words of General de Gaulle. To speak from this same historic rostrum is a sobering experience. To be back among so many friends is a happy one.

I am confident that that friendship will continue. Our Constitution wisely assigns both joint and separate roles to each branch of the Government; and a President and a Congress who hold each other in mutual respect will neither permit nor attempt any trespass. For my part, I shall withhold from neither the Congress nor the people any fact or report, past, present, or future, which is necessary for an informed judgment of our conduct and hazards. I shall neither shift the burden of Executive decisions to the Congress, nor avoid responsibility for the outcome of those decisions.

I speak today in an hour of national peril and national opportunity. Before my term has ended, we shall have to test anew whether a nation organized and governed such as ours can endure. The outcome is by no means certain. The answers are by no means clear. All of us together—this administration, this Congress, this Nation—must forge those answers.

But today, were I to offer—after little more than a week in office—detailed legislation to remedy every national ill, the Congress would rightly wonder whether the desire for speed had replaced the duty of responsibility.

My remarks, therefore, will be limited. But they will also be candid. To state the facts frankly is not to despair the future nor indict the past. The prudent heir takes careful inventory of his legacies, and gives a faithful accounting to those whom he owes an obligation of trust. And, while the occasion does not call for another recital of our blessings and assets, we do have no greater asset than the willingness of a free and determined people, through its elected officials, to face all problems frankly and meet all dangers free from panic or fear.

I

The present state of our economy is disturbing. We take office in the wake of 7 months of recession, 3½ years of slack, 7 years of diminished economic growth, and 9 years of falling farm income.

Business bankruptcies have reached their highest level since the great depression. Since 1951 farm income has been squeezed down by 25 percent. Save for a brief period in 1958, insured unemployment is at the highest peak in our history. Of some 5½ million Americans who are without jobs, more than 1 million have been searching for work for more than 4 months. And during each month some 150,000 workers are exhausting their already meager jobless benefit rights.

Nearly one-eighth of those who are without jobs live almost without hope in nearly 100 especially depressed and troubled areas. The rest include new school graduates unable to use their talents, farmers forced to give up their part-time jobs which helped balance their family budgets, skilled and unskilled workers laid off in such important industries as metals, machinery, automobiles, and apparel.

Our recovery from the 1958 recession, moreover, was anemic and incomplete. Our gross national product never regained its full potential. Unemployment never returned to normal levels. Maximum use of our national industrial capacity was never restored.

In short, the American economy is in trouble. The most resourceful industrialized country on earth ranks among the last in the rate of economic growth. Since last spring our economic growth has actually receded. Business investment is in a decline. Profits have fallen below predicted levels. Construction is off. A million unsold automobiles are in inventory. Fewer people are working—and the average workweek has shrunk well below 40 hours. Yet prices have continued to rise—so that now too many Americans have less to spend for items that cost more to buy.

Economic prophecy is at best an uncertain art—as demonstrated by the prediction 1 year ago from this same podium that 1960 would be, and I quote, "the most prosperous year in our history." Nevertheless, forecasts of continued slack and only slightly reduced unemployment through 1961 and 1962 have been made with alarming unanimity—and this administration does not intend to stand helplessly by.

We cannot afford to waste idle hours and empty plants while awaiting the end of the recession. We must show the world what a free economy can do—to reduce unemployment, to put unusued capacity to work, to spur new pro-

ductivity, and to foster higher economic growth within a range of sound fiscal policies and relative price stability.

I will propose to the Congress within the next 14 days measures to improve unemployment compensation through temporary increases in duration on a self-supporting basis—to provide more food for the families of the unemployed, and to aid their needy children, to redevelop our areas of chronic labor surplus, to expand the services of the U.S. employment offices, to stimulate housing and construction, to secure more purchasing power for our lowest paid workers by raising and expanding the minimum wage, to offer tax incentives for sound plant investment, to increase the development of our natural resources, to encourage price stability, and to take other steps aimed at insuring a prompt recovery and paving the way for increased long-range growth. This is not a partisan program concentrating on our weaknesses, it is, I hope, a national program to realize our national strength.

II

Efficient expansion at home, stimulating the new plant and technology that can make our goods more competitive, is also the key to the international balance-of-payments problem. Laying aside all alarmist talk and panicky solutions, let us put that knotty problem in its proper perspective.

It is true that, since 1958, the gap between the dollars we spend or invest abroad and the dollars returned to us has substantially widened. This overall deficit in our balance of payments increased by nearly $11 billion in the 3 years—and holders of dollars abroad converted them to gold in such a quantity as to cause a total outflow of nearly $5 billion of gold from our reserve. The 1959 deficit was caused in large part by the failure of our exports to penetrate foreign markets—the result both of restrictions on our goods and our own uncompetitive prices. The 1960 deficit, on the other hand, was more the result of an increase in private capital outflow seeking new opportunity, higher return or speculative advantage abroad.

Meanwhile this country has continued to bear more than its share of the West's military and foreign aid obligations. Under existing policies, another deficit of $2 billion is predicted for 1961—and individuals to those countries whose dollar position once depended on these deficits for improvement now wonder aloud whether our gold reserves will remain sufficient to meet our own obligations.

All this is cause for concern—but it is not cause for panic. For our monetary and financial position remains exceedingly strong. Including our drawing rights in the International Monetary Fund and the gold reserve held as backing for our currency and Federal Reserve deposits, we have some $22 billion in total gold stocks and other international monetary reserves available—and I now pledge that their full strength stands behind the value of the dollar for use if needed.

Moreover, we hold large assets abroad—the total owed this Nation far exceeds the claims upon our reserves—and our exports once again substantially exceed our imports.

In short, we need not, and we shall not, take any action to increase the dollar price of gold from $35 an ounce, to impose exchange controls, to reduce our anti-recession efforts, to fall back on restrictive trade policies, or to weaken our commitments around the world.

This administration will not distort the value of the dollar in any fashion. And this is a commitment.

Prudence and good sense do require, however, that new steps be taken to ease the payments deficit and prevent any gold crisis. Our success in world affairs has long depended in part upon foreign confidence in our ability to pay. A series of executive orders, legislative remedies and cooperative efforts with our allies will get underway immediately—aimed at attracting foreign investment and travel to this country—promoting American exports, at stable prices and with more liberal Government guarantees and financing, curbing tax and customs loopholes that encourage undue spending of private dollars abroad, and (through OECD, NATO, and otherwise) sharing with our allies all efforts to provide for the common defense of the free world and the hopes for growth of the less developed lands. While the current deficit lasts, ways will be found to ease our dollar outlays abroad without placing the full burden on the families of men whom we have asked to serve our flag overseas.

In short, whatever is required will be done to back up all our efforts abroad, and to make certain that, in the future as in the past, the dollar is as "sound as a dollar."

III

But more than our exchange of international payments is out of balance. The current Federal budget for fiscal 1961 is almost certain to show a net deficit. The budget already submitted for fiscal 1962 will remain in balance only if the Congress enacts all the revenue measures requested—and only if an earlier and sharper upturn in the economy than my economic advisers now think likely produces the tax revenues estimated. Nevertheless, a new administration must of necessity build on the spending and revenue estimates already submitted. Within that framework, barring the development of urgent national defense needs or a worsening of the economy, it is my current intention to advocate a program of expenditures which, including revenues from a stimulation of the economy, will not of and by themselves unbalance the earlier budget.

However, we will do what must be done. For our national household is cluttered with unfinished and neglected tasks. Our cities are being engulfed in squalor. Twelve long years after Congress declared our goal to be "a decent home and a suitable environment for every American family," we still have 25 million Americans living in substandard homes. A new housing program under a new Housing and Urban Affairs Department will be needed this year.

Our classrooms contain 2 million more children than they can properly have room for, taught by 90,000 teachers not properly qualified to teach. One-third of our most promising high school graduates are financially unable to continue the development of their talents. The war babies of the 1940's, who overcrowded our schools in the 1950's, are now descending in 1960 upon our colleges—with two college students for every one, 10 years from now—and our colleges are ill prepared. We lack the scientists, the engineers, and the teachers our world obligations require. We have neglected oceanography, saline water conversion, and the basic research that lies at the root of all progress. Federal grants for both higher and public school education can no longer be delayed.

Medical research has achieved new wonders—but these wonders are too often beyond the reach of too many people, owing to a lack of income (particularly among the aged), a lack of hospital beds, a lack of nursing homes, and a lack of doctors and dentists. Measures to provide health care for the aged under social security, and to increase the supply of both facilities and personnel, must be undertaken this year.

Our supply of clean water is dwindling. Organized and juvenile crimes cost the taxpayers millions of dollars each year, making it essential that we have improved enforcement and new legislative safeguards. The denial of, constitutional rights to some of our fellow Americans on account of race—at the ballot box and elsewhere—disturbs the national conscience, and subjects us to the charge of world opinion that our democracy is not equal to the high promise of our heritage. Morality in private business has not been sufficiently spurred by morality in public business. A host of problems and projects in all 50 States, though not possible to include in this message, deserves—and will receive—the attention of both the Congress and the executive branch. On most of these matters, messages will be sent to the Congress within the next 2 weeks.

IV

But all these problems pale when placed beside those which confront us around the world. No man entering upon this office, regardless of his party, regardless of his previous service in Washington, could fail to be staggered upon learning—even in this brief 10-day period—the harsh enormity of the trials through which we must pass in the next 4 years. Each day the crises multiply. Each day their solution grows more difficult. Each day we draw nearer the hour of maximum danger, as weapons spread and hostile forces grow stronger. I feel I must inform the Congress that our analyses over the last 10 days make it clear that—in each of the principal areas of crisis—the tide of events has been running out and time has not been our friend.

In Asia, the relentless pressures of the Chinese Communists menace the security of the entire area—from the borders of India and South Vietnam to the jungles of Laos, struggling to protect its newly won independence. We seek in Laos what we seek in all Asia, and, indeed, in all of the world—freedom for

the people and independence for the government. And this Nation shall persevere in our pursuit of these objectives.

In Africa, the Congo has been brutally torn by civil strife, political unrest, and public disorder. We shall continue to support the heroic efforts of the United Nations to restore peace and order—efforts which are now endangered by mounting tensions, unsolved problems, and decreasing support from many member states.

In Latin America, Communist agents seeking to exploit that region's peaceful revolution of hope have established a base on Cuba, only 90 miles from our shores. Our objection with Cuba is not over the people's drive for a better life. Our objection is to their domination by foreign and domestic tyrannies. Cuban social and economic reform should be encouraged. Questions of economic and trade policy can always be negotiated. But Communist domination in this hemisphere can never be negotiated.

We are pledged to work with our sister republics to free the Americas of all such foreign domination and all tyranny, working toward the goal of a free hemisphere of free governments, extending from Cape Horn to the Arctic Circle.

In Europe our alliances are unfulfilled and in some disarray. The unity of NATO has been weakened by economic rivalry and partially eroded by national interest. It has not yet fully mobilized its resources nor fully achieved a common outlook. Yet no Atlantic power can meet on its own the mutual problems now facing us in defense, foreign aid, monetary reserves, and a host of other areas; and our close ties with those whose hopes and interests we share are among this Nation's most powerful assets.

Our greatest challenge is still the world that lies beyond the cold war—but the first great obstacle is still our relations with the Soviet Union and Communist China. We must never be lulled into believing that either power has yielded its ambitions for world domination—ambitions which they forcefully restated only a short time ago. On the contrary, our task is to convince them that aggression and subversion will not be profitable routes to pursue these ends. Open and peaceful competition—for prestige, for markets, for scientific achievement, even for men's minds—is something else again. For if freedom and communism were to compete for man's allegiance in a world at peace, I would look to the future with ever increasing confidence.

To meet this array of challenges—to fulfill the role we cannot avoid on the world scene—we must reexamine and revise our whole arsenal of tools: military, economic, and political.

One must not overshadow the other. On the Presidential coat of arms, the American eagle holds in his right talon the olive branch, while in his left he holds a bundle of arrows. We intend to give equal attention to both.

First, we must strengthen our military tools: We are moving into a period of uncertain risk and great commitment in which both the military and diplomatic possibilities require a free world force so powerful as to make any aggression clearly futile. Yet in the past, lack of a consistent, coherent military strategy, the absence of basic assumptions about our national requirements, and the faulty estimates and duplication arising from interservice rivalries have all made it difficult to assess accurately how adequate—or inadequate—our defenses really are.

I have, therefore, instructed the Secretary of Defense to reappraise our entire defense strategy; our ability to fulfill our commitments; the effectiveness, vulnerability, and dispersal of our strategic bases, forces and warning systems; the efficiency and economy of our operation and organization; the elimination of obsolete bases and installations; and the adequacy, modernization, and mobility of our present conventional and nuclear forces and weapons systems in the light of present and future dangers. I have asked for preliminary conclusions by the end of February—and I then shall recommend whatever legislative, budgetary, or executive action is needed in the light of these conclusions.

In the meantime, I have asked the Defense Secretary to initiate immediately three new steps most clearly needed now:

First, I have directed prompt attention to increase our airlift capacity. Obtaining additional air transport mobility—and obtaining it now—will better assure the ability of our conventional forces to respond, with discrimination and speed, to any problem at any spot on the globe at any moment's notice. In particular it will enable us to meet any deliberate effort to avoid or divert our forces by starting limited wars in widely scattered parts of the world.

(*b*) I have directed prompt action to step up our Polaris submarine program. Using unobligated shipbuilding funds now (to let contracts originally scheduled for the next fiscal year) will build and place on station, at least 9 months earlier than planned, substantially more units of a crucial deterrent—a fleet that will never attack first, but possess sufficient powers of retaliation, concealed beneath the seas, to discourage any aggressor from launching an attack upon our security.

(*c*) I have directed prompt action to accelerate our entire missile program. Until the Secretary of Defense's reappraisal is completed, the emphasis here will be largely on improved organization and decisionmaking—on cutting down the wasteful duplications and the timelag that have handicapped our whole family of missiles. If we are to keep the peace, we need an invulnerable missile force powerful enough to deter any aggressor from even threatening an attack that he would know could not destroy enough of our force to prevent his own destruction. For as I said upon taking the oath of office: "Only when our arms are sufficient beyond doubt can we be certain beyond doubt that they will never be employed."

Secondly, we must improve our economic tools: Our role is essential and unavoidable in the construction of a sound and expanding economy for the entire non-Communist world, helping other nations build the strength to meet their own problems, to satisfy their own aspirations—to surmount their own dangers. The problems in achieving this goal are towering and unprecedented—the response must be towering and unprecedented as well, much as lend-lease and the Marshall plan were in earlier years, which brought such fruitful results.

(*a*) I intend to ask the Congress for authority to establish a new and more effective program for assisting the economic, educational, and social development of other countries and continents. That program must stimulate and take more effectively into account the contributions of our allies, and provide central policy direction for all our own programs that now so often overlap, conflict, or diffuse our energies and resources. Such a program, compared to past programs, will require—

More flexibility for short-run emergencies.

More commitment to long-term development.

New attention to education at all levels.

Greater emphasis on the recipient nation's role, their effort, their purpose, with greater social justice for their people, broader distribution and participation by their people, and more efficient public administration and more efficient tax systems of their own.

And orderly planning for national and regional development instead of a piecemeal approach.

I hope the Senate will take early action approving the Convention establishing the Organization for Economic Cooperation and Development. This will be an important instrument in sharing with our allies this development effort—working toward the time when each nation will contribute in proportion to its ability to pay. For, while we are prepared to assume our full share of these huge burdens, we cannot and must not be expected to bear them alone.

To our sister Republics to the south, we have pledged a new Alliance for Progress—alianza para progreso. Our goal is a free and prosperous Latin America, realizing for all its states and all its citizens a degree of economic and social progress that matches their historic contributions of culture, intellect, and liberty. To start this nation's role at this time in that alliance of neighbors, I am recommending the following:

That the Congress appropriate in full the $500 million fund pledged by the Act of Bogotá, to be used not as an instrument of the cold war, but as a first step in the sound development of the Americas;

That a new interdepartmental task force be established under the leadership of the Department of State, to coordinate at the highest level all policies and programs of concern to the Americas;

That our delegates to the OAS, working with those of other members, strengthen that body as an instrument to preserve the peace, and to prevent foreign domination anywhere in the hemisphere.

That, in cooperation with other nations, we launch a new hemispheric attack on illiteracy and inadequate educational opportunities to all levels; and, finally,

That a food-for-peace mission be sent immediately to Latin America to explore ways in which our vast food abundance can be used to help end

hunger and malnutrition in certain areas of suffering in our own hemisphere. This administration is expanding its food-for-peace program in every possible way. The product of our abundance must be used more effectively to relieve hunger and help economic growth in all corners of the globe. And I have asked the director of this program to recommend additional ways in which these surpluses can advance the interests of world peace—including the establishment of world food reserves.

An even more valuable national asset is our reservoir of dedicated men and women—not only on our college campuses but in every age group—who have indicated their desire to contribute their skills, their efforts, and a part of their lives to the fight for world order. We can mobilize this talent through the formation of a National Peace Corps, enlisting the services of all those with the desire and capacity to help foreign lands meet their urgent needs for trained personnel.

Finally, while our attention is centered on the development of the non-Communist world, we must never forget our hopes for the ultimate freedom and welfare of the Eastern European peoples. In order to be prepared to help reestablish historic ties of friendship, I am asking the Congress for increased discretion to use economic tools in this area whenever this is found to be clearly in the national interest. This will require amendment of the Mutual Defense Assistance Control Act along the lines I proposed as a Member of the Senate, and upon which the Senate voted last summer. Meanwhile, I hope to explore with the Polish Government the possibility of using our frozen Polish funds on projects of peace that will demonstrate our abiding friendship for and interest in the people of Poland.

Third, we must sharpen our political and diplomatic tools—the means of cooperation and agreement on which an enforceable world order must ultimately rest.

I have already taken steps to coordinate and expand our disarmament effort—to increase our programs of research and study—and to make arms control a central goal of our national policy under my direction. The deadly arms race, and the huge resources it absorbs, have too long overshadowed all else we must do. We must prevent that arms race from spreading to new nations, to new nuclear powers, and to the reaches of outer space. We must make certain that our negotiators are better informed and better prepared—to formulate workable proposals of our own and to make sound judgments about the proposals of others.

I have asked the other governments concerned to agree to a reasonable delay in the talks on a nuclear test ban—and it is our intention to resume negotiations prepared to reach a final agreement with any nation that is equally willing to agree to an effective and enforceable treaty. We must increase our support of the United Nations as an instrument to end the cold war instead of an arena in which to fight it. In recognition of its increasing importance and the doubling of its membership—

We are enlarging and strengthening our own mission to the U.N.

We shall help insure that it is properly financed.

We shall work to see that the integrity of the office of the Secretary General is maintained.

And I would address a special plea to the smaller nations of the world—to join with us in strengthening this organization, which is far more essential to their security than it is to ours—the only body in the world where no nation need be powerful to be secure, where every nation has an equal voice, and where any nation can exert influence not according to the strength of its armies but according to the strength of its ideas. It deserves the support of all.

Finally, this administration intends to explore promptly all possible areas of cooperation with the Soviet Union and other nations "to invoke the wonders of science instead of its terrors." Specifically, I now invite all nations—including the Soviet Union—to join with us in developing a weather prediction program, in a new communications satellite program and in preparation for probing the distant planets of Mars and Venus, probes which may someday unlock the deepest secrets of the universe.

Today this country is ahead in the science and technology of space, while the Soviet Union is ahead in the capacity to lift large vehicles into orbit. Both nations would help themselves as well as other nations by removing these endeavors from the bitter and wasteful competition of the cold war. The United States would be willing to join with the Soviet Union and the scientists of all nations in a greater effort to make the fruits of this new knowledge avail-

able to all—and, beyond that, in an effort to extend farm technology to hungry nations, to wipe out disease, to increase the exchanges of scientists and their knowledge—and to make our own laboratories available to technicians of other lands who lack the facilities to pursue their own work. Where nature makes natural allies of us all, we can demonstrate that beneficial relations are possible even with those with whom we most deeply disagree—and this must someday be the basis of world peace and world law.

V

I have commented on the state of the domestic economy, our balance of payments, our Federal and social budget and the state of the world. I would like to conclude with a few remarks about the state of the executive branch. We have found it full of honest and useful public servants—but their capacity to act decisively at the exact time action is needed has too often been muffled in the morass of committees, timidities, and fictitious theories which have created a growing gap between decision and execution, between planning and reality. In a time of rapidly deteriorating situations at home and abroad, this is bad for the public service and particularly bad for the country; and we mean to make a change.

I pledge myself and my colleagues in the Cabinet to a continuous encouragement of initiative, responsibility, and energy in serving the public interest. Let every public servant know, whether his post is high or low, that a man's rank and reputation in this administration will be determined by the size of the job he does, and not by the size of his staff, his office, or his budget. Let it be clear that this administration recognizes the value of dissent and daring—that we greet healthy controversy as the hallmark of healthy change. Let the public service be a proud and lively career. And let every man and women who works in any area of our National Government, in any branch, at any level, be able to say with pride and with honor in future years: "I served the U.S. Government in that hour of our Nation's need."

For only with complete dedication by us all to the national interest can we bring our country through the troubled years that lie ahead. Our problems are critical. The tide is unfavorable. The news will be worse before it is better. And while hoping and working for the best, we should prepare ourselves now for the worst.

We cannot escape our dangers—neither must we let them drive us into panic or narrow isolation. In many areas of the world where the balance of power already rests with our adversaries, the forces of freedom are sharply divided. It is one of the ironies of our time that the techniques of a harsh and repressive system should be able to instill discipline and ardor in its servants—while the blessings of liberty have too often stood for privilege, materialism, and a life of ease.

But I have a different view of liberty.

Life in 1961 will not be easy. Wishing it, predicting it, even asking for it, will not make it so. There will be further setbacks before the tide is turned. But turn it we must. The hopes of all mankind rest upon us—not simply upon those of us in this chamber, but upon the peasant in Laos, the fisherman in Nigeria, the exile from Cuba, the spirit that moves every man and nation who shares our hopes for freedom and the future. And in the final analysis, they rest most of all upon the pride and perseverance of our fellow citizens of the great Republic.

In the words of a great President, whose birthday we honor today, closing his final State of the Union Message 16 years ago, "We pray that we may be worthy of the unlimited opportunities that God has given us."

[From office of the White House press secretary, the White House, Sept. 25, 1961]

TEXT OF THE PRESIDENT'S ADDRESS TO THE UNITED NATIONS, DELIVERED AT 11:30 A.M., EASTERN DAYLIGHT TIME, SEPTEMBER 25, 1961, NEW YORK CITY

Mr. President, honored delegates, ladies, and gentlemen: We meet in an hour of grief and challenge. Dag Hammarskjöld is dead. But the United Nations lives. His tragedy is deep in our hearts, but the task for which he died is at the top of our agenda. A noble servant of peace is gone. But the quest for peace lies before us.

The problem is not the death of one man—the problem is the life of this organization. It will either grow to meet the challenge of our age or it will be gone with the wind, without influence, without force, without respect. Were we to let it die, to enfeeble its vigor, to cripple its powers, we would condemn the future.

For in the development of this organization rests the only true alternative to war, and war appeals no longer as a rational alternative. Unconditional war can no longer lead to unconditional victory. It can no longer serve to settle disputes. It can no longer concern the great powers alone. For a nuclear disaster, spread by winds and waters and fear, could well engulf the great and the small, the rich and the poor, the committed and the uncommitted alike. Mankind must put an end to war, or war will put an end to mankind.

So let us here resolve that Dag Hammarskjöld did not live—or die—in vain. Let us call a truce to terror. Let us invoke the blessings of peace. And, as we build an international capacity to keep peace, let us join in dismantling the national capacity to wage war.

II

This will require new strength and new roles for the United Nations. For disarmament without checks is but a shadow, and a community without law is but a shell. Already the United Nations has become both the measure and the vehicle of man's most generous impulses. Already it has provided—in the Middle East, in Asia, in Africa this year in the Congo—a means of holding violence within bounds.

But the great question which confronted this body in 1945 is still before us—whether man's cherished hopes for progress and peace are to be destroyed by terror and disruption—whether the "foul winds of war" can be tamed in time to free the cooling winds of reason—and whether the pledges of our charter are to be fulfilled or defined: Pledges to secure peace, progress, human rights, and world law.

In this hall, there are not three forces, but two. One is composed of those who are trying to build the kind of world described in articles I and II of the charter. The other, seeking a far different world, would undermine this organization in the process.

Today of all days our dedication to the charter must be maintained. It must be strengthened first of all, by the selection of an outstanding civil servant to carry forward the responsibilities of the Secretary General—a man endowed with both the wisdom and the power to make meaningful the moral force of the world community. The late Secretary General nurtured and sharpened the United Nation's obligation to act. But he did not invent it. It was there in the charter. It is still there in the charter.

However difficult it may be to fill Mr. Hammarskjold's place, it can better be filled by one man rather than by three. Even the three horses of the troika did not have three drivers, all going in different directions. They had only one—and so must the United Nations executive. To install a triumvirate, or any rotating authority, in the United Nations administrative offices would replace order with anarchy, action with paralysis, and confidence with confusion.

The Secretray General, in a very real sense, is the servant of the General Assembly. Diminish his authority and you diminish the authority of the only body where all nations, regardless of power, are equal and sovereign. Until all the powerful are just, the weak will be secure only in the strength of this Assembly.

Effective and independent executive action is not the same question as balanced representation. In view of the enormous change in membership in this body since its founding, the American delegation will join in any effort for the prompt review and revision of the composition of United Nations bodies.

But to give this organization three drivers—to permit each great power to decide its own case—would entrench the cold war in the headquarters of peace. Whatever advantages such a plan may hold to my own country, as one of the great powers, we reject it. For we far prefer world law, in the age of self-determination, to world war, in the age of mass extermination.

III

Today, every inhabitant of this planet must contemplate the day when this planet may no longer be habitable. Every man, women, and child lives under a nuclear sword of Damocles, hanging by the slenderest of threads, capable of

being cut at any moment by accident or miscalculation or by madness. The weapons of war must be abolished before they abolish us.

Men no longer debate whether armaments are a symptom or a cause of tension. The mere existence of modern weapons—10 million times more powerful than anything the world has ever seen, and only minutes away from any target on earth—is a source of horror, and discord and distrust. Men no longer maintain that disarmament must await the settlement of all disputes, for disarmament must be a part of any permanent settlement. And men may no longer pretend that the quest for disarmament is a sign of weakness, for in a spiraling arms race, a nation's security may well be shrinking even as its arms increase. For 15 years this organization has sought the reduction and destruction of arms. Now that goal is no longer a dream—it is a practical matter of life and death. The risks inherent in disarmament pale in comparison to the risks inherent in an unlimited arms race.

It is in this spirit that the recent Belgrade Conference—recognizing that this is no longer a Soviet problem or an American problem, but a human problem—endorsed a program of "general, complete, and strictly an internationally controlled disarmament." It is in this same spirit that we in the United States have labored this year, with a new urgency, and with a new, now-statutory agency fully endorsed by the Congress, to find an approach to disarmament which would be so far-reaching yet realistic, so mutually balanced and beneficial, that it could be accepted by every nation. And it is in this spirit that we have presented with the agreement of the Soviet Union—under the label both nations now accept of "general and complete disarmament"—a new statement of newly agreed principles for negotiation.

But we are well aware that all issues of principle are not settled—and that principles alone are not enough. It is therefore our intention to challenge the Soviet Union, not to be an arms race, but to a peace race—to advance together step by step, stage by stage, until general and complete disarmament has been achieved. We invite them now to go beyond agreement in principle to reach agreement on actual plans.

The program to be presented to this assembly—for general and complete disarmament under effective international control—moves to bridge the gap between those who insist on a gradual approach and those who talk only of the final and total achievement. It would create machinery to keep the peace as it destroys the machines of war. It would proceed through balanced and safeguarded stages designed to give no state a military advantage over another. It would place the final responsibility for verification and control where it belongs—not with the big powers alone, not with one's adversary or one's self—but in an international organization within the framework of the United Nations. It would assure that indispensable condition of disarmament—true inspection—and apply it in stages proportionate to the stage of disarmament. It would cover delivery systems as well as weapons. It would ultimately halt their production as well as their testing, their transfer as well as their possession. It would achieve, under the eye of an international disarmament organization, a steady reduction in forces, both nuclear and conventional, until it has abolished all armies and all weapons except those needed for internal order and a new United Nations peace force. And it starts that process now, today, even as the talks begin.

In short, general and complete disarmament must no longer be a slogan, used to resist the first steps. It is no longer to be a goal without means of achieving it, without means of verifying its progress, without means of keeping the peace. It is now a realistic plan, and a test—a test of those only willing to talk and a test of those willing to act.

Such a plan would not bring a world free from conflict or greed—but it would bring a world free from the terrors of mass destruction. It would not usher in the era of the super state—but it would usher in an era in which no state could annihilate, or be annihilated by, another.

In 1945, this Nation proposed the Baruch plan to internationalize the atom before other nations even possessed the bomb or demilitarized their troops. We proposed with our allies the Disarmament Plan of 1951 while still at war in Korea. And we make our proposals today, while building up our defenses over Berlin, not because we are inconsistent or insincere or intimidated, but because we know the rights of freemen will prevail—because while we are compelled against our will to rearm, we look confidently beyond Berlin to the kind of disarmed world we all prefer.

I therefore propose, on the basis of this plan, that disarmament negotiations resume promptly, and continue without interruption until an entire program for general and complete disarmament has not only been agreed but has been actually achieved.

IV

The logical place to begin is a treaty assuring the end of nuclear tests of all kinds, in every environment, under workable controls. The United States and the United Kingdom have proposed such a treaty that is both reasonable, effective, and ready for signature. We are still prepared to sign that treaty today.

We also proposed a mutual ban on atmospheric testing, without inspection or controls, in order to save the human race from the poison of radioactive fallout. We regret that that offer was not accepted.

For 15 years, we have sought to make the atom an instrument of peaceful growth rather than of war. But for 15 years, our concessions have been matched by obstruction, our patience by intransigence. And the pleas of mankind for peace have met with disregard.

Finally, as the explosions of others beclouded the skies, my country was left with no alternative but to act in the interests of its own and the free world's security. We cannot endanger that security by refraining from testing while others improve their arsenals. Nor can we endanger it by another long, uninspected ban on testing. For 3 years we accepted those risks in our open society while seeking agreement on inspection. But this year, while we were negotiating in good faith in Geneva, others were secretly preparing new experiments in destruction.

Our tests are not polluting the atmosphere. Our deterrent weapons are guarded against accidental explosion or use. Our doctors and scientists stand ready to help any nation measure and meet the hazards to health which inevitably result from the tests in the atmosphere.

But to halt the spread of these terrible weapons, to halt the contamination of the air, to halt the spiraling nuclear arms race, we remain ready to seek new avenues of agreement, our new disarmament program thus includes the following proposals:

First, signing the test-ban treaty by all nations. This can be done now. Test ban negotiations need not and should not await general disarmament.

Second, stopping the production of fissionable materials for use in weapons, and preventing their transfer to any nation now lacking in nuclear weapons.

Third, prohibiting the transfer of control over nuclear weapons to states that do not own them.

Fourth, keeping nuclear weapons from seeding new battlegrounds in outer space.

Fifth, gradually destroying existing nuclear weapons and converting their materials to peaceful uses; and

Finally, halting the unlimited testing and production of strategic nuclear delivery vehicles, and gradually destroying them as well.

V

To destroy arms, however, is not enough. We must create even as we destroy—creating worldwide law and law enforcement as we outlaw worldwide war and weapons. In the world we seek, the United Nations Emergency Force which have been hastily assembled, uncertainly supplied, and inadequately financed, will never be enough.

Therefore, the United States recommends that all member nations earmark special peacekeeping units in their armed forces—to be on call of the United Nations—to be specially trained and quickly available—and with advance provision for financial and logistic support.

In addition, the American delegation will suggest a series of steps to improve the United Nations' machinery for the peaceful settlement of disputes—for on-the-spot factfinding, mediation, and adjudication—for extending the rule of international law. For peace is not solely a matter of military or technical problems—it is primarily a problem of politics and people. And unless man can match his strides in weapoury and technology with equal strides in social and political development, our great strength, like that of the dinosaur, will become incapable of proper control—and like the dinosaur, vanish from the earth.

VI

As we extend the rule of law on earth, so must we also extend it to man's new domain: outer space.

All of us salute the brave cosmonauts of the Soviet Union. The new horizons of outer space must not be driven by the old bitter concepts of imperialism and sovereign claims. The cold reaches of the universe must not become the new arena of an even colder war.

To this end, we shall urge proposals extending the United Nations Charter to the limits of man's exploration in the universe, reserving outer space for peaceful use, prohibiting weapons of mass destruction in space or on celestial bodies, and opening the mysteries and benefits of space to every nation. We shall further propose cooperative efforts between all nations in weather prediction and eventually in weather control. We shall propose, finally, a global system of communications satellites linking the whole world in telegraph and telephone and radio and television. The day need not be far away when such a system will televise the proceedings of this body to every corner of the world for the benefit of peace.

VII

But the mysteries of outer space must not divert our eyes or our energies from the harsh realities that face our fellow men. Political sovereignty is but a mockery without the means of meeting poverty and illiteracy and disease. Self-determination is but a slogan if the future holds no hope.

That is why my Nation—which has freely shared its capital and its technology to help others help themselves—now proposes officially designating this decade of the 1960's as the United Nations Decade of Development. Under the framework of that resolution, the United Nations' existing efforts in promoting economic growth can be expanded and coordinated. Regional surveys and training institutes can now pool the talents of many. New research, technical assistance, and pilot projects can unlock the wealth of less-developed lands and untapped waters. And development can become a cooperative and not a competitive enterprise—to enable all nations, however diverse in their systems and beliefs, to become, in fact as well as in law, free and equal nations.

VIII

My country favors a world of free and equal states. We agree with those who say that colonialism is a key issue in this Assembly. But let the full facts of that issue be discussed in full.

On the one hand is the fact that, since the close of World War II, a worldwide declaration of independence has transformed nearly 1 billion people and 9 million square miles into 42 free and independent states. Less than 2 percent of the world's population now lives in dependent territories.

I do not ignore the remaining problems of traditional colonialism which still confront this body. Those problems will be solved, with patience, good will and determination. Within the limits of our responsibility in such matters, my country intends to be a participant, and not merely an observer, in the peaceful, expeditious movement of nations from the status of colonies to the partnership of equals. That continuing tide of self-determination, which runs so strong, has our sympathy and our support.

But colonialism in its harshest forms is not only the exploitation of new nations by old, of dark skins by light—or the subjugation of the poor by the rich. My Nation was once a colony—and we know what colonialism means; the exploitation and subjugation of the weak by the powerful, of the many by the few, of the governed who have given no consent to be governed, whatever their continent, their class, or their color; and that is why there is no ignoring the fact that the tide of self-determination has not reached the Communist Empire where a population far larger than that officially termed dependent lives under governments installed by foreign troops instead of free institutions—under a system which knows only one party and one belief—which suppresses free debate and free elections, and free newspapers, and free books and free trade unions—and which builds a wall to keep truth a stranger and its own citizens prisoners. Let us debate colonialism in full—and apply the principle of free choice and the practice of free plebiscites in every corner of the globe.

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IX

Finally, as President of the United States, I consider it my duty to report to this Assembly on two threats to the peace which are not on your crowded agenda, but which causes us, and most of you, the deepest concern.

The first threat on which I wish to report is widely misunderstood: the smoldering coals of war in southeast Asia. South Vietnam is already under attack—sometimes by a single assassin, sometimes by a band of guerrillas, recently by full battalions. The peaceful borders of Burma, Cambodia, and India have been repeatedly violated. And the peaceful people of Laos are in danger of losing the independence they gained not so long ago.

No one can call these wars of liberation. For these are free countries living under governments. Nor are these aggressions any less real because men are knifed in their homes and not shot in the fields of battle.

The very simple question confronting the world community is whether measures can be devised to protect the small and weak from such tactics. For if they are successful in Laos and South Vietnam, the gates will be opened wide.

The United States seeks for itself no base, no territory, no special position in this area of any kind. We support a truly neutral and independent Laos, its people free from outside interference, living at peace with themselves and with their neighbors, assured that their territory will not be used for attacks on others, and under a government comparable (as Mr. Khrushchev and I agreed at Vienna) to Cambodia and Burma.

But now the negotiations over Laos are reaching a crucial stage. The cease-fire is at best precarious. The rainy season is coming to an end. Lao territory is being used to infiltrate South Vietnam. The world community must recognize—all those who are involved—that this potent threat to Lao peace and freedom is indivisible from all other threats to their own.

Secondly, I wish to report to you on the crisis over Germany and Berlin. This is not the time or the place for immoderate tones, but the world community is entitled to know the very simple issues as we see them. If there is a crisis, it is because an existing peace is under threat—because an existing island of free people is under pressure—because solemn agreements are being treated with indifference. Established international rights are being threatened with unilateral usurpation. Peaceful circulation has been interrupted by barbed wire and concrete blocks. One recalls the order of the Czar in Pushkin's Boris Godunov: "Take steps at this very hour that our frontiers be fenced in by barriers * * * That not a single soul pass o'er the border, that not a hare be able to run or a crow to fly."

It is absurd to allege that we are threatening a war merely to prevent the Soviet Union and East Germany from signing a so-called treaty of peace. The Western allies are not concerned with any paper arrangement the Soviets may wish to make with a regime of their own creation, on territory occupied by their own troops and governed by their own agents. No such action can affect either our rights or our responsibilities.

If there is a dangerous crisis in Berlin—and there is—it is because of threats against the vital interests and the deep committments of the Western Powers, and the freedom of West Berlin. We cannot yield these interests. We cannot fail these commitments. We cannot surrender the freedom of these people for whom we are responsible. A peace treaty which carried with it the provisions which destroy the peace would be a fraud. A free city which was not genuinely free would suffocate freedom and would be an infamy.

For a city or a people to be truly free, they must have the secure right, without economic, political, or police pressure, to make their own choice and to live their own lives. And, as I have said before, if anyone doubts the extent to which our presence is desired by the people of West Berlin, we are ready to have that question submitted to a free vote in all Berlin and, if possible, among all the German people.

The elementary fact about this crisis is that it is unnecessary. The elementary tools for a peaceful settlement are to be found in the charter. Under its law, agreements are to be kept, unless changed by all those who made them. Established rights are to be respected. The political disposition of peoples should rest upon their own wishes, freely expressed in plebiscites or free elections. If there are legal problems, they can be solved by legal means. If there is a threat of force, it must be rejected. If there is desire for change, it must be a subject for negotiation and if there is negotiation, it must be rooted in mutual respect and concern for the rights of others.

The Western Powers have calmly resolved to defend, by whatever means are forced upon them, their obligations and their access to the free citizens of West Berlin and the self-determination of those citizens. This generation learned from bitter experience that either brandishing or yielding to threats can only lead to war. But firmness and reason can lead to the kind of peaceful solution in which my country profoundly believes.

