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PT. 3 1962 NASA AUTHORIZATION

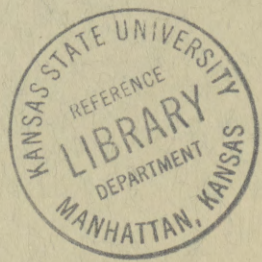
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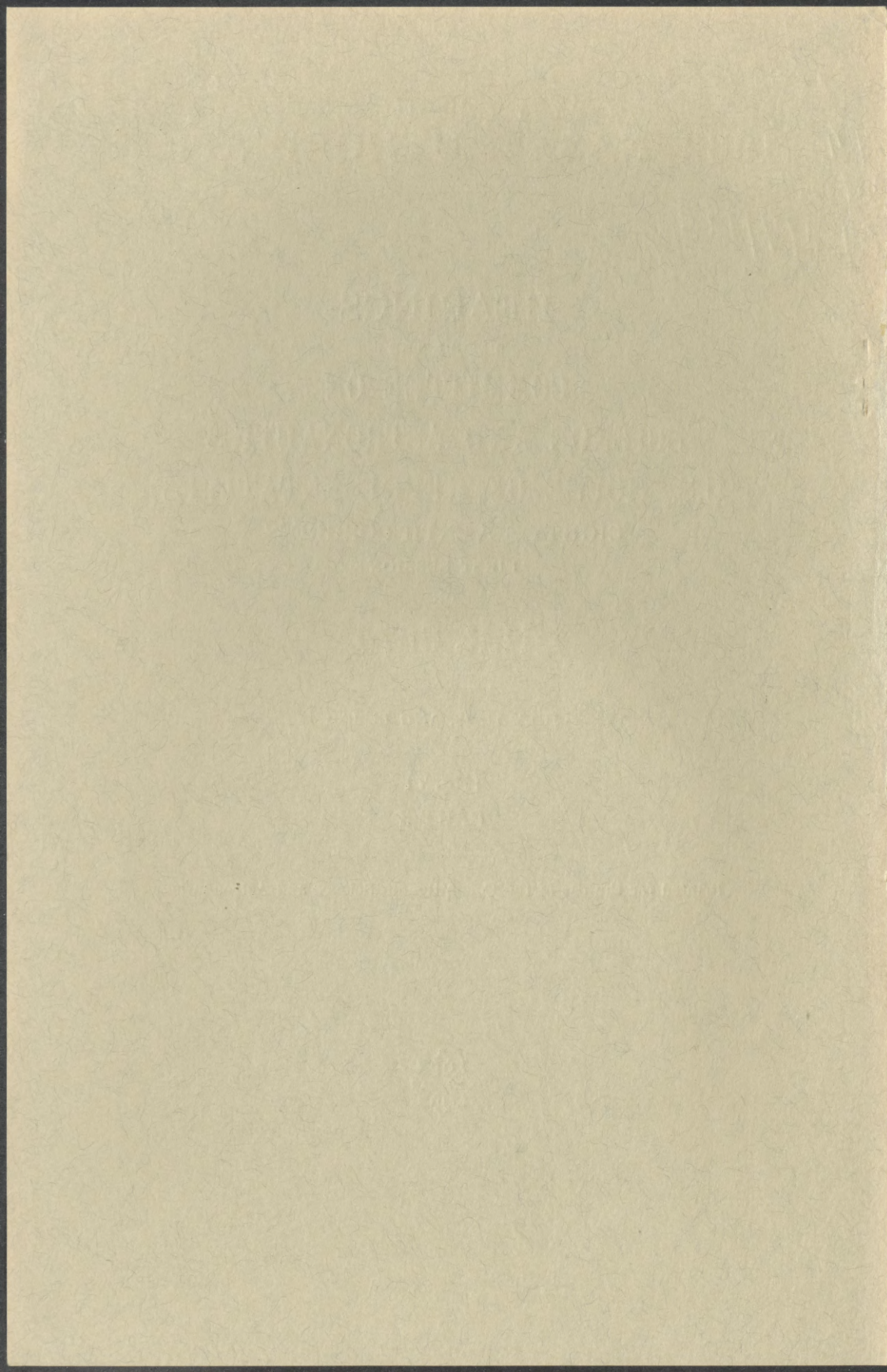
HEARINGS
BEFORE THE
COMMITTEE ON
SCIENCE AND ASTRONAUTICS
U.S. HOUSE OF REPRESENTATIVES
EIGHTY-SEVENTH CONGRESS
FIRST SESSION
ON
H.R. 6874

JULY 11, 12, AND 13, 1961

[No. 7]
PART 3

Printed for the use of the Committee on Science and Astronautics





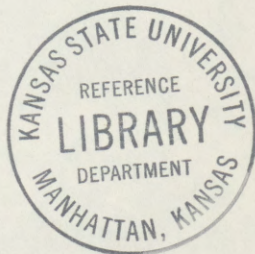
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U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1961

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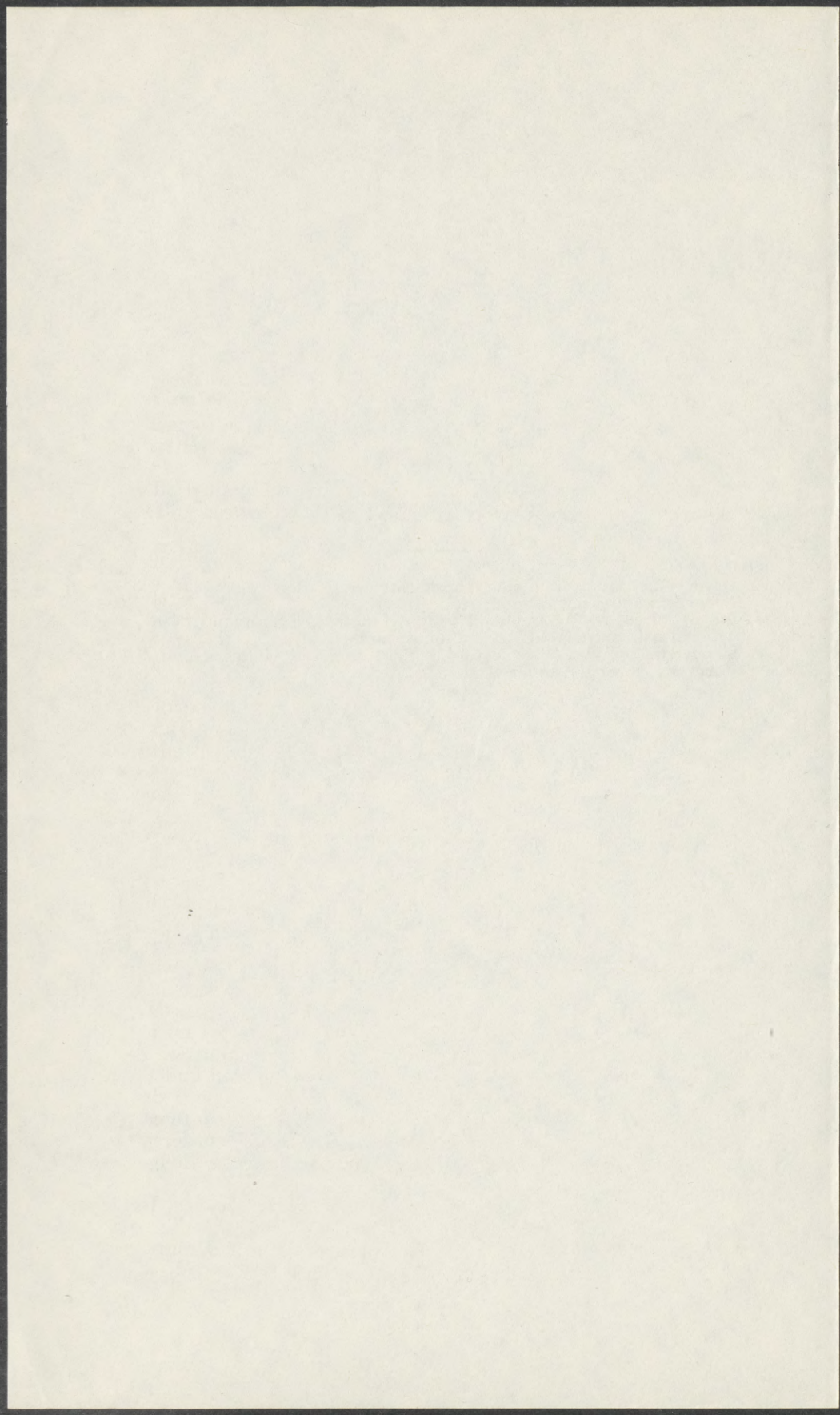
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1962 NASA AUTHORIZATION

TUESDAY, JULY 11, 1961

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C.

The committee met at 10:30 a.m., pursuant to notice, in room 214-B, New House Office Building, Hon. Overton Brooks (chairman) presiding.

The CHAIRMAN. This morning we are taking up again H.R. 6874 which is the authorization bill for the National Aeronautics and Space Administration for the fiscal year 1962.

Members will recall that this bill was given extensive hearings by this committee during April and May.

As recommended to Congress in March, the bill carried a total authorization of \$1,250,300,000. After careful deliberation of the various items requested, the committee added additionally the amount of \$126,600,000. All of the money added had been requested initially by NASA from the Bureau of the Budget—with the exception of \$15 million for solid propellant research—but it was not included in the recommendation sent by the President to the Congress. This committee reported the bill on May 12 this year. It was passed in the House of Representatives on May 24. Subsequently, an increase of \$549 million was recommended by the administration. This increase was considered and approved without change by the Senate. The amended bill was thus passed by the Senate on June 28. As it stands, the bill now contains authorization of \$407,400,000 more than the measure which passed the House of Representatives.

The Senate struck all after the enacting clause of the House bill and inserted its own measure incorporating the increases requested by the administration. Since this committee has not had testimony on the additional amounts involved, we have asked NASA witnesses to appear today and tomorrow in order to explain these increases and give us some detail on how the additional funds are to be used. It is expected that this information will bring the committee up to date providing the essential data to all members of the committee.

Of course, it would not be expedient at this time, and under these circumstances, to consider new legislation, so that these 2 days of hearings will also serve to provide information which conferees will need in taking up the matter in the House and Senate conference.

Unless there is objection, the committee will proceed along these lines.

This morning, I might say, we have Dr. Hugh L. Dryden, Deputy Administrator of NASA;

Dr. Abe Silverstein, Director, Office of Space Flight Programs;

Dr. Charles H. Roadman, Acting Director, Office of Life Science Programs;

Maj. Gen. Don R. Ostrander, Director, Office of Launch Vehicle Programs;

Mr. Ira H. Abbott, Director, Office of Advanced Research Programs;

Mr. DeMarquis D. Wyatt, Director, Office of Programs;

Mr. Ralph E. Ulmer, Assistant Director for Facilities;

Mr. Albert F. Siepert, Director, Office of Business Administration;

Mr. Aaron Rosenthal, Director, Financial Management Division.

We have a distinguished array of witnesses this morning. We will proceed with asking Dr. Dryden, the Deputy Administrator, to bring us up to date on what NASA is now doing. We were sold, I might say to the good doctor, on the program of NASA as given to this committee. We thought we went far ahead of the Bureau of the Budget in adding \$127 million, and two of our members felt that we were going too far in that respect. But almost within an hour after our bill had passed the House of Representatives, the amount had been increased over the representations of NASA witnesses to this committee by \$400 million. So I think that this committee is entitled to an explanation of the reason for the increase and the type and character of the increases.

STATEMENT OF DR. HUGH L. DRYDEN, DEPUTY ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. DRYDEN. Mr. Chairman, I am very happy to come before the committee to explain the events which have taken place since the committee acted on the authorization bill.

You will recall that with the coming into office of a new administration, the budget which had been submitted by President Eisenhower was reviewed to see what changes should be made. In this first review NASA put up to the President two policy matters for decision.

The first was the question of further acceleration of the big booster program, since this was an area in which obviously we were still behind although we have been making good progress with Saturn in coming forward with greater capacity.

The second policy question was: Shall the recommendation of President Eisenhower be accepted that the manned space flight program be confined to research and development beyond Project Mercury or should steps be taken to move to the follow-on vehicle development?

At the time of the first review, the President made the decision that he would go along with the acceleration of the big booster program, leading then to the budget which was presented to you as the first Kennedy budget revision and on which the committee took its action.

The first column shows the original budget request of President Eisenhower with the breakdown in construction of facilities, \$99.8 million; salaries and expenses, \$190 million; research and development, \$819.8 million, for a total of \$1,109,600,000.

The result of the first review was to add \$126 million primarily for the acceleration of the booster development. The budget then on

which you acted was \$119.1 million on construction of facilities; \$196.7 million, salaries and expenses; \$919.5 million in research and development.

The committee, as Mr. Brooks has outlined, taking cognizance and having knowledge of the magnitude of the original budget request of NASA to the Bureau of the Budget, did add certain amounts to the authorization bill as described by the chairman in his opening statement.

The President, in taking this first step, reserved the second item, the manned space flight beyond Mercury, for further study within the executive branch. I think at the time most of us felt he was contemplating reconsidering this in connection with the following budget: Nevertheless, certain things happened.

The Space Council legislation was passed. The Vice President took office as Chairman of the Space Council and began to actively review the space program with the help of people in the executive branch and numerous consultants that he called in from outside, representing professional experts and certain persons from the general public whom he wished to consult. This was one event. The second event was Gagarin's flight.

The third event was Shepard's flight. I am not attempting to say which of these various events was responsible for the action that was finally taken. There was a very considerable discussion within this group and with the President of the total space program and of our position relative to the U.S.S.R., the steps that might be taken and what these steps might cost.

The outcome of this consideration was a message to the Congress by the President on May 25 which, as you have said, happened very shortly after the action of the committee.

As you know, it was not possible for us to acquaint the committee with the details of the discussions going on within the executive branch until a final decision had been made. This accounts for the timing which is somewhat unfortunate from the point of view of the committee.

On May 25 the President gave his message to Congress from which I quote only a very few words:

Now it is time to act, to take longer strides, time for a great new American enterprise, time for this Nation to take a clearly leading role in space achievement. I believe that the Nation should commit itself to achieving the goal before the decade is out of landing a man on the moon and returning him safely to earth.

I may say that in none of the original submissions from NASA had we submitted estimates involving a beginning on the vehicle which would take man to the moon and return. As a result of this decision of the President, we did begin estimates, revising estimates previously made in our long-range planning.

We established groups to study the problem more intensively with a view to coming up with what would be required in 1962 if Congress accepts and the Nation accepts this challenge of the President.

We also made some attempt to forecast the general level of expenditures in future years by this advancing of the lunar landing which in our original long-range plans, as you know, happened beyond 1970 to a date prior to 1970.

The President, on the following day, submitted increases in his budget to the Congress involving several agencies, and there is a table which was released at the time which I think it would be useful for you to have in the record at this point.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, FISCAL YEAR 1961 ESTIMATES

Appropriation summary

	Salaries and expenses	Research and development	Construction of facilities	Total
Approved, fiscal year 1960:				
Supplemental Appropriation Act, 1960; Public Law 86-213.....	\$91,400,000	\$347,550,000	\$84,625,000	\$523,575,000
Appropriation transfers; Public Law 86-213.....	-550,000	-14,450,000	+15,000,000	-----
Total.....	90,850,000	333,100,000	99,625,000	523,575,000
Approved, fiscal year 1961:				
Independent Offices Appropriation Act; Public Law 86-626.....	170,760,000	621,453,000	122,787,000	915,000,000
Third Supplemental Appropriation Act; Public Law 87-14.....	-----	49,000,000	-----	49,000,000
Appropriation transfers; Public Law 86-213.....	-----	-1,950,000	+1,950,000	-----
Total.....	170,760,000	668,503,000	124,737,000	964,000,000
Requested, fiscal year 1962:				
Original, January.....	189,986,000	819,819,000	99,825,000	1,109,630,000
Revised, March.....	196,686,000	919,539,000	119,075,000	1,235,300,000
Current recommendations.....	226,686,000	1,295,539,000	262,075,000	1,784,300,000

Summary—Salaries and expenses

	Employees			Appropriations		
	Original January	Revised March	Current recommendation	Original January	Revised March	Current recommendation
NASA Headquarters.....	919	951	1,451	\$13,032,000	\$13,302,000	\$19,339,000
Langley Center.....	3,220	3,330	3,628	31,451,000	32,197,000	34,702,000
Ames Center.....	1,437	1,437	1,570	16,134,000	16,134,000	17,290,000
Lewis Center.....	2,754	2,824	2,993	27,800,000	28,284,000	29,985,000
Flight Center.....	494	494	494	4,268,000	4,268,000	4,268,000
Goddard Center.....	1,798	1,828	2,028	25,124,000	25,424,000	27,237,000
Space Task Group.....	800	840	1,640	9,900,000	10,260,000	17,103,000
Wallops Station.....	299	299	399	3,118,000	3,118,000	3,808,000
Marshall Center.....	5,500	5,960	6,960	61,119,000	65,319,000	73,854,000
Western office.....	65	85	85	917,000	1,107,000	1,107,000
AEC-NASA nuclear office.....	5	23	23	61,000	211,000	211,000
Life Sciences Station.....	51	51	151	476,000	476,000	1,286,000
Total.....	17,342	18,122	21,422	193,400,000	200,100,000	230,100,000
Less anticipated reimbursements.....	-----	-----	-----	-3,414,000	-3,414,000	-3,414,000
Total appropriations.....	-----	-----	-----	189,986,000	196,686,000	226,686,000

Summary of research and development programs

	Original January	Revised March	Current recom- mendation
Support of NASA plant.....	\$74,310,000	\$77,110,000	\$89,110,000
Research grants and contracts.....	7,600,000	7,600,000	7,600,000
Life sciences.....	8,620,000	8,620,000	20,620,000
Sounding rockets.....	7,000,000	7,000,000	9,000,000
Scientific satellites.....	64,700,000	64,700,000	72,700,000
Lunar and planetary exploration.....	103,899,000	103,899,000	159,899,000
Meteorological satellites.....	28,200,000	28,200,000	50,200,000
Communication satellites.....	34,600,000	44,600,000	94,600,000
Mercury.....	74,245,000	74,245,000	74,245,000
Apollo.....	29,500,000	29,500,000	160,000,000
Launch vehicle technology.....	15,000,000	15,000,000	27,000,000
Launch operations development.....	9,500,000	1,500,000	1,500,000
Spacecraft technology.....	10,360,000	10,360,000	10,360,000
Solid propulsion.....	3,100,000	3,100,000	3,100,000
Liquid propulsion.....	68,700,000	78,020,000	93,020,000
Electric propulsion.....	6,800,000	6,800,000	6,800,000
Nuclear systems technology.....	24,000,000	28,000,000	36,000,000
Space power technology.....	5,500,000	5,500,000	5,500,000
Scout.....	3,675,000	3,675,000	3,675,000
Delta.....	2,900,000	2,900,000	2,900,000
Centaur.....	30,800,000	56,400,000	56,400,000
Saturn.....	168,160,000	224,160,000	224,160,000
Tracking and data acquisition.....	38,650,000	38,650,000	38,650,000
Nova.....			48,500,000
Total appropriations.....	819,819,000	919,539,000	1,295,539,000

Summary of construction programs

	Original January	Revised March	Current recom- mendation
Langley Research Center.....	\$3,980,000	\$3,980,000	\$3,980,000
Ames Research Center.....	6,380,000	5,680,000	5,680,000
Lewis Research Center.....	3,590,000	3,590,000	3,590,000
Goddard Space Flight Center.....	9,212,000	9,212,000	9,212,000
Wallops Station.....	6,313,000	6,313,000	6,313,000
Jet Propulsion Laboratory.....	3,642,000	3,642,000	3,642,000
Marshall Space Flight Center.....	8,891,000	12,891,000	12,891,000
Atlantic Missile Range.....	32,583,000	49,583,000	49,583,000
Pacific Missile Range.....	998,000	998,000	998,000
Various locations:			
Tracking facilities.....	16,811,000	15,761,000	20,761,000
Propulsion development facilities.....	1,175,000	1,175,000	31,175,000
Nova development and launch facilities.....			28,000,000
National nuclear rocket development facility.....			15,000,000
Manned space flight laboratory.....			60,000,000
Sounding rocket facilities.....	500,000	500,000	500,000
Damage repair and special construction.....	750,000	750,000	750,000
Advanced facility planning and design.....	5,000,000	5,000,000	10,000,000
Total appropriations.....	99,825,000	119,075,000	262,075,000

Adjustments to fiscal year 1962 estimates

[In millions]

Appropriation	March adjustments	Current adjustments
Salaries and expenses:		
Number of employees.....	780	3,300
Personal services.....	\$6,200,000	\$25,140,000
Travel and transportation of persons.....	500,000	2,000,000
Transportation of things.....		875,000
Rents, communications, and utilities.....		865,000
Security investigations.....		1,120,000
Total.....	6,700,000	30,000,000
Research and development:		
Support of NASA plant.....	2,800,000	12,000,000
Life sciences.....		12,000,000
Sounding rockets.....		2,000,000
Scientific satellites.....		8,000,000
Lunar and planetary exploration.....		56,000,000
Meteorological satellites.....		22,000,000
Communications satellites.....	10,000,000	50,000,000
Apollo.....		130,500,000
Launch vehicle technology.....		12,000,000
Launch operations development.....	-8,000,000	
Liquid propulsion.....	9,320,000	15,000,000
Nuclear systems technology.....	4,000,000	8,000,000
Centaur.....	25,600,000	
Saturn.....	56,000,000	
Nova.....		48,500,000
Total.....	99,720,000	376,000,000
Construction of facilities:		
Vivarium.....	-700,000	
Ground instrumentation.....	-1,050,000	
Saturn static test facility.....	4,000,000	
Saturn C-2 launch pad.....	11,000,000	
Modifications to launch complex No. 36.....	6,000,000	
Tracking station.....		5,000,000
Propulsion development facilities.....		30,000,000
Nova development and launch facilities.....		28,000,000
National nuclear rocket development facility.....		15,000,000
Manned space flight laboratory.....		60,000,000
Advanced facility planning and design.....		5,000,000
Total.....	19,250,000	143,000,000
Total, all adjustments.....	125,670,000	549,000,000

There were additional items within the NASA budget totaling \$549 million. There was an item, two items totaling \$77 million in the Department of Defense budget. An item of \$53 million in the Weather Bureau, and there were certain adjustments to be made by reprogramming within the Atomic Energy Commission itself.

In connection with the President's speech—I have not looked up this passage recently—but in that or in the message which sent these numbers there was the statement that the Department of Defense, because of its past activities in solid propellants in the development of Polaris and Minuteman, would for NASA take on the responsibility of a parallel development based on solid propellants in addition to a vehicle based on the liquid propellant F-1 engine for the lunar mission to be carried on by NASA, that this work would be responsive to the needs of NASA, and with a view to potential military usefulness of the same rockets at a later date.

So that in the Department of Defense item there is \$62 million for solid booster development, and \$15 million for an upper stage on Titan II, which both agencies desired as a vehicle, regarded in a certain sense as backing up our whole program because of the potentialities

of Titan II and to be specifically designed for the Advent communication satellite of the Department of Defense whose weight has been increasing as the design developed. This additional backup was desired. So far as the amount for the Weather Bureau is concerned, this item of \$53 million, this was looking forward to—

Mr. ANFUSO. Before you go into the Weather Bureau, Doctor, how much did NASA provide for solid fuels as amended by the Senate?

Dr. DRYDEN. This stays at the value which came to your committee for \$3.1 million. When I conclude this, Mr. Anfuso, I will take up the actions of this committee in amending the authorization submitted and show what has happened to them in this final adjustment.

Fifty-three million dollars looked forward to an operational weather satellite based on Nimbus. It is the understanding that NASA will do the launchings; launching and procurement of the satellite itself will be handled through NASA channels.

The CHAIRMAN. The committee approved \$103 million.

Dr. DRYDEN. Yes. The added amount refers now to an operational system based on the Nimbus satellite which is, of course, not yet developed, but for which the long leadtime items of procuring boosters and so on must be started a couple of years earlier. That amount I believe was not considered in the regular appropriation bill of the Weather Bureau, but is under consideration in connection with one of the supplementals which Congress will pass.

To return to NASA, the overall result is to add, as I have mentioned, \$549 million, the difference between \$1,235 million and \$1,784 million and the distribution is as follows:

Construction of facilities is increased from \$119 million to \$261 million. The long leadtime items here are launch facilities for very large rockets. We have studies underway jointly with General Davis at Canaveral on such questions as: Is it possible to fire these very large rockets from Canaveral? If so, what is needed?

We know these launch facilities are the longest leadtime items. Salaries and expenses, \$226.7 million. Research and development, \$1,295.5 million.

I do not want to leave the impression that this \$549 million is all related to lunar landing; \$531 million of the \$549 million is directly related to manned lunar landing, as we will describe in a moment.

The amendment included the full support of the Rover nuclear rocket, including the \$15 million engine test facility which the committee added in its action. It included \$50 million to expedite an early capability in communication satellites. It included the idea that a Tiros would be kept in the air continually until Nimbus was operational. This went a little bit beyond the action of the committee which added the funds for two Tiros.

This provides adequate backup. There were involved, in addition to manned lunar landing, the nuclear acceleration, and acceleration in the applications of satellites both to communications and meteorology.

I think at this point it might be well to take the committee's report and its recommendations on authorization and the action. The committee recommended the sounding rocket item to be increased from \$7 to \$9 million. That has been done.

It recommended an increase from \$64.7 to \$77.7 million in scientific satellites. The figure which came out of our final survey of this program was \$72.7 million. For meteorological satellites, the committee recommended an increase from \$28.2 to \$40.2 million. This has been further increased to \$50.2 million to give backup and be sure we have one Tiros up continually.

This action was taken because of the very great utility of Tiros both in the civil weather applications and in the military weather applications. There is great support as evidenced in the so-called POMS—panel on meteorological satellites—report. This panel is a joint group that studied the needs of both the Department of Defense and the civil agencies for information from weather satellites. They did propose a program; an essential part of the program was to have a Tiros in the air continually so that the information was available to the several agencies.

The committee recommended for Project Apollo an increase from \$29.5 to \$72.1 million. You cannot see it here, but the amount for Apollo is now further increased to \$160 million.

This contemplates the early selection of a contractor for the vehicle, an accelerated program in the reentry testing, the probable use of Mercury capsules for longer missions than the three orbit missions with man, and the use of Mercury capsules with animals for more prolonged periods of weightlessness.

There is also involved a program of radiation effects on both animals and man.

So that the increase in the new program contemplates a very aggressive moving forward with the practical development of the Apollo capsule. If you recall the past presentations of Apollo, this same vehicle is used for a manned earth satellite, for circumlunar flights, and eventually for manned lunar landings and return.

We are not building something for a very narrow mission, but the capsule will serve the steps along the way as we gain the experience in manned space flight. The committee recommended an increase in launch technology from \$18 to \$23 million. This present budget provides \$27 million.

I have mentioned that the solid propulsion effort in the large propulsion field was to be carried on by the Department of Defense, specifically by the Air Force, addressed to the lunar missions. This means a parallel approach to Nova, consisting of a solid propellant alternate to liquid propellant F-1 engine vehicles.

The language of the President's speech said that these developments would be carried forward until a clear decision could be made as to which one was the more promising for reaching the goal of manned flight before 1970.

The committee recommended an electric propulsion increase from \$6.8 to \$9.7 million. The figure remains at \$6.8 million.

For nuclear technology, as I have stated, the committee's recommendation was followed, an increase from \$28 million to \$36.5 million. We have provided the full financing of the Rover at the maximum rate that the technical people wished.

The committee added \$5 million for tracking facilities for Apollo. That is in this budget although it is not separated out on this particular chart. It is in the budget book that some of you have.

The \$15 million for the construction of a nuclear rocket test facility is in this budget.

The committee added \$2.6 million in the salaries and expense portion of this budget. That amount and very much more was included in the salaries and expenses part of the budget submitted to you.

This figure of \$1,784 million overall represents an increase of the Eisenhower budget by 61 percent, in the two increments, the \$125.67 million and the \$549 million.

The expenditure estimate is \$1,380 million, which is an increase of about 43 percent over the estimate under the Eisenhower budget, which was about \$965 million.

I think this gives a very general rundown on what took place. I emphasize again there was a major national decision to push forward with great earnestness toward this goal. I mentioned that we did forecast the amounts for the future. This program will require the budget level certainly to rise to the order of \$5 billion in a few years. On the assumption that we were going to the moon after 1970 under the original plan, this represents a moving forward of the goals, and a resultant increase of cost in this decade of \$7 to \$9 billion over what would have been spent had we been content to proceed at the slower rate.

Another figure that you have seen in the press, not too well determined at the present time, is the cost associated with that part of the program related to the manned lunar landing. Originally in our very rough studies we said somewhere between \$20 and \$40 billion.

We have now refined this much more. It is much closer to \$20 billion than \$40 billion for the total over a period of some 8 to 10 years, depending on when we reach the goal.

I think that I should say one more thing about the goal of manned lunar landing. In some ways it is a little unfortunate to have to use these shorthand titles, because in many parts of our country I think that going to the moon is a symbol for something which has no value, something which just brings psychological benefits.

It is much like the situation before we had flight when people who had propositions that one didn't believe in said, "You might as well try to fly." Today you will hear the remark, "You might as well try to go to the moon." Or "shooting the money to the moon."

Actually, of course, these billions of dollars do not go to the Moon. They are spent here on Earth and the major value of this program is the advance of technology in this new and unknown field of operations in space. Setting a goal of this kind does two things:

First of all, it motivates the people on the job. There is a specific task ahead which gets people a bit more excited than research on vibrations of structures or research on the heating of something at very high speeds.

Here is a definite undertaking which motivates people.

Furthermore, it has the effect of advancing the technology very rapidly. If you will recall the history of the research airplane, beginning with the X-1, and now represented by the X-15, none of these airplanes was a useful military device or civilian device. The X-15 is not a weapon. Nevertheless the effort required to build the X-15, the studies of new materials, of the working of new materials into parts of the air frame, of the excessive heating problems involved,

produced the information which is the basis of all of our modern developments in supersonic aircraft.

The B-70 certainly profits greatly from our experiences in the X-15, just as our early supersonic military aircraft were based on information derived from the X-1. So in this way the launch vehicles, the guidance devices, this special materials, the techniques that are developed for putting a man on the Moon and bringing him back, the knowledge of the human body and its reaction to various sorts of stresses, all of this gives you the material on which you can do whatever you find desirable in space, for military purposes, for civilian purposes, or whatever is needed.

More than this, it has been the experience of all the great technologies, such as the development of the automobile, the development of nuclear energy, the development of the airplane, that the technology produces results that throw off benefits to all of our industry.

I address myself to Mrs. Weis for a moment. This is perhaps a fantastic example and yet I think it is true. We have in most of our homes a washing machine in which we throw the clothes and push a button. We go away and come back and take out the dry clothes. This is what we call automation in our industry. It is a kind of thing that was developed very early in the automotive industry.

Mrs. WEIS. You will find more of the men have worked the washing machines than I have.

Dr. DRYDEN. You remember the production line methods of Henry Ford and the way in which the machinery was made automatic, in which all these many holes in a cylinder block were drilled all at once. The workmen put a piece in and the machine drilled one hole, then rotated the piece and drilled another automatically. That technology is being applied all around us.

We don't always recognize the origin because the origin is at some time in the past. Space technology is bound to do the same thing.

It is bound to greatly accelerate our progress in science and technology. It may not give just exactly the emphasis that some scientists would like to give if they had a free hand, but it has been the experience that the work in atomic energy has done as much to strengthen our universities, to strengthen the work in physics as anything you could think of.

So that the real meaning of landing a man on the Moon and return is not just to be found in that shorthand phrase. But it is the effort, the work of men and women that is bound up in this \$1,700 million that is the important thing. The primary effort, of course, is to gain experience in a new technology so that we are not caught by military surprise, by new weapons utilizing a technology that we don't understand, or more broadly, that our industry is not caught by technological obsolescence because we have not worked at the frontiers in materials and electronics that is required to accomplish this job.

So this is the real meaning of the program in my opinion. It is a meaning that somehow we must get the American people to understand.

This briefly, Mr. Brooks, gives you the picture. We are prepared to go down program by program. If you wish to do that, Dr. Silverstein is ready.

The CHAIRMAN. Let me ask you a question or two. The first two questions I have to ask are off the subject in a way and in another way they are not. You were in charge of NACA when it was active, and you refer to the X-15 which is a NASA program.

Dr. DRYDEN. It is a joint NASA-Air Force-Navy program.

The CHAIRMAN. Do you have any information other than what we have read in the paper about the tremendous movement forward of the Soviets in the development of hot airplanes?

Dr. DRYDEN. I think the Soviets have shown us the airplanes that they have been developing over the past 4 or 5 years. I think we have known that they were developing new aircraft. We have not known how many they were developing.

The CHAIRMAN. You hadn't known how fast they are or how advanced the designs are?

Dr. DRYDEN. We do not yet know exactly how fast these planes are. One of the technical journals estimates they are mach No. 2 airplanes. I have no knowledge of that.

The CHAIRMAN. That would be equivalent to the Hustler or B-58, if it is a mach 2.

Dr. DRYDEN. I must say I have not studied in detail anything other than the newspaper reports at the present time. I have not yet read the assessment by the experts who have seen the airplanes.

The CHAIRMAN. I think it shows definitely that the work of NASA in reference to advanced types of airplanes can't be completely overlooked, that NASA is going to have to push ahead, too, to keep up with the Soviets in advanced development of planes.

Dr. DRYDEN. You jog my memory. There is in the salaries and expenses part of this item support for the supersonic transport airplane as a specific item. The Federal Aviation Agency has received \$10 million in the appropriation. The original estimate was \$12 million to begin a program in which they, the Defense Department as managers and contractors, and we in technical support are involved.

The CHAIRMAN. You know this committee recommended that supersonic transport?

Dr. DRYDEN. Yes.

The CHAIRMAN. What is your thought going to be in reference to that development?

Dr. DRYDEN. Our part is in the technical support. We at the present time have a rather extensive program on materials which is going to be one of the very key items. I think Mr. Abbott can present this in some detail either now or later.

The CHAIRMAN. Is there money in this particular budget—

Dr. DRYDEN. Yes, in the salaries and expense item.

The CHAIRMAN. How much is that?

Mr. ABBOTT. It is a little over \$2 million.

Dr. DRYDEN. That is for the in-house work. This is bound to go up as the project goes forward.

The CHAIRMAN. I have one more question and then I will yield to the committee.

I want to ask you this: We presented the original bill to the House, and I think we got a very good reception from the House.

Dr. DRYDEN. Yes.

The CHAIRMAN. The House has confidence in us. But now when we go back, if we do, to the House saying that we were short by \$400 or

\$500 million, just how do we explain that you were proceeding at what you said was the top speed that you could economically proceed at when we presented that bill—and now you find that you are able to go much faster than you felt at that time you could? I am putting it—

Dr. DRYDEN. Yes. I think this is not quite the way to say it. We, of course, are governed by policy determinations which are made in the first instance by the executive department. What has happened is that a new President has been elected. There is a new administration. There has been a change in the policy on which the budget originally submitted was based.

The CHAIRMAN. Can you say that if this or any part of this money is given to you that you can spend it economically and profitably for the advancement of the state of the art?

Dr. DRYDEN. Yes, I think I should say this, emphasizing the words which the President, himself, used, that this really is not worth spending unless you are going to accept this goal of manned lunar landing and return within the decade. In other words, to start now on the design of a very large vehicle, on the design and construction of launch sites for very large vehicles, and then to say next year that the cost of this cannot be met would amount to wasting this money.

The CHAIRMAN. You recall, Doctor, that some of our committee reports referred to the fact that 1970 was the cutoff date, beyond which you had no program whatsoever. Our committee reports are replete with references to that fact.

Dr. DRYDEN. We have detailed planning for about 10 years ahead. It is a little hard to see beyond that point.

The CHAIRMAN. We also referred in the committee hearings to the fact that the wait to get to the moon till 1970 was a long, long period of time.

Dr. DRYDEN. I think this is true. As I say, we have had to act in accordance with the joint policy decisions of the President and the Congress. We have not been free, we were not free to submit cost estimates based on reaching the moon before 1970 prior to May 25 when the President announced his decision. It is as simple as that.

The CHAIRMAN. Mr. Anfuso.

Mr. ANFUSO. I suppose, Dr. Dryden, that we could explain this increase due to the new objective—

Dr. DRYDEN. Setting new objectives.

Mr. ANFUSO. By the new administration, new goals for us to conquer as a result of the flight of the Russian astronaut and our own—

Dr. DRYDEN. In part. As I mentioned before, the President in making his first review did not decide against going beyond project Mercury but said he wanted to take longer to review the matter.

Mr. ANFUSO. I knew he had this under consideration even long before. He just went along with that temporarily. It was a temporary decision. You said, Dr. Dryden, you were going to explain the solid fuel thing. I understand that the Air Force is going to do most of it, is that it?

Dr. DRYDEN. This was a decision made within the executive department, to use the capability of the military services in this area, to divide this load somewhat, and very frankly to introduce a little element of competition in the development of vehicles.

Mr. ANFUSO. How much was it? Was it \$69 million?

Dr. DRYDEN. \$62 million is the beginning. That development, of course, if carried to completion, will be a half billion dollars or more.

Mr. ANFUSO. We had appropriated \$18 million, and then you went back to your original figure. Would you explain that, please?

Dr. DRYDEN. Under this policy decision, that the development of the large solid boosters for this mission would be carried out by the Department of Defense responsive to our mission requirements, no increase for NASA was included in the solid propellant item.

Mr. ANFUSO. You will continue your experiments on the solid booster or the smaller ones?

Dr. DRYDEN. Yes.

The CHAIRMAN. Further questions?

Mr. FULTON. The question comes up, because I have a pretty good memory, if how much money was needed in order to get the best possible economical development of these programs. Those of us on the committee who had been urging speed and development of various programs, we were told time after time by the witnesses of NASA, including yourself, that any additional money would be wasted, that you had all that was necessary to make the best possible progress at the most economical rate.

Dr. DRYDEN. On the approved objectives, yes.

Mr. FULTON. I think the questioning was beyond the approved objectives. It was a question of how you would make progress, for example, on Saturn. Now, evidently on that program there is no change, so that was a correct—

Dr. DRYDEN. On Saturn C-1 there is no change. There was an acceleration in the later versions of Saturn, in the first adjustment by Mr. Kennedy.

Mr. FULTON. In the Nova program, when that went through our committee, there was nothing needed for vehicle development, on the original bill, but now I understand there is. Why is the change?

Dr. DRYDEN. The change is one of a national decision that you will try to go to the moon before 1970. It means that right at the present moment we have to look at vehicles based on the F-1 engine, vehicles based on solid propellants, and this represents a change in the ground rules.

Mr. FULTON. What are you doing on Nova now under this proposal which you did not intend to do when you came before this committee earlier this year?

Dr. DRYDEN. To begin the actual development of vehicles based on the F-1 engine.

Mr. FULTON. That was not possible earlier this year?

Dr. DRYDEN. It was possible if a policy decision had been made, yes.

Mr. FULTON. Are we to be assured now that this will be adequate money for you and there will not be more money requested later for fiscal 1962?

Dr. DRYDEN. We believe that this will cover our needs for 1962. The amount next year will be very much larger.

Mr. FULTON. How large do you think it will be if you can estimate by the years because the President has given us a total for going to the moon. Will you please take the figure he had in dollars for the moon flight, lunar flight, and then give us by years how it would be spent?

Dr. DRYDEN. I have not a breakdown of the lunar flight at all.

Mr. FULTON. Just approximately. There has been a figure given to the press—

Dr. DRYDEN. The overall NASA budget will reach \$4 or \$5 billion in a couple of years. I have not the figure for the next year at the moment.

Mr. FULTON. About how is the President's figure broken down? Did he just grab that figure out of the air, or was it a figure that was reached on plan?

Dr. DRYDEN. Which figure, sir?

Mr. FULTON. That is the figure, the cost of going to the Moon.

Dr. DRYDEN. The total cost given to the President was very much of a horseback estimate based on the relative size of a Nova vehicle compared to Saturn and the known cost of Saturn. Since that time we have been putting in many hours of work refining these estimates, particularly of the needs in future years. We have actually listed all of the things that one has to do to get a man to the Moon and back. There are about 1,500 separate jobs that have to be done ranging all the way from new launch pads to more information about radiation effects on man. We have tried to outline the timetables and costs of such a possible program, put it on the kind of computing machine system that the Navy has used in its Polaris project, the Pert system, to refine these estimates of times and cost, to identify the jobs that have to be done first, and so on.

As I mentioned, we gave originally a figure of somewhere between \$20 and \$40 billion. Our present figures are much closer to \$20 billion.

Mr. FULTON. How is that \$20 billion distributed in time?

Dr. DRYDEN. I do not have this in detail. Approximately it will rise to a maximum and remain roughly the same after about 2 years from now.

Mr. FULTON. What would that figure be annually?

Dr. DRYDEN. It will get up in the neighborhood of \$4 or \$5 billion a year.

Mr. FULTON. How soon will that come?

Dr. DRYDEN. In about 2 years.

Mr. FULTON. Within a 2-year period, by 1964, on the Moon flight alone, there will be budgeted \$4 to \$5 billion?

Dr. DRYDEN. I am sorry. I do not have broken out that part related to the manned lunar mission. I think our total budget will be of this general order of magnitude.

Mr. FULTON. How much would be budgeted for the Moon flight?

Mr. WYATT. I would say the items that we do not charge in as part of the manned lunar program will probably rise to a billion and a half a year. The rest will be charged to the lunar flight program. The total will rise to about \$5 billion is our estimate.

There will be about \$3½ billion on the manned lunar landing. Of that we estimate about 30 percent is in requisite scientific information which stands on its own merits, but is essential to accomplishing the lunar program.

Mr. FULTON. On figuring your \$20 billion budget for landing on the Moon, can you give us how you progress toward it? How do you make that up? Certainly, it isn't just a guess. It has to be made up of this step and this step and in 5 years get to the Moon. How do you break that down so we have some idea?