We are committed to no rigid formula. We see no perfect solution. We recognize that troops and tanks can, for a time, keep a nation divided against its will, however unwise that policy may seem to us. But we believe a peaceful agreement is possible which protects the freedom of West Berlin and allied presence and access, while recognizing the historic and legitimate interests of others in assuring European security.

The possibilities of negotiation are now being explored; it is to early to report what the prospects may be. For our part, we would be glad to report at the appropriate time that a solution has been found. For there is no need for a crisis over Berlin, threatening the peace—and if those who created this crisis desire peace, there will be peace and freedom in Berlin.

X

The events and decisions of the next 10 months may well decide the fate of man for the next 10,000 years. There will be no avoiding those events. There will be no appeal from these decisions. And we in this Hall shall be remembered either as part of the generation that turned this planet into a flaming funeral pyre or the generation that met its vow "to save succeeding generations from the scourge of war."

In the endeavor to meet that vow, I pledge you every effort this Nation possesses. I pledge you that that we shall neither commit nor provoke aggression—that we shall neither flee nor invoke the threat of force—that we shall never negotiate out of fear, we shall never fear to negotiate.

Terror is not a new weapon. Throughout history it has been used by those who could not prevail, either by persuasion or example. But inevitably they fail—either because men are not afread to die for a life worth living—or because the terrorists themselves came to realize that freemen cannot be frightened by threats, and that aggression would meet its own response. And it is in the light of that history that every nation today should know, be he friend or foe, that the United States has both the will and the weapons to join freemen in standing up to their responsibilities.

But I come here today to look across this world of threats to the world of peace. In that search we cannot expect any final triumph—for new problems will always arise. We cannot expect that all nations will adopt like systems—for conformity is the jailor of freedom, and the enemy of growth. Nor can we expect to reach our goal by contrivance, by fiat, or even by the wishes of all.

But however close we sometimes seem to that dark and final abyss, let no man of peace and freedom despair. For he does not stand alone. If we all can persevere—if we can in every land and office look beyond our own shores and ambitions—then surely the age will dawn in which the strong are just and the weak secure and the peace preserved.

Ladies and gentlemen of this assembly—the decision is ours. Never have the nations of the world had so much to lose—or so much to gain. Together we shall save our planet—or together we shall perish in its flames. Save it we can—and save it we must—and then shall we earn the eternal thanks of mankind and, as peacemakers, the eternal blessing of God.

[From office of the White House press secretary, the White House, Mar. 17, 1962]

TEXT OF A LETTER FROM PRESIDENT KENNEDY TO CHAIRMAN NIKITA S. KHRUSHCHEV

MARCH 7, 1962.

His Excellency NIKITA S. KHRUSHCHEV,
Chairman of the Council of Ministers of the Union of Soviet Socialist Republics, Moscow.

DEAR MR. CHAIRMAN: On February 22 last I wrote you that I was instructing appropriate officers of this Government to prepare concrete proposals for immediate projects of common action in the exploration of space. I now present such proposals to you.

The exploration of space is a broad and varied activity and the possibilities for cooperation are many. In suggesting the possible first steps which are set out below. I do not intend to limit our mutual consideration of desirable cooperative activities. On the contrary, I will welcome your concrete suggestions along these or other lines.

1. Perhaps we could render no greater service to mankind through our space programs than by the joint establishment of an early operational weather satellite system. Such a system would be designed to provide global weather data for prompt use by any nation. To initiate this service, I propose that the United States and the Soviet Union each launch a satellite to photograph cloud cover and provide other agreed meteorological service for all nations. The two satellites would be placed in near-polar orbits in planes approximately perpendicular to each other, thus providing regular coverage of all areas. This immensely valuable data would then be disseminated through normal international meteorological channels and would make a significant contribution to the research and service programs now under study by the World Meteorological Organization in response to Resolution 1721 (XVI) adopted by the United Nations General Assembly on December 20, 1961.

2. It would be of great interest to those responsible for the conduct of our respective space programs if they could obtain operational tracking services from each other's territories. Accordingly, I propose that each of our countries establish and operate a radio tracking station to provide tracking services to the other, utilizing equipment which we would each provide to the other. Thus, the United States would provide the technical equipment for a tracking station to be established in the Soviet Union and to be operated by Soviet technicians. The United States would in turn establish and operate a radio tracking station utilizing Soviet equipment. Each country would train the other's technicians in the operation of its equipment, would utilize the station located on its territory to provide tracking services to the other, and would afford such access as may be necessary to accommodate modifications and maintenance of equipment from time to time.

3. In the field of the earth sciences, the precise character of the earth's magnetic field is central to many scientific problems. I propose therefore that we cooperate in mapping the earth's magnetic field in space by utilizing two satellites, one in a near-earth orbit and the second in a more distant orbit. The United States would launch one of these satellites, while the Soviet Union would launch the other. The data would be exchanged throughout the world scientific community, and opportunities for correlation of supporting data obtained on the ground would be arranged.

4. In the field of experimental communications by satellite, the United States has already undertaken arrangements to test and demonstrate the feasibility of intercontinental transmissions. A number of countries are constructing equipment suitable for participation in such testing. I would welcome the Soviet Union's joining in this cooperative effort which will be a step toward meeting the objective, contained in United Nations General Assembly Resolution 1721 (XVI), that communications by means of satellites should be available to the nations of the world as soon as practicable on a global and nondiscriminatory basis. I note also that Secretary Rusk has broached the subject of cooperation in this field with Minister Gromyko and that Mr. Gromyko has expressed some interest. Our technical representatives might now discuss specific possibilities in this field.

5. Given our common interest in manned space flights and in insuring man's ability to survive in space and return safely, I propose that we pool our efforts and exchange our knowledge in the field of space medicine, where future research can be pursued in cooperation with scientists from various countries.

Beyond these specific projects we are prepared now to discuss broader cooperation in the still more challenging projects which must be undertaken in the exploration of outer space. The tasks are so challenging, the costs so great, and the risks to the brave men who engage in space exploration so grave, that we must in all good conscience try every possibility of sharing these tasks and costs and of minimizing these risks. Leaders of the U.S. space program have developed detailed plans for an orderly sequence of manned and unmanned flights for exploration of space and the planets. Out of discussion of these plans, and of your own, for undertaking the tasks of this decade would undoubtedly emerge possibilities for substantive scientific and technical cooperation in manned and unmanned space investigations. Some possibilties are not yet precisely identi-

fiable, but should become clear as the space programs of our two countries proceed. In the case of others it may be possible to start planning together now. For example, we might cooperate in unmanned exploration of the lunar surface, or we might commence now the mutual definition of steps to be taken in sequence for an exhaustive scientific investigation of the planets Mars or Venus, including consideration of the possible utility of manned flight in such programs. When a proper sequence for experiments has been determined, we might share responsibility for the necessary projects. All data would be made freely available.

I believe it is both appropriate and desirable that we take full cognizance of the scientific and other contributions which other states the world over might be able to make in such programs. As agreements are reached between us on any parts of these or similar programs, I propose that we report them to the United Nations Committee on the Peaceful Uses of Outer Space. The Committee offers a variety of additional opportunities for joint cooperative efforts within the framework of its mandate as set forth in General Assembly Resolutions 1472 (XIV) and 1721(XVI).

I am designating technical representatives who will be prepared to meet and discuss with your representatives our ideas and yours in a spirit of practical cooperation. In order to accomplish this at an early date, I suggest that the representatives of our two countries who will be coming to New York to take part in the United Nations Outer Space Committee meet privately to discuss the proposals set forth in this letter.

Sincerely,

JOHN KENNEDY.

Dr. GARDNER. The United Nations resolution established a public registry by the U.N. Secretary General of all objects launched by states into orbit or beyond and called for the exchange of scientific and technical information.

Third, it noted that the International Telecommunication Union plans to call a special conference in 1963 to make allocations of radio-frequency bands for outer space activities and proposed that the ITU consider other aspects of space communication in which international cooperation will be required.

Fourth, it proposed that the World Meteorological Organization (WMO) undertake studies on the means of developing existing weather forecasting capabilities and advancing atmospheric science and technology.

The WMO, which has been asked to take leadership in this field, is, as you know, one of the specialized agencies in the United Nations system, having 113 members. Its Secretary General is a British national, David Arthur Davies. The Convention of the WMO was drawn up by a Conference of Directors of the International Meteorological Organization, an international nongovernmental organization founded at Utrecht, the Netherlands, in 1878. The convention came into effect in 1950 and the Organization was established at its first Congress on April 4, 1951.

The basic objective of the WMO is to coordinate, standardize, and improve world meteorological activities and to encourage an efficient exchange of meteorological information between countries. The United States was assessed 19.03 percent on a budget of $666,179 for the calendar year 1961. The WMO Congress convenes once every 4 years; the next Congress convenes on April 1, 1963, in Geneva. An Executive Committee meets every year. Dr. F. W. Reichelderfer, Chief of the U.S. Weather Bureau, is a member of this Committee.

The U.N. resolution called upon the WMO to prepare an initial report in consultation with UNESCO (United Nations Educational, Scientific, and Cultural Organization) and the scientific community

on two possible programs. The first is an international weather service program—a global network to receive, process, and transmit meteorological information from weather satellites as well as earth-based instruments. The second is an international research program to yield information essential for improved weather prediction and perhaps eventually weather control.

Following passage of the General Assembly resolution on December 20, 1961, the WMO invited the United States and the Soviet Union to send experts to Geneva to help develop these proposals for cooperation.

In response to this invitation, Dr. Harry Wexler, Director of Meteorological Research of the U.S. Weather Bureau, and Dr. V. A. Bugaev, Director of the Soviet Central Weather Forecasting Institute, were made available, and they produced a first draft which, with some modifications, was approved by the WMO's Executive Committee in June.

This report will be considered by the Committee on the Peaceful Uses of Outer Space in its meeting this week and later by the U.N. General Assembly. The WMO quadrennial Congress of Government representatives to be held in April 1963 will also give extensive consideration to this subject.

In the field of weather forecasting, the WMO proposes a system of satellites and conventional observations called the "world weather watch," which would bring improved weather services to every country of the world. First steps in the execution of this program would include the establishment of three world weather centers for the collection and dissemination of data in Washington, Moscow, and a city in the Southern Hemisphere; the establishment of regional centers; and the filling of existing gaps in the network of ground and ship observatories in order to establish global weather coverage.

The improved weather services this program is designed to develop could lead to substantial economic benefits in the United States and other countries. They hold special promise for countries in the Tropics and Southern Hemisphere where vast uninhabited and ocean areas cannot be covered by conventional techniques.

More accurate prediction of storms, floods, rainfall, and droughts will bring major savings in life and property. Significant increases in farm production will be made possible as the nature and timing of crop planting are adjusted to take account of future weather patterns. Fuels can be more effectively distributed where needed. All forms of transportation will benefit—air, sea, and surface.

The research aspects of cooperation in the weather field may be no less significant than the service aspects. Increased knowledge of the atmosphere may lead to new solutions to air pollution above our cities. Eventually it may help us to break up dangerous storms and achieve some control over climate and rainfall.

In the words of the WMO report, "It is not unrealistic to expect that mankind will eventually have the power to influence weather and even climate on a large scale."

By encouraging cooperation now we may reduce the risk that this power will eventually be used by one nation to achieve selfish military or economic advantage at the expense of others.

The WMO report outlines, in a preliminary fashion, the possibilities for research in the weather field. The challenge to the United Nations, in the months ahead, is to find ways to encourage the necessary cooperation among nations in research, in the training of weather experts, in the tracking of weather satellites, and in the exchange of weather information.

I would like to call attention to a related development in this field.

President Kennedy, in his letter of March 7, 1962, to Chairman Khrushchev, on possible areas of space cooperation, observed:

> Perhaps we could render no greater service to mankind through our space programs than by the joint establishment of an early operational weather satellite system. Such a system would be designed to provide global weather data for prompt use by any nation. To initiate this service, I propose that the United States and the Soviet Union each launch a satellite to photograph cloud cover and provide other agreed meteorological services for all nations.

In reply, Chairman Khrushchev, in a letter to President Kennedy on March 20, stated:

> It is difficult to overestimate the benefit which could be brought to mankind by organizing a world weather observation service with the aid of artificial earth satellites. Precise and timely weather forecasts will be another important step along the way to man's conquering of nature, will help him still more successfully to cope with natural calamities, and open up new prospects for improving the well-being of mankind. Let us cooperate in this field, too.

(The complete text of Chairman Khrushchev's reply to President Kennedy is as follows:)

His Excellency JOHN F. KENNEDY,
President of the United States of America, Washington.

DEAR MR. PRESIDENT: Having carefully familiarized myself with your message of March 7 of this year, I note, with satisfaction, that my communication to you of February 21, containing the proposal that our two countries unite their efforts for the conquest of space, has met with the necessary understanding on the part of the Government of the United States.

In advancing this proposal, we proceeded from the fact that all peoples and all mankind are interested in achieving the objective of exploration and peaceful use of outer space, and that the enormous scale of this task, as well as the enormous difficulties which must be overcome, urgently demand broad unification of the scientific, technical, and material capabilities and resources of nations. Now, at a time when the space age is just dawning, it is already evident how much man will be called upon to accomplish. If today the genius of man has created spaceships capable of reaching the surface of the moon with great accuracy and of launching the first cosmonauts into orbit around the earth, then tomorrow manned spacecraft will be able to race to Mars and Venus, and the farther they travel the wider and more immense the prospects will become for man's penetration into the depths of the universe.

The greater the number of countries making their contribution to this truly complicated endeavor, which involves great expense, the more swiftly will the conquest of space in the interests of all humanity proceed. And this means that equal oportunities should be made available for all countries to participate in international cooperation in this field. It is precisely this kind of international cooperation that the Soviet Union unswervingly advocates, true to its policy of developing and strengthening friendship between peoples. As far back as the beginning of 1958, the Soviet Government proposed the conclusion of a broad international agreement on cooperation in the field of the study and peaceful use of outer space, and took the initiative in raising this question for examination by the United Nations. In 1961, immediately after the first space flight by man had been achieved in the Soviet Union, we reaffirmed our readiness to cooperate and unite our efforts with those of other countries, and most of all with your country, which was then making preparations for similar flights. My message to you of February 21, 1962, was dictated by these same aspirations and directed toward this same purpose.

The Soviet Government considers, and has always considered, the successes of our country in the field of space exploration as achievements not only of the Soviet people but of all mankind. The Soviet Union is taking practical steps to the end that the fruits of the labor of Soviet scientists shall become the property of all countries. We widely publish notification of all launchings of satellites, spaceships, and space rockets, reporting all data pertaining to the orbit of flight, weight of space devices launched, radio frequencies, etc.

Soviet scientists have established fruitful professional contacts with their foreign colleagues, including scientists of your country, in such international organizations as the Committee for Outer Space Research and the International Astronautical Federation.

It seems to me, Mr. President, that the necessity is now generally recognized for further practical steps in the noble cause of developing international cooperation in space research for peaceful purposes. Your message shows that the direction of your thoughts does not differ in essence from what we conceive to be practical measures in the field of such cooperation. What, then, should be our starting point?

In this connection, I should like to name several problems of research and peaceful use of space, for whose solution it would, in our opinion, be important to unite the efforts of nations. Some of them, which are encompassed by the recent U.N. General Assembly resolution adopted at the initiative of our two countries, are also mentioned in your message.

1. Scientists consider that the use of artificial earth satellites for the creation of international systems of long-distance communication is entirely realistic at the present stage of space research. Realization of such projects can lead to a significant improvement in the means of communication and television all over the globe. People would be provided with a reliable means of communication, and hitherto unknown opportunities for broadening contacts between nations would be opened. So let us begin by specifying the definite opportunities for cooperation in solving this problem. As I understood from your message, the United States of America is also prepared to do this.

2. It is difficult to overestimate the advantage that people would derive from the organization of a worldwide weather observation service using artificial earth satellites. Precise and timely weather prediction would be still another important step on the path to man's subjugation of the forces of nature; it would permit him to combat more successfully the calamities of the elements, and would give new prospects for advancing the well-being of mankind. Let us also cooperate in this field.

3. It seems to us that it would be expedient to agree upon organizing the observation of objects launched in the direction of the Moon, Mars, Venus, and other planets of the solar system, by radio-technical and optical means, through a joint program.

As our scientists see it, undoubted advantage would be gained by uniting the efforts of nations for the purpose of hastening scientific progress in the study of the physics of interplanetary space and heavenly bodies.

4. At the present stage of man's penetration into space, it would be most desirable to draw up and conclude an international agreement providing for aid in searching for and rescuing spaceships, satellites, and capsules that have accidentally fallen. Such an agreement appears all the more necessary, since it might involve saving the lives of cosmonauts, those courageous explorers of the far reaches of the universe.

5. Your message contains proposals for cooperation between our countries in compiling charts of the earth's magnetic field in outer space by means of satellites, and also for exchanging knowledge in the field of space medicine. I can say that Soviet scientists are prepared to cooperate in this and to exchange data regarding such questions with scientists of other countries.

6. I think, Mr. President, that the time has also come for our two countries, which have advanced farther than others in space research, to try to find a common approach to the solution of the important legal problems with which life itself has confronted the nations in the space age. In this connection, I find it a positive fact that at the U.N. General Assembly's 16th session the Soviet Union and the United States were able to agree upon a proposal on the first principles of space law which was then unanimously approved by the members of the U.N.; a proposal on the applicability of international law, including the U.N. Charter, in outer space and on heavenly bodies; on the accessibility of outer space and heavenly bodies for research and use by all nations in accordance with interna-

tional law; and on the fact that space is not subject to appropriation by nations.

Now, in our opinion, it is necessary to go further.

Expansion of space research being carried out by nations definitely makes it necessary to agree also that in conducting experiments in outer space no one should create obstacles for space study and research for peaceful purposes by other nations. Perhaps it should be stipulated that those experiments in space that might complicate space research by other countries should be the subject of preliminary discussion and agreement on an appropriate international basis.

I have named, Mr. President, only some of the questions whose solution has, in our view, now become urgent and requires cooperation between our countries. In the future, international cooperation in the conquest of space will undoubtedly extend to ever nearer fields of space exploration if we can now lay a firm foundation for it. We hope that scientists of the U.S.S.R. and the United States of America will be able to engage in working out and realizing the many projects for the conquest of outer space hand in hand, and together with scientists of other countries.

Representatives of the U.S.S.R. on the U.N. Space Committee will be given instructions to meet with representatives of the United States in order to discuss concrete questions of cooperation in research and peaceful use of outer space that are of interest to our countries.

Thus, Mr. President, do we conceive of—shall we say—heavenly matters. We sincerely desire that the establishment of cooperation in the field of peaceful use of outer space facilitates the improvement of relations between our countries, the easing of international tension, and the creation of a favorable situation for the peaceful settlement of urgent problems here on our own earth.

At the same time it appears obvious to me that the scale of our cooperation in the peaceful conquest of space, as well as the choice of the lines along which such cooperation would seem possible, is to a certain extent related to the solution of the disarmament problem. Until an agreement on general and complete disarmament is achieved, both our countries will, nevertheless, be limited in their abilities to cooperate in the field of peaceful use of outer space. It is no secret that rockets for military purposes and spacecraft launched for peaceful purposes are based on common scientific and technical achievements. It is true that there are some distinctions here; space rockets require more powerful engines, since by this means they carry greater payloads and attain a higher altitude, while military rockets in general do not require such powerful engines—engines already in existence can carry warheads of great destructive force and assure their arrival at any point on the globe. However, both you and we know, Mr. President, that the principles for designing and producing military rockets and space rockets are the same.

I am expressing these considerations for the simple reason that it would be better if we saw all sides of the question realistically. We should try to overcome any obstacles which may arise in the path of international cooperation in the peaceful conquest of space. It is possible that we shall succeed in doing this, and that will be useful. Considerably broader prospects for cooperation and uniting our scientific-technological achievements, up to and including joint construction of spacecraft for reaching other planets—the Moon, Venus, Mars—will arise when agreement on disarmament has been achieved.

We hope that agreement on general and complete disarmament will be achieved: we are exerting and will continue to exert every effort toward this end. I should like to believe that you also, Mr. President, will spare no effort in acting along these lines.

Yours respectfully,

N. KHRUSHCHEV.

Moscow, *March 20, 1962.*

Dr. GARDNER. As a followup of this exchange of correspondence, bilateral conversations were held between Hugh Dryden, Deputy Director of the National Aeronautics and Space Administration, and Anatoli Blagonravov, of the Soviet Academy of Sciences, during the March and June meetings of the Outer Space Committee in New York and Geneva. They discussed the possibilities of cooperation in meteorology, a world magnetic survey, and satellite telecommunications, and forwarder recommendations to their governments.

Plans were discussed for the gradual increase in the exchange of data from weather satellites during the next few years, looking forward eventual coordinated launchings of meteorological satellites with rapid dissemination of data to other states in accord with the general recommendations of the WMO.

The United States has a considerable program of cooperation with other countries in the exchange of meteorological information. Twenty-seven countries are already cooperating in the Tiros program, and it is expected that even more countries will participate in later versions of Tiros which will be able to photograph cloud cover over more countries.

Twenty-six countries and territories attended an international meteorological satellite workshop sponsored by the National Aeronautics and Space Administration and the U.S. Weather Bureau in Washington from November 13 to 22, 1961.

The workshop included representatives from Argentina, Brazil, Canada, Republic of China, Denmark, Dutch West Indies, El Salvador, Finland, Federal Republic of Germany, France, Honduras, Ireland, Israel, Italy, Jamaica, Netherlands, New Zealands, Nigeria, Norway, Pakistan, Portugal, Republic of South Africa, Thailand, Trinidad, United Arab Republic, and United Kingdom.

Mr. HECHLER. The Soviet Union from your description did not attend that workshop?

Dr. GARDNER. No, Mr. Chairman.

Mr. HECHLER. As I understand it, they indicated that they would attend and did not; is that correct?

Dr. GARDNER. That is correct.

Mr. HECHLER. I wonder if there had been any indication as to why they did not attend?

Dr. GARDNER. Mr. Cartwright?

Mr. CARTWRIGHT. I don't think we have a satisfactory answer, Mr. Chairman.

The opinion was that they were not prepared to contribute measurably so they felt possibly that it was better than they did not attend.

Mr. ROUSH. Was this their answer or was that your conclusion?

Mr. CARTWRIGHT. This was our conclusion.

Their answer was simply that they were not able to be present.

Mr. HECHLER. Thank you.

Colonel PEACOCK. What about the other Communist countries that, indicated that they were going to attend and did not show up; was there any indication on why they did not arrive?

Mr. CARTWRIGHT. No; there was no indication.

Places were prepared for them, but they simply did not appear.

Colonel PEACOCK. Did they give the same reason that the U.S.S.R. did?

Mr. CARTWRIGHT. The reason given by the U.S.S.R. was that they could not attend, and I do not believe there was a definite reply from Czechoslovakia.

Colonel PEACOCK. Or Poland?

Mr. CARTWRIGHT. I think there was no specific reply from Poland.

Colonel PEACOCK. The only reply was from the U.S.S.R.?

Mr. CARTWRIGHT. Yes.

Mr. HECHLER. You may proceed, Mr. Gardner.

Dr. GARDNER. Thank you.

This workshop was significant in that the representatives of foreign meteorological services received instruction in the techniques of utilizing satellite produced data.

The weather services of the cooperating countries were accordingly placed in a better position to utilize information gained from satellites into their own conventional weather forecasting and analyzing services.

Meteorological sounding rockets are also being utilized as an important tool for research in meteorology. NASA has cooperated with Government agencies in Italy, Japan, Pakistan, and Sweden in sounding rocket programs and in the near future a group of countries will conduct sounding rocket programs in the Indian Ocean area to determine the causes for weather patterns in that region.

It is clear from this review that the progress of cooperation in space meterology, as in other areas of space cooperation, serves the national interest of the United States in a number of ways:

In the first place, they provide a way, despite political differences, to exploit the enormous possibilities which the space age opens for all mankind.

This approach is not based on faith or on a fuzzy idealism. We recognize that the deep political differences of our time place an upper limit on cooperation. But we hope in the foreseeable future to develop cooperative projects with the Soviet Union, if not in the form of joint ventures, at least in the coordination of activities.

It is in the interest of all countries, whatever their ideology, that worldwide weather services be developed. Recent meetings have emphasized this common interest to Soviet scientists and technical experts. While the U.N. and its specialized agencies are not the only institutions to promote cooperation, they do help to stimulate affirmative Soviet actions and fit U.S.-Soviet cooperation into a broader framework which recognizes the interests of other countries.

In the second place, U.N. and bilateral programs can help widen and deepen cooperation on a free world basis even if universal participation is not achieved. The assistance of many nations is needed if our national space program is to be successfully carried on. In weather and communications, for example, the technology of the United States can yield dividends to ourselves and others only if many nations join in allocating radio frequencies, in tracking and communicating with space vehicles, and in placing necessary ground installations on their territories.

A good start has already been made in bilateral cooperation through the activities of the National Aeronautics and Space Administration, which has cooperative ventures with some 40 countries involving tracking stations, exchanges of personnel, and joint space experiments. For certain countries and for certain activities, however, cooperative projects may be easier of achievement if they are multilateral and bear United Nations endorsement.

In the third place, the program of space cooperation has deep significance for the U.N. itself. The United Nations and specialized agencies will have new responsibilities for promoting scientific cooperation and information exchange and for assisting in the development of worldwide weather and communications services. Such ac-

tivities cannot fail to strengthen the United Nations as a force for peace by binding its members together through ties of common interest. This is particularly true of the developing countries which stand to derive some of the greatest benefits.

Looking toward the future, we hope to continue the cooperative ventures now underway. The Committee on the Peaceful Uses of Outer Space is now meeting in New York to examine the first report of the WMO covering weather forecasting and research. The U.N. General Assembly will then consider this report. The WMO congress next April will prepare further recommendations on this subject. We look forward to further meetings with the Soviet Union in this field. Our bilateral programs through NASA will no doubt continue to reach more countries.

A special committee of the National Academy of Science has been constituted to prepare recommendations on the atmospheric sciences and hydrology. The title of this committee is the Committee on International Planning in Atmospheric Sciences and Hydrology (CIPASH). It is preparing recommendations on the scientific aspects of these programs. At the same time we have established an interagency committee under the chairmanship of Mr. J. Herbert Hollomon, Assistant Secretary of Commerce for Science and Technology, which includes representatives of the Department of State, the Department of Commerce, the National Science Foundation, NASA, and the Office of Science and Technology to consider the recommendations of CIPASH and to prepare a Government policy position on these programs.

In conclusion, it is the view of the Department of State that the meteorological satellite program is important in our relations with other countries and that we should actively continue to follow up on the initiative and leadership we have already taken in this activity. Our willingness to share the information received through the Tiros satellites with other countries has resulted in foreign cooperation of practical importance to our own efforts as well as good will for the United States. Full support should be given to the weather satellite program by the United States nationally as well as internationally. Here is a program in the peaceful uses of outer space which is not only important to us nationally for economic and social reasons, but in addition is recognized as vitally important to the daily needs of people in all countries. It is a program in which we need the participation of all countries because we cannot do this task alone effectively. It is an extraordinary example of the need for international cooperation in the peaceful uses of outer space.

Mr. HECHLER. Thank you, Dr. Gardner.

It is my recollection that the initial reaction of the Soviet Union was violent when the first series of Tiros satellites were launched and some of their results became apparent.

The reaction as I recall was for the Soviet Union to take the position that these were akin to spy satellites and that it seemed to indicate that the Soviet Union was afraid of what our meteorological satellites might be able to accomplish as a weapon in the cold war.

I wonder if that attitude has changed any?

Dr. GARDNER. I am not familiar, Mr. Chairman, with the reactions which you have cited.

Mr. HECHLER. This was reported in the Soviet press at the time and I think re-reported in the American press, the New York Times and other papers.

Dr. GARDNER. Without commenting on what their reaction was initially, I think we can say that their willingness to send a high ranking expert to Geneva, Dr. Bugaev, to help draw up the plan for a world weather watch which will make use in part of satellite data, and their willingness to discuss this subject of coordinated launchings of meteorological satellites in the bilateral talks between Dr. Dryden and Mr. Blagonravov would indicate that they are taking a more affirmative line on the subject.

Mr. HECHLER. I would like to get a little more clearly in mind what our Government's philosophy is with respect to its relations with the Soviet Union in the development of meteorological satellites and the use of the information therefrom.

Is it a feeling that this might relieve some of the tensions of the cold war, or is this a feeling that such cooperation might be beneficial to us in our relations with other nations?

Or what is the basic thrust of our cooperation with the Soviet Union on meteorological satellite development?

Dr. GARDNER. I think one could say in summary that there are essentially two overriding objectives here as far as the national interest of the United States is concerned.

The first is to promote our practical self-interest in using this new technology with all the economic and commercial benefits it holds for our own people.

To use this technology—to make use of satellite weather data as well as conventional weather data—we need the cooperation of other countries for obvious reasons.

We need to know what the weather is that is coming at us, so to speak, from other continents. In some of the later developments of the meteorological satellites we will need various installations on the territories of other countries for the reading out of this data.

Even in the Tiros program we need tracking facilities on other countries' territories.

Now, for all these various reasons it is useful to engage as many countries as possible in this effort because the more countries we can engage the more adequate this data is that we receive.

It helps, I think, to engage the Soviet Union as well because to the extent that this becomes a global effort under U.N. auspices, to that extent it is easier to link in a number of countries which might be reluctant to take part in an enterprise which was less than universal.

Mr. HECHLER. Neutralist countries?

Dr. GARDNER. That is correct.

What I am saying, Mr. Chairman, is that a program under the WMO and under the U.N. is in our judgment very useful in order to encourage cooperation on the widest possible basis.

So that, I think, is the first motive we have here.

The second motive is, you might say, more political. We see in these measures of scientific and technical cooperation instruments for improving relations between other nations, including the Soviet Union, and ourselves.

We have no illusions, of course, that science will help to dispel entirely the cold war. We know that is unrealistic. We do think these sustained contacts between specialists, between scientists, can make more likely cooperative programs in our mutual interests, and thus overcome political obstacles.

I had the privilege of taking part myself as the deputy U.S. representative to the U.N. Outer Space Committee in the meetings in New York and in Geneva and also in the bilateral conversations with the Soviet Union, and I was struck there at the degree of cooperation that was achieved.

I think that meetings of this kind demonstrate in a striking way to the experts the benefits that can be gained through cooperation in this field as in others.

I think that through such meetings the respective governments can be made to see the advantages in terms of national interest that can come through cooperative programs of this kind.

So I would say, in conclusion, Mr. Chairman, that these two overriding interests, deriving information and assistance we need for the carrying on of our own weather program, and second, improving cooperation across political lines, are the overriding motives which have prompted us to take this initiative.

Mr. HECHLER. The cold war blows hot and cold and ebbs and flows from time to time.

Do you notice any reaction so far as this specific program is concerned?

Do you notice that cooperation gets closer or further apart as the cold war steams up?

Dr. GARDNER. That is a difficult question to answer.

It is our hope, Mr. Chairman, that programs of this kind of a scientific and technical character will not be affected by ups and downs in the political climate of the day.

I think it is interesting to note, for example, to take an example in a somewhat different field, that the ITU has been able to get on with its job of laying down rules for the allocation of radio frequencies, even during periods of acute political tension, in fact, even during the Second World War, and the WMO has had a long and successful history of cooperation in the weather field, despite the rise and fall of tensions.

Weather is inherently international, as are communications, and we would hope cooperation could go forward.

Mr. HECHLER. I don't intend my question to be philosophical. I was trying to find out whether you had observed any correlation. I guess the answer is "No".

Dr. GARDNER. I have not myself, sir, observed any correlation between political events and this program in the last few months.

Mr. HECHLER. I can see some great advantage of having a station at Moscow supply us as part of a—what do you call it? National weather——

Dr. GARDNER. World weather watch?

Mr. HECHLER. I can see the advantage of this, of course, since we do not have an opportunity to get information otherwise, but what else has the Soviet Union contributed, scientifically or otherwise, to the development of this program?

Dr. GARDNER. By "this program," Mr. Chairman, you mean only the satellite program or the general business of improving weather forecasting?

Mr. HECHLER. Both.

Dr. GARDNER. I think here, if you will permit me, Mr. Chairman, I would like to call upon one or two of my colleagues, who are more expert in the technical details.

Again I think perhaps Mr. Cartwright would care to comment.

Mr. HECHLER. Let me preface this by observing that the United States is very far ahead in this field and perhaps we have a great deal more to offer than the Soviet Union.

Mr. CARTWRIGHT. Yes, Mr. Chairman, I think we do all agree this is true as far as we have been able to ascertain from them.

I think there is recognition that they have a large capability in the satellite field generally.

We hope that this will be carried over into the meteorological satellite field, where we are confident we have the lead.

On the other side—the general contribution to meteorology—the Soviet Union has probably the strongest, largest most capable weather service outside of that of the United States and we have numerous discussions with them at the technical level on a variety of problems.

We meet with them frequently through the auspices of the WMO, and I think that the proposed satellite cooperation follows as a rather natural consequence to this kind of cooperation.

We hope that by our own offerings they will reciprocate and that there will be a mutual advantage to this exchange.

They do have great capability in the weather field.

Thank you.

Mr. HECHLER. But there is no specific contribution that you could put your finger on?

Mr. CARTWRIGHT. In the meteorological field?

Mr. HECHLER. Yes.

Mr. CARTWRIGHT. Not at this stage.

Mr. HECHLER. Is there anything further that you could add, Mr. Gardner, about the results or implementation of the conversations?

Dr. GARDNER. As you know, Mr. Chairman, these conversations involved this subject of coordinating launching satellites and the exchange of weather information.

The agreements reached were referred to the two governments. So it remains for the two governments, as it were, to adopt the agreements as formal international intergovernmental undertakings.

We for our part are ready to proceed.

The talks between Doctors Dryden and Blagonravov will, I believe, carry forward and continue this week in New York during the meetings of the Outer Space Committee, but the understandings reached between them have not yet become the subject of a formal intergovernmental agreement.

Mr. HECHLER. Perhaps for the logical development of the subject matter here we could proceed to examine a little further the question of relations with the Soviet Union and get on to relations with the free nations.

Mr. Roush?

Mr. ROUSH. Mr. Chairman, I would like to defer to the counsel.

Mr. HECHLER. Mr. Hines?

Mr. HINES. Dr. Gardner, is it true that the Soviet Union objected to the original resolution passed in the U.N., that they desired to have more teeth in the resolution than the original had? The resolution that was passed in the U.N. for a WMO study was actually their resolution; is that not so?

Dr. GARDNER. No; I don't think that is quite the history.

This resolution—and I think you are referring to General Assembly Resolution 1721, passed at the 16th Geneva Assembly——

Mr. HINES. That is correct.

Dr. GARDNER. Was a resolution initiated by the United States. It was advanced under U.S. sponsorship. It was drafted originally here in Washington. It was negotiated with other countries.

It really is an implementation of the four-point program which President Kennedy put forward to the United Nations in September.

It is quite an interesting history. After we were able to get a broad consensus among our friends on the substance of this resolution we asked the Soviet Union to cosponsor it with us.

First they showed a little hesitation, said they wanted some more time to get instructions from home.

We felt that, in view of the fact that the agenda item was up for discussion we had to lay it on the table, so the resolution went down initially under the sponsorship of the United States and two or three other countries outside of the Soviet bloc.

Ambassador Stevenson then made a speech introducing it, and then later we were informed by the Soviet Union that they, after consideration, would be willing to cosponsor it.

So the resolution was finally put forward under the sponsorship of the Soviet Union as well as the United States. But the resolution is essentially one which embodies the program of President Kennedy and was drafted largely by the United States and modified in collaboration with like-minded countries—our Western friends.

Mr. HINES. It is my understanding the first draft would not have included a specific study; is that correct?

Dr. GARDNER. Mr. Hines, this is the first time I have ever heard that question posed, and I don't know what the basis of it is.

It was our intention from the very beginning to ask the WMO to draw up a program in this field.

This is one of the things we wanted very much to happen. That was in the very early drafts.

I was involved in the negotiation of this resolution from the beginning to end, and I am not aware that the Soviets wanted to go any further in this field than we did. I think the limiting factor, frankly, was that a matter as technical as this is always difficult to negotiate in the General Assembly, where the representatives are not experts in the weather field.

As you know, these are the permanent representatives who attend the General Assembly, or people who come specially; they are political people, and the limiting factor on the degree of detail was simply the lack of information of most of the people in New York on this whole subject.

They said, let's just call for a study, but let's not get into all this detail, because we do not understand it. We feel, therefore, that this

part C of the resolution was the high watermark of cooperation which we felt we could get at the U.N. last year.

I think on reflection this was the best way to proceed, because it is for the WMO, where you have the expertise, not for the General Assembly, where you have political representatives, to draw up the details, to put flesh and blood on this whole enterprise.

Mr. HINES. Would you say that the exchange of notes between Mr. Khrushchev and President Kennedy would be an end run around the WMO because the Soviet Union failed to participate in the program?

Mr. GARDNER. No. We don't see any inconsistency between the exchange of notes between Kennedy and Khrushchev or the bilateral talks on the one hand and cooperation with the WMO and the U.N. on the other.

The fact is that as of this moment there are two states in the world who are space powers in the sense of being able to launch objects into outer space, only two states that have the potential in the immediate future to have meteorological satellite programs.

At the same time, there are a large number of other states who are interested in the exchange of weather information.

To have on the one hand bilateral conversations calling for the coordinating of launching by these two space powers of weather satellites and to go on at the same time in negotiations designed to fold this bilateral cooperation into a broad multilateral framework seems to us to be a very logical and consistent way of proceeding.

Mr. HINES. I did feel there was an inconsistency in the fact the Soviet Union would be willing to participate operationally and yet seem to be quite reluctant to participate in any other area.

This seems to be inconsistent as far as the World Meteorological Organization is concerned.

Am I being accurate?

Dr. GARDNER. As you know, the Soviet Union does participate in the WMO. They sent an expert to help draft this report for the world weather watch. So they are actively participating in the WMO program.

Mr. HINES. I'm sorry, I was thinking of the workshop.

I did not mean to say WMO.

Dr. GARDNER. Oh. They failed to come to the workshop, that is true, but they are participating actively in the WMO program.

Mr. HINES. Yes. I did feel there was an inconsistency there.

Forgive my inadvertent reference to the WMO.

Dr. GARDNER. Your question is as to the contrast between their failure to come to the workshop on the one hand and the subsequent cooperation on the other?

Mr. HINES. Yes.

Dr. GARDNER. I do not know the answer to that.

Soviet behavior is often difficult to explain. I think that the initiative which the United States took in December in the U.N. has paid off in getting started a lot of cooperation with the Soviet Union which might otherwise not have taken place. We were stalled on dead center up until December of last year as far as space cooperation with the Soviets was concerned. For 2 years the U.N. Committee on the Peaceful Uses of Outer Space had been unable to meet because of the disagreements over its rules of procedure.

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When we took the initiative in putting this resolution forward I think we built such a ground swell of enthusiasm among other nations for going forward that the Soviet Union was obliged to come in lest it be left on the sidelines to watch the rest of the world go ahead without it.