Mr. WYATT. The technique we use in the estimating that was to actually break the program down into 1,800 separate tasks and try to time phase and establish a rough price tag for each of the tasks.

Mr. FULTON. Can you put in the \$20 billion projected for next year, and the year after, approximately? As the Doctor said, it will rise in 2 or 3 years to \$4 or \$5 billion a year.

Dr. DRYDEN. Total budget.

Mr. FULTON. Can you give us that phase?

Mr. WYATT. If I understand your question, sir, in the next year it will rise some place between three and four billion; the next year four to five, and we estimate it will remain at that level.

Mr. FULTON. Until 1966 or 1967?

Mr. WYATT. Until late in the decade.

Mr. FULTON. Is that on the basis of competition with the Russians, or is that on the basis of this measured 10-year program that has been talked of many times?

Mr. WYATT. That is on the basis of accomplishing a manned lunar landing before the decade is out.

Mr. FULTON. The question is in competition with the Russians or at your measured decade progress?

Dr. DRYDEN. Just as fast as it can be done.

Mr. FULTON. So you would call that a crash Moon program?

Dr. DRYDEN. No, I wouldn't call it "crash" in this sense, that the only planned parallel development at the moment is the solid propellant for the vehicle. We are also looking into the method of accomplishing the mission by rendezvous with a smaller vehicle. But we will not carry that forward at least initially with the same intensity as the direct ascent method.

Mr. FULTON. The next Mercury flight has been set for July 18. What is your recent estimate on that?

Dr. DRYDEN. What is that?

Mr. FULTON. Your recent estimate of time on Mercury.

Dr. DRYDEN. It will come within that week.

Mr. FULTON. Is this committee welcome to go?

Dr. DRYDEN. You will be kept informed.

Mr. FULTON. About the Apollo flight, is that considered as part of the lunar probe or is that separate?

Dr. DRYDEN. Apollo is the name given to the whole lunar program which has within it the manner satellite flight, the circumlunar flight, and ultimately the manned landing on the moon and return.

Mr. FULTON. When you make the estimate of the lunar flight there are these intermediate objectives which could be said to be, for example, a maneuverable vehicle in space, a rendezvous program, and things of that type?

Dr. DRYDEN. Yes. We are developing the whole technology of how man can operate in space.

Mr. FULTON. Could you give us shortly how you are moving up both the communications satellite as well as the Rover program?

Dr. DRYDEN. In the Rover program, as I think the committee knows, negotiations are in progress with Aerojet and Westinghouse as a team to first support the ground testing that is going on on Rover and to begin the design concepts and actual design of an engine as the program proceeds.

Mr. FULTON. I want to congratulate you on moving ahead on that program, as some of us think it is of prime importance not only for scientific research but for security reasons.

Dr. DRYDEN. On the communications satellite, the present situation is that the competition that was held by NASA resulted in the selection of RCA for the Project Relay launching. In addition to this, as you know, A.T. & T. desires to launch at their own expense what they consider to be a prototype of a possible operational satellite. And we are at present in negotiation with them as to the terms under which we will do it. The terms involve a complete payment of the out-of-pocket cost, payment for the launch vehicle, the launch services, everything that goes with it.

Mr. FULTON. I strongly recommend that both RCA and A.T. & T. program—

Dr. DRYDEN. Both are going forward. We have agreements with France, England, and now Germany has announced their interest, I believe, to build stations at their own expense, for cooperation in the experimental work with both programs. As a matter of fact, we have been in consultation with them very recently.

Mr. FULTON. That is all.

The CHAIRMAN. In that connection, Doctor, where private industry is willing to put up the money for something of that sort, weather satellite and communications, don't you invite them to do it?

Dr. DRYDEN. Yes, subject to proper agreements that protect the Government's interest. There are matters, of course as you know, relating to the patent aspects of our legislation, there are matters relating to the reporting and the availability of the information which we cover in our agreement when we undertake such a project.

The CHAIRMAN. And matters relating to regulation after any utility—

Dr. DRYDEN. This doesn't enter into the research and development part of the program.

The CHAIRMAN. Any questions? Mr. King?

Mr. KING. Dr. Dryden, I had a question or two on the manned lunar landing program, and I will not take long on it. As I understand it, the present thinking is that the space vehicle will be a Nova which will be completed sometime in 1967, 1968, 1969, there is some uncertainty?

Dr. DRYDEN. There are hopes for earlier.

Mr. KING. 1967, 1968, 1969, or 1970, or 1971. It becomes a theoretical target date—

Dr. DRYDEN. Our theoretical target dates are before the end of the decade.

Mr. KING. I understand there are other schools of thought with regard to our approach to this problem. I have been told, for example, by some who are experts in this line that the docking principle, the docking approach, offers some real possibilities and could cut off as much as 2 or 3 years from our target date, and that this principle involves sending not three men but one man and sending a craft which contains the fuel for only getting to the Moon. But that before the man lands on the Moon we send up, by a series of flights, fuel which will be available to him after he lands on the Moon; he will then refuel his craft from the resources that have preceded him

and that refueling will enable him to come back, and that by following that approach we can use the C-1 or the C-3 engine, which will be completed by 1964, perhaps. So that if we followed that approach we would have a theoretical target date of perhaps 1966 instead of 1968 or 1969 so we could cut off 2 or 3 years. To me this is a matter of extreme importance.

Dr. DRYDEN. There are five different ways of doing this job at which we are looking. We have taken the direct ascent and figured this one in great detail to get a basis for budget estimates. There are five methods if I can think of them all. One is the direct ascent with liquid rockets, direct ascent with solid rockets, the rendezvous in Earth orbit. This would mean in one form sending up seven Saturn C-2's, I think. In other words, you have to arrive with enough fuel from six of them to refuel the seventh so it will go on to the Moon. This we call rendezvous in Earth orbit. Rendezvous in lunar orbit, which doesn't seem to offer any advantages. Rendezvous on the Moon, which you have mentioned. This is being looked at. The problems are those of accuracy in getting the material where the man can use it. It is much like a parachute operation in the Far East, where you can resupply the man, but you have the problem of getting the stuff down to where he can get hold of it. A man on the Moon with his supplies scattered over an area of 25 square miles is going to have a bit of a time assembling all of this to come back.

Mr. KING. Wouldn't it involve, however, sending a large flare or a beacon first, and then it would be zeroing in on that beacon, with available technology. Today, presumably, you could come within 25 or 50 or 100 feet of that beacon on either side so you would not have an insuperable technological problem?

Dr. DRYDEN. You have stated the problem. It concerns a guidance problem which is more severe than some of the other methods. We are looking at this method as well as the others. I should say the final technical decisions cannot be made until we know what resources we have from the Congress. We cannot go ahead—we in effect have said, I think, I said a while ago, that there is not much use spending this money unless you are going ahead with the project. If you give us half the money, I wouldn't know how best to proceed, to be quite frank.

Mr. KING. Isn't it true that this method that we are discussing from a technological point of view is a much more modest program, at least from a financial outlay, than some of the more elaborate programs which presumably are the ones toward which you are bending your efforts now?

Mr. WYATT. I think it would be unfair to say it is much more modest. The development of the rendezvous technique, the development of the very highly specialized guidance, when we talk about placing objects to a predetermined spot of, say, 100 feet or so, is a rather large step forward in technology. Well, in essence, our studies indicate there are no gross differences at this point, that we can determine that one is inordinately cheaper than another. There is a tremendous amount of technological development that has to be done in any event.

Dr. DRYDEN. In about 2 years we should know much more about rendezvous techniques and their capabilities.

Mr. WYATT. That is correct.

Mr. KING. I would like to say for the record, and I am sure I am expressing your own feeling that in view of the fact that we are definitely in a race with Russia to the Moon, I would hope that NASA would give fullest consideration to every possible method, I won't say alternative method because different methods have different capacities, different assets. They accomplish different objectives, so they are not exactly equivalents. I would hope that they pursue every possible path that will bring us to the Moon and to the Moon as quickly as possible.

Dr. DRYDEN. The race is not to the Moon, but to get the man back. We can put the man on the Moon if you are willing to leave him there very much earlier.

Mr. KING. I agree.

Mr. FULTON. I will always go. I volunteered.

Dr. DRYDEN. You want to go and stay?

Mr. FULTON. I have some people who would like me to.

Mr. CHENOWETH. Am I wrong in the impression that I had that you had contemplated this trip to the Moon all along in your original program?

Dr. DRYDEN. All along except the first steps toward Nova were in the 1963 budget.

Mr. CHENOWETH. When we had Dr. Seamans who is in charge of that program before the committee I thought he said 1969 would be about the time that we would complete the project.

Dr. DRYDEN. I think he said he thought you could do it in 1969 if it was adequately supported.

Mr. CHENOWETH. I thought it could be moved up beyond that if you spent more money. How important do you think it is to put this man on the Moon? I don't think the American people—

Dr. DRYDEN. I think I said earlier the mere putting the man on the Moon is not very significant, but the effort to put him there and all that brings to this Nation is indispensable to our Nation. This is a symbol.

Mr. CHENOWETH. You think there is no substitute for putting a man on the Moon? Do you feel that sincerely and honestly?

Dr. DRYDEN. Someone has said why don't you take the manned-earth satellite as the only objective. The Russians can do that tomorrow if they have been building the vehicles. We are going to build an earth satellite as one of the necessary steps in the manned lunar landing program.

Mr. CHENOWETH. We have great respect for you. You have changed your attitude a little bit here in the last few months.

Dr. DRYDEN. In what way?

Mr. CHENOWETH. You didn't present such a program when you were here before. What has caused the change in your thinking?

Dr. DRYDEN. Two or three months ago you had a document before you from President Eisenhower which said that he saw no reason for going beyond Project Mercury with manned flight. I could not submit this kind of a budget under the rules as you know.

Mr. CHENOWETH. I don't think it makes much difference who is President of the United States.

Dr. DRYDEN. I think it makes a lot.

Mr. CHENOWETH. As far as rendezvous with destiny is concerned. Who was it said that? We used to have the fireside chats and he said the future fireside chats will be with the tax collector.

Dr. DRYDEN. The first step is a decision, as I understand it—

Mr. CHENOWETH. Do you think just by spending money, which is proposed here, additional amounts of money, we are going to put ourselves in any more substantial or protected position so far as our safety is concerned? Do you really feel that?

Dr. DRYDEN. I really do. I have talked with many Germans who have said, "Our country used to be a great industrial nation. We have lost many years. Space technology is something we cannot stay out of because if you are going to be a leading industrial nation, you have to work at the frontiers of science and technology."

That is where the frontier is today. You read in the paper the German Government the other day voted some \$20 or \$30 million, I have forgotten the amount, to join with the British in a European development of a launch vehicle. Any country which wants to be among the leading powers in science and technology can just not ignore the field where the frontiers are.

Mr. CHENOWETH. How much are you increasing the budget for 1962?

Dr. DRYDEN. From \$1 billion to \$1.7 billion, roughly. It is 61 percent over the original submission.

Mr. CHENOWETH. How much has it been increased since you were here before?

Dr. DRYDEN. \$549 million.

Mr. CHENOWETH. Next year to \$5 billion.

Dr. DRYDEN. Within about 2 years.

Mr. CHENOWETH. That will stay at \$5 billion for about how many years?

Dr. DRYDEN. For the rest of the decade, I think.

Mr. CHENOWETH. Run about \$50 billion?

Dr. DRYDEN. Yes.

Mr. CHENOWETH. That is the amount that you are going to spend to put the man on the Moon.

Dr. DRYDEN. That corresponds to what you spend in the Defense Department in a year and a half.

The CHAIRMAN. You are increasing the amount over the committee by \$400 million.

Dr. DRYDEN. Yes, about that.

Mr. CHENOWETH. Suppose you increased it to \$1 billion?

Dr. DRYDEN. The money would stay on the accounts until we could get the necessary preparatory work and specifications and so on.

Mr. CHENOWETH. I had the impression that that was your situation before, that we were giving you all the money you could economically spend.

Dr. DRYDEN. With the objectives that were then stated, which was circumnavigation of the Moon within the decade, not landing and return.

Mr. CHENOWETH. Around the Moon and return.

Dr. DRYDEN. Yes.

Mr. CHENOWETH. Now, we are going to land and stay awhile.

Dr. DRYDEN. Yes.

Mr. BROOKS. May I ask you a question or two, Doctor, that may open up some other questions? The Senate bill differs from the House bill in a number of particulars. For instance, take the last section, section 4 of the Senate bill on page 10. It refers to the transfer to other agencies of the Government of funds, not more than \$20 million may be transferred by the Administrator. What does that mean? After we authorize it to you, then you transfer it to another agency.

Dr. DRYDEN. This refers to such matters as have been discussed in connection with life sciences of utilizing the facilities of the Department of Defense. This would make it possible to transfer up to a certain amount to the Department of Defense for such purposes, and if the amount is of a certain magnitude, it is necessary to consult the committees.

The CHAIRMAN. That is a considerable amount, \$20 million. Why do you need any \$20 million for that?

Dr. DRYDEN. I can't give you a particular example at the present time. But we at the present time, of course, are reimbursing the Department of Defense for services. I don't know what the totals run. The object was in the program of a size of \$1.7 billion and under directions to utilize all the resources of the Government and the United States that this transfer authority would make it possible to use facilities that existed in other Government agencies to carry out certain obligations.

The CHAIRMAN. Let me ask you about another provision. These will probably provoke questions later on of other witnesses.

Mr. MILLER. May I ask a question. In the Armed Services Committee, wasn't it usual that we set aside a percentage?

The CHAIRMAN. We are coming to that in the next question. In reference to section 3, we had not to exceed 5 percent of the funds—under what was it, research and development?

Dr. DRYDEN. That is an internal adjustment, sir.

The CHAIRMAN. This changes the rule, however, so that the 5 percent would be increased up to \$50 million under this arrangement—I am corrected. I am told this might even go to \$120 million, the 5 percent. Why would you need all of that?

Mr. ULMER. Mr. Brooks, the bill that was before your committee provided that a total of 5 percent of the sum of the S. & E. appropriation and the R. & D. appropriation could be used for emergency construction purposes.

This provision parallels the annual provision contained in the appropriation act that permits the transfer of up to 5 percent between appropriations provided nothing is done to increase the salaries and expenses appropriation.

This gives us the kind of flexibility that allows us to undertake a construction project, if it comes up, that we had not had time to discuss with you people. It allows us to fund that project by the transfer of funds from the S. & E. and the R. & D. appropriations. Some program in one of those appropriations would have to be cut to fund this emergency construction project.

The situation can well arise where it would be more desirable to adjust the projects within the construction of facilities appropriation rather than by cutting programs under the R. & D. appropriation. So that we have asked to get a somewhat comparable flexibility within

the construction appropriation that you have already indicated you are favorable to provide us by the transfer of S. & E. and R. & D.

The CHAIRMAN. We didn't indicate any favor of giving you \$125 million flexibility. Ours was much more limited than that.

Mr. ULMER. The figure you mention, of course, is correct, sir, if you used the sum of 5 percent of the S. & E. appropriation, 5 percent of the R. & D. appropriation, and the \$50 million authority requested in the construction of facilities appropriation; you could conceivably come up to that figure. I believe it is fair to say we have no intention as far as I know at this time of exercising the full amount. It is important that we have the flexibility of determining from which appropriation it would be most desirable to fund emergency construction projects.

The 5-percent figure was picked primarily to provide comparability with the appropriation transfer amount that is provided annually in the appropriation act.

The CHAIRMAN. You have the intention of using how much of that?

Mr. ULMER. We don't know, sir.

Dr. DRYDEN. We don't know if we will use any.

The CHAIRMAN. I want to ask you another question then for the benefit of opening this up. You have a provision in the Senate bill on page 7 for grants to nonprofit institutions of higher education. You have a provision there which permits the use of \$250,000, not more than that, for construction purposes, as I read this, grants, rather.

Mr. ULMER. I believe the \$250,000 figure is the limit at which committee notification is required. This is the same limitation placed on the use of any emergency authorization. Any item costing more than \$250,000 through emergency authorization provision must be placed before your Committee and the Senate committee on a notification basis.

Dr. DRYDEN. I think that sentence is not really connected with the grant authority of the preceding sentence. This is a whole series of sentences dealing with the research and development appropriation.

The CHAIRMAN. That is correct.

Dr. DRYDEN. The authority requested for universities is parallel to that of the Science Foundation.

The CHAIRMAN. I wanted to mention that. I think we ought to go into that a little deeper as we proceed with these hearings.

Dr. DRYDEN. I might make this general statement: That to carry out any such major enterprise as going to the moon, I have spoken of enlisting the facilities of the Department of Defense in certain areas. I think it is also apparent we have to have a greater base in our university population. We are going to have the capabilities of sending many tons of material into space. The development of scientific equipment of any such magnitude has to begin at a very much earlier date in the universities. We feel that we have to strengthen the work that is going into the advanced thinking about experiments, the prototype experimentation at universities, and the problem that we often come up against relates to facilities. For example, Van Allen at the State University of Iowa, is working in terrible conditions in the basement of an old building.

We can give him a million dollars to help us in the development of instrumentation, but we can't help him remedy the housing situation at all.

The CHAIRMAN. No safeguards are provided whatsoever. You can simply make a gift, a grant of \$250,000, up to that amount—

Dr. DRYDEN. Only if there is some value to the Government in this. This is exactly the same authority that the Science Foundation has in its university program.

Mr. MILLER. Mr. Chairman, why can't the Science Foundation do this thing? Why should we have two agencies doing it, Doctor? I am a little concerned when you talk about the implication that we could go out to a State university and make a grant, a substantial grant in order to house someone. This may be necessary, but if the Science Foundation can do this, and they can, why do we have to duplicate that work here?

Dr. DRYDEN. We are talking about our work and not that of the Science Foundation. We are talking about the people who are developing the scientific instrumentation to be used in the scientific investigation of space.

Mr. MILLER. I have gone through this with another agency with respect to grants. Suppose it is necessary to construct a \$250,000 laboratory, a \$500,000 laboratory, for Dr. X at University Y; who is going to own this building and the facilities, the equipment, after he is disposed of?

Dr. DRYDEN. This equipment? It provides that under certain circumstances the title may be vested in an institution, but only where there is a benefit to the United States that justifies the making of such a grant.

Mr. MILLER. What could constitute that? I see this thing, and I have had it before, with a proposition of opening up, that any university can come in and say, "We are going to do this, somebody is going to give you a million dollars to do it," and it is very easy to say, "Well, this is in the best interests of the United States."

If we are going to do this, why can't we do these things in our own laboratories?

Dr. DRYDEN. I think the provisions for committee notification of certainly anything which is substantial—

Mr. MILLER. You know this committee notification. The deal is all made before it comes to the committee as a matter of practice. We can come in here and always justify a lot of things. To me it looks as if some people in science feel that under the guise of doing this thing we can do anything.

I have had one university approach me, telling me what they can do, and all they want is \$4 million.

I believe that it is going to be necessary to do these things, but any physical facilities that are built should be built and retained in the name of the U.S. Government and not given to—

Dr. DRYDEN. As I say, this was patterned after the authority of the Science Foundation. Our purpose in all this is the same as the purpose in utilizing other facilities rather than still further increasing facilities at our own laboratory to persuade the scientists of the country that they must come to our laboratories and work directly for us.

We would like to have the benefit of the brains of people like Van Allen, of Simpson at Chicago, and others in this program.

At the present time we can make contracts with them and grants in certain cases, to work in specific areas of instrumentation, to par-

ticipate in the flights of satellites. We are not able to remedy even the worst possible situation in this area of facilities.

If the committee wishes to introduce a provision that the title remains with the Government, I think this is certainly something which the committee can do.

I would still like to be in a position in the unusual cases of being able to get the job done at universities where people with the brains required are located.

The CHAIRMAN. Doctor, may I ask you this: You have authority to contract. Couldn't that be done under your present contractual authority?

Dr. DRYDEN. We do this now. We do make contracts with many institutions and universities.

The CHAIRMAN. Couldn't this authority really be utilized under your contract authority that you presently have?

Dr. DRYDEN. I think that if we built any facility at a university of any magnitude, that this has to be treated as one of our own facilities as part of the construction and facilities item in which we retain title, of course.

The CHAIRMAN. You would retain title even though your contract provided for certain research work to be done in return for which—

Dr. DRYDEN. It is just like facilities—

The CHAIRMAN. You would give them certain facilities in which to do—

Dr. DRYDEN. It is like a test stand at a manufacturer's test plant to which the Government retains title.

Mr. MILLER. I can see in the liquidation of this eventually you are not going to get much out of it. I think legislation or a restriction of that kind would get away from the criticism that there is a grab bag open, and that—

Dr. DRYDEN. The essential point from my point of view is to be able in a few cases to provide certain facilities.

The matter of title is a matter that you can decide. This is left flexible so that the title could be passed—

Mr. MILLER. I wonder if the staff could work out with their proper opposite numbers in NASA some solution for this plan and present it to us where we might have more control and some protection in federally owned property?

The CHAIRMAN. I think that is a good idea. I think the staff should go over these three changes in detail with their counterparts in NASA, more detail than the full committee is able to do.

Mr. Bell.

Mr. BELL. Dr. Dryden, I noted by the chart that you had, that there was from the original amount of the nuclear propulsion engines that we had advocated in our bill of \$28 million, you upped it to \$36 million, approximately that.

As you will recall, this committee discussed the increasing of—the reinstating of the amount of \$15 million for construction facilities and another \$8 million for Kiwi B tests in the research and development.

Dr. DRYDEN. That has been done. That is the \$36 million.

Mr. BELL. That made the \$28 million?

Dr. DRYDEN. Your own report says an increase from \$28 million to \$36½ million.

Mr. BELL. Then I was mistaken. This amount is our report?

Dr. DRYDEN. Yes, your report.

Mr. BELL. Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Ryan.

Mr. RYAN. Going back to the subject, which Mr. Miller brought up, you stated that your determination about the construction of the placement of these facilities would be according to the person, the individual who was doing the work at the university, is that correct?

For instance, Van Allen at Iowa? What happens if Van Allen—

Dr. DRYDEN. I would say our interest is primarily in the capable individuals and scientists in the space program rather than the universities where they are at the moment, that is correct.

Mr. RYAN. Say the person you are interested in moves to the University of Pittsburgh.

Mr. FULTON. That is fine.

Mr. RYAN. Say that—are you going to continue construction at Iowa?

Dr. DRYDEN. I think you are bringing out the fact that we must have a proper kind of protection in the agreements with the university before we go into such an enterprise.

The situation that you have described is not an unusual one. It does happen. In certain key projects, if the man moves, we have to move the project with him because it makes no sense if there is no one left who has the capability, and you are perfectly correct, you couldn't move an item of capital equipment of this kind.

Mr. BELL. I hadn't quite finished my question there. Dr. Dryden, I wanted also to add my remarks to Mr. Fulton's to congratulate you for increasing the amount on Project Rover. I was wondering relative to nuclear propulsion if this plus the Snap takes in all the nuclear propulsion methods of vehicles—

Dr. DRYDEN. Not all that people have conceived. We have on the research side of our house an advisory committee on nuclear matters generally. They have recently completed a review of all these many methods.

In general, our present reactors are solid reactors. There is much interest in gaseous fuels. There are certain schemes conceptually under study in which you can pass gas through and still retain the fuel element within the system.

There is a project called Orion that you may know which has been in a research and development stage and will have to be as long as the nuclear test ban is on because they cannot make the kind of experiments at present to carry that forward.

Mr. BELL. Are you at all familiar with that project Orion?

Dr. Dryden. Yes. It is a project that you cannot test on a small scale. It presents a difficult public policy question because you have to spend a large amount of money to test its feasibility. You cannot make an inexpensive model of it.

The CHAIRMAN. I want to make a short announcement.

Some time ago I asked Mr. Finch, of our staff, to get for the committee room appropriate pictures representative of the work in the background and history and aspirations of this committee.

I think you can look around you and see some of the results. We have, for instance, this picture from NASA here to the left. And the picture just beyond that is from the Air Force, and here we have a picture from the Navy; and over here another picture from the Navy. This is an Army picture. In this work he has had the help of Captain Silberstein and Colonel Goodwin and Colonel Sims, all of whom have made very valuable contributions.

I think you are doing a good job, Mr. Finch, and just continue it. We have one blank space over there and one here. We would like to get some nice pictures for that.

Mr. FULTON. Is this a suggestion to the current witness?

Dr. DRYDEN. We might do something about that.

The CHAIRMAN. I trust the witnesses are listening.

Mr. BELL. In view of the possibility of what we have been reading in the newspapers about the nuclear test ban being lifted, is there any possibility of further exploration of this Project Orion as a possible vehicle to be of importance?

Dr. DRYDEN. This has been discussed between some of our people in Defense. I am not up to date on the most recent discussions.

I think our position has been that we have been interested in carrying forward research in this field. We hesitate about saying that we will spend many hundreds of millions of dollars just to try it out and see if an idea works. This has been the problem.

Mr. FULTON. On that point, Orion is a series of nuclear explosions in space as a propellant. As a matter of fact, if we are going to have deep space probes with higher than ordinary space speed, we are going to really need Orion, aren't we?

Dr. DRYDEN. This I can't answer categorically at this time. It is a means of starting, let us say, a few hundred tons on the way.

Mr. FULTON. So that if we are going to have, for example, a deep space probe or to have major carriage of freight on a trucking basis to the moon, we do need something—

Dr. DRYDEN. It has been proposed for placing a little village in Earth orbit, many hundreds of tons in orbit many miles above the Earth. I think you would have to use it as a launch platform, if you like, for deep space probe rather than using the principle out to a great distance.

Mr. BELL. It hasn't been disproven as yet, has it?

Dr. DRYDEN. I don't think the proponents have ever advocated deep missions in space with it. They have talked about very heavy weights in Earth orbit.

Mr. FULTON. Another point is this: On the Moon, if the Moon is to be a propaganda symbol, which it evidently is getting to be between Russia and the United States, and we are in a competition for landing on the Moon for prestige purposes as well as research and development, isn't it possible now that the Russians could aim at the Moon because they have already impacted the Moon with a rocket, and have an explosion on the Moon's surface which would create a red dust and turn the whole Moon red, because there is a great probability the Moon is just dust.

I think that is possible right now.

Dr. DRYDEN. I have seen many discussions of putting a red spot on the Moon. I have never seen anybody who thought they would cover the whole globe with red dust.

Mr. FULTON. They could at least put a red symbol on the Moon is what I am coming to, couldn't they?

Dr. DRYDEN. This has been discussed. It takes quite a quantity to be seen by other than with a very large telescope.

Mr. FULTON. Maybe we should have a project, a blue project to scatter blue dust so then that the Moon is red, white and blue.

Dr. DRYDEN. That is an interesting idea.

The CHAIRMAN. Further questions?

If not—

Dr. DRYDEN. May we introduce in the record a chart on this emergency authority question? It identifies various authorities in the appropriation and authorization bills. I think it will help the staff to have it in the record.

The CHAIRMAN. If there is no objection, it is so ordered.

(The information requested is as follows:)

June 26, 1961

REQUESTED APPROPRIATION ACT FUND TRANSFER AUTHORITY AND AUTHORIZATION ACT REPROGRAMMING

AND EMERGENCY CONSTRUCTION AUTHORITY - FISCAL YEAR 1962

Appropriation Act
fund transfer authority 1/

Appropriation title

Authorization Act authority

Congressional notification

5% to →
R&D or CoF

Salaries and Expenses

Not to exceed 5 per centum of any appropriation made available to the National Aeronautics and Space Administration by this Act may be transferred to any other such appropriation, but the "Salaries and expenses" appropriation shall not be thereby increased. 1/

Research and Development

5% to →
CoF

Any portion of authorized amount may be used for capital items which may be required for the performance of research and development contracts and for grants to non-profit institutions of higher education for purchase or construction of additional research facilities (Sec. 1(d)).

Required if estimated cost, including collateral equipment, exceeds \$250,000.

Not required.

5% adjustment between line item authorizations (Sec. 2.).

Required

\$50 million available for emergency construction at any location, by reprogramming line items (Sec. 3.).

Construction of Facilities

5% to →
R&D

Required.

5% of total of S&E plus R&D appropriations available for emergency construction at any location (Sec. 3.).

1/ This authority has been included in previous years' Independent Offices Appropriations Act and is included in H.R. 7445 the fiscal year 1962 Independent Offices Appropriations Act.

2/ In addition, the National Aeronautics and Space Act of 1958 (Public Law 85-568) in Sec. 307(b) provides emergency repair authority as follows: "Any funds appropriated for the construction of facilities may be used for emergency repairs of existing facilities when such existing facilities are made inoperative by major breakdown, accident, or other circumstances and such repairs are deemed by the Administrator to be of greater urgency than the construction of new facilities."

The CHAIRMAN. We will adjourn until tomorrow morning at 10 o'clock.

We want to thank the witnesses for being present this morning. We will try to close it up tomorrow.

(Whereupon, at 12:07 p.m., the committee adjourned, to reconvene at 10 a.m., Wednesday, July 12, 1961.)

1962 NASA AUTHORIZATION

WEDNESDAY, JULY 12, 1961

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C.

The committee met at 10 a.m., pursuant to notice, in room 214-B, New House Office Building, Hon. Overton Brooks (chairman) presiding.

The CHAIRMAN. The committee will come to order.

We have two matters of business to take up, but I think we had better wait until later, probably just before 12 o'clock to take up these two particular matters.

In the meantime, this morning we are continuing with the hearings which we began yesterday, to bring us down to date on the recommendations of the NASA in reference to their needs for development.

Dr. Dryden was here yesterday and I told him I didn't think we would need him this morning. We will begin this morning, however, with Dr. Abe Silverstein, Director, Space Flight Programs. He will be supported by Mr. D. D. Wyatt, Assistant Director, Program Planning and Coordination.

I think Dr. Silverstein has a statement he wants to make before getting into his testimony to the committee.

I think it is of general interest to all the members of the committee; that is in reference to Tiros.

Do you want to make your statement at this time?

Dr. SILVERSTEIN. Yes, sir.

I just wanted to announce that this morning at 6:25 we launched a Tiros satellite into orbit; Tiros III. The launch was very successful. We are getting pictures from it now. If possible, we may be able to bring a picture in this morning taken on the satellite.

The CHAIRMAN. How high is Tiros?

Dr. SILVERSTEIN. About 400 miles high—

The CHAIRMAN. Is it an elongated orbit?

Dr. SILVERSTEIN. It is nominally circular.

The CHAIRMAN. You expect it to be in orbit for some time?

Dr. SILVERSTEIN. Yes, sir. As you know, Tiros II is still transmitting pictures. We are getting good pictures from Tiros III, which differs from Tiros II in that we have put two wide-angle cameras in Tiros III.

Our experience has indicated the value of the wide-angle pictures for meteorological purposes.

The CHAIRMAN. You have nothing else in the Tiros III?

Dr. SILVERSTEIN. Nothing but the equipment that I stated.

The CHAIRMAN. You are in the program that you are presenting to us this morning?

Dr. SILVERSTEIN. You will find in our presentation this morning funds to insure that we can continuously maintain in space one of the Tiros satellites in operating condition.

The CHAIRMAN. I read something the other day in reference to the arrangement of the clouds in a hurricane or in the formation of a hurricane in rows, one row on top of another row, which was a matter of study from pictures of Tiros. Is that the purpose of the Tiros at this time? This is the beginning of the hurricane season, now.

Dr. SILVERSTEIN. The date for this flight was picked deliberately in an attempt to get pictures of the origin of the hurricanes and to watch their development.

This sort of data has never been available and we hope as the hurricanes form during the season we will be able to watch them as they are initiated, grow, and develop. I am sure this will add data to the basic meteorological field that cannot be obtained in any other way.

The CHAIRMAN. I hope you get those pictures in time before we adjourn this morning. We would like to see them.

Is there any question on this announcement from any member of the committee?

If not, Doctor, will you proceed then to explain to us the additions that were added to the House bill by the Senate bill and the recommendations of NASA in support of these additions.

STATEMENT OF DR. ABE SILVERSTEIN, DIRECTOR, SPACE FLIGHT PROGRAMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. SILVERSTEIN. Yes, sir. I thought I would first review briefly some of the material that Dr. Dryden presented yesterday. You will recall he described the additions to the program. My phase of the program is spacecraft. These are the satellites and deep space probes that we launch into orbit or out into space, and in this area we have requested additional funds for the Apollo spacecraft program. The funds that were recommended in the House bill were in the amount of \$72,100,000.

In the new request based on the President's request, they are \$160 million, or an increase of about \$88 million.

I thought it would be desirable to review briefly with you the Apollo program, so that you would know how these funds are to be spent and the missions to be accomplished, if you think this is desirable.

The CHAIRMAN. I think that is very desirable.

Dr. SILVERSTEIN. I have a few charts for that purpose.

The CHAIRMAN. Can the members see? If not, you can come forward some.

Dr. SILVERSTEIN. I would like to emphasize something I think that is obvious to almost all of you who have thought about this lunar landing program, and that is, it is a very difficult mission. As you study this problem, with its many, many tasks that need to be performed successfully, I think it is possible to recognize the magnitude of this technical attempt.

In order to lay a proper background technically to accomplish this feat, there are many things we must do and many approaches we must take, all of which must be accomplished successfully before we can make the final effort.

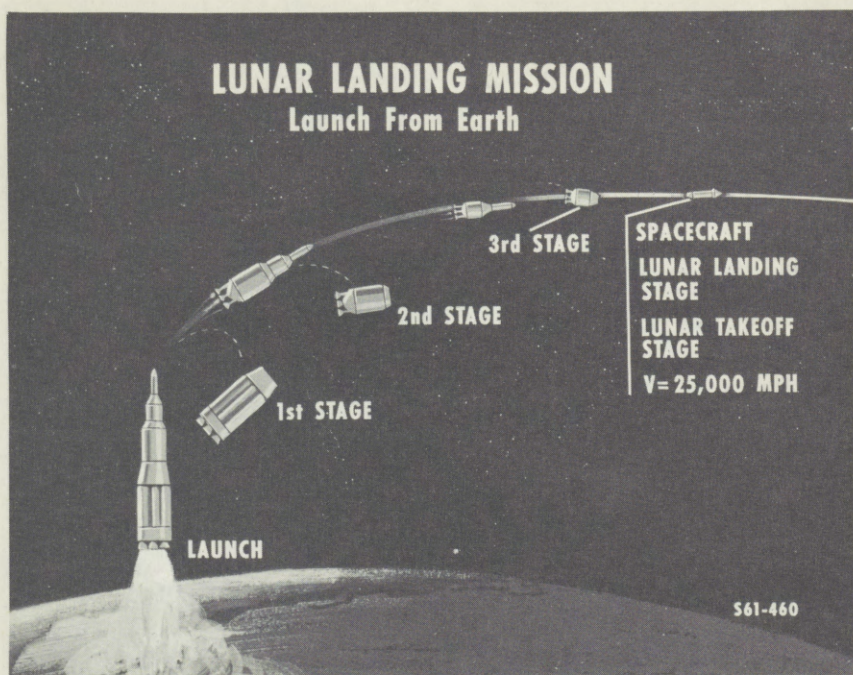


FIGURE 333

To do this we have arranged a program which will include both direct ascent to the Moon, as well as an approach through rendezvous. In the direct ascent method, we boost from the ground the major booster, with upper stages for a number of principals, plus additional smaller stages for control, and go directly to the Moon on the path, landing on the Moon and then taking off from the Moon.

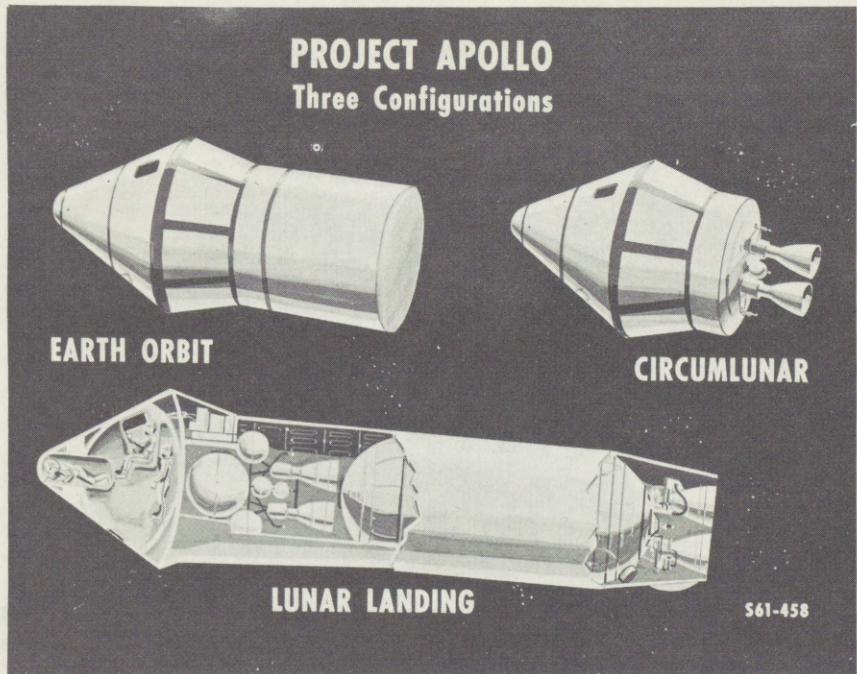


FIGURE 334

On the rendezvous method, Dr. Dryden yesterday, I think, briefly sketched out five different rendezvous approaches that can be used; instead of going directly, you stop at an intermediate point in space, whether it be in an orbit around the Earth or an orbit around the Moon or on the Moon, and resupply in some fashion the vehicle in which the men are being carried.

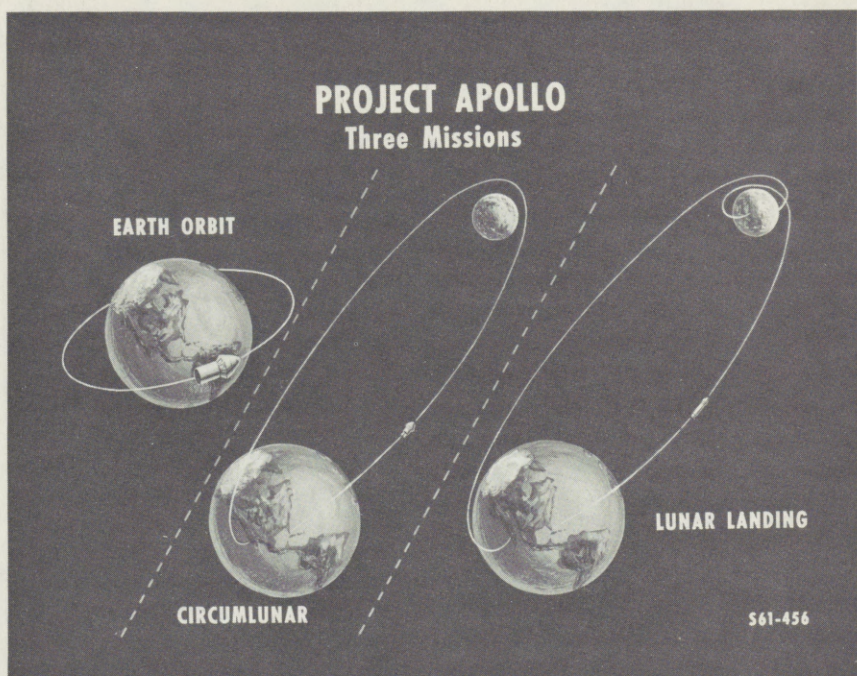


FIGURE 335

We have examined these various approaches. No final decision on the best approach for using the rendezvous technique has been reached. There are some who favor rendezvous around the Earth, in which you would send into orbit a number of supply vehicles, tanks full of fuel, and then send the man up and join him to these tanks of fuel, and continue the trip.

Or you might send up the man with a big tank and refuel the tank in space. Either one of these methods is included in what is called the Earth rendezvous.

Or you could send vehicles to the vicinity of the Moon, which would orbit the Moon, and then rendezvous at this point.

Or you could send tanks of fuel ahead to the Moon, then send the man to the Moon, and have him use the tanks of fuel that you have sent ahead for the return flight.

The CHAIRMAN. Which is the preferable method to use, Doctor?

Dr. SILVERSTEIN. Right now I think there is some technical disagreement among the people who are studying it. I personally have a preference for a rendezvous around the Earth. There are others who argue for the other point. I think this will be settled fairly quick.

Mrs. WEIS. Do they feel that is more successful than the direct approach?

Dr. SILVERSTEIN. I think there again you will find that there are, as there are in most technical problems, different groups of people who have very firm points of view, and some of their points of view are very solidly based.

I think we must say that there are also in any engineering problem several ways of accomplishing an end object, an end mission.

Sometimes either one of the methods that is pursued vigorously, intently, and intelligently will accomplish the job. I think we might be in that sort of situation here.

Mrs. WEIS. There seems to be more discussion of the rendezvous method than the direct approach.

Dr. SILVERSTEIN. I think it depends on whom you talk to last. I get inputs from many sources and I find both schools of thought. I think we must of necessity at the present time follow both methods. It is the true parallel approach.

The CHAIRMAN. Is it easier to make this launching, a lunar launching, when the Moon is 219,000 miles away, or is it easier to make it when it is 240,000 miles away, like it was last night when you saw it.

Dr. SILVERSTEIN. Actually the Moon, the orbit of the Moon, is almost circular. There really isn't quite that change in its radius. It does change in radius some but the orbit of the Moon is quite circular. So you don't have quite that choice in selection of time.

Mr. RIEHLMAN. Doctor, the rendezvous approach, may I put it that way, seems to me tremendously complicated. I am just wondering, in your own mind do you feel confident that this can be accomplished?

Dr. SILVERSTEIN. Yes, I feel absolutely confident it can be accomplished after the right sort of development. When you say "it seems complicated," you are exactly right about it.

I must also say that the development of the booster of the size required for the direct ascent is also complicated. What you are weighing here is the complication of the rendezvous method versus that of development of a booster of a large enough size to do the direct ascent. You can use a booster for a rendezvous technique which is very much smaller. You are weighing these two complications. I think currently the only safe approach is to do both for the time being.

Mr. RIEHLMAN. My biggest apprehension or greatest apprehension that I have in regard to this is the timing for the rendezvous in space.