I think that has had a measurable effect on the whole Soviet attitude with respect to cooperation both in this field and in others.

Mr. HECHLER. Then it is fair to say that the multilateral system has great potentiality?

Dr. GARDNER. Again, Mr. Chairman, we feel that bilateral and multilateral instruments are both useful.

We think there are certain advantages which the multilateral system has, and I think experience demonstrates this, but we would not want to say for a moment that the bilateral cooperation should be supplanted.

That has also an important role to play, in our judgment.

Colonel PEACOCK. I would like to refer back to the chairman's statement regarding the release in Moscow on the 23d of July 1961 in which the Soviet Union said the U.S. launching of two experimental observation satellites have been acts of espionage and aggression.

The newspaper Krasnaya Zvezda, the newspaper of the Soviet Armed Forces, compared the orbiting of Tiros III weather reporting satellite and Midas III rocket detonating satellite with flights over the Soviet Union of the U–2 reconnaissance plane. I have two questions, sir.

No. 1: Was this a reconnaissance activity as far as Tiros III was concerned in the true connotation of intelligence, gathering activities; and, No. 2, was the Soviet's reason for accusing the United States of utilizing Tiros III as the spy in the sky done because of their fear that it in essence was an intelligence-gathering mission, or that the tremendous effect that this program had on the uncommitted nations of the world by providing weather forecasting for them was of such value that they felt they must discredit this activity, even though they were participating in it?

Dr. GARDNER. Well, Congressman, in the first place, the Tiros——

Colonel PEACOCK. I am a staff member.

Dr. GARDNER. I am sorry, Colonel Peacock.

The Tiros program is for the purpose of meteorology. That is its sole purpose. Its purpose is to aid us in improving our weather forecasting capability and improving our research work in the weather field.

Colonel PEACOCK. There is no military or reconnaissance activity carried on as a part of this Tiros program as far as you are concerned?

Dr. GARDNER. Certainly not. But on the broader question, our national position on this whole subject is quite clear.

International law imposes no restraint on photography from satellites. Satellites are in outer space. Outer space, as the U.N. has now affirmed, is free for use by all—like the high seas.

There is no basis for objecting to observation and photography from outer space.

So that these Soviet statements are just without foundation in law.

Colonel PEACOCK. In your opinion why did they make this accusation to try and discredit our program?

Were they trying to discredit the Tiros program?

Or did they seriously feel we were carrying on intelligence activities?

What is your evaluation of the situation?

Dr. GARDNER. I have not seen the speeches to which you referred and I prefer to withhold comment until I have had a chance to study them.

Colonel PEACOCK. These were made last year—in 1961.

Mr. HECHLER. My own reaction when I saw that comment was that it was the reaction of the small boy that had been beaten in a race and was yelling a little about it.

Colonel PEACOCK. One other question along that line:

Do you feel that any utilization of the Tiros activity to meet military requirements would discredit the program on a worldwide basis as far as—forgetting the Soviet Union for a minute—of bringing in other nations to participate in this program, especially the United Nations?

Dr. GARDNER. Well, as I said, Mr. Peacock, the Tiros program is a program which is concerned exclusively with the gathering of weather information.

Now, I don't know one can distinguish entirely an operation like that so far as the end use of the product is concerned.

I daresay that the Coast Guard and the Navy can make use of weather forecasts as well as the merchant ships but I cannot myself see how that in any way makes the program less desirable or less attractive.

Colonel PEACOCK. The State Department's position is, even though its data would be utilized to meet military requirements, this would have no connotation on the program that it was a quasi-military activity, and thereby discredit the activity carried on under the Weather Bureau and NASA.

Dr. GARDNER. No; I would not think it would.

Colonel PEACOCK. Thank you.

Mr. HECHLER. I think these Tiros satellites are tremendous weapons of freedom. I believe you have described in your opening statement the way they have fired the imagination of the people throughout the world.

I wonder if you could be a little more specific.

Does the average person in other countries really understand the significance of the tremendous development which the United States has made in weather satellites?

Dr. GARDNER. Mr. Chairman, again this is a difficult question to answer with any degree of detail. It is our impression that this program is gaining increasing recognition around the world, not only among the specialists and the scientists but also by the man in the street.

We have sought wherever possible through the USIA and elsewhere to emphasize the practical benefits for man on earth of our outer space program.

The Soviets have emphasized the big, dramatic man in space enterprise and have emphasized the potential military significance of those activities.

They have done very little in the field of those space activities in communications and weather, for example, which bring tangible benefits to man on earth.

We have sought to emphasize these latter aspects of our space program.

Mr. HECHLER. How do you do that?

Dr. GARDNER. Well, for example, by putting forward Resolution 1721 in the U.N., the heart of which is concerned with cooperation in the weather and communications field, and by emphasizing in our USIA broadcasts and our public statements by high officials here and abroad how our space program is designed to bring tangible benefits to mankind.

Mr. HECHLER. But do you have concrete evidence that this is really getting across to the man in the street?

Dr. GARDNER. Well, it is very hard to measure a thing like that, Mr. Chairman, as you know.

I don't know of any polls that have been taken on the subject.

Perhaps some of my colleagues can provide additional information on that.

I can only say that through my own contacts with foreign leaders at the U.N. and in Geneva at WMO I have noted how they have been struck by our progress in this field and how they appreciate the benefits which this progress is making possible in their own interest.

Mr. HECHLER. My question, of course, sought to ascertain whether the people beneath the leaders understand this.

As I say, you cannot determine this except perhaps by taking a poll. I wondered if you really have followed very closely what the USIA is doing, or do you have any direction or coordination with USIA?

Dr. GARDNER. We certainly do. I can give you an example of this, Mr. Chairman, even though it is perhaps on a slightly different subject.

In the Telstar program, for example, that has similarly aroused attention all over the world, there has been a great deal about Telstar in the European press and in the press of other countries.

We have announced publicly that we would like to see this facility used in such a way as to widen and deepen communications between countries.

We have offered specifically to use this Telstar that is now up in orbit for the broadcasting of programs from the U.N. starting with this General Assembly next week.

Now, that whole line of approach has been designed to dramatize for people everywhere the practical utility in terms of human benefit of our space program.

We have tried to do the same thing in the field of our meteorological satellites. We do work very closely with the U.S. Information Agency in this effort to get that story across.

Mr. HECHLER. I think you ought to do a good deal more.

Here is a field where we have made marked progress for the advantage of peoples all over the world. I think that a good deal more can be done toward expressing this information to the average person in these countries.

For example, what is the Peace Corps doing?

Are they informing the people of what the United States has done and is capable of doing, in order to improve the lot of the average person, through weather information?

Dr. GARDNER. I am not familiar with the Peace Corps activities in this weather field.

Again I may ask Mr. Cartwright.

Are you familiar with any programs they may have?

Mr. HECHLER. I merely threw this out as a suggestion in conjunction with their other activities.

Mr. CARTWRIGHT. I am not familiar, but the suggestion of the chairman that they might be used to facilitate the spread of this information seems like something that could be considered.

We do not have a formal collection of material on the reaction of the average man in the street.

We do have a feeling that he is aware, in certain countries, at least, of the value of the meteorological satellite. This is particularly true in Australia. Australians being surrounded by large water areas, have been eager to receive the satellite weather data, and I believe there has been some publicity in the press there as to its value.

Mr. HECHLER. I am concerned not only with the publicity but with the practical application of the data which we secure from Tiros, its practical application to the advantage of the average person in these countries.

Has anything been done that you can elaborate on in that way?

Dr. GARDNER. The question is as to the practical benefit which the program has brought to people in the other countries?

Mr. HECHLER. Yes.

Dr. GARDNER. I think we have ample evidence of that.

One dramatic example is that this very year Tiros V which is now in orbit, observed and photographed no fewer than 10 tropical storms of hurricane or near hurricane proportions and in five of these cases, the Tiros sighting was the first warning.

Mr. HECHLER. Yes. That has been brought out before the committee by Dr. Singer.

Dr. GARDNER. We have made that information available to the interested countries and as a result of that, instructions were sent out and precautions taken with respect to ships and aircraft and so on.

That is a very dramatic way in which the information from this technology can save lives and property, and this is a use which is widely appreciated and widely publicized in the countries concerned.

Mr. HECHLER. Dr. Singer, of the Weather Bureau also brought out the fact that these weather satellites can now identify locust clouds.

How can the State Department and its agencies utilize information such as that in its relations with underdeveloped nations?

Dr. GARDNER. Mr. Nesbitt, I think, can comment on that.

Mr. NESBITT. I can speak from firsthand experience.

I had 3 years duty in Beirut as chief economic officer.

We had stationed there a pest control plane, I believe controlled by the Department of Agriculture.

Periodically we received requests from countries for the plane to assist in eradicating these plagues of locusts.

If they can be discovered prior to the time they approach the wheat fields—the crop areas—they can prevent a lot of damage.

It can have an effect on the magnitude of our Public Law 480 programs and other programs.

I think it is decidedly beneficial. The Arabian Peninsula and northern Africa is an area interested in this.

Mr. ROUSH. Mr. Chairman?

Mr. HECHLER. Mr. Roush.

Mr. ROUSH. It occurs to me that one of our prime problems in communicating our achievements and ability to assist these nations would be one of communicating to the people of these nations in which we are most interested, the underdeveloped countries of the world; for example, where radio and television is probably unknown to the man in the street.

This was brought to mind during your testimony this morning. It also caused me to think back to a time when, I think 3 years ago, we had Mr. Allen appear before our full committee. He testified as to the terrific impact the launching of Sputnik I had on the world. He dramatized this by saying that even the people in the backwoods of Africa were aware that the Russians had launched Sputnik I.

Apparently there is some means of communicating to these people in these backward countries. I am wondering what we are doing to solve this problem of communications with people other than the leaders, people other than the diplomats and the State Department people, people who are working in these countries.

Could you comment on this?

Dr. GARDNER. Of course the whole field of our public information policy overseas is really one which is in the domain of the U.S. Information Agency.

It would be up to Mr. Murrow and his staff to give you the kind of detail on that I think you wish to have.

We have, as I have said earlier, tried as much as we can to bring this story not only to the scientists and political leadership but to the man in the street in all countries.

We have sought to do this through the USIA posts in the various countries, we have distributed material on this subject, we have had radio broadcasts on it, and so forth.

Mr. ROUSH. Just as an example, do we have a program whereby we are trying to place a radio set in, say, community centers, such as villages in Vietnam, so that we might have a means of communicating with the people?

Do we have any program of that sort?

Dr. GARDNER. Well, of course, that example suggests there may be limits to the extent to which the United States can set up communications operations in a foreign country when you get into the sensitivity of the host country.

I don't know if we could establish a facility of that kind. I think in all cases the U.S. programs have to be broadcast within the foreign country as a result of an agreement with the authorities, the communication authorities in the country, to take it over their national network.

But, again, I am simply not able to give you details because now you are moving into an area which is essentially a public information area and that is not my responsibility in the Department of State.

Mr. ROUSH. The countries I am thinking of probably do not have a national network.

Referring to countries of Africa, for example, I doubt if there is a single radio in the great majority of the villages of Ghana. I wonder if we have a program to place a radio in these villages and tell our story to these people?

I can appreciate the difficulties and I think I understand what you are doing. But having been in some of these countries it always seems to me we are dealing with the diplomats and the office downtown that the U.S. Information Service has. I wonder how successful we are in communicating to the people where it actually counts, to the multitudes on the streets.

I have belabored this point too long, Mr. Chairman.

Mr. HECHLER. If the gentleman will yield: I think this is clearly a diplomatic weapon.

I would like to see the State Department push it a little bit more.

Dr. GARDNER. We share, Mr. Chairman, the concern of the committee with respect to the relationship between the mass media communications and our foreign policy.

I think we have in the last year tried to intensify our effort across the board.

The Peace Corps is in fact an institution designed to bring American policy down to the grassroots, to get us out, as you say, beyond the major cities into the countryside.

We have major programs of information we beam on the Voice of America and that reaches not only people in the cities but in the countryside.

Mr. HECHLER. That is why I would hope the Peace Corps and our other representatives could tell the people in the other nations what the potentiality for their own development of these improvements and weather information will provide.

We could understand why sputnik and Telstar could have their impact, but here is something which is, I think, going to provide tremendous benefits, and I would hope that it can be utilized.

In your statement, Dr. Gardner, you mentioned that 27 countries are already cooperating in the Tiros program. How?

Dr. GARDNER. I think again, Mr. Chairman, with your permission, I would like to ask Dr. Cartwright to make a presentation on this aspect.

Mr. HECHLER. Dr. Cartwright?

Mr. CARTWRIGHT. It is "Mister" Cartwright, Mr. Chairman.

When the first Tiros was launched there was such immediate interest in it that it was decided to capitalize on this by asking countries to participate in the program to the extent they could. Letters were sent out to approximately a hundred weather services prior to each of the subsequent launchings of the Tiros series inviting them to make supplementary observations on their own territories that could be used to assist them in understanding the significance of the Tiros cloud pictures for their own areas.

The basic idea was to stimulate the individual countries to use the Tiros data, both in research and in daily forecasting, so that when the operational system—the Nimbus satellite system—came into use, people round the world would be prepared, they would understand the meaning of the data and be prepared to use it on a current basis.

I think that this is in line with part of the objective that you have mentioned earlier, to try to get awareness of the program and what it really contributes to their own country.

Mr. HECHLER. Are these 27 countries the ones that were represented at the workshop, or which countries are they?

Mr. CARTWRIGHT. No, not in every case. I think they have changed somewhat as one Tiros succeeded another.

I don't know that we have a list of those at hand.

Do we have one?

Mr. HECHLER. If you have a number 27 we certainly ought to have a list.

Mr. CARTWRIGHT. Excuse me. I believe that the 27 referred to—I think that probably referred to Tiros III.

There have been subsequent numbers available on subsequent Tiros experiments. We can provide a list.

Mr. HECHLER. It might be helpful to give us a list of the nations that are cooperating on Tiros V, for example.

Mr. CARTWRIGHT. This can be done.

(The following countries and territories have indicated their participation in the Tiros meteorological satellite experiments:)

1. Argentina
2. Australia
3. Austria
4. Belgium
5. Brazil
6. Burma
7. Canada
8. Chad
9. China, Republic of
10. Colombia
11. Costa Rica
12. Czechoslovakia
13. El Salvador
14. Germany, Federal Republic of
15. France
16. Hong Kong
17. Hungary
18. Iceland
19. India
20. Iraq
21. Ireland
22. Japan
23. Kenya
24. Mauritius
25. Mozambique
26. Netherlands
27. Netherlands New Guinea
28. New Zealand
29. Poland
30. Portugal
31. Senegal
32. South Africa, Republic of
33. Southern Rhodesia
34. Sudan
35. Switzerland
36. Thailand
37. United Arab Republic
38. United Kingdom
39. West Indies Federation

Mr. HECHLER. Dr. Gardner, what about the usefulness of meteorological satellite information to establish better relations with countries that are neutralist in nature?

Has this helped us any in opening up diplomatic negotiations or in making progress so far as unstable governments and our relations with them are concerned?

Dr. GARDNER. Again, Mr. Chairman, it is hard to be very specific in answering that question, but I think we could say generally that this program, as well as our Telstar program, our general willingness to be forthcoming in making the benefits of our space activities generally available, does bring us political benefits in the uncommitted world.

It makes it easier for us to get cooperation from these countries in tracking our vehicles and other things in which we may want them to participate.

It gives them a feeling that our purpose in outer space is not national self-glorification or other things, it is to bring practical benefits to ourselves and other people.

So I think from that general point of view, the program of space meteorology and work in the atmospheric science generally is politically useful.

I think we will see more of this in the future. So far we have been mainly in the experimental stage, as you know. We are moving rapidly, I think, into a period in the middle of this decade where we will be going operational and I think at that point the benefits will be even more dramatic, and the degree of cooperation with the uncommitted countries as well as the countries of the free world, and, hopefully, the Soviets, will profoundly increase.

Mr. HECHLER. Colonel Peacock.

Colonel PEACOCK. In drawing up agreements with these particular countries how do you actually go about this?

Does the State Department draw up an individual agreement with each country or do you have a blanket invitation extended to these particular countries and those that want to come in and participate do, and at a later date you probably formalize the dissemination of the information?

Dr. GARDNER. Speaking of the agreements in the weather field?

Colonel PEACOCK. In the weather field, per se.

How do you open the door for these people? After you open the door, how do you take care of them, and how do they get the information? What level does it have to go through before they get it, or do they get it at the working level?

Tell us how it is handled.

Dr. GARDNER. Mr. Cartwright?

Mr. CARTWRIGHT. In the first place, the information that is immediately available from the satellite is transmitted to virtually all the countries of the world over the normal weather communications channels.

The particular cooperative program to which you have referred was worked out by NASA and the Weather Bureau. Letters were sent to the directors of weather services and the directors of Space Research Committees in the various countries, offering this program.

The response depended on their interest and ability to do something themselves which would give the cooperation significance for them.

The objective of the United States is primarily to provide the foreign weather services with advance information on when the Tiros satellite might be able to take photographs over their area so that they themselves could take additional observations which would make the Tiros photographs more meaningful. Then, if they were able to take special observations, we would supply them as soon as possible, copies or Tiros photographs that were actually taken by the satellite as well as any other supplementary data that would help them to interpret their own observations.

This program has been worked out directly between the weather services of the United States and other countries with NASA being kept fully informed.

Colonel PEACOCK. What kind of agreement do you have in the diplomatic level to carry out these responsibilities?

Do you have some kind of formal agreement with the country that is participating?

Mr. CARTWRIGHT. Yes, I believe so.

You are speaking now of something more extensive than the international cooperative program that I have described?

Colonel PEACOCK. You say there are 27 countries participating?

You have no agreements with these 27 countries then along this line?

Mr. CARTWRIGHT. That is right.

It is arranged by an exchange of correspondence.

Colonel PEACOCK. Do you have any agreements with any countries that are tied into this meteorological program where tracking facilities or other facilities are located in their country and manned by our personnel?

Mr. GARDNER. Mr. Nesbitt?

Mr. NESBITT. We are negotiating one now with Canada for Nimbus. That is in the state of negotiation.

Colonel PEACOCK. That is the only one?

Mr. NESBITT. Yes.

Colonel PEACOCK. Are these facilities that are being utilized by the meteorological satellite program, being provided under other agreements; in other words, they are already established and being utilized in other programs in addition to the meteorological program, so it does not warrant separate agreements just for this program per se?

Mr. NESBITT. That is correct.

Mr. HECHLER. Would you think this could develop into something that would be more substantial, that would necessitate including some more formal arrangements as our cooperation becomes closer?

Mr. NESBITT. I would think the Nimbus program would call for that.

Mr. HECHLER. You don't think that there would be any other requirements for agreements pending Nimbus?

Dr. GARDNER. As I understand it, Mr. Chairman, the Tiros does not require read-out facilities on the territory of other countries; is that correct, Mr. Cartwright?

Mr. CARTWRIGHT. Yes.

Dr. GARDNER. Nimbus, I believe, will.

So that gives rise to a new situation.

Mr. HECHLER. Yes.

Dr. GARDNER. Which will require establishment of a specific facility. So far as tracking is concerned, it is my understanding that those stations, as has been pointed out by Colonel Peacock, are established pursuant to a general understanding. The stations are multipurpose, they are tracking all vehicles, not just for this purpose.

Mr. HECHLER. Have you noticed any disposition on the part of representatives of these 27 countries to come forward with offers for assisting us in collecting weather information, that might supplement our own developments?

Mr. CARTWRIGHT. Yes, Mr. Chairman, there has been a great deal of interest in this respect and we have established in the National Weather Satellite Center an achival system which will make these data available to all our research scientists.

Mr. HECHLER. It would seem to be that would be an additional way not only to gain scientific information but it would also be an additional way to tie these nations and peoples there into us diplo-

matically as active participants instead of simply being on the receiving end.

Mr. CARTWRIGHT. Exactly. I think this was the heart of the international cooperative program.

It is still working at a rather modest level.

Mr. HECHLER. I don't want to suggest that it be immodest.

I would hope that it would gain some additional support.

Dr. GARDNER. Again, Mr. Chairman, I think we would like to emphasize that the satellite meteorological program is only a part of a total effort in which conventional observations play a major part, perhaps still the largest part.

Mr. HECHLER. Yes.

Dr. GARDNER. This "World Weather Watch"—this report of the WMO—calls for international cooperation in both the conventional as well as in the space meteorology.

As far as participation by other countries is concerned, they will participate very directly in the conventional part of this, in the observatories to be established on islands, on ships, on their own territories, through the regional centers that are established for reception and analysis and dissemination of weather data from whatever source.

So there will be an active participation on a wide scale as envisioned in this WMO report.

Mr. HECHLER. I wish you would look into means of getting more people to participate on the ground level in the various nations because I think that has great potentiality for the future.

Dr. GARDNER. In this connection, Mr. Chairman, one of the specific and one of the first things that is envisioned in connection with this whole program is the increase in training of meteorologists in the less developed countries.

Mr. HECHLER. Good.

Dr. GARDNER. You know WMO is already carrying on a significant program of this kind. It gets its money from the United Nations expanded program of technical assistance and the U.N. Special Fund.

It serves, in other words, as the executing agent for technical and preinvestment aid in this weather field.

This goes for the granting of fellowships to bring people from the less developed countries to the countries of Europe and North America for training in the weather field.

U.S. WEATHER BUREAU PARTICIPATION IN METEOROLOGICAL TRAINING FOR FOREIGN METEOROLOGICAL SERVICES

The first occasion in which the U.S. Weather Bureau offered meteorological training to foreign meteorologists on a significant scale occurred in 1942–43. At that time, the Weather Bureau, in collaboration with the Department of State, trained 200 Latin Americans in aeronautical meteorology at Medellin, Colombia, and 8 in hurricane meteorology at New Orleans, La. Following the war, the Weather Bureau directed a $2,500,000 project involving the training of personnel and the provisions of the meteorological equipment to the Philippines. Under this program, 109 meteorologists were trained in the United States.

During the past 20 years, the Weather Bureau, in collaboration with AID (and its predecessors) and the United Nations, has arranged training programs for participants from more than 60 different countries. (See app. A.) It administers these programs and makes arrangements for academic training at American universities and/or practical training at Weather Bureau field offices and in Washington, as required. Practical training, in all cases, includes instruction in the processing and interpretation of data from meteorological satellites.

The Weather Bureau has several consultants serving foreign governments abroad. They advise recipient governments concerning the organization of the meteorological services, the placement of students for training, equipment requirements and general overall improvement of the organization of meteorology in the country. Some of the consultants have conducted very successful classroom training within the recipient country. A geographic analysis of Bureau technicians and supporting personnel utilized in oversea projects from 1957 to 1962 is indicated in appendix B.

In addition, the Weather Bureau has conducted special workshops. The most recent of these was the International Meteorological Satellite Workshop, sponsored by NASA and the Weather Bureau, which met in Washington, D.C., in November 1961. This workshop provided weather services throughout the world an opportunity to study the processing of data from meteorological satellites and the utilization of such data for research and operational purposes. It represented a significant step toward preparing the meteorological community for the time when the meteorological satellite data may be available routinely for daily weather analyses and forecasting.

It has become more and more evident that the successful development of large-scale economic aid programs require early consideration of meteorological factors. For example, some of the first programs approved under the U.N. Special Fund have been in the field of hydrometeorology, in recognition of the fact that large-scale water resources projects should be based on reliable hydroclimatic data. The same principle applies to such things as airport development, agricultural programs, public utilities, etc.

The Weather Bureau program, although relatively modest, has provided training in the last two decades for hundreds of meteorologists, and has, in our view, contributed to the development of the meteorological services of the world.

Appendix A

Number of foreign nationals trained in meteorology and related subjects under the direction of the U.S. Weather Bureau pursuant to various technical cooperation programs sponsored by the United States and the United Nations.

1942–61

Argentina	36	Lebanon	2
Bolivia	11	Liberia	1
Brazil	61	Mexico	42
Burma	4	Netherlands	5
Canada	3	New Zealand	1
Chile	42	Nicaragua	5
China, Republic of	7	Nigeria	2
Colombia	30	Norway	2
Costa Rica	8	Pakistan	11
Cuba	18	Panama	5
Denmark	1	Paraguay	4
Dominican Republic	5	Peru	21
Ecuador	7	Philippines	110
El Salvador	8	Poland	1
Ethiopia	8	Portugal	3
Finland	2	Somalia	2
France	2	South Africa, Republic of	1
Germany, Federal Republic of	5	Southern Rodesia	1
Guatemala	5	Spain	9
Haiti	6	Sudan	3
Honduras	15	Syria	2
Hong Kong	1	Thailand	32
India	8	Turkey	28
Indonesia	5	United Arab Republic	2
Iran	6	United Kingdom	2
Iraq	2	Uruguay	9
Ireland	3	Venezuela	5
Israel	5	Vietnam	6
Italy	2	West Indies Federation	2
Japan	5	Yugoslavia	5
Korea	1		

APPENDIX B

Geographic analysis of U.S. Weather Bureau technicians and supporting personnel utilized in overseas projects

	1957	1958	1959	1960	1961
Brazil				1	1
Chile	1	1	1	2	1
Colombia	1	1			
Honduras	1	1	1	1	1
Panama	1	1	1	1	
Pakistan					1
Thailand	1	1	1	1	1
Vietnam			1	1	1
Turkey	1	1			
Total	6	6	6	7	6

Dr. GARDNER. There is on-the-spot training; there is the establishment of workshops and institutes in these countries, and so forth.

This is going forward, but we wish to see it increased.

Mr. HECHLER. How many people have we brought to the United States under this program?

Mr. CARTWRIGHT. Under the WMO program I believe it is quite small—about 10 a year.

In addition, the USAID program does provide a certain number to the United States.

Mr. HECHLER. Don't you think it should be bigger?

Mr. CARTWRIGHT. Indeed it should.

This is our feeling.

Mr. HECHLER. In what areas do you think it would be useful to expand it?

Mr. CARTWRIGHT. There are two aspects: One is to train at the technical level; that is, the preparation of people to do the weather observing. The other aspect is to give advance training the scientific level having to do with forecasting and research.

Both aspects need to be expanded greatly.

Mr. HECHLER. Many, many people can observe, and I think this is an area where we ought to concentrate. Mr. Hines.

Mr. HINES. Dr. Gardner, does not the State Department conduct operations which observe and examine public opinion in foreign countries, such as examining the news media, for editorial opinions, to get an assessment of the effect of our programs?

Dr. GARDNER. Yes; we do.

Mr. HINES. Is this being done with regard to outer space activities?

Dr. GARDNER. Our embassies abroad report regularly on foreign press comment and on U.S. foreign policy generally.

This would certainly include comment on the U.S. outer space program and specifically on our work in the meteorological field.

Mr. HINES. The communication media in foreign countries are the means by which we directly or indirectly can meet and inform these people.

Would you not agree it is just as important to increase our prestige with our friends as it is to win new friends abroad?

Dr. GARDNER. I certainly would.

Mr. HINES. Then I would expect the State Department would also try to gain an assessment of that opinion in countries that are not so friendly with us in order to try to win this friendship.

Could you arrange a short statement for inclusion in the record on just how this is done and what has been the general opinion in the State Department of the frequency with which our technical program such as the meteorological satellite program is communicated to these people?

Dr. GARDNER. We will supply that for the record.

(The information referred to follows:)

U.S. INFORMATION AGENCY,
Washington, September 27, 1962.

Hon. KEN HECHLER,
House of Representatives.

DEAR MR. HECHLER: I want to express the appreciation of the Agency for the opportunity you have given us to make our participation in the dissemination of information on the weather satellite program (Tiros) a part of the official record.

We are proud of the heavy oversea press and radio coverage that USIA has been able to arrange for U.S. peaceful developments in space, especially to the Tiros series, and more specifically to Tiros 6.

Our Information Center Service did an outstanding and impressive job in bringing Tiros to the attention of people in many countries and I would like to cite some examples. In Peru there were four different showings of an exhibit including Tiros which were viewed by a total of nearly 200,000. Reports from the sponsors and observations made by USIS, Lima, indicate that those who saw these were impressed and enthusiastic. This exposition was sponsored by the Latin American Convention on Astronomy. In Karachi our exhibit displayed models of the NS *Savannah*, X–15 and Tiros I, plus visuals with captions explaining these important developments of American science and technology. This exhibit attracted the largest audience—600,000—ever recorded by USIS, Karachi. USIS, Rangoon, exhibited the Tiros and Pioneer V in conjunction with the meteorology exhibit sponsored by the Burma Meteorological Department to more than 2,000 visitors including scientists. In April of 1961 the Tiros I exhibit was diverted from its schedule in order that it could be exhibited during the Singapore Air Show, and our post reported that it answered a most important purpose.

In addition to the above, there follows a brief, but detailed, résumé of the coverage given the satellite program by all media and distributed worldwide.

PRESS SERVICE

(*a*) *Pamphlets*

"Space Science Aids the Weatherman," a pamphlet currently being printed in Beirut on the Tiros series and future similar satellites. We expect to make distribution to our 219 posts in 99 countries.

(*b*) *Features*

1. "Weather and Satellites," a packet including seven photos.
2. "Weather Satellites Will Aid People Everywhere" (scheduled for early October), in a packet "The U.S. Space Program," and will include one photo.
3. "U.S. Plans To Launch Nimbus Weather Satellite in 1962," includes two photos.
4. "U.S. Space Research Expanding in 1962 and 1963."
5. "Space Activities Have Impact on All Nations."
6. "Meteorological Satellites and Weather Forecasting," in packet with "Research in Space Sciences" and "Space Research and Meteorology."

(*c*) *Wireless file*

Copy has been consistently strong since the first Tiros was launched in 1960. For example, during the last 6 months there have been 24 stories of 7,210 words carried on the wireless. This does not include copy moved on other space exploration stories which included material on Tiros. In addition, summaries of the Tiros program have been written from time to time. Also NASA kits on each Tiros were distributed to all posts in advance of the launchings.

(*d*) *Pictures*

There were 83 subject photos made showing the various Tiros satellites, and a total of 19,200 prints were distributed.

(*e*) *Plastic mats*

Distribution of plastic mats on the Tiros satellites, which were considered to be timeless in concept, totaled 11,320.

(*f*) *Graphic features*

Four pen-and-ink drawings of the Tiros were distributed to approximately 675 publications. The titles of these drawings are listed below:

"U.S. Space Achievements."
"Man and Outer Space."
"The U.S. Weather Bureau."
"Man in Orbit."

BROADCASTING SERVICE—VOA

Developments in the field of weather satellites received wide coverage in the VOA broadcasts. VOA currently broadcasts over 800,000 words each day in a total of 38 languages.

(*a*) *Public service*

A public service was performed by VOA in the news broadcasts to the Far East area during the hurricane season. Information on the impending hurricanes and typhoons was broadcast to the area and clearly credited to the U.S. Weather Bureau based on the knowledge provided by the weather satellites.

(*b*) *Weekly scientific feature*

This regular weekly feature devoted three full programs to the five Tiros satellites and the world's weather. For example, the International Meteorological Satellite Workshop in November of 1961 was carried. Other scripts included portions of taped interviews with such outstanding authorities in this field as Dr. Harry Wexler, U.S. Weather Bureau, Chief of Research; Dr. Morris Tepper, Director of Meteorological Systems, NASA; and Dr. William Widger, NASA.

(*c*) *General coverage*

News analysis on the Tiros vehicles have also been widely used in programs centrally produced and broadcast to all areas.

MOTION PICTURE SERVICE

Our Motion Picture Service has given considerable coverage to the five launchings of the weather or meteorological satellites by the production and distribution of films to a large number of countries in many languages. Details on three of these films are given below:

In February 1958, we completed production of "Explorer in Space" which dealt in part with the contribution satellites would make to the general knowledge of mankind with respect to weather and other data and the part satellites would play in the program for the International Geophysical Year. This film was provided to 82 countries in 33 languages, 651 16-millimeter prints, 188 35-millimeter prints.

"In Which We Live," a film released to the field in April 1958, content of which dealt with the International Geophysical Year, devoted approximately a third of the film to the earth's atmosphere and the part that weather and meteorological satellites would play in the adding to man's knowledge of outer space. The film was provided to 74 countries in 23 languages, 416 16-millimeter prints, 40 35-millimeter prints.

On October 31, 1960, we acquired the film "Tiros Experimental Weather Satellite" (two reels, color) from the Radio Corp. of America. It was furnished in English and 14 foreign languages to 71 countries. A total of 305 16-millimeter and 20 35-millimeter prints were provided to posts in all programing areas throughout the world. This film showed the development and construction of the Tiros, explained the purpose of this type of satellite, and dealt in detail with the payload.

TELEVISION SERVICE

(*a*) *Film*

A 30-minute film entitled "Advancing Frontiers" was devoted to the practical application of space research, including Tiros I and II. This was sent worldwide.

(*b*) *Monthly series*

A 15-minute monthly series for Nigeria, entitled "Personal Report," devoted 2 minutes to Tiros. The "Washington Report" a series produced for Thailand for use by the local television station included a folder of pictures on Tiros.

INFORMATION CENTER SERVICE

(*a*) *Oversea activities*

This office known as our Information Center Service, mailed 100 copies of "Meteorological Satellites," a staff report of the Senate Committee on Aeronautical and Space Sciences, to the principal oversea centers of the Agency.

(*b*) *Exhibits for worldwide use*

An exhibit entitled "U.S. Progress in Space Sciences" with a portion to be concerned with the Tiros weather satellite. This exhibit should be available for oversea use in November or December 1962. We plan to produce 11 copies of this exhibit which will include 30 photo panels and seven satellite models. This exhibit will be for worldwide use.

An exhibit entitled "Tiros Satellite Exhibit" was produced earlier and the eight sets produced are currently in the field. The following is the itinerary of each set:

(1) Moscow, Kiev, Tblisi (with the Plastics U.S.A. Exhibition), presently in Rio de Janeiro for long-term use in Brazil.
(2) Stockholm, Helsinki, Brussels, London, Luxembourg, Paris, Madrid.
(3) Lima, Bogotá, Guatemala.
(4) Bangkok, Canberra, Wellington, Manila.
(5) Tokyo, Singapore, Taipei, Rangoon, Saigon, other Far Eastern countries.
(6) Freetown, Conakry, Rabat, Dakar.
(7) Karāchi, Kābul, Lahore, Dacca, Tel Aviv, Athens, Nicosia, Ankara, Cairo, Baghdad.
(8) Tananarive, Pretoria, Salisbury, Nairobi, Kampala, Khartoum.

(*c*) *Bibliographic division*

Several books containing material which publicize our meteorological satellites are included among the books sent to our 190 libraries. The titles of those selected are listed below:

Asimov, Isaac, "Satellites in Outer Space" (Random, 1960), $1.95, 79 pages.
Eisner, Will, "America's Space Vehicles, a Pictorial Review" (Sterling, 1962), $4.95, 140 pages.
Holmes, Jay, "America on the Moon" (Lippincott, 1962), $4.50, 272 pages.
Lapp, Ralph Eugene, "Man and Space: The Next Decade" (Harper, 1961), $4.95, 183 pages.

Sincerely,

STANLEY PLESENT,
General Counsel and Congressional Liaison.

Mr. HECHLER. Mr. Roush?

Mr. ROUSH. Mr. Chairman.

Isn't it true that the training of an individual who can interpret this information is quite complicated and takes a long time?

Is this true?

Dr. GARDNER. It is complicated.

Mr. ROUSH. Would not it be well if these underdeveloped countries were provided with the simplest type of equipment possible, so as to give them the material after it has been interpreted, rather than train their people to read this material and interpret it?

Send it to them in an interpretative form so that it has immediate practical value and can be immediately used by this country.

I am speaking of weather material, weather data, information that is the type of information if it is going to be useful has to be used immediately.

Has any thought been given to that sort of program?

Dr. GARDNER. Yes, this whole question has been very thoroughly studied in the U.S. Government.

It is a highly technical subject, and I will throw it to Mr. Cartwright in just a moment, but would like to make this comment myself:

As I understand it, the information which a specific less-developed country may require in order to develop weather forecasts is only partly information which it receives from abroad, from satellite or other observations abroad.

It also has to get information within its own territory with conventional techniques and to make an accurate forecast it is my understanding that they have to take a look at the totality of information, the stuff that comes in from abroad, the stuff they get on their own territory, and on the basis of all of this to make a forecast.

So I think a lot of work can be done for them, so to speak, abroad, but I think there still requires to be done some analyses on the spot to give adequate forecast to the people in that country.

I would like to ask Mr. Cartwright if he would amplify this because it is certainly a fundamental question and one which we are considering.

Mr. CARTWRIGHT. Mr. Chairman, Dr. Gardner, I think, has described the situation very well.

Speaking particularly to the satellite data, the information that is now transmitted is, we feel, in its most elementary form, a form which can be used almost directly by the meteorologist in the country to which it is transmitted.

The pictures themselves, you may recall, are not normally sent over the communication system to other countries. They are released to a pictorial analysis of the photograph which can be sent either in a coded form or by facsimile, so that the recipient gets a representation of the cloud system as seen by the satellite.

If the photographs were sent he has to first decide what geographical area is covered, how the picture is oriented with respect to the Earth surface, then attempt to deduce from it the major elements of importance. This is being done now by the U.S. Satellite Center here in Suitland before the data is transmitted.

There is the further step, of course, in deciding what this really means for the weather tomorrow. This is the kind of thing that is being investigated in great detail here, and the kind of thing we were trying to encourage other countries to study through these international cooperative programs.

What is being sent now to them every day as a token from the Tiros photographs is this [indicating] kind of picture, a pictorial representation of the cloud cover as viewed by the satellite [indicating].

Mr. ROUSH. There would have to be an interpreter in Ghana who knows what the symbolic picture means if you sent that picture there.

We had that before the committee.

I don't believe anyone here could make heads or tails of it.

With the use of the symbolic chart it will still mean an individual on the ground capable of interpreting that.

My thought was, why put an individual there to interpret that, why can't that be sent in language that they understand?

Mr. HECHLER. Couldn't you just say, "Hey, a hurricane is coming?"

Mr. CARTWRIGHT. That has been done, also.

When the indications are clearcut a word telegram is sent.

I should mention that in every country there is someone of competence to whom these messages would be directed and it would be up to him then to interpret its meaning for his own locality.

Colonel PEACOCK. Where these countries did not have a capability, or it was not, we will say, as advanced where they could receive this and make the maximum use, what is the State Department doing to not only train the individual but, as Mr. Roush points out, to provide him with the equipment, even if it is a simple read-out of a facsimile, to make sure he is making maximum use of it and going on to integrate additional capabilities within his country?

We have an excellent opportunity—you might say open-door policy—to set up a real good weather forecasting capability.

Are we taking advantage of this?

Mr. CARTWRIGHT. I think the first element of such a program is here [WMO report].

It proposes regional weather processing centers which could take the most complex data and convert it to a form which each country could use.

The United States is planning to set up a radio facsimile weather broadcast which would put this information in the hands of any country within range of the broadcast, if they have the proper receiving equipment.