It seems to me this is tremendously complicated and the timing has to be just about 100 percent accurate or you are not going to make this rendezvous.

Dr. SILVERSTEIN. Throughout this mission, and I stress it again because it is the most important point, the accuracies required are extremely high. They are no higher for the rendezvous than for hitting a certain spot on the Moon. The type of guidance and control equipment that we develop and the type of navigation equipment that we use for this mission are going to require a very high level of performance from the equipment.

We really don't escape the problem, whether we go one way or the other.

Mr. RIEHLMAN. The rendezvous versus the direct ascent is a question of construction of a booster large enough to make the direct ascent, versus the number of smaller boosters with payloads to accomplish this feat?

Dr. SILVERSTEIN. That is right. There are certain probabilities involved here. For example, with the rendezvous technique you have to be assured of getting these flights off in succession successfully within a given time period. This means that your assurance with

regards to the vehicle integrity and your probabilities of success of every flight, need to be known.

Mr. RIEHLMAN. What size booster do you estimate would be necessary for a direct ascent?

Dr. SILVERSTEIN. This is variously calculated but with liquid propellants our current calculations are that you need about 12 million pounds of thrust in the base booster.

Mr. RIEHLMAN. We don't have anything anywhere near that at the present time?

Dr. SILVERSTEIN. We prepared ourselves some time ago in developing one engine with a million and a half pounds thrust. If we group eight engines, as we do in the Saturn, that would make 12 million pounds.

Mr. RIEHLMAN. That would be a pretty large booster.

Dr. SILVERSTEIN. Yes.

Mr. RIEHLMAN. We have no facilities at the present time to launch such a booster?

Dr. SILVERSTEIN. That is a problem. I think General Ostrander, as he discusses the launch problem, will mention the fact that this is part of the cost of this program.

The CHAIRMAN. You don't even have a barge to take it down to Canaveral.

Dr. SILVERSTEIN. I think yesterday it was mentioned there were close to 1,500 separate tasks to be accomplished and one of them is the problem of construction and transport of the vehicle.

Mr. RIEHLMAN. Another question of great interest to me is this: Do we have available at this time the personnel that are necessary to put this great program that we have outlined before us into operation?

Dr. SILVERSTEIN. I think that this country is blessed with a very extensive industrial complex which is qualified to do this job, and some of it is available due to the fact that our aircraft industry, as you know, has not initiated new aircraft construction at a high level during the last few years. This industry that was able to turn out many new airplanes year after year is not now occupied as heavily as in the past.

So I think we have the industrial capability. Within this budget we have shown additional personnel required by NASA to manage the program.

It is extremely important that we bring abroad additional people of high quality to help manage the contracts that we will let with industry and to help coordinate our industrial and university efforts. It is equally important that we bring into this program over the period of years the youngsters that will have to join in the program, see that they are properly educated, and support their efforts. In this way as the program grows for the next 10 years, and as our whole technological development grows, these people will be able to contribute to it.

Mr. RIEHLMAN. This is one of my great interests, whether or not you in NASA can get the people that you need for the managing of this type of program. I hate to use the word, but it is a fantastic type of program that we are approaching. It is going to take the best minds, and the best men that we can possibly get, not alone in industry, but to manage the program and see it is followed through to a successful conclusion.

Dr. SILVERSTEIN. I feel sure that we can accomplish getting the right personnel. We now have on board, as you know, over 16,000 trained people in the NASA organization, plus the people at our JPL organization.

We are asking as you know, in this amended budget, for more people. There is sufficient interest in this program among highly trained people in the country so that the people required to accomplish this new part of the program can be added.

I think I can say our organization is one of the finest technical organizations that has ever been put together.

Mr. KARTH. Mr. Chairman, this technology that is involved in getting a man to the moon and back is so extremely important that I think it merits a few minutes discussion. I agree it is extremely complicated no matter which of the two approaches that we use. It would appear to me that although great technological problems are involved, it might be easier to work them out when you can work them out on the Earth rather than to work them out in space, where you cannot work them out so easily, and an error, if one does occur, would be much more disastrous than it would if it occurred right here.

I have this question, Doctor; if you had the booster that was big enough to make the direct flight and return, which then would be the preferable method?

Dr. SILVERSTEIN. Obviously if you had the booster and this booster were man-qualified in some way, you would use the technique that was developed. As I pointed out, there are always different ways of accomplishing an engineering task. For example, we can build suspension bridges or we can build bridges on piers. There are many ways of crossing a river. It is a very hard to say whether one is better than the other.

If, however, any one of them were developed right now, you would use that technique, I am sure. The fact is we do not have this booster now. We do have the basic engine that has been under development for almost 3 years, and which is currently beginning to shape up as a propulsion system.

Mr. KARTH. One wouldn't do that job, doctor, even the rendezvous job, would it?

Dr. SILVERSTEIN. No, sir.

Mr. KARTH. You are talking about a C-2 or 3?

Dr. SILVERSTEIN. It is C-3 that is required.

Mr. KARTH. It is not in the immediate future? It is several years away, is it not?

Dr. SILVERSTEIN. If you examine the developments that have gone on in the past, the long leadtime item in most of the programs that we have had has been the basic propulsion system, the engine. This has always been the longest leadtime item. This is why our starting development of the F-1 back in January, 1959, was a very good thing to do, because it has given us now under our belt almost 3 years of work on this engine. It takes about 5 years to go from a drawing to an engine. Admittedly you don't have the booster system. This is again a problem, to develop the system, where you put the engines together with the tankage and with the various control systems that are required, and make a true vehicle out of it.

Mr. KARTH. Even longer than the technology involved in rendezvousing in space, let's say eight or nine vehicles, probably?

Dr. SILVERSTEIN. I can't answer this exactly, because I think that different people have different points of view as to how difficult this problem is. Actually I view the greatest difficulty here is that of assurance that you can get these vehicles into the proper orbit in the right time period to accomplish the mission.

There is another problem, of course, of locating and guiding the rendezvousing vehicles together. But I look upon this as not being as difficult as actually getting a reliable vehicle.

If you knew each time you fired you were going into orbit I think the rendezvous vehicle technique would be capable of rapid accomplishment.

The CHAIRMAN. It seems to me too you have a matter of speed. You might want to speed up your rendezvousing vehicle. You may want to reduce the speed. Do you have that problem whipped?

Dr. SILVERSTEIN. This is a matter of adding propulsion to your spacecraft. The propulsion is not primarily in the sense that the required total thrusts, total impulses, and total energy needed to change the orbit are not large compared to that of lifting it from the ground.

The CHAIRMAN. It is a question of adding not to the initial propulsion but additional propulsion later on?

Dr. SILVERSTEIN. Yes, in rather small quantities compared to that required originally.

Mr. ANFUSO. How much of a booster would you need for a rocket—

Dr. SILVERSTEIN. Let me say that a booster of perhaps a fourth of the thrust that I listed of 12 million pounds for the direct ascent might prove quite adequate for rendezvous. You might use four vehicles to carry the fuel into orbit.

Mr. ANFUSO. How long will it take us to get a 3-million-pound booster?

Dr. SILVERSTEIN. With the developments that we have underway it would require grouping together of two of these million-and-a-half-pound rockets we have under construction.

Mr. ANFUSO. A matter of how many years?

Dr. SILVERSTEIN. The planning of this right now shows that a booster like this would be available for flight in about 1964.

Mr. ANFUSO. How long will it take to develop a 12-million-pound booster?

Dr. SILVERSTEIN. Until late 1965 or early 1966.

Mr. KARTH. It is the same engine that you use on C-3?

Dr. SILVERSTEIN. Yes, except the system is four times larger.

Mr. ANFUSO. That would be a year later.

Dr. SILVERSTEIN. Perhaps a year and a half later.

Mr. ANFUSO. What is the possibility of a failure of a rendezvous as compared to a direct landing?

Dr. SILVERSTEIN. I can't answer that accurately, largely because we don't know—you never know with a launch vehicle what the probabilities of your failure are going to be until you go through a certain period of development. For example, if we look back at the development times for all of our basic boosters that we are using now, we find that during the first 10 development booster flights we are liable to get 4 successful flights. This is what the statistics will show.

On a vehicle such as Delta, which we are using with Tiros, we have had four successes out of five. As I mentioned earlier, one of these was successfully launched this morning. We lost only the first of those, and we have had four successes in a row.

It has a lot under its belt. It has Thor as the major booster. It has the second and third stages from Vanguard, and it is using the guidance from Titan which has been under development for a long time.

We have finally gotten ourselves to a position where instead of being on a 1-to-2 ratio of vehicle success, we have four out of five.

Mr. ANFUSO. From what you know now, Doctor, wouldn't you say that a direct landing would have less chance of failure?

Dr. SILVERSTEIN. I wouldn't say that. From what I know now, since we have quite a bit of experience with the technique of directly ascending bodies into space, it would probably have a greater probability of success.

What I might know a year from now could be different.

Mr. ANFUSO. I take it you favor a rendezvous?

Dr. SILVERSTEIN. No, I think you must take it that I favor a parallel approach.

The CHAIRMAN. What kind of approach?

Dr. SILVERSTEIN. Parallel.

Mr. ANFUSO. What would be the cost of a failure in dollars and cents of a rendezvous?

Dr. SILVERSTEIN. It would be the cost of the entire vehicle system. I think I had better make a calculation and put this in the record for you, because probably off the top of my head I would give you a wrong answer.

Mr. ANFUSO. Approximately.

Dr. SILVERSTEIN. Perhaps the failure of any one vehicle might cost \$25 million. Then depending on how many vehicles you had, which might be five, you might lose five times that amount.

Mr. ANFUSO. If you then found out that rendezvous was not possible then would you have lost that much time?

Dr. SILVERSTEIN. I don't think we will find that rendezvous is not possible. I think we are only talking about the time for development. I am quite confident rendezvous is possible. I don't question it.

The CHAIRMAN. Too, the development of the rendezvous idea is going to give us future practical applications of the principle, both for military and nonmilitary purposes, isn't it?

Dr. SILVERSTEIN. Yes.

The CHAIRMAN. There is a side advantage that is tremendous, it is incalculable, as a matter of fact, by developing the principle of rendezvous, isn't that correct?

Dr. SILVERSTEIN. I would say exactly that.

Mr. ANFUSO. Does Dr. von Braun share a different view than you do?

Dr. SILVERSTEIN. No, sir, I think not. I think that we see eye to eye in this area.

Mr. ANFUSO. Is there anyone in your group that thinks that a direct landing would be better?

Dr. SILVERSTEIN. I really can't speak for everyone in the group. I know technically you can enter into long discussions and I think you will find groups that might think one thing or another. I think as

it simmers down that they will agree that the parallel approach is the proper approach.

Mr. ANFUSO. Is that the view in NASA at the present moment?

Dr. SILVERSTEIN. I think it is.

The CHAIRMAN. I know coming to the bill here originally you requested \$77.7 million for the scientific satellite program. That has been reduced by \$5 million. What are we losing by reducing that \$5 million?

Dr. SILVERSTEIN. I think that if you will note within the program that the next item under scientific satellites is lunar and planetary exploration, in this program it has been increased by \$56 million. There are certain common researches within the instrument area that are shared between those two programs.

I think you will find that most of this \$5 million which was cut from the scientific satellites will be covered within the lunar and planetary exploration.

The CHAIRMAN. Will that have any effect on the orbiting of the astronomical observatory?

Dr. SILVERSTEIN. It could, and if it does, we will probably reprogram to take care of it from the other funding.

The CHAIRMAN. You mean it will delay it?

Dr. SILVERSTEIN. We will not allow it to be delayed. We cannot allow it to be delayed.

The CHAIRMAN. You will reshuffle the cards there to prevent a delay?

Dr. SILVERSTEIN. In a program such as the OAO, we find the method we used for auditing our contractors' activities require them to present, on a continuing basis, a projection of their costs in the year ahead. This is reviewed monthly as he comes in with his requirements.

If we find as we move along in this program that their requirements change during the year, which is characteristic of these kinds of programs perhaps we will have to make some adjustments within the total funding.

I will assure you that we will not allow this program to slip.

The CHAIRMAN. I think that is a very important program.

Dr. SILVERSTEIN. I agree.

The CHAIRMAN. In working on this lunar approach shot you are not abandoning the man-in-orbit program, are you, for the end of this year?

Dr. SILVERSTEIN. No, sir. We are moving in the Mercury program as rapidly as we can; as you well know, I think we are proposing in the very near future to attempt a second suborbital flight.

The CHAIRMAN. You are still working on the orbit of a man in the Mercury program by the end of this year?

Dr. SILVERSTEIN. We are working toward that goal.

The CHAIRMAN. That is a necessary part of space development as a prelude to landing someone on the Moon, isn't it?

Dr. SILVERSTEIN. Yes.

That was, of course, somewhat the subject matter of this first chart to show the various missions as you proceed to the final lunar landing and return.

If I may have that chart now I will show that the first mission of the three general classes of missions we need to accomplish is Earth

orbit. The Mercury is a prelude, as you said, to Earth orbiting of the Apollo capsule.

The CHAIRMAN. For instance, if you use the rendezvous method there you must have a man in orbit at that time, in order to assist you in transferring fuel and supplies and so forth into the major vehicle intended to be used in the Moon shot?

Dr. SILVERSTEIN. This would be the most expeditious way. There are those who believe it would not be necessary initially to have a man in orbit to do a rendezvous. For most of us who have studied it, we feel it would make a great difference in the success of the mission if you had a man there.

The CHAIRMAN. In the Mercury shot the man is a necessary prelude to the major shot to the Moon?

Dr. SILVERSTEIN. Yes. There are other preludes too. For example in the Mercury mission the capsule will orbit three times around the Earth, a 4½-hour flight, and return.

Following that, within the Apollo program, a continuation of the Mercury program, recognizing that simply orbiting a man for 4½ hours is not going to give us enough life science information over an extended period of time, as we will require for the lunar mission, we are initiating a more extended flight with the Mercury capsule, modifying it so it will stay in orbit longer than 4½ hours. That is one phase of the Apollo funding that we are requesting here.

The CHAIRMAN. How much longer should he stay in space?

Dr. SILVERSTEIN. The general planning is for a period of 2 weeks in space for the lunar landing mission, with 3 additional days of supplies available to him after he lands.

The CHAIRMAN. Would you orbit him 2 weeks before taking the lunar shot?

Dr. SILVERSTEIN. In all probability.

The CHAIRMAN. You would have a need for a man in orbit for 2 weeks before attempting your 1966 landing on the Moon?

Dr. SILVERSTEIN. Yes, sir. Beyond that, again, we feel we would have to put the man into what we call a circumlunar flight in which he would take off from the Earth by direct ascent, circumnavigate the Moon, and return. This adds a new piece of technology to the system; that is, we would be introducing the reentry phase. Without taking on the problems of lunar landing we would be able to study the reentry. The reentry phase is one of the major problems in any lunar return. Returning from a satellite orbit at a velocity of around 18,000 miles an hour gives you a very extreme heating problem. However, returning from the Moon from a velocity of around 25,000 miles an hour increases the severity of the heating problem by two or three times. There are new problems at these higher velocities that do not occur in reentry from satellite velocities.

The CHAIRMAN. You would send a man to orbit the Moon and bring him back to the Earth before you would attempt a landing of a man?

Dr. SILVERSTEIN. Yes; that would be the second phase of the mission.

The CHAIRMAN. He would report to you all the scientific data that he obtained up to the Moon and back and you would use that as the basis of your landing the man on the Moon?



FIGURE 336

Dr. SILVERSTEIN. That is correct. Then once you have the orbiting mission and the circumlunar mission adequately handled, you could make the lunar landing on the Moon and return.



FIGURE 337

Mr. KARTH. Would your circumlunar flight be a direct flight? Would that be a flight as a result of a rendezvous also?

Dr. SILVERSTEIN. It could be either way, although there would be less need for the rendezvous for this mission because the circumlunar requirement can be handled by the C-3 vehicle.

You don't have to carry the propellant to slow you down to land on the moon or the propellant required to fire you off to the Moon into return orbit.

The CHAIRMAN. Would you need one or three men to do a 2-week flight orbiting the Earth?

Dr. SILVERSTEIN. You would in all probability exercise your whole crew.

The CHAIRMAN. Three, you mean?

Dr. SILVERSTEIN. Three.

The CHAIRMAN. The same thing when you orbit the man and come back to an Earth landing, you would have three men, not one man, on that trip?

Dr. SILVERSTEIN. As you can see, it is a rather lengthy flight. There is a great deal of navigation required during this flight. The navigational requirements here are quite extreme, because in coming back to the Earth and reentering into the Earth's atmosphere, the man must hit a corridor out in space that is really quite narrow compared to the radius of the Earth.



FIGURE 338

This requires extreme accuracy in the approach to the Earth, so that the capsule will neither burn up nor skip around the Earth.

The CHAIRMAN. What do you mean by hitting a spot that is very narrow?

Dr. SILVERSTEIN. The capsule must reenter into a narrow corridor about 40 miles wide. The corridor width is about 1 percent of the radius of the Earth in order to make a successful return.

Mr. BASS. Why is this narrow corridor set up this way? Why can't he—

Dr. SILVERSTEIN. There are two problems here. If he doesn't come through this narrow corridor probably he would come down too low and burn up because of the heating of the atmosphere or the acceleration will be too high for the crew to endure. Or, on the other hand, if too high, he may skip out of the Earth's atmosphere and into some orbit in space from which he might or might not be able to again reenter. It is a problem in mechanics of the body in the Earth's atmosphere.

Mr. ROUDEBUSH. Are you going to phase out Project Mercury after one orbital flight, or how many orbital flights do you anticipate?

Dr. SILVERSTEIN. Mercury will not phase out after one orbital flight. Mercury will be continued in the program as part of the Apollo program.

Mr. ROUDEBUSH. In other words, the line of demarcation gets rather thin after you get into the orbital business?

Dr. SILVERSTEIN. The Mercury capsule is a very fine tool that we have developed in this country for continued work in manned flight. In order to extend our knowledge of man's capabilities of existing space, we can use the capsule for longer flight times. We feel the Mercury capsule can be modified for long duration flights with animals which we feel must also be a prelude to extended duration manned flight.

Before we put a man into space for 2 weeks we feel we should fly animals into space for 2 weeks, and that this is a necessary step to take.

We will attempt to modify the Mercury capsule in the Apollo program to carry out this part of the mission. All of this is technological underpinning for the final mission.

Mr. ROUDEBUSH. You don't feel that too many flights are anticipated? In other words, what I am trying to get at, Doctor, are we making actual flights where, let us say, experience from a laboratory could be substituted by simulated conditions?

Dr. SILVERSTEIN. I think that it will be our effort to use the Earth laboratories as extensively as we can. I think the secret of success in a mission of this type is dependent upon how well you use your ground facilities.

There are certain data, however, which cannot be obtained except by flight in space. Thus we must finally provide the test.

Mr. ROUDEBUSH. Our second suborbital, which the radio informs me is planned next week, what value will that be after the successful first Mercury shot?

Dr. SILVERSTEIN. One of its values is quite obvious, and that is you are bringing back a pilot to the Earth with the experience to be obtained.

You may recall that Commander Shepard said it was his belief after he made his flight that the value of the flight was very great, from the standpoint of training, for bringing the pilot into the actual environment of space flight.

He has recommended that we continue, based on his experience. I don't know how much experience you have had in actually piloting an aircraft, but here again when you move into a very complicated environment like the cockpit of an aircraft, and undergo extensive maneuvers, there is a period required for adaptation.

Mr. ROUDEBUSH. This couldn't be simulated in the laboratory?

Dr. SILVERSTEIN. We have simulated many of these things in the laboratory already. There has been a heavy training program in this direction. We realize how important it is that man become acclimated to the environment of the capsule as best he can before flight.

The CHAIRMAN. Any further questions?

Mr. FULTON. On your coming Mercury flight, what will be the advance over the previous man in space flight?

Dr. SILVERSTEIN. As I mentioned, one of the purposes is continued training. But aboard this next capsule will be several advances in the capsule design. Several changes have been made in the capsule.

The changes that we have made here are the changes that will be used in the orbital capsule. For example, there is a new control system in it. In addition to this control system, there is also a new structural arrangement around the windows and a new window sys-

tem in it. The exit door system is different. These are changes that have been made in adapting the capsule to the orbital mission, and they will be tried first on this suborbital flight.

Mr. FULTON. Commander Shepard had rudimentary controls for controlling the capsule in flight. Are you developing further on the controls so that this is an experiment on really controlled space flight?

Dr. SILVERSTEIN. As you recall, his control was one of attitude. Your question is whether we intend to control actual flight path. This will not occur until we get into the Apollo program at which time we will have a capsule that will be controllable through power, making it capable of changing its orbit and to thus effect rendezvous in space.

Mr. FULTON. He will control his positioning in this ballistic flight? He will be able to turn the capsule and do various other things?

Dr. SILVERSTEIN. Yes.

Mr. FULTON. How long do you expect if it is a perfect flight?

Dr. SILVERSTEIN. The next one or the Apollo?

Mr. FULTON. The next one.

Dr. SILVERSTEIN. I think the next one will be quite similar to the past one, the MR-3 flight.

Mr. FULTON. This is just a perfecting flight rather than a big step forward?

Dr. SILVERSTEIN. It is a continuation of the program for purposes of training and for purposes of qualifying the modified capsule for the orbital flight.

Mr. FULTON. What is the next step prior to the orbital flights?

Dr. SILVERSTEIN. The next step will include the orbital flight of unmanned capsules of the type that will be used in the MR-4 or the next flight. This will be followed by some orbital animal flights, and then manned orbital flights.

Mr. FULTON. Is there going to be an attempt to go any further distance or any higher altitude?

Dr. SILVERSTEIN. Not in the Mercury program. This will be taken care of in the Apollo program.

Mr. FULTON. Has the man been chosen yet for the next flight?

Dr. SILVERSTEIN. I think the statement is currently that the man's name will be announced shortly before the flight.

The CHAIRMAN. They announced two of them.

Dr. SILVERSTEIN. I don't think they are official announcements as yet.

Mr. FULTON. Has he been chosen? I don't say who was he.

Dr. SILVERSTEIN. He has been chosen.

Mr. FULTON. He is in training at the moment and knows he is going?

Dr. SILVERSTEIN. Yes.

Mr. FULTON. The flight is scheduled for the early part of next week?

Dr. SILVERSTEIN. Yes, sir.

Mr. DADDARIO. If we had followed the NASA 10-year program when would we have after that had been completed and reached the point where we would have placed a man on the Moon?

Dr. SILVERSTEIN. Our statement was some time after 1970 on the previous program.

Mr. DADDARIO. How much additional cost will there be added to this accomplishment because of the accelerated program?

Dr. SILVERSTEIN. I think Dr. Dryden yesterday mentioned during the next 10-year period there will be an increased cost of \$7 to \$9 billion over this 10-year period.

Mr. DADDARIO. My question does not contemplate what the cost will be from this point on, considering an accelerated program. Would it have cost us less to have achieved this end by spreading it over the period of time during which we would have built up these capacities?

Dr. SILVERSTEIN. This is a question I think that experience gives a number of different answers to. As long as you don't crash the program by going through too many parallel programs you can sometimes do it cheaper in a short period of time than you can over a long period of time.

Mr. DADDARIO. It is your opinion that we are doing it cheaper through this accelerated program?

Are these the gains that we will achieve by pushing it ahead?

Dr. SILVERSTEIN. I don't honestly know the answer to that question because it is so dependent on what kind of problems we encounter during the program.

Sometimes there are certain kinds of problems that you encounter which if you try to solve too rapidly run into very high cost.

They are fundamental and you have to bull your way through them, and it becomes expensive.

Mr. DADDARIO. Do you think we are doing that under this new program?

Dr. SILVERSTEIN. I don't think so, but we will have to find out. There is an interesting thing about this landing a man on the Moon and return. There doesn't seem to be any real breakthroughs in technology required although advanced technology is required.

I differentiate a breakthrough from increased technology in this way: a breakthrough in technology is something like the development of the fusion reaction for power; you don't know when you can do it because a wholly new idea is required. In this lunar landing there are no elements in the program that require this type of breakthrough. It does require advanced extension of the technology that we have. But the guidelines for making this extension are pretty well rooted. We see the path, unless we do encounter something new and different.

There might be a question of the effects of radiation on man in space that would require a breakthrough. But here again our calculations show this problem may be taken care of with what we know and will learn.

Mr. DADDARIO. It is a better utilization, an increased utilization of our present capabilities?

Dr. SILVERSTEIN. It is that plus a broad expansion of our technology, bringing in many new fields and areas of work, geared together properly. It is a very complicated gearing process to bring together all that is needed to accomplish the mission.

Mr. DADDARIO. From your own experience are you in favor of the new accelerated approach and do you believe it is worth the gains that will be achieved as a result?

Dr. SILVERSTEIN. I am very much in favor of it. I think it is a major step forward in the overall program to set ourselves goals of

this type, because as I think Dr. Dryden described yesterday it will react favorably to the overall development of this country, both economically and educationally; that is, we must, I think, set ourselves goals that are at the limit of what we can see can be done.

If we set our goals too low then the level we reach is too low. We must set for ourselves goals that are high and attempt to reach them. When we do that we raise the level of all participating as they strive to the higher goals.

In taking on this mission—a very difficult mission—you are setting for the country long-range goals on an accelerated basis that will require all of us, everyone participating, to essentially perform at the top level of his performance.

Not a level below the top, but at the top, and extend everyone to make him think and make him imagine the kind of things this Nation can accomplish.

Mr. DADDARIO. Then we have here set a national goal of which we are capable of achieving?

Dr. SILVERSTEIN. Yes, but I think it is right at the limit. This is the place we should set it.

Mr. DADDARIO. We are setting a goal which you say is within our limit, and it is a high goal which will push us to our fullest capabilities and by accomplishing it we will be able, will we not, to have the technical requirements to face what might be ahead of us in the future much quicker than we would have if we had gone along with the program as previously established by NASA.

Dr. SILVERSTEIN. I agree fully with what you have said.

Mr. BASS. Doctor, I would like to follow in a little more detail this matter of relative cost as compared to the Eisenhower stretched out program.

Do you mean to say that you feel that the total cost of the man to the moon program on this accelerated basis won't be any greater than if we stretched it out beyond 1970?

Dr. SILVERSTEIN. I think my remark was that I didn't know. I pointed out that I didn't think it would be any more unless we encountered a real tough problem that required absolute force to push our way through it. If we go through a program of development that takes nothing more than this very high level of performance that I have discussed, then I think the cost might be comparable, because I think as all of you know from your own experience that if you simply continue on a thing at any rate, there is a fixed overhead item that goes along with you all the time.

It is an overhead on all the organizational systems you have got in position that are working. If you just let this overhead continue to stretch out as you well know it will eat you up in time. If you cut this overhead by program acceleration you weigh this gain against the costs of doing parallel work and I don't know how it would come out.

Mr. BASS. You have told us of one type of parallel operation, in that we are pursuing the direct ascent and orbital rendezvous approach. It this were stretched out over a long period of time, that would not be necessary would it?

Dr. SILVERSTEIN. I think what we want to say about orbital rendezvous is that this is an approach that we will have to develop in any event. For military and civilian purposes it will have to be accomplished, whether it is included in this program or not.

Mr. BASS. On a parallel basis?

Dr. SILVERSTEIN. Yes, perhaps not accelerated quite as much. But to accomplish it over a longer time period would bring us into the same question that you asked before, whether it could be done cheaper or not.

Mr. BASS. On your original 10-year program, there was a plan for a man, a space flight to the Moon?

Dr. SILVERSTEIN. A plan after 1970. The program had not been developed in detail. We had taken it only—may I take the slide again—through this circumlunar flight, as you may recall from our previous presentation to your committee.

Mr. BASS. Can't you tell this committee how much this new accelerated program accelerates the man to the Moon mission?

Dr. SILVERSTEIN. I would say probably 5 years.

Mr. BASS. Under this present program you hope to do this in 1965 or 1966, around in there. Is that right?

Dr. SILVERSTEIN. I think what we have said is we will do it within the next decade. This is the President's request, that it be done within the decade.

Mr. BASS. Under the original 10-year plan—

Dr. SILVERSTEIN. After 1970. Our planning had not picked out the year, because we did not know what year the funds would be available to start the Nova program, on which this program was hinged.

Mr. FULTON. When you are in competition with somebody, you either look back over your shoulder and see him or you look ahead and see his heels. On this flight to the Moon, as compared to Russia, where do we stand? Are we ahead of them or behind them or running should to shoulder with them?

Dr. SILVERSTEIN. I think the answer here is dependent of course on a pretty detailed understanding and knowledge of what the Russians are doing which unfortunately I don't have.

Mr. FULTON. In the race to the Moon, where do we stand? It is just that simple.

Dr. SILVERSTEIN. My information on what the Russians are doing is not very accurate. So any statement I make would be inaccurate. In setting our goals on this very difficult mission at some time period ahead, we are very much better off in the competition than we were when we started competing on manned flight, for example.

You may recall that the Russian effort in manned flight must have started as early as 1954, because in 1957 they flew animals. This was quite obviously an approach to manned flight and the date 1954 can probably be picked out because that is the time when they established the committee in Russia for carrying on the work.

So that up to the time of actual flight time, there was a period of some 7 years in which they were at work; whereas our work started in a serious way and the first funding was available, you recall, in October of 1958, shortly after NASA was born. We only had a period of some 2½ years of work up to Commander Shepard's flight.

We have this comparison of 7 years that they have been working against our 2½ on the satellite mission. From where we stand now on this longer range lunar mission, the ratio of time shouldn't be that bad, and our competitive position should be better.

Mr. DADDARIO. At any rate, if we do shoot for our highest national goals, to use our capacities to their fullest extent, the competition then will take care of itself, will it not?

Dr. SILVERSTEIN. I think you are right. The winning isn't nearly as important in the end point as is the buildup. What we would be doing in this country would be strengthening ourselves and building a better technological platform. Whether we win the competition or not we will have the strong platform we have built to work from in the future.

The CHAIRMAN. What we are doing is really to learn how to operate in and utilize space, isn't that it?

Dr. SILVERSTEIN. That is it.

The CHAIRMAN. In a broad way.

Dr. SILVERSTEIN. I think we are actually doing much more than that. We are building a solid base of technology for space activity which will diffuse through and build the base for our entire technology.

It is this diffusion effect through the whole industry and the whole science that is very important.

Mr. FULTON. The President has said that we can beat the Russians to the Moon and has set the target date through you people by 1965 or 1966. Obviously somebody has to make some calculation of the Russian target date. From what I can get from what you have said, we are starting out a pace or two behind in this race, and we accept the competition. What is the basis that the President gave that we could beat the Russians if we move this program up? Who calculated, giving him the advice on when the Russians would reach the Moon?

Dr. SILVERSTEIN. I don't know myself whether he made his decision on that basis or not. Perhaps he made it on the basis of the broader argument that I was using a minute ago.

I think what we must ask is not whether we should enter a race, but what will happen if we don't. We must ask the question, "Where will we be 10 years from now?" If 10 years from now we have failed to build up our technology we will be soft in technology and weak as a nation.

Mr. FULTON. May I compliment you people from NASA, the witnesses who are coming up this year, because you are different people. Previously those of us who had—I have been one of the big boosters for space—we were always being told by NASA that you couldn't reasonably and economically, with progress, spend more than you were getting.

Now you are up here saying you think it is going to be better, cheaper, to go faster, if you get \$400 or \$500 million more.

I am going to help you get it. I want to congratulate you people on doing the first loop the loop in space. You made a wonderful landing here on this approach.

Mr. HECHLER. That is what leadership does.

Mr. FULTON. I have just one more question.

The CHAIRMAN. We are trying to make speed in space now.

Mr. FULTON. I will yield.

The CHAIRMAN. Go ahead and ask the question.

Mr. FULTON. My question is on the coming Venus shots. I understand there has been no decision made on it and the optimum time

for the Venus shot will be in 1962, July or August. If we are going to have a Venus shot which Russia probably will do, we are going to have to get started and we are going to have to decide whether to use the Centaur which will be experimental, as a booster, or the Atlas-Agena, which has not worked out too well on many occasions.

The question is this: First, are you considering such a program of a Venus shot in 1962, and secondly, is it practical with the boosters that we have, where we might get too much danger of a failure, and then if we need a backup on it, maybe of three or four, we could institute a program that would be—this is my own idea—of one vehicle following another with relays of communication back so that we can get over the hurdle the Russians ran into where they lost track of their own vehicle?

Could we do it as a communications satellite program as well as a deep space probe?

Dr. SILVERSTEIN. Mr. Fulton, let me attempt to answer your questions in order, if I can. I think you asked first whether we plan on continuing with the Centaur flights and the answer is, of course, "yes."

We have planned a Centaur flight on the Venus mission with two vehicles and the success of the flight will depend in large measure on how well the Centaur vehicles develop to this point in time.

Beyond that, you mentioned the possibility of using other vehicles for flights. Here we are studying the possibility of using these vehicles. The decision has not been made, as you mentioned. The decision is a technical one.

A year and a half ago we had a program to attempt this deep space mission involving four vehicles which were cobbled up especially for the flight and all were failures. We are hesitating about entering into another program of this type based on this experience. It is a matter of technical judgment, I think, as to whether we will or won't. We are currently studying the technical problems in great detail.

Mr. FULTON. As a matter of decision, could this committee, by its resolution, back you up by saying we would like the Venus probe, which we think the Russians are going to do certainly?

Dr. SILVERSTEIN. I don't think that you would want to make a resolution like this until we could show you technically that it is a sound venture. I don't think we are helped by failures. It is a matter of evaluating our probabilities of success with the new vehicle system and spacecraft we would have to use.

Mr. FULTON. When will the decision be made?

Dr. SILVERSTEIN. I think it will be made shortly. It will have to be.

The CHAIRMAN. Coming back to the bill itself, Doctor, we want to thank you for the fine testimony you have given us. I think Dr. Silverstein is a very brilliant scientist. If you could stay with us during the rest of the hearing we would appreciate it, very much.

At this time I think we ought to go into the matter of life sciences. There is some difference in the bill. We have Mr. Alfred Mayo this morning representing life sciences. Colonel Roadman is here, I understand, but he is not able to talk much. He has laryngitis. We will excuse him and ask Mr. Mayo. You are familiar with the life sciences program, are you not?

Mr. MAYO. Yes, sir.

The CHAIRMAN. What do you have in connection with that?

Mr. MAYO. I am acting deputy director.

The CHAIRMAN. Tell us about the life sciences program. I have one question I would like to read to you in advance and you can then answer it in the course of your testimony.

You recall that NASA had to give this committee a special justification for \$8.6 million which you initially requested for the life sciences program. You are now asking for \$12 million additional, and a personnel increase of 100 employees.

Where do you plan to get this personnel and how do you plan to distribute them?

Mr. MAYO. As you know, this request of the President to accelerate the program has put quite a strain on our national life science capability. It will be first necessary for us to achieve full utilization of all of the life science capability now existing in Government laboratories, the Department of Defense, universities, and in industry. This alone will require a significant amount of effort by NASA.

In addition to that, we must move decisively to increase the national life science capability in order to meet the accelerated needs of this program in this particular area.

The CHAIRMAN. Do you want to make a general statement, and then I am going to recognize Mr. Daddario. He has made a special study of life sciences.

I will ask him to make any statement he wishes to make and ask any questions.

Mr. MAYO. We have a study here which goes into some of the efforts of the intergovernmental relations of NASA in the life sciences area and the manner in which we have been soliciting and acquiring support from other agencies, as well as the necessary buildup within NASA. I would like to submit this for the record, if I may.

The CHAIRMAN. If there is no objection, it will be submitted for the record.

(The report referred to is at the end of the day's hearing.)

STATEMENT OF ALFRED MAYO, ACTING DEPUTY DIRECTOR, LIFE SCIENCE PROGRAMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. MAYO. At the previous hearing of the Office of Life Science Programs, the request was submitted for a 1962 research and development budget of \$8.6 million, as you just stated. The President's request for a manned lunar landing program requires a large increase in this effort. The need for early information necessary to the design of protective and functional equipment to meet this request makes it necessary to immediately increase the present level of funding to a new total of \$20.6 million, or the additional \$12 million. This figure illustrates that we must assure the contribution of man in successful space flight exploration. In doing this, we must determine man's capabilities and limitations, to assure his effective use in space programs, and to provide adequate life support, not only for survival but also to insure efficient performance (fig. 339).

May I have the next slide, please?

The objectives of this program require further knowledge about life and development, including the search for extraterrestrial life, which is the second major objective. And the program plans in this area require that we determine physical, chemical, and biological characteristics of life and to utilize these data and methods in the search for life in space (fig. 340).

These two broad objectives must be met in parallel because we get opportunities to study during the exploration, and, of course, this knowledge is the important product, so we must approach the objectives in parallel.

The next chart, please.

This chart merely illustrates the breakdown of effort and the form of breakdown in which we expect to spend our money (fig. 341).

I think you will notice the emphasis here of the large amount of money is in the area of flight experiments. This becomes one of our key problems at the present time, because the critical lack of knowledge, particularly in the areas of prolonged weightlessness and radiation environment can only be studied now in flight.

As a result of this, we are forced to greatly accelerate the efforts to gather these data in time to mesh with the rest of the program.

Perhaps if I skip over the major portion of the discussion here in order to conserve your time and go directly to these flight programs, we could better utilize the time of the committee.

May I have the figure 344, please?

The flight experiments that we need to do must include the investigation of space radiation, weightlessness, and the concomitant scientific work in search for extraterrestrial life.

In addition to the acquiring of information on the properties and effects of space radiation, the NASA has proposed a series of biological space probes—we now call these BIOS or biological investigation of space probes, a new name for the modified nuclear emulsion recovery vehicle series.

It is necessary with these probes to investigate——

Mr. FULTON. What was it, "nuclear emulsion"?

Mr. MAYO. Yes, that was a previous program designed to gain primarily physical data. It had aboard some organisms, ordinary bread mold spores. The information which came back indicated the need for further study.

We had some indications of high rates of mutation which were not explained by the known amount of radiation the organisms received. Therefore this becomes an important area of investigation.

Mr. FULTON. Not the propulsion?

Mr. WYATT. If I can help, you recall we discussed the so-called NERV flight, N-E-R-V. That was the 1,200-mile altitude recovery that we performed in August of last year.

Mr. MAYO. May I have the next chart, please (fig. 345)?

This chart illustrates the flight trajectory of the BIOS systems currently in process. This probe will fly into the lower Van Allen Belt region and return. It will give us approximately 24 minutes of weightlessness, plus a reasonable amount of time to check our equipment and organisms.

The flight will carry, of course, both living organisms and physical measuring equipment.

The CHAIRMAN. Will it carry a man?

Mr. MAYO. No, indeed. This is a very small vehicle, an adaptation from our previous probe work, and will be utilized to get data before the availability vehicles large enough to carry a man into these regions.

We are currently planning one shot late this fall to gather prime information, and depending on the kind of information we get it will be followed by other similar shots, and later more time-consuming orbital radiation shots.

The biological systems will be designed to be sensitive in various ranges of radiation, in order that we can cover the probable effects using these biological organisms as sensitive damage indicators, which we are unable to assess from physical data.

Secondarily there will be an experiment to study cell fertilization and division in the weightless state, and some physical experiments in which we will gather further data on micrometeoroids and the radiations.

The experiment will penetrate about halfway into the lower Van Allen Belt, fall back, and it will undergo approximately 25 minutes of zero-G flight.

This study is being conducted, or the life portion of it, by our Ames group. The General Electric Co. at Philadelphia is the vehicle contractor and the prime contractor for the program.

The Navy group at the Pacific Missile Range is supporting for launch and recovery.

The information gained from this flight will by no means be the last needed but may give us some indication why the Russians have reportedly lowered the orbit of their dogs to keep them from having a possible flight rise in the white blood cell count. We don't know the reason. One possibility would be possible radiation infections.

This information will then be used to design further flight experiments to gather more complete data which is necessary for the spacecraft designer to adequately protect man.

Spacecraft orbiting within the inner and outer Van Allen areas are needed to complete the more complex experiments needed for final determination and testing of shield configurations.

In the investigation of the weightless state, it is planned to orbit spacecraft laboratories under the radiation belts for prolonged periods of time.

In this environment it is planned to study the effect of weightlessness on primates and lower biological systems (fig. 346).

Earth orbiting recoverable biological satellites, as flight experiment, have been designed to study the effects of weightlessness.

May I have the next slide, please (fig. 347)?

The biological experiments are well on their way as far as ground controlled research studies are concerned, but cannot be known until the NASA can provide a recoverable spacecraft.

It is our hope, as you can see from the picture, that the Mercury system can be utilized. At this time, an adequate spacecraft is not available to carry these experiments. This experiment is comprised of a number of biological systems that complement one another in the investigation of weightlessness.

Mr. FULTON. "Inadequate," what do you mean by that?

Mr. MAYO. At the present time we have not available a spacecraft for this purpose which we can immediately fire. With the higher priority of this program, studies are being made now to accelerate and modify some of the Mercury equipment, such that it will be usable for this type of operation.

Mr. FULTON. My point is, you need the Scout vehicle, for example, that the Navy with Sea Scout is talking about, and the Air Force with Blue Scout, a smaller rocket, that costs about \$750,000 rather than these big ones that we are always using.

Don't you need a program like that?

Mr. MAYO. We are making this sort of study in the BIOS system and in conjunction with the Air Force are looking into the potential use of some of the vehicles used in the Discoverer series.

The Scout is a pretty roughriding vehicle for these experiments. The work to date has indicated, for the more sensitive biological experiments, we will have some problems in utilizing these vehicles, although we will know more after the completion of the BIOS shot using the Argo D-8, which of course is somewhat comparable to the utilization of Scout.

Perhaps with the smaller organisms we will be able to get some help from this class of vehicle.

As you can see from this chart, our need is to look at a wide range of biological problems. It has been discovered that by utilizing a trained chimpanzee rather good performance information of a sensitive type may be gathered. Any degradation of performance can be measured much more easily than the broad cross section of other measurements needed for similar results.

We back the performance measurements up with other experiments which allow us to study the physiological basis of any deteriorations which may occur in performance as a result of the testing—

The CHAIRMAN. I don't want to interrupt you because you are making a very interesting discussion. We only have about 20 more minutes. I want to get over to the question of solid propulsion, too.