Colonel PEACOCK. If they do not have the basic equipment, would you provide it?

Mr. CARTWRIGHT. This is being discussed with AID now.

Colonel PEACOCK. Who would provide it, the State Department?

Mr. CARTWRIGHT. Through AID; yes.

This is one means of doing it. This has already been discussed with AID, particularly with reference to Latin America, where there is a great need for this kind of thing.

Colonel PEACOCK. When will you start doing this?

Are you doing it now?

Mr. CARTWRIGHT. A proposal is still being discussed with U.S. AID. Once it is agreed here, it will be sent to the U.S. missions in each country for discussion with the local officials. If they agree that this is something which they want to use their AID funds for it will be a simple matter to get the program going.

Colonel PEACOCK. What is your forecast date you will start implementing the first one?

Mr. CARTWRIGHT. The facsimile broadcast of the data from the United States has just been tried on an experimental basis during June.

It will be reestablished, I believe.

Mr. JOHNSON. If I could just comment: I am going to a meeting from here at which we will decide when to reestablish the broadcast.

Mr. HECHLER. Good.

Mr. JOHNSON. It will probably be in early October.

Colonel PEACOCK. Can you give us a read-out of how you expect to handle this; how you will implement it?

Will you send your own people out to do this?

Will you bring them in here and send them back?

Mr. CARTWRIGHT. I think both methods will be used.

First, the equipment to receive the broadcasts, which Mr. Johnson hopes to set up, will be installed, with the necessary technicians to advise them on the receipt of the actual picture.

Once they get the picture they have to know how to interpret it. This is why a certain amount of assistance will be required.

So far as Latin America is concerned, we are considering increasing our staff in Miami, which is our principal center for Latin American weather, so that one man can be available at all times to go from one country to another to assist in the interpretation of the data.

I quite agree that this is the real payoff so far as the practical use of the data is concerned, and we are aware of this need.

Colonel PEACOCK. This is where the man on the street really derives the benefit.

Mr. CARTWRIGHT. Precisely.

Mr. HECHLER. Can you give us any more specifics for the record on this proposal?

Mr. CARTWRIGHT. The proposal has just been discussed with AID as far as Latin America is concerned.

We have not had a formal reply from them as to whether or not they will be able to proceed with it.

I discussed on Friday of last week with the chief forecaster in Miami the means for providing for one of his staff to go to each of these countries as soon as the facsimile equipment is available. Our expert would work with the forecasters in each country to help them use the charts and weather data sent to them from the United States and assist them in analyzing the weather data for their area.

So I would say that our plan is to try to have this program worked out by the time the Nimbus weather satellite system becomes operational.

Mr. HECHLER. I would not want anyone reading these hearings to feel this was a little cliff hanger and wonder when the other shoe would be dropped, so I would hope that you will inform the committee on the progress of this development just as quickly as you get any further information on the result of your conferences with AID.

Mr. CARTWRIGHT. I will be pleased to do that, Mr. Chairman.

Dr. GARDNER. In this connection, Mr. Chairman, I would like to say again that we are approaching a number of important decisions in this whole field.

We have this World Meteorological Organization report——

Mr. HECHLER. On this report—could I stop you there?

Dr. GARDNER. Yes, sir.

Mr. HECHLER. I notice there is some limitation of the public.

Would it be possible to include as part of the documentation for our hearings the major substance of this report, or would it be possible to include the entire report?

Dr. GARDNER. I think we can include the entire report.

It is a public document.

Mr. HECHLER. Without objection, it will be included.

(The report referred to above follows:)

WORLD METEOROLOGICAL ORGANIZATION

FIRST REPORT
ON
THE ADVANCEMENT OF ATMOSPHERIC SCIENCES AND THEIR APPLICATION IN THE LIGHT OF DEVELOPMENTS IN OUTER SPACE

Secretariat of the World Meteorological Organization - Geneva - Switzerland

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FIRST REPORT OF THE

WORLD METEOROLOGICAL ORGANIZATION

ON THE ADVANCEMENT OF ATMOSPHERIC SCIENCES AND THEIR

APPLICATION IN THE LIGHT OF DEVELOPMENTS IN OUTER SPACE

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SUMMARY OF REPORT AND RECOMMENDATIONS

Scope and preparation of report

1. In view of the length of the report, the most important points and the recommendations which arise from them are presented in this summary. As the report has been prepared in response to a request of the United Nations, contained in Part C of General Assembly Resolution 1721 (XVI), the summary follows the order of the items as given in the resolution.

2. This report should be regarded as a first report. It is recommended that WMO should submit further reports to the General Assembly as necessary.

3. This first report is intended to cover in a general way the requirements for the next ten years but some specific targets are set for completion in the next three years.

4. The U.N. Resolution called upon WMO to consult with other international organizations in the preparation of its report. This has been done and valuable assistance was provided by UNESCO, ICAO, ITU, IAEA and ICSU. WMO also had the benefit of assistance by meteorologists from USA ans USSR in the preparation of the report.

Developments in outer space

5. Resolution 1721 refers to measures to be taken "in the light of developments in outer space", and these developments, which have both operational and research aspects, may be summarized as follows :

6. On the operational side, cloud photographs from the TIROS series of satellites have already proved to be of value in weather analysis and forecasting. In a number of cases the photographs have been of direct and demonstrable operational utility, particularly for oceanic areas, such as the Southern and Indian Oceans, the South Pacific and the Central Atlantic, where conventional data are extremely sparse. Looking to the future, there is also evidence that satellite pictures of the distribution of sea-ice and snow cover and the measurement by infra-red detectors of the temperatures of sea and land surface and of cloud tops will be of direct operational value. Furthermore, the development of communications satellites will obviously assist in the exchange of meteorological data between various regions of the earth and in other problems of data exchange and collection, such as collection and transmission of observations from automatic weather stations in remote areas.

7. On the research side, the very considerable potential which meteorological satellites offer has been clearly demonstrated by TIROS satellites. The cloud pictures have yielded new and unique information regarding cloud form and distribution which have already stimulated new ideas regarding the nature of atmospheric processes. The radiation measurements referred to above also contribute to the study of the heat balance of planet Earth. The more sophisticated instruments to be installed in future satellites will also undoubtedly yield data which can be used for research in many different aspects of atmospheric processes.

Advancement of state of atmospheric science

8. Resolution 1721 refers to measures to advance the state of atmospheric science and technology so as to provide greater knowledge of basic physical forces affecting climate and the possibility of large-scale weather modification. There can be no doubt that the increased observational data provided by meteorological satellites open up new perspectives for meteorological research. With a view to stimulating progress in research, WMO proposes the establishment of a WMO Advisory Committee and, pending its establishment, a WMO Panel of Experts on Research has been set up to be composed of leading scientists. This body would recommend the action required to fill the gaps in our knowledge of the atmosphere and its basic physical forces, which would in turn facilitate a solution of many urgent problems associated with weather prediction, climatic changes, water resources and large-scale weather modification.

9. Ultimately, mankind may well have the power to influence weather and even climate on a large scale. However, it is imperative that the consequences of any large-scale interference with the atmosphere be accurately evaluated in advance.

Improvement of weather forecasting capabilities

10. Resolution 1721 refers to "regional meteorological centres" which would help Member States to make effective use of improved weather forecasting capabilities. WMO believes that the full exploitation of the new meteorological data which can be provided by artificial satellites necessitates an expansion and rearrangement of the present system whereby conventional meteorological observations are made and exchanged under procedures laid down by WMO. This proposed system, which combines satellite and conventional observations, would be called the World Weather Watch; its purpose is to ensure availability to each country of that combination of processed information and observations, including satellite data, best suited to meet its needs.

11. The first steps should be aimed at establishing World and Regional Centres and at filling the main gaps in the world network of conventional meteorological observing stations. The full operation and utilization of the world and regional centres will require improved telecommunication facilities (particularly facsimile) in many countries. WMO recommends that the World Weather Watch should be introduced

step by step over the next few years.

12. With regard to the World Centres, WMO designates the meteorological centres being established at Washington and Moscow as World Centres. The establishment of a similar Centre in the Southern Hemisphere is envisaged.

13. As regards the Regional Centres, it has not been possible to consult the Member States concerned but it would seem reasonable to hope that the first of these might be established within the next year or two, preferably in Western Europe, and that this might lead shortly to the establishment of additional centres, including some in less-developed areas.

14. Data from meteorological satellites do not make redundant the existing world network of meteorological stations. On the contrary, the need is for improved networks if maximum benefit is to be derived from satellite data. The need for eliminating large gaps in the world network has been emphasized in Resolution 829 (XXXII) of the Economic and Social Council which was adopted unanimously. The WMO plan calls for the establishment of a minimum number of stations to fill the most serious gaps, particularly in the tropics and in the southern hemisphere. The plan involves 100 automatic surface stations, 30 in the northern hemisphere and 70 in the southern hemisphere; it also recommends the installation of 53 new upper-air observing stations, 33 on continents and islands and 20 on ships to be stationed at fixed locations on the high seas.

15. Regarding the improved telecommunication facilities which will be needed, use of communication satellites would help to solve many of the problems. A future possibility is that a satellite might be able to collect information from automatic weather stations located in uninhabited areas as it passes overhead and to transmit this information to read-out stations. It is most important that interference-free radio frequency bands be allocated for these purposes.

16. The full exploitation of satellite data calls for continued development of techniques whereby these data may be used alongside conventional data and also for improvement of the techniques already in use with conventional data, including mathematical weather prediction.

17. With the advent of satellites and other developments referred to in the above paragraphs, training of meteorological personnel now becomes a matter of even greater importance and urgency. WMO is actively considering the overall question of meteorological training but countries with experience in the specialized field of satellite meteorology are encouraged to arrange training schemes on this particular subject.

Organizational and financial arrangements

18. WMO is specifically requested in Resolution 1721 to include in its report proposals regarding the organizational and financial arrangements which are necessary to achieve the various measures mentioned in the resolution.

19. The implementation of the WMO plan of action outlined in this report would involve the creation of only one new body - the WMO Advisory Committee. Thus, from an organizational point of view, the proposals are relatively simple. The plan will, of course, place considerably increased responsibilities on WMO and proposals to meet these responsibilities are being placed before the WMO Congress in 1963.

20. The launching and operation of the meteorological satellites will, it is assumed, continue to be a national responsibility and the financial aspects of these activities are not therefore discussed.

21. The WMO plan involves the establishment and operation of various centres and stations, and the provision of various facilities (telecommunications, etc.) which will have financial consequences; the following proposals are made to meet these :

(i) All countries should be urged to do everything possible within national programmes and budgets to implement the proposed plan of action for meteorological satellites. Where this is not possible or appropriate, the following proposals should apply;

(ii) As an immediate measure, sympathetic consideration should be given to country requests for assistance in implementing this plan in the form of projects within the Expanded Programme and/or the Special Fund;

(iii) Other possible sources of rendering assistance to countries in the implementation of the plan should be carefully examined;

(iv) In particular, consideration should be given by the United Nations to the establishment of a special financial arrangement for providing technical assistance in the implementation of the plan. The financial order of magnitude of such assistance cannot be given at the moment but an indication may be obtained from the estimated cost of bringing networks to the desired standard (and this is only a part of the overall plan). The estimated cost is $35.7 million for purchase and installation of equipment and $16.5 million for annual expenditure. Much of this expenditure will, it is believed, need to be met from international sources. Such financial arrangements could take the form of the establishment of what might be called a UN World Weather Fund, which would be used to provide technical assistance in the implementation of all the various aspects of the WMO plan as described in the preceding paragraphs. Details of the manner in which such a fund would operate would, of course, need to be worked out but the approval and supervision of projects financed by the Fund would clearly need to rest with WMO;

(v) UN should make an immediate subvention of $20,000 to WMO to enable the arrangements for the proposed WMO Advisory Committee (and the Panel of Experts which precedes it), to proceed without delay.

22. On the research side, it is proposed that WMO should accept responsibility for the financial aspects of the arrangements for meetings of the WMO Advisory Committee, except as proposed in (v) above. As regards the financing of research projects approved or endorsed by the Committee, the financial proposals (i) to (iv) above should apply.

I. INTRODUCTION

1. The launching of the first artificial earth satellite SPUTNIK I on 4 October 1957 aroused the intense interest of the whole world. Scientists were particularly impressed and not least those engaged in the study of the atmosphere. The interest of these latter arose from the fact that while their field of study was the atmosphere itself rather than outer space, for the first time, a platform from which the atmosphere could be observed from beyond the earth, became feasible.

2. The launching of the first successful meteorological satellite, EXPLORER VII, on 13 October 1959, raised hopes of a new impetus in the atmospheric sciences. The subsequent launching of the TIROS meteorological satellites showed that the atmospheric sciences and their practical applications (especially weather forecasting) may be greatly advanced by this new observational technique - a technique which for the first time, corresponds to the global character of the atmosphere itself.

3. With these and other related successes in mind, the General Assembly of the United Nations on 20 December 1961 adopted resolution 1721 (XVI) (International Co-operation in the Peaceful Uses of Outer Space). This resolution deals with several aspects of outer space development and includes a specific section on the atmospheric sciences, weather forecasting and related questions. The resolution is reproduced in Appendix A. It was adopted unanimously.

II. PURPOSE AND SCOPE OF REPORT

4. It will be seen that Part C of the resolution contains two operative paragraphs. The first "recommends to all Member States, the World Meteorological Organization and other appropriate specialized agencies to make early and comprehensive study, in the light of developments in outer space of measures :

(a) To advance the state of atmospheric science and technology so as to provide greater knowledge of basic physical forces affecting climate and the possibility of large-scale weather modification;

(b) To develop existing weather forecasting capabilities and help Member States make effective use of such capabilities through regional meteorological centres".

5. The second "requests the World Meteorological Organization, consulting as appropriate with the United Nations Educational, Scientific and Cultural Organization and other specialized agencies and governmental and non-governmental organizations, such as the International Council of Scientific Unions, to submit a report to its member Governments and to the Economic and Social Council at its thirty-fourth session regarding appropriate organizational and financial arrangements to achieve these ends, with a view to their further consideration by the General Assembly at its seventeenth session". The present document constitutes the required WMO report.

6. As regards the first operative paragraph, all Member States of UN (and Members of WMO) and all other specialized agencies were invited in January 1962 to submit copies of any studies carried out, to the United Nations and the World Meteorological Organization. As is perhaps to be expected, relatively few such studies were received during the relatively short period between the adoption of the resolution and the drafting of this report, but all so received have been taken into account. WMO considers that this present report constitutes the study requested of the Organization in the first operative paragraph of the resolution.

7. As mentioned above, the importance of the development of the meteorological satellite lies in the fact that it provides a platform for observing atmospheric and solar phenomena from outside the atmosphere itself. This at once makes feasible a tremendous new range of observational data of which full advantage should evidently be taken in advancing the state of knowledge of the atmospheric sciences and in applying such advances in practical benefits to mankind. While these two aspects of the question are clearly inter-related, they nevertheless constitute two convenient compartments into which the later discussion in this report will be separated.

8. It is important to note that the terms of the resolution are very broad and involve in effect a complete re-appraisal of the atmospheric sciences and their applications in the light of the satellite development together with the preparation of a plan (with organizational and financial details).

9. The broad interpretation of the resolution presents tasks which cannot be fully accomplished in the few months between the adoption of the resolution and the presentation of a report to ECOSOC. Indeed with the still unforeseeable technological developments in satellite operations, any report and plan drawn up now may well require amendments within a short time. For example, the question of whether manned satellites are likely to be available within the next few years for such purposes on a routine basis or at least as special efforts during important research projects, can hardly be answered at this stage. Thus the task presented in the resolution is one which will need to be kept under review; it is thus a task of a more or less permanent nature rather than one which can be covered by a single report.

10. In addition to considerations of this kind, the various technical bodies of WMO should all be given an opportunity of commenting and advising. For example, the WMO Congress, which is the highest organ of the Organization (which meets in 1963) will need to take certain decisions regarding future WMO activities in this field. Each of the eight permanent technical commissions of WMO should study the significance of this development in its own particular field. Each of the six WMO regional associations should similarly have an opportunity of examining fully the regional aspects.

11. With these thoughts in mind, it is felt that the most realistic approach is to envisage a plan for the next ten-year period (1963-1972) which will make provision for a phased implementation, with adjustments being made to the plan at appropriate stages in the implementation in the light of the discussions, and developments in the intervening periods. In the present report, however, it is only possible to give the broad features of such a plan, leaving many of the details to be completed in later reports.

12. In drafting the report, the aim has been to present the subject-matter in an orderly sequence and couched in language which does not require highly specialized technical knowledge to comprehend. Some more technical matters are, however, included in a series of appendices.

13. Thus the report includes a description of the types of meteorological data obtainable from present satellites and likely to be obtained from future satellites. This is followed by an explanation of the impact which the availability of this information makes upon the atmospheric sciences and their applications; this in turn leads to the next section which brings out the factors (technical services, organizational questions, etc.) which require attention if full utilization is to be made of these new data. The action necessary to ensure full utilization then becomes clear and each of the fields in which action is necessary (international co-ordination, development of world and regional centres, etc.) is explained in some detail. Consideration of these fields of action leads to a general plan for future action in this field including some recommendations.

14. Before turning to these aspects of the report some explanation of the steps taken by WMO to consult experts from national institutions and international organizations would seem desirable.

III. ASSISTANCE IN THE PREPARATION OF THE REPORT

15. It is evident that any authoritative report on the peaceful uses of outer space should benefit from the experience of the two leading countries in this field. Accordingly, the USA and USSR were invited to send experts to Geneva to assist in drafting the report. The invitations met with a ready response and top-level scientists were detached to WMO for several weeks to work together on the report.

16. The resolution calls upon WMO, in preparing the report, to consult with other specialized agencies and interested governmental and non-governmental organizations. As a result of a preliminary inquiry in this connexion UNESCO, ICAO, ICSU, ITU and IAEA indicated interest and were accordingly consulted during the preparation of this report. The consultations took place in two main stages : In the first stage, the above Organizations with the exception of ICAO participated in a meeting to discuss the research aspects of the resolution. In the second stage, all the organizations were invited to be represented at a meeting of the WMO Panel on Artificial Satellites during which the completed report was discussed. The present text incorporates the many useful ideas and proposals offered by the various Organizations.

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17. Finally, the report benefitted from advice inside WMO, notably from the Panel on Artificial Satellites mentioned above, and from the Presidents of the various Technical Commissions.

IV. TYPES OF DATA OBTAINABLE FROM SATELLITES - PRESENT AND FUTURE

18. Historically, meteorological observing networks have grown outward from centres of population. Occasionally, as a result of International Polar Years (1882-83,1932-33) and the International Geophysical Year (1957-58) there have been sudden increases in both horizontal and vertical observing capabilities. Perhaps, even more important as a stimulant for observational growth, particularly aloft, have been the demands for aviation services. But even with the combined scientific and practical requirements, we are still far from having a satisfactory global observing system. Satellites, on the other hand, offer the means of observing the atmosphere on a global basis with a frequency limited only by the number of satellites in operation at any one time. Although it must be emphasized from the start that observations from satellites do not represent a substitute for conventional meteorological observations, they can, nevertheless, provide useful information where no conventional observations are made and can, moreover, enhance the value of such observations in regions where the conventional observational network is adequate.

Photographs of the Earth's Surface and of Cloud Cover

19. The field of view of a satellite-borne camera orbiting at several hundred kilometres altitude covers at any one time thousands if not millions of square kilometres of the earth's surface, depending upon the type of camera.

20. By combining photographs taken in quick succession, views covering huge areas of the earth's surface become available, portions of which are covered by cloud systems associated with storms and other atmospheric features. Previously meteorologists, in portraying cloud systems associated with storms and other phenomena, have pieced together individual observations. Now with the earth-orbiting satellite, meteorologists have, for the first time, a global platform from which to observe the entire earth's atmosphere and to take advantage of the syntheses performed by Nature herself in organizing cloud systems as indicators of air masses, fronts, jet streams, storms, etc.

21. Satellites can thus serve as a valuable interpolative and extrapolative observing device to reinforce and strengthen conventional observations, particularly over regions where these are sparse. When one considers that about three quarters of the earth's surface is covered by oceans from which relatively few meteorological reports are at present received and that the network of meteorological stations over many land areas (including some tropical regions and the Southern ocean) is very sparse, one realizes what a major step forward in man's observing of global cloud distribution satellite photographs constitute.

22. Even in regions for which by conventional standards the network of meteorological stations is considered dense, a downward look from a satellite often reveals cloud and other patterns not previously suspected. It must therefore be emphasized that observations of both kinds - satellite and conventional - supplement one another and when so combined form a meteorological observing system which for the first time, can cope with the gigantic problem of observing the procession of world weather events. Some of the striking observations which have been made and which, in the future, can best be made by satellite, are briefly described below :

23. Satellite cloud observations have already proved of great value in synoptic analyses and forecasting in regions from which conventional data is sparse, such as the Southern and Indian Oceans and the Pacific, and Central and South Atlantic.

24. It has been found possible to locate or detect the existence of trough lines, tropical storms and extra tropical depressions which would not have been possible without satellite observations. For example, satellite cloud observations have revealed the presence of Hurricane "Esther" two days before it was officially recognized on 12 September 1961, west of the Cape Verde Islands.

25. Satellites have also yielded information about cloud patterns which were previously unsuspected and which will be of very great value in a better understanding of atmospheric processes.

26. Clouds are not the only meteorological phenomena which satellite photographs reveal. Snow and ice-fields have been identified on many of the satellite photographs. The geographic extent of snow covered land areas, combined with representative snow depth measurements, should provide information on water resources available for irrigation, river navigation and water power requirements. The determination of ice-fields - their horizontal extent, open-water areas and passages - would be of assistance in navigating ice-locked harbours and water-ways, including the polar seas. But in addition to these practical uses, the location and extent of snow and ice-fields will serve as natural indicators of seasonal, and secular time variations of global weather patterns.

Solar and Terrestrial Radiation Measurements

27. The observation from satellites of solar radiation and the infra-red radiation emitted by the earth and its atmosphere offers many important contributions to meteorology. The first successful meteorological satellite, EXPLORER VII, observed the total incoming and outgoing radiation. The difference between these quantities is an important factor in studies of climate. These measurements will continue, and in the future it will be possible to maintain a close watch on the incoming solar radiation in all wavelengths.

28. Within a certain range of wave-lengths, infra-red radiation passes through cloud-free regions of the atmosphere with little absorption by water

vapour, carbon dioxide or ozone. Thus measurements within this range permit an approximate determination of the temperature of the surface of the emitter, whether land, ocean or tops of clouds. This enables detection of clouds at night, usually as cold areas against the warmer background of land and ocean. These nocturnal measurements are important since present satellite television cameras do not have the sensitivity to observe clouds in absence of sunlight. Also the cloud-temperatures can be converted into approximate heights of the tops of cloud layers, a valuable aid to aviation.

29. Infra-red determination of sea-surface temperature offers useful possibilities in delineating ocean currents. Observation of "hot" spots developing on land areas in response to absorption of solar radiation, may enable early detection of those regions likely to be afflicted with severe convective phenomena, such as thunderstorms and tornadoes.

30. More refined measurements of the upcoming infra-red radiation in various wavelength bands may permit determination of :

a) The mean temperatures of deep layers of the upper atmosphere,

b) A broad picture of the distribution of water vapour and ozone in upper atmosphere.

31. Observation of the solar ultra-violet after passage through or reflection from the atmosphere will permit determination of the vertical profile of ozone in the upper atmosphere.

Radar and other Observations

32. Going still to other portions of the electro-magnetic wave spectrum, it is not unrealistic to foresee that future developments in satellite techniques will provide the possibility of measurements by radar in the centimetre wave-length band. These will reveal the presence of precipitation areas - both their geographical and vertical extents and also whether the precipitation is in the form of rain or snow. Future developments should also allow lightning to be observed either as visible flasches during the night or as sferics discharges, night and day.

Indirect Observational Aids

33. In addition to the above atmospheric properties which are or may be directly observable by satellites, there are other measurements of a global nature which would be greatly facilitated by the location and communications capabilities of satellites. These include such measurements as, for example, those which might be obtained from surface automatic weather stations which could be located on continents and oceans and capable of observing air pressure, temperature, wind and other meteorological elements. It might be possible in the future to arrange for this information to be transmitted to satellites for storage and later transmission to read-out stations.

V. IMPACT OF THE AVAILABILITY OF THESE DATA ON ATMOSPHERIC SCIENCES

Impact on Day-to-Day Meteorological Operations

34. By 1965 satellites will make possible a global survey of clouds and various radiation measurements. Thereafter, in the foreseeable future, it is expected that satellites will yield :

(i) Global information on precipitating cloud layers, thunderstorms and surface pressures and temperatures;

(ii) Some information on upper winds;

(iii) Partial coverage of the average temperature of thick stratospheric layers; and

(iv) An indication of the content of water vapour and ozone in the upper atmosphere.

35. Aside from the obvious direct value to aviation, the knowledge of the distribution of precipitation and thunderstorms, the above information will greatly assist in filling the present large gaps in the observation network and in extending weather maps and predictions to the whole world. Knowing the details of present weather is the first step in anticipating future weather.

36. Weather prediction is usually done :

(i) Empirically - based on present trends, the forecasters' past experience and simplified application of physical reasoning.

(ii) By analogy - with similar past weather patterns.

(iii) By mathematical modelling of the atmosphere and solving of the governing equations.

37. With regard to item (i) above, satellite observations have already been used in preparing operational forecasts in data sparse regions by providing knowledge of clouds and other phenomena; they have also extended the scope and accuracy of weather charts on which forecasts for more heavily populated regions depend.

38. As regards item (ii) above, past observed cloud distributions can also be converted into digital representation (black and white dots) for storage and automatic recall to find an analogy to currently observed cloud patterns.

39. Similarly for item (iii), satellites can also assist materially in acquiring the data necessary for mathematical predictions based on the laws of physics. For this type of prediction any information at all - even intelligent guesses - over areas of no observations will lead to some improvement;

the prognostic equations are quite sensitive, and the forecast at any one point is affected to some extent by the weather (wind, pressure) distribution everywhere else. Thus, the systematic acquisition, with the aid of satellites, of surface pressures, temperatures and winds observed over the world by a large number of automatic weather observatories and the combination of these with upper temperatures and winds observed by radiosondes and by means of satellites and cloud-derived information from the latter, would make possible the construction of world weather maps - both for the surfaces and, by differential analysis, for the upper air.

40. Observations of the cloud distribution and pattern may make an important contribution to the knowledge of the present state of atmospheric structure and motions required for the mathematical predictions. First, the fact that clouds exist at all, generally means that there is a field of upward velocities in those regions. This information by itself, in areas of sparse observations, could serve as data of some use in the mathematical prediction equations. Second, the cloud patterns, particularly the "streakiness" features may be interpreted in terms of wind and wind-shear. Other features, such as cloud waves and cells, may enable definition of various types of atmospheric stratification, such as unstable and stable layers.

41. Observations of the total content of ozone in the vertical column, or better still, its vertical distribution, may assist in deducing stratospheric temperature and wind patterns.

42. Measurements of the total radiation balances (incoming solar minus outgoing terrestrial radiation) may also supply energy terms now neglected in most mathematical models.

Impact on Meteorological Research

43. The very considerable potential which meteorological satellites offer for research has also been clearly demonstrated by TIROS satellites. The satellite cloud pictures have yielded new and unique information regarding cloud form and distribution which cannot fail to stimulate new ideas regarding the nature of atmospheric processes. The measurement of temperatures of cloud and land and sea surface by infra-red detectors located in the satellite is providing a wealth of valuable information for the investigation of heat flux in the atmosphere and between the atmosphere and land and sea surface.

44. Future measurements from satellites of conditions in the stratosphere and upper atmosphere are also likely to be valuable for meteorological research. The observation of extra terrestrial conditions should also assist investigations aimed at determining the extent to which these influences cause fluctuations in atmospheric processes.

Observations from Satellites in Relation to Conventional Observations

45. It should be emphasized again that satellite observations will not replace conventional observations but will supplement them, so that together both types of observations will form a world observational system capable of detecting and tracking each major atmospheric disturbance wherever it may occur.

46. To illustrate the contributions of each type of observation a weather map of the Northern Hemisphere, combining two types of analyses is shown in Appendix B. The first analysis, based on conventional observations consists of dark lines arranged in circles and waves, which portray the wind flow at a height from 17.500 ft (about 5,300 metres) to 19.500 ft (about 6,000 metres) above sea-level observed at 00 GMT, May 20, 1960. The high (H) and low (L) pressure areas are designated by the appropriate symbol and refer to large-scale eddies rotating clock-wise and counter clock-wise respectively. This "isobaric" weather-map based on perhaps 300 individual observations, represents the principal working chart of the meteorologist and gives the quantitative information required for mathematical weather prediction. In many areas, where observations are few or missing, the lines may be seriously in error.

47. Superimposed on this conventional analysis are patchy white areas portraying clouds observed by the weather satellite, TIROS I, in the 24-hour period from 12 GMT May 19 to 12 GMT May 20, 1960. The satellite observed only th se areas enclosed by the dotted black and white curves, or less than one-third of the total area shown in the map. In the regions where clouds are observed, their positions and large-scale configurations, on the whole, agree reasonably well with the "Highs" and "Lows". But the much greater complexity of the cloud patterns compared to the simple, smooth patterns of the dark lines or stream-lines is noteworthy. When on the basis of research in areas where data of both types are available meteorologists are able to decipher and interpret the cloud patterns in terms of wind and temperature structure, this will add greatly to the amount of detailed, quantitative information needed for more accurate weather analyses and prognoses.

48. Since the view of the atmosphere from above is so new to meteorologists who traditionally have looked upward, it is apparent that a period of study and application will be required to interpret fully the satellite observations in terms of familiar atmospheric entities, such as cyclones, anticyclones, fronts, line-squalls, thunderstorms, etc., which form the present basis of weather analysis and prediction. The interpretation of satellite observations will be greatly aided by having available, as complete as possible, documentation in the form of conventional observations from both surface and aloft - pressures, winds, temperatures, humidities, radiation fluxes, etc., and also additional pictures of the same cloud systems observed by other means.

51. The above requirements involve expensive operations and equipment, and a multitude of highly skilled personnel. It is therfore essential that there be world-wide co-operation to ensure most effective use of personnel and facilities and to avoid wasteful duplication.

The following steps would meet the above requirements :

(i) Development of an internationally co-ordinated plan for meteorological satellites;

(ii) Establishment of a "World Weather Watch";

(iii) Augmentation of the present network of conventional meteorological observations in areas where they are sparse or non-existent.

(iv) Improvement of telecommunications networks for the exchange of both satellite information and conventional meteorological observations.

(v) Establishment of a WMO Advisory Committee.

The above-mentioned steps are discussed in some detail in the following sections.

VII. INTERNATIONALLY CO-ORDINATED PLAN FOR METEOROLOGICAL SATELLITES

52. This plan should provide for co-operative efforts of WMO Member countries directed to the rational utilization of artificial earth satellites for meteorological purposes.

53. It should be envisaged that there will be a co-ordination of types and scope of observations, periods and sequence of observations as well as orbits used.

54. Great attention will be required to ensure :

(i) The co-ordinated collection, dissemination, processing and storage of data;

(ii) The allocation of interference-free frequency bands for communication with meteorological satellites;

(iii) The establishment of weather analysis and prognosis centres using data from satellites;

(iv) Comparability of observational accuracies.

55. Co-ordination should be ensured with regard to research work relating to the use of satellite data in meteorology by means of scientific symposia and conferences organized by WMO according to previously established and agreed plans.

56. A plan should be worked out for the exchange of experience gained by meteorological services of different countries as well as for personnel training.

VIII. THE WORLD WEATHER WATCH

57. The World Weather Watch is intended as a co-operative global meteorological observing and prediction system designed to assist meteorological services of the world to discharge their responsibilities without each service having to perform all the steps needed for this purpose. The inauguration and co-ordination of this system would be a natural extension of the role that the World Meteorological Organization already plays in the taking and standardization of meteorological observations, the scheduling of meteorological communications, etc. The new activity would be with regard to the orderly creation and dissemination of processed meteorological information, both from conventional and satellite sources and would be based on a system of World Centres and Regional Centres, designed to avoid duplication in preparing analyses and prognoses, but still making available to each meteorological service the data and background information it requires for carrying out its responsibilities.

58. The design of the WWW is given schematically in Appendix C. We start with the various sources of global meteorological observations : surface manned and automatic stations, upper-air observations and satellite observations. A selected, representative sample of the data necessary to establish the main features of the world weather picture is transmitted to World Centres. Here world and hemispheric analyses and prognostic charts are prepared both for the World Data and Charting Centres* for climatological and research uses, and for transmission as background information to each of the several Regional Centres. Each of these Regional Centres selects from daily output of world observations those data required for its purposes and prepares regional analyses and prognoses for use by each of the countries of the region. Each of these countries, in accordance with its needs, selects those observations from the world observational pool to be used as a supplement to the background charts furnished to it by the World and Regional Centres.

59. The terms of reference of the two types of Centres follow :

World Centres

60. By World Centres are envisaged Centres which would have :

(i) Access to conventional meteorological data from as much of the world as possible : this requires location close to a large communications facility.

(ii) Access to world-wide data coming from meteorological satellites. This does not necessarily mean that the Centre should be located at a satellite read-out station but should possess the proper communications facilities to permit the rapid receipt of satellite cloud pictures and other information from the read-out stations.

(iii) Adequate data processing equipment to convert the conventional meteorological data speedily into objective analyses, numerical weather predictions, etc., and additional specialized equipment for processing and piecing-together of satellite information to produce analyses (such as cloud mosaics, heat radiation charts), covering large areas of hemispheric or world size.

(iv) Staff facilities to blend together the conventional and satellite data to produce comprehensive hemispheric and world analyses and prognostic charts.

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* A World Data and Charting Centre would have to be affiliated to each of the World Centres. In some cases it may be an integral part of the World Centre. In subsequent sections the expression "World Centre" is intended to include the associated World Data and Charting Centre.

(v) Access to communications facilities to disseminate speedily the analyses and prognostic charts, preferably by facsimile.

(vi) Facilities for training of meteorologists in producing world-wide analyses and prognostic charts using both conventional and satellite information.

(vii) A research facility not only to perform practical research seeking better means of carrying on day-to-day operations but also to engage in a more basic synoptic and dynamic research into meteorological problems, particularly of a hemispheric and world-wide scale.

(viii) Close liaison with a World Data and Charting Centre to assist in providing documentation to research groups in all countries interested in hemispheric and world problems.

Regional Centres

61. A number of Regional Centres would be established throughout the world each of which could :

(i) Receive satellite meteorological data for an appropriate area.

(ii) Receive the necessary conventional meteorological observations.

(iii) Possess equipment for speedy processing and analysis of data.

(iv) Receive from a World Centre as background information, hemispheric or world analyses and prognoses.

(v) Possess computers to perform numerical weather prediction or similar computations on regional problems (including mesometeorological and smaller scales) making use of the hemispheric or world predictions prepared by the appropriate World Centre as auxiliary information in the solution of the prognostic equations.

(vi) Have adequate communication facilities, particularly facsimile, to disseminate analyses and prognoses to various countries within the Region.

(vii) Maintain a regional forecasting staff for aviation and other purposes.

(viii) Provide training in regional weather analysis and prediction to the meteorologists of the countries involved. Regional Centres would be maintained cooperatively or, if only one country is involved, nationally.

(ix) Provide training to meteorologists of other countries to assist in the establishment of other Regional Centres.

(x) Perform research, both basic and applied, concentrating on problems of that region taking into account the characteristic geography and topography.

62. Thus, in a cascading manner, starting with receipt of hemispheric or other large-area products from the World Centre, plus more detailed regional information from its Regional Centre, supplemented by additional local observations, including direct information from satellites, the meteorological service of a particular country could obtain the combination of charts and data best suited for its needs without itself being required to receive and process all of the data and to perform analyses and prognoses over large areas.

63. It is stressed that the main purpose of the establishment of Regional Centres is to make available to all countries in the region in a convenient form the vast amount of additional data, in raw and processed form, which meteorological satellites provide. They will in no way replace but will rather assist existing national meteorological services in the preparation of synoptic charts (surface and upper air) needed for them to meet their respective national responsibilities.

IX. OBSERVATIONS REQUIRED

64. Satellite observations alone, despite their global coverage, do not yield the quantitative data needed for modern mathematical modelling of the atmosphere, and conventional observations, despite their quantitative character, cannot be practically extended to give the desired global coverage. But both satellite and conventional observations, judiciously blended can yield an optimum world observing system which can give us data needed for the study of the atmosphere.

65. In the next few years, however, satellites will provide daily pictures of clouds and radiative fluxes over millions of square kilometres which do not possess a single conventional sounding station. Although the satellite data alone will be useful in the sense that some data are better than no data, they by themselves cannot, at the present stage of meteorological knowledge, substitute for quantitative observations of wind, pressure, temperature and humidity obtained by conventional soundings.

66. The earth's atmosphere, and for longer time periods, the atmosphere and the surface of the earth form a single system. To predict the future state of this system, we must know its present state. Meteorologists have never had this knowledge to a sufficient extent, but this lack has not prevented their future projections. They have some success because they limit their forecast for limited areas for only a few days in advance. Despite ingenious empiricism, forecasts for longer periods have not been very successful partly because such large volumes of the earth's atmosphere are involved that we soon come to regions of little or no data.

Observations Required on a Permanent Basis

67. To solve the problem of global meteorology, we must have global observations, which will give us a description of the fields of motion, temperature, momentum, pressure, humidity, and ozone to a height of about 80 km and the fluxes of matter and energy through the lower and upper boundaries. The present global system of conventional observations is deficient in two major respects.

(i) The number of stations making these observations is insufficient; and

(ii) The techniques and devices for the systematic measurement of the atmosphere above 30 km and for the fluxes of heat and moisture from the earth's surface are inadequate.

Additional Observations at Selected Stations during Satellite Passage

68. Since the view of the atmosphere from above is new to meteorologists, it is evident that a period of study and application is required to interpret satellites' observations in terms of state and motion parameters of the atmosphere. Until sufficient experience is gained in this respect, it is desirable that additional conventional and auxiliary meteorological observations should be made at existing meteorological stations during satellite passage. Indeed WMO has already urged Members to make such observations.

X. TELECOMMUNICATIONS FACILITIES

69. For the World and Regional Centres to carry out their activities, it is obvious that increased communications facilities will be necessary. Not only will there be a large increase in "normal" traffic but there will also be an extra load on communications circuits by satellite observations; this would be a situation giving rise to grave concern were it not for the promise that satellites themselves will in due course help materially in facilitating the dissemination of meteorological observations, analyses and prognoses. For the interim period, however, the present meteorological communications facilities must be greatly strengthened and broadened to facilitate world-wide dissemination of the growing volume of traffic, particularly of pictorial information - analyses, prognoses, cloud observations, vertical cross-sections, etc. It is possible, however, that this increase of pictorial information will be accompanied by a marked decrease in word traffic, as envisaged in the World Weather Watch concept (Appendix C). Nevertheless a great expansion of land-line and radio telecommunications including facsimile facilities appears to be required. This recommendation is supported by recent experience in the use of radio facsimile in disseminating TIROS nephanalyses from the United States to areas overseas.

70. Towards the end of the present decade, one may visualize a system of meteorological satellites, each with sufficient capacity to carry meteorological sensors of many types, storage and possibly initial data-processing facilities and communications equipment. By this means, a world-wide system of line-of-sight communications could be established which would assist the conventional meteorological communications system in transmitting both word and pictorial traffic.

71. One of the prime requirements is the availability of interference-free radio frequencies. To this end the Extraordinary Administrative Radio Conference of the International Telecommunications Union should be requested to provide adequately protected frequencies to meteorological satellites, and countries should be encouraged actively to monitor these frequencies in order to ensure that in no case will they be used by other radio stations.

72. In view of the importance of the services expected from meteosatellites, it seems obvious that such frequency allocations should have a priority status.

XI. WMO ADVISORY COMMITTEE

73. There can be no doubt that the new possibilities for improving weather forecasting capabilities provided by meteorological satellites can only be realized by an intensification of meteorological research.

74. As explained in Section VIII, the observations to be made under the World Weather Watch are primarily intended for meeting the routine needs of meteorological services. These same observations will also be of great value

for research in the atmospheric sciences, but for this purpose some additional observations will be required. Several international projects to obtain special data for research work have been organized in the past, the most outstanding being the International Geophysical Year (IGY).

75. Since the IGY, new instruments and methods of observation have been developed to explore the higher layers of the atmosphere so that it is now possible to extend the information collected during the IGY about the general circulation of the upper atmosphere. The meteorological programme for the International Year of the Quiet Sun, details of which are given in Appendix D, has been designed with this end in view. This clearly shows the necessity for international collaboration. An interesting feature of the programme is the manner in which the observations from satellites interweave with conventional observations.

76. The above is only one example among many of the types of atmospheric problems which require international planning and co-operation. Another type of problem is connected with the conscious and unconscious modification of weather and climate (see Appendix E).

77. The future needs of research workers can best be met by the establishment of an Advisory Committee on which representatives of UNESCO, ICSU (including IUGG) and other interested international organizations would be invited to sit. The WMO Executive Committee is accordingly proposing the establishment of such a committee. Pending the endorsement of this proposal by the WMO Congress (1963) and in order not to delay the implementation of the provisions of Part C of UN Resolution 1721 (XVI), the Executive Committee has established a new WMO Advisory Panel of Experts on Research on which representatives of other organizations as indicated above will be invited to serve.

78. The existing Panel of Experts on Artificial Satellites will be kept in existence until Fourth Congress, with its present terms of reference, to advise on other aspects of developments in this field, including the operational aspects.

79. Since, however, the operational aspects are, in some respects, closely related to those aspects which facilitate research, Fourth Congress may wish to combine the responsibility for the two aspects into the above-mentioned WMO Advisory Committee and, in this case, the Executive Committee proposes that the terms of reference of the committee should be as given in Appendix H. Pending consideration of this matter by Congress, the terms of reference of the new Panel of Experts referred to above will be as indicated in the first part of Appendix H under the heading "Research".

XII. GENERAL PLAN OF ACTION

Operational Aspects

Plan for Satellite Observations

80. Owing to the fact that the construction and launching of satellites and the reception of observational data and their processing require great expenditures it is desirable that meteorological services should consult with each other and with WMO in order to avoid duplication of efforts.

81. During the first years of meteorological services' satellite activities in different countries, the launching of meteorological satellites by countries would be made on an experimental basis with a view to working out :

(i) The most advanced methods of satellite observations;

(ii) Methods of complex processing of both conventional meteorological data as well as the data received from the satellites for the purposes of weather services;

(iii) System of rapid dissemination and exchange of meteorological information

82. Satellite launchings are carried out on a national basis. Co-ordination of efforts through WMO will be concentrated mainly on the above-mentioned (ii) and (iii), and will be carried on quite naturally with the help of existing WMO bodies. However, the more the experience gained and the more the satellite data used in research work, the closer will be the co-operation which would be needed on problems listed in "International Co-ordinated Plan for Meteorological Satellites". Agreement will be needed concerning the types and orbit orientation in space useful from the viewpoint of making studies of physical conditions of the atmosphere. The orbits should be as circular as possible and should be designed to secure a maximum of observational coverage of the earth's surface and a minimum of distortion. The programme of co-ordinated observations should be made in such a way that global observational coverage could be secured including the polar and equatorial regions, and that over each point on the earth's surface meteorological observations could be carried out twice a day with an interval of 12 hours.

83. Meteorological instruments installed on satellites by different countries should have comparable accuracy in radiative-thermal (actinometric) and other measurements as well as in resolution of television sensors.

84. Alongside with this, there would be requirements for establishing uniform methods of meteorological satellite data-processing, standardization of methods for graphical representation of data in the form of charts and schemes, codes for compact data transmission in the international exchange.

Conventional and Auxiliary Observations

85. For the layers below 30 km, a concerted effort should be made in the next 5 years to standardize available sounding devices. WMO is well-suited to co-ordinate such an effort but ultimate success is contingent on the willingness of the many countries involved to co-operate.

86. In addition, the number of meteorological stations making upper-air observations should be increased to cover all meteorologically important areas. By Resolution 829 (XXXII), the Economic and Social Council of United Nations has already called attention to the urgent need for eliminating gaps in the existing networks of permanent meteorological stations and has invited Governments to take steps, individually or collectively to establish meteorological stations where serious gaps exist. The problem of meteorological networks has preoccuppied WMO for many years and has been tackled from both the theoretical and practical viewpoints. The Commission for Synoptic Meteorology, for instance, has drawn up criteria for determining the optimum network. More important, perhaps, from the viewpoint of feasibility is a plan for a minimum network, drawn up by a working group recently established by the Executive Committee, and intended to fill the most serious existing gaps. Appendix F shows the locations of 53 additional stations required to achieve a minimum acceptable network. The implementation of such a network will not involve new knowledge or techniques but will require considerable human and financial resources.

87. The more difficult problem is connected with techniques for the systematic sounding of the atmosphere above 30 km and for the measurement of heat and moisture fluxes, from the earth's surface. For the former, action is required to accelerate the development of light-weight, inexpensive rocketsondes capable of reaching at least 80 km. Such rockets are now under experimental use and steps should be taken to accelerate their utilization on an operational basis, perhaps first in the Northern Hemisphere and then globally. Similarly action should be taken to stimulate the rapid development of simple, inexpensive automatic devices capable of measuring heat and moisture fluxes over the globe.

88. With regard to the auxiliary observations during satellite passage, all stations should initially be encouraged to make such observations. Later, however, when satellites are capable of providing daily world-wide coverage, a programme of auxiliary observations involving all meteorological stations would produce more information than can be studied. It would then be desirable to limit the programme of auxiliary observations during satellite passage to a carefully selected network of stations and, possibly, to internationally agreed short intervals such as the World Geophysical Intervals.

Establishment of the World Weather Watch

89. The elaborate nature of the proposed WWW and its concomitant system of World and Regional Centres, outlined in the previous section and illustrated in Appendix C, makes it quite clear that its complete implementation will not be an overnight affair, since this will involve employment of many highly qualified

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personnel, expensive data-processing and computing equipment and greatly enhanced communication facilities. Furthermore, international staffing may prove to be necessary or desirable. Our aim at this stage is to outline the more important desiderata for this world plan and recommend a tentative time-table for its progressive implementation over the next decade.

90. World Centres : Theoretically, a single World Centre should suffice, but in actual practice, it is likely that three centres would be required : one in North America, another in the European area and a third in the Southern Hemisphere. It is hoped that in the three-year period (1963-1965), two World Centres will be placed in operation in Washington and Moscow. In this connexion it is pertinent to mention that arrangements are already underway to enlarge the National Meteorological Centre of the US Weather Bureau in Washington into a World Centre in which meteorologists from other countries would be asked to participate. The Hydrometeorological Administration of the USSR has already expressed its intention to establish a World Centre. These two World Centres should have between them reliable telecommunications systems and the international aspects of their activities should be co-ordinated by WMO in accordance with the agreed programme which will be established.

91. Regional Centres : It is hoped that at least one Regional Centre would be set up during the period 1963-1965, preferably in Western Europe where there exist skilled man-power, data-processing and computing facilities and access to communications. The Centre could be staffed by meteorologists from European countries, possibly supplemented by personnel from those countries which possess experience in the processing and utilization of satellite information.

92. The Centre would also serve as an experimental operational model for the establishment of other Centres. After a trial period of operation, say a year or two, procedures might be sufficiently established to warrant splitting off a segment of the personnel to form another Regional Centre, preferably in a less-developed area of the World. This could be arranged in advance by assigning to the Centre personnel from countries outside the Region who, after training, could be detached to form a nucleus for a second Centre and so on, in a cascading manner, until a full-fledged system of Regional Centres would be in operation. It is hoped that this may be accomplished by the end of the decade.

93. The number of Regional Centres must be determined by a judicious blend of the ideal and the feasible. To cover completely the surface of the earth would require numerous Centres; however, in actual practice, this number is likely to be, perhaps only ten, located in the main areas of human activity.

94. Telecommunications : In due course the fullest use will need to be made of communication satellites for the exchange of the increased meteorological traffic which meteorological satellites will give rise to. In the meantime, the present meteorological communications facilities must be strengthened and broadened. An increase in the land-line and radio telecommunications, including facsimile facilities, will in particular need to be arranged. Arrangements for the allocation of appropriate frequencies will also need to be made (see Section X, para. 71 and 72).

95. Towards the end of the present decade, one may visualize a system of meteorological satellites, each with sufficient capacity to carry meteorological sensors of many types, storage and possibly initial data-processing facilities and communications equipment. By this means, a world-wide system of line of sight communications could be established which would replace the conventional meteorological communications system in transmitting both word and pictorial traffic.

Research Aspects

Co-ordination of research

96. It will be recommended to the WMO Congress (1963) to establish a WMO Advisory Committee as indicated in Section XI. In the meantime, a Panel of Experts on Research has been established and will begin work at the earliest opportunity. Financial assistance as described later in this present section will need to be approved.

Some Problems for Research

97. One of the most important tasks of this Panel of Experts is to draw up a list of specific research problems which have to be performed to advance the physics and mechanics of the atmosphere. This is a task which requires a great deal of thought. However, without prejudice to the decisions of the Panel in this respect, the following preliminary short list of problems readily suggest themselves as being of prime importance and are worthy of efforts on an international scale :

(i) Problems in connexion with solar and other external influences on the earth's atmosphere and the interaction between upper and lower atmosphere;

(ii) Problems on the general circulation and heat balance;

(iii) Problems on numerical weather prediction;

(iv) Medium and long-range forecasting.

98. Details relevant to the successful study of the above problems including observational and instrumental requirements and the manner in which data from satellites may be of assistance are given in Appendix G.

Financial Aspects

Co-ordinated Plan for Meteorological Satellites

99. On the assumption that the production and launching of satellites will continue to be the responsibility of individual governments (or groups of governments), no further consideration is given to the financial aspects of such

activities. The preparation of an internationally co-ordinated plan for meteorological satellites will be undertaken by WMO at the appropriate time utilizing as necessary the various technical bodies of the Organization and consulting other appropriate organizations. No financial provision from sources external to the Organization is therefore necessary for this purpose.

World and Regional Centres

100. It will be clear from section VIII, that the establishment of a World Centre will be a major undertaking. It will involve the installation of costly equipment, the employment of substantial numbers of highly-skilled staff; it will also involve the provision of certain research and training facilities. If all these facilities are to be established at the chosen location as part of a national programme (as for example Washington and Moscow) then no financial assistance from outside sources will be necessary. If on the other hand the country concerned cannot accept financial responsibility for such a commitment (as may for example be the case for the centre to be established in the Southern Hemisphere), then some form of assistance from international sources may be necessary. Similar remarks apply in general to Regional Centres although the facilities to be provided will of course not be so great, but there will be considerably more of them.

101. Thus it seems clear that some means of providing financial assistance for the establishment and operation of the World and Regional Centres will be needed. There are various ways in which such assistance may be organized and different ways may be preferred in different instances. Among the possibilities are :

(i) Assistance from existing United Nations technical assistance programmes;

(ii) Countries in one region may jointly finance and operate their Regional Centre. Such a joint enterprise might be organized directly between the countries concerned or it might be organized as a joint support scheme under the aegis of WMO;

(iii) A combination of the above schemes may be possible; for example, UN might assist in the initial installation of equipment and in training personnel while the operation of the centre might be conducted on a joint regional basis;

(iv) Assistance in the form of financial loans from IBRD or IDA might be possible in some cases;

(v) The approval by UN of special financial arrangements (such as the creation of a new Fund). Assistance under item (i) above will be essential to the prompt implementation of some aspects of the plans for World and Regional Centres. The possibility of action under items (ii) - (iv) will, of course, need to be examined further but

it is believed that any such action is unlikely fully to meet requirements. Thus the approval by UN of special financial arrangements for the meteorological satellite programme seems essential (item (v)). As will be seen later, such a course also seems essential for the satisfactory implementation of other aspects of the plan of action.

102. The completion of a comprehensive plan with full financial details should not however hold up such progress as can be made without delay. For this reason, WMO urges the Government of the United States to proceed with its existing plans for the development of a World Centre at Washington and urges the Government of U.S.S.R. to undertake the establishment of a World Centre in Moscow. WMO approves at once the designation of Washington and Moscow as World Centres in the overall plan. The early completion of such Centres is indeed essential to the completion of the overall plan and the assessment of its financial implications.

103. For similar reasons, the early establishment of a Regional Centre in Western Europe is urged.

104. As already mentioned, it is hoped that these Centres will be established by the end of the first three-year period (1963-1965).

Telecommunications

105. The diagram attached as Appendix C shows clearly the extent to which telecommunications facilities are essential for the World Weather Watch. Here again, further studies will be needed to obtain an estimate of the financial assistance which will be needed, but the establishment of a special UN programme of assistance is likely to be the only satisfactory long-term solution. The full operation and utilization of the World Centre and the Regional Centre planned for the next three years will, however, require immediate improved telecommunications facilities (particularly facsimile) in many countries, for which assistance from international sources will be needed. It is therefore urged that pending further consideration of the overall financial question, requests for such assistance addressed to the Technical Assistance Board and the Special Fund should receive sympathetic consideration. It may be mentioned that a provision to this effect was included in Part D of the General Assembly resolution on Space communications.

Networks of meteorological stations

106. As explained in previous sections, an adequate global network of conventional observations plays an essential role in deriving the utmost benefit from meteorological satellites. The Economic and Social Council has also drawn attention of the countries of the world to the need for adequate networks of meteorological stations for economic development (Resolution 829 (XXXII)). A plan to provide a minimum network has already been evolved by WMO which calls for establishment of automatic surface weather observatories, 53 new upper-air observing stations of which 20 will need to be on ships on the high seas. The

estimated cost of implementing this plan is $ 35.7 million for purchase and installation and $ 16.5 million for annual operation. While the national programmes of some countries will no doubt enable the plan to be implemented in part, in many other cases substantial financial assistance will be necessary. The various possibilities have been mentioned above and special financial arrangements seem necessary.

Training

107. The establishment of a full plan for training must await the completion of the overall plan for the World Weather Watch but some immediate steps should be taken. The United States have already held one international satellite workshop which was attended by participants from many countries. Further workshops of this kind are encouraged and financial assistance under existing UN technical assistance programmes, should be available when necessary to enable countries to send participants.

108. This very highly-specialized form of training is not the only form of training that will be necessary and WMO has reached an advanced stage in the study of plans to meet overall training requirements in meteorology. Financial assistance for the implementation of these plans is contemplated under the Expanded Programme and the Special Fund.

WMO Advisory Committee

109. Aside from the full role which WMO will play in the scientific work of the proposed Advisory Committee and the Panel of Experts on Research set up pending its approval, it is intended that WMO should provide the necessary administrative support. If this Committee is to conduct its work satisfactorily it will be essential to hold regular meetings not only of the main committee but possibly also of small working groups established to study highly-specialized problems. Invitations to high-level scientists to participate in some meetings on an individual basis may also from time-to-time be necessary if the highest scientific status is to be maintained. Thus some funds for travel costs and possibly honoraria will be necessary. An annual sum of the order of $ 20,000 might be envisaged for this purpose. It is felt that UN might wish to make a subvention of this amount to WMO for the year 1963, pending consideration of the WMO budget for 1964 and onwards by the WMO Congress, after which the matter could be reviewed in the light of the Congress decisions.

110. When the Committee begins its work, various projects will be developed and it will be necessary to consider for each of these the financial implications. Without further study of this problem, it is not possible to put forward specific proposals. While in many cases, research projects will, it is thought, be financed on a national basis, (such as was the case in the IGY), in other cases some financial assistance to countries will probably be necessary, and special arrangements to that end will have to be made.

Financial Proposals

111. The remarks in the preceding paragraphs lead to the following proposals :

(i) All countries should be urged to do everything possible within national programmes and budgets to implement the proposed plan of action for meteorological satellites. Where this is not possible or appropriate the following proposals should apply.

(ii) As an immediate measure, sympathetic consideration should be given to country requests for assistance in implementing this plan in the form of projects within the Expanded Programme and for the Special Fund.

(iii) Other possible sources of rendering assistance to countries in the implementation of the plan should be carefully examined.

(iv) In particular, consideration should be given by the United Nations to the establishment of a special financial arrangement for providing technical assistance in the implementation of the plan. The financial order of magnitude of such assistance cannot be given at the moment but an indication may be obtained from the estimated cost of bringing networks to the desired standard (and this is only a part of the overall plan). The estimated cost is $ 35.7 million for purchase and installation of equipment and $ 16.5 million for annual expenditure. Much of this expenditure will, it is believed, need to be met from international sources.

Such financial arrangements could take the form of the establishment of what might be called a UN World Weather Fund, which would be used to provide technical assistance in the implementation of all the various aspects of the WMO plan as described in the preceding paragraphs. Details of the manner in which such a fund would operate would, of course, need to be worked out but the approval and supervision of projects financed by the fund would clearly need to rest with WMO.

(v) UN should make an immediate subvention of $20,000 to WMO to enable the arrangements for the proposed WMO Advisory Committee (and the Panel of Experts which precedes it), to proceed without delay.

XIII. ACKNOWLEDGEMENTS

112. WMO acknowledges with deep appreciation the great assistance rendered in the drafting of this report by the governments of the U.S.A. and U.S.S.R. in providing the services of high-level scientists experienced in the subject of the report. These scientists spent considerable periods working in the WMO Secretariat in Geneva without any cost to the Organization. This fine example of goodwill and collaboration has enabled a report to be prepared which is scientifically authoritative in all respects.

113. The spirit of friendly co-operation shown by the scientists themsleves, Professor V.A. Bugaev from the U.S.S.R., Dr. H. Wexler and Dr. M.A. Alaka from the United States, was also a noteworthy and important factor in this task.

114. Thanks are also due to assistance given by many international organizations either by sending participants to meetings or by correspondence, particularly UNESCO, ITU, ICAO, IAEA and ICSU. WMO appreciates their co-operation in the past and looks forward to further co-operation in the future.

APPENDIX A

UNITED NATIONS

RESOLUTION ADOPTED BY THE GENERAL ASSEMBLY

1721 (XVI). International Co-operation in the Peaceful Uses of Outer Space

A

The General Assembly,

Recognizing the common interest of mankind in furthering the peaceful uses of outer space and the urgent need to strengthen international co-operation in this important field,

Believing that the exploration and use of outer space should be only for the betterment of mankind and to the benefit of States irrespective of the stage of their economic or scientific development,

1. Commends to States for their guidance in the exploration and use of outer space the following principles :

(a) International law, including the Charter of the United Nations, applies to outer space and celestial bodies;

(b) Outer space and celestial bodies are free for exploration and use by all States in conformity with international law and are not subject to national appropriation;

2. Invites the Committee on the Peaceful Uses of Outer Space to study and report on the legal problems which may arise from the exploration and use of outer space.

B

The General Assembly,

Believing that the United Nations should provide a focal point for international co-operation in the peaceful exploration and use of outer space,

1. Calls upon States launching objects into orbit or beyond to furnish information promptly to the Committee on the Peaceful Uses of Outer Space through the Secretary-General for the registration of launchings;

2. Requests the Secretary-General to maintain a public registry of the information furnished in accordance with paragraph 1 above;

3. Requests the Committee on the Peaceful Uses of Outer Space, in co-operation with the Secretary-General and making full use of the functions and resources of the Secretariat :

(a) To maintain close contact with governmental and non-governmental organizations concerned with outer space matters;

(b) To provide for the exchange of such information relating to outer space activities as Governments may supply on a voluntary basis, supplementing but not duplicating existing technical and scientific exchanges;

(c) To assist in the study of measures for the promotion of international co-operation in outer space activities;

4. Further requests the Committee on the Peaceful Uses of Outer Space to report to the General Assembly on the arrangements undertaken for the performance of these functions and on such developments relating to the peaceful uses of outer space as it considers significant.

C

The General Assembly,

Noting with gratification the marked progress for meteorological science and technology opened up by the advances in outer space,

Convinced of the world-wide benefits to be derived from international co-operation in weather research and analysis,

1. Recommends to all Member States and to the World Meteorological Organization and other appropriate specialized agencies the early and comprehensive study, in the light of developments in outer space, of measures .

(a) To advance the state of atmospheric science and technology so as to provide greater knowledge of basic physical forces affecting climate and the possibility of large-scale weather modification;

(b) To develop existing weather forecasting capabilities and to help Member States make effective use of such capabilities through regional meteorological centres;

2. Requests the World Meteorological Organization, consulting as appropriate with the United Nations Educational, Scientific and Cultural Organization and other specialized agencies and governmental and non-governmental organizations, such as the International Council of Scientific Unions, to submit a report to its member Governments and to the Economic and Social Council at its thirty-fourth session regarding appropriate organizational and financial arrangements to achieve these ends, with a view to their further consideration by the General Assembly at its seventeenth session;

3. Requests the Committee on the Peaceful Uses of Outer Space, as it deems appropriate, to review that report and submit its comments and recommendations to the Economic and Social Council and to the General Assembly.

D

The General Assembly,

Believing that communication by means of satellites should be available to the nations of the world as soon as practicable on a global and non-discriminatory basis,

Convinced of the need to prepare the way for the establishment of effective operational satellite communication,

1. Notes with satisfaction that the International Telecommunication Union plans to call a special conference in 1963 to make allocations of radio frequency bands for outer space activities;

2. Recommends that the International Telecommunication Union consider at this conference those aspects of space communication in which international co-operation will be required;

3. Notes the potential importance of communication satellites for use by the United Nations and its principal organs and specialized agencies for both operational and informational requirements;

4. Invites the Special Fund and the United Nations Expanded Programme of Technical Assistance, in consultation with the International Telecommunication Union, to give sympathetic consideration to requests from Member States for technical and other assistance for the survey of their communication needs and for the development of their domestic communication facilities so that they may make effective use of space communication;

5. Requests the International Telecommunication Union, consulting as appropriate with Member States, the United Nations Educational, Scientific and Cultural Organization and other specialized agencies, governmental and non-governmental organizations, such as the Committee on Space Research of the International Council of Scientific Unions, to submit a report on the implementation of these proposals to the Economic and Social Council at its thirty-fourth session and to the General Assembly at its seventeenth session;

6. Requests the Committee on the Peaceful Uses of Outer Space, as it deems appropriate, to review this report and submit its comments and recommendations to the Economic and Social Council and the General Assembly.

E

The General Assembly,

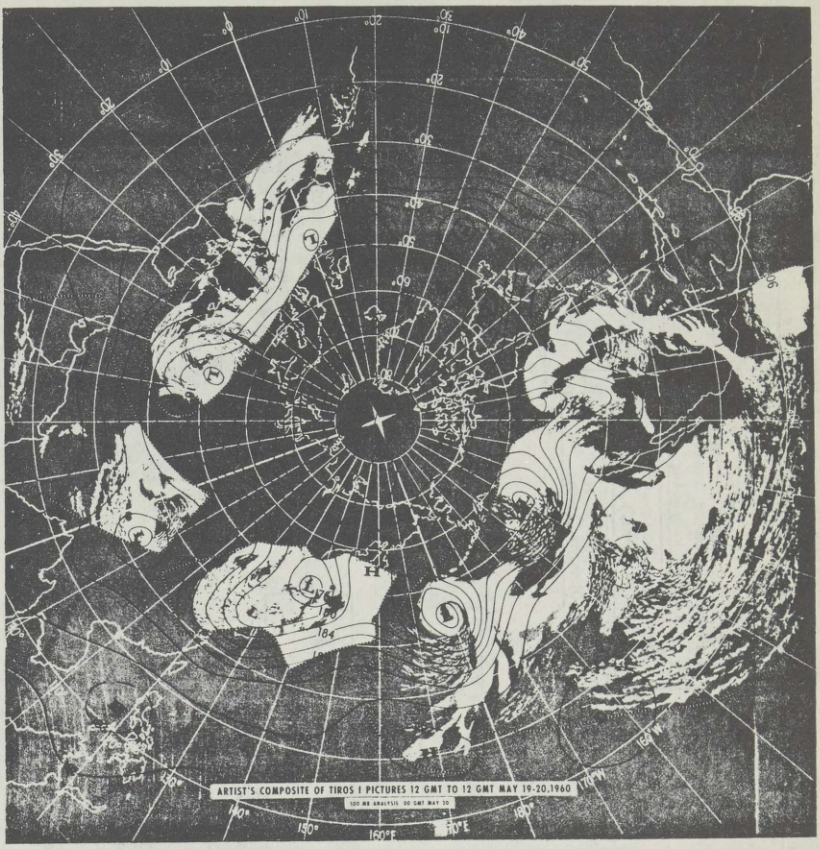
Recalling its resolution 1472 (XIV) of 12 December 1959,

Noting that the terms of office of the members of the Committee on the Peaceful Uses of Outer Space expire at the end of 1961,

Noting the report of the Committee on the Peaceful Uses of Outer Space (A/4987),

1. Decides to continue the membership of the Committee on the Peaceful Uses of Outer Space as set forth in General Assembly resolution 1472 (XIV) and to add Chad, Mongolia, Morocco and Sierra Leone to its membership in recognition of the increased membership of the United Nations since the Committee was established;

2. Requests the Committee to meet not later than 31 March 1962 to carry out its mandate as contained in General Assembly resolution 1472 (XIV) to review the activities provided for in the present resolution and to make such reports as it may consider appropriate.



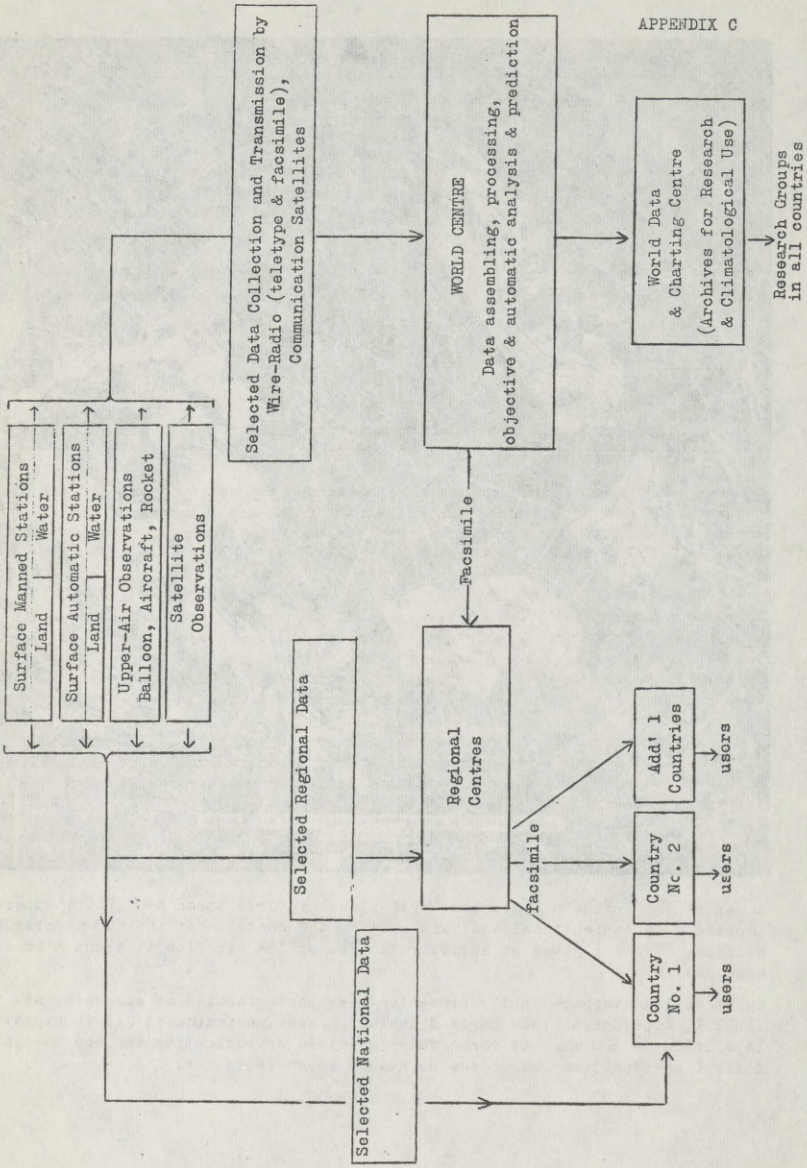
A map of the Northern Hemisphere with cloud pictures taken by TIROS I superimposed on a conventional analysis showing the contours of the 500-mb pressure surface. The map gives an approximate idea of the air flow at about 5 km above mean sea level.

Carte de l'hémisphère Nord représentant des photographies de nuages prises par TIROS I, superposée à une carte d'analyse classique indiquant les isohypses de la surface de 500 mb. La carte donne une idée approximative des mouvements de l'air à environ 5 km au-dessus du niveau moyen de la mer.

APPENDIX C

WORLD WEATHER WATCH

Schematic presentation of the flow of Observations and processed information



APPENDIX D

METEOROLOGICAL PROGRAMME FOR THE INTERNATIONAL YEAR OF THE QUIET SUN (IQSY)

1. The meteorological programme for the IQSY has been conceived with a view to studying the large-scale physical, dynamical and thermodynamical characteristics of the atmosphere above 100 mb and the relations between the upper and lower atmosphere.

2. In order to reach the objectives of the IQSY meteorological programme, the following synoptic measurements have recently been recommended :

- total content and vertical distribution of ozone with particular attention to the ozone production region,
- net radiative flux at the earth's surface and all possible heights in the atmosphere and from satellites,
- pressure temperature and motion of the atmosphere at all heights accessible to balloon and rocket vehicles.

3. In fact the IQSY programme is an upward extension of the IGY-IGC programme. However, the meteorological study of the upper layers of the atmosphere can only be meaningful if it can be linked to processes in the lower layers.

4. Accordingly, the Meteorological Service in those areas in which full exploration to the 100 mb level was not achieved during IGY-IGC, should make a major effort during IQSY to establish an appropriate network of aerological stations. An adequate surface network of observing stations must supplement satellite observations. Conventional meteorological observations are indispensable for the full interpretation of satellite data.

5. In addition to meteorological rockets, which will be an essential tool for extending pressure, temperature and wind observations above the maximum burst level of balloons, the following satellite-borne experiments are recommended by the IQSY Committee of CIG (1964-65) :

(i) World-wide observations from satellites of the total upward radiation from the earth and atmosphere have been shown to be correlated with cloud distributions and temperatures in the free atmosphere, and are essential in the study of the radiation balance in the high atmosphere. It is also desirable to study the possibility of determining the solar constant by space experiments during IQSY.

(ii) Synoptic cloud cover and albedo observations from meteorological satellites, while essentially concerned with the troposphere, also have important implications to the radiation balance in the entire atmosphere.

(iii) Certain techniques are being developed for measuring the ozone distribution in the stratosphere by observations from a satellite of either the ultra-violet sunlight absorbed by the earth's limb at twilight or by measurements of the ultra-violet sunlight scattered by the atmosphere, either of which would be of value in studies of atmospheric ozone.

(iv) Observations from satellites of high-level aerosols or clouds (e.g. noctilucent clouds) would contribute to the meteorology of the high atmosphere.

(v) Observations of changes in solar ultra-violet and X-ray fluxes, necessarily made from outside the earth's atmosphere, are essential to an understanding of solar-terrestrial relationships.

(vi) The changes in density above about 150 km accompanying magnetic storms, determined by observations of satellite drag, while somewhat above the region of primary interest in the meteorological programme of IQSY, are of great interest in studies of solar terrestrial relationships, being in fact one of the most direct indications so far obtained of actual heating in the upper atmosphere due to solar disturbances.

APPENDIX E

MODIFICATION OF WEATHER AND CLIMATE

1. From current and contemplated research programmes, aided by satellites and other observational techniques, it is reasonable to expect a better knowledge of the general circulation and the heat balance of the atmosphere which in turn will lead to an improvement in our understanding of weather and climate.

2. Indeed, it is not unrealistic to expect that mankind will eventually have the pover to influence weather and even climate on a large scale; for example the artificial melting of the Arctic ice cap has been proposed. It is, however, imperative that the consequences of any such large-scale interference with the existing climatic balance should be accurately foreseen and evaluated.

3. The complexity of atmospheric processes is such that an artificially induced change in the weather in one part of the earth will necessarily have repercussions in other parts. This principle can be affirmed on the basis of our present knowledge of the mechanism of the general circulation of the atmosphere. Our knowledge, however, is still very far from enabling us to forecast with confidence the degree, nature or duration of the secondary effects to which a change in weather or climate in one part of the globe may give rise, nor even to predict whether these effects may be beneficial or detrimental.

4. It must furthermore be borne in mind that a change of climate, even if regarded as beneficial, would necessarily lead to ecological changes in plant and animal life, whose consequences would be felt not only in the agriculture but in the whole economic and social life of the region concerned.

5. Therefore, before starting an experiment on large-scale weather modifications, we must be sure of our capability of forecasting accurately the expected modification in the heat balance and the circulation of the atmosphere. Otherwise we could face some day the dangerous situation of undesired irreversible weather and climate changes.

6. Consciously or not, man is engaged in a large-scale contamination of the earth's atmosphere which is bound to become more serious. We refer not only to contamination of the lower atmosphere by carbon dioxide and other gases, particulates, etc., which may have a significant effect on the earth's radiational balance, but also to the increasing contamination of the upper atmosphere.

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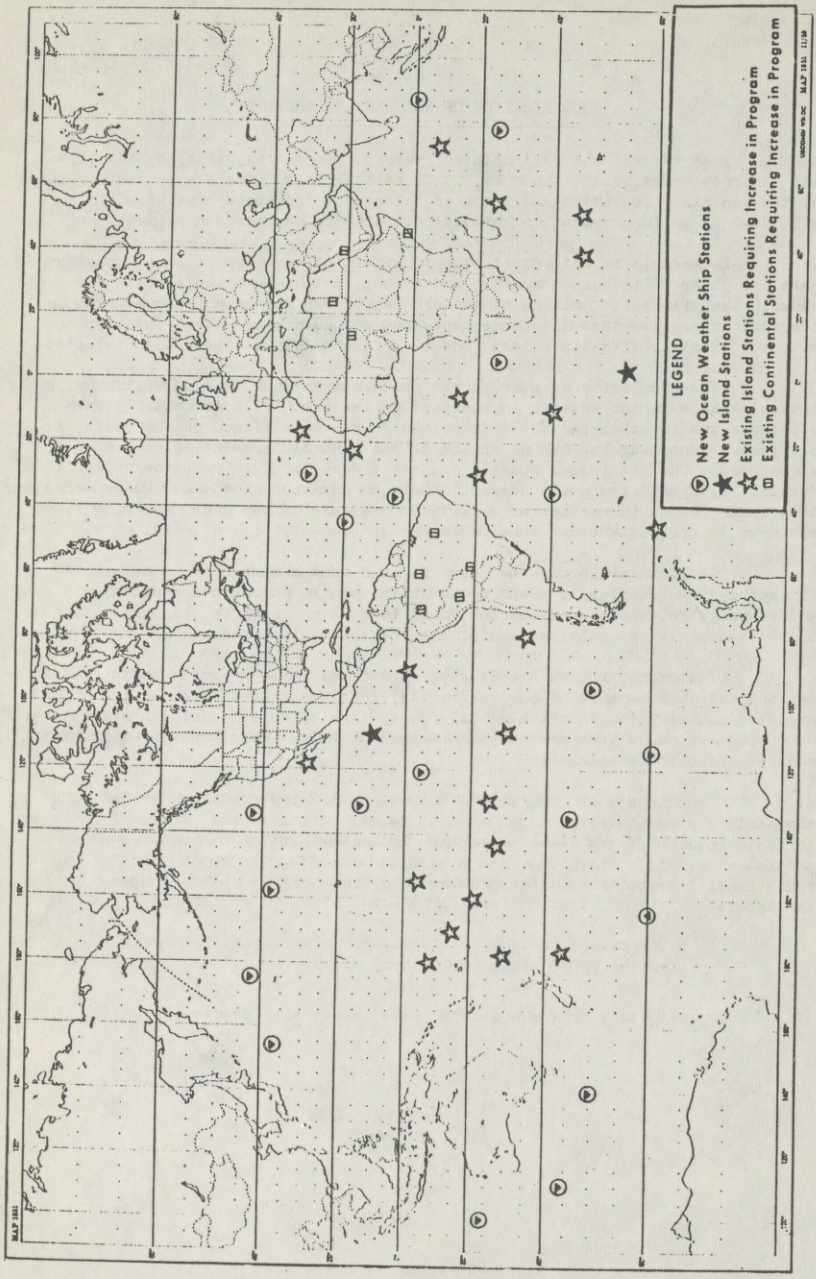
APPENDIX F

ADDITIONAL UPPER AIR STATIONS REQUIRED TO FILL MAJOR EXISTING GAPS IN WORLD-WIDE WEATHER NETWORK



APPENDIX G

PROBLEMS FOR RESEARCH

1. Problems in connexion with solar and other external influences on the earth's atmosphere and the interaction between upper and lower atmosphere

(i) Studies of radiative properties of atmospheric gases and aerosols (to very low pressures and great dilution).

(ii) Atmospheric studies of radiative transfer (transmission and extinction of solar and artificial sources of radiation, atmospheric emission).

(iii) Further studies of photochemical theory of ozone.

(iv) Development of dynamical theory of the consequences of anomalous radiational heating at high levels (including the vertical propagation of such effects).

(v) Development of techniques for the calculation of the vertical propagation of radiative effects (and their interactions with dynamic processes).

(vi) Studies of correlations between global data on ozone, and temperature in the 25-60 km layer and direct solar-spectrum satellite data.

(vii) Critical review and extension of studies of solar-terrestrial relationships.

The observational requirements for studying the above problems are :

(i) Data on vertical distribution of ozone, water vapour and aerosols.

(ii) Global data on the dynamic and thermodynamic state of the 25-60 km layer (meteorological balloons and rockets).