Are you about completed in your statement?

Mr. MAYO. We have a number of other flight experiments, including the radiation experiments with balloons and so forth to complete the spectrum. I believe the committee is sufficiently familiar with them. In light of the shortness of time I would attempt to answer any questions.

The CHAIRMAN. Mr. Daddario has a very interesting report he has made on the question of life sciences. It is lengthy but he has devoted a lot of time to it.

If there is no objection, I would like to place his report, make it a part of the record.

(The report above referred to starts on p. 1130.)

Mr. DADDARIO. I don't think you answered the chairman's first question, and I hope we do have time to get to them. Perhaps included in those pamphlets that you have before you is the kind of information that we are all seeking, and that is the better tying together of our capacity throughout the country:

I have had no doubts as to whether or not the life sciences program in NASA has done this. I think we have gone a long way since we

have sat down and had an opportunity to talk to each other. The change in emphasis, for example, in the canceling of the vivarium and the utilization of personnel that would have been encompassed within that program to other areas so that these will better mesh are steps in the right direction.

I was concerned as you know when we were discussing how it happened that the number of people requested still corresponded exactly when this program was changed during the last several months. For example, 21 of the 51 people requested would have been working as scientists at the viravium. When that was eliminated, and the emphasis diverted in another direction, I wanted to know why. Dr. Dryden testified that these were just a few animal trainers, where you stressed that there was a complete change, that the personnel requested were entirely different, and were to be adapted to the new program.

I understand these things can happen. I don't bring it out to criticize but I do bring it out rather to show how the experts must bring us the necessary information, and I think you and Colonel Roadman are the experts we must depend on to justify this life sciences program.

What is the nature of the strain that has been placed on our life sciences capacity, by the President's accelerated program, to place a man on the Moon within this decade?

Mr. MAYO. As you well know, and your study has brought out, it will be necessary for us to assure very nearly optimum utilization of the life sciences capacity. I think some surveys of the approximate amounts of money being spent might give an idea of this. The Department of the Air Force has a total life sciences budget, I understand, in the general range of \$36 million, of which they are now utilizing in the order of \$12 million, according to General Flickinger's testimony in space related life sciences.

Our total budget of \$20.6 million for this year would contemplate making further and increased use of the Department of Defense, not only in the Air Force but in other areas of the Department of Defense. As you know, we spent, last year, approximately 20 percent of our initial budget on a transfer basis to the Department of Defense. That was over and above the work which the Department of Defense would have done, anyway, applicable to our purpose.

Mr. DADDARIO. The chairman asked you a question as to where you were going to get the personnel. How many people are actually working on the life sciences at this point? When we last discussed this you had something like five or six with just three or four more applicants who were being reviewed. What is that situation? How are you approaching the 21 as of the last fiscal year? How are you approaching the 51 under the first program which was proposed? And how are you going to then jump from the place where you now stand to the 151 without diverting from other agencies of Government personnel now operating within their programs?

Mr. MAYO. As we mentioned before, we will certainly require some key people from these other agencies. It is our intention to do this work in close concert with them, such that it will not dislocate their important work in the process.

In order to identify and properly coordinate with the effort in the other parts of the Government, it is necessary that an appropriate portion of our people come from those organizations.

In addition, of course, we plan to get people from universities and from industry to add up to this total. In addition to that we are making studies with universities to look into means to provide us with additionally trained personnel to expand this total complement.

Mr. DADDARIO. What do you base your statement on, so far as numbers are concerned? What about the number of people you will be getting from the other agencies, in what numbers and where and what do these agencies say the effect will be on their programs?

Mr. MAYO. As of right now, we have discussed it at quite a length with the Air Force. This is to be handled on an individual basis. If there is an individual, and there have been two recent cases, Dr. Vorhis has been assigned to us from the Navy, and Dr. Turner from the Air Force, with the specific intent of helping in this problem.

General Wilson pointed out that it was every intention of the Air Force to give the maximum support to NASA, which I am sure they will do.

As to the exact number which will come from other laboratories, from universities and industry, we will have to arrive at this as a result of continuing discussions of the type we have mentioned.

Mr. DADDARIO. Is this the best way of doing it?

Mr. MAYO. We think that it is, because as you can see, the President's requirements on the NASA give to us a very large problem which must be oriented in a manner to meet the needs of a specific program. It is going to be quite difficult to accomplish this program if NASA does not have sufficient capability to provide the leadership necessary to do the job in a reasonable manner.

Mr. DADDARIO. There is no question about that. That goes to the heart of the problem. The fact is you have a goal placed before you which is causing you concern and you are naturally looking around for the people to help you.

The problem which concerns me now is the problem which has concerned me in the past. It just becomes more accentuated, that is, in the Department of Defense.

Each of the services has programs, looking to the future, so that they can figure out how best they can prepare themselves for the environment in which our service personnel may find themselves.

This goes under the ocean, in space, in the Arctic areas where our people may fight, and our medical people have to help prepare for this kind of future.

I don't think we can subvert this, make this secondary to the NASA program. These are all goals which are important to achieve. Are we going to hurt our capacity to maintain the security of this country, not as of the moment, but as of the future?

Are we going to prevent, let us say, the Air Force from providing the capacity to prepare their people for the environment in which they will find themselves in space by diverting their programs, the programs which have worked so successfully in preparing our pilots for the aircraft that flies so high and so fast in such a rarified atmosphere and on which our security in great part depends; are we going to interfere with this?

Are we tying these together? Should we perhaps bring all of these people under one roof and have both the Department of Defense, the other agencies of Government, and yourselves, place your requirements before such a group, brought together so we would have full utilization of this narrow capacity which exists?

Mr. MAYO. We certainly look on this problem as one of a national effort in which NASA in the space area has been assigned the leadership. We must, as you pointed out, be very careful that we do not allow either NASA or the Department of Defense to divert those people essential to the present Department of Defense missions.

In your study, I believe you indicated the Air Force had approximately 1,200 scientific people in this immediate field. We think a buildup of 150 in the NASA as against the 1,200 in the Air Force is quite a reasonable ratio and should in no way strike to the critical heart of the problem.

We think in fact it is necessary to help build up the additional capability that you point out we need.

Mr. DADDARIO. It depends on where you sit. Do you think we are doing it so that we are not lessening the capacity of the other services and do your reports show the services agree with you?

The CHAIRMAN. You haven't answered. We are going to have to move on to the solid propellant.

Colonel ROADMAN. I would like to address myself to this group, Mr. Chairman, and to Mr. Daddario's last comment. It is my feeling the magnitude of this program, Mr. Congressman and members of the committee, is such and will require such an effort, say in the life sciences area, that in my view this Nation could not pursue this program and meet its goal in the life sciences area as it pertains to the support of a manned lunar landing effort and return without the utilization of these facilities that do exist say specifically in the Department of Defense.

I certainly will admit that up until now we have not been able to integrate programs until we got this program in terms of planning; it is our view that we must plan in concert.

I would view, Mr. Daddario, it would be necessary in the NASA, say within the headquarters of NASA, specifically, to configure our personnel structure so that we have in effect a task force headquarters NASA planning organization which looks at the problem, which defines the requirements, which in order to get this done, let's say, might use the School of Aviation Medicine at Pensacola or the Aero Space Medical Center at Brooks Air Force Base as the best prepared, the best talent to conduct this segment of the effort.

We envision we will have to define the problems more stringently, identify where best the work can be done with the personnel and talent that exists in this country. This we intend to do. We must. I would like to speak to the 151 personnel figure, Mr. Chairman.

In my view, we do not intend as far as planning purposes at this moment to necessarily utilize all of the 151 people within the NASA structure.

Let me say, for example, that in radiation work existing down at the School of Aviation Medicine, where they have some of the best talent in the country, that in this manpower situation we thoroughly intend to augment their personnel requirements, where the Air Force

is not able to do under their personnel ceilings, in which we can conceivably put people who are employed within the NASA to augment their capability say in the radiobiology field, and this we intend to do.

Mr. DADDARIO. I understand that, Colonel. I think we are pointing in the right direction. This is how we accomplish the placing of the man on the Moon and returning him safely back to Earth. But it does not get to the other proposition as to how it may weaken the biomedical capacity in the services, which I believe is of extreme importance and will affect therefore our national security.

Mr. Chairman, I understand we do have to get on. I would like to have your permission to sit down with the doctor and the Colonel on these reports that they have, to follow just further through so that I may be properly acquainted with the situation.

I also feel that part of this is the Manned Space Flight Center, which brings in intriguing problems as to the utilization of facilities which do exist and how these will either complement those, or be duplicative or will be properly in addition to them.

The CHAIRMAN. May I say to the gentleman there are other members of the committee too who are very anxious to ask some questions on this same point, who may not share his view entirely.

We will try next week to get in another committee hearing on this same problem. Tomorrow we have scheduled the communication hearings, which are very pressing. We have postponed them three or four times at the request of NASA. We have our witnesses scheduled for tomorrow on that.

We will try to work in a hearing next week to complete this.

Mr. DADDARIO. If we couldn't do that, if sometime I might have the opportunity to submit questions which could then be entered in the record—

The CHAIRMAN. Surely. There is no objection to that. I believe these gentlemen will be glad to answer—

Mr. MAYO. We would welcome those.

Mr. WYATT. May I inquire?

I believe Mr. Mayo did not finish his prepared testimony, if it might be inserted in the record for completion.

The CHAIRMAN. I thought he had finished.

If Mr. Mayo will do that, we will be glad to have the completed testimony. I know we had pushed Mr. Mayo a little bit on his testimony.

(The complete testimony of Mr. Mayo is as follows:)

EXPANDED LIFE SCIENCES PROGRAM FOR FISCAL YEAR 1962

(By Charles H. Roadman, M.D., Acting Director, Office of Life Science Programs)

At previous hearings the Office of Life Science Programs of the National Aeronautics and Space Administration submitted requirements for a 1962 research and development budget of \$8.6 million. The President's request for a manned lunar landing program requires a large increase in this effort. The need for early information necessary to the design of protective and functional equipment to meet this request makes it necessary to immediately increase the present level of funding to a new total of \$20.6 million. In my view, this new task will require full utilization of all space-related life-science capability in our Nation. Full use of all existing Government, university, and industrial facilities must be assured. In addition, appropriate expansion of capability must be initiated.

LIFE SCIENCE PROGRAMS

FISCAL YEAR 1962

OBJECTIVES

- 1. ASSURE THE CONTRIBUTION OF MAN TO THE SUCCESS OF SPACE FLIGHT AND EXPLORATION.**

PROGRAM PLANS

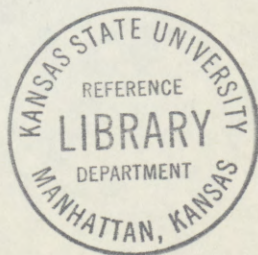
**DETERMINE MANS CAPABILITIES AND LIMITATIONS
TO ASSURE HIS EFFECTIVE USE IN SPACE SYSTEMS.**

**PROVIDE ADEQUATE LIFE SUPPORT - NOT ONLY FOR
SURVIVAL - BUT ALSO TO INSURE EFFICIENT PERFORMANCE.**

561-512

FIGURE 339

The basic objectives of life science programs have not changed; they are:
(Fig. 339) (1) To assure the contribution of man in successful space flight exploration. For this purpose, man must be protected from the hazards of the space environment and be able to work at high efficiency.



LIFE SCIENCE PROGRAMS

FISCAL YEAR 1962

OBJECTIVES

2. ACQUIRE FURTHER KNOWLEDGE ABOUT LIFE AND ITS DEVELOPMENT INCLUDING THE SEARCH FOR EXTRATERRESTRIAL LIFE.

PROGRAM PLANS

DETERMINE PHYSICAL, CHEMICAL, AND BIOLOGICAL CHARACTERISTICS OF LIFE, AND UTILIZE THESE DATA AND METHODS IN SEARCH FOR LIFE IN SPACE.

561-513

FIGURE 340

(Fig. 340) (2) To acquire knowledge about life and its development including the search for extraterrestrial life. Acceleration of the achievement of these objectives is now mandatory. An accelerated in-flight program is proposed to provide the information necessary for NASA to design adequate manned lunar spacecraft in time to meet scheduled objectives.

The new total research and development program is associated with a salaries and expenses budget of \$1,286,000 for field personnel. The new request increases life science field personnel from 51 to a new total of 151. An expansion of the headquarters staff from a presently authorized strength of 24 to 37 is requested. This will require \$388,987 for fiscal year 1962. The C of F budget includes a request for \$800,000 to allow construction of additional life science laboratories to add to facilities already available at the NASA Ames Research Center.

Before final design of a manned spacecraft to accomplish the Moon landing and return mission, many areas now unknown must be investigated and defined. The areas of radiation and prolonged weightlessness are the major ones to be understood before one can design a suitable spacecraft to protect man from the hazardous environment of space and let him work at an efficiency level which is better than can be accomplished with an automated device.

To understand these problems, one must depend on actual space flight experiments inasmuch as complete simulation of the problem is impossible here on earth. These flight experiments will require extensive ground-based control experiments and support. You will see this reflected in our requests in the aerospace medicine and space biology areas.

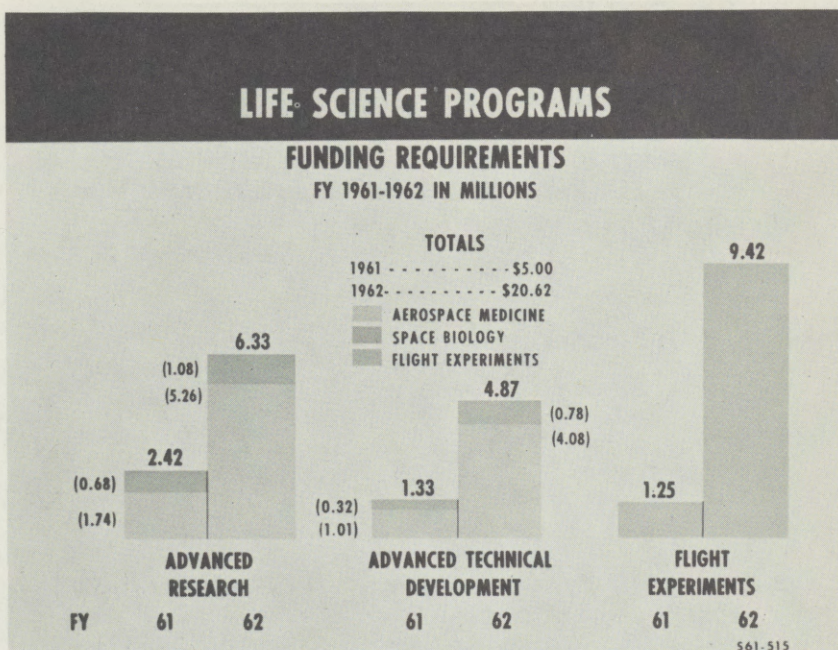


FIGURE 341

Advanced research and advanced technical development in these ground-based research and development areas will require (fig. 341) in the expanded program, \$6.33 million and \$4.87 million respectively, and the flight program will require \$9.42 million.

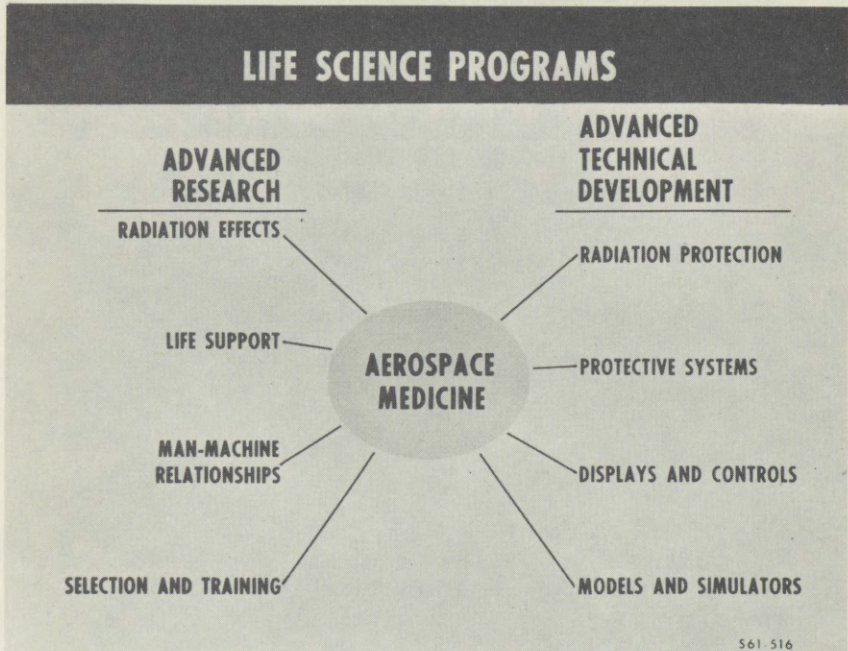


FIGURE 342

Aerospace medicine is concerned with an understanding of the human psychophysiology and the mechanisms by which the human systems react in changes of environment. Figure 342 illustrates some of the work areas.

Aeromedical research carried on for aircraft flight has provided a considerable amount of the information necessary concerning the effects of acceleration forces; of noise and vibration; the needs for oxygen; and for cabin pressure and temperature control. It was this background of information that was tapped to develop the Mercury capsule system and to provide the protection needed for the first small ventures into space.

Lunar flights will be of much longer duration and will be outside the protective influence of the Earth's atmosphere, magnetic and other fields. Before the flights can be safely and effectively carried out it is essential that knowledge be gathered to define environments to insure adequate protection and conditions conducive to effective human performance.

Basic knowledge is lacking concerning the prolonged effects of reduced gravity and weightlessness. The extent of the threat and the protection required against the vast spectrum of unshielded radiations in space must be defined. The effects of combinations of environmental stresses must be determined as a function of time in order that the necessary design specifications can be made available. To meet these needs, it is necessary to understand how each of the body systems reacts to each of the changes in environment. Some of these reactions are known; some can be determined by ground experiments; and others will require biological experiments in actual space flight. The biological information acquired from actual flight experimentation is necessary to do the final assessment of these factors, as they are necessary for the design criteria of space vehicles.

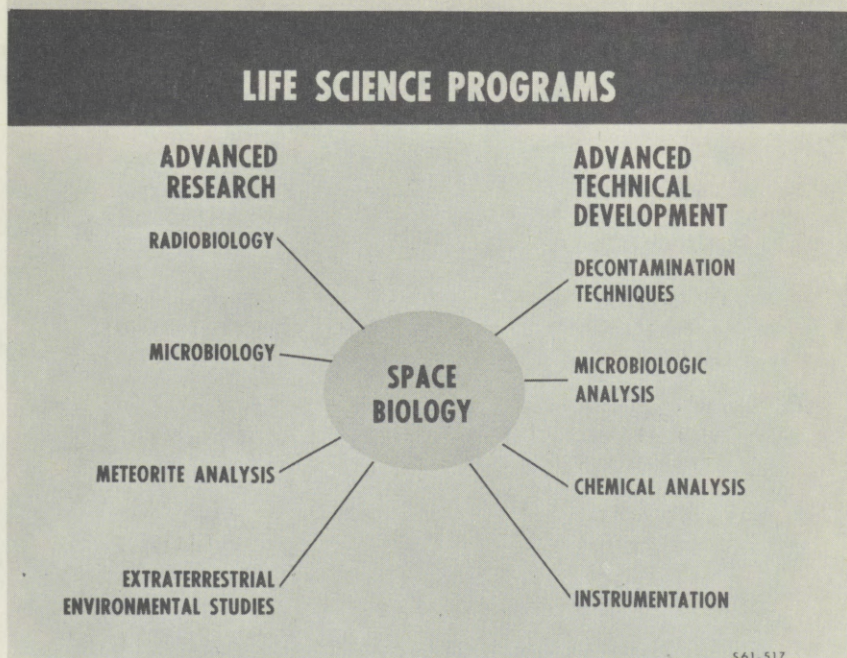


FIGURE 343

Space biology includes the exploration of space for life forms including the search for extraterrestrial life and for studying the evolution of life in our universe. Figure 343 illustrates some of the areas into which this work is divided.

It is now believed by many that life can and has originated wherever the conditions have been right. University scientists working on this premise have been able to synthesize protein particles from gases typical of some planetary atmospheres. They have found that the size of the particles formed is a function of the gravitational force during the experiment. One g. for example, produces particles about the size of bacteria but supernormal gravity yields much larger units.

While much of the life detection work must await returned samples from manned landings, preliminary work is underway to do infrared observations of planetary atmospheres for the detection of lifelike compounds. Studies are also being made of meteorites for signs of life.

Important work is underway also to prevent contamination of the Moon and planets by Earth organisms carried by exploratory vehicles and to provide in turn for the protection of the Earth from the possible danger of rapidly growing extraterrestrial organisms which could conceivably be carried back to Earth with our spacecraft.

Much of the "space biology" initiated for a better understanding of life processes is directly applicable to the manned lunar landing mission. For example, studies of change in subsequent generations of rapidly reproducing lower forms of life provide one of the best means of measuring the effects of damaging radiation on living organisms. This information can be used to determine the type and amount of radiation shielding necessary for the manned lunar spacecraft.

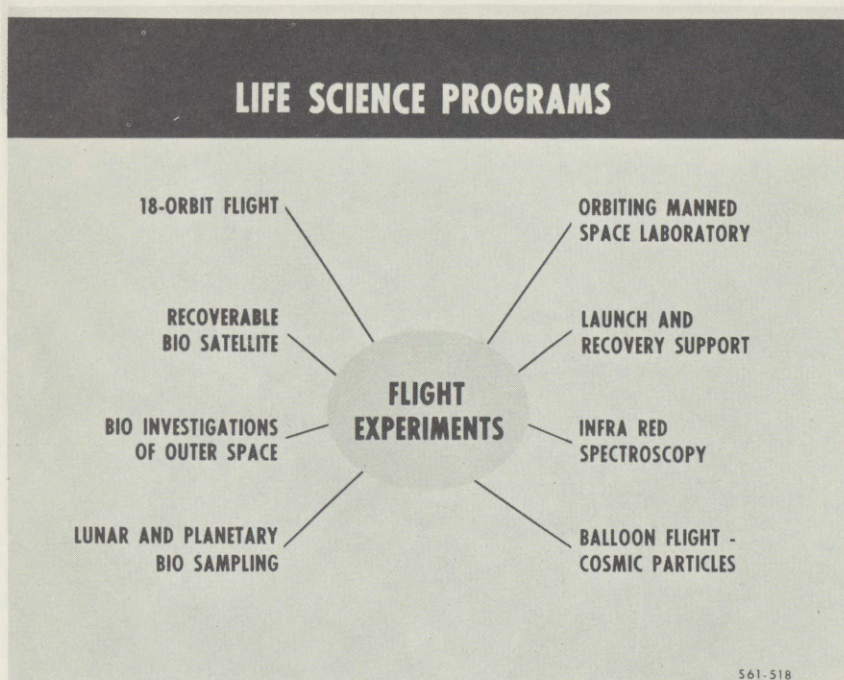


FIGURE 344

The flight experiments (fig. 344), can be divided into the investigation of space radiation, weightlessness, and the search for extraterrestrial life.

In the acquiring of information on the properties and effects of space radiation, the NASA has proposed a series of biological space probes "BIOS" (previously NERV to investigate the inner Van Allen belt. BIOS I is primarily a radiation experiment that has been designed to reveal information needed to design protection methods for man's survival on a lunar flight.

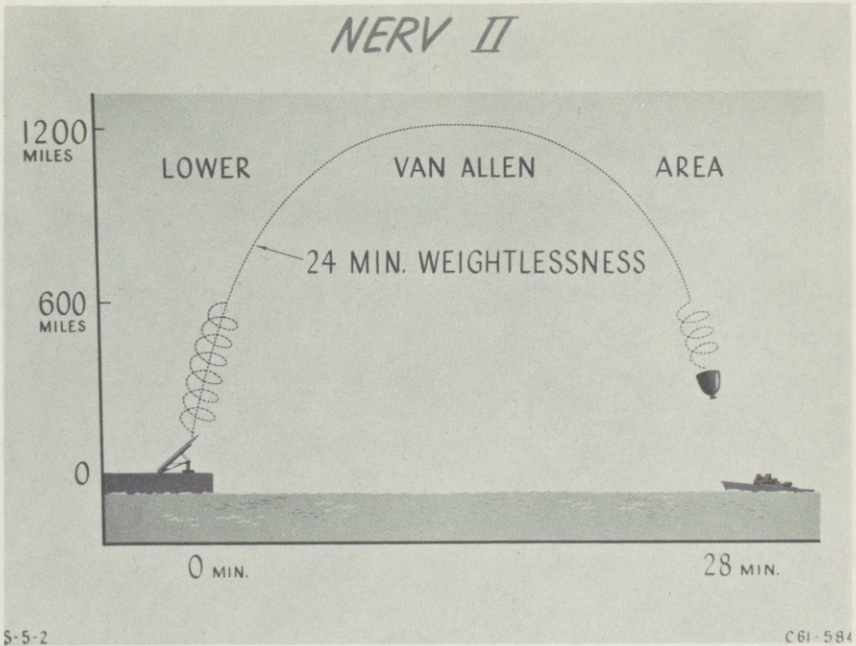


FIGURE 345

This experiment (fig. 345) will take place on a ballistic flight using an Argon-D8 vehicle with a modified NERV I nosecone. Biological systems sensitive in various ranges of radiation have been assembled to establish radiation measurements meaningful in terms of their effects on man. Supporting physical experiments are being conducted by GSFC.

Secondarily there will be an experiment to study cell fertilization and division in the weightless state and one to determine micrometeorite flux and penetrability.

You can see from the chart that this experiment will penetrate about half way into the lower Van Allen region then fall back out and that it will have approximately 25 minutes of near zero g. flight. This study is being conducted by our Ames group. The General Electric Co. at Philadelphia, Pa., is the prime contractor, and the Navy group at PMR is supporting for launch and recovery operations.

The information gained from this flight will by no means be the last needed, but may give us some indication why the Russians have reportedly lowered the orbit of their dogs to keep from having a postflight rise in the white blood cells (postradiation infection?). This information will then be used to design further flight experiments to gather more complete data which is necessary for the spacecraft designer to adequately protect man. Spacecraft orbiting within the inner and outer Van Allen areas as well as those in ambient space are needed to complete the more complex experiments needed for final determination and testing of radiation shield configurations.

In the investigation of the weightless state, it is planned to orbit spacecraft laboratories under the radiation belts for prolonged periods of time. In this environment, it is planned to study the effect of weightlessness on primates and lower biological systems.

*EARTH ORBITING RECOVERABLE BIOLOGICAL SATELLITE PROJECT
(PROBABLY USING MERCURY SYSTEM)*

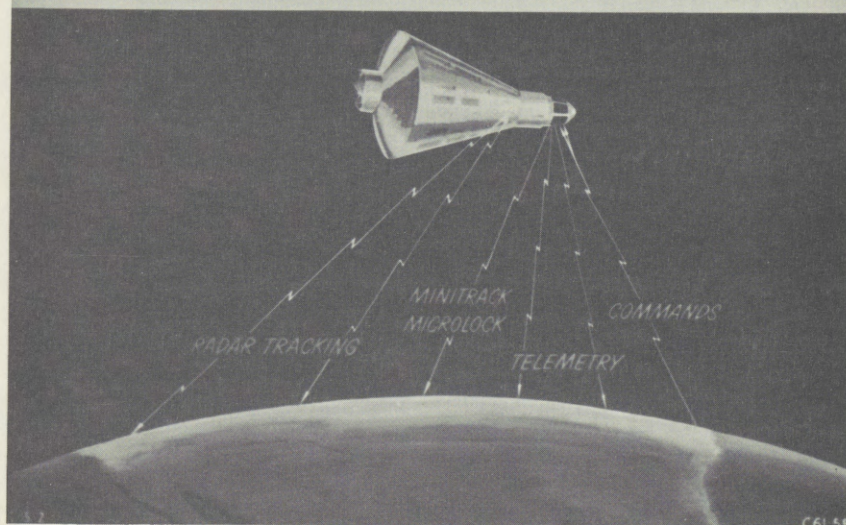


FIGURE 346

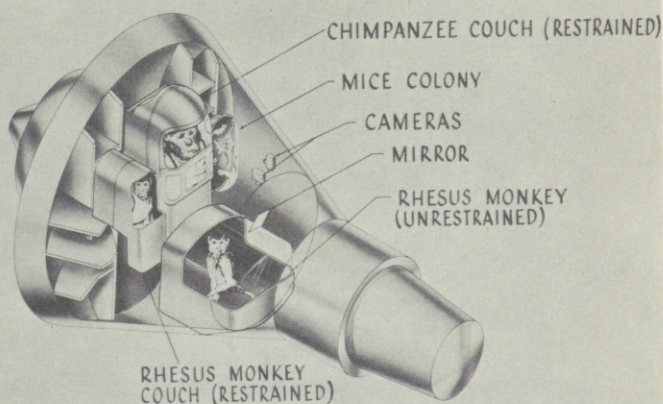
Earth orbiting recoverable biological satellite (EORBS). A flight experiment has been designed to study the effect and/or effects of weightlessness (fig. 346). The biological experiments are well on their way as far as ground controlled research studies are concerned, but cannot be flown until the NASA has a recoverable spacecraft. It is our hope that the Mercury system can be utilized. At this time, there is not an adequate spacecraft available for prolonged orbiting flight.

This experiment is comprised of a number of biological systems that complement one another in the investigation of weightlessness.

Starting with the highest order of organism we will study performance in prolonged flight (14 days).

Russia has demonstrated relatively short orbiting flight capability, but has not by means of the longer orbiting dog flights revealed for us any pertinent data on the performance of the higher animals.

EARTH ORBITING RECOVERABLE BIOLOGICAL SATELLITE



5-2

Col-584

FIGURE 347

If performance in the chimpanzee should deteriorate or cease, the second level, an instrumented rhesus, will give us the reason why. Deep brain probes will enable us to assess consciousness (fig. 347). If unconscious the heart function measurement may be a clue to why—if that is gone, or normal, why then?—move to a level lower and evaluate hormonal and endocrine function and even to a lower level if necessary, to tissue cultures and other test tube systems that have been included.

The unrestrained rhesus acts as a flight control as well as a study in movement and orientation during weightlessness.

Although not a primary radiation experiment this will include mice and other systems to study the long-range effects of the radiation spectrum that exist below the Van Allen belts.

Information in this area is extremely important prior to designing space laboratories essential for lunar and planetary flight. Every university or agency contacted has unanimously supported and offered to participate in this experiment.

The flight experiments phase is well underway in all of these areas. The 18 orbiting capsule flights will utilize the Mercury system, which, as you know, is now under development and test. The scientific experiments are well on their way as far as ground-based controls, training, and design is concerned; many of these are already prototype hardware and await the money for integration into the spacecraft.

The effect of the heavy cosmic particle has become increasingly interesting. This is one component of the radiation spectrum that has never been simulated here on earth. It is, however, one of the easiest to reach in a flight program.

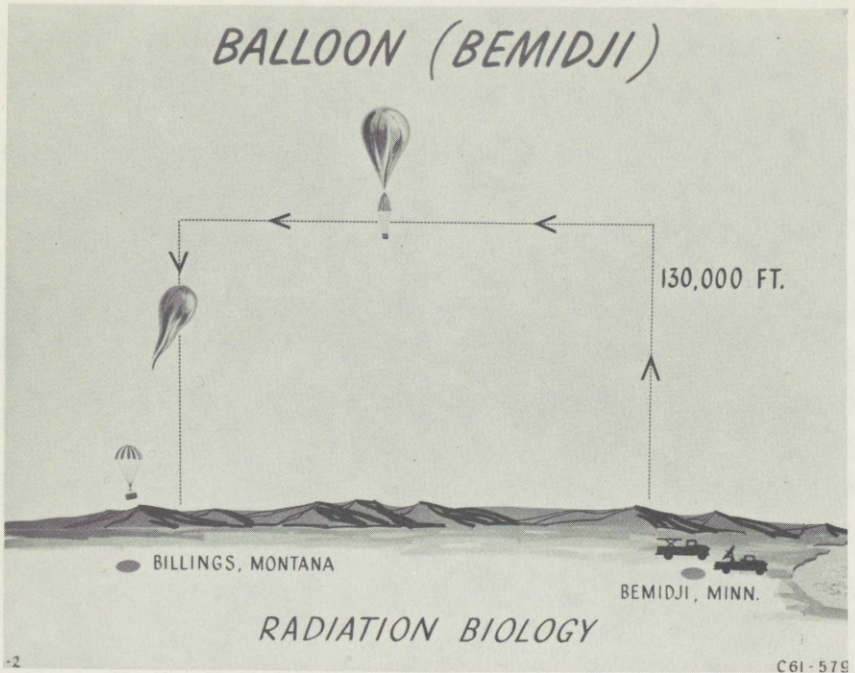


FIGURE 348

We have studied the effect of these particles by exposing biological specimens to the northern latitude's high altitude, fig. 348. This was a joint Air Force/NASA program wherein NASA, AF SAM, and the AFIP cooperated to gather a wide range of information. Flights of over 130,000 feet for 4 hours or longer have been used.

Dr. Haymaker, a noted scientist in neuropathology, has been the principle investigator on these experiments and will carry on this effort in conjunction with those of GSFC at Fort Churchill, Canada, this summer.

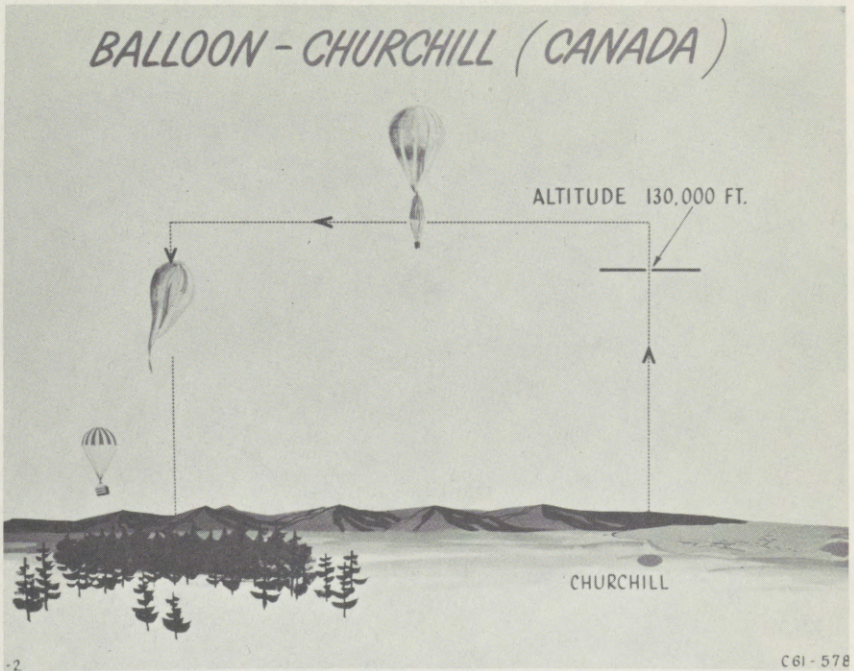


FIGURE 349

Figure 349 shows the planned flight path for this summer's launchings and figure 350 demonstrates techniques and equipment for studies of this kind.

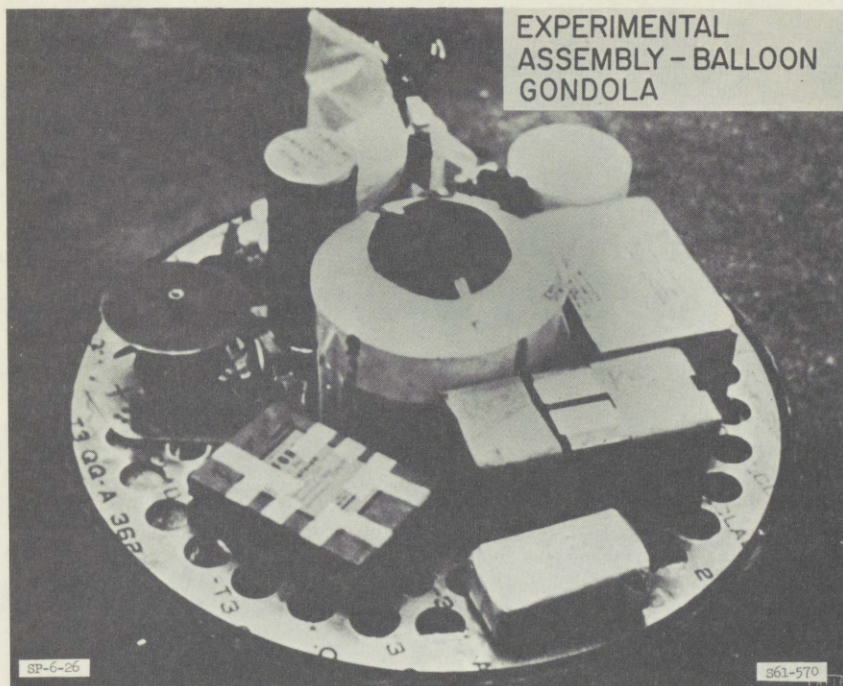


FIGURE 350

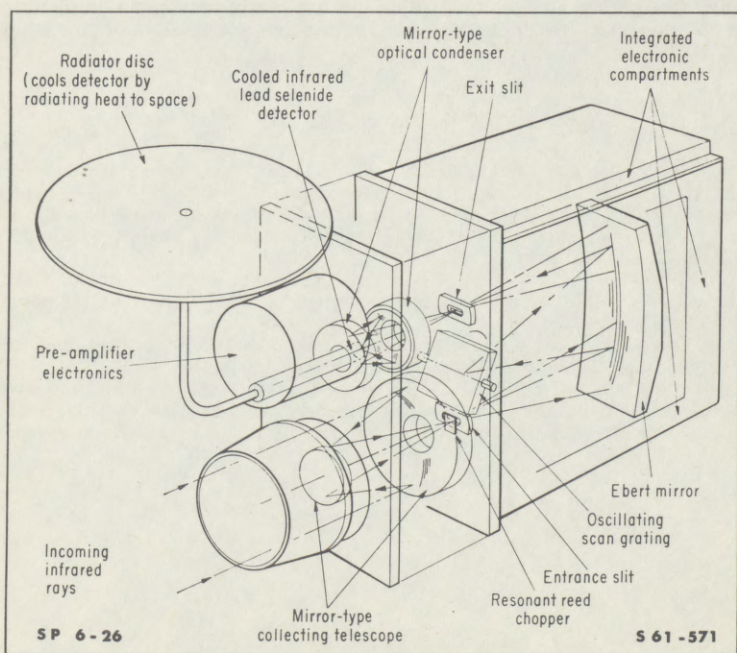


FIGURE 351

In the investigation and search for extraterrestrial life it has been decided that infrared studies in the 2 to 6 micron range is the most effective method now available with which to proceed (fig. 351).

Figure 352 depicts the flight programs to support these studies. The helicopter will be used for gathering downward looking control data—incidentally, also to check the instrument designed for use in the Venus and Mars flyby de-

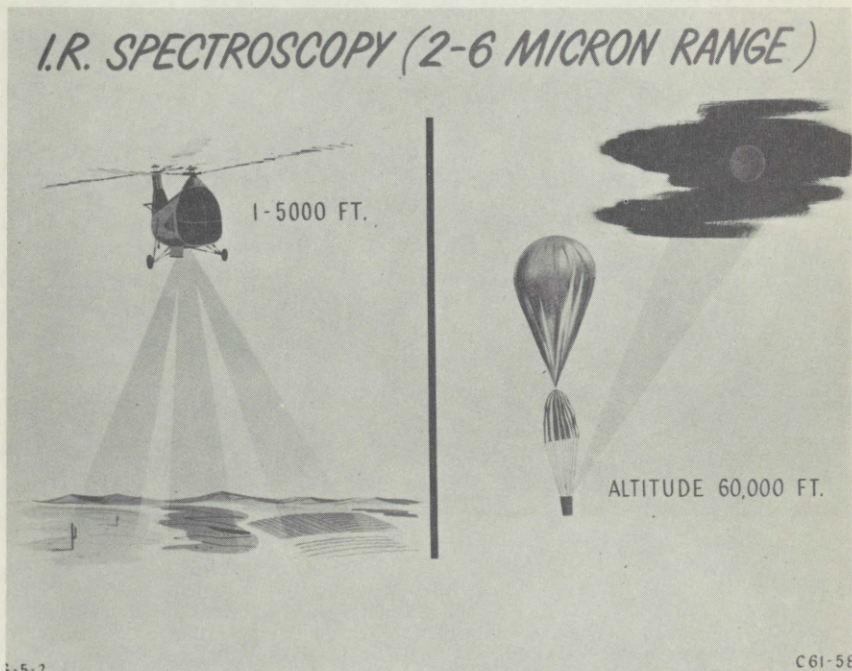


FIGURE 352

veloped by JPL—stable flight—from 1,000 to 5,000 feet above the earth or above the earth's reflected radiation. The Balloon and Schwartzchild's telescope above 60,000 feet above the water vapor will be used in the upward looking (at the Moon and planets) phase. In this IR range one would expect to identify material associated with life.

The JPL is presently working with Dr. Sagan of the University of California on this project. The Air Force is participating with logistical support (helicopters, etc.).

Study programs are now being accomplished in both the manned orbiting laboratories and for the manned lunar and planetary base.

The ground control experiments in this program area are now underway for lunar and future manned space flight needs. An example of this is the biological radiation satellites designed to follow the BIOS and balloon experiments for orbit in the Van Allen belts and above.