(iii) Improvements in synoptic networks, particularly for oceanic, tropical and southern hemisphere areas.

Successful study of the problems listed above also requires :

(i) Further development of satellite radiation sensors to yield global data on stratospheric ozone, water vapour and temperatures;

(ii) Continuation of satellite development to yield continuous monitoring of entire solar spectrum (on at least a relative basis) plus integrated solar radiation (on an absolute basis).

2. Problems for research on the general circulation and heat balance

(i) Large-scale physical, dynamical and thermodynamical processes in the various layers of the atmosphere;

(ii) Heat balance of the atmosphere, in particular the radiation balance, in relation to the general circulation; heat exchanges between the atmosphere, on the one hand, and the continents and the oceans, on the other;

(iii) Correlations between global data on ozone, water vapour, net radiation flux, temperature and circulation in the 25-60 km layer and satellite data on radiative fluxes;

(iv) The continually changing distribution in the atmosphere, on a planetary scale, to at least 10 mb, of momentum, vorticity, entropy and the various forms of energy (potential energy, kinetic energy, sensible heat, latent heat); horizontal transfer in various layers and vertical transfer between these layers (incorporating vertical motions from NWP models); large-scale influence of friction and surface topography on the balance of momentum, vorticity and kinetic energy; momentum exchanges between the atmosphere and the oceans;

(v) Flow patterns in lower latitudes, including interactions between circulations of the two hemispheres and between tropical and extratropical circulations; relations between the upper and lower layers of the atmosphere.

3. Numerical weather prediction

As a result of recent action by the Commission for Aerology of WMO, a significant advancement in the international co-ordination of research in numerical prediction is taking place. Resolution 1 (CAe-III) established a working group with terms of reference directing it to undertake active international co-ordination of research in this subject. In this respect, it is not only an advisory group (as is the case with most working groups) but an actively operating group. It will arrange, monitor and facilitate the exchange of research information, select test cases, and co-ordinate the necessary technical details. The activities of this group should ensure complete exchange of information among research workers on this subject and enable the workers to avoid any unnecessary duplication of efforts. They will be able to take advantage of each other's progress in their own activities with little delay.

The present stage of our abilities in numerical weather prediction is not sufficiently advanced to allow us to profit by the inclusion into the prediction models of the appropriate radiation balance terms, as determined by satellite measurements. While the neglect of these terms leads to errors of prediction, substantially larger errors from other sources must be eliminated or greatly reduced before it will be worthwhile to include radiation balance calculations. This will no doubt require several years of work. Despite this it will be profitable to investigate now from a theoretical point of view the radiation terms in the prediction equations.

The time for the use of cloud distribution observations in numerical prediction is much closer. Already cloud and precipitation forecast calculations (distinct from the usual motion and temperature forecasts of numerical prediction) are being tested. These require initial moisture distribution values. The satellite cloud observations at least give us the locations of areas having saturation values of humidity. Although the depth of the cloud material is not always known, the information available is helpful to a crude forecast model, and more comprehensive satellite observations will certainly be more useful for this purpose.

The most urgent data requirement for numerical prediction is for parameters of motion and state in the troposphere and stratosphere. The problem is then how to obtain the maximum possible information on the above parameters by means of artificial satellites.

Meteorological satellites as presently designed do not measure such parameters but give information on other parameters. The presently measured parameters can be used to infer the above-listed required parameters only in a very limited and qualitative sense. It is possible that further study and research with existing types of data will lead to improvement of its use, but the main hope appears to lie in the development of more advanced satellite systems which will give this type of information more completely and quantitatively.

Since it is evidently not possible, at this time, to design and build satellite systems to measure directly the desired parameters of motion and state, it will be necessary to take advantage of the possibilities that exist. These include measurements of temperature at high altitudes in the atmosphere, possibly the determination of tropopause height, and at later dates the possible measurements of temperature through deeper atmospheric layers. Additionally, research now under way may produce usable quantitative relations between cloud patterns and tropospheric flow. This work is directed in the following lines of approach :

(i) Given a vertical motion field which has been inferred from cloud distributions, to obtain a most probable corresponding field of horizontal motion. The solution of this problem may be attained progressively on a regional basis.

(ii) Given the details of the cloud pattern (streaks, rows, vortices) to obtain quantitative values of the field of horizontal motion.

Research on these subjects ought to be expanded in order to bring ideas from many different sources to bear on the problem. This type of work may be especially suitable for investigation in diverse regional centres.

4. Medium and extended range forecasting

Significant progress in forecasting for periods in excess of a few days (three) will come only after a better understanding of atmospheric motions if this time scale is achieved. At the present, forecasting for these periods appears to be one of the most difficult problems in meteorology. Yet the economic importance of this subject is very great. Relatively slight improvements in long-range forecasting skill will bring very substantial economic benefit. What appears to be required at this time is new understanding, new ideas and global data.

APPENDIX H

WMO ADVISORY COMMITTEE

PROPOSED TERMS OF REFERENCE

(To be submitted for the approval of the WMO Congress (1963))

To advise on all aspects of the implementation of Part C of the General Assembly Resolution 1721 (XVI) and in this context :

(a) Research

(i) To study the observational requirements of research workers in the atmospheric sciences and to recommend steps for meeting these requirements;

(ii) To examine all scientific aspects of the objectives mentioned in Part C of the General Assembly Resolution 1721 (XVI) and to submit recommendations on the scientific problems that have to be solved in order to implement the resolution;

(iii) To list specific research tasks which have to be performed to advance the atmospheric sciences and to keep up-to date the list of these tasks;

(iv) To advise on proposals volunteered in support of these research tasks;

(v) To evaluate, at appropriate intervals of time, the progress achieved and to recommend, in the light of the results attained, the discontinuance or reorientation of parts of research tasks that have been listed.

(vi) To study the further research possibilities afforded by new atmospheric data.

(b) Operations

To examine all operational aspects of the objectives mentioned in Part C of the General Assembly Resolution 1721 (XVI) and to submit appropriate recommendations.

(c) Co-ordination

(i) To assist in co-ordinating plans for meteorological satellites, and for the utilization of the data obtained;

(ii) To co-ordinate the activities of other constituent bodies of WMO relating to meteorological satellites.

Dr. GARDNER. This report, as you know, recommends not only merely the establishment of world weather centers, but also regional centers, several of those in the less developed countries, and a considerable extension in the existing network of observatories on ships and on the ground.

This means that some capital facilities will have to be established.

The U.N. and World Meteorological Organization and its various members, including the United States, will have to decide in the months ahead how this is to be done, who is to pay, and so on.

It is for this reason we have established the interagency committee, to enable us to establish a U.S. policy, the nature of what we are doing, and the timing of what we are prepared to do.

I would emphasize, Mr. Chairman, that to a large extend we hope that the financing of these capital facilities may be a shared effort.

We do not see any reason why the United States should do it alone. There are a number of sources of funds which might be available for this. Of course, first we expect the nations, themselves, who are to derive benefits to make contributions for facilities in their own territories.

Beyond that, we have, as I mentioned earlier, U.N. resources in the form of the expanded program of technical assistance and the U.N. Special Fund where there are moneys available for this kind of thing.

Beyond that, there is the International Development Association, which is a specialized agency of the U.N., and an affiliate of the World Bank, which makes money available on easy credit terms for the establishment of capital facilities in less-developed countries.

What I am saying is that there are sources of funds, international sources of funds, as well as national, other than the United States, which we think should be engaged in this worldwide undertaking as well as bilateral U.S. assistance.

Mr. HECHLER. What national sources?

Dr. GARDNER. I mean other participating countries we hope will make financial contributions with respect to facilities on their own territories.

Mr. HECHLER. Mr. Hines?

Mr. HINES. With regard to these available funds, would the United Nations be called upon?

Would the U.N., as part of its educational program, be asked to contribute?

Dr. GARDNER. Yes. We have the expanded program of technical assistance, which is now running at something like $50 million a year.

This is for the training of people.

It would not be available for the building of capital facilities but would help in the training of human facilities necessary to get along with the job.

That is one resource.

In addition, you have the U.N. Special Fund. This is the institution which Mr. Paul Hoffman is head of, and they spend money for so-called preinvestment work; that is surveys of resources and establishing training institutes.

They could finance, for example, an educational institution in the weather field in a less developed country. This U.N. fund is running $50 million a year or more and we are hoping to expand it. That is another potential resource.

Then you have the International Development Association, which is affiliated with the World Bank.

They are engaged in providing money for capital equipment as opposed to technical aid and preinvestment. That is another resource we think should be explored.

So we have all these various U.N. instruments in addition to the national financial programs.

Mr. HECHLER. I note that the budding European Space Organization, particularly the Italians are planning to do some high altitude sounding shots for atmospheric purposes and upper atomospheric purposes.

Will that information be input to our world meteorological satellite information as applied to these specific countries?

Do you anticipate the Weather Bureau would be recipients of that information?

Mr. CARTWRIGHT. Yes, I think so. There is an established system that grew out of the IGY for transmitting this data to world centers and this has been very well observed by all participants in these international programs.

So I am sure the data will flow into the world centers and be available.

Mr. HECHLER. Mr. Nesbitt, do you feel that you have your finger pretty closely on scientific developments as they occur in the Weather Bureau and other weather organizations that enables you to keep very closely in touch with new research in this field?

Mr. NESBITT. We are keeping in very close touch with the Weather Bureau.

Mr. HECHLER. Is the arrangement satisfactory?

Mr. NESBITT. The liaison is very satisfactory. It is a two-way street; it is excellent.

Mr. HECHLER. Dr. Gardner, does the Department of State have any relationship with the National Academy of Sciences in the development of world meteorological satellite systems?

Dr. GARDNER. We are going to be drawing upon the conclusions of CIPASH, which is this committee affiliated with the National Academy of Sciences, Mr. Chairman, and to that extent we will be drawing upon the best judgment of the sicentific community.

I would like to say that in the preparation of this U.N. resolution which gave birth to this program and this WMO report, we consulted at every step of the way with the private scientific community as well as the people in the Government.

In fact, we called down to Washington last summer—the summer of 1961—a group of leading experts in the atmospheric sciences to help us draft part C of U.N. General Assembly Resolution 1721, to be sure that what we were calling for in the atmospheric sciences made sense.

So we do have these continuous contacts to draw the best advice we can from the private scientific community.

Mr. HECHLER. I would like to give you an opportunity to end this hearing on a high note and I wondered if you had any concluding observations on how this great weapon of freedom could be utilized?

Dr. GARDNER. Well, I think that I would like to emphasize again, Mr. Chairman, that the United States sees in this program an opportunity to dramatize that our space activities can have material benefits here and now to people on earth, that this is not just a stunt, and that

it is not even just for pure research, that it has applications which can ease men's burdens.

We think that is important.

We think further that this will help us politically with our allies, with the uncommitted countries, and even with the Soviet Union, by demonstrating that practical measures of technical and scientific cooperation are in the interest of all.

Perhaps I may add this one further thought, since you have encouraged me to do so.

We feel that the way to get on with cooperation in outer space is not to try to sit down and draft some great code of law for all time, but to use the common law approach in this field as in others, that is to say, to develop law out of specific practical functional cooperation in weather, in communications, in the exchange of scientific information, and thus to build a regime of law and order based on experience in the application of this new technology in the service of human needs.

Mr. HECHLER. Thank you, Dr. Gardner, Mr. Nesbitt, and Mr. Cartwright.

The committee stands adjourned.

(Whereupon, at 11:45 a.m., the committee adjourned.)

METEOROLOGICAL SATELLITES

SEPTEMBER 13, 1962

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE NO. 4,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Ken Hechler (chairman) presiding.

MR. HECHLER. The committee will be in order.

Over the past few years there has been a great deal of research carried forward under the leadership of the National Science Foundation in the field of weather modification and weather control. Unfortunately we cannot have Mark Twain with us but we do have the Director of the National Science Foundation, Dr. Waterman, and in addition to that, we have Dr. Earl G. Droessler, Program Director of the Atmospheric Sciences Program Office, Division of Mathematical Physical, and Engineering Sciences, National Science Foundation.

Under Public Law 85–510, passed July 11, 1958, Congress directed the National Science Foundation—and I quote: "to initiate and support a program of study, research, and evaluation in the field of weather modification."

Of course if we could control both the damaging and beneficial effects of weather, many economic and human benefits would result.

The efforts to seed clouds by silver iodide to produce rain are well known. There has been a vast amount of research in other aspects of weather control, such as breaking up hailstorms, blunting or diverting hurricanes and other damaging weather phenomena which threaten human life and property.

All of these efforts toward a better understanding of the weather and possible control of the weather are important for farmers, for businessmen and, also for our Armed Forces.

I think it is heartening to note also that many nations of the world are carrying on active research in weather control and the mechanism for exchanging information seems to be working out very well.

I would like to call particular attention this morning to the report of the National Science Foundation on weather modification, which just came across my desk.

This report summarizes the work which has been carried on under the leadership of the National Science Foundation.

The purpose of this hearing is to gain more insight into the progress being made and also the future potentialities of weather modification and control.

Dr. Waterman, it is a pleasure to have you again before our committee. You may proceed with whatever statement you have.

Mr. WATERMAN. Thank you, sir.

STATEMENT OF DR. ALAN T. WATERMAN, DIRECTOR, NATIONAL SCIENCE FOUNDATION; ACCOMPANIED BY DR. EARL G. DROESSLER, PROGRAM DIRECTOR, ATMOSPHERIC SCIENCES PROGRAM OFFICE, DIVISION OF MATHEMATICAL, PHYSICAL, AND ENGINEERING SCIENCES, NATIONAL SCIENCE FOUNDATION

Dr. WATERMAN. Mr. Chairman and members of the committee, I welcome the opportunity to appear before you today to discuss the subject of weather modification, the significance of which is being increasingly recognized.

The National Science Foundation has supported a special program of research in the field over the past 4 years and I will report to you on aspects of this program.

By way of background: Changing or controlling the weather has been one of man's age-old dreams. He has longed to mitigate the effects of disastrous storms and to have water when and where it was needed.

So great is this desire that, in general, any claim for weather control, given some credence, can usually be used to promote the necessary financial support for the effort.

In the 1890's, for example, the Congress appropriated funds for experiments involving the detonation of explosives within clouds, for it was a popular belief of the time that "it always rains after a battle."

But not until the World War II investigations of fog particles by Drs. Langmuir and Schaefer, of the General Electric Co., was it demonstrated that clouds could be modified and some precipitation produced by scientific means, in this case one very spceial method—dry-ice seeding of supercooled clouds.

The military possibilities of the discovery led the Department of Defense to establish Project CIRRUS in 1947, while the civilian implications were investigated by the cloud physics program of the U.S. Weather Bureau in 1948.

Commercial rainmaking activities on a multi-million-dollar scale were soon underway, especially after the discovery that silver iodide particles were somewhat similarly effective. These projects mostly employed ground generators which produced silver iodide smoke as the cloud seeding material.

We recall that a major drought gripped parts of the country during the late forties and early fifties and made the subject of precipitation a matter of serious national concern.

The inflated claims of some "rainmakers" were countered by severe criticism from parts of the scientific community.

These controversies led Congress in 1953 to create an Advisory Committee on Weather Control "to study and evaluate public and private experiments in weather modification."

The Advisory Committee made an extensive survey of cloud-seeding operations in the United States and also gathered data on activities abroad.

In addition, two scientific organizations conducted similar investigations at about the same time. All three groups published important reports.

That the bright hopes sparked by the experimental research of Langmuir and Schaefer in 1946–47 had failed to bring forth the anticipated results was apparent by the time these reports were published.

Moreover, the requirements of the missile and space age were pointing up our urgent need for much greater knowledge of the atmosphere. Direction for future progress was required. And the three separate reports all reached essentialy the same conclusions.

First to appear was the report of the Council of the American Meteorological Society, published in June 1957. Reviewing the scientific achievements of the decade, the council concluded by saying:

> All cloud-seeding operations should be considered as experiments, since the techniques are still under development and there is no sound basis for the quantitative estimation of the results in advance of the operation. As experiments they should be designed primarily to yield optimum sceintific results. There is good reason to believe that improved returns from cloud seeding will result from a sound experimental approach and this should be fostered by all concerned.

The final report of the Advisory Committee on Weather Control was published in December 1957. The Committee recommended as follows:

1. Encouragement be given for the widest possible competent research in meteorology and related fields.
2. The Government sponsor meteorological research more vigorously than at present.
3. The administration of Government-sponsored research provide freedom and latitude in choosing methods and goals, with emphasis on encouraging talented men as well as their specific projects.
4. An agency—the National Science Foundation—be designated to promote and support research in the needed fields, and to coordinate research projects.
5. Facilities required to achieve a research project should be provided by the appropriate agency whenever the project has the endorsement of the National Science Foundation.

The third report, that of the Committee on Meteorology of the National Academy of Sciences, was issued in January 1958 and dealt specifically with problems of manpower, education, and research in atmospheric sciences.

Basic to its recommendations were plans for the recruitment and training of an increased number of young scientists in meteorology and allied sciences, for the creation of a suitable working environment for mature scientists in a National Institute of Atmospheric Research, and for increased Federal support of university departments conducting basic research in atmospheric sciences. Much progress has been made in all these directions.

Present program: Under Public Law 85–510 of July 11, 1958, the National Science Foundation was directed to "initiate and support a program of study, research, and evaluation in the field of weather modification."

Since that time the Foundation has directly supported a significant program of research in this field and in a larger sense has maintained a central position of leadership in stimulating adequate and pertinent research throughout the scientific community, in the universities, and

other parts of our civilian research sector, and within the various laboratories of the Federal Government.

Following the usual pattern of Foundation operation, the program is administered principally through grants and contracts with universities and other research groups.

Annual reports have been prepared for the Congress by the Foundation which portray the development of the program, listing all of the grants and contracts made.

The third annual report, as the chairman just stated, covering the activities of fiscal year 1961, has just recently been published and we brought copies with us today for distribution to the committee, its staff, and to the members of the press in attendance.

The following tabulation shows the amounts of Federal funds directed toward the support of weather modification research over the past several years:

Federal funds for support of weather modification

[In thousands of dollars]

Reporting agency	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961	Fiscal year 1962	Fiscal year 1963
Agriculture	75	61.0	80.0	119.0	104
Commerce: Weather Bureau	15	57.8	59.3	[1] 224.5	250
Department of Defense:					
Army	30	67.9	156.0	376.0	[2] 100
Navy	215	40.0	230.0	370.0	330
Air Force	225	279.9	363.0	395.0	415
ARPA				1,605.0	([3])
Interior				[4] 100.0	
FAA				[5] 37.3	
NSF	1,141	1,391.0	1,345.5	1,343.0	1,300
Total	1,701	1,897.6	2,233.8	4,569.8	2,499

[1] This large increase over fiscal year 1961 includes proportionate operating costs ($126,500) of hurricane aircraft used for cloud modification flights.

[2] In carrying out the joint program with the contractor under an ARPA funded program added effort was required and funds were obtained through reprograming. No similar effort is programed for fiscal year 1963.

[3] Planned fiscal year 1963 program was eliminated from the appropriation by the House Committee on Appropriations.

[4] In connection with the water resources problem in the western section of the United States research projects were initiated with the University of Wyoming, South Dakota School of Mines and Technology, University of Nevada, U.S. Weather Bureau, and the U.S. Bureau of Reclamation. Primary emphasis was placed on physical observations of cloud physics.

[5] For an experimental program on the dissipation of fog at the airport, using carbon dioxide as a principal chemical agent.

Mr. HECHLER. May I note, there are certain ups and downs in the figures. For example, Agriculture goes from 75 to 214, and down to 64, and up to 210.

Navy goes from 215 down to 40 and then up to 230.

Is there any particular reason for that?

Dr. WATERMAN. That figure is incorrect, as are a few others. We are submitting, therefore, a corrected table for the record. These would be contracts for a large project which would last over that next year and then the contracts signed in the next year would be dropped to the lower figure.

Mr. HECHLER. Yes.

Dr. WATERMAN. Another error in this table, by the way, is that the Air Force, in 1961, should be 363,000 instead of 563,000.

Mr. HECHLER. Then there has been an actual decrease between fiscal 1961 and 1962 for the Air Force; is that correct?

Dr. WATERMAN. No, the corrected table shows an increase.

This, again, depends on the contracts, the size of them, and the time schedule of awards.

The general trend is more significant than the year-by-year figure.

Mr. HECHLER. Yes. Mr. Hines?

Mr. HINES. Dr. Waterman, I notice ARPA is a latecomer in this program——

Dr. WATERMAN. Yes.

Mr. HINES. With a considerable amount of money.

Are these funds directed toward a general program of research or toward direct military applications?

Dr. WATERMAN. Somewhat of both.

Will you answer the question, Dr. Droessler?

Dr. DROESSLER. The ARPA program in 1962 was an attempt to pick up the lagging priority in weather modification research in the Department of Defense, in the Army, Navy, and Air Force, and the ARPA funds were distributed through the Office of Naval Research, Cambridge research laboratories of the Air Force, and the Army's Signal Corps laboratories.

Actually, it served both purposes, of providing support for the general advance in weather modification, at the same time there are military applications linked in.

Quite a bit of instrumentation, development, and research was supported with the ARPA funds.

Mr. HINES. Is that money reflected in the Army, Navy, and Air Force items?

Dr. DROESSLER. Not in this budget breakdown, no.

We kept it straight to identify precisely where the funds came from in the Department of Defense.

Mr. HINES. Fine. Thank you.

Mr. HECHLER. Mr. Fulton?

Mr. FULTON. Why was there a lag in the Army, Navy, and Air Force budgets for weather research in 1961?

Dr. WATERMAN. I can speak to that from my acquaintance with it when I was with the Office of Naval Research.

At first, as I indicated, the Department of Defense figured that this new discovery of cloud modification would be of very great importance, depending on how it worked out.

So they went through a very ambitious program to determine of what use it could be. It turned out, as we since found, there was nothing very sensational about the results to date. They involve particular cases, where man can have an effect, but it is not an overriding effect at all. So the interest cooled over the years.

Then interest has picked up again as more research has been done. So what ARPA really did was to note that the Department of Defense had lagged somewhat in this field and brought it back, which was, of course, with our knowledge and full endorsement.

Mr. FULTON. Considering the Centaur II program, by which the first manmade cloud was created, has there been any research on how that might affect the weather; for example, the practicality of putting orbiting clouds over areas that are subjected to severe sunlight?

Dr. WATERMAN. Yes.

Mr. FULTON. Could the weather be modified by such a means?

Dr. WATERMAN. Yes. Our program is actually considering movements of that kind.

These, of course, would be very large in scope, and ought to be looked at very carefully, because here you could even influence climate in a big way, if you succeed. That is a very important thing, and we must look at all such experiments very carefully.

Mr. FULTON. But you are investigating the possible effect of man-made clouds orbiting at high altitudes that might cause local modification or even climate modification?

Dr. WATERMAN. Yes; I refer to some of these later.

Mr. FULTON. I wanted to make sure we were making use of the results of the Centaur II experiments.

Dr. WATERMAN. Yes.

Mr. HECHLER. You mean you can make clouds and also seed them to produce rain?

Dr. WATERMAN. No; we can't quite have our cake and eat too, but we may move in that direction. [Laughter.]

Mr. FULTON. You were going much further than I, Mr. Chairman, in making a cloud first and then seeding it. [Laughter.]

Mr. HECHLER. You may proceed.

Dr. WATERMAN. The Department of Interior has entered the scene since 1959 and since 1962 has $100,000 devoted to this purpose.

And the FAA has entered, with about $37,000.

Our program in the National Science Foundation, which in 1959 was $1,141,000, is estimated to be approximately $1,300,000 in 1962.

So that the total figure for 1959 was $1,701,000; in 1960, Federal Government support was close to $2 million; in 1961, $2,233,806; and 1962, an estimated $4,569,800.

Mr. HECHLER. One other brief question before we leave this table.

Does the reduction in the National Science Foundation for fiscal 1962 indicate any diminution of interest on the part of the National Science Foundation?

Dr. WATERMAN. Not the slightest, the grants made in one year maybe more or less than the next year, but overall, the program is increasing.

Mr. FULTON. Could I have the explanation of the figure for ARPA?

Your comment is that ARPA has no firm weather research program of its own, but that the $1,600,000 for fiscal year 1962 budget is actually divided among the Army, Navy, and Air Force, is that not correct?

Dr. WATERMAN. Yes.

ARPA could have done it itself but——

Mr. FULTON. Actually ARPA is not a new agency getting into weather research, is it?

Dr. WATERMAN. No, only for the planning side, and ARPA did take care of that, and found that the other departments of the Department of Defense could handle the contracts.

Mr. FULTON. Then could we have added to the various figures for Army, Navy, and Air Force in 1962 the breakdown of the 1.6 million designated for ARPA in this paper?

Dr. WATERMAN. Yes; we can furnish that.

(The information is as follows:)

Office of Naval Research	$705,000
Air Force Cambridge Research Laboratory	200,000
Army Signal Corps Research and Development Laboratory	695,000

Dr. WATERMAN. With regard to the interests of the Federal Government in the entire field of the atmospheric sciences, as you know, all interested Government agencies have appointed representatives to an Interdepartmental Committee for Atmospheric Sciences formed to keep the Government fully advised of the expanding science of meteorology and to encourage coordination among related programs.

The Interdepartmental Committee operates under the Federal Council for Science and Technology and not only fosters effective coordination but helps to prevent any unwarranted overlap and duplication.

The Foundation looks to the committee to insure a cohesive and effective program with each Federal agency conducting specific projects suitable to its own interest.

As evidence of cooperation, several joint research projects have been established between the Foundation and the Departments of Commerce, Agriculture, and Defense.

Incidentally, the Interdepartmental Committee for Atmospheric Sciences is chaired by the National Science Foundation.

Under the NSF program a full range of laboratory and field experimental work along with theoretical studies is being pursued under the direction of research physicists, chemists, mathematicians, and engineers as well as meteorologists.

The problems of weather modification are interdisciplinary in nature and trained scientists from many fields find challenging and worthwhile problems to undertake.

The program is managed as an integral part of the much broader program for atmospheric sciences, for weather modification is inseparable from the field of meteorology as a whole.

The Foundation believes that planned steps in weather modification must be accompanied by a broadening of man's knowledge of the processes, both large and small, that take place in the atmosphere and at its boundaries.

The whole history of the study of this subject emphasizes that fact. We must have a better understanding of how a raindrop is produced, how hail and snow is produced and the mechanics of this very difficult question, and until we understand this process we are not likely to have any very striking successes in the major purpose of the program.

The broader program in the atmospheric sciences supports a background of basic research activities within which progress as in the more general problems of the atmosphere is advanced. Topics under investigation range from ocean-air interface problems to the global circulation of the atmosphere and include studies of the phenomena of the upper atmosphere, such as aurora and airglow and solar-weather relationships.

Under the NSF program in weather modification, some 37 individual research studies are now underway, mostly at university research centers. Approximately 50 graduate students are involved in these studies. They range from a carefully designed field research effort at the University of Arizona where the objective is to determine whether aerial silver iodide seeding can modify the cumulus clouds which form over the Santa Catalina Mountains of southeastern Arizona, to the support of a planning conference at the South Dakota School of Mines and Technology which brought together scientists

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and educators to outline a program of weather modification research for the Black Hills area of South Dakota.

Also included is support for a research meteorologist of the U.S. Weather Bureau investigating the number and variation of freezing nuclei in the atmosphere and their relationship to global patterns of heavy rainfall; and a research project under a team of scientists from Arthur D. Little, Inc., and the University of Illinois calling for a series of experiments on the question of how artificially induced electrical space charge affects the growth of cumulus clouds during the summertime over an extensive weather station network in central Illinois.

It has been determined that the electric properties of the atmosphere are very much involved in rainmaking.

We see this happening in thunderstorms, where the electric discharge is very obvious.

So this is an important factor in the whole process which is far from being understood.

There are approximately 33 independent private groups in the United States that deal commercially with meteorology, most of whom offer services in cloud and weather modification. Each year the Foundation asks for a report on all weather modification operations conducted by these private groups and thus a general overview of the amount of commercial cloud seeding carried on in the country is centrally maintained.

In fiscal year 1961, 33 weather modification operations were conducted by 9 commercial organizations, mostly in the Western United States. Owing to the nature of these operations, commercial weather modification is generally deficient in scientific control and analysis.

Countries other than the United States are also conducting research and attempting to develop methods and techniques of weather modification suitable to their problems.

For the first time all the known activity throughout the world has been described in the NSF third annual report on weather modification.

The material for each of the national program reviews was supplied for the most part by scientists conducting research work in the countries themselves.

Information on the U.S.S.R. and Communist China was derived from scientific articles published in the open literature.

Progress toward control: There are several rather significant things that can be said about progress toward weather and climate control, such as the following:

1. We know that clouds by artificial means, can be modified, particularly certain special types.

For example, certain kinds of supercooled fog or cloud can be dissipated over areas large enough to be of practical importance.

In these cases generally not a significant amount of precipitation is produced. It is the dissipation of the cloud or fog that occurs.

2. There is general agreement that under certain specialized conditions and only to a limited degree, rainfall can be augmented artifically and the evidence that this increase may be of practical importance in certain areas must be reckoned with.

This is not by a large percent. In certain special clouds, where you are going to get rain, the rain can be increased by something of the order of 15 percent, not a large amount, but still it is an average positive effect.

Mr. FULTON. Let me ask what you mean by that?

Is the total rainfall from this particular cloud formation increased?

Dr. WATERMAN. On the average.

Mr. FULTON. Or do you mean the total over a particular area, so that the distribution is varied?

Dr. WATERMAN. The rainfall is increased over the area marked out where precipitation is expected to occur by an average of about 15 percent.

Mr. FULTON. So you are really saying there is simply a change in the distribution of the rainfall rather than a quantum increase in the total rainfall from the particular cumulus cloud formation?

Dr. WATERMAN. That may be.

Mr. FULTON. Which is it?

Dr. WATERMAN. It is very hard to determine how the rainfall goes over certain areas, and one attempt is to cover the area where the rainfall occurs.

Mr. FULTON. How can you determine between the two if you did not know ahead of time what was going to happen?

You say it has been increased.

I say, "How do you make your comparisons?"

Dr. WATERMAN. This is a troublesome problem.

A great deal of work has been done on this.

We have learned how to do it reasonably well.

Thus, if one knows the type of cloud that occurs, then he knows the pattern of rainfall that in the past has occurred over that area, he then——

Mr. FULTON. You take the model average of what occurs the most number of times and compare it to that?

Dr. WATERMAN. That is right.

Mr. FULTON. The Indian rainmaker can do a pretty good job by just applying that principle.

I can't perceive the cause and effect. I can see there is a correlation.

Dr. WATERMAN. One takes the type of cloud which he recognizes is going to produce rain in a certain area and then establishes rain gages to check on where the rain occurs; then by a random technique when these situations occur he decides to seed or not to seed.

Then he makes a large number of experiments. In the end the statistical analysis shows that on the average over these situations the areas seeded produced this amount of additional rain over the ones that were not seeded.

This takes a long careful study and has to be done by men who understand thoroughly how to make a valid statistical estimate.

Mr. FULTON. I am glad to see the same chances in statistical figures keep both the scientists and Indian rainmakers in business.

[Laughter.]

Dr. WATERMAN. This is a troublesome and very difficult problem and has been given a great deal of attention. There are two noteworthy facts. One is that there is a positive effect in an overall statistical sense. You understand when you say statistically you cannot be

certain, swear any single case will conform. The other is that the result is not really impressive. It is an increase, but it is nothing that would cause any great damage. It is helpful as a start; it is not as much as one would like.

Those are the conclusions to date.

Mr. HECHLER. You may proceed.

Dr. WATERMAN. No. 3: Evaporation processes can be altered to some extent over water surfaces and recent results suggest the possibility of artifically interfering with transpiration processes over vegatation-covered land. The significance of such interruption in one phase of the hydrologic cycle is really not yet known, but the fact that it can be done is more than merely intriguing and points to the importance of further research.

4. It has been demonstrated that by artificially modifying the electrical space charge in the lower part of the atmosphere, the electrical properties of cumulus clouds can be altered with possible effect upon precipitation resulting. And that needs further study.

5. The possibility of triggering the release of energy stored in the upper atmosphere in the form of atomic oxygen and free radicals through the use of suitable catalysts is being explored, although the consequences are still a matter of conjecture.

6. We have come to appreciate the serious results of altering our atmosphere by polluting it with wastes from industry, homes, and transportation vehicles.

This, of course, may have its effect on climate and weather, and that must be studied.

7. We continue to study the as yet undetermined effects on meteorological processes of using the atmosphere as the site for testing nuclear weapons.

8. We have conducted highly preliminary seeding experiments on hurricanes in an attempt to explore further the energetics of these severe storms.

And work on that is proceeding intensively, of course.

9. Speculations have been offered on the possible consequences of filling in or deepening the Straits of Gibraltar, damming the Bering Strait, and pumping water from the Arctic Ocean into the Pacific to stimulate warm currents from the Atlantic into the Arctic Ocean, opening up passes in the Sierra Nevadas to permit the passage of moist air into the Nevada desert, or creating an ice crystal fog over the Arctic to interfere with the radiation balance, and the possibility of high altitude clouds.

All of these speculations are dealing with man's interest in arriving at effective control of his climate. However, experiments of this tremendous scope must be examined with great care so as to be reasonably sure of no dangerous consequences.

Further study: It is clearly recognized that a truly formidable scientific problem must first be solved before we can learn how to control local weather effectively or modify the climate.

However, this problem may be no more formidable than problems that have been solved by this generation of scientists in other fields, such as the degree of control we have over nuclear energy.

We do have at hand a variety of theoretical tools, such as increasingly realistic mathematical models of the atmosphere, and we have

the technical tools, such as electronic computers with which to analyze complex equations and data dealing with the physical consequences of artificial disturbances in model atmospheres, and thereby design meaningful experiments which might be conducted in nature.

One of the most important would be the weather satellite, with the enormous quantity of data that can be gotten quickly with that.

The opportunities for progress in meteorological research are now very great, far greater than at any time in the past. Not only are our instruments and techniques for study of the atmosphere vastly improved in accuracy and variety, but the study has become a thoroughgoing three-dimensional one because of our almost limitless potential for experimental observations throughout our atmosphere into outer space.

Of great significance is the opportunity we now have to study the really fundamental problem, which is not merely the local circulation of the atmosphere of the earth and its associated climatic and weather fluctuations, but the overall view of the relationships between the sun and earth as a gigantic thermodynamic system.

The IGY observations showed clearly for the first time that the earth must be regarded as traveling in a real sense through the outer atmosphere of the sun. The whole might be regarded as a form of heat engine with the sun as source and the earth as receiver.

We must understand much more of this gigantic machine before we can make any really fundamental theories about how our weather is controlled.

There is a very great variety of approaches that could be listed to develop further the scientific basis of weather modification. I should like to highlight several which appear to offer particular interest or opportunity at this time.

1. The NSF, the Weather Bureau, and the Navy will jointly make more attempts at seeding hurricanes when safe opportunity offers, and undoubtedly will extend the seeding operations to other severe storms, such as tornadoes.

A hurricane, like any cyclonic system, is a stable, rotating vortex and many weather scientists believe that if this stable system can be disturbed in some way, its destructive effect may be minimized.

This is true in physics. In the study of vortexes: if one can upset the motion somewhat the effect is quite considerable. But, on the other hand, these are gigantic vortexes and it is not easy for man to do something which will have a major effect without considerable study.

2. It appears timely to undertake a careful program of systematic study and experiments in the use of our new space technology for concentrating and perhaps altering the radiation from the sun. The key to large-scale weather control may be found by altering the balance between the amount of solar heat reaching the surface and that reflected back into space. Cloud cover can clearly modify the distribution of heat and there is the possibility that artificial clouds could be produced and maintained over large areas.

Mr. FULTON. At the present rate of technology the possibility of changing the amount of solar radiation received by the earth, either by reflecting it back out into outer space or reflecting it possibly to the northern climates of the earth surface, is not too far out in imagination. It is pretty practical, isn't it?

Dr. WATERMAN. Yes. The real problem is when you do it to follow the consequences of doing it.

Mr. FULTON. Yes, we must be careful about it. But the concept now becomes a programing matter that we should look into. It is important research.

Dr. WATERMAN. That we are doing, yes.

Mr. FULTON. Thank you.

I want to tell you something. You have just cleared up a big campaign issue for me. I said that a year ago, and a Pittsburgh newspaper had me looking like Benjamin Franklin, on the front page, in a double column cartoon, putting up a kite. I was sending up an umbrella on the string, and likewise was sending up a mirror to do the reflecting.

So you certainly have helped me tremendously. I want to thank you.

Mr. HECHLER. I think the gentleman should not object to being compared to Benjamin Franklin.

Mr. FULTON. Well, he is a Pennsylvanian and we like him. I will accept that. [Laughter.]

Mr. HECHLER. You may proceed.

Dr. WATERMAN. The effects of inadvertent modification of the upper atmosphere by space rockets has been singled out as an important problem and needs greater emphasis. There are possibilities that the accelerated rocket programs with much larger missiles in prospect might cause worldwide changes in the upper atmosphere.

Large amounts of complex molecules for example may be introduced into the upper atmosphere which may have serious effects on the infrared emission characteristics of the atmosphere at selected levels.

This is merely to generalize a precaution which I have already stated in the case of such global experiments.

4. Because of its presumable global consequences weather modification on a large scale is a field of human endeavor where close international cooperation should be established and maintained. We should recognize the wisdom and prudence of fostering international cooperation especially now while the problem of weather control is a purely scientific one of uncertain outcome.

We are dealing here, as I have said, with forces almost beyond our imagination, and we must not forget that we might touch off a catastrophic reaction.

At the same time, the possibilities of benefit are also very great, and for this reason it is more than ever important these subjects be approached through very careful and thorough basic research to guard as best we can against the possibility of losing the control that we may seek.

We have here then, to sum up, a problem of tremendous dimensions and a marvelous opportunity, both from the scientific and practical point of view, the potentialities of the field are such that the best thinking and collaboration of science from all countries will be required to do the subject justice.

Mr. HECHLER. Thank you, Dr. Waterman, for a very stimulating statement and for outlining very exciting possibilities for the future.

You mentioned the data which is obtained from weather satellites. I wonder if you would elaborate on how the data we have obtained

from the Tiros series has been helpful in furthering your research on weather modification.

Dr. WATERMAN. The pictures which are taken by Tiros are of most direct application. Now these come in at a terrific rate.

In 2 months I think Tiros No. 1 got about 20,000 of them. So there is no lack of material. These pictures are remarkably clear, too.

One use is the very direct one, of spotting a storm and seeing it before the surface measurements on the earth can find it.

There was one I recall, for example, a Tiros photograph—which showed a cyclone, a storm center, developing over the southwestern United States—a large very clear one, from the Tiros photograph.

At the time the photograph was taken the weather observations at the surface stations showed no evidence it was there. It was in the upper atmosphere and the surface observations did not show it. But it did appear here very clearly.

As a result, people were alerted to look for it and in about 24 hours on the surface you could see evidence of it, and it became a severe storm, which moved east and northeast. This is the kind of thing which has a direct application.

Similarly, as you know from the papers, one of the strong hurricanes of last year was detected off the west coast of Africa by Tiros and therefore we had about 2 days warning that it was generating and coming across the Atlantic, before we could get observations in the western Atlantic and the Gulf of Mexico when it actually came over and hit us.

So, this enables us to tell the presence and characteristics of a storm in advance and follow its course and be able to be ready for detailed preparations and forecasts when it finally strikes.

Those are direct benefits from weather satellites.

The more long-range benefits are that these photographs tell us the cloud patterns in a way that we have never had before, because they are so complete, taken from above, so we can see evidence of the general circulation of the atmosphere, how storms evolve, how they move.

One can make weather maps then of such situations and follow them through in their regular course. This is having and will have a profound affect on our theories of generation of storms and general atmosphere circulation.

These two I would say are the outstanding features.

Mr. HECHLER. Dr. Droessler, would you care to elaborate?

Dr. DROESSLER. I could give one specific example, I think, which follows the theme of the subject raised by Mr. Fulton this morning.

The weather satellite pictures have shown us not only the direction but the extensive nature of cloud cover over the earth's surface.

We had no idea about the extensive cover of cloud over our earth surface before, because many of these clouds are of a thin, cirrus type, ice crystal cloud, when the weather observer would look up to observe and report the cloud cover he might record a hazy condition, but when you go aloft on the satellite and look down the cloud clearly stands out.

This has given rise to some new thoughts about the nature and the role that cloud cover plays in the distribution of the radiation from the sun.

Mr. HECHLER. I have quite a few more questions. But I would like to defer to other members of the committee.

Mr. Davis.

Mr. DAVIS. Mr. Chairman, I would like first to ask something that is a little bit unrelated to the testimony given here this morning.

Sometime ago I read of a theory advanced by a meteorologist—whose name I have forgotten—that stated it was highly probable that our rain clouds receive their dust which they need to form raindrops from cosmic dust. He formulated a table wherein the earth passed through a cosmic cloud at a certain time of the year, in a certain position with respect to the sun. He attempted to prove that that was true.

Has the National Science Foundation taken cognizance of this and attempted to prove or disprove this theory?

Dr. WATERMAN. Yes, indeed. This has been a subject of some great interest and some controversy over the years.

This theory was put forward by an Australian, Dr. Bowen, a very brilliant man in the field.

What it amounts to is that there are periods of excessive rainfall all over the earth at certain days and the only way he could account for it was that the earth passed through an area of cosmic dust, meteoric dust, about 30 days, I think it was, before the rainfall occurred and picked up this dust.

His theory was that the dust gradually settled and took about a month to settle to the point where these dust particles would serve as condensation nuclei—that is what cause the excessive rain.

This has been subject to careful review. I believe the final evidence is in this, that this in fact occurs.

Mr. DAVIS. Assuming that it is true, that would offer great possibilities as to the general conditions effecting rainfall on the earth, would it not? It would be a comparatively easy matter to plant cosmic dust at certain points in the earth's orbit around the sun perhaps.

Dr. WATERMAN. This offers a possibility. One has to know the nature and size the particles have to be. That gets into the nature of the precipitation process—which we don't fully understand.

Obviously, this is stimulating a great deal of thought and research. As you say, it does open the possibility.

Dr. DROESSLER. I would like to offer this: There is going to be an up-to-date discussion of this problem in the September 7 issue of Science. This is a publication of the American Association for the Advancement of Science, and should be available very shortly.

Dr. WATERMAN. American Association for the Advancement of Science.

Dr. DROESSLER. I understand an article by Dr. Bowen, our colleague in Australia, will be in this issue of Science.

Some further evidence tending to back up the Bowen theory about cosmic dust and its relationship to heavy rainfall patterns throughout the world has resulted from study under National Science Foundation grant at NYU by Dr. Max Woodbury, statistician, with consulting advice from Dr. Glenn Brier of the U.S. Weather Bureau.

I myself am looking forward to reading the article. I think it will be rather stimulating and an up-to-date discussion of the questions you have raised.

Mr. DAVIS. Another question, Mr. Chairman.

I am willing to be cut off at any time. I know our time is limited.

Mr. HECHLER. Proceed.

Mr. DAVIS. As it stands, of course, there is a balance between the amount of heat received by the earth and the amount of heat given off from the earth.

If this balance should be altered in either direction it would most certainly produce a change in the ocean levels, would it not? It would cause a melting of snow if the heat were raised a few degrees and would cause an enlargement of the ice cap if lowered a few degrees.

Either one of those events would, of course, change the whole shoreline of every continent.

Is that not true?

Dr. WATERMAN. If these things should happen.

Mr. DAVIS. Or it would sink the State of Florida if we raised the ocean 10 feet.

Mr. FULTON. That is not a suggestion?

Mr. DAVIS. Not a suggestion. [Laughter.]

Mr. DAVIS. That is a concrete example of the important possibilities that exist, is it not?

Dr. WATERMAN. Yes. One of the reasons why I made these precautions about how one goes at this is because little changes may not seem much to Mother Nature but are much to us, so these are things that have to be watched.

What is hard to do is to trace the chain of events. One can say that if the earth receives more heat than it gives off, it will get warmer. It will melt ice. This produces cloud cover. That tends to shut off radiation, so, there begins a chain of events. One has to look carefully to see what comes next.

Mr. DAVIS. A moment ago you mentioned the infrared radiation as the main one that you felt affected this picture.

I wanted to ask if there is evidence that there are other areas of electromagnetic spectrum that are heavily involved?

Dr. WATERMAN. Yes. I mentioned infrared because this is known as heat radiation.

As we know, in the case of a greenhouse, the glass lets through visible light which gets in and is absorbed by the soil, this is given back in the form of heat radiation, which cannot get through the glass. Therefore, the greenhouse becames a heat trap.

That is a case where the visible radiation is producing heat effects. This happens all the time.

Light of all kind from the sun hits the earth, it is transformed, and becomes other kinds of radiation, which have their effects then in producing the changes that we see.

These are complicated matters. For example, ultraviolet changes the constitution of the atmosphere by its effects on the atoms it strikes. All these things are involved and that makes the whole process a very complicated problem.

Mr. DAVIS. Most of the interference that occurs between the radiation of the sun and the surface of the earth is caused by water vapor—what interruption there is, is that of water vapor, plus the earth's atmosphere, is that not true?

Dr. WATERMAN. Not entirely water vapor. These other radiations are mostly absorbed by physical processes not involving water molecules.

Mr. DAVIS. I was counting that as part of the earth's atmosphere. Water vapor is one of the principal things.

Dr. WATERMAN. Yes.

Mr. DAVIS. Has thought been given to introducing some other substance to interrupt radiation, such a clouds of vapor, which are not normally found in the atmosphere?

Dr. WATERMAN. There have been experiments of that kind. There have been fluorescent clouds sent up to see what extent you might be able to illuminate the earth's surface.

There are many experiments that could be done which are more than just water vapor clouds; yes.

Mr. DAVIS. My thought is, could we possibly send up enough of that to make much difference—is that possible?

Dr. WATERMAN. That is hard to say. If you are trying to get a very large effect in nature, you look for a critical situation, where nature has not decided quite what to do—on the point of doing something but hasn't made up its mind—if you can give it a nudge you may prevent or encourage an effect.

In that case you may get a big effect. But if something starts out like a well-developed storm, and you try to do something about it, the amount of energy there is so tremendous—nature, has made up its mind to have one—you can't do a great deal about it. So you would like to interfere at the start, when your feeble push can do something.

Similarly, with the establishment of very large clouds. If you can get nature's cooperation in the formation of the clouds you do more than just plant a seed or have a small local effect.

Does that help?

Mr. DAVIS. Yes, it does. One other question.

You spoke a while ago of attempting to influence the formulation of cumulus clouds over Indiana.

I would like to know this. My understanding is that the present thinking on cumulus clouds and their formation is that they consist largely of an updraft, of a big bubble of warm air that turns loose and goes up like a bubble of steam would in a boiling pan of water.

Now, of course, it strikes me, if you were to put a cloud in orbit to control the amount of heat that hit the fields of Indiana, or something like that, you would effect a strip all around the earth.

Is that what you had in mind? Or do you expect just an isolated shot, placing something in the atmosphere immediately over Indiana that would try to control the formation of cumulus clouds?

Dr. WATERMAN. One wouldn't rule anything out by way of experiment, but to start with one would expect it would be more feasible to make a local cloud cover and watch what happened under it.

Mr. DAVIS. You were not talking about anything in orbit.

Dr. WATERMAN. It is early to speculate about that. It might happen.

Mr. FULTON. We have Centaur.

Dr. WATERMAN. Yes.

Mr. DAVIS. If you put anything in orbit you are not affecting only Indiana but a strip all around the earth.

Dr. WATERMAN. That is right.

That is one reason it would be helpful to get the cooperation of the other nations, because they are affected, and many of them have brilliant people in the field, too, to help work on it.

Mr. DAVIS. Is it possible that a cloud big enough to make any difference in the formation of cumulus clouds—that is, an intercept or of sunrays big enough to make any difference—could be put into the sky by human beings?

It strikes me it would take a very big artificial cloud to make much difference.

Dr. WATERMAN. One's first thought would be that, of course, it would take a very big one indeed. Cumulus clouds, as you said, are due to rising columns of moist air and when it reaches the temperature where water vapor condenses, a cloud forms.

That is why the cumulus clouds are characterized by a flat base. They start at about the same level and go up from there. They are a common type of clouds, and have had a great deal of study.

They are apparently quite complicated and it is hard to see what one can do about modifying them.

At first sight they are a very promising source of moisture, but seem to be very hard to deal with.

They are subject to very concentrated study wherever they occur though. They are common over land which is heated, as you say, by the sun.

Mr. DAVIS. That is all.

Mr. FULTON. Would you yield for a point?

Mr. DAVIS. Certainly.

Mr. FULTON. In this discussion I don't think we should rule out changing radiation effects, or that we should rule out the changing of electrical charges.

Dr. WATERMAN. Certainly not.

Mr. FULTON. Or ruling out fog dispersal, which is not in the nature of the cumulus cloud structure.

I believe that if we limit our thinking to cumulus clouds with their masses of water crystals or content, we are talking about tremendous weights. But we can think in terms of what might be done by reflective or electrical charge materials, or even in the free radical zone, 60 to 70 miles up, on the use of, for example, potassium ammonia.

Random shots in our rocket programs might make material changes that would not be equivalent of putting large masses or weights of any fluid or material into these atmospheric areas. Would you agree?

Dr. WATERMAN. Yes. One thing that one realizes in the position we are in is that one has to explore all possibilities and not get too excited about only one because all must be looked into.

Dr. DROESSLER. Yes; I would say that the only part of the atmosphere that can support a cumulus cloud development would be the troposphere, that part of the atmosphere in which we live.

Here there is a sufficient abundance of moisture to support a towering cumulus type development. Above the troposphere into the stratosphere and on up and the kind of cloud that maybe artificially produced would be a layer type cloud, a stratus cloud.

Mr. FULTON. The startling success of the Centaur cloud program certainly opens up new avenues that we should do research on, does it not?

Dr. WATERMAN. Oh, yes.

Mr. FULTON. The nation that would first get weather control, to me, would have the ultimate weapon, far beyond the nuclear atomic bomb capability. It could give or withhold lifegiving water and rain. Wouldn't you agree?

Dr. WATERMAN. If this could be pinpointed locally, where you want to do it.

One thinks of these experiments as possibly having some local benefit. That is one type of experiment which could be used in all sorts of ways.

Mr. FULTON. Not only of benefit but detriment if a hostile power got ahead of you.

Dr. WATERMAN. Yes; and the other would be a general effect, which would occur all over the world, and wouldn't be pinpointed.

You would have to regard those as possibilities.

Dr. DROESSLER. Thinking in basic terms, the life and activity of mankind is controlled by weather and climate, and if one exercise a great degree of control on man's weather and climate, one would certainly have dramatic influences in his day-to-day life. Everybody throughout the world can understand this.

Mr. FULTON. So since we have begun with a small degree of success in weather control research then, we for our own security certainly should look ahead, both for peacetime use as well as military use to the whole problem of weather control, should we not?

Dr. WATERMAN. Yes.

Mr. FULTON. Dr. Droessler?

Dr. DROESSLER. Yes.

Mr. FULTON. So I see a real justification to these programs and a need for accelerated programs.

Could you comment on the relative program on weather control of Russia?

Dr. DROESSLER. We have a section on that in our book here.

Mr. FULTON. Can you put it in? I won't take the time now because it is late.

Dr. WATERMAN. Yes.

(The material referred to follows:)

WEATHER MODIFICATION

U.S.S.R. AND COMMUNIST CHINA

A. U.S.S.R.

Shortly after the V. Shaefer and I. Langmuir discoveries in 1946, Soviet scientists began intensive studies of the ice-nucleating properties of dry ice. Although the available scientific literature contained little information until the late fifties there is evidence that the research was started some 10 years earlier. Investigations of the cloud-seeding properties of certain chemical agents have been in progress since the early fifties and perhaps earlier. Bashkirova and Krasikov (1957) made laboratory investigations of silver iodide, lead iodide, and other substances. They supported earlier work regarding the efficacy of silver iodide for ice nucleation. Nikandrov (1956) concluded, from laboratory experiments, that AgI and PbI act as sublimation nuclei. Balabanova et al. (1959) concluded that the deactivation of AgI nuclei was not a function of temperature, but was caused by photolytic effects of sunlight. Moskvitin et al. (1959) studied the adsorption of water vapor on AgI and AgCl. They concluded that these crystals adsorb about 3 monolayers of water. This result is in disagreement with earlier work by S. Birstein in the United States, who reported the adsorption of about 100 monolayers. The Russian work may be closer to the correct value according to surface chemists working on somewhat similar problems.

Many field tests have been made by the Russians to test the efficacy of CO_2-seeding for dissipating supercooled fog and stratus. During the middle fifties, scientists of the Arctic Institute and the Main Geophysical Observatory established a base in the Arctic for studying all aspects of thes clouds (Voskresenskii, 1959). Among the projects was the development of techniques for putting cloud-clearing techniques on a practical basis. New airborne dry-ice and silver-iodide generators were developed (Voskresenkii and Morachevskii, 1959). Practical procedures specifying the quantities of seeding material as a function of cloud thickness, as well as the optimum flight pattern, were developed (Morachevskii and Nikandrov, 1959). Earlier work on the use of ground-based silver-iodide generators for clearing supercooled clouds was reported by Seregin (1958).

There have been a number of Russian studies of the importance of hydroscopic nuclei for the purpose of increasing rainfall of "warm clouds," e.g., Malabanova et al. (1959). However, the reports have been sketchy. In a recent report Agayan (1960) mentions Soviet investigations of the use of acoustical techniques for modification of clouds. It is visualized that the sound waves lead to cloud droplet coalescence. Powerful sound generators have been installed in the mountains in the Caucasus. In the past there have been unsuccessful attempts to employ sound waves for the purpose of accelerating cloud droplet coalescence.

Krasikov and Chikirova (1958) have made tests which show that artificial clouds in the laboratory can be made to last longer when ammonium chloride is added. For various reasons their results cannot be extrapolated to atmospheric conditions. For example, the clouds they used had excessive quantities of liquid water.

There has been considerable discussion of the value of modifying convective clouds in order to suppress hail formation, increase rainfall, and cause dissipation. Most research in this area has been done by the Main Geophysical Observatory and has involved dry-ice seeding. Chuvayev (1957) has carried out extensive studies and has concluded that the quantity and size of the dry-ice pellets determine whether a cloud develops precipitation or dissipates. Imyanitiv and Chuvayev (1957) have concluded that dry-ice seeding can cause a marked increase in the electric fields in convective clouds. Balabanova et al. (1959) have seeded convective clouds with silver iodide burned in red phosphorous fires at the ground and report that precipitation was produced in some clouds. None of the Russian articles specifically deals with hail observations and the effects of seeding on the frequency and size of hailstones. In all studies of convective clouds, one or more clouds were seeded and their behavior was compared with that of other clouds in the vicinity. The question of the validity of the results has not been discussed because of the possible bias which can enter in the selection of clouds.

In the field tests noted above, investigators have frequently reported that radar echoes in the clouds or rainfall were caused to form in clouds. However, no Russian reports have appeared which deal quantitatively with this problem or with the statistical aspects of rain-stimulation studies. The open literature contains no reports of Soviet efforts to modify cloud systems on the scale of cyclones, or attempts to duplicate the periodic seeding experiments performed by I. Langmuir in the late forties. On the other hand, there have been a number of Russian reports (e.g., Golovanov, 1960) which deal with modification of the weather over a large section of the earth by causing a warming of the Arctic regions.

There is no doubt that the Soviet Union is expanding its overall efforts in the studies of cloud physics and weather modification. Aleksandrov (1959) reported that at the Sixth All-Union Cloud Conference held at the Institute of Applied Geophysics during June 1959, there were representatives from 44 organizations from the Soviet Union and China. An account was taken of deficiencies in the existing program. Resolutions were passed calling for expansion of many aspects of the cloud physics program. The year 1962 will be an "all cloud" year in the Soviet Union, presumably for the purpose of making extensive cloud physics studies. Another All-Union Cloud Conference was held at the Main Geophysical Observatory in June 1961.

B. Communist China

Since the summer of 1958, the Chinese Communists have been actively engaged in weather modification experiments. These experiments began as a result of a severe drought which then gripped the Province of Kirin in northeast China. There is no evidence that any prior cloud physics research had been conducted

at the time the experiments began. A 12-year plan for meteorology in Communist China formulated in 1956 called for both cloud physics research and experiments in weather modification; however, it would normally be expected that the research should precede the experiments.

Most of the modification experiments conducted by Chinese Communists have involved known and previously tested cloud-seeding techniques. In addition to the cloud-seeding experiments, they have also worked on the glaciers of the Ch'i-lien Mountains in north-central China, blackening the surfaces with coal dust or burned grass wood in order to increase the absorption of solar radiation and thereby accelerate the melting process of the glaciers. Nearly all the Chinese experiments have been a cooperative effort between the Institute of Geophysics of the Chinese Academy of Sciences, units from the People's Liberation Army, and the meteorological bureau of the Province in which the experiments were conducted. During some of the experiments, groups from the Central Meteorological Bureau and from various universities also participated.

The Kirin experiments begun on August 8 and continued through September 13, 1958, involved a total of 22 attempts to increase percipitation by seeding with dry ice or salt. Seeding generally was conducted on supercooled clouds, but there were some instances in which warm clouds were seeded. Seeding in this series of experiments was all done from aircraft belonging to the People's Liberation Army. During the same period of time, another series of experiments were being conducted over Kansu Province in north-central China, these extending through October 1958. Aircraft were used for seeding dry ice, salt, quicklime, water, or a salt solution into or above the clouds, while ground-based and balloon-borne generators were used for seeding with a mixture of silver iodide and sodium iodide.

During October and November 1958, six experiments were conducted in Hupeh Providence of east central China to influence warm clouds. In these tests, aircraft seeded twice with dry ice, three times with saturated salt solution, and once with flaked ice. From these experiments, the Communist Chinese concluded that a salt solution is a more effective seeding agent than dry ice for warm clouds.

Since this beginning in 1958, Communist Chinese weather modification experiments have continued throughout the country, but more particularly in the heavily populated areas of eastern China. In almost all cases, these experiments have been carried out during periods of drought or at least of deficient rainfall. Experiments have been conducted on a massive scale but with little or no statistical control either for choosing the clouds for seeding or for evaluating the results of seeding.

An evaluation of the Kansu experiments appeared in the February 1959 issue of the Acta Meteorologica Sinica. According to this article, a test was considered positive when precipitation reached the ground, virga appeared (precipitation was noted to be falling but evaporated before it reached the ground), or when the clouds dispersed following the seeding. With these criteria, there were 9 positive and 2 negative reactions using dry ice, and 20 positive and 2 undetermined reactions when salt, quicklime, water, or salt solutions were used. Of the 9 positive results with dry ice, there were 5 cases in which precipitation reached the ground, 3 in which virga was observed, and 1 of cloud dispersal. There were 16 cases of cloud dispersal and 4 cases in which virga was observed for the 20 positive reactions noted for seeding agents other than dry ice. This type of evaluation gives little opportunity to judge the actual success of the experiments, since it gives no information as to the steps taken, if any, to determine whether the results considered as positive would have occurred naturally.

Ku Chen-ch'ao wrote in the Communist Chinese Academy of Sciences publication K'o-hsueh T'ung-pao in 1959 that these weather modification experiments were begun earlier than planned at the suggestion of the Chinese Communist Party. Ku states that the Communist Party pointed out to the scientists that their prior research was not sufficient to satisfy the "grand expectation of changing nature." Ku then expressed the future need for basic cloud physics research in Communist China along with scientific methods for evaluating weather modification experiments. The acceptance of Ku's suggestions has not yet become apparent in the scientific literature reaching this country from Communist China. However, it is expected that future work will reflect his ideas, and when this occurs, Communist Chinese efforts in this field will become scientifically more significant.

NOTE.—The above information is based entirely on Russian and Communist Chinese articles published in the open literature.

Mr. FULTON. One other point I would like to make. Consider the recent experiments with million or billions of needles in outer space. Are you planning further programs of such nature to see what the effects might be?

Dr. WATERMAN. This is an Air Force program, of course, and I believe they have this under consideration, as a matter of course.

The first, as you know, didn't pan out. This again was one of the experiments that has to be looked at carefully to tell what its consequences would be.

But this would presumably not have a direct effect on the sort of thing we are talking about but would have a more direct effect on the electrical properties of the atmosphere high up—its transparency, and so forth.

Mr. FULTON. On these electrical properties of the radiation belts, don't you think that we should have experiments to see what the far-reaching effects might be?

For example, the suggested experiment to blast open the Van Allen Belts by tremendous explosions, would be the first time that any part of the earth's surface ever received directly cosmic rays, ever got direct radiation from the sun, and ever got high energy particles.

Dr. WATERMAN. May I make a correction on that? The polar regions now receive cosmic rays quite freely. The radiation belts in which charged particles are trapped don't extend to the poles.

Mr. FULTON. Well, I realize that, but aren't the poles then at an angle, so that they are almost—the land surface would be perpendicular almost to the center of the rays?

Dr. WATERMAN. Yes. These other effects you speak of don't all come from the sun. Cosmic rays also come from all over the sky.

But the earth's magnetic field sees to it that these get in more frequently at the poles; between the poles they form radiation belts, the Van Allen Belts.

Mr. FULTON. I compliment you and thank you for the excellent statement.

Mr. HECHLER. I wondered if you would indicate any significant changes here in the requests for fiscal 1963 or the trends?

Dr. WATERMAN. We shall be glad to, yes.

Mr. HECHLER. And would you direct your remarks for a minute to the adequacy of the funds?

Dr. WATERMAN. At the present time the limitation on the use of funds is mostly in the direction of competence to use them, that is, the skilled investigators which can use the money wisely.

This number is growing rapidly and we are trying to see the funds keep pace with the growing number of research workers in the field.

We have been able to do pretty well by this field in the past.

I would like Dr. Droessler to speak to it.

Mr. DROESSLER. Dr. Waterman, you put your finger right on the limit of ability to move forward in this field of weather modification—it is skilled manpower.

Cloud physics and the follow-on studies of weather modification received very little emphasis in this country up to the midforties. Very little instruction was given in our universities and subsequently very few bright minds were attracted into the field.

Now the studies of our atmosphere, studies of our weather, have opened up in a really marvelous way and have become perhaps one of the most exciting areas of the new developments in science and technology. The word is getting about among the young students of the country.

More graduate students are coming into the field. I estimate that we will be needing rather sharply increased funding for the NSF weather modification program and the weather modification program activities of the other Government agencies within the next few years.

As a matter of fact, in looking ahead as we have had to in trying to make projections of future budgeting of several areas under our cognizance, we estimated this field particularly would need rather substantial additions in funds about the fiscal year 1965–66.

And too, keeping in mind particularly some of the things Mr. Fulton touched on this morning—opportunities for conducting new experiments in our atmosphere are rapidly arising. To do this experimental work well, will be rather costly. And I think we should be prepared to go into it.

Mr. HECHLER. We have an automatic rollcall. We will have to interrupt the hearing and adjourn, but there are a number of questions that I would like to pose to be answered for the record.

For example, I would like to find out more specifically what you are doing to encourage a greater pool of scientific manpower and younger people to get interested in this field.

Dr. WATERMAN. Research facilities for this are also important.

In the budget this year we thought we had a fair statement of need, but this is bound to increase.

Mr. HECHLER. Also to get more data on the extent of your research as a result of the data that you secure from the Tiros.

Dr. WATERMAN. Yes.

Mr. HECHLER. There are several other questions that we will submit to you for the record.

Dr. WATERMAN. Very well.

QUESTIONS TO BE ANSWERED FOR RECORD IN CONNECTION WITH THE HEARINGS OF SEPTEMBER 13, 1962, BEFORE SUBCOMMITTEE NO. 4 OF THE HOUSE COMMITTEE ON SCIENCE AND ASTRONAUTICS ON THE SUBJECT OF WEATHER MODIFICATION

1. What is the cooperation and relationship between the Interdepartmental Committee for Atmosphere Sciences of the Federal Council for Science and Technology and those agencies involved in the meteorological satellite programs?

The agencies most involved in the national meteorological satellite, the National Aeronautics and Space Administration and the U.S. Weather Bureau, sit as full members of the Interdepartmental Committee for Atmospheric Sciences.

ICAS held one of its regular meetings at the U.S. Weather Bureau Weather Satellite Center and another at the NASA weather satellite laboratory to review this important and growing technical area at firsthand. The cooperation between ICAS and the agencies involved in the meteorological satellite program is excellent.

2. Would you supply for the record those agencies participating in the Interdepartmental Conference on Weather Modification?

The agencies listed below participate in the Interagency Conference on Weather Modification:

Department of Agriculture: U.S. Forest Service.
Department of Commerce: U.S. Weather Bureau.
Department of Defense: Office of the Secretary.
Department of the Army: U.S. Army Research and Development Laboratories.

Department of the Navy: Bureau of Naval Weapons; Office of Naval Research; Naval Research Laboratory; Naval Weather Service.
Department of the Air Force: Geophysics Research Directorate; Air Weather Service.
Federal Aviation Agency.
Department of the Interior: Bureau of Reclamation.
National Science Foundation.
Central Intelligence Agency.

3. The 1957 report of the Advisory Committee on Weather Control highlighted the serious shortage of competent scientists and engineers in the field of weather modification. Does this situation still exist?

It is true that in the field of weather modification our greatest deficiency today is skilled manpower. However, with the advent of the National Science Foundation program, the United States has launched for the first time a sustained and concentrated attack on the problem of weather modification and in doing this has created new research opportunities in important numbers. These new opportunities coupled with the great challenge and tremendous promise of weather modification have begun to attract fresh, imaginative young scientists to work on the problem in our graduate school laboratories.

The University of Chicago has doubled its graduate research classes in advanced meteorology; the University of Wisconsin reports a threefold increase in 3 years with a noticeable improvement in the caliber of the new graduate students. At the University of California at Los Angeles a new laboratory for atmospheric sciences has been established to meet the growing graduate research needs. Future manpower prospects appear to be very good.

4. If so, what steps are being taken by the National Science Foundation and other agencies to overcome this shortage?

In addition to the regular research grants programs, the graduate and undergraduate research participation programs, and the fellowship programs, the Foundation supports a number of activities under the aegis of the American Meteorological Society which are aimed at encouraging and stimulating broad interest in meteorology and which include:

1. Visiting scientist program—a lecture program of prominent meteorologists to visit various colleges and universities.
2. Visiting foreign scientist program by foreign scientists at various universities—a lecture and consultation program in universities.
3. Preparaton of a film series in meteorology for ninth-grade level and another for university level.
4. Preparation of a series of popular monographs on meteorology for wide distribution at the high school and college level.
5. Preparation and distribution of two career guidance booklets presenting career opportunities and educational facilities in meteorology.
6. Preparation of weather kits with aids and sources of material for science teachers in secondary and elementary schools. This is jointly supported by the National Science Foundation and the American Association for the Advancement of Science.

5. What cooperative arrangements has the NSF made with other Government agencies to conduct its R. & D. program on weather modification?

The Foundation has from the beginnings of its program in weather modification in 1958 actively encouraged the other Government agencies to cooperate in this important national problem area. Some specific arrangements are noted below:

1. Joint support with the U.S. Forest Service of Project Sky Fire, a research study of cloud seeding aimed at minimizing lightning-caused forest fires.
2. Joint support with the Office of Naval Research of the fundamental research of Dr. B. Vonnegut and his group at Arthur D. Little, Inc., who are exploring cloud dynamics and electrification.
3. Grant support for U.S. Weather Bureau scientist Dwight Kline investigating the freezing nuclei abundance and variations in the atmosphere.
4. Grant support for U.S. Weather Bureau scientist Robert Simpson who is conducting a broad experimental program of cloud seeding of hurricanes and other severe storms.
5. Encouragement and advice to the Advanced Research Project Agency to come into the field with over a million-dollar support program for the Department of Defense agencies in fiscal year 1962. Provided counsel on final distribution of these funds.

6. Encouragement to the Bureau of Reclamation to support research in weather modification and advice on the distribution of funds within within the Bureau's new program in fiscal year 1962.

6. What exchanges of information on weather modification with other countries has the National Science Foundation experienced in the past 5 years?

The National Science Foundation Third Annual Report on Weather Modification reports on weather modification activities throughout the world. In gathering this material, the Foundation corresponded with all the known workers in the many nations. Their response was prompt and gratifying and they were eager to help the Foundation in making this first report on worldwide activities. In addition, over the past 4 years, the Foundation has rendered support to several international conferences on cloud physics and weather modification by providing travel grants for American scientists.

7. A body of law and legal definitions has been built since 1954 that has established the legal background for interstate relationships with regard to weather modification. Have there been any significant changes in the body of law since that time? What are they?

Statutory provisions relating to weather research have been enacted in a number of States. However, these relate primarily to intrastate activities and are generally limited to licensing or reporting requirements. As yet, there is no substantial body of law concerned with interstate weather modification research activities. There are relatively few court cases on the subject of weather research and they are inconclusive.

8. Following the recommendation of the 1957 Advisory Committee on Weather Control, does the National Science Foundation have the same legal authority given to the committee to obtain scientific information on this program? Have ambiguities in the law been defined and made clear?

The National Science Foundation has the same legal authority to obtain information on weather modification research activities as did the Advisory Committee on Weather Control. Cooperation in this area has been excellent and it has not been necessary to resort to the authority of the Foundation's statute. Therefore, there has been no occasion to test possible ambiguities in the law.

Mr. FULTON. Mr. Chairman?

Mr. HECHLER. I will give the gentleman one other question.

Mr. FULTON. The reflection possibilities of materials that are put in orbit around the earth's surface challenge the imagination.

Mr. WATERMAN. Yes.

Mr. FULTON. For example, if a reflection band were put in orbit to pass around the earth, the sun's rays could so hit that an hour or two of extra sunlight every morning or evening could be achieved. Or if the reflection bands were put in a certain way, they could refract the sun's rays northward or southward on the polar axis of the earth. You could find possibly a distribution of more sunlight in northern and southern temperate climates that might affect those regions that, right now, are not usable for agricultural production. Wouldn't that be possible?

Could you both comment on that? It is of interest to me.

Dr. WATERMAN. The reflection possibilities are there. You make a cloud that can reflect or scatter light in all directions.

One could add the possibility of making a cloud that would be luminous so that we would have light all night. I am not sure we want that. [Laughter.]

Mr. FULTON. Could we have the doctor comment on perhaps changing the bands of the temperate zones—in the north temperate zones?

Dr. WATERMAN. The refraction method would seem impossible—to get light to bend enough by this device. Reflection of scattering might be possible.

Dr. DROESSLER. I would want to put all of these things in the realm of sound scientific speculation at this time, things that we ought to keep in mind, and conduct further studies on, because we are rapidly approaching the time when we will have an opportunity to conduct such experiments.

Our space technology is getting to the point where we will have this capacity.

Mr. FULTON. Even over the equatorial zones or the rain forest zones, the placing in orbit of material that does not let the sun's rays through might cause a tremendous climate change.

Dr. DROESSLER. Yes.

Mr. FULTON. That would be comparatively easy to do—because over Pittsburgh we used to have it. [Laughter.]

Wouldn't you agree to that?

Dr. WATERMAN. Yes; that should have a big effect.

Mr. HECHLER. Thank you, Dr. Waterman and Dr. Droessler.

Mr. FULTON. It has been very interesting.

I am certainly appreciative.

Mr. HECHLER. It has been a most illuminating session.

Thank you.

We will have other questions for you to include for the record.

The committee stands adjourned.

(Whereupon, at 11:10 a.m., the committee was adjourned.)

METEOROLOGICAL SATELLITES

SEPTEMBER 21, 1962

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE NO. 4,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., September 21, 1962.

The subcommittee met at 11:10 a.m., Hon. Ken Hechler (chairman) presiding.

Mr. HECHLER. The subcommittee will come to order.

Over the past few weeks this subcommittee has held hearings on the development of meteorological satellites. And since our last hearing we had a successful launching of Tiros VI.

This morning we have asked Mr. Arthur W. Johnson, the Assistant Director for Operations of the National Weather Satellite Center, to come up to tell us a little about what has been learned from Tiros VI. Mr. Johnson, you may proceed and also add any further comments that you care to make about the future of the weather satellite program.

STATEMENT OF ARTHUR W. JOHNSON, ASSISTANT DIRECTOR FOR OPERATIONS, NATIONAL WEATHER SATELLITE CENTER

Mr. JOHNSON. Thank you, Mr. Chairman.

I do not have a prepared statement with me. I can make some remarks about Tiros VI and its effect upon our activities.

I have with me Mr. Lee Mace, who is in charge of programing and processing of our satellite operations.

This means he develops the daily program of the meteorological satellite and is responsible directly for the handling of the data and its distribution nationally and internationally.

Tiros VI was launched on Tuesday, September 18, and is an extremely successful satellite so far.

It is in what appears to be the best orbit of the Tiros series, by that I mean the closest to the planned orbit.

It is nearly circular.

It is in the intended inclined orbit of 58 degrees. Both camera systems are working extremely well.

I have samples of the photography from Tiros VI with me, which I will be glad to distribute and introduce into the record.

(The photographs are as follows:)

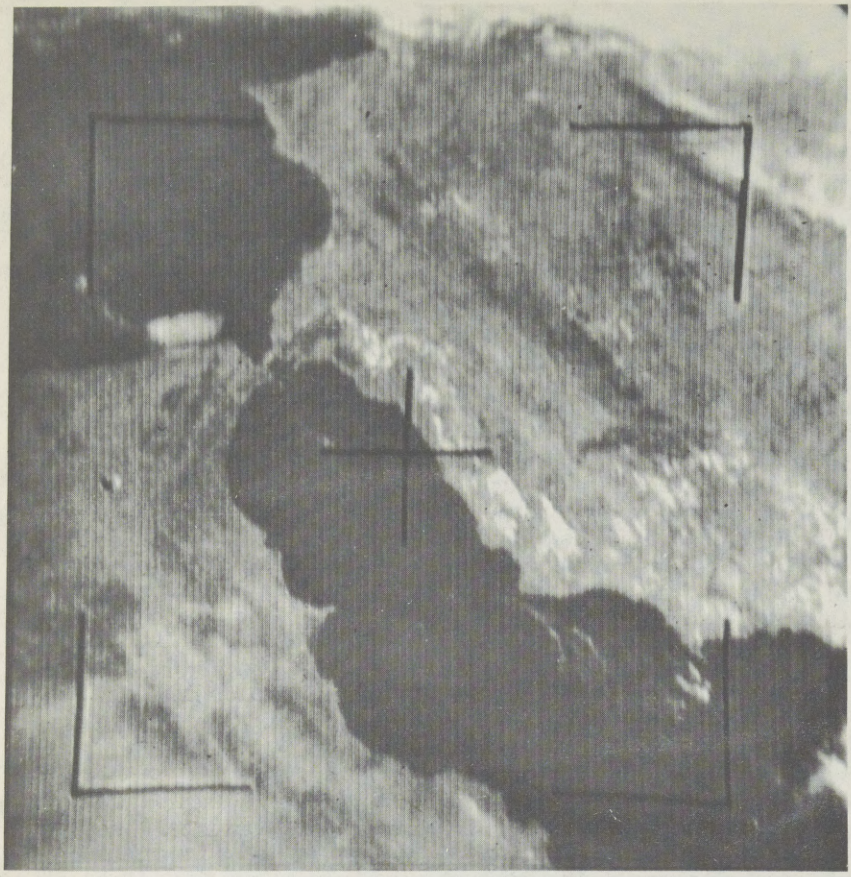

FIGURE 14.—Tiros VI, the U.S. weather satellite, took this picture showing Portugal, Spain, Strait of Gibraltar, the Mediterranean Sea, and northern Morocco on its second orbit September 18, 1962, launch day. Both television camera systems aboard the satellite are supplying pictures of excellent quality for operational use.

Mr. JOHNSON. There are two separate photographs and several copies of each.

Mr. HECHLER. Are you going to comment specifically on the photographs and their meaning so far as the development of our weather information is concerned?

Mr. JOHNSON. I can if you wish, Mr. Chairman.

I would like to say that the quality of the photography although excellent is not necessarily better than that achieved, for example, with Tiros V.

In fact, it is true to say that the single camera system still functioning on Tiros V is after over 3 months doing extremely well, and the pictures from it are virtually as good as those which you now see from Tiros VI.

FIGURE 15.—A weather formation over the west coast of the Caspian Sea is shown in this Tiros VI photograph as the weather satellite passed over the area on its 14th orbit September 19, 1962. Iran is visible in the lower part of the picture. At the right the Gulf of Kara-Bogaz-Gol is clearly visible. Tiros VI was launched September 18, 1962, by the National Aeronautics and Space Administration.

My comments on the usefulness of Tiros VI would not be in terms of improved photography, but improved coverage.

Mr. HECHLER. Yes, and greater capability of the dual system.

Mr. JOHNSON. You will see in these pictures that the contrast achieved is excellent, that the landmarks are sufficiently significant for us to have a comparatively easy job of locating ourselves in the analysis of the pictures.

The two pictures which you see are not particularly significant meteorologically. They are indications of the quality of photography that might be expected, or that can be expected at this time from Tiros VI.

The committee has from earlier witnesses seen pictures of meteorologically significant photographs, and I did not bring any of that sort with me this time.

In fact, Tiros VI has not yet seen a great deal that you would consider unusually significant meteorologically. It certainly will before it dies, but so far it has not.

Tiros VI has been interrogated on each of the days since launch. We have now acquired, through yesterday, some 1,300 usable pictures from the two camera systems. And we have prepared NEPH analyses—n-e-p-h—cloud analyses, of the photographs, some 48 of them, of which 45 have been distributed both nationally and internationally.