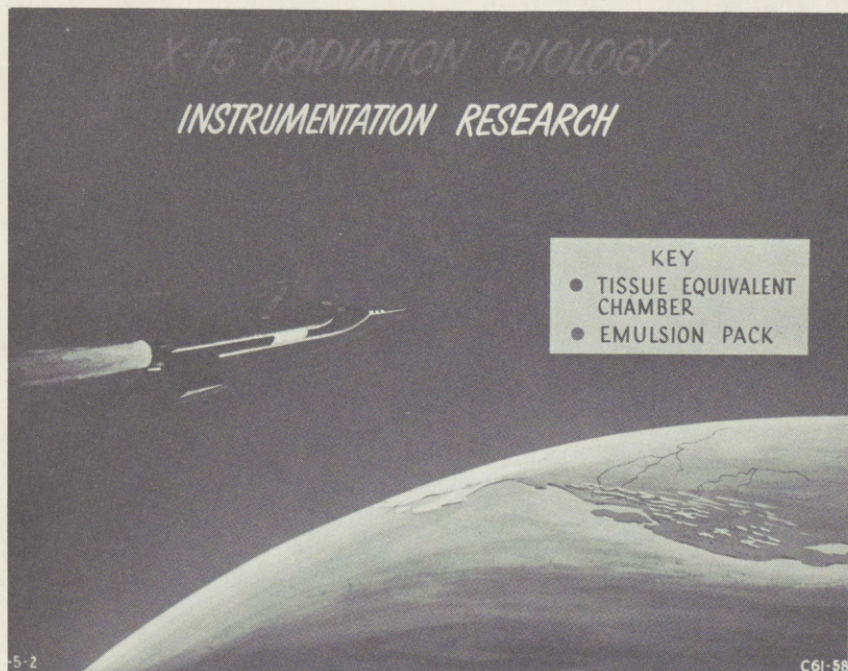


FIGURE 353

Figure 353. Experiments are presently incorporated into the X-15 aircraft.

These are radiation counters which have tissue equivalent material around them and blocks of photographic emulsion which when struck by radioactive particles leave tracks. This aircraft is being used as a test bed for radiation instrumentation wherein confidence will be gained in the instrument and practice will be afforded in receiving and interpreting telemetered data.

Besides this radiation biology there are many experiments in the X-15 which give us information on man—such as control handling capability and medical monitoring information in a dynamic situation.

In the flight experiments the biological portion will be the responsibility of the life science facility at the Ames Research Center.

This year we are spending \$1.25 million on this program, and next year as our recoverable satellite becomes available we expect to increase the amount by at least three times.

In summary, accelerated research and development in Aerospace Medicine and Space Biology is proposed to provide NASA with the vital information needed to design spacecraft adequate to insure the survival of crews and the effective accomplishment of a manned lunar landing during this decade. The core of the needed information will be achieved by a series of in-flight experiments utilizing biological specimens and men. The necessary ground-based research, development, and training of personnel will require full utilization of available government, university, and industrial life science capacity plus appropriate expansion of capability in new areas.

The CHAIRMAN. I have this question of someone: about this security clearance. I notice the new bill provides \$1.1 million for security investigations. Is that in addition to the amendment which the committee adopted and which the House approved, setting aside not to exceed \$2 million for the purpose of pushing that security clearance?

Mr. SIEPERT. The program that is in the present revised budget is the program that has been discussed with your committee. It is not an increase beyond that. It is a program that has since been worked out with the Civil Service Commission. They are a key factor in this in that they do the investigations for us.

The CHAIRMAN. Will that program push and speed up the clearances of these people?

Mr. SIEPERT. It will do so on the basis of the schedule that was discussed with committee staff.

The CHAIRMAN. No slowing down?

Mr. SIEPERT. No, sir.

The CHAIRMAN. Any questions on that point?

If not, we will take up the solid propellants.

Would you give us a brief statement on that, because we need the last 5 minutes to go over some committee matters.

I want to ask the members of the committee if they will stay.

General OSTRANDER. I have no prepared statement, as such, on the specific question of solid rockets. However, I can tell you briefly, if you wish, our plans as we see them to date.

As Dr. Dryden told you yesterday, there is in the President's recommended budget an amount of \$62 million, which is included in the budget of the Department of Defense, for the development of large, solid rockets.

By an agreement between NASA and the Department of Defense, the Department of Defense, or more specifically the Air Force, would be working for NASA in this program. NASA would still be responsible for the overall vehicle using a solid propellant first stage.

We would have the responsibility of integrating such solid-propellant motors, or stages, as the Air Force developed, with the upper stages of the vehicle. The Department of Defense has agreed to act in a responsive way to NASA requirements in carrying on this development work.

The CHAIRMAN. You are not going to push the solid-propellant development?

General OSTRANDER. We are going to push it, but because of the magnitude of the program we are asking the Air Force to help us in doing the job. They have, as you know, a great deal of background and experience which they have gained in connection with the Minuteman program, which uses the largest solid-propellant motor which has been flown to date. We would like to take advantage of this knowledge and background and let them supervise this part of the program for us.

The CHAIRMAN. What about the semisolid propellants? Who is going to take that up?

General OSTRANDER. At the present time we have no plans to support this development with NASA funds. We will follow it with interest, but we have not currently planned—

The CHAIRMAN. Would that be the obligation of the Air Force?

General OSTRANDER. I do not know, Mr. Chairman, whether they have any funds to support the program or not.

The CHAIRMAN. At one time the NASA thought that they wanted funds for the solid propellant program. Do you still want funds for it?

General OSTRANDER. We still have a small amount of funds, the same amount that we had in our original program to continue some of the advanced technology. I believe that the funds included in the Department of Defense budget are sufficient to carry on the actual large solid propellant motor development.

The CHAIRMAN. We added, I think, \$10 million over and above what you said you could use for that purpose on the House side. You don't want that money?

General OSTRANDER. We have funds, Mr. Chairman, included in our request for the Nova vehicle which would take care of our responsibilities for integrating whatever solid propellant motors were developed by the Air Force into the overall vehicle.

The CHAIRMAN. You must recognize the fact the the armed services have studied solid propellants much more than NASA. You have the Army with the Pershing, the Navy with the Polaris, the Air Force with the Minuteman—these are three. All three of them use solid propellants which indicate the armed services have made a study of that.

General OSTRANDER. This is precisely the technology and experience that we would like to take advantage of in the national program.

Mr. FULTON. My amendment increased it from $\$8\frac{1}{10}$ million to $\$18\frac{1}{10}$ million for solid propellants. With this new plan of yours, are you going to need the \$10 million for another purpose so that we should need it?

General OSTRANDER. No, sir; I don't think so. As I mentioned, the money which we will require for the adapting of the solid propellants are included in the funds we are requesting for the Nova vehicle.

Mr. FULTON. NASA is cooperating with the Department of Defense and the Air Force, the various services, on solid propellants. That brings up the question, why shouldn't we then, on the NASA level, emphasize liquid propellants? For example, I have been interested right along in pentaborane high-energy fuel research and development. We have the Callery Chemical Co. in Oklahoma working on the production of pentaborane, that got the contract by competitive bidding.

The work on the engine is being done at the Edwards Air Force Base under the Air Force. They have about 100,000 pounds of inventory of pentaborane and are producing at the rate of about 4,000 pounds a month. What is happening is that there is not enough emphasis to me being put on the development of the engine, the rocket engine, so we may lose this scientific group or team of 325 or 350 people expert on research and development on high-energy fuels by having to shut down the Oklahoma plant.

My feeling all along has been to keep these scientific teams together, keep them working. When we have a high-energy liquid fuel like pentaborane which is our sole U.S. storable liquid fuel which we have in sight, and which needs no special insulation for high-far-out vehicle flights, I think that this program is something to which we should give our close attention and strong support. My recommendation is strongly to NASA, if the Air Force is going along at its own ordered place on the development of the engine and has other greater interests of a more pressing nature than NASA, when there is a civilian space effort, should keep a research and development program too, don't you think?

General OSTRANDER. Mr. Fulton, we have made arrangements with Dr. Charyk in the Air Force to discuss this program. I arranged yesterday for some of my people to go over and discuss with Dr. Charyk and the Air Force people the use of this facility and how it might fit into the NASA program.

Mr. FULTON. The liquid high energy fuel research and development program is worth while. It was in 1959 that the committee said we want to have a determination made of the capabilities of this high energy fuel, pentaborane derivatives. If we can make a determination that it is worth while for the rockets' use, we wanted certainly to keep the scientific teams together working on it.

General OSTRANDER. We are looking into it.

Mr. FULTON. The thing that worries me about it is. I had Mr. Richard Hines on our Science Committee staff about a month ago check with the Air Force, and they said they had no present programs for the use of pentaborane. It brings us up to the same thing that we had before, where we lose a \$35 million plant that is already installed and in operation. We now actually have a rate of production at a high cost rate, where if it were 20,000 pounds a month production, the cost per pound would be much cheaper.

I believe the engine development for pentaborane fuel could move ahead faster. This is not criticism, but I don't believe the engine development is moving fast enough so that our solid propellant research and development can move ahead at the rate we need it for this Moon program, and various other space programs of NASA.

Do you agree with that?

General OSTRANDER. I think that there are some very basic problems in the use of this material, as you know. It has a lot of advantages but it has some basic problems which have to be worked out before we can go into an engine development.

Because of this I think the Air Force has decided to drop or at least to slack off on their work. What we propose to do is to sit down with them and find out whether there are some specific uses in the NASA program to which those limitations would not apply, and whether we should go ahead with further development programs.

Mr. FULTON. I hope you do.

The CHAIRMAN. At this point we want to thank the general. We are going to try to schedule another hearing next week, if we can work it in, to round out some of the features of this hearing that we haven't covered.

Today we have a little bit of committee business and we want to thank all of you from NASA for being here.

Mr. FULTON. May I join in thanking them and calling attention—

The CHAIRMAN. We are very happy to have Justice Reed here this morning.

The hearing session on NASA authorization stands adjourned.

The CHAIRMAN. At this point we have something that I think is very important to the committee. You drafted the resolution here which the committee authorized for Captain Silberstein. The captain is going to leave the committee this week to return to the Navy. He has been a most valuable and gifted man on the staff of the committee.

If you will read the resolution, Mr. Hines, we will appreciate it very much.

Mr. HINES. Whereas Capt. Howard J. Silberstein, USN, since his assignment in July 1960 to the Committee on Science and Astronautics has distinguished himself by his outstanding performance as staff consultant; and whereas Captain Silberstein consistently demonstrated a broad technical knowledge, analytical judgment, and devotion to duty; and whereas in pursuing his professional responsibilities he has made material contributions to the committee's deliberations through many significant reports and papers; and whereas the members and staff of the committee have found Captain Silberstein ever cooperative, helpful, and unsparing of himself; and whereas it is the consensus of the committee that Captain Silberstein, through his association with our committee, has made an outstanding contribution to our national space effort: Therefore be it resolved, that the committee extend to Captain Silberstein, upon the termination of his tenure with the committee, its deepest appreciation for his work. During the year he has been with the committee he has reflected great credit upon himself and upon the U.S. Navy.

The CHAIRMAN. You have heard the resolution. I am sure there is no objection to it. If not, it is unanimously adopted.

Mr. HECHLER. I just wanted to extend something for the record, that since Captain Silberstein happens to come from my hometown of Huntington, W. Va., we are particularly proud of him. He has been most helpful to the committee and me personally. I think he has done a really superior job for the committee.

The CHAIRMAN. We have never had a man more helpful than the captain has been. We are going to miss him. Perhaps under the law which permits us to call back men after they have retired, we could call him back to the committee.

Mr. FULTON. We certainly have enjoyed working with Captain Silberstein. We are glad he is in the Navy.

The CHAIRMAN. We have two things here. I want to tell the members of the committee that I have asked a member of the staff, he has not yet been appointed, to work on the question of whether or not NASA can be of greater help to small business. As you know, the House has a number of committees interested in small business. The Senate likewise has. We want to cooperate with those committees. We are not in any way treading on their jurisdiction, but if there is a way by which we can help NASA work out its small business problems, that is what I am going to ask a member of the staff to study.

There is one more matter this morning, that is the trip which Mr. Fulton brought up yesterday. That occurs on Tuesday morning, July 18, all being well at that time. All the members of the committee are invited to attend a closed-circuit television coverage of this event at the NASA auditorium at 15th and H Street NW., in the event they don't go to Canaveral. NASA has also advised the staff that it will endeavor to provide transportation for the members who wish to attend the event at Cape Canaveral, although no firm committee trip is planned at that time. For those who wish to go to Cape Canaveral, it is expected that a NASA plane will leave Washington on the evening of Monday, July 17, and to return after the shot on Tuesday,

July 18. If the shot is canceled or delayed, the plane will be returned to Washington on Tuesday, the 18th, regardless.

The committee stands adjourned until tomorrow morning at 10 o'clock.

(Whereupon, at 12:05 p.m. the committee adjourned, to reconvene at 10 a.m., Thursday, July 13, 1961.)

(The following information was later supplied for the record:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LIFE SCIENCE EFFORT FOR
THE MAN-IN-SPACE PROGRAM AND ITS INTERGOVERNMENTAL RELATIONSHIPS

On May 26, 1961, President Kennedy requested the support of Congress for a greatly accelerated national program of space exploration aimed at landing a U.S. exploratory team on the Moon within this decade, and its safe return to Earth. To assure fully coordinated and successful man-in-space effort, the National Aeronautics and Space Administration is striving to marshal the total national resources and is taking the necessary steps to expedite and implement the President's request for a major national commitment of scientific and technical manpower, material and facilities.

In this context, NASA is endeavoring to carry on a program designed to produce the information needed by this country to proceed at maximum speed and with confidence in the man-in-space program. Research and development in the life sciences is of critical importance to the achievement of these national goals. Full utilization of present capabilities within the Government agencies, to the extent that they are not essential to programs peculiar to the assigned role of the particular agency, in industry and in the universities is an absolute necessity.

But, this alone is insufficient to meet exploding technical needs. In addition it is necessary to rapidly augment the national life science capability to meet these requirements. In order to marshal the existing national resources in life sciences and to provide the required new facilities, it is essential that NASA have immediate access to responsive and effective life science activity.

Toward these ends working arrangements with the Department of Defense and especially the Department of the Air Force are in being, and essential activity is being implemented. To illustrate NASA's utilization of available life sciences capabilities, a statement of agreement for task assignments with the Department of the Air Force is referred to in a letter dated March 13, 1961, from the Associate Administrator of NASA, Dr. Robert Seamans to Lt. Gen. Roscoe C. Wilson, Deputy Chief of Staff for Development, U.S. Air Force:

"DEAR GENERAL WILSON: I enjoyed the opportunity of discussing our life sciences with you recently. As I indicated, the objectives of our program include both an investigation of the effects of extraterrestrial environment on living organisms and the scientific and technological advances relating to manned space flight. We are establishing basic biological capability at Ames Research Center in California to provide personnel competent for the research related to these objectives.

"This center will carry out both inhouse and contracted activities with universities and industries. We recognize the strength of the U.S. Air Force in biotechnology and plan to make use of this capability whenever possible.

"In our February 23 discussion, you indicated on behalf of the Air Force that you would conduct work for NASA on a task basis arrived at mutually and defined in terms of objective schedules of costs. The Air Force shall endeavor to be responsive to NASA requests for assistance to the fullest extent consistent with available facilities and personnel and Air Force program commitments.

"The agreed tasks will be managed by USAF personnel subject to overall monitoring by NASA. We anticipate similar arrangements will be made with the Army and Navy for work appropriate to their medical conditions. The Life Sciences Committee of the Manned Space Flight Panel of the Air Force Aerospace and Astronautics Coordinating Board, will continue to operate according to the charter approved by Dr. York and Dr. Dryden on January 24, 1960. This committee will review all aeronautical and space life sciences effort sponsored by NASA and DOD from the standpoint of program content, location, and costs, in order to assure each of us no unnecessary duplication of effort exists.

"Management of the NASA life science projects will be vested in the NASA Office of Life Sciences Programs. This office will be responsible for the life sciences research effort at the Ames Research Center as well as the overall monitoring of NASA-financed life sciences research tasks which have been assigned to the USAF with the approval of your office.

"In accordance with other existing agreements between NASA and the USAF, the Air Force will continue in a responsive manner to furnish operational support and test operations and other assistance directed to the space tasks group, Mercury, or such other NASA entities as may request assistance.

"The clear desire of the Air Force to support our program to the fullest extent is greatly appreciated and we look forward to a mutually satisfactory relationship and a successful prosecution of the NASA life sciences effort.

"Sincerely,

"ROBERT C. SEAMANS."

To further illustrate, in the Mercury project, conferences between the NASA and DOD have been held to plan and coordinate the life sciences effort within the program. Requirements based on studies conducted by the three services within the DOD as well as studies by civilian advisers and NASA personnel were incorporated. In response to the needs of the program, early implementation was possible through the use of existing Department of Defense laboratories and personnel. At the time, this effort taxed on the capabilities of available laboratories and manpower. A facilities and personnel buildup and a shift of missions within the Department of Defense laboratories to support Project Mercury was made. The funds needed for this portion of the program were made available jointly by NASA and DOD. This shift of mission within the Air Force from air aeromedical orientation to the space medical area has paralleled and been responsive to the growing requirements of the manned space flight program (see attachment No. 1, letters, agreements, and funding level for all branches of the DOD).

But, beyond the requirements of Project Mercury, as the life sciences effort became a functioning element of the NASA organizational activity there began a "looking forward" in the research and development areas to anticipate the kind of life sciences support future manned and unmanned missions would require. With only a small internal complement to carry out planning for such future missions, it became necessary to establish advisory committees and coordinating panels. A life sciences coordinating panel was set up between NASA and the Department of Defense to coordinate the national resources and activities. This panel became the present Life Sciences Committee to the Manned Space Flight Panel of the Aeronautics and Astronautics Coordinating Board. In addition this committee, there was established a point of contact between NASA and the Air Force Headquarters (Deputy Chief of Staff, Development) in the life sciences areas.

This has developed into a very effective coordinating mechanism—many important advances have been made through this point of contact.

There have been numerous tasks assigned, particularly to the Air Force, and there are other major ones now in the planning stage to be assigned and funded by NASA. To illustrate joint assignment of tasks:

1. The NASA is making funds available to the Air Force for additional animal facilities at Holloman Air Force Base. After completion of the work, additional personnel to operate and maintain a central chimpanzee colony for use in the national space medical effort will be funded (see attachment No. 2).

2. Presently, the NASA is funding the Air Force teams which participate in the Air Force Discoverer project to assemble a flight radiation experimental program for assessing radiobiological effects on living organisms. The information is needed in the national manned space flight effort. When the experiments are approved, assignment will be given to these teams by NASA and funds will be transferred to implement the experiments (see attachment No. 3).

3. When the Air Force and Atomic Energy Commission nuclear propelled airplane program was abandoned, the NASA agreed to fund the Air Force—University of Texas (Balcones Laboratory) in its long-range studies of ionizing radiation effects on living tissue (see attachment No. 4).

4. In addition to this, other branches of the Department of Defense are being funded and utilized by the NASA: examples are the Navy School of Aviation Medicine at Pensacola, Fla., and the Air Force Special Weapons Center, radiobiology group, at Albuquerque, N. Mex.

The NASA has established cooperation programs with other Government agencies: the National Institutions of Health of the Department of Health, Education, and Welfare has collaborated in assessing the physiological monitoring devices in the manned space flight program and has supplied monitoring personnel for the worldwide tracking network. At the present time, a program for establishing baseline data on the chimpanzee is underway.

The Atomic Energy Commission and the NASA have established an agreement of understanding which permits full utilization of their respective field centers and laboratories to carry out research on the problem of the effect of space radiation on humans in space. In this area of research on radiation and its effects, the NASA is depending on the Atomic Energy Commission to advise both the NASA and its Department of Defense assigned task groups on procedures and design of space flight experiments (see attachment No. 5, list of Atomic Energy Commission laboratories).

Although the foregoing is, by necessity, only a brief summarization of the total NASA life sciences effort and the coordination of available and augmented national life sciences resources, it is intended to illustrate the direction and magnitude of the task ahead. No little part of the U.S. ability to place men into space—to land humans on the Moon and safely return them to Earth—will be determined by the success of the NASA life sciences program and the cooperation of the many organizations and people, both in and outside of our Government. Activities thus far, particularly by participating Government agencies, are most encouraging.

Tasks assigned to Department of Defense and funding level for each branch of service—Does not include support for Project Mercury

Service	Number of tasks	Funding
Army.....	1	\$30, 038
Navy.....	6	498, 595
Air Force.....	4	628, 070
Armed Forces Institute of Pathology.....	2	51, 886
Total.....	13	1, 208, 589

See following table.

Résumé of Department of Defense life science support for Project Mercury, fiscal years, 1959-61

Parachutes.....	\$287, 000
WADC (biological test).....	42, 000
Bioastronautics program (Knauf).....	160, 000
AMC (pressure suits).....	397, 000
Recovery service.....	3, 576, 000
Pensacola (stress tests, etc.).....	62, 000
Medical equipment (nonexpendable).....	87, 000
Johnsville (centrifuge).....	166, 000
MATS airlift.....	235, 000
Medical support (expendable).....	798, 000
Human eng (ACEL, Philadelphia).....	44, 000
Animal test program.....	66, 000
Oxygen masks.....	2, 000
Wind tunnel (Arnold pressure tests).....	47, 000
Range support, DOD.....	2, 169, 000
AOMC (Army vessel-dampship).....	56, 000
Flotation device (Pensacola).....	125, 000
Frankford Arsenal (Squibb).....	29, 000

DECEMBER 2, 1959.

Reference: Op-542B/mmp; Ser 2017154.

Subject: Biomedical support for Project Mercury.

Mr. JAMES H. WAKELIN, Jr.,
*Assistant Secretary of the Navy (Research and Development),
Department of the Navy, Washington, D.C.*

DEAR MR. WAKELIN: Thank you for your letter of November 10, 1959, offering the assistance of the U.S. Navy in the biomedical manning of Mercury operations sites.

Our aeromedical staff has very recently completed preliminary requirements for the professional medical support for manned flight operations. These requirements indicate that medical personnel will be required to monitor Mercury flights, man recovery positions, and to conduct postflight analyses. We believe that because of the training required, the temporary and operational nature of the duty, and the arduous nature of many of the assignments, the use of civilian physicians is impractical; we also believe that individuals with the requisite skills may be found in all the services.

We have therefore requested the Department of Defense, through Maj. Gen. Donald N. Yates (DOD representative for Project Mercury support), to provide the required medical support for Project Mercury. This request, coincidentally, was forwarded to General Yates at about the same time your offer of support was sent to us. In this request we suggested that a meeting between NASA, DOD, and representatives of the several Surgeons General be held at an early date. It is therefore anticipated that the Surgeon General of the U.S. Navy will be notified of such a meeting in the near future.

We are sincerely grateful to the U.S. Navy for this offer of assistance to the National Aeronautics and Space Administration.

Sincerely yours,

RICHARD E. HORNER, *Associate Administrator.*

DEPARTMENT OF THE NAVY,
OFFICE OF THE SECRETARY,
Washington, D.C., November 10, 1959.

Memorandum for Administrator, National Aeronautics and Space Administration.

Subject: Biomedical support for Project Mercury.

1. It is anticipated that biomedical services will be required at launch, tracking, and recovery sites for certain preorbital and orbital Project Mercury events.

2. The Chief of Naval Operations and the Surgeon General of the U.S. Navy are prepared to assist the Administrator of the National Aeronautics and Space Administration in the biomedical manning of such sites as the Administrator may designate through the assignment of specifically qualified naval flight surgeons, Medical Service Corps specialists, and other experienced Medical Department personnel.

3. Requests for the assignment of such Medical Department personnel, as indicated above, should be directed to the Chief of Naval Operations.

JAMES H. WAKELIN, Jr.,
*Assistant Secretary of the Navy,
(Research and Development).*

NOVEMBER 13, 1959.

Subject: Medical personnel to support Project Mercury flight operations.

Maj. Gen. DONALD N. YATES,
*DOD Representative Project Mercury Support,
Air Force Missile Test Center,
Patrick Air Force Base, Fla.*

DEAR GENERAL YATES: Project Mercury will require the support of a substantial number of professional medical personnel in conducting NASA manned flight operations. Your assistance is requested in making the arrangements for obtaining this help.

Medical personnel will be required to monitor Mercury flights, man recovery positions, and to conduct postflight analyses. Space Task Group believes that individuals with the requisite skills may be found in all of the services. Because of the training required, the temporary and operational nature of the duty, and the arduous nature of many of the assignments, it is believed that the use of civilian physicians is impractical. Consequently, the Department of Defense is requested to provide the medical support.

It is realized that it might not be feasible or practical to detach the medical personnel from their present duty station and assign them full time to Project Mercury. It is suggested that the personnel desired retain their present duty stations, but be available for Project Mercury duties which will include a training period as well as duties during actual Mercury operations on a TDY basis. As might be expected, the number of personnel who might qualify for these positions is relatively small and, as a consequence, many of them are known to the aeromedical group now working on Project Mercury. This group has selected some monitoring personnel by name as shown in the attached document. This represents a sample of how background and current assignment might be used. In general, the personnel mentioned have actually performed monitoring of biological systems in unusual environments and have a background of military experience and research which would be helpful. It is recognized that not all of those mentioned will be available.

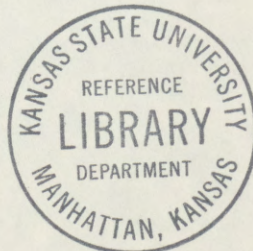
Recovery medical personnel requirements will require a more detailed analysis of the recovery system. It is likely that the Department of Defense will be asked to deploy one or two field medical units or to augment certain existing facilities. Space Task Group regards Capt. Ashton Graybiel (MC) USN as an eminently desirable senior medical officer to direct the medical recovery and research program. Additional personnel aboard some recovery vessels or in certain areas may be requested.

A meeting to discuss the expected needs of NASA Space Task Group with representatives of the Department of Defense and representatives of the several Surgeons General seems indicated at an early date. Space Task Group suggests that representatives of NASA, plus Col. George Knauf and Lt. Col. Rufus Hesserberg, USAF (MC), attend this meeting to explain the Space Task Group plan. A list of questions to be discussed should include:

- (a) Will it be feasible to train and deploy physicians on a TDY basis?
- (b) How is medical support to be controlled and administered?
- (c) What additional personnel in excess of NASA requirements will be trained?
- (d) What are the estimates of cost?
- (e) Is it correct to assume that NASA will only be required to pay the travel and per diem of assigned officers?
- (f) Can some assignments be integrated with other service medical plans and assignments?
- (g) Will it be possible for NASA to express a particular interest in certain personnel by name?

Yours very truly,

WALTER C. WILLIAMS,
Associate Director of Project Mercury.



SUMMARY OF MONITOR PLAN

1. The following assumptions are made:
 - (a) Department of Defense physicians will be used.
 - (b) Personnel to be trained and assigned on a TDY basis.
 - (c) When possible, station assignment will be close to duty station.
 - (d) Provision will be made to train additional DOD personnel to provide a pool of trained monitors for later operations and to provide a reserve for Mercury operations.
 - (e) Advanced residents in aviation medicine would be a good source for extra personnel.
 - (f) STG-NASA reserves right to review and interview qualifications of personnel to be assigned in direct support of Mercury.
 - (g) STG-NASA will be responsible for monitor training.
 - (h) Where possible Mercury personnel will be used to accomplish other national objectives as a byproduct.
 - (i) Approximate total time for monitor training—4 to 6 weeks over a period of about 10 months.
2. For certain key monitor positions in Project Mercury, Space Task Group medical personnel will be used. Included in this list should be:
 - USAF (MC):
 - Lt. Col. Stanley C. White—STG.
 - Lt. Col. William K. Douglas—STG.
 - Lt. Col. James P. Henry—STG.
 - Lt. Col. Rufus R. Hessberg, Holloman Air Force Base, N. Mex.—project officer for STG animal research program.
 - Col. George Knauf—USAF MTC—whose close work in support of Mercury will have given him the detailed knowledge of the project necessary for a key monitor.
 - USA (MC): Capt. William S. Augerson—STG.
3. Suggested monitors are as follows on the chart:



Station	Name	Location	Background and comments
Phoenix Island	Thomas R. A. Davis, M.D.	Civilian scientist, Fort Knox.	M.D., specialty research in environmental physiology, experienced in public health, formerly at USAF Arctic Aero-Med Laboratory, surgical training.
Hawaii	Capt. Charles Wilson, U.S. Air Force or U.S. Navy or U.S. Public Health Service as alternate. Maj. Harry Scott, U.S. Air Force.	Harvard.	Flight surgeon, aviation medicine, resident Wright Air Development Center, stress research, man high monitor.
West coast, United States	Capt. William Blanchard.	BMD, Edwards.	Flight surgeon, board certificate in aviation medicine, Wright Air Development Center, research.
Baja California	Pacific Missile Range Staff (Captain Pruitt, U.S. Navy). BMD, Edwards staff.	Aero-Med Laboratory, Wright Air Development Center. Point Mugu, Calif.	Flight surgeon, board certificate in aviation medicine.
Grand Bahama Island	U.S. Air Force, School of Aviation Medicine, Lt. Col. David Simons, U.S. Air Force.	Edwards Air Force Base, Calif.	Navy flight surgeon, R. & D. experience.
Grand Turk Island	Brooke Army Hospital.	Brooks Air Force Base, Tex.	X-15 flight surgeon, pilot, R. & D. monitor experience.
Mid-Atlantic ship	Not decided.	San Antonio.	Flight surgeon, boards in aviation medicine, researcher in physiology, space flight.
Canary Islands	2 U.S. Navy personnel; Omdr. Frank Austin, U.S. Navy.	Pensacola Naval Air Station.	Specialist in internal medicine, surgical research unit.
Nigeria	Maj. John Ward, U.S. Air Force.	U.S. Air Force, Europe.	1 or another of these may be considered a critical station. Would be important during reentry. Will consider feasibility of manning from cape.
Tanganyika	Col. Vance Marchbanks, U.S. Air Force. Maj. John Lawson, U.S. Army.	SAC, Loring Air Force Base, Limestone, Maine. Fort Rucker, Ala.	Navy flight surgeon with R. & D. experience. Naval aviator with suit test experience, knows several astronauts personally. Test pilot.
Indian Ocean ship Perth, Australia	2 U.S. Navy. (1) Maj. Gerald Champlin, U.S. Army.	Pensacola staff. At Navy School of Aviation Medicine.	Flight surgeon, boards in aviation medicine Discoverer and School of Aviation Medicine research.
Woomera, Australia	(2) United Kingdom Associate. (1) Australian. (2) Lt. Col. Richard Taylor, U.S. Army.	Surgeon General's Office, Washington.	Senior flight surgeon, expert in flight stresses, on B-52 around the world and over the pole flights. Background would assist U.S. prestige in Nigeria.
			Flight surgeon, specialist in internal medicine, training in physiology research, N. public health, tropical medicine. Background would be useful in station and local recovery.
			Aviation medicine training, specialist in surgery.
			Board certificate in internal medicine, cardiology, pulmonary diseases; research in physiology; participated—Able-Baker; Chief, Biophysics, Bioastronautics, Army Medical R. & D. Command.

4. Additional consultants and monitors regarded as desirable:

Corpus Christi: Dr. Larry Lamb, cardiologist, USAF-SAM.

Baja California: Maj. Per Langjoon, cardiologist, Wm. Beaumont Army Hospital.

Hawaii: Colonel Sandifir, Chief of Cardiology, Tripler Army Hospital.

Canary Islands: Maj. Clyde Kretschvil, USAF, ARDC Liaison Office Europe (Ph.D. in physiology, SAM researcher, flight surgeon).

Bermuda (or elsewhere):

Maj. Charles Berry, USAF-SGO, flight surgeon, space medicine researcher, boards in aviation medicine.

Lt. Col. William Turner, USAF, flight surgeon, boards in aviation medicine, WADC researcher.

APRIL 13, 1959.

Subject: Request for use of centrifuge at AMAL, Johnsville.

Capt. F. K. SMITH,

*Director, AMAL, Naval Air Development Center,
Johnsville, Pa.*

DEAR SIR: As part of the pilot training program for Project Mercury, a requirement exists for centrifuge testing. The capabilities of the Johnsville centrifuge are well suited to the mission profiles peculiar to Project Mercury.

A preliminary discussion of Project Mercury requirements was held at Langley on April 2, 1959, with Dr. Chambers, AMAL, in attendance. It was considered desirable to schedule approximately 2 months of centrifuge testing during the next 12-month period.

The NASA requests support of the previously mentioned centrifuge testing program for Project Mercury; the details of which will be determined at a joint NASA-AMAL meeting in Johnsville on April 20, 1959.

Yours very truly,

WARREN J. NORTH,

Program Chief, Manned Satellite.

MARCH 9, 1959.

From: Space Task Group.

To: NASA Headquarters.

Subject: Project Mercury. Request for use of centrifuge at AMAL, Johnsville. (Attention: Mr. George Low).

1. As part of the test program for Project Mercury, a requirement exists for tests using the centrifuge at the Aviation Medical Acceleration Laboratory at Johnsville, Pa. In determining these requirements, the need for utilizing certain characteristics peculiar to the Johnsville centrifuge was apparent. These characteristics include closed loop operation and gimballed gondola motion as well as high g capability.

2. Our requirements contemplate two distinct phases of testing. The first phase involves research, development, and pilot orientation and would require a 1-month test period. A desirable time for commencing these tests would be in the first half of July 1959. The second phase primarily involves pilot training and would require 1 month commencing during the last half of November 1959.

3. The first phase of the centrifuge program would be used to validate the types of display and manual control contemplated for the Mercury capsule as well as to familiarize the pilots with the close loop control operation in the high acceleration region during reentry. This work would be preceded by appropriate fixed base simulator studies. In addition to the foregoing centrifuge tests, certain basic problems might be investigated. These problems include (a) study of pilot's ability to rapidly reorient the capsule immediately following abrupt termination of the high launch acceleration, (b) study of tolerance of oscillatory motion during escape deceleration period, and (c) investigation of the effect of acceleration following weightlessness or acceleration tolerance.

4. The second phase program would be a comprehensive training program involving closed loop simulation of the capsule dynamics. The high acceleration situations involved in the Mercury mission would be simulated. Approximately six pilots would be trained to high proficiency prior to initiation of the actual manned flight operations.

5. With regard to specific development or qualification testing associated with the final capsule, no requirement is foreseen at the present time.

6. It is requested that a letter be sent to the Chief, Bureau of Aeronautics, asking that they support this program as outlined. This request should be coordinated with Mr. B. Maggin who is concerned with similar programs at headquarters.

CHARLES J. DONLAN,
Assistant Director of Project Mercury.

AGREEMENT BETWEEN THE DEPARTMENT OF THE DEFENSE AND THE NATIONAL
AERONAUTICS AND SPACE ADMINISTRATION, SEPTEMBER 14, 1959

CONCERNING PRINCIPLES GOVERNING REIMBURSEMENT OF COSTS

1. Purpose

Section 203(b)(6) of the National Aeronautics and Space Act of 1958, authorizes the National Aeronautics and Space Administration (NASA) "to use, with their consent, the services, equipment, personnel, and facilities of other Federal agencies with or without reimbursement, and on a similar basis to cooperate with other public and private agencies and instrumentalities in the use of services, equipment, and facilities." Federal agencies are also required to cooperate fully with NASA in making their services, equipment, personnel, and facilities available, and are authorized by this statute "to transfer to or to receive from NASA, without reimbursement, aeronautical and space vehicles, and supplies and equipment other than administrative supplies or equipment." It is the purpose of this agreement to set forth the general principles governing the reimbursement of costs incurred by DOD or NASA in providing for use by the other of its services, equipment, personnel, and facilities and in transferring equipment and supplies.

2. Principles governing reimbursement

Subject to the provisions of paragraph 3 hereof, DOD and NASA agree upon the following general principles governing the reimbursement of costs:

A. Orders contracted out.—Where DOD or NASA places an order with the other which is contracted out (in whole or in part) to industry, reimbursement will be limited to the direct costs to the contracting agency of the contract, or the standard price established for the item being procured where procurement is accomplished through consolidated contracts covering the same or similar items (or components thereof) for the contracting agency. Except as otherwise provided in subparagraph E below, the agency placing the contract shall bear without reimbursement therefor the administrative costs incidental to its procurement of material or services for the ordering agency. As used in the foregoing sentence the term "administrative costs" includes the normal administrative services performed in connection with placing, administering or terminating contracts, and such related administrative services as security, contract auditing, inspection, etc. (not all inclusive). Administrative costs are to be distinguished from the procurement costs of end items or services, the latter being appropriate for reimbursement under the provisions of this subparagraph.

B. Orders performed "in house."—Where DOD performs an in house order for NASA and the order is performed (in whole or in part) in facilities using an industrial-type cost accounting system, the basis of billing will be the same as that used for all customers of the Federal Government. Where the order is performed in facilities not using an industrial-type cost accounting system, reimbursement will be limited to the direct costs (including an allowance for annual and sick leave, holidays, contributions for group life insurance and civil service retirement, etc.) attributable to the performance of the order. In no case, however, will charges be made for depreciation or rent for use of facilities and equipment in connection with the performance of orders.

C. Administration of other agency's contract.—Where DOD or NASA assigns one of its contracts to the other for purposes of administration, the administering agency may be reimbursed for the cost of contract administration services performed in connection with the contract to the extent of the special direct costs incurred in providing these services to the other and mutually agreed upon as clearly identified added costs.

D. Materiel.—Where DOD or NASA provides the other with materials, supplies, or equipment from stock, reimbursement will be made in accordance with established agency pricing practice. DOD materials, supplies, or equipment which are in excess of DOD requirements (called transferable-nonreimbursable property in the DOD), will be furnished without charge, except that the furnishing agency may require reimbursement for transportation and handling costs. DOD may loan equipment to NASA without charge, subject to return in the same condition as when loaned, normal wear and tear excepted. The return of such equipment may be waived by DOD under the circumstances set forth in paragraph 3 of this agreement. Where the loaned equipment is not returned, DOD will be reimbursed for the value thereof, unless the return of the equipment has been specifically waived by DOD under the circumstances set forth in paragraph 3 of this agreement. Where the loaned equipment is returned in a damaged condition, DOD will be reimbursed for the cost of restoring it to the same conditions as when loaned, unless such reimbursement has been waived under the provisions of paragraph 3 of this agreement, or waived on the basis that the equipment, at the time of return, is excess to the requirements of DOD.

E. Travel.—In connection with the services covered by subparagraphs A, B, and C, above, special travel costs attributable to the performance of these services will be reimbursed.

F. Construction or public works.—Construction or public works projects undertaken by the DOD for NASA will be charged directly to NASA funds (or where appropriate will be reimbursed) on the basis of "project costs," the customary basis used by the DOD for charging DOD-sponsored projects.

G. Tenancy on installation.—Except where other arrangements are in existence or are agreed upon, where either DOD or NASA is a tenant on an installation of the other, all direct costs of increases in direct costs attributable to such tenancy will be reimbursed.

H. Use of Government-owned facilities.—No charge will be made for rent or depreciation in connection with the use by either DOD or NASA of Government-owned facilities under their cognizance whether operated by the Government or by a contractor.

3. Exceptions

The foregoing principles do not apply to work or services, materials, supplies or equipment furnished to NASA or DOD for use in connection with specific projects of either agency, which are of mutual interest and benefit to each. In such cases, work or services, materials, supplies or equipment furnished by one agency to the other will be on a nonreimbursable basis to the extent of the furnishing agency's interest in the particular project.

4. Effective date

This agreement is effective immediately, but it does not apply to existing agreements or arrangements already agreed upon which may not yet be formalized between NASA and the military departments or ARPA. However, all future arrangements, agreements, and amendments of existing agreements between NASA and the military departments or ARPA shall conform to the provisions of this agreement.

5. Duration of agreement

The provisions of this agreement may be revised at any time, based upon further experience of the two agencies.

_____, Secretary of Defense.

_____, Administrator,
National Aeronautics and Space Administration.

Date -----

C O P Y					NATIONAL AERONAUTICS AND SPACE ADMINISTRATION PROCUREMENT REQUEST				
I FOR INITIATING OFFICE USE									
1. FROM Jack Posner		2. OFFICE Life Science Programs		3. TELEPHONE 5342	4. CODE S	5. DATE 5/4/61			
6. DESCRIPTION OF PROPOSED WORK. (Complete in detail, include background information, use additional sheet if necessary.) Modifications to the present high bays (#4 and #5) of the Aeromedical Field Laboratory building #1264 at Holloman Air Force Base, New Mexico to provide the necessary expanded chimpanzee colony capability to support NASA Research Programs. The modifications will provide 12,000 square feet of augmented laboratories, clinical veterinary support area, and offices, 9,100 square feet of additional chimpanzee maintenance and caging, and a 1,000 square foot heating and air conditioning room. Provide funding for the purchase of 50 chimpanzees. For further details please see the proposal attached hereto. U. S. Air Force RF									
7. PROPOSED INITIATION DATE 5 May 1961		8. TECHNICAL REPRESENTATIVE Dr. G. Dale Smith		OFFICE Life Science Programs		TELEPHONE 5341			
9. TARGET COMPLETION DATE 5 November 1961		10. OTHER SUGGESTED CONTACTS Dr. George J. Jacobs		OFFICE		TELEPHONE			
11. ESTIMATED COST \$490,000									
12. SOURCE OF FUNDS INSTALLATION Hdq R & D Life Sciences				FISCAL YEAR 1961		13. CONTRACT ☐ WILL Involve access to classified ☒ WILL NOT Information. (If access to classified information is involved, attach NASA Form 446, "Request for Contractor Clearance")			
☐ S & E OBJECT NO.				14. APPROVED BY		DATE			
☐ C & E PROJECT NO.				/s/ G. D. Smith		5/4/61			
☐ R & D PROGRAM TITLE <u>Life Sciences</u>				/s/ C. H. Roadman		5/4/61			
APPROPRIATION SYMBOL									
II FOR BUDGET DIVISION USE Fl. Med. & Bio. 810									
15. FUNDS ☐ ARE AVAILABLE ☐ ARE NOT				16. REMARKS					
17. SIGNATURE				18. DATE					
III FOR PROCUREMENT AND SUPPLY DIVISION USE									
19. ASSIGNED TO:				22. RECORDED BY: (Contract Service Branch)					
20. BY:				23. COPY FORWARDED TO INITIATOR AND FISCAL OFFICE		24. DATE		25. REQUEST NO. HS-	

NASA FORM NO. 404 REV. (OCTOBER 1959)

1. PROCUREMENT

APRIL 14, 1961.

Memorandum for Deputy Chief of Staff, Development Headquarters USAF.
Subject: Baseline studies on the chimpanzee.

1. Reference is made to correspondence, dated March 13, 1961, between Dr. Robert C. Seamans, Associate Administrator of the NASA and Lt. Gen. Roscoe C. Wilson, DCS/D concerning life science programs.

2. The NASA Office of Life Science Programs has the requirement to establish a research program to obtain baseline data on the chimpanzee.

3. Inasmuch as the Air Force has a singular and unique capability in this area, it is proposed that a joint NASA-AF program be established to accomplish this desired research.

4. Initially, it will be necessary to identify and define the experimental parameters and approach, and to precisely define the objectives.

5. Your interest in the suggested cooperative and joint effort is invited.

CHARLES H. ROADMAN,
*Colonel, U.S. Air Force (Medical Corps),
Acting Director, Office of Life Science Programs.*

Coordination:

AL MAYO.
G. DALE SMITH.

HEADQUARTERS, AIR FORCE SYSTEMS COMMAND,
U.S. AIR FORCE,
ANDREWS AIR FORCE BASE,
Washington, D.C., May 2, 1961.

Subject: Baseline studies on the chimpanzee.

To: Hq NASA (S), Attention of Dr. Dale Smith, 1520 H Street NW., Washington, D.C.

1. Per your memorandum to the DCS/D, Hq USAF, dated April 14, to establish a research program for chimpanzee baseline studies, the following is submitted.

2. Hq AFSC can support in part the NASA request through utilization of the Aeromedical Field Laboratory capability at Holloman Air Force Base, N. Mex. Six chimpanzees can be made available to NASA immediately.

3. In order to support the additional research requested it will be necessary to enlarge the research animal capability along with the research efforts. Augmented research animal facilities and equipment are required as described on the attached statement of work.

4. As agreed by Dr. Dale Smith (Hq NASA) and Lt. Col. Rufus Hessberg (Hq AFSC) at their preplanning meeting on April 20, 1961, the most urgent requirement is to provide the required capability to house and maintain the additional chimpanzees which will be procured by NASA.

5. Because of the urgency to be able to adequately house, maintain, and provide additional research animals (chimpanzees), the attached requirement for 490M fiscal year 1961 funding is submitted.

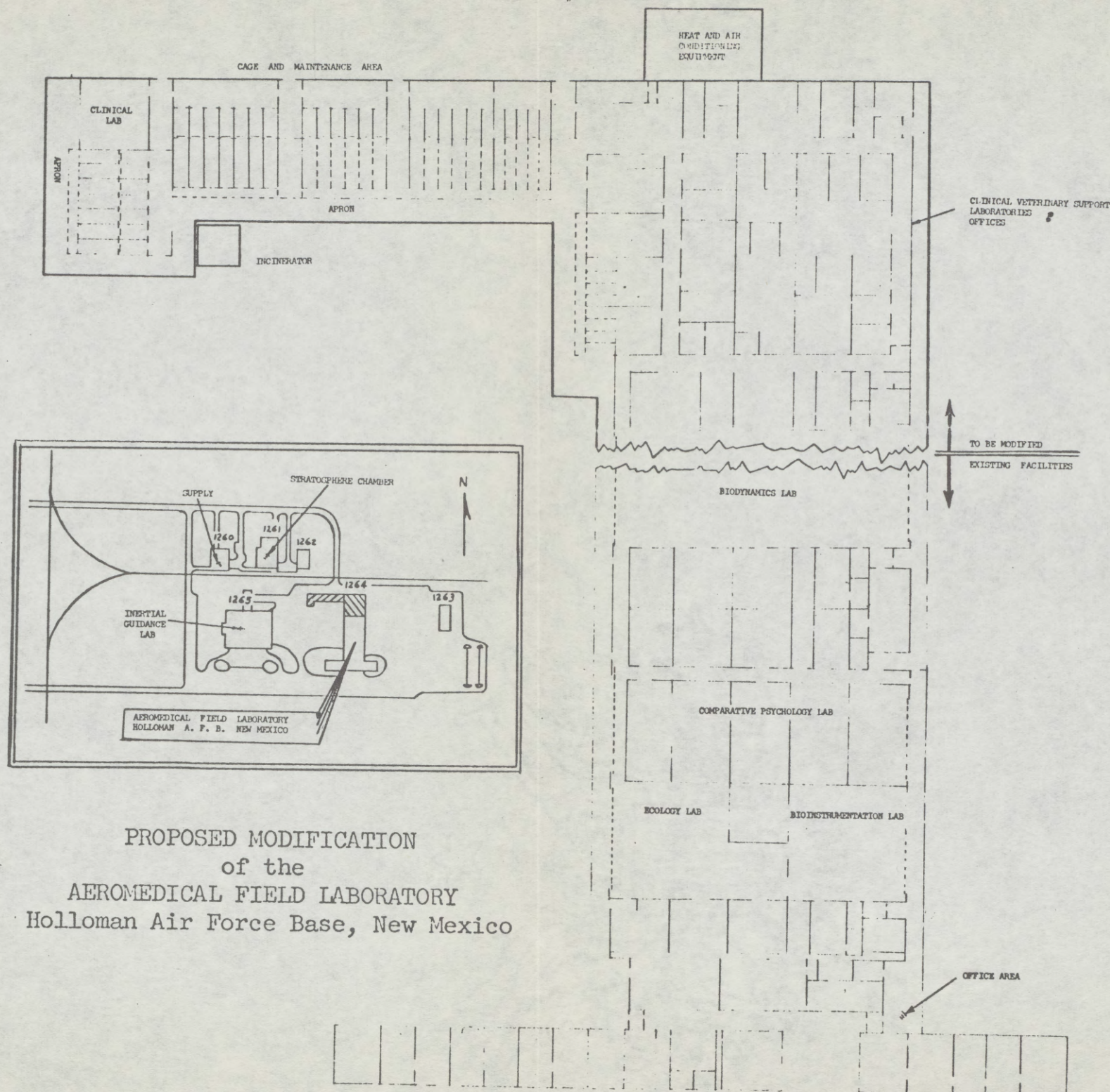
6. Following the approval of this aspect of the program, manpower requirements inherent to the augmentation will be the subject of further planning meetings between Dr. Smith and Lieutenant Colonel Hessberg.

7. The last part of this program will encompass additional research efforts to obtain dynamic physiological and behavioral chimpanzee baseline studies correlatable to man over and above those already being accomplished.

PROPOSED INCREASE IN AMFL CHIMPANZEE RESEARCH CAPABILITY

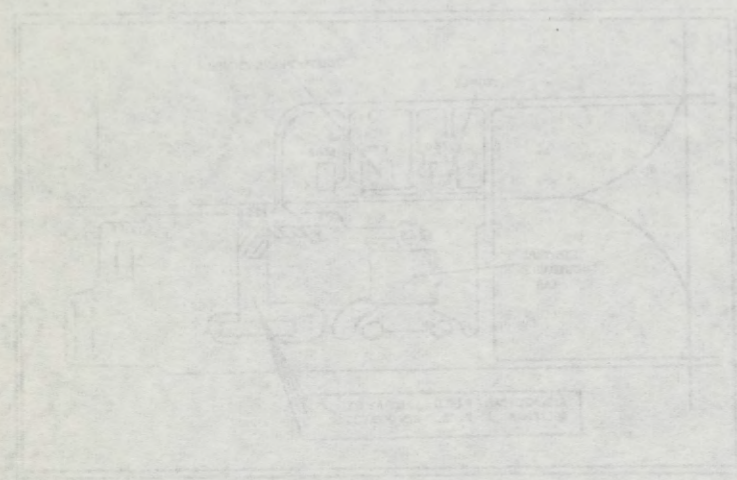
The AMFL has analyzed the requirement to support a joint NASA-USAF research program to obtain complete dynamic physiological and behavioral baseline data on chimpanzees correlatable to man. To accomplish this it has been determined that an immediate requirement exists to increase the present facilities for housing and maintaining 50 additional chimpanzees. The increased research support capability will consist of 31 maximum security cages, 19 pre-adolescent chimp cages, a chimp housing area, and necessary associated research laboratories (i.e., augmented biochemistry laboratory, expanded clinical lab, surgery, autopsy, EKG and screen room, limited office space, and an animal handler's locker and shower room.)

Cost estimate: The cost estimate for increasing the AMFL capability to perform additional chimpanzee baseline studies and provide chimpanzees to support NASA programs is \$490,000.



SECTION 10
EAST SIDE
100' 0" 100' 0" 100' 0"

SECTION 11
EAST SIDE
100' 0" 100' 0" 100' 0"



PROPOSED MODIFICATION
of the
ARCHITECTURAL FLOOR PLAN
BELLAMY AIR FORCE BASE

Cost breakdown, bays 4 and 5

Standard modification building 1264, 12,000 square feet at \$11 per square foot-----	\$132, 000
Cages and maintenance area, including special feeders and watering devices -----	142, 000
Temperature and humidity control (includes heating, airconditioning, and humidifiers to maintain the proper thermal environment for the health and maintenance of the research colony of chimpanzees) -----	90, 000
Special construction and equipment (includes morgue refrigeration, floor drains for sanitation and hygiene, walls suitable to withstand steam cleaning, EKG and screen room, lab tables, sinks, and associated outlets, and incinerator) -----	76, 000
Chimp procurement (50 chimps at \$1,000 each) -----	50, 000
Total -----	490, 000

8. The latter two aspects can be resolved with fiscal year 1962 funds without delaying the accomplishment of the program. This is due to the fact that the Aeromedical Field Laboratory, in addition to its own baseline studies, can provide six chimpanzees at this time to support university research already under consideration by headquarters, NASA.

9. The proposed augmented capability in no way duplicates any existing capability in the United States.

For the commander:

B. A. STRICKLAND, Jr.,
Brigadier General, USAF, MC
 (For Don Flickinger, Brigadier General, USAF, MC,
 Assistant for Bioastronautics.)

DEPARTMENT OF THE AIR FORCE,
 HEADQUARTERS U.S. AIR FORCE,
 Washington, D.C., April 21, 1961.

Subject: Baseline studies on the chimpanzee.

To: Colonel CHARLES H. ROADMAN, USAF (MC), Acting Director, Office of Life Science Programs, National Aeronautics and Space Administration, 1520 H Street NW., Washington 12, D.C.

1. Reference is made to your letter of April 14, 1961, subject as above.

2. A letter (copy attached), which is self-explanatory, has been forwarded to AFSC implementing your request.

VICTOR R. HAUGEN,
Major General, USAF,
Assistant Deputy Chief of Staff, Development.

DEPARTMENT OF THE AIR FORCE,
 HEADQUARTERS U.S. AIR FORCE,
 Washington, D.C., April 20, 1961.

Biomedical studies in support of NASA.
 AFSC (SCGB).

1. The National Aeronautics and Space Administration has requested USAF assistance in obtaining urgently needed data on the chimpanzee necessary in the support of present and future projects of NASA. This Headquarters approves this request for assistance.

2. It is requested that AFSC contact Dr. Dale Smith of the Office of Life Science Programs and mutually arrive at a satisfactory program of investigation. The work is carried on the master urgency list as Brick-Bat O1. For your purposes the program should be classified as importance category I, even though it is not shown on the current Air Force importance category list.

3. Normal established procedures should be employed for reimbursement.

RALPH L. WASSELL,
Brigadier General, USAF,
Director of Research and Technology, DCS/D
 (For the Chief of Staff).

JUNE 2, 1961.

Lt. Gen. R. C. WILSON, USAF,
*Deputy Chief of Staff, Development,
Headquarters, USAF, Room 4e-324, Pentagon, Washington, D.C.*

DEAR GENERAL WILSON: The National Aeronautics and Space Administration has a critical need for information necessary to define radiation shielding adequate to protect personnel in space flights in and through the Van Allen radiation belts, including data for protection against solar flares. The background of capability for recovery of small orbital vehicles by the Department of the Air Force and the assessment and collection of data from such vehicles is well known.

It is, therefore, requested that the Department of the Air Force prepare a study for the use of the NASA Office of Life Science Program. Full consideration should be given to Government, university, and industrial capabilities, including the use of any necessary consulting help. Information available from the NASA, DOD, and AEC should be fully utilized. The study should outline a plan for the earliest practical implementation, by taking advantage of available vehicle systems such as the Thor-Agena B.

Sincerely yours,

ROBERT C. SEAMANS, Jr., *Associate Administrator.*

DEPARTMENT OF THE AIR FORCE,
HEADQUARTERS U.S. AIR FORCE,
Washington, D.C., June 8, 1961.

AFDRT.
Radiation shielding.
ATC.
AFSC.

1. The National Aeronautics and Space Administration has asked the Department of the Air Force to study and prepare a plan for the acquisition of essential scientific information necessary for the design of shielding adequate to protect personnel in space flight in and through the known Van Allen radiation belts and during solar flare. It was specified that the plan should take full advantage of recoverable vehicle systems such as the Thor-Agena B. A critical need for the information was expressed and a desire for early practical implementation was indicated.

2. It is proposed as an initial effort that a two-shot Thor-Agena B test program be presented to the NASA for their consideration. The format of the presentation should follow the abbreviated system development plan supplemented by a technical appendix for each shot furnishing details of the experiments to be carried and technical objectives to be achieved.

3. To accomplish this required action expeditiously, it will be necessary that the ATC and the AFSC prepare and integrate certain elements of the required plan. To prevent any misunderstanding the Aerospace Medical Center, ATC, will have responsibility for the development of the appendixes to the developmental plan detailing the biological experimental package, AFSC will have responsibility for preparing the final plan furnishing details of schedule, budget and financial, and other considerations.

4. In preparing this plan, which will have national significance and carry a high priority, it is urged that full utilization be made of technical talent that exists in NASA, Department of Defense, Atomic Energy Commission, industry or university groups. The NASA has indicated a willingness to fund travel and other expenses involved and will arrange for the transfer of the necessary funds to the Aerospace Medical Center, ATC. The NASA contact is Dr. Dale Smith, Office of Life Science Programs, National Aeronautics and Space Administration, 1520 K Street NW., Washington, D.C. Direct communication with NASA is authorized to finalize these arrangements.

5. It is requested that the above plan be transmitted to this headquarters at the earliest date possible, however, no later than July 5, 1961.

RALPH L. WASSELL,
*Brigadier General, U.S. Air Force,
Director of Research and Technology, DCS/D
(For the Chief of Staff).*

HEADQUARTERS, SPACE SYSTEMS DIVISION,
AIR FORCE SYSTEMS COMMAND,
UNITED STATES AIR FORCE,
Los Angeles, Calif., June 1, 1961.

Dr. CHARLES H. ROADMAN,
*Acting Director, Office of Life Sciences,
Code S, NASA Headquarters, Washington, D.C.*

DEAR CHUCK: I enjoyed my visit on Wednesday very much and if at times I sounded impatient with the wheels of progress it is because I am. After fighting a battle for as long as we have out here, one begins to wear a little thin after a while.

I am quite concerned about a couple of things that are of sufficient importance to review, I think.

First of all, Chuck, the very real problem associated with Thor-Agena B launchings which I mentioned and which will require a secretarial resolution must not be overlooked. And while I fully understand the kind of priorities NASA may enjoy, this situation is an extremely tight one.

I indicated that it would be possible to effect a December launch if we were given a green light to proceed. This must be understood, however, to be based on an early go-ahead, borrowing of vehicles from the current program, and very little in the way of system design change. I view with considerable alarm the tendency to want to make sweeping changes, programwise. There are some things we can do, and should do, to get the best scientific data possible. I must say that replacing the monkey with tissue-culture devices and others, appears to me to be most controversial. However, it must not be forgotten that our recommendation to go the Agena B route means that the 6 months before us can shrink very rapidly. For example, final system test and evaluations plus van activities would require a November 1 delivery date of all flight articles in order to meet a mid-December launch.

Well, I guess all I am saying is that there is a tremendous amount of work to be done and very little time to do it.

Insofar as BOSS is concerned, I agree that much needs to be done yet in the way of experimental protocol. It must be remembered, however, that there are objectives to BOSS other than the strictly biological assessment of certain regions in space; as we conceived it, that is. There is an operational consideration in terms of future manned systems which must be kept in mind and I don't think we should go completely overboard on the biological side. Some balance is needed here—particularly is this so when we consider the kinds of people who will pass on the program. Thus, to cite an example, cabin atmospheres and pressure schedules for animal research may not be at all applicable to future manned systems, yet we are striving toward the design of systems suitable for manned operation.

Enough of all of this. I don't know if I have added anything or not. I did want to reemphasize our feeling of urgency concerning the program.

Sincerely,

EDWARD L. COLE,
*Colonel, USAF,
Director, Bioastronautics/Reentry Office.*

SCHOOL OF AEROSPACE MEDICINE,
USAF AEROSPACE MEDICAL CENTER (ATC),
Brooks Air Force Base, Tex., June 20, 1961.

Dr. DALE A. SMITH,
*Office of Life Science Programs,
National Aeronautics and Space Administration,
Washington, D.C.*

1. The Aerospace Medical Center has received a letter from the Air Force Directorate of Research and Technology, DCS/D, requesting the preparation of a joint plan for the acquisition of essential data necessary for shield design. In implementing this request and utilizing national talent available, contacts have been made with Dr. Webb Haymaker, National Aeronautics and Space Administration; Dr. Wright H. Langham, Atomic Energy Commission; Dr. Cornelius A. Tobias, University of California; and Dr. John Winkler, University of Minnesota; to become active participants in this scientific endeavor. The

preparation of a technical plan is to be completed by July 8 for integration with a development plan to include scheduling and budgeting for missile systems through the Air Force Systems Command by July 19.

2. This same correspondence indicated willingness of the National Aeronautics and Space Administration to fund for travel and other expenses involved in this program preparation by transfer of funds to the Aerospace Medical Center. It is planned to convene two meetings of this group to include members of the Department of Defense probably in the San Antonio area and/or Vandenberg Air Force Base, Calif. To accomplish these meetings and prepare a developmental program it is requested that favorable consideration be given to the transfer of \$5,000 for the conduct of this program. It is estimated that 6 working days will be required plus travel time; per diem for 10 people, \$1,080. Commercial air travel in the amount of \$2,000. Additionally, the four civilian scientists have been programed for consultation fees in the amount of \$1,400. Telephonic and teletype communications will absorb the remaining \$520. If this request is favorably considered by your headquarters, fund transfer should be made through Maj. C. J. Werderman, USAF, MSC, Comptroller, Aerospace Medical Center, Brooks Air Force Base, Tex.

JOHN E. PICKERING,
Colonel, USAF,
Chief, Medical Research Division.

Berkeley, Calif., to San Antonio (San Francisco), jet surcharge-----	\$240. 60
Minneapolis, Minn., to San Antonio-----	182. 90
Los Angeles, Calif., to San Antonio, jet surcharge-----	194. 70
Washington, D.C., to San Antonio, jet surcharge-----	206. 40
Sante Fe, N. Mex., to San Antonio (Albuquerque)-----	106. 60
Round trip, 1st class.	

NASA HEADQUARTERS,
Washington, D.C., June 27, 1961.

Memorandum to procurement.

Subject: Transfer of funds to the Aerospace Medical Center, Brooks Air Force Base, Tex.

The following information should be used in the formulation of this award:

1. Title: "Joint Plan for the Acquisition of Essential Data Necessary for Shield Design."
2. Principle investigator: Col. John E. Pickering.
3. Address: Aerospace Medical Center, School of Aerospace Medicine, Brooks Air Force Base, Tex.
4. Work statement: Please see attached proposal.
5. Agreement form: Usual NASA procedure, transfer of funds.
6. Duration: Continuous beginning June 27, 1961.
7. Cost and payment schedule; \$5,000 payable in fiscal year 1961.
8. This is an unsolicited proposal.

G. DALE SMITH,
Assistant Director for Program Planning and Coordination,
Office of Life Science Programs.

Coordination:

A. M. MAYO.

JUNE 28, 1961.

Dr. G. Dale Smith, life science programs, 5341, SP, June 27, 1961.

Travel and other expenses involved in the preparation of a joint plan for the acquisition of essential data necessary for shield design. Participants in the program are Dr. Webb Haymaker, NASA, Dr. Wright H. Langham, Atomic Energy Commission, Dr. Cornelius A. Tobias, University of California, and Dr. John Winkler, University of Minnesota. The preparation of a technical plan is to be completed by July 8 for integration with a development plan to include scheduling and budgeting for missile systems through the Air Force Systems Command by July 19.

For further details, see attached proposal.

Aerospace Medical Center, School of Aerospace Medicine, Brooks Air Force Base, Tex.

June 27, 1961: Dr. G. Dale Smith, life science program, 5341, \$5,000. Headquarters R. & D. Life Science, 1961.
Life Sciences:

DR. G. DALE SMITH.
DR. CHARLES H. ROADMAN.

Coordination:

A. M. MAYO.

APRIL 14, 1961.

Memorandum for directorate of Research and Technology, DCS/D
ATTN: AFDRT-HF, Col. Jack Bollerud, USAF, Chief, Human Factors
Division
Subject: Balcones Laboratory.

1. This office has learned that with the concellation of the aircraft nuclear propulsion work there may be a requirement for added support to the group at Balcones Laboratory.

2. This memorandum states our desire to have this work carried on and an offer of monetary support to the program, if such is needed.

CHARLES H. ROADMAN,
Colonel, USAF (MC),
Acting Director, Office of Life Science Programs.

Coordination:

AL MAYO.
G. D. SMITH.

MAY 23, 1961.

Brig. Gen. RALPH E. WASSELL,
Director of Research and Technology, DCS/Development, Headquarters, USAF,
Pentagon, Washington, D.C.

DEAR GENERAL WASSELL: Reference is made to your letter of April 21, 1961, subject: "NASA-USAF Life Sciences Research" and letter of April 25, 1961, from the Chief, Human Factors Division, Directorates of Research and Technology, DCS/Development, subject: "Radiation Research; Balcones Laboratory."

The Office of Life Science Programs is in favor of supporting the programs outlined in the above-referenced letters, however, funding of these programs will have to await authorization of the fiscal year 1962 budget.

CHARLES H. ROADMAN,
Colonel, USAF (MC),
Acting Director, Office of Life Science Programs.

DEPARTMENT OF THE AIR FORCE,
HEADQUARTERS, U.S. AIR FORCE,
Washington, D.C., April 25, 1961.

Subject: Radiation research; Balcones Laboratory.

To: Director, Office of Life Science Programs, National Aeronautics and Space Administration, Washington, D.C.

1. Cancellation of the aircraft nuclear propulsion (ANP) program will reduce funds available for radiation research of the School of Aviation Medicine in the amount of \$180,000 in fiscal year 1962. These funds were to be applied to continue analyses of ionizing radiation to aircrews to determine dose against relative biological effectiveness of different ionizing radiations and methods of diagnosis and prognosis in acute and chronic radiation. These studies are funded through September 1961.

2. Some 475 irradiated and 104 control animals have been followed about 10 years and continuation of observations throughout the remainder of the animals' lives is essential for long-term effects studies like cataractogenesis, longevity, and carcinogenesis. Therapeutic regimes will continue. Data from these studies are directly translatable to any space program involving the effects of prolonged heterogenous effects of ionizing radiation.

3. The offer contained in your memorandum of April 14, to support this program is appreciated. Continued support by ANP was contemplated, and provisions were not made to continue the program from other resources. NASA support for the total or any part of the \$180,000 program in fiscal year 1962 and subsequent years will be appreciated and of mutual benefit.

DONALD C. ALMY,
Colonel, USAF,

(For Jack Bollerud, Colonel, USAF (MC), Chief, Human Factors Division, Directorate of Research and Technology, DCS/Development).

DEPARTMENT OF THE AIR FORCE,
HEADQUARTERS, U.S. AIR FORCE,
Washington, D.C., April 21, 1961.

Subject: NASA-USTF life sciences research.

To: Director of Life Science Programs, attention: Colonel Roadman, National Aeronautics and Space Administration, Washington, D.C.

1. Your letter of September 9, 1960, on this subject expressed interest in participating with the Air Force in the area of radiation research. Our letter of November 9, 1960, described certain studies which are being pursued with NASA support. The following studies, comprising investigations of the biological significance of cosmic radiations, are additional parts of the program described in our November 9 letter but were not far enough along in the planning to include at that time. These studies will be accomplished by the Biophysics Division, Air Force Special Weapons Center.

(a) Develop and calibrate tissue-equivalent ion chamber devices for measuring tissue radiation rates encountered in ambient space; \$25,000 is required to complete these devices.

(b) Develop radiation instrument packages for X-15 flights to assess crew exposure; \$30,000 is needed to instrument the X-15 and complete appropriate measurements.

(c) Procure a feasibility study of a passive radiation monitoring satellite and biological equivalent instrumentation capable of selective activation only during solar flares or in other instances or regions of high radiation. This study will cost \$96,600.

(d) Develop a film emulsion containing encapsulated virus for space biological dosimeter; \$65,600 is required for this development.

(e) Improved methods of ultracentrifugation and resuspension of viruses for application to biological dosimeters. These studies will cost \$7,800.

2. Studies where additional support is needed and where NASA participation and support is invited are recapitulated as follows:

(a) Tissue equivalent ion chamber devices.....	\$25,000
(b) Instrumentation of X-15 flights.....	30,000
(c) Feasibility study of passive radiation monitoring satellite.....	96,600
(d) Film emulsion containing encapsulated virus.....	65,600
(e) Ultracentrifugation and resuspension of virus.....	7,800
Total.....	225,000

RALPH L. WASSELL,
Brigadier General, USAF,
Director of Research and Technology, DCS/D.

Résumé of Atomic Energy Commission laboratories, fiscal year 1961

[Figures in millions of dollars]

Laboratory	Scientific man-years	Operating costs	Plant in- vestment
(1) Argonne Cancer Research Hospital.....	48	\$2.2	\$4.4
(2) Argonne National Laboratory.....	99	4.568	7.0
(3) Atomic Bomb Casualty Commission.....	84	2.3	1.0
(4) Brookhaven National Laboratory.....	90	3.9	8.0
(5) Lawrence Radiation Laboratory.....	110	2.227	1.1
(6) University of California at Los Angeles.....	93	1.66	0
(7) University of California Medical School, San Francisco.....	6	.285	.5
(8) General Electric Co., Hanford Works.....	65	2.472	2.6
(9) Health and Safety Laboratory.....	44	1.723	0
(10) Los Alamos Scientific Laboratory.....	26	1.015	2.0
(11) Oak Ridge Institute for Nuclear Studies.....	27	.978	.8
(12) Oak Ridge National Laboratory.....	189	6.0	5.0
(13) University of Rochester.....	29	1.360	3.2
(14) University of Tennessee (Oak Ridge).....	23	.620	1.0
(15) University of Washington.....	23	.412	0
Total.....	960	31.801	36.600
Offsite programs include University of California dog colony at Davis, Calif., and the University of Utah dog colony at Provo, Utah.			
Includes also 600-odd contracts with universities ranging from \$2,000 to \$200,000.....	1,412	18.430	2.100
Grand total.....	2,372	50.231	38.700

ATOMIC ENERGY COMMISSION

Operating costs, fiscal year 1961, broken down into categories

[Millions of dollars]

	Onsite	Offsite
1. Somatic effects of radiation.....	\$8.548	\$3.895
2. Radiation genetics.....	2.318	1.489
3. Combating detrimental effects of radiation.....	1.381	.985
4. Molecular and cellular level studies (includes a great deal of cell biology).....	6.111	3.169
5. Environmental radiation studies.....	3.469	5.786
(a) Terrestrial and fresh water ecologies.		
(b) Marine biological sciences.		
(c) Atmospheric radiation activity and fallout.		
6. Radiological and health physics and instrumentation.....	3.455	1.560
7. Nuclear energy civil effects (covers some of the test site activities; has bearing on public health problem, shelter problem, etc.).....	.442	.700
8. Cancer research.....	4.216	.444
Equipment not included in construction.....	1.673	.590

LIFE SCIENCES REPORT
(By Representative Emilio Daddario)

CONTENTS

Letter to Chairman :

- I. Introduction.
- II. Military research programs in life sciences.
- III. Bioscience progress in Europe.
- IV. The NASA Life Sciences Program.
- V. Conclusions.
- VI. Recommendations.

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- Appendix B.
- Appendix C.
- Appendix D.

BIOSCIENCES

DEAR MR. CHAIRMAN : When the Committee on Science and Astronautics concluded its review of the space program during the past session of the Congress, it expressed particular concern over possible duplication and waste in the life sciences. It enjoined the executive branch to avoid duplication of effort as well as the neglect of available unused facilities in this vital area. Although NASA's Office of Life Sciences Program had been activated only briefly at that time, it was clear that it was intended to assume broad responsibilities in this area. The ad hoc report of the NASA Kety committee, on which establishment of this office was based, treated only briefly existing life sciences resources within the armed services and its implied purpose was to insure that biological, medical, and behavioral divisions were "adequately" represented in NASA.

Because this committee is empowered by the Congress with the authority to oversee the employment of the sciences in achieving our national goals, it bears responsibility to encourage space effort as well as to keep a rein on the ambition and natural inclination of bureaucracy to grow. Only if the committee insists on scrupulous attention to the maximum use of all our space resources can it play a part in forestalling differences among agencies and the waste of resources.

NASA regards its mission as a broad mandate in the space field. This enthusiasm for its program is laudable. I believe, however, that the entire spectrum of work in the life sciences ought to be more closely appraised so that the real necessity of a separate NASA can be set in proportion to the requirements and resources involved in our total space effort.

It should not be part of this program, however, to overlook the military capacity and accomplishments in the biosciences. Both the civilian and military programs have many similar goals, and the capabilities of both must be employed to the fullest if the national effort is to benefit.

In this interest, I believe that every effort must be made to build a harmonious relationship between the civilian and military programs. Let me state at the outset that I am not impressed by the argument that only civilian authority in the life sciences area will produce results because the dedication and accomplishments of scientists in uniform have already belied the commonly held theory that the pursuit of scientific truth is a civilian prerogative. I have been immensely proud of the work I have seen performed in military laboratories or under military contracts and I have found at first hand that scientists of other lands deem it a privilege to work with our military scientists. For, in truth, there is no class distinction in pure research—the sole uniform that matters is the garb of the laboratories and the research centers.

The work I have seen has been of the highest quality and, while I am not prepared to technically evaluate these programs, I do want to give unstinting praise to the dedication of the men who are engaged in this work. I recognize,

both from the NASA presentations before this committee and from the records of the Department of Defense, the nature of the challenge and the scope of the opportunity that await exploration in the biosciences. It is because of this that I am convinced we must make a truly coordinated effort in this field.

EMILIO Q. DADDARIO,
Member of Congress.

WASHINGTON, D.C., *January 31, 1961*

PART I. INTRODUCTION

On March 1, 1960, an Office of Life Science Programs was created within the National Aeronautics and Space Administration, with Dr. Clark T. Randt as its director. Subsequently this was described as providing a fifth functional element to the NASA direction of the space program.

Creation of this office came at a time when National interest in the biomedical space effort was increasing rapidly, as a result of work already in progress in the agencies of the Defense Department which had long been concerned with these problems. One authority in this field estimated that "nearly every institution and industrial organization has some facet of a space medicine research effort."¹ There arose natural doubt as to the successful coordination of Federal efforts in this area so that taxpayers' money would not be wasted.

This committee explored the field of space medicine research and subsequently issued a report² which noted that "part of the testimony makes clearer the division of labor with the military laboratories.

"What is called biotechnology * * * is to be left largely to these existing military laboratories. Even so, it seems rather an arbitrary line between biotechnology and the work NASA refers to as basic medical and behavioral sciences. For even if in theory biotechnology draws upon the basic knowledge discovered in the primary field, it is likely in practice to be pushing so hard upon this fund of knowledge that the line will blurred, if our programs are to move with all speed."

Various testimony showed that a conflict existed in the confidence of various qualified authorities regarding the proper delineation of this field.

Dr. T. Keith Glennan, then Administrator of the National Aeronautics and Space Administration, under questioning by Congressman Daddario, said: "In the broad sweep of the life sciences, I think there isn't any question but someone has to do this, and we believe that we can't duck that responsibility, sir."

Dr. Hugh Dryden, deputy administrator, referring to the military capability, said: "They are concerned with what many of us call bioengineering, the engineering problems of getting a man in space. You are talking mainly about what is called bioscience, the underlying scientific work which is applied in the bioengineering. This is not something which the present staffs of these laboratories can do."

NASA supported its case with the ad hoc Kety report prepared by a committee of distinguished scientists and made plain the fact that it wanted a separate life sciences capability. Saying that "we must get into this area" of really basic studies of the biological type, it inferred a specific mandate for life science research in the Space Act of 1958 which it felt it must carry out.

On the other hand, important testimony disputed the need of still another agency entering the field of basic research in biomedicine on a large scale. In the words of Vice Adm. John T. Hayward:

"I would say offhand that they should not get into it. The Department of Defense will do any of the aerospace medicine that they need."

Lt. Col. Richard Taylor, Army Medical Corps, testified that although successful tests had already been carried out by the Army on flights with monkeys which related to space flight and particularly to Project Mercury the whole matter was dropped. The Army Medical Service, he testified was directed by higher headquarters to discontinue activity in this area. Coloney Taylor also said that the Army has a primary interest in basic research and not in bioengineering and that it, therefore, had a capacity in bioastronautics as a byproduct of its work.

¹ Col. John E. Pickering, USAF, quoted in "Space Research in the Life Sciences," p. 189, committee print for Senate Committee on Aeronautical and Space Sciences, July 15, 1960.

² "Life Sciences and Space," H. Rept. 2227, 86th Cong., 2d sess.

Dr. William H. Pickering, director of the Jet Propulsion Laboratory, California Institute of Technology, said he did not believe that basic NASA plans would necessarily lead to duplication, but that if additional facilities had to be developed:

"I think I would build it on the Department of Defense capability in this case. I think that there is a precedent for this sort of thing if you look at the NACA operations with the Department of Defense, in such things as testing new aircraft."

Lt. Gen. Bernard A. Schriever, commander of the Air Research and Development Command, said:

"I personally feel that the setting up of a life sciences organization of a large scale in terms of facilities and resources in NASA should be looked at very carefully."

The problem posed by the entry of a new Government agency in the life sciences field fall into the traditional areas of men, money, and facilities. What additional competition will be posed for skilled scientific manpower already in critical supply? Can the request for more money be justified when all funding is limited? And, in the area of facilities where the most expense is involved, what firm guarantees can be established to insure that full use be made of already existing capacities before new ground is broken?

The original NASA plans for a bioscientific capability envisioned a small research establishment, either on the grounds of the Goddard Space Flight Center or perhaps at the National Institutes of Health. The ultimate strength of the NASA office would be 60 scientists.

On January 13, 1961, NASA announced that it would establish a life sciences research laboratory at its Ames Research Center at Moffett Field, Calif.—close to several research institutions—where it could attract talent for leadership in the life sciences. Thus its plans are already advanced in this area. At the same time, the Navy is reportedly moving ahead with its own program to make the Point Mugu facility on the west coast a major center of research in the life sciences.

This committee, in its report on Life Sciences and Space, highlighted the question: Does NASA plan to duplicate work already underway in military laboratories? Such a question makes clear that it would be useful to look more closely at the work already in progress at these laboratories, at the scope of their programs, and at the caliber of the results. It also calls for a detailed comparative evaluation of NASA's life sciences schedule with that work planned or completed by other agencies in accordance with their own missions.

Pursuant to this need, and under authorization by the chairman, Congressman Daddario made a tour of several representative Air Force biomedical installations in November 1960. Subsequently, he also looked at work in progress at various European installations where the Air Force and Navy have established working contracts with skilled European scientists.

This report outlines many of the contributions of the Air Force program in biomedicine. The Navy's support of basic research has earned many generous tributes in the past and the work done by the Navy's own scientists also deserves high praise. Knowledge generated in the basic research programs of the Navy has contributed significantly to Navy effectiveness, as the 1959 report of the Navy Research Advisory Committee ably pointed out. That service has been a leader in conducting, financing, and encouraging basic research in this country.

The Army, as the eldest service, also lends great strength and tradition to this work, as well as its own capability in modern medical research. No one can forget the contributions of Walter Reed against yellow fever, or of others against typhoid and malaria. It was the Army's Central Medical Research Laboratory at Mineola, N.Y., that became in 1918 the foundation of all aviation medicine. Also of historical value is the recollection that the Armed Forces Medical Library which was established in 1836 became the National Library of Medicine and has been called "America's greatest gift to medicine."

It cannot fairly be said that the military services have only a bioengineering capacity, or that a capability for basic biological scientific research is not represented in great depth in these laboratories. The material which follows indicates the type of work now being conducted or sponsored by one of those services, and it is clear, based upon information available, that good work is also in progress in the other services.

A representative survey must not, however, be taken as indicating that all possible cooperation has already been achieved, even among the services. With the insistence that NASA utilize to the fullest extent available military biomedical capabilities should also go further investigation to make sure that these military research efforts, too, are being coordinated and that duplication is eliminated wherever it may be found.

PART II. MILITARY RESEARCH PROGRAMS IN LIFE SCIENCES

Since World War I, the U.S. Armed Forces have been conducting programs of biomedical research that have grown in scope and capacity to meet the challenges of ever-increasing human demands for technological progress. World-wide recognition of American leadership in military medical research is based not only on the capabilities of personnel but also on many well equipped laboratories that represent a significant capital investment.

Life sciences in the Army

For more than 185 years, the U.S. Army Medical Service has been conducting research programs in basic biological research that have made major contributions to the welfare of all mankind. It is only necessary to cite Army leadership in the conquests of such human scourges as smallpox, yellow fever, malaria, hookworm, dengue fever, beri beri, typhoid, and "trench fever," to name only a few, to demonstrate the value of Army research.

From 1918 to 1947, aviation medicine research was the responsibility of the Army Medical Service, until the Air Force became a separate Defense entity. Thus, Air Force biomedical research is based upon and draws from the experience and background of Army medical research that stretches back even to the days of the American Revolution.

It is no doubt true that the biological factors of space flight are of such magnitude that some aspects of every biological research field will be involved. Already the Army bioscience research teams have participated, along with the Navy and Air Force, in providing biological preparations for sending primates into preorbital space flights. Also, the Army Medical Service is providing scientists and doctors to the bioastronautics team that is assisting in Project Mercury.

The three general areas in which the Army can significantly contribute from its own in-house research currently underway to the national man-in-space program are radiation, physiological, and psychological stress, and survival under extreme environments.

The effects of radiation and their countermeasures through chemical antiradiation are especially being investigated at the Walter Reed Army Institute of Research. Efforts are concentrated in developing a drug that will counter the effects of exposure to atomic weapons on the battlefield. Success in this work, which is extremely promising, would obviously be of inestimable value to astronauts who will soon be confronted with the hazards of cosmic radiation and the Van Allen belts surrounding the earth.

Investigations into psychological and physiological effects of extreme stress upon men to develop counteragents to alleviate such effects are also underway at the Walter Reed Army Institute. For instance, experiments to determine human capabilities and level of performance under conditions of hypersonic and random high decibel noise environments are being conducted. The results of this work would be of great value not only to our present Project Mercury astronauts but also to those in the follow-on program to come.

In the Army Medical Research and Nutrition Laboratory at the Fitzsimons General Hospital in Denver, extensive research is in progress to determine basic nutritional standards and unique agents to establish a minimum survival level for men in extreme environments such as polar cold and jungle heat. Obviously, again, such work will be essential to man's survival in space, on the Moon, and on planetary satellites.

Although the biomedical research activity of the Army is designed to satisfy present and foreseeable Army needs, the monumental backlog of experience, and the present high level of scientific capability that characterize Army biomedical research can permit expansion of present facilities and personnel in specialized fields to handle specific man-in-space biomedical problems that may be encountered by NASA.

It is fundamentally evident that the basic resource of the Army has been man, not rifles, tanks, and artillery. The Army's traditional concern has been the preservation of the soldier under all conceivable conditions, which in turn has provided the single concept that has oriented Army biomedical research. This is equally applicable to man in space.

Life sciences in the Navy

"Our dollars invested in basic research programs are essentially our growth stock—they have the greatest potential payoff." That is a quotation taken from a speech given by Rear Adm. Charles B. Martell, USN, Assistant Chief of Naval Operations for Development, before the American Rocket Society meeting in Santa Monica, Calif., on September 29, 1960. It applies completely to bioscience research, and progress in bioengineering is completely dependent upon the advances achieved in basic bioscience research.

The Navy has long been aware of that fact, since its main preoccupation is the performance of men in association with machines under widely varying and often extreme conditions. For instance, one need only point to the recent voyage around the world by the *Triton*, one of our nuclear submarines, with a 100-man crew in about 40 days without once surfacing. The psychological and psychological implications of this feat of human achievement to prolong spaceflight should be immediately evident.

Under the direction of the Astronautical Division of the Bureau of Medicine and Surgery, the Navy is conducting space biomedical research in the human engineering and basic bioastronautics in six laboratories. These have two missions to achieve: First, to meet the biospace requirements associated with Navy space operations, and, second, to assist and coordinate scientific programs, facilities, and scientific personnel with other Government agencies, particularly NASA in the National man-in-space program.

At the Johnsville, Pa., Acceleration Laboratory is located the largest human centrifuge in the world, in which basic criteria on human tolerance to various regimes have been established. The Mercury astronauts have undergone several tests in the centrifuge to check out their abilities to withstand and still perform during the necessary "flight" operations under "G" loadings anticipated during the preorbital phases of the Mercury flight programs.

The full pressure suits to be worn by the astronauts were designed and built at the air crew equipment laboratory at Philadelphia, from data obtained through basic biomedical investigations conducted by the Navy's bioscientists.

The School of Aviation Medicine at Pensacola has a well-developed, long-standing capability for aerospace medical research and cosmic radiation, disorientation, effects of noise, respiration, cardiology, and central nervous system functions. The first successful flight in May 1959 of a primate into space was accomplished through employing basic equipment designed at the Pensacola laboratory. Supervision of the medical factors associated with the recovery of the Mercury capsule has been assigned to laboratory personnel.

The success of the Navy in operating under closed environments for unusually prolonged periods has already been mentioned. Much of the medical research leading to this capability was accomplished under the direction of the Naval Research Medical Laboratory at New London, Conn. The Laboratory has achieved a worldwide reputation for its work in respiratory physiology. This relates to long-term exposure to carbon dioxide, determination or requirement of the role of nitrogen in man's natural and artificial atmospheres, and other similar problems which, in developing acceptable environments aboard submarines, the Laboratory can analyze to realize significant contributions in developing spacecraft. Incidentally, the Mercury astronauts are trained in underwater escape techniques by laboratory personnel.

The Naval Research Institute at Bethesda, Md., because of its well-established research personnel and scientific tools used to solve the problems of naval medicine, is well equipped and adapted to handle problems of a similar nature that have arisen in NASA's Mercury program and will arise in planning for future space missions.

Human heat exchange criteria can be established in the Institute's human calorimeter, telemetering parameters for transmitting physiological information from spacecraft can be provided, and means for determining the biological effects of radiation upon man in extended space flight can be devised. These are only a small indication of the capabilities that have been built up over many years in the laboratories of the Institute.

As part of the range facilities of the naval missile center at Point Mugu, Calif., a life sciences department has recently been established there. This organization will have laboratories and medical-scientist personnel to study men and animals sent into space and is qualified to carry out important programs in basic research.

In addition to the Navy inhouse laboratory work, a program of biomedical research is being mounted through the Office of Naval Research with several universities and medical organizations.

In summation, it is pertinent to quote from the testimony of Capt. Clifford B. Phoebus, Director, Astronautical Division, Bureau of Medicine and Surgery, before the committee on June 16, 1960:

"We welcome the opportunity to place our laboratories at the disposal of NASA insofar as our mutual interests dictate. We feel that we can provide a service to NASA which is unavailable elsewhere, while at the same time carrying out programs of interest to the Navy which would be difficult to pursue adequately without NASA's support."

Life sciences in the Air Force

The Air Force work in space biomedicine is a logical extension of its present capability in aviation medicine. Beginning in 1947, Air Force bioscientists began active preparations for manned space flight by putting animals into space environments using Aerobees and captured German V-2's. Since then Air Force interest and work on such programs, with widely varying degrees of support and emphasis, has been continuous.

The appearance of sputnik in 1957 gave new impetus to Government interest in this work and the Aerospace Medical Laboratory began studies to meet criteria of a ballistic capsule for manned space flight. This activity was extended to become the Air Force man-in-space research program now concerned with not only the bioengineering but also the basic bioscience aspects of such major areas of research as radiation, stress tolerance, capsule habitability, human engineering, bioelectronics, and bionics. A description of the work presently underway in these and other vital space medicine fields is included in appendix A.

Since 1958, following the creation of NASA, by the 85th Congress, the Air Force has furnished all of its bioengineering data and some scientific personnel to the support of Project Mercury.

Air Force bioastronautics in the United States

The results of Air Force biomedical research programs are testimony to the basic American principle that the man, not the machine, is the most important and valuable component of any flight system. His physical security can be insured only by obtaining and utilizing every available scientific and medical research technology and the best-equipped laboratory facilities.

Air Force bioengineering inhouse capacity is presently made possible by more than 1,200 professional scientific and technical personnel and has been supported over the past 10 years by funds varying from \$7.5 million to \$11 million a year. The present value of all Air Force life science installations (including not only buildings but also highly specialized equipment appraised at today's replacement cost) is the estimated value of \$40,118,893. (See app. A.)

Bioscience research programs are conducted by the Air Force at several installations located throughout the country. The most important Air Force facility in the life sciences is at the School of Aviation Medicine, Aerospace Medical Center, Brooks Air Force Base, Tex. This was visited by Congressman Daddario during the course of an inspection trip.

The mission of the School of Aviation Medicine includes aviation medicine education, basic and applied medical research, and specialized medical practice. The research mission of the school includes inhouse research, as well as contracts with universities, nonprofit organizations, and industry. Included in the bioastronautics activities is emphasis on closed ecological systems for space flight including component waste disposal systems and recycling systems, to name but a few. Research leading to the development of related components and techniques of bioinstrumentation, and data accumulation and processing is also conducted. The research potential of the facilities available at the Aerospace Medical Center include all of the clinical medical field related to aerospace medical research.

One of the activities in process at the time of Congressman Daddario's trip was in the Radiobiology Section of the School of Aviation Medicine, where research was taking place to determine the biological effect of cosmic radiations

at the cellular level and to correlate observed biological effects with the types of intensities of measured cosmic radiations. The subject for these experiments was a biopak prepared at the School of Aviation Medicine and included in the capsule of Discoverer XVII, which orbited the earth for 50 hours, and was recovered by air catch on November 14, 1960. Because the Discoverer capsule had been exposed to the radiation of a severe solar flare in its orbiting, the results of this investigation did provide significant information about radiation exposure that would be vital to the safety of future astronauts.

Other activities he observed while at the Aerospace Medical Center included—

- (1) The primate training program established in 1951—now having about 700 primates in an animal colony—to evaluate, measure, and train primate performance under a variety of conditions and stresses that would apply to man.

- (2) The sealed environment section which conducts in simulated space cabin environments basic research in the physiological, biochemical, medical, psychiatric, and psychological problems of man in a space cabin environment and with the study of the logistic aspects of maintaining him in this environment.

- (3) The ecological systems section conducting basic research studies on space travel logistics as concerned with the management of biological life support systems necessary to provide the astronaut with oxygen, removal of carbon dioxide waste recycling, production of food supplements and balancing of man's respiratory processes.

- (4) The aeromedical consultation service, in existence since World War II, includes the largest pool of data available on various aspects of medical selection and maintenance of flight personnel, including, for example, all electrocardiograms on all flying personnel in the U.S. Air Force.

Congressman Daddario also visited the Aerospace Medical Laboratory at Wright Air Development Division, Wright-Patterson Air Force Base, Ohio.

The mission of the Aerospace Medical Laboratory is "to achieve maximum effectiveness of man in performing his functions in advanced systems * * * through research programs in the biomedical and behavioral sciences and adverse environments." The major research programs currently being conducted by the Aerospace Medical Center include basic and applied records in the following: (1) life support systems; (2) toxicity and health hazards on materials and radiation; (3) acoustic energy control; (4) human factors in nuclear operations; (5) human factors in design of training equipment; (6) manning and personnel training requirements; (7) functional analogs of living systems; (8) human performance in advanced systems, acceleration in flight, and physiology of man in space and in isolation.

One of the most interesting and important activities Congressman Daddario viewed at the Wright Air Development Division was the program of experiments in weightlessness, a condition existing when the outward centrifugal force of the vehicle in which one is traveling equals the pull of gravity. While brief periods of weightlessness do not seem to present serious problems, certain physiological changes do result from more extended periods of weightlessness. Because it is desirable that man not be simply a passenger in space flight but an active participant who is able to perform duties and make scientific observations, the training program of the seven Mercury astronauts included orientation and training in weightlessness at the Wright Air Development Division in C-131 aircraft flights which achieved weightlessness. Other conditions of isolation and confinement are studied in acoustic chambers and immersion tanks.

The Wright Air Development Division is also active in the new field of bionics, which has been defined as the science of applying knowledge of biology and biological techniques to the design of electronic devices and systems.

At the Aeromedical Field Laboratory, Air Force Missile Development Center, Holloman Air Force Base, N. Mex., Congressman Daddario had the opportunity of viewing the animal training programs. It was there that Ham and the other chimpanzees of the group from which he was chosen were trained and prepared for the flight which was successfully launched from Cape Canaveral on January 31, 1961.

The mission of the Aeromedical Field Laboratory, established in 1952, is "to develop improved techniques for human factors studies with high-speed, track-testing procedures and instrumentation, to determine human physiological tolerance to abrupt deceleration, to develop methods and procedures for testing biosatellite capsules and components, to maintain adequately conditioned

animals for all track, chamber and biosatellite test operations, and to provide pretest and posttest clinical evaluation of test animals."

In addition to being designated as the Department of Defense agency for directing the Project Mercury animal program, the Aeronautical Field Laboratory is also currently involved in part in such programs as physiological tolerance and capability in unusual environments, impact force tolerances, and research animal physiology.

Another installation of significance is the Human Factors Branch, Air Force Flight Test Center, Edwards Air Force Base, Calif.

The mission of the Human Factors Branch is "to evaluate the human factors design and functional characteristics of Air Force weapons systems, manned spacecraft, and personal equipment under flight test and other special test conditions."

The purpose of Congressman Daddario's visit to this installation was to observe various areas of aeromedical support of the X-15 rocket research aircraft program, including: (1) physiological telemetered data console development; (2) physiological data package development; (3) oxygen consumption study; and (4) pressure suit maintenance and test program.

One of the most important areas of aeromedical support of the X-15 program involves the personal equipment used by the pilot. The MC-2 full pressure suit, worn for every flight, resulted from a prototype garment which was first flown at Edwards Air Force Base in May of 1958. These suits are individually tailored and incorporate a ventilation garment, an upper and lower rubber garment, upper and lower restraint garment, and an aluminized reflective coverall incorporating seat restraint, shoulder harness, and parachute attachment.

The upper and lower rubber garments form a seal at the waist by having their edges folded over three times. The 2-piece rubber suit completely covers the body below the neck seal and is restricted to a limited expansion by finely woven upper and lower restraint garments. The MC-2 suit has been in a state of continuing improvement and minor modification since its first flight. A TF-102 aircraft is used at Edwards Air Force Base for pilot training and familiarization with the MC-2 suits, and for physiological instrumentation research and development.

Another support area of interest concerns the air-conditioned semitrailer van to support the X-15 program. This 30- by 9-foot van is parked next to the B-52 mother ship prior to X-15 flights and is equipped for communications and pressure suit checkout. The van carries its own diesel generator for electric power and can use externally supplied electrical power. Prior to each X-15 flight, the pilot dresses in the van and goes through a complete oxygen, ventilation, pressurization, anti-G, and communications checkout before walking some 60 feet to the X-15 aircraft. The van, an intimate part of the X-15 program, has proven to be a very useful device and will continue providing aeromedical support during this program.

Another important objective of the X-15 program is to obtain quantitative physiological data during flight. To accomplish this, a biomedical package is being used to gather this information. Selected physiological parameters, in addition to temperature, altitude, and vibrator tests, were demonstrated for the first time in flight on April 21, 1959, and are in the final stages of evaluation in a TF-102 aircraft at the Air Force Flight Test Center. The package dimensions are 5 by 6.5 by 11.5 inches, and it weighs 10.5 pounds. Helmet versus suit pressure and suit versus cockpit pressure have been telemetered on several occasions. Onboard oscillograph recordings of respiratory rates, body temperatures, and electrocardiographic data have been obtained on five occasions. The objective of this inflight physiological monitoring program is to obtain a dual system of data acquisition with telemetry, the primary methods, backed up by onboard oscillograph recording.

Future aeromedical research programs will emphasize pilot physiological monitoring to a much greater extent, and tentatively plan for life support parameters to be simultaneously telemetered and recorded.

At the Biophysics Branch situated at Kirtland Air Force Base, N. Mex., research is mainly concentrated on the effects of radiation on living subjects, leading to critical dosage criteria and to means of reducing or eliminating such hazards.

A more complete listing of facilities, programs, and special research tools, existing or planned, is contained in appendix B.

It must be clear that the progressive extension of the Air Force biomedical programs concerned with aviation medicine into space biomedicine could not be done purely on the basis of human engineering principles, without continuous reference to basic and unique biomedical research.

The Air Force has had long-term contractual relationships with universities and medical research organizations throughout the United States which are working on investigations into the basic biological processes of plants, animals, and man. At the present level of programing, the funding for these activities is \$4 million, with about 90 universities and nonprofit organizations participating. See appendix C, which indicates the wide area of coverage under this program.

The University of California (Los Angeles) is conducting experiments in the life sciences under contract with the Air Force, and has been visited by Congressman Daddario.

This contract with the university's brain research institute is divided into three categories: (1) Research of the brain; (2) research training; and (3) service through publications and conferences.

The research supporting our space program and the final utilization of man in space is a leading problem of the day. It is not enough for man to survive in space, he also has to perform, and the organ of performance is exclusively the brain. How will man's brain carry out its function in a new environment under the stresses and strains it will encounter in outer space? We can watch man, work with him, make observations on his motor activity, his heart, etc., but these methods are indirect and have many blind spots. We can also measure something from the brain directly. For example, by looking at the record of the brain activity without even seeing the creature in which that brain is contained, we can get an idea of the range of his stimuli and reactions. With the aid of such observations, we can get a good idea of what man will be able to do when he is in space and determine the perimeter of tolerance for the short-and-long-haul duration, as well as the prospective needs of man.

Basic studies at the brain research institute are aimed at the feasibility of electrical recording devices tracing behavior on simulated orbital flight. We must study electrical activity in the brain so that we can understand how it affects man and society. For example, we have learned that electrical patterns change when trained animals do the right or the wrong thing.

Using these techniques, experiments are being conducted on the brain pattern in cats and monkeys under stress, where it is necessary to go inside the brain to determine certain effects. For example, monkeys raised in darkness will work harder for light than for food. What can we learn that will help us study individual behavior on a predictable basis?

The Russians are seriously interested in the patterns of electrical activity in the brain and our scientists who have visited the U.S.S.R. have seen highly modern electrical apparatus imported from France and Denmark. This equipment is being utilized in programs similar to those going on at UCLA and elsewhere. About 500 scientists are reported to have been drafted into this field. The Russians are apparently making an extra effort in this area of basic research.

PART III. BIOSCIENCE PROGRESS IN EUROPE

In the skill and ability of free world scientists, the Western World has an asset of incalculable value. The brilliant success of the International Geophysical Year bears witness to the way in which these talents can be harnessed for a common purpose.

Since the end of the Second World War, the free nations of the West, whose total population exceeds 500 million, have been moving toward closer social and economic union. NATO authorities have recognized that cooperation in science is particularly important.³ An official report has asserted:

"It needs to be encouraged for two reasons. First, the classical way in which science advances is through the interchange of ideas and personnel. One idea or discovery leads to others, and thus cooperation in science means better science. Second, freedom of scientific exchange is a powerful binding force between nations.

"If science can be strengthened in the nations of the Western World, it will promote their cohesion and bring them great benefits as it penetrates their social

³ "Increasing the Effectiveness of Western Science," Fondation Universitaire, Brussels, 1960.

and economic life. To bring this about, the obstacles which at present retard the growth of science must be removed."

Because of the rich reserves of scientific knowledge and ability present in the universities and study centers of Western Europe, our Air Force, Army, and Navy have long sought to maintain effective liaison with work in progress and to enlist, within the limits of funds and requirements, the brains and skill of research scientists in areas of particular importance. This has been one approach taken to ease the critical pressure on American resources and it is interesting to note that private industry, as well, has been making increasing use of liaison representatives to keep abreast of developments in foreign laboratories.

Congressman Daddario examined closely many instances of projects in the biosciences now being carried out under contract as part of the overall effort. The Office of Naval Research in London has been a principal agent in appraising European scientific capabilities for help in mutual weapons development and other programs. It assumed some years ago the responsibilities of the London liaison offices of the Office of Scientific Research and Development.

Of primary interest in this report will be certain work performed by the European office, Air Research and Development Command, at Brussels. First established in 1952, it has drawn wide participation by European scientists in Air Force programs and has been the object of warm appreciation for the nature of its support. An evaluation in an American scientific journal, based on interviews with European scientists, had this to say.⁴

"Even more significant (than its success in contributing to the mission of the Air Force) may be the contribution of the European office to the cause of world peace, for it has demonstrated that an intelligently administered program of international support for scientific research weaves a sturdy fabric of understanding among nations that cannot be purchased with dollars alone and can serve as a template for long overdue civilian enterprise in this direction."

The investigator found a widespread feeling of good will evident toward EOARDC among European scientists. Those he interviewed testified that the grants received enabled them to pursue lines of research otherwise closed to them. Congressman Daddario, questioning specifically the way in which this research supports the American aims, reported a similar feeling of respect for the program among those with whom he talked, gratitude for the chance to pursue basic research of the type in which they engaged, and praise for the professional abilities of the Air Force liaison officers with whom they dealt.

The scientists with whom Congressman Daddario talked stated consistently that without Air Force support they could not have obtained the necessary resources nor manpower to concentrate their research efforts in such specialized areas, nor would the present level of bioscience knowledge in Europe be as high as it is today. Further, the results of such Air Force-sponsored investigations have been significant contributions to the advancement of medical knowledge generally, thereby benefiting all mankind.

The practice of the Brussels office, ARDC, is to screen all proposals submitted by European investigators in certain fields for suitability. About 75 percent of the proposals are forwarded to one or more ARDC laboratories in the United States for evaluation. If one is accepted as a useful contribution to a specific research program, then that laboratory arranges to transfer funds from its budget to support it.

Scientists are encouraged to publish and make available the results of their research. Thus the Air Force stimulates fundamental studies which can produce new information concerning the life processes. While these may add significantly to the Air Force programs, they also enlarge the general scientific body of knowledge.

The European effort is particularly concentrated in the field of neurobiology, where EOARDC seeks increased knowledge of the nervous system, where the sensory mechanism, the motor mechanism, the integrating mechanism and, most important of all, the thinking and decisionmaking mechanism, are intimately interwoven.

The average cost of the 80 bioscience contracts now being funded in Europe because they fit into the research program of ARDC is \$10,000 per year. A list of countries and institutions where such research is being done may be found

⁴ "How Our Air Force Supports Basic Research in Europe," Howard J. Lewis, *Science*, Jan. 1, 1960, 131: 3392. Another, more recent report may be found in "ARDC—Europe Stressing Space Research," Cecil Brownlow, *Aviation Week*, Jan. 16, 1961, vol. 74, No. 3, p. 117.

in appendix D. A more detailed account of certain specific projects, among those examined by Congressman Daddario, follows:

"Human Performance as Indicated by Analysis of Nervous Function," Dr. Antoine Remond at Salpetriere Hospital, Paris, France (AF 61(052-203)): Dr. Remond has been working for about 8 years to develop a means of analysis of the electroencephalogram (EEG) that involves the detection of small potentials that can be evoked in the brain wave when the subject is given a stimulus such as a touch or a flash of light. A single stimulus causes such a small perturbation in the EEG that it cannot be detected. The essence of Dr. Remond's scheme is an electronic means to summate the evoked EEG potential from repetitive stimuli. This involves the averaging out of the normally random EEG and displaying only the potential due to the stimulus. This contract is providing for an improved design of an 8-channel machine, and the integration of 8 of these machines into a 64-channel system. It is anticipated that this method of EEG analysis will be a prototype which can be miniaturized for use in monitoring the physiological and psychological state of flyers in hazardous or unusual test flights.

The Salpetriere Hospital, where Dr. Remond's clinic is located, offers great possibility of research since there are some 4,000 neurological patients located there. The observation of these patients allows for the development of electronic computer equipment geared to record patient reaction by a clinically trained staff. It is worth noting that the Massachusetts Institute of Technology is also working on a similar program. There is constant collaboration with MIT, which should work advantageously toward better results in this field.

Dr. Remond is constructing electronic computer equipment which can gage the state of consciousness of man and through this equipment is learning how man can be kept under constant surveillance so that we can understand why and when man becomes drowsy. We can learn how to stimulate him and become alert to the dangers which result under such conditions. It is important to consider that 10 years ago no neurological illnesses were curable by surgery, but that with the aid of electronic computers we have been able to penetrate, analyze, and develop operative cures for some such illnesses. The next 10 years will, in Dr. Remond's opinion, see remarkable achievements in the area of operative cures for those suffering from mental illness. He cites the fact that there is a constant expansion of scientists in all areas who are aware of the problems of the day and states a vital statistic that "90 percent of all the scientists who have ever existed are still living." We know that the world scientific community will continue to grow.

"Nervous Processes Underlying Learning Behavior," Dr. A. E. Fessard, College de France, Paris (AF 61(052)-103): Since May of 1958, Dr. Fessard has been implanting permanent electrodes into different parts of the brain of cats and monkeys. He has then made electrical recordings during different stages of their training routines in an attempt to elucidate the role of the various brain areas and centers in the learning process.

These careful studies of the basic processes in the central nervous system are essential to any comprehensive understanding of the learning process.

Microelectrode Studies of Unit Activity in Relation to Behavior, G. Ricci, University of Rome, Italy, AF 61 (052)-38: For the past 3 years, Dr. Ricci has been conducting studies on the basic mechanisms and pathways underlying the responses of test animals to various external stimuli. After surgically implanting microelectrodes into the brain substance, he records the experimentally evoked brain potential on an electroencephalogram.

His work has clarified several important brain pathways and centers involving the learning process. Such an understanding is basic for any eventual attempt to modify or improve learning.

Dr. Ricci is correlating information on the differences which exist between the normal brain and the sick brain. Since the brain cells are in the thousands and each cell reacts differently, the work is precise and long range. It is through these differences, however, that cures will eventually come about.

Effects of Drugs on the Activity of Spinal Cord Interneurons, V. G. Longo, Instituto Superiore di Sanita, Rome, Italy, AF 61 (052)188: Until recently, the pharmacological study of drugs upon the spinal cord was done using an indirect approach—measuring the mechanical end point (such as the knee jerk reflex) on a kymograph. Since 1958, Dr. Longo has been studying the effects of drugs on spinal cord nerve circuits by surgically implanting microelectrodes and recording all potentials under various test situations.

This method has enabled him to define precisely the site of action of several drugs, and also to select the optimum drug for a desired physiological response.

He has synthesized and tested a new compound, 1757 IS, which appears to be therapeutically more effective and more useful than its relative—strychnine—in types of disorders in which control of muscle strength and tone is weakened.

Central Action of Adrenergic Blocking Agents, Dr. Floyd R. Domer, Istituto Superiore di Sanita, Rome, AF 61 (052)-469: Dr. Domer is one of the newer contractors in the Air Force program. He began work on October 1, 1960, studying the correlation between the chemical structure of drugs and their biologic activity. This correlation is not only interesting from a theoretical viewpoint, but also promises the possibility of tailoring drugs for specific purposes.

This study is of interest to the military because it may ultimately allow a better understanding and/or control of the body's response when subjected to various types of stress.

Relation of Brain Stem Reticular Formation to Animal Behavior, G. Maruzzi, University of Pisa, Italy, AF 61 (052)-107: Professor Maruzzi and his colleagues have been systematically exploring the effects of cutting the cat's brain stem at different levels. They have found an area in the vicinity of the pons which is critical in determining whether the cat is "awake" or "asleep." When the brain stem is cut at the border of the pons and the midbrain, the animal gives the appearance of being in deep sleep. If, however, the pons is severed a few millimeters below this point, the situation is completely reversed; now there is a tendency to insomnia. They are now trying to pinpoint the area involved with even greater precision. They are also striving to learn more of the mechanism by which sleep is prevented.

It has often been demonstrated that drugs can frequently mimic surgical procedures by selectively stimulating or inhibiting a specific physiological action. Thus, knowledge of the nervous control of sleep in cats may ultimately facilitate greater vigilance or attentiveness in men.

Dr. Maruzzi has been interested in the behavior of the nervous system and his experiments are aimed in that direction. It is his belief that electronics have opened up possibilities to explore the nervous system which have allowed for more progress in the last 20 years than ever before in history.

It is his further feeling that there must now be strong collaboration between neurological scientists, physicists, and chemists. He states that "scientific progress will depend on collaboration," and that such collaboration can no longer be accomplished in one university. The United States has already demonstrated its leadership in bringing scientists together and at the University of Pisa has allowed Dr. Maruzzi to accomplish 80 percent more than he would otherwise have been able to since the end of World War II. In this work there has been the opportunity to transmit ideas through publication, to deal with other scientists, to exchange foreign students, and to develop electronic computer equipment. Much of this has been done as a direct result of U.S. assistance.

PART IV. THE NASA LIFE SCIENCES PROGRAM

NASA will shortly submit its budget request for the second year of its life sciences program. A news release on January 13 indicated that it is ready to press ahead with the establishment of a Life Sciences Laboratory at Moffett Field, Calif., to include three divisions—flight medicine and biology, space medicine and behavioral sciences, and space biology. Each division will have several branches, the first of which will be concerned with environmental biology.

The release said the divisions were responsible for the following investigations:⁶

"Flight medicine and biology—operational aspects of biomedical experiments in flight and associated biotechnology. Space medical and behavioral sciences—studies of the effects of environmental stresses through the disciplines of physiology, radiology, and psychology. Space biology—determination of space environmental effects upon simple living organisms at cellular and subcellular level, and ground-based research and development pertaining to the search for extraterrestrial life."

When NASA presented its fiscal year 1961 budget to the committee for approval, the life sciences division was in its formative stages, and only two items could

⁶ NASA press release No. 61-5, Jan. 13, 1961.

be clearly identified as bioscience research. These totaled \$4.9 million. One was in the area of research grants and contracts, for \$2 million. The other was associated with the Mercury project and was described as biological and human engineering studies for \$2.00 million.

A reappraisal of the NASA life sciences research program for fiscal year 1961 has been made available to the committee, with a new level of funding. The new total is \$5 million, or \$910,000 more than the original estimates reviewed by the committee. An examination does not disclose whether this increase was arranged through reallocation or not, but it would indicate that emphasis in this area has increased.

In the early justifications, the programs were always general in the extreme. No effort was made to correlate the proposed programs with those already in existence, except to suggest that these would, somehow, go far beyond any existing area of competence.

Present indications are that a substantial increase may be sought in the fiscal year 1962 budget for the life sciences. An appraisal of progress so far in designating fiscal year 1961 research projects raises certain doubts regarding the direction and criticality of the work in being. It would be proper to ask these questions:

What is the nature of the priorities in assigning areas of investigation?

How does NASA ascertain that it is not duplicating existing research?

Are the dollar amounts assigned based on any realistic criteria for assuring results?

What are the primary, intermediate, and advanced goals, in specific terms, to which each project is expected to contribute? Are these goals approved in consonance with overall national priorities recognized within the space program?

A comparative summary of NASA life sciences research projects with those of the U.S. Air Force alone, indicates that over a period of 6 months, the Air Force committed six times as much to projects in operational support, basic and applied research as NASA committed in 3 months, and that the U.S. Air Force program covered 72 projects where NASA commissioned only 23.

What elements of these programs may represent duplication or unnecessary work at this time deserves more study.

PART V. CONCLUSIONS

There is no question that the Department of Defense, through the agencies of the Air Force, Navy, and Army, has the capability, the facilities, and scientific talent to perform substantial biomedical and bioscientific research consonant with the national space program.

This capacity has been described in part in this report and verified by personal investigations by Congressman Daddario. Additionally, other agencies of the Government have useful capacity which should be exploited.

Outstanding among the capabilities at the command of the Government is the U.S. Air Force program in the biosciences. Working as they have through the years with the need to know about man as he flew higher, faster, and farther with each development in aircraft, the U.S. Air Force has acquired experience, competence, and extensive facilities in this area.

It is Congressman Daddario's conviction that agencies of this Government have the facilities and scientific talent to meet any needs that NASA may prescribe at this stage of its program for the exploration of space. The work described in this report appeared to be of the highest quality and professional standing. The services have established an outstanding working relationship with scientists of all countries which produces effective results.

NASA primarily based its claim for a need of a life sciences research program on two grounds—that it had a responsibility for one under the Space Act of 1958, and that the existing service capability was limited to bioengineering.

This report clearly demonstrates that the service capability goes far beyond bioengineering. The argument that the law entrusting NASA with all facets the space program requires is no argument. No program is justifiable unless it can be clearly shown to make a substantial, unduplicated contribution to the progress toward national goals.

The report that originally proposed to the NASA Administrator that a biosciences division be established paid insufficient heed to the existing national capability. America must make effective use of the talent it possesses in its armed services. It must not allow them to be shunted aside to permit the

establishment of parallel or competing resources. Only with the effective use of all such resources, without artificial restraints, can the national leadership attain national objectives in the quickest time and in the most economical method.

In a time when all assets must be husbanded, it is impossible to escape duplication in life sciences research unless an effective means of coordination is established. This entails full use of the existing capacity and requires a detailed inventory of present facilities.

It must not be overlooked that the Soviet Union has committed a far greater proportion of its resources within its space program to biomedical research than has the United States. Hence the Soviets now have more scientific knowledge and technological skills to support manned-space operations than does the United States. Even under the optimum conditions of national support of a bioastronautical program, it is unlikely that we could achieve parity in a period shorter than 5 to 7 years.

This makes it of great importance that we examine our program closely to forestall the construction of expensive laboratories that would duplicate existing capability, employ scientists or technicians without regard to work in progress, or conduct research programs in biomedical areas where the answers are already established or being sought.

NASA's claim to a technical staff to evaluate and direct its man-in-space programs from the point of establishing what it needs to know and then obtaining such knowledge from channels where it may be available, is justifiable. Plans for a separate line of research, without reference to existing capability are not, and any plans for new facilities would most certainly be an intolerable waste of national time and money, when no exhaustive inventory of existing capacity had not shown a need.

PART VI. RECOMMENDATIONS

The national program in the field of life sciences is of extreme importance to the success of our space program. Even a limited examination of our life sciences efforts indicates that there is no comprehensive program in this field and that several agencies of Government are working toward similar, and in some cases identical, goals.

It is, therefore, recommended that—

1. A study be conducted of all life sciences activities contributing to the national space program, including policies, plans, and accomplishments of all agencies of the United States engaged in such activities.

2. Immediate steps be taken to review the scope of parallel efforts existing within the three military services and the Department of Defence take steps to guarantee that these efforts are brought within the strict limitations of a single program, possibly under the supervision of a single service as executive agent for the Department of Defense.

3. A central authority be established to formulate a comprehensive program of life sciences to be conducted by agencies of the United States.

4. Such central authority shall review and validate objectives and establish requirements for space oriented life sciences basic and applied research directed to both civilian and military goals. Such authority should assign primary responsibility for such research with a view to the maximum effective use of existing resources. Where necessary, responsibility for the use of existing facilities may be reassigned within Government agencies for this purpose to insure against unnecessary duplication.

5. When it is necessary and justifiable to carry on research activities concurrently within more than one agency, such central authority should monitor and exercise control over this research.

6. In the interest of a more efficient utilization of our capabilities to accomplish national space goals, the National Aeronautics and Space Administration be enjoined from further expansion of its life sciences research efforts until the recommended studies are completed, a coordinated program established, and responsibilities delineated.

Congress, in the National Aeronautics and Space Act of 1958, assigned authority in this area to the Executive and charged the Space Council with advising him of differences and duplications that arose.

It is further recommended that the Executive take cognizance of the question of research in the life sciences as having progressed beyond the point of orderly and single development and that he direct the Space Council to make this issue one of immediate attention.

Under the terms of Executive Order 10521 of March 17, 1954, the National Science Foundation is responsible for "comprehensive studies and recommendations regarding the Nation's scientific research effort and its resources for scientific activities, including facilities and scientific personnel, and its foreseeable scientific needs * * *" and for the study of "areas of basic research where gaps or undesirable overlapping of support may exist" with a view to recommendations in such areas. It is further recommended that a study of the life sciences could be made a subject for action by the National Science Foundation within the scope of this authority.

The avoidance of duplication and the development of a unified program in the sciences has long been an objective of Government.⁶ The work being performed in the life sciences by many Government agencies must be brought together under one unified program.

APPENDIX A

TOTAL INVESTMENT IN USAF LIFE SCIENCES AND BIOASTRONAUTICS RESEARCH FACILITIES

	<i>Present value of installation</i>
Installations:	
Aerospace Medical Laboratory-----	\$9, 186, 877
USAF School of Aviation Medicine-----	¹ 16, 996, 017
Aeromedical Field Laboratory-----	7, 238, 000
Personnel Laboratory-----	779, 897
Life Sciences Directorate, Air Force Research Division-----	
Biophysics Division, Air Force Special Weapons Center-----	679, 000
Operational Applications Laboratory-----	250, 000
Arctic Aeromedical Laboratory-----	2, 384, 463
Directorate of Air Force Bioastronautics, Air Force Ballistic Missile Division-----	
Human Engineering Laboratory-----	270, 000
Human Factors Branch, Air Force Flight Test Center-----	2, 124, 666
Human Factors Office, Air Proving Ground Center-----	10, 000
Training Equipment Branch, Aeronautical Accessories Laboratory-----	200, 000
Total-----	40, 118, 893

¹ The \$16,996,017 value of installation for the School of Aviation Medicine includes \$8,500,000 which has been approved and funded. The military construction program will be completed during fiscal year 1960 through fiscal year 1963. Items approved and estimated cost for each are listed below:

<i>Item:</i>	<i>Estimated cost</i>
Bionucleonics building-----	\$1, 787, 000
Bioastronautics and biodynamics building-----	1, 610, 000
Professional building-----	1, 310, 000
Library-----	603, 000
Vivarium support facility-----	670, 000
Heating and cooling plant, other utilities and related costs-----	1, 533, 000
Sitework-----	987, 000
Total-----	8, 500, 000

APPENDIX B

U.S. AIR FORCE—A REPRESENTATIVE LISTING OF BIOASTRONAUTICS RESEARCH EQUIPMENT, JANUARY 12, 1961

(Compiled by the Office of the Assistant for Bioastronautics, Headquarters, Air Research and Development Command, Andrews Air Force Base, Washington, D.C.)

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Total investment in USAF life sciences and bioastronautics research facilities:

Tab A: Aerospace Medical Laboratory, Wright Air Development Division, Wright-Patterson AFB, Ohio.

Tab B: Aeromedical Field Laboratory, Holloman AFB, N. Mex.

⁶ It is worth noting that as recently as Mar. 13, 1959, under Executive Order 10807 establishing the Federal Council for Science and Technology, this Council was also empowered with a responsibility to recommend policies "to provide more effective planning and administration of Federal scientific and technological problems" and that would "achieve more effective utilization of the scientific and technological resources and facilities of Federal agencies, including the elimination of unnecessary duplication."

- Tab C: Biophysics Branch, Research Directorate, Air Force Special Weapons Center, Kirtland AFB, N. Mex.
 Tab D: Operational Applications Office, Air Force Command and Control Division, L. G. Hanscom Field, Mass.
 Tab E: Personnel Laboratory, Det Number 1—WADD, Lackland AFB, Tex.
 Tab F: Human Engineering Laboratory, Rome Air Development Center, Griffiss AFB, N.Y.
 Tab G: School of Aviation Medicine, Brooks AFB, Tex.
 Tab H: Edwards AFB, Calif.
 Tab I: Arnold Engineering Development Center, Arnold Air Force Station, Tenn.
 Tab J: Vandenberg AFB, Calif.
 Tab K: Patrick AFB, Fla.

AIR FORCE FACILITIES MANNED SPACE FLIGHT

WRIGHT-PATTERSON AFB, OHIO

Title: Zero-Gravity Aircraft—C-131B, AF No. 53-7823 (Convair 340).

Status: Existing.

Application: Simulates zero gravity for 15 to 20 seconds at 125 KTS airspeed at apex.

Title: Zero-Gravity Aircraft—KC-135, AF No. 55-3129.

Status: Existing.

Application: Simulates zero gravity for 25 seconds at 180 KTS airspeed (IAS) at apex. Entry speed: 0.86 mach. Padded lighted chamber 70 feet long, 6 feet high, 7 feet wide. Portable: sound-recording equipment, high and normal speed photographic equipment, biological measuring equipment.

Title: Elevated Temperature Testing Facility.

Status: Existing.

Capability: Temperature, 3,000°F.; flux density, 200 B.t.u./ft.²/sec.

Application: This facility can simulate elevated temperatures (constant or programed) by using radiant heat. It is utilized for determining structural integrity of complete airframes under simulated force and thermal environment. The simulation of elevated temperatures caused by programed heat rates and proper loading of the space vehicle configuration will produce panel buckling and airframe distortion. Reproduction of conditions caused by thermal stresses and loads will permit designer to design an acceptable airframe.

Note.—Planned expansion of this facility will permit testing of flux densities up to 750 to 1,000 B.t.u./ft.²/sec; completion of this facility is estimated by mid-1962.

Title: High Altitude Facility (Shaw-Estes).

Status: Existing.

Capability:

Test space size: Accumulator chamber 23 by 8 feet by 6 feet 6 inches; auxiliary chamber 12 by 6 feet by 6 feet 6 inches; one-man capsule chamber 50 cubic feet.

Pressure: Excess 100,000 feet—rate of climb 20,000 feet per minute.

Application: Explosive decompression can be simulated by using the accumulator chamber by vacuum and exploding through a piston decompression valve into the main auxiliary chamber. Another one-man (capsule) chamber, approximately 50 cubic feet inside connected to the locked section of the auxiliary chamber will withstand atmospheric pressure in excess of 100,000 feet equivalent and rates of climb to 20,000 feet per minute. This facility can simulate high-altitude conditions encountered during the terminal phase of a reentry vehicle.

Title: Bioacoustics Research Facility.

Status: Existing.

Capability:

Anechoic chamber, 30 by 30 feet.

Coupled reverberation room area, three rooms, sizes 32 by 14 feet, 22 by 15 feet, and 20 by 15 feet; interior surfaces of rooms are nonparallel, highly reflecting surfaces; wall transmission loss 70 decibels or greater.

Audiometry area, four basement rooms, sizes 15 by 10 feet, 15 by 14 feet, and two 10 by 12 feet; wall transmission loss for sound 70 decibels or more.

Hearing and speech communication experimentation area, two basement rooms, sizes 40 by 14 feet and 30 by 20 feet; a studio with provisions for altering the reverberation time of the studio and a control, observation, and recording room, wall transmission loss for sound 70 decibels or more.

Noise protective equipment design area, two rooms, sizes 28 by 8 feet and 12 by 10 feet at ground level; wall sound transmission loss of 70 decibels or greater.

Application: These facilities can simulate the noise environment including that associated with rocket boosters, under controlled laboratory conditions. This capability permits the testing of manned space systems and astronauts under the conditions of launch. This includes testing of the subjects pre- and post-exposure, speech communication testing under noise conditions, and testing of protective equipment and devices.

Title: Dynamic analyzer.

Status: Under construction (estimated to be operational July 1961).

Description: The basic configuration will be a high vacuum cylindrical capsule supported by 6 hydraulic rams which provide 6 degrees of freedom. The facility with instrumentation, control, and support will occupy approximately 20,000 square feet. This facility will be capable of accommodating up to 2,000 pounds of either electronic, electrical, electromechanical, or mechanical equipment.

Capability:

Test space: 10 feet long by 6 feet in diameter.

Vacuum: 3.8×10^{-7} mm. of Hg.

Temperature: -90°F. to plus 450°F.

Application: The dynamic analyzer for advanced space systems and subsystems is a highly scientific instrument under development, which will be uniquely capable of providing typical aerospace environments and will be capable of demonstrating the operational efficiency and practical reliability of the systems or subsystems, under the influence of these environments. The dynamic analyzer will be capable of providing a vacuum in the order of 3.8×10^{-7} mm. of Hg (approximately 140 nautical miles) within 100 minutes. Also, the capsule may be chilled to -90°F. while at the same time the other half of the capsule is heated to plus 400°F. Six degrees of freedom are included in the basic design of the facility. Three of the six are represented by (1) roll plus or minus 15° , in the order of 3 cycles per second to 30 minutes per cycle; (2) pitch plus or minus 15° in the order of 3 cycles per sec to 30 minutes per cycle; and (3) yaw plus or minus 2° , in the order of 3 cycles per second to 15 minutes per cycle. The three degrees of freedom of the vibration system incorporated in the design of the dynamic analyzer will provide simultaneous three-directional motion within the frequency spectrum of 5-800 c.p.s., one-half maximum double amplitude, or 5 g., whichever is the limiting factor. Both high and low temperature may be either automatically programmed, manually varied, or maintained at a preset level. Electronic signal simulation is planned as well as the conductance of radio-interference tests under true operational environment (high vacuum, high-low temperature, vibration). Both actual and simulated flight profiles can be programmed into the facility and modular and evaporative cooling will also be available.

Title: Sonic fatigue test facility.

Status: Under construction (estimated operational date July 1962).

Capability: Test section:

Large Chamber 40 feet by 50 feet by 70 feet; intensity sound 50 to 9,600 cycles per second; pressure level 162 db re 0.0002u bar to 174 db re 0.0002u bar; acoustic power maximum 1 million watts

Small Chamber 1 foot by 1 foot; pressure level 174 db; acoustic power 50,000 watts.

Application: The sonic fatigue test facility will generate high intensity sound environments for full scale and model simulation of sound effects on structures, electronic, and guidance equipment of missiles, aircraft, and aerospace vehicles, and components thereof. The test method employed by this facility consists of exposing the test specimen to the sound field of known distribution and measuring of either local strains, amplitudes, temperatures, accelerations, and sound pressure levels with the purpose of determining or predicting the behavior and fatigue life of the item, up to 72 channels can be measured simultaneously and 387 transducer outputs can be recorded using time sharing techniques.

Method of application: A guide as to the type of space environments which can be simulated is listed below.

Variables	Range	Method used
Frequency.....	50-9,600 c.p.s.....	Siren generated.
Spectrum, pure tone, wide band.....		Amplitude modulated siren, wide band siren.
Specimen temperature.....	Ambient to 2,000° F. in design goal.	Electrical heating.
Wave characteristic, progressive or incident.	Full test chamber coverage.....	Reflective or absorbent chamber wall treatment.

Title: Four megawatt electro gas dynamic facility.

Status: Programed. (Estimated operational dates: July 1961-December 1961.)

Capability:

Altitudes: 100,000 to 280,000 feet.

Velocity: 22,000 feet per second.

Test section: 2 feet in diameter.

Application: This facility will provide a means for conducting aerodynamic, magnetohydrodynamic, and heat transfer tests of reentry shapes and configurations and is capable of simulating transient or steady state reentry into terrestrial or extraterrestrial atmospheres.

NOTE.—A future power increase of 8 megawatts will allow velocities up to 26,000 feet per second at 160,000 feet.

Title: 50 megawatt electro gas dynamic facility.

Status: Programed. Fiscal year 1962 (estimated to be operational in 1965).

Description: Existing buildings, equipment, and structures from a deactivated transonic wind tunnel will be used in the construction of a 50-megawatt ARD heated electro gas dynamic research and structural development facility. The new facility will operate essentially continuously at supply pressures up to 1,500 p.s.i., stagnation air temperatures to 18,000° R., and airstream speeds approaching orbital velocities. Basic electrical power transformers and controls will use existing 30-megawatt equipment supplemented by the 20-megawatt transformers and switchgear. Major components of the facility are—

(a) A 50-megawatt power supply including controls and instrumentation. This power supply may be a.c. or d.c. depending upon the outcome of current research efforts. It will furnish electrical power in regulated and controllable amounts to the arc head.

(b) The arc head produces a controlled air stabilized electrical discharge which heats the pressurized air to 18,000° R. It contains an integral cooling system for protection of the electrode and supporting structure.

(c) Nozzles with throat diameters between 1 and 2 inches accelerate and expand the heated air from the arc head to hypersonic speeds and an air stream diameter up to 7 feet. An integral cooling system protects the inner surface of the throat and expansion cone of the nozzle.

(d) The test chamber utilizes the existing structure of the transonic test cabin and will include several rapidly interchangeable model support assemblies for mounting the various structural and aerodynamic test items.

(e) A cooled diffuser captures the hypervelocity, high-temperature airflow leaving the test section and efficiently decelerates it.

(f) The diffuser exit duct is the existing diffuser leg of the old transonic circuit. This leg, approximately 19 feet maximum diameter, is cooled externally by a waterspray.

(g) A high-temperature cooler is constructed inside the duct just upstream of the first turning vanes. It will remove heat from the airflow at a rate up to 30,000 B.t.u. per second using existing water-cooling towers. The air continues around the existing duct and passes through.

(h) The low-temperature cooler. This cooler is located in the 40-foot diameter section, and provides the final heat removal from the air. It will utilize the basic refrigeration system, coolant flow circuits, and heat exchanger of the existing facility.

(i) Vacuum pumps for evacuating the 358,000-cubic-foot duct, or vacuum reservoir, will permit operation at test section static pressures less than 1 millimeter of mercury.

(j) A compressor system to supply the main airflow through the arc head at pressures up to 1,500 p.s.i. and at the rate of 10 pounds per second.

(k) All necessary test instrumentation, including balances and flow visualization systems.

Application: The reentry of vehicles at near orbital velocities into the Earth's atmosphere has led to immediate requirements for high stagnation enthalpy gaddynamic facilities for performing high-temperature hypervelocity research and development work. The arc-heated facility is the best known method for obtaining sustained simulation of the extreme conditions of temperature, velocity, and flow phenomena (such as dissociation and ionization) which are encountered during reentry flight. Two features necessary for reliable investigation of these hypervelocity problems are best obtained in an arc-heated facility having a test section of sufficient size to minimize scaling problems, and testing times of long duration.

Title: Science lab, biomedical acceleration.

Status: Planned.

Capability:

1. Simulate changes in linear velocity up to 100 g. using radius of centrifugation up to 100 feet.

2. Three-dimensional rotational freedom of the gondola with largest amplitude and high frequency possible.

3. Three-dimensional translational freedom of the gondola to produce as large amplitude and frequency of movement as possible.

4. Consideration of payloads (3,000 pounds) to the extent of providing capability to test complete capsule units.

5. Means of programing simultaneous complex accelerations as they occur in the rocket vehicle and methods for allowing closed-loop (pilot machine) simulation.

Application: For testing system components and equipment which will be subject to complex stresses. Provide for the testing of reconnaissance, communication, auxiliary power, navigation, guidance subsystems.

Title: Aerospace System Environmental Chamber Mark II.

Status: Planned (development of design criteria).

Capability:

Vacuum: 10^{-8} mm. Hg.

Temperature: 100° K.

Heat sink: 5 MW.

Solar radiation: 1,400 watts/square meter on a 175 square meter projected area.

Albedo: Correct for a 300-mile orbiter.

Atmospheric composition: N_2 , O_2H_2 .

Vibration: Two 10,000 kg. shakers.

Shock: 200 g. for 1 millisecond to 15 g. for 11 milliseconds.

Angular velocity and acceleration: Power driven gimbal mount.

Size: 200 feet in diameter, 135 feet working height—adjoining entry locks.

Application: The complete aerospace vehicle will be tested, and with and without the crew inside, checking the operation and maintenance of the integrated weapon system in as near as possible the flight environment. Special tasks such as: assembly of vehicles in space, construction and operation of planet bases, and emergency procedures will be accomplished for training, demonstration of design adequacy, and satisfaction of specifications, under comparatively safe, controlled conditions. The chamber may also be used for acceptance testing and preflight testing of production articles.

Title: Simulators and computers.

Status: Existing.

Application: The simulator is used to evaluate new training techniques and to conduct studies for testing the reliability and realism of innovations in simulator development. The computer is used to program aircraft performance characteristics for the simulator.

Design: Both the simulator and the small computer are used for pilot studies of flight characteristic programs for use in larger operational computers and trainers.

Title: Combination temperature-altitude chamber.

Status: Existing.

Capability:

Altitude: Sea level to 100,000 feet.

Temperature:

Air temperature -50° F. to $+350^{\circ}$ F.

Wall temperature -0° F. to $+500^{\circ}$ F.

Dewpoint (air) -50° F. to $+100^{\circ}$ F.

Test space size: 4 feet by $7\frac{1}{2}$ feet by $6\frac{1}{2}$ feet.

Application: The upper and lower half of the test space can be controlled independently; a controlled air velocity of 50 to 800 cubic feet per minute; a dewpoint (air) from minus 50° F. to plus 100° F.; and altitude simulation from sea level to 100,000 feet. The rate of change of these six variables is such that each can be changed from one extreme to the other, in a programmed fashion, in about 5 minutes.

Title: Human centrifuge.

Status: Existing.

Capability:

Speed: Maximum of 90 r.p.m.

Force: 22 g.

Load limit: 700 pounds net.

Axis: 20 feet radius.

Application: This is an electrically controlled and powered structure consisting of horizontal twin booms 40 feet long which rotate on a central axis of 20 feet radius. A free swinging cab is supported at one end and between the booms so that during rotation the cab tilts outward to near horizontal plane and positive radial acceleration. (Centrifugal force) is imposed upon the object in the cabin. A stationary horizontal platform is installed at the opposite end of the boom.

NOTE.—There is a contract to modify the present centrifuge to allow a faster rate of g. onset to gimbal the cab with 2° of freedom and to increase the load limit of the cab to about 1,000 pounds.

Title: All-weather room.

Status: Existing.

Application: This is a room in which the temperature can be controlled from minus 40° F. to plus 180° F. and the humidity can be varied from essentially zero to 100 percent. Human tolerances to long-term effect of temperature and humidity are studied, and environmental equipment is tested to determine its limits of usefulness.

Title: Heat pulse chamber.

Status: Existing.

Application: This is a cylindrical chamber capable of containing and subjecting a man and his personal protective equipment to rapidly changing heat pulses. Human tolerances to short-term, rapidly changing heat pulses can be studied and personal equipment tested. The chamber is useful in determining the effects of high levels of radiant energy and frictional heat produced by supersonic wind blast as is experienced when a pilot ejects at supersonic speeds.

Title: Vertical accelerator.

Status: Existing.

Application: This is a research and development mechanism on which man and animals can be subjected to rapidly changing forces of acceleration, duplicating that produced by an aircraft during buffeting. This mechanism is especially useful in determining the effects produced on man by supersonic flight at very low altitudes.

Title: Vertical decelerator tower.

Status: Existing.

Application: This tower is used to investigate the effects of abrupt deceleration, such as impact on the human body, and to design methods of attenuating and protecting from these forces. The mechanism provides peak g. and rate of onset reproducible within close tolerances which provides for the quantitative evaluation of test items as well as greater safety and accuracy for tests of human subjects.

Title: Mobile Acoustics Laboratory.

Status: Existing.

Application: This is a trailer-mounted unit in which noise levels produced by aircraft and missiles can be charted and studied. The noise patterns are used to determine areas of high noise levels harmful to man and equipment.

Title: Test pool.

Status: Existing.

Application: This is a water-filled pool useful in numerous underwater and water surface studies. It is especially useful in developmental testing of survival and flotation emergency air crew equipment.

Title: Inclined drop test facility.

Status: Existing.

Application: This is an out-of-doors structure from which man, animals, and protective equipment of various kinds can be dropped at various angles from vertical to horizontal to study tolerances, effects, and means of protecting man from the forces of impact.

Title: Equilibrium chairs.

Status: Existing.

Application: These are chairs which can be righted by the occupant using a control stick similar to that in an aircraft. The chairs are programed to tip in various directions in a random sequence at the same time the occupant is subjected to checking motion at chosen frequencies and distances. The chairs are especially useful in determining man's ability to control flight vehicles subjected to the forces of buffeting.

Title: Isolation chamber.

Status: Existing.

Application: These are rooms in which an experimental subject can be placed and deprived of some of the normal stimuli to which he is accustomed such as noise and light. The chambers are useful for various types of studies particularly those concerned with man's ability to remain rational under long periods of time in experimentally produced stress conditions.

Title: Horizontal spin table.

Status: Existing.

Application: This is a table which can be whirled to produce low levels of increased gravitational forces and on which human subjects can be spun to produce effects similar to the spinning of an airman when he ejects from an aircraft under emergency conditions. This spin table is useful in studying the long term effects of low levels of increased gravitational forces on animals and in studying the effects and tolerances of spinning.

HOLLOMAN AFB, N. MEX.

Title: High-speed test track.

Status: Existing.

Capability: The track consists of two 35,000-foot, continuous 171-pound/yard crane rail of 7-foot gage. The Holloman track is not only unique by its great length, but also in alinement. The west, or master, rail is alined ultimately to plus or minus 0.005 inch of a straight line. The other rail is adjusted to the master with plus or minus 0.01 inch. This accuracy is critical to the guidance system testing for measurement purposes and to the relatively low onset and acceleration free flight missile environment simulation provided by the track. Finally, on the track bed itself and adjusted to accuracy of plus or minus 0.001 inch are the interrupter blades for the space-time system.

Application: The Holloman track provides a component and system test bed in an environment closely simulating that of free flight of a missile. Onset, acceleration, high velocity, and vibration parameters are the most important. The track itself provides an accurate yardstick against which a guidance system's performance may be measured. This is attained by constant purvey and alinement of the rails and velocity measuring system interrupters. Astronomical references are provided for track reference points as well as gravity and magnetic field strengths. Sled run data is transmitted via RF link to receiving stations where data is recorded on tape for later processing.

Title: Decelerator device (Daisy).

Status: Existing.

Capability: The 120-foot long Daisy decelerator is used for experimentation with dummies, animals, and humans to determine the effect of abrupt deceleration. Variables available for testing are peak G, rate of onset of G, duration of G, and position of subject. Associated equipment includes high speed X-ray for determining characteristics of organ displacement in specially prepared animals. Equipment such as harnesses, ejection seats, and escape capsules are tested for their capability of providing adequate protection when subjected to their anticipated G time curves.

Application: Development testing of operating techniques and/or equipment conceived as a result of applied research effort in biodynamics of flight.

Title: Stratosphere chamber.

Status: Existing.

Capability:

Altitude: 140,000 feet in 4 minutes; 200,000 feet in 20 minutes; 220,000 feet ultimate.

Temperature: -100° F. to plus 200° F.

Humidity: 15 to 90 percent RH at 33° to 140° is possible.

Vibration: 5 to 2,000 cycles per second, 5,000 pounds force, one-half inch maximum displacement.

Test space size:

Chamber 8 feet wide by 8 feet high by 11 feet long.

Anteroom 4 feet wide by 8 feet high by 4 feet long.

Application: The chamber incorporates a programmer and controllers which make it possible to stimulate, within the limits noted under capability, environments encountered in flights of missiles, and high altitude balloons and aircraft. Environmental tests are conducted on aeromedical specimens as well as air vehicle components.

Title: Closed environmental system.

Status: Existing.

Capability: This is a closed chamber capable of holding one chimpanzee or several smaller animals and controlling four variables of the subject's environment; pressure, temperature, gas composition, and humidity.

Application: The measurement of animal performance is a continuing requirement to provide behavioral data which may be applied to manned operation of space vehicle.

Title: Laboratory, bioastronautical.

Status: Planned.

Capability: Will consist of—

(a) Astroecology laboratory, to conduct animal experiments in environments such as isolation, confinement, and prolonged wakefulness.

(b) Bioastronaut operant conditioning laboratory, to study psychological problems of various environments and to evaluate the reductions in animal performance.

(c) Bioastronautics laboratory, to study radiation effects on biological specimens.

(d) Bioelectronics laboratory, for fabrication of electronic components which are peculiar to the aeromedical mission.

(e) Vivarium for the receipt and holding of research animals.

Application: To be used for environmental and proof-testing of life support equipment for space flight.

Title: Underwater decelerator.

Status: Existing.

Application: This is a specially constructed device for use on rocket sleds. Animals and human subjects are submerged in water and subjected to high levels of gravitational forces applied rapidly for short periods of time to determine man's tolerance to acceleration and the protective effect of water submergment.

Title: Micronex X-ray.

Status: Existing.

Application: This is an X-ray capable of taking photographs very quickly. It is used to determine the displacement of animal and human origins while the subject is subjected to high deceleration forces. This instrument is an

aid in determining the limits of human tolerances to deceleration and is also useful in determining cause of damage which in turn leads to means of protection.

KIRTLAND AIR FORCE BASE, N. MEX.

Title: Science laboratory hazardous standards.

Status: Proposed fiscal year 1962 MCP.

Capability: This facility is capable of investigating the biological effects of ingested or inhaled ionizing radiation to determine at what point these effects present service restriction to AF operations. The facility will permit the detection of fractional microcurie quantities of gamma-emitting radioisotopes, and is used for the mass screening of personnel and for the counting of isotopes. Detection and identification of unknown gamma-emitting radioisotopes will also be possible.

Application: The data obtained will be used to determine the biological hazards involved in operation of nuclear reactors, space flight, and accidental release of nuclear materials.

Title: 256 channel analyzer.

Status: Existing.

Application: This is a complex electronic laboratory tool used in determining the levels, energies, sources, and characteristics of radioactivity emanating from an unknown source.

Title: Cobalt and cesium source.

Status: Existing.

Application: These are used to expose experimental animals to ionizing radiation similar to nuclear auxiliary power sources. Also they are used to calibrate radiac equipment.

Title: Ten-acre farm.

Status: Existing.

Application: This is a laboratory farm used in experimentation and care of a variety of laboratory animals, the largest of which are goats. The farm is equipped with various types of instrumentation useful in making radio-biological studies. For example: Studies of the effects of ingestion of food contaminated with radioactive isotopes typical of fallout from nuclear weapons.

CAMBRIDGE RESEARCH CENTER, HANSCOM FIELD, MASS.

Title: System laboratory with electronic equipment for partial system mockup and analysis of system effectiveness.

Status: Existing.

Application: This equipment is used to simulate an operational problem in a laboratory situation, i.e., a command and control center (SAGE) may be simulated to study the effectiveness of particular operations.

Title: Anechoic chamber, 10 feet by 16 feet (inside dimensions), for studies of communication, noise, and audition problems.

Status: Existing.

Application: The anechoic chamber allows much greater precision for collection of data in communication, noise, and audition problems.

Title: Nine experiment chambers, 10 feet by 10 feet, light and soundproof, shielded against all electronic interference.

Status: Existing.

Application: The experimental chambers provide an accurately controlled environment for conducting visual and audition studies.

Title: Special hearing experimentation equipment.

Status: Existing.

Application: The hearing experimental equipment is used to generate, with accuracy and precision, sounds needed for hearing studies.

Title: Digital system for tabulations and analysis of research data.

Status: Existing.

Application: This equipment is primarily used to analyze research data and for data reduction and data storage.

Title: General laboratory equipment necessary for building human engineering experimental devices.

Status: Existing.

Application: This type of equipment is used to compliment and support research efforts utilizing the equipment described above.

LACKLAND AIR FORCE BASE, TEX.

Title: IBM type 650 computer with 5 tapes. One RAMAC unit plus normal EAM support equipment.

Status: Existing.

Application: This facility is used for ready access storage in tape files of aptitude and qualifications data from incoming officers and airmen. One of the uses of such data is to compare the qualification of officers and airmen on board with future Air Force personnel qualification requirements.

For prediction of the impact of policy decisions on the operation of the personnel system by solving equations related to the development of mathematical and manpower models.

For the scoring and computation of normative data for airmen proficiency tests.

For supporting the research effort of personnel laboratory, by computing factor analytic problem, multiple-linear regression equations and other statistics for testing hypothesis and evaluating experimental tests when large amounts of data are involved.

GRIFFISS AFB, N.Y.

Title: Auditory and vision experimentation room.

Status: Existing.

Application: The auditory and vision experimental rooms at the Rome Human Engineering Laboratory are equipped with auxiliary devices to permit the study of a broad range of problems related to types and characteristics of information transmission via visual displays, auditory signals, and for the testing of various human engineering problems and design characteristics.

Title: Experimental psychology evaluation facility for human behavioral measurements under controlled conditions.

Status: Existing.

Application: The evaluation facility is for studying of types of information relevant to the control of forces, damage assessment and decisionmaking and related problems.

BROOKS AFB, TEX.

Title: Neutron generator.

Status: Existing.

Application: This is used to give accurate doses of neutron radiation to experimental animals. Nuclear reactors and atomic weapons can cause exposure of man to neutrons. Therefore, a more accurate determination of their biological effects is required.

Title: Cobalt 60 irradiation facility and 260KVP deep therapy unit.

Status: Existing.

Application: This is used to give accurate doses of ionizing radiation (gamma rays) to experimental animals. A great variety of experiments are required for the use of this facility including drug therapy and prophylaxis experiments.

Title: Altitude and temperature chamber.

Status: Existing.

Application: This 20 foot by 47 foot by 12 foot chamber can vary temperature (-67°F. to $+150^{\circ}\text{F.}$), humidity (10 percent to 90 percent) and pressure (0 to 100,000 ft.). It is used to simulate the various combinations of these variables to be expected in manned aerospace flight to evaluate human tolerances and efficiency under these conditions.

Title: One-man space cabin simulator and two-man space cabin simulator.

Status: Existing.

Application: This is used to simulate the conditions of a space flight for one and two men, respectively, with regard to atmosphere, isolation, cabin configuration, duties rest, recreation, feeding, and waste disposal.

Title: Altitude chambers (a) through (i).

Status: Existing.

Application: These are used for animal and human experimentation on the effects of decreased atmospheric pressure, explosive decompression and various cabin atmospheres.

Title: Audiology chamber 10 feet by 10 feet.

Status: Existing.

Application: This is used for research requiring an extremely quiet environment or very accurate control of the level and spectrum of sound in the environment. It has application to the study of the effects of the low sound environment of orbital flight with quiet accessory equipment.

Title: Reverberation chamber 9 feet by 11 feet.

Status: Existing.

Application: This is used to simulate a very high sound level environment. It permits the study of the effects of high noise levels, such as may be expected during launch and reentry, on man.

EDWARDS AFB, CALIF.

Title: Low-pressure altitude chambers.

Status: Existing.

Capability: Capability of the chambers allows for routine altitude indoctrination of approximately 16 men at a time, or pressure-suit training of individuals on an hourly scheduled basis. Maximum altitude of the 16-man chamber is 160,000 feet. The parasite chamber has a maximum altitude capability of over 200,000 feet, with a rate of climb of approximately 60,000 feet per minute. All chambers and locks are air conditioned, and heating capability to 160° F. is to be added in the near future. A support vehicle (tractor and trailer) is also provided for on-the-line use of altitude suits.

Application: To provide simulated high-altitude conditions for equipment testing, and personnel training, in relation to personal flying equipment for high-altitude missions. Ancillary equipment includes suit and helmet testing instruments and medical monitoring equipment including Nitralyzer, Visoscope, and other medical support instruments for emergency treatment of reactors. Personnel are also trained in the use of partial and full pressure high-altitude suits as required for flights above 50,000 feet in Air Force aircraft. Also, direct support for 111 suits (MC-2 and A/P 22 S-2) full-pressure suits in connection with the X-15 program.

Title: High-speed track facilities.

Status: Existing.

Capability—test tracks: AFFTC high-speed test track, 20,000 feet in length. Standard inside gage, continuously welded 171 pound/yard rails on continuous concrete beams, and equipment with 2,400-foot simulated rainfall range, 9,000-foot permanent metric camera range, 20,000-foot space-time data acquisition system, and 4,500-foot usable waterbrake trough at present, although 6,000 feet will be available some time in the future.

Application: Provide suitable test facilities for accomplishment of missile test programs, such as radomes, gyrostabalized mechanisms, warhead fuse devices, escape systems such as seat and canopy jettison tests, empennage flutter testing, retardation device testing, rain erosion, and similar types of testing.

ARNOLD ENGINEERING DEVELOPMENT CENTER

Title: Aerospace system environmental chamber, Mark I.

Status: Fiscal year 1962 MCP (final design underway).

Capability:

Vacuum: 10^{-8} mm. Hg (300 miles).

Temperature: 85° K. walls.

Radiation: Solar (0.14 watt per square centimeter), earth albedo, earth radiance.

Vibration: 200,000 pound shaker, 20–2,000 cycles per second.

Size: 30 feet in diameter, 70 feet in height.

Ascent pressure: Real time simulation to 10^{-2} mm. Hg (60 miles).

Application: The chamber will be capable of testing complete satellite vehicles such as the Agena for prolonged periods of time under simulated environmental conditions with the components with exception of engines operating as they would in an actual flight. The functional parameters which can be studied during such a test are the thermal equilibrium of the vehicle and its components; the operation of all electrical equipment, particularly high voltage equipment; the operation of all bearings and other mechanical moving parts; the vibration response of the structure; the materials effects such as cold welding, outgassing,

and chemical changes brought about by the low pressure; and the ability of the vehicle to withstand rapid changes in external pressure experienced during the launch ascent.

EDWARDS AIR FORCE BASE, CALIF.

Title:

- (a) Instrumentation developments.
- (b) Physiological data packages for the X-15.

Status: Existing.

Capability and application—airborne telemetry: One unique capability of the Air Force Flight Test Center allied to the life sciences is in the area of airborne telemetry. An active program of physiological telemetry in support of the X-15 program has been pursued with the X-15 carrying 1,300 pounds of equipment and capable of telemetering nearly 5 times as much data and recording on board over 20 times as much information as its predecessor the Bell X-2. Two physiological data packages, each weighing 11 pounds, have been developed and tested to obtain recordings of body temperatures, respiratory rates, electrocardiograph tracings, helmet versus suit pressure, and suit pressure versus cockpit pressure. This represents the first time a rocket research vehicle has been equipped so that a flight surgeon viewing a ground monitor will be able to observe directly the pilot's suit inflation pressure, helmet positive pressure, real-time coded signal and an oscilloscope tracing of the telemetered signal.

Future techniques under development call for the following physiological and environmental parameters to be presented visually in real time, along with telemetered vehicular data—ventilation rate, breathing rate, blood pressure, heart rate, skin conductance, oronasal oxygen and carbon dioxide partial pressure, suit and cabin pressures, cabin temperature and relative humidity, airflow and residual carbon dioxide partial pressure, emergency and main oxygen supply, vertical and transverse acceleration, internal body temperature, external body temperature, reaction time, and radiation. While many of the new physiological telemetry developments may not be ready for the X-15, it is anticipated that they will have a significant contribution to make to the Mercury, Dyna-Soar, and subsequent space research projects.

Full pressure suits: An equally important and parallel program is being pursued in the test and evaluation of full pressure suits. Each of the individually fitted garments worn by X-15 pilots is designed and equipped with sensors to permit in-flight, telemetered, physiological data acquisition. To date, with 11 of the expensive protective garments having been issued to a total of 8 Air Force, NASA, and North American Aviation pilots, over 267 hours of suit-time has been recorded, with over 30 hours of this time representing actual X-15 captive and free flight experience. The Air Force Flight Test Center has now achieved a greater operational capability in "space suit" use and maintenance than any organization in the Air Force.

VANDENBERG AFB, CALIF.

Title: Animals trailer vans.

Status: Existing.

Application: There are six trailer vans in the complex to support space bioastronautics efforts consisting of two animal holding vans, one instrumentation van, one assembly van, one equipment van, and an auxiliary power unit van. These vans are equipped to do a complete ground checkout including altitude chamber room for over 200,000 feet of animal space flight capsules. We have facilities for complete instrumentation, for repair and modification if required during checkout, and also we can keep our animal subjects separated in the two medical vans, both of which have a complete laboratory including X-ray and operating room facilities. The cost of the complete complex is \$750,000. They are air supportable and could be used either as a permanent holding facility or test facility or could be disbursed downrange for support of biomedical space flight research.

PATRICK AFB, FLA.

Title: Trailers.

Status: Existing.

Capability and application: A completely instrumented trailer is on hand to transport the astronaut or biological specimen from the bioastronautics holding facility to the launch pad. The trailer is air conditioned and equipped to monitor the physiological and psychological aspects of the subject until launch time.

This biomedical holding facility is designed to provide housing for the astronaut for a period of 72 hours prior to launch. The necessary prior launch physical examination, placement in the pressure suit, and other physiological tests to determine baselines are verified prior to launch.

Title: Computers.

Status: Existing.

Capability and application: Complete array of computers are installed which are used to reduce the preflight and flight data of missiles in report form for further analysis.

Title: Portable hospital facilities.

Status: Existing.

Capability and application: There are three portable prefabricated aluminum hospital facilities which we direct to any downrange island for use in the medical support bioastronautics program. In the event of a launch pad abort, we have a medical station in the immediate vicinity of the launch site. This facility is equipped and located to serve as an emergency medical facility in case of a launch disaster. Attached is a heliport which is part of the facility. Also adjacent to this medical station is the astronauts' feeding facility where meals are prepared and served during the final 72 hours.

Title: Missile Test and Range Support Division (formerly the Occupational Health Research Laboratory).

Status: Existing.

Capability and application: The mission of the Missile Test and Range Support Division is to develop plans and programs for medical support of missile tests and missile range facilities. This requires identifying and investigating occupational health hazards associated with missile prelaunch and launch activities. Preventive medical information is thereby obtained for use by missile test personnel, as well as those personnel in operational missile units. To accomplish this, industrial hygiene studies are periodically performed along with laboratory analyses, medical examinations, and surveys on the physical aspects of missile operations, such as noise and blast. These studies and surveys aid in the establishment of requirements and standards for protective clothing and equipment thereby helping to safeguard personnel during missile tests. Essentially, personnel in this Division formulate tasks and monitor their implementation by personnel of the PAA Medical Department. In addition, the human factors of missile operations are covered by devising selection criteria and training programs for missile units; by human engineering the complete missile weapon system.

HEADQUARTERS, AIR RESEARCH AND DEVELOPMENT COMMAND,

ANDREWS AIR FORCE BASE,

Washington, D.C., January 23, 1961.

Memorandum for Mr. Hines.

This is a more detailed listing of the bioastronautics research program covered by contracts with nonprofit institutions. The list which we sent to you last week was obtained from the machine records and lists absolutely all contracts either directly or indirectly with bioscience implications.

It is hoped that this additional listing compiled from information from our laboratories will be of use to you. Please call on us for any additional information which you might need.

Sincerely,

BENJAMIN A. STRICKLAND, Jr.,
Brigadier General, U.S. Air Force, Medical Corps,
Deputy Assistant for Bioastronautics.

APPENDIX C

U.S. AIR FORCE BIOASTRONAUTICS RESEARCH CONTRACTUAL PROGRAM, CONDUCTED
BY NONPROFIT INSTITUTIONS OF THE UNITED STATES, JANUARY 18, 1961

<i>Name of contractor</i>	<i>Subject of contract</i>
Albany Medical College-----	1. Body fluids. 2. Cardiovascular physiology. 3. Impedence plethysmograph.
American Institute for Research-----	1. Occupational analysis research. 2. Development of optimal methods of organizing and presenting operator job information in training equipment.
Antioch College-----	1. Anthropological research. 2. Collection and analyzing of psychological research data.
Arizona State University-----	1. Investigation of spectral estimation. 2. Experimental and theoretical investigation of information feedback with respect to disrupted space communication.
Armour Research Foundation-----	1. Feasibility and functional requirements study of viability data acquisition. 2. Infection in sealed cabins.
Baylor University-----	1. Electroencephalogram telemetry. 2. Neuroendocrinology. 3. Enzymology in nephrotoxicology. 4. Research on multiple-channel period analyzer. 5. Nervous and humoral control of thyroid stimulating hormone release and synthesis.
Boston University-----	1. Effects of antifibrillation drugs on hypothermia.
Brooklyn College-----	1. Tissue trauma biochemistry.
Brown University-----	1. Cutaneous radiobiology. 2. Aerothermoacoustics.
Bryn Mawr College-----	1. Animal biosatellite requirements.
California Academy of Sciences-----	1. Biophysics-astronavigation in migratory birds
Chicago Medical School-----	1. Endocrinological and metabolic changes induced by total body vibration. 2. Tissue mechanical strength and relative displacement resulting from externally applied sinusoidal force.
Colorado State University-----	1. Environmental stress in adrenal-thyroid relationship.
Columbia University-----	1. Prediction and classification (personnel). 2. Pharmacologic neurophysiology. 3. Assay of steroids. 4. Scaling of subjective estimate of magnitude.
Cornell University-----	1. The metabolism of carbon during photosynthesis.
Duke University-----	1. Renal excretion of protein. 2. Respiratory adjustments to environmental stress.
Einstein, Albert, Medical Center-----	1. Thiononium radiation protectives.
Federation of American Societies for Experimental Biology.	1. Biological handbook.

U.S. AIR FORCE BIOASTRONAUTICS RESEARCH CONTRACTUAL PROGRAM, CONDUCTED
BY NONPROFIT INSTITUTIONS OF THE UNITED STATES, JANUARY 18, 1961—Con.

<i>Name of contractor</i>	<i>Subject of contract</i>
Florida State University-----	1. Radiobiology genetics. 2. Contagion biometrics. 3. Effects of similarity and time of tests on transfer.
George Washington University-----	1. Biophysics, computing facility.
Georgia Institute of Technology-----	1. Cellular ozone effects.
Hanford Laboratory of Atomic Energy Commission.	1. Plutonium inhalation.
Harvard University-----	1. Electrical studies of cortical behavior. 2. Hypothalamic secretory factor for adrenocorticotrophic hormone. 3. Research on relationship between behavioral and physiological responses to sensory deprivation. 4. Pharmacological effects of cerebral metabolism.
Indiana University-----	1. Retinal circulation oxygenation. 2. To obtain information on the ways in which noise prevents or reduces the intelligibility of speech communication. 3. Research on cumulative auditory effects of multiple exposure to intense acoustic stimulation in animals. 4. Vision accommodation and convergence relationships. 5. Night and space myopia. 6. Study of visual performance using ophthalmic filters.
Jefferson Medical College-----	1. Altitude tolerance.
Johns Hopkins University-----	1. Pulmonary physiology. 2. Single unit studies of cortical and subcortical function in unrestrained animals. 3. Molecular basis of muscle mechanics studied by paramagnetic electron resonance techniques.
Kent State University-----	1. Study of properties of phototropic materials.
Lankenau Hospital-----	1. Effects of short time diet modification on human response to stress.
Long Island Biological Association----	1. Biophysics, symposium on "Biological Clocks."
Lovelace Foundation for Medical Education and Research.	1. Techniques for analysis of urine for alpha-emitting radioisotopes.
Massachusetts Eye and Ear Infirmary-	1. Vitreous body radiation.
Massachusetts General Hospital-----	1. Brain and behavior.
Massachusetts Institute of Technology-	1. Research on comparative investigation of neural operations. 2. High energy metabolites. 3. Recovery of usable materials from wastes. 4. Exploration of information measurement and mathematical computation to develop techniques for measuring flow of information. 5. Research directed toward exploration or neurological correlates of information reception and decision-making. 6. Behavioral activities related to perceptual deprivation.

U.S. AIR FORCE BIOASTRONAUTICS RESEARCH CONTRACTUAL PROGRAM, CONDUCTED
BY NONPROFIT INSTITUTIONS OF THE UNITED STATES, JANUARY 18, 1961—Con.

<i>Name of contractor</i>	<i>Subject of contract</i>
Massachusetts Mental Health Center--	1. Critical parameters of sensory deprivation.
Mayo Clinic-----	1. Measurement of blood flow in tissue of human centrifuge subject. 2. Objective measures of acceleration tolerance.
Medical College of Virginia-----	1. Human stress pathways.
Miami University-----	1. Collection and analysis of psychological research data.
Miami Valley Hospital-----	1. Isotope application to research.
Mississippi Southern College-----	1. Auditory perception in humans.
Mississippi State University-----	1. Ecological nutrition.
Mount Holyoke College-----	1. Quantitative relations between human threat evaluation and action selection performances and data presentation parameters. 2. To investigate the effect of uncertainty of position and movement upon visual detection of airborne targets.
New York Eye and Ear Infirmary----	1. Study to determine relative biological effectiveness of neutrons. 2. Effects of thermal energy on retinal functions.
New York State Psychiatric Institute--	1. Amine and ammonia metabolism of damaged and normal brain tissues.
New York University-----	1. Water recovery. 2. Effects of isolation on cognitive function.
Northwestern University-----	1. Protein denaturation radiobiology. 2. Auditory efficiency. 3. Purification of erythropoietin. 4. Effects of ionizing radiation on pyrimidines.
Oklahoma State University of Agriculture and Applied Science.	1. Studies on urease.
Ohio State University-----	1. Hyperventilation mechanisms. 2. Radiobiology of roentgenography. 3. Spectral absorption. 4. Research in vision, nonuniform contracts. 5. Research investigation on voice communication in noise. 6. Efficacy of bands of electromagnetic spectrum in the production of chorioretinal burns. 7. Cerebral blood flow during acceleration. 8. Investigation of speech communication in systems performance. 9. Human factors in the design of training equipment. 10. Learning and transfer of motor skills. 11. Effects of enhancement in complex radar visual display. 12. Systems research and design methodology. 13. Simulation facility for human factors research. 14. Coronary hemodynamic response to environment.

U.S. AIR FORCE BIOASTRONAUTICS RESEARCH CONTRACTUAL PROGRAM, CONDUCTED BY NONPROFIT INSTITUTIONS OF THE UNITED STATES, JANUARY 18, 1961—Con.

<i>Name of contractor</i>	<i>Subject of contract</i>
Pasadena Foundation for Medical Research.	1. Cellular cerebral radiobiology.
Presbyterian Hospital-----	2. Nucleic acid radiation protection.
Princeton University-----	1. Closed cerebral injury.
	1. Physiological stress in relation to innate daily rhythm.
Regis College for Women-----	1. Psychological experimentation in communication systems.
St. Louis Hospital-----	1. Hematological radiobiology.
St. Louis University-----	1. Human circulatory, respiratory, and sweat response to thermal stress.
Southwest Research Institute-----	1. Algae classification.
	2. Analysis of body fluids.
	3. Radiation-induced radicals.
Stanford University-----	1. Erythrocytic oxygen transport.
	2. Neuraminic acid and central nervous system function.
	3. Molecular biology—biological investigations using magnetic resonance methods.
	4. Review of research on neurosecretions.
Temple University-----	1. Vestibular function.
Texas Agricultural & Mechanical College Research Foundation.	1. Cholesterogenic properties of fatty acids.
	2. Cataract formation.
Texas Christian University-----	1. Personality test prediction.
Texas Technological College-----	1. Methods for controlling animals' behavior in space environments.
Trinity University-----	1. Research consultation.
Tufts College-----	1. Biological effects of microwave irradiation on the eye.
Tulane University-----	1. Neurophysiological effects of microwave irradiation.
University of Buffalo-----	1. Investigation of ventilation—perfusion distribution in pulmonary gas exchange.
University of California-----	1. Metabolic profile studies—human physiological response to environmental stresses.
	2. Human thermal tolerance and thermal biotechnology.
	3. Cellular effects of chronic microwave irradiation in animals.
	4. Biological effects of air ions.
	5. Hypothermia.
	6. Cardiac bioelectronics.
	7. Irradiated animal stress.
University of California at Los Angeles.	1. Tolerance and adaptability of the brain to environment imposed by space flight.
University of Chicago-----	1. Ionizing radiobiology.
	2. Vestibular histopathology and physiopathology.
	3. Basic exploratory research investigation of the neurological correlates of information reception.
	4. Cosmic ray counter.
	5. Biophysics—application of information theory to the nervous system.

U.S. AIR FORCE BIOASTRONAUTICS RESEARCH CONTRACTUAL PROGRAM, CONDUCTED
BY NONPROFIT INSTITUTIONS OF THE UNITED STATES, JANUARY 18, 1961—Con.

<i>Name of contractor</i>	<i>Subject of contract</i>
University of Cincinnati-----	1. Generality of trouble-shooting skill. 2. Propulsion simulation techniques.
University of Colorado-----	1. Radiobiology—biological recovery rate.
University of Dayton-----	1. Human factors of aerospace flight operation. 2. Analysis and interpretation of acoustical and bionics data. 3. Collection and analysis of respiratory physiology data. 4. Data analysis services. 5. Human engineering experiments. 6. Biostatistical support of acceleration research.
University of Delaware-----	1. Human intellectual function.
University of Florida-----	1. Hypoxia. 2. Body temperature endocrinology. 3. Humidity and temperature requirements of selected fungi.
University of Georgia-----	1. Theoretical and experimental research investigation in the areas of resolution of uncertainty of visual displays.
University of Illinois-----	1. Tissue nitrogen barophysiology. 2. Molecular biology—electron microscopy of ultrasonically irradiated muscle. 3. Quantitative theory of form perception. 4. Study of organ displacement during deceleration using implanted strain gages. 5. Classification of tasks for ordering knowledge of human learning. 6. Laboratory investigation of SAGE operator performance factors contributing to operator fatigue in SAGE operation. 7. Long-range performance prediction. 8. Analysis of principles of the mammalian auditory system.
University of Iowa-----	1. Biological effect of microwave irradiation—time and depth heat gradients.
University of Kentucky-----	1. Effects of aircraft buffeting on Air Force personnel.
University of Miami-----	1. Biological effects of microwave irradiation.
University of Michigan-----	1. Aerodynamic equations for simulation. 2. Development of personality tests. 3. Investigation of quantitative relations between human threat evaluation and action selection performances and several data presentation parameters. 4. Vision-transmission of ocular media. 5. To explore the technique of information measurement and mathematical computation in order to develop practical and reliable techniques for measuring information flow.

U.S. AIR FORCE BIOASTRONAUTICS RESEARCH CONTRACTUAL PROGRAM, CONDUCTED BY NONPROFIT INSTITUTIONS OF THE UNITED STATES, JANUARY 18, 1961—Con.

<i>Name of contractor</i>	<i>Subject of contract</i>
University of Minnesota-----	1. Post mortem carbon dioxide detection. 2. Respiratory physiology. 3. Molecular biology—oxidation-reduction reactions and complex formation. 4. Neurological aspects of radiobiology.
University of North Carolina-----	1. Effects of acute and chronic increase in pulmonary dead space.
University of Oklahoma-----	1. Pulmonary physiology.
University of Oregon-----	1. Biometrics.
University of Pennsylvania-----	1. Biological effects of microwave irradiation—measurement of biologically effective dosages. 2. Psychophysiological studies of stress. 3. Control of mammalian temperature. 4. Neurohumoral control of the pituitary gland. 5. Cerebral blood flow.
University of Pittsburgh-----	1. Hematological radiobiology. 2. Biosynthetic mechanisms—flash spectroscopy and flash fluorimetry in photosynthetic studies.
University of Rochester-----	1. Comparative radiobiology studies. 2. Physiological response of animals exposed to both microwaves and X-radiation. 3. Cardiovascular function during unsteady states. 4. Research in vision—pattern discrimination.
University of South Carolina-----	1. Development of personality variables.
University of Southern California-----	1. Research in acceleration.
University of Tennessee-----	1. Human tolerance and response to stress by evaluation of sympatho-adrenal system.
University of Texas-----	1. Photosynthetic exchangers. 2. Hematopoietic radiobiology. 3. Psychophysiology of ionizing radiation. 4. Audiotrauma. 5. Stress effects on blood clotting. 6. Study of chimpanzee electrocardiograms. 7. Occupational analysis.
University of Utah-----	1. Aptitude test development.
University of Virginia-----	1. Guidance for research planning and activities.
University of Washington-----	1. Development of biothermal analog computer.
University of Wisconsin-----	1. Studies on the complex precursors of induced enzymes in yeast. 2. Renal tubular transport systems by means of stop flow analysis.
Veterinary Administration Hospital, Boston, Mass.	1. Biophysics: Neurophysiological principles of learning mechanisms.
Wake Forest College-----	1. Renal effects of the urinary diuretic factor.

U.S. AIR FORCE BIOASTRONAUTICS RESEARCH CONTRACTUAL PROGRAM, CONDUCTED BY NONPROFIT INSTITUTIONS OF THE UNITED STATES, JANUARY 18, 1961—Con.

<i>Name of contractor</i>	<i>Subject of contract</i>
Western Reserve University-----	1. Vasopressin biosynthesis.
	2. Neural paths and integration centers for pituitary hormone release.
Winifred Masterson Burke Relief Foundation.	1. Nutritional requirements of man for protein and the individual essential amino acids.
Worcester Foundation-----	1. The influence of hormones on intestinal hyperplasia.
	2. Metabolic studies of chimpanzees.
Yale University-----	1. Cosmic radiobiology.
	2. Brain electrodes for toxicological application.

APPENDIX D

Following is a list of countries and institutions receiving support from the U.S. Air Force for their research activities. In some instances a large share of support for a particular item of research is provided by the Air Force, whereas in others only a small part of the cost of a given investigation is provided. In almost all cases, the Air Force is not the sole support for a particular study but provides the amount of funding necessary to make possible an increased effort in the laboratory; most often a positive and significant gain in research capability results, and the return is markedly advanced both in terms of time and of information obtained.

Belgium:

	<i>Subject</i>
Universite Libre de, Bruxelles, Prof. Genetics.	
J. Brachet.	
University of Louvain, Louvain, Prof. Pain.	
J. Colle