(The material referred to follows:)

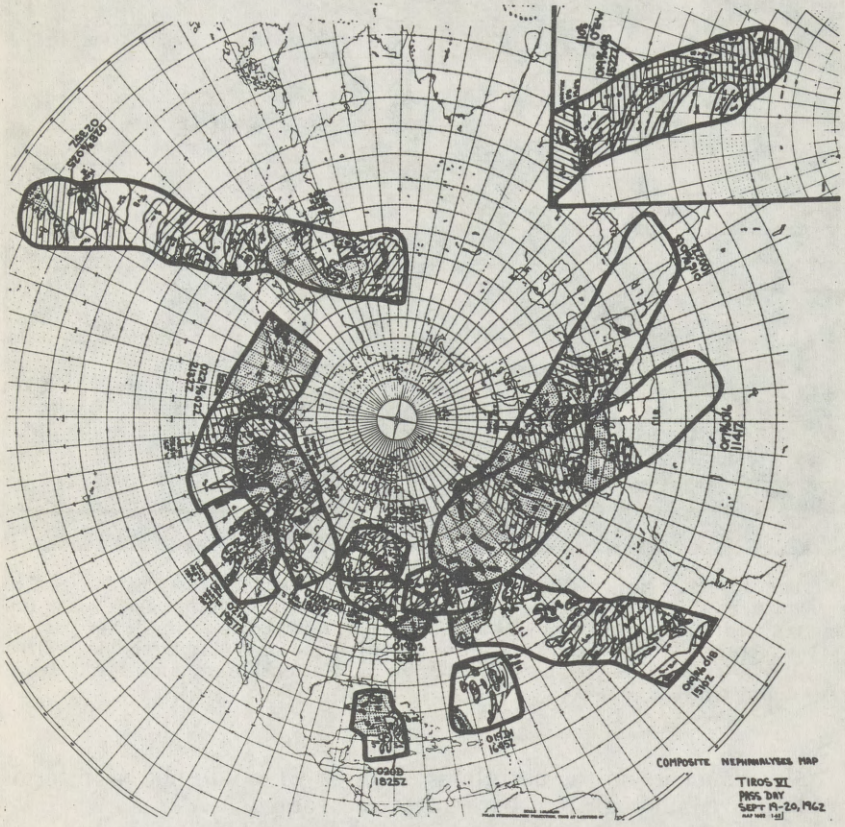

FIGURE 16

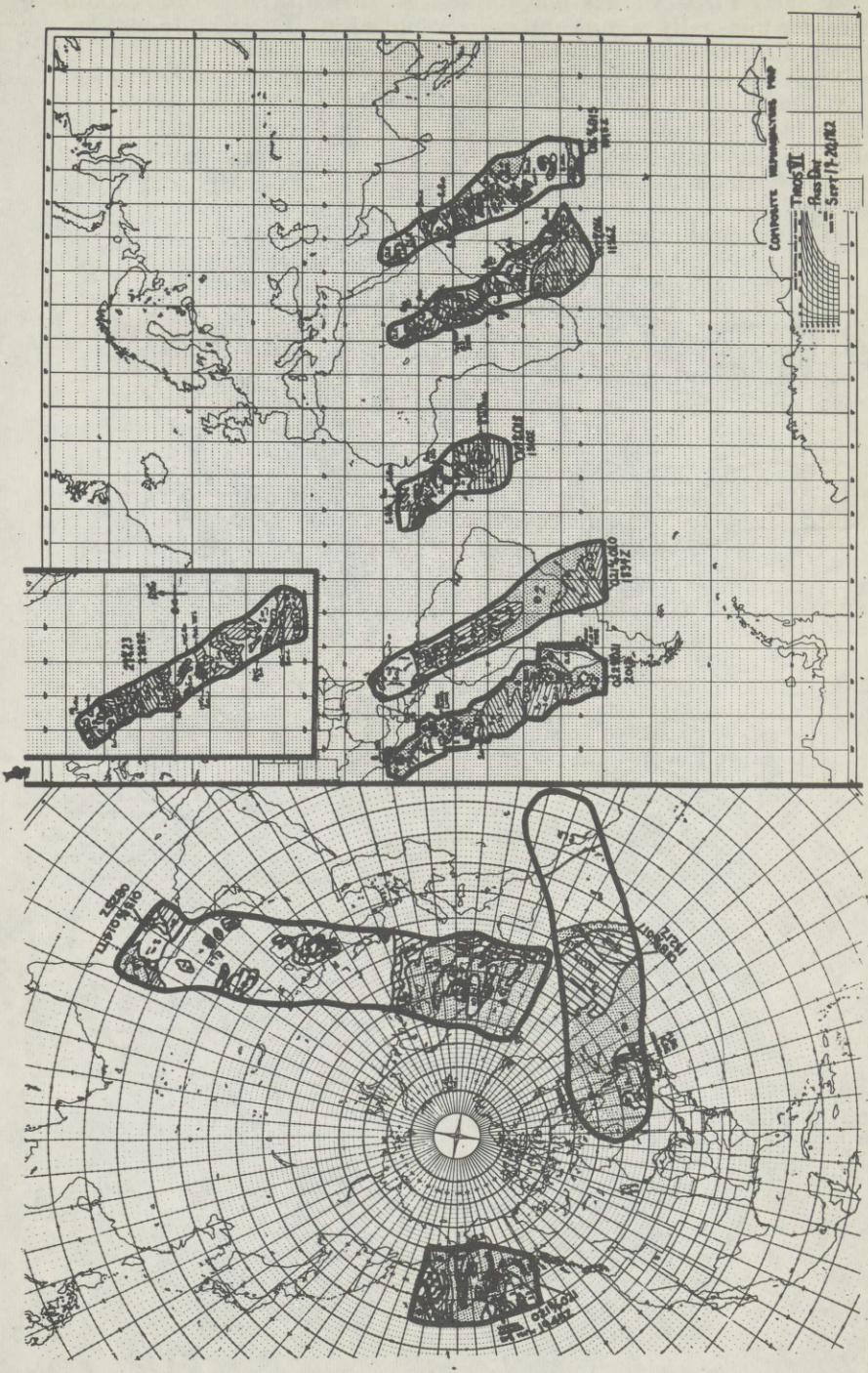

FIGURE 17

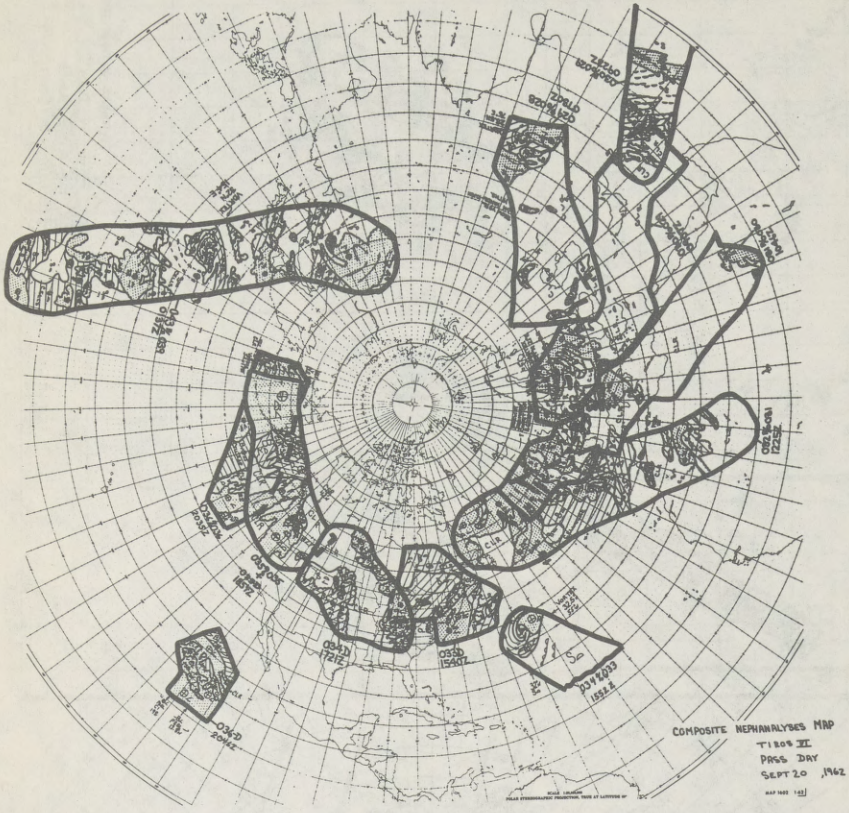

FIGURE 18

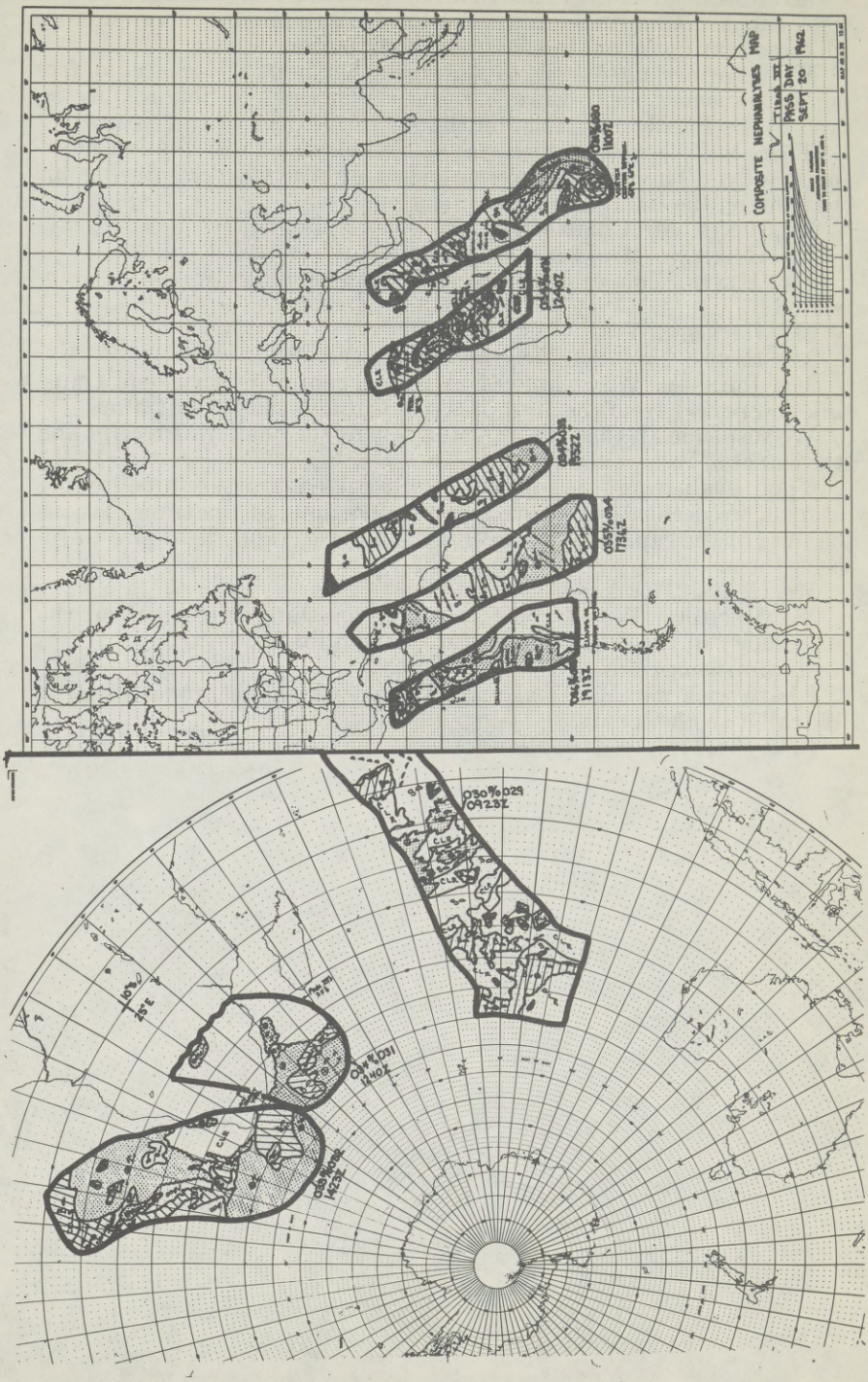
COMPOSITE NEPHANALYSES MAP
TIROS III
PASS DAY
SEPT 20
1962
1100Z
VORTEX
1240Z
1532Z
035%034
1736Z
1913Z
030%029
0923Z
CLR
1240Z
1423Z
10°S
25°E

FIGURE 19

Mr. JOHNSON. On this distribution question, I might digress for a moment, Mr. Chairman, and comment further on an earlier question in these hearings about international distribution.

We have arranged now to reinstate the international radio facsimile transmissions to Europe, to the Caribbean and South America, and to the Pacific and Asia, on the 1st of October of this year.

There will be routine pictorial as well as coded distribution internationally. This was a question asked of Mr. Gardner during his hearing on the international implication.

Mr. HINES. Mr. Chairman?

Mr. HECHLER. Mr. Hines?

Mr. HINES. You said the facsimile transmission would be reinstated?

Mr. JOHNSON. Yes.

Mr. HINES. How long has this been suspended?

Mr. JOHNSON. We conducted an experimental international transmission period from the 15th of April through the 30th of June.

We suspended it then for an evaluation of the quality of receipt and the extent of receipt abroad.

Upon evaluating the information received from our colleagues abroad, we decided to reinstate certain portions of the transmissions because of the capability to receive them abroad and the desire to receive them.

Mr. HINES. Thank you.

Mr. HECHLER. Would you care to add anything further about the superiority of the dual system over one satellite?

Mr. JOHNSON. Yes.

I have with me, Mr. Chairman, a chart which we prepared daily. We call it an alert chart.

(The chart referred to follows:)

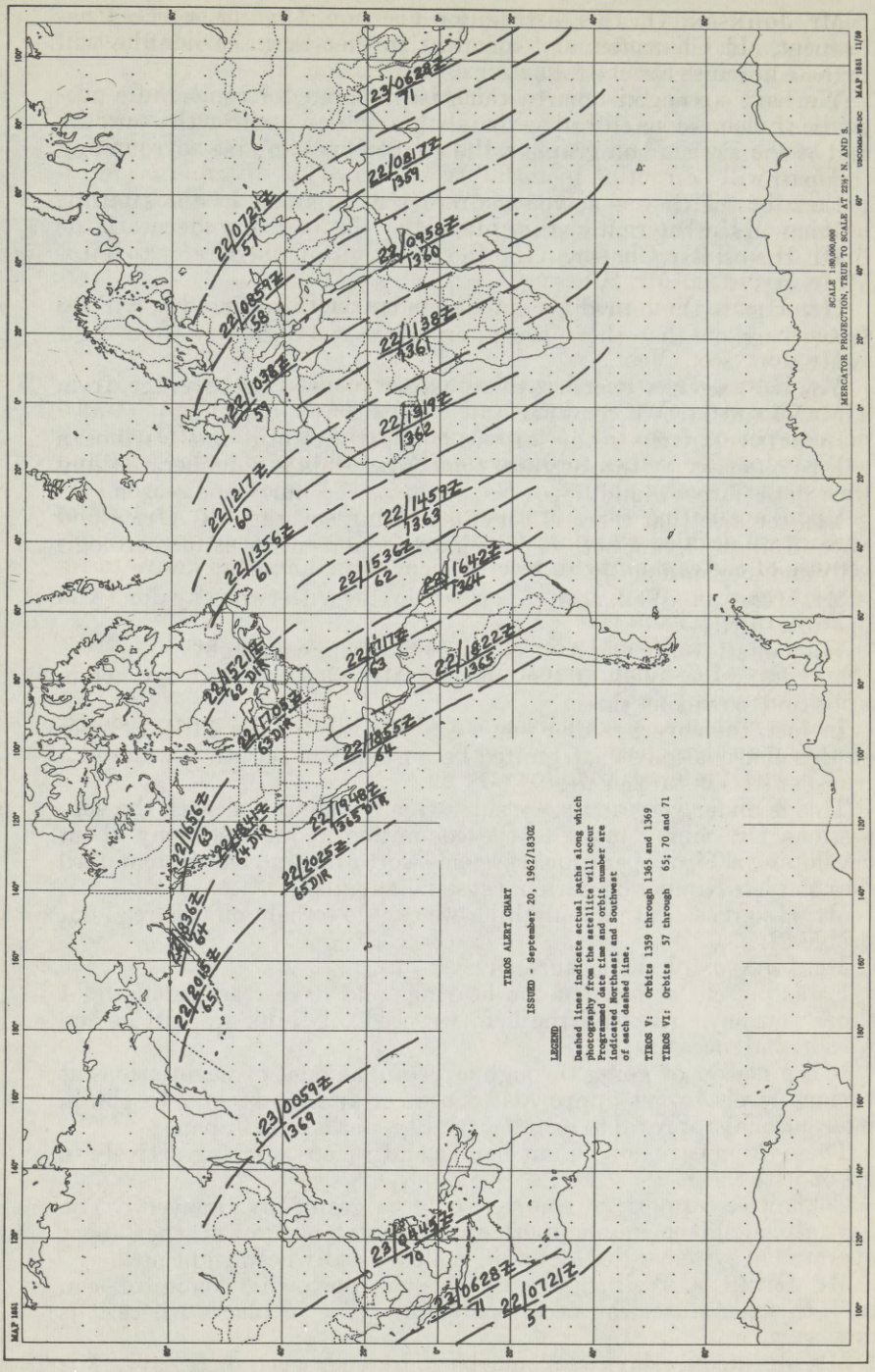
TIROS ALERT CHART
ISSUED - September 20, 1962/1830Z
LEGEND
Dashed lines indicate actual paths along which photography from the satellite will occur
Programmed date time and orbit number are indicated Northeast and Southwest of each dashed line.
TIROS V: Orbits 1359 through 1365 and 1369
TIROS VI: Orbits 57 through 65; 70 and 71
MERCATOR PROJECTION, TRUE TO SCALE AT 22½° N. AND S.
SCALE 1:80,000,000
22/0721Z 57
22/0817Z 1359
22/0858Z 1360
22/0938Z 58
22/1138Z 1361
22/1319Z 1362
22/1457Z 1363
22/1642Z 1364
22/1822Z 1365
22/1855Z 64
22/2035Z 65 DIR
23/0059Z 1369
23/0628Z 71
22/0721Z 57

FIGURE 20

Mr. JOHNSON. It is a chart designed to give all weather offices, nationally and internationally, information on where the satellite will take photographs on the following day.

You will see on this chart, which is prepared for tomorrow's program of the two satellites, an indication of the path of the satellite and of course the photographs will be taken over an area surrounding that path.

Each of the lines that you see represents a swath of the satellite.

You will see, beginning at the far right—the number underneath the line is the orbital number. And the two-digit numbers refer to Tiros VI.

If you go to the four-digit number under the third line, you will see from there on that there are alternating two-digit and four-digit swaths.

You will see that tomorrow we expect to get this coverage from Tiros VI and Tiros V, together.

In particular, the whole of the tropical Atlantic and Caribbean will be observed by the satellites tomorrow—this is a deliberate thing with both Tiros V and Tiros VI, to cover the hurricane season.

You see also that there is very interesting coverage of Africa and of the Indian Ocean, both of which are important to us meteorologically and internationally.

Mr. HECHLER. Well, now, if you can do this with two, why don't you put up a third?

What effect would this have in improving your coverage?

Mr. JOHNSON. Well, at the moment, Mr. Chairman, we are not in a position to read out three.

In fact, the coverage that you see to the west of the United States on this chart is somewhat limited because of the fact that we need a read-out station further west.

This is under very active consideration in connection with the suggestions Dr. Singer made to the committee in his testimony about developing a Tiros operational system—sort of an interim system until the complete Nimbus operational system is available.

Mr. HECHLER. Is there anything we can do to help on this read-out problem?

Mr. JOHNSON. I am not sure, sir.

I was present at most of the hearings and have read them, and I think you have given all the help we need. I think we will get on with it, and successfully.

It is a matter of going through a certain amount of negotiations at various levels to get approvals to use certain funds, and to obtain international approval to install a facility, perhaps in Japan.

These things are now in our hands, and we are working actively to get on with them.

Committee support, of course, would be gratefully received. You have already given your support, and your statement of urgency about operational systems; that, I think, is all we really need right now.

Mr. HECHLER. Well, this committee can push, this committee can pull, this committee can occasionally intervene in places where it is necessary.

Mr. JOHNSON. May we come back to you when necessary, Mr. Chairman?

We are working actively on this.

And I have no reason to believe, right now, that we will not be successful in developing a fully operational Tiros system.

Mr. HECHLER. What is your timing now?

Mr. JOHNSON. I introduced the proposal into the appropriate interagency committee last Friday and received the enthusiastic endorsement of the Air Force and the Navy and the Army.

I now must——

Mr. HECHLER. Anybody who is unenthusiastic?

Mr. JOHNSON. I would say that the proposal had not been available long enough in written form for the people from NASA to have studied it completely. And they could not take a position either in favor or against at that time.

With my colleagues in NASA, I have discussed this, and again it is just a matter of developing the details.

They certainly do not oppose the idea of using the Tiros satellite to the maximum extent possible.

We will just have to work out how.

There will be some time required for procurements of additional vehicles.

These are all being worked on as rapidly as we can.

There is no opposition that I am aware of to a Tiros operational system.

Mr. HECHLER. You think now they realize the sense of urgency?

Mr. JOHNSON. I am quite convinced of that, Mr. Chairman.

Mr. HECHLER. Colonel Peacock?

Colonel PEACOCK. Mr. Johnson, can you give us a brief description of your automatic data processing system?

It appears to the committee that you are going to receive more and more and more photographs. And you are going, eventually, to need more and more qualified people to look at these photographs.

What have you done about developing an automatic filter or data-processing system which will tell you to look at a certain photograph that there is something there that must be looked at? Wouldn't this be better than having individual interpreters go through such a large mass of photography which I imagine will get greater and greater as time goes by?

Mr. JOHNSON. Yes, Colonel Peacock.

The extensive planning for the data-processing system has been tied until very recently to the Nimbus program.

The Tiros data-processing system is under continuing refinement.

The refinements are really relatively minor as compared to the impact of Nimbus.

But when we get into the operational use of Nimbus data, with its increased photography and its increased data from other sensors, we will be in a much more complicated situation.

On this we have developed—and I can show to the committee, though I do not have it with me—a very detailed plan for the installation of a new computer complex at the National Weather Satellite Center in Suitland.

This will include an IBM 7094, with an associated IBM 1401. These are high speed, highly sophisticated electronic computers.

Our analysis of the data input is that the full time use of computers of this speed will be required to ingest and digest and put out the Nimbus data.

The system will include rather interesting peripheral equipment for photographic display in real time of the data produced and will be on the floor ready for use, in our present estimate on April 1, 1963.

This is in advance of the expected availability of Nimbus.

It will give us the necessary time to prove a system as complex as this will be.

This we estimate will take some 3 months.

The digital programs are now being worked on.

We have many of the computer programs already completed.

We anticipate no real difficulty in developing the means of using the data processing complex.

We have as a further byproduct of the proposed Tiros operational system the opportunity to use the Tiros data to prove the Nimbus data processing system.

And it is in our Tiros operating planning to alter the Tiros data processing system to some extent so that we will exercise the computer complex to be sure we are ready for Nimbus.

Colonel PEACOCK. But you do not now have any type of filter or scanner that can automatically analyze these photographs and screen out only the ones that should be looked at?

In other words, it appears to me that there are a lot of photographs that are routine, since they are identical to ones received previously.

At the present time, they have to be individually examined, do they not?

Mr. JOHNSON. Not quite, Colonel Peacock.

Someone will look eventually at all of the pictures.

This is true.

But operationally, the Nimbus output will go through a computer analysis before being used by hand at all.

So that the analysts will see a computer processed output, the computer already having looked at the picture and already having prepared an analysis.

The pictures which are routine or insignificant meteorologically can be looked at very quickly and there will not be that many that we anticipate a great problem.

There will be some 96 pictures from each orbit of Nimbus.

And if only 20 of them are meteorologically significant, we feel that the manual analysts can look at this in connection with the computer output reasonably quick and keep up to the data flow.

Colonel PEACOCK. The volume is not going to be so great that you feel you have to have a filter to do this?

Mr. JOHNSON. No, not on the photographic data.

On the other data there will be quality controls and checks before using it.

Colonel PEACOCK. No; I just was referring to the photographic data.

Mr. JOHNSON. On the photographic data, I might interject, that pictures that show nothing in the sense of clouds may also be meteorologically significant.

We cannot automatically ignore them.

Colonel PEACOCK. Well, what I was thinking about is a filter and a scanning system similar to those that would be used for the output of reconnaissance type satellites. They can send back millions of pictures, and it would be impossible to have somebody actually look at each one of them to try and determine if there is anything significant. They have a filter and a scanner to indicate where changes appear on the photograph. Those photos drop out and an interpreter only looks at the changes.

But you feel you do not need this because you don't have the significant volume to look at?

Mr. JOHNSON. In that context our volume is not that great.

The overlap in the pictures is not that great that we would have the redundancy that you describe in other types of satellites.

Colonel PEACOCK. That is all I have, sir.

Thank you.

Mr. HECHLER. Mr. Hines.

Mr. HINES. Mr. Johnson, your interim Tiros system is a requirement that the Weather Bureau is laying upon NASA, is this correct?

Mr. JOHNSON. Yes; we hope not alone. There will be support from other user services as well.

Mr. HINES. I take from your statement that the enthusiasm of the other agencies indicates, in a preliminary sense, vigorous support of this plan.

Will this decision impose, to your knowledge, any delay or unusual R. & D. burden, upon NASA to meet the requirement?

Mr. JOHNSON. In our view, no.

We are very grateful to NASA for having produced such a good satellite as Tiros.

We find it operationally useful and we would essentially like to freeze the design of Tiros and go ahead and use it operationally.

So that you get into a production and a workload problem, a staffing problem, a phasing of the orbit problem, and a technical management problem of putting these things in orbit so that your acquisition stations are not in conflict when they try to interrogate the satellites.

These are difficult problems, to be sure, but they can be worked out, and they are not what we would consider to be an R. & D. load at all.

Mr. HINES. What would be the funding contributed by the Weather Bureau?

Mr. JOHNSON. For a Tiros operational system?

Mr. HINES. Yes.

Mr. JOHNSON. This has not been completely worked out yet.

For the spacecraft and launch vehicles, we would look to fund initially approximately four. And the cost of doing this is roughly $16 million. Maybe a little bit less than this.

And there are associated costs of data handling and communications, and so on.

So that perhaps for a Tiros operational system alone—something like $20 million.

Mr. HINES. This was not anticipated in the initial funding.

Mr. JOHNSON. This is correct.

Mr. HINES. Will you have to get additional funds?

Mr. JOHNSON. Not necessarily, Mr. Hines.

We find that the slips in Nimbus are such that in our judgment at least—and this of course is subject to certain approvals—there can be some reprograming of existing or anticipated funds without any significant delay in the Nimbus program at all.

Mr. HINES. When do you expect to receive the evaluation of NASA on your interim proposal?

Mr. JOHNSON. This may take another month to 6 weeks.

Mr. HINES. With the chairman's permission, I think it would be valuable to the subcommittee if this could be submitted to the subcommittee at that time for perhaps any additional evaluation to be made of it?

Mr. JOHNSON. If what could be submitted, please?

Mr. HINES. The NASA's response to the Weather Bureau on this proposal—if this is agreeable to you, Mr. Hechler?

Mr. HECHLER. Well, we could ask NASA for that.

Colonel PEACOCK. Yes; I think we could get it.

Mr. HECHLER. It would be more appropriate.

Colonel PEACOCK. I don't think it is a question of a conflict——

Mr. HECHLER. Off the record.

(Discussion off the record.)

Mr. HECHLER. Back on the record. If there is any way the subcommittee can help in these negotiations, why be sure and let us know.

Mr. JOHNSON. Thank you.

Mr. HECHLER. Is that all?

Mr. HINES. On this question, sir, yes.

Mr. HECHLER. Would you care to review just briefly the advantages of Tiros VI over Tiros I, and the sweep of development, other than the advantages of having a dual system at one time.

Mr. JOHNSON. This is more difficult; VI is better than I from the operational point of view, certainly, because we know so much better how to use it.

At the time of Tiros I there were many uncertainties as to just what would come back and what to do with it.

So we have gone through a period of 2 years of refinement of procedure, development of advanced computer programs, so we know what the pictures will be. And we have grids in advance for these photographs.

We have a much more rapid method of processing the data at field stations and of getting it to Washington.

We have developed means of photographic distribution of the material to the field which we have had only in Tiros V and VI.

Tiros VI is in an orbit different from Tiros I, II, III, and IV, and is giving a coverage of more northerly and more southern latitudes than was possible before.

It also has different camera systems. At least one of the cameras is quite different from the Tiros I configuration.

We think we have resolved for our present needs anyway upon a very useful combination of camera systems—one rather wide angle and one we call medium angle, which is a good combination, as compared with the earlier wide and narrow angle.

The difficulty with the narrow angle camera was that if you for some reason did not have the wide angle camera information, you had

no overlap of the narrow angle pictures and could not locate yourself geographically.

With the pictures showing a larger area, our task is much eased.

We also find that except for very restricted applications the pictures are of sufficient resolution with the medium and wide angle so that they are meteorologically useful.

I can't say, Mr. Chairman, that Tiros VI is a remarkably better satellite than Tiros V or Tiros IV.

I would say it the other way.

We have come to a situation of having such a good series of Tiros now that we in the user agencies want to freeze it and get on with it operationally.

It repeats itself very satisfactorily.

Mr. HECHLER. Yes.

What is the approximate total number of photographs since the beginning of the series that have been sent?

Mr. JOHNSON. 25,000 apiece?

Mr. MACE. Approximately, yes.

Mr. JOHNSON. The first five on the average, something like 25,000 pictures, maybe a little bit more than that, which would make 125,000 until now.

And there are 1,300 from Tiros VI.

If the committee wants an exact figure, I would have to get that for you.

Mr. HECHLER. No, that is sufficient.

I think it would be useful to have an exact figure from the first five, to date.

Mr. JOHNSON. Yes. You understand that Tiros V is still operating.

Mr. HECHLER. Yes.

Mr. JOHNSON. So, I can give you an exact figure to date, if you wish.

Mr. HECHLER. Yes. We would like that for the record.

(The information is as follows:)

The total number of usable pictures received from all of the Tiros satellites, including Tiros VI, up through September 21 are as follows: Tiros I, 19,389; Tiros II, 25,574; Tiros III, 24,000; Tiros IV, 23,370; Tiros V, 21,498; Tiros VI, 1,730. Total, 115,561.

Mr. HECHLER. What is the estimated life now of V and VI?

Mr. JOHNSON. Tiros V is surprising all of us and still doing beautifully with its single camera system.

There is no real evidence that Tiros V is failing.

It isn't going through the rather progressive degradation of picture quality that some of the earlier satellites have done at the comparable age.

I hesitate to guess when Tiros V may die.

We hope that Tiros VI will be up through this calendar year, and work hopefully until the next launch, which would be in early 1963.

Tiros VI was launched as you know at this time because of the fear that Tiros V might not still be operating.

Mr. HECHLER. Well, of course, the word "slippage" has been used on several occasions before this committee to describe the Nimbus program.

Mr. JOHNSON. Yes.

Mr. HECHLER. Therefore, I believe we ought to stand up and cheer because Tiros VI has accomplished something unusual. I guess there isn't even a word the lexicographers have invented for this business of beating a schedule. We talk so much about slippage.

Would you care to coin a new word to indicate beating the clock?

Mr. JOHNSON. No. But we are amazed. [Laughter.]

Mr. HECHLER. Colonel Peacock, did you have any questions?

Colonel PEACOCK. No, sir; nothing else.

Mr. HINES. I have a question, sir.

Mr. HECHLER. Mr. Hines.

Mr. HINES. Tiros V and Tiros VI are opposite to each other in their orbits; is that correct?

Mr. JOHNSON. Not quite, Mr. Hines.

The satellites are in very close proximity.

The launch time was determined so that the satellites would at least for some days not be over the acquisition stations at or near the same time. So that we would not have conflict in the acquisition of the data.

It would have been better from the point of view of the question that you asked if Tiros VI could have been launched some days later.

And we would have achieved then somewhat better coverage, even, than what you have seen on the alert chart.

There are factors beyond our control that caused us to be unable to delay.

It was remarkable that we could go earlier than expected.

But once that decision was made the other factors beyond Weather Bureau control and even beyond NASA's control within some limitations caused us to go on the date that was planned.

Colonel PEACOCK. What are these factors? Do you mean launch facilities?

Mr. JOHNSON. Yes.

Colonel PEACOCK. Launching requirements?

Mr. JOHNSON. Yes.

Colonel PEACOCK. Over the range.

Mr. JOHNSON. You have to have the pad. You have to have the range. You have to have the facilities at the cape. And you have to have the people.

There is a very complicated series of things.

These are questions appropriate to NASA, really, Colonel Peacock, and not to me.

Mr. HECHLER. Yet you are submitting the requirements in a sense.

We are interested in what your reaction is with the existing facilities and whether existing facilities need to be improved from the standpoint of user requirements?

Mr. JOHNSON. Yes, sir. I welcome that question.

We concurred, of course, with NASA in the decision to launch Tiros VI still within the hurricane season.

At that time we were thinking in terms of the possibility that Tiros V would not continue to operate.

So that when the opportunity came to launch Tiros VI early, we were anxious to do so.

I should say on this question of being able to go when you want to go: We have included, or will include in our Tiros operational sys-

tem planning some arrangement for an alternate launch facility—another pad, at perhaps some other location.

This raises many problems. Because these are very expensive and complicated things.

But we want at least to look into what we would gain by having an alternate launch facility that would not be obligated quite as completely to other programs as well as the meteorological plan.

We are in the situation now, Mr. Chairman, of having two pads in the United States, one adjacent to the other. That is, two pads capable of launching the Thor-Delta vehicle. If anything happens there, we are out of business.

Mr. HECHLER. Well, every Federal official balks when somebody makes a suggestion that we ought to have a motor pool. Then they can't draw on their own car when they need it.

Wouldn't it be nice if the Weather Bureau had its own little pad that it could use whenever it wanted to?

Mr. JOHNSTON. Well, Mr. Chairman, I believe it is the intent of Congress that the national facilities be used.

And it is not for us to develop separate and distinct launch and range facilities.

Mr. HECHLER. I don't mean to develop it yourself, but just to have it sort of set aside for your own use.

Mr. JOHNSON. Well, I think our preferred approach, Mr. Chairman, would be to define the requirement.

Mr. HECHLER. Yes.

Mr. JOHNSON. And fund the requirement, and use the capability of the agency directly in this business to operate it for us.

Mr. HECHLER. Do you feel the need for any higher priority on launching facilities for your use?

Colonel PEACOCK. This is a matter of priority, is it not?

Mr. JOHNSON. Priorities are involved.

This may develop, Mr. Chairman. I am not quite sure what assurance we will get from NASA on launch dates down the line as we produce our operational satellite.

It could well be that we will need to have stated emphatically the urgency of getting on with this system, including the availability of all facilities required.

Mr. HINES. Wouldn't you agree, Mr. Johnson, that an administrative function or scheduling should not interfere with achieving optimum launch conditions? The arbitrary scheduling,, say, of launch pads or range support should not be allowed to minimize or degrade desired optimum results?

Mr. JOHNSON. This is, of course, the position we would take. We can define the requirement of an operational system.

And I think they have been essentially defined before the subcommittee here, namely, that if a system is to be operational it must be continuous. To be continuous, you have to have two satellites in orbit at all times. So that as soon as one fails you put another one up.

This means you have to be able to get on to a launch pad very quickly. And under the present system of the two adjacent launch pads, this is not always possible.

This is why we are considering in our plan some alternate facility to be assured of the operational capability.

Mr. HINES. That is all.

Mr. HECHLER. Do you have anything further, Colonel Peacock?

Colonel PEACOCK. Yes.

Mr. Johnson, the committee feels as you do, that this program is of the highest national priority. I think that if you have difficulty, or the Weather Bureau has difficulty in getting adequate priorities insofar as launch facilities are concerned, you ought to make this known to the committee.

I think it is mandatory that the committee take action to make sure you have adequate facilities to launch these satellites, even if we have to go and provide additional facilities over and above those existing on the national range.

So, with the chairman's permission, I think that we would like to leave you with this thought.

If you cannot get adequate priorities to carry the program out as you see fit, you return to the committee and make it aware of this problem.

I think that you will get some support.

Mr. HECHLER. Yes, I would like to underline that.

This committee very strongly supports pushing this program forward as fast as possible.

And if there is anything that is standing in your way, in the way of not getting sufficient priorities, why we want to help you remove the obstacles.

Mr. JOHNSON. Thank you, Mr. Chairman.

I think you are aware of our enthusiasm for this program, and with an offer of support such as this we will come back to see you when we are in need. I thank you.

Mr. HECHLER. We are as enthusiastic as you are.

Mr. JOHNSON. I know.

Colonel PEACOCK. We think you are a small agency in a giant organizational complex, but a very important one.

But I think you have some very powerful friends that could help you in case you need help.

Mr. JOHNSON. Thank you.

Mr. HECHLER. And every time the Weather Bureau comes before this committee, I always ask you this question: Are you having any difficulty in getting personnel by reason of the fact that the glamor agencies can sometimes outcompete you?

Mr. JOHNSON. Well, I think we are all having some difficulty getting personnel, Mr. Chairman.

We do not yet have the staff we need to conduct the operational satellite system.

However, we are——

Mr. HECHLER. A limitation of funds or limitation of scientifically trained personnel?

Mr. JOHNSON. The latter, Mr. Chairman.

Mr. HECHLER. Yes.

Mr. JOHNSON. We have the necessary funds to employ the people we can find who are qualified to do the job we want done.

There is the grade problem.

Mr. HECHLER. Yes.

Mr. JOHNSON. I would like to say that there is progressive improvement on this point in the Weather Bureau.

And if the record is examined over several recent years, there is, well, a progressive improvement.

Mr. HECHLER. We want to stimulate further improvement along these lines.

Mr. JOHNSON. Well, I have heard you address the chief of the Bureau on this point, Mr. Chairman. And I would prefer to let him speak to the point.

Mr. HECHLER. Also, I hope you carry this back to the Chief, that we also want to encourage more younger people to get into this field.

Mr. JOHNSON. Yes.

As an aside, Mr. Chairman, I was down at the Cape for this last launch. And it is a young man's business.

[Laughter.]

Mr. HECHLER. Any further questions?

Colonel PEACOCK. No, sir.

Mr. HINES. No, sir.

Mr. HECHLER. We appreciate your coming up before the committee this morning, Mr. Johnson, and Mr. Mace.

And again I would hope that you will keep us informed of any way that this subcommittee can help to move this program forward. Because it means a great deal in the overall American space program.

Mr. JOHNSON. We certainly shall, Mr. Chairman.

Thank you.

Mr. HECHLER. The committee stands adjourned.

(Whereupon, at 11:50 a.m., the committee adjourned, to meet at the call of the Chair.)

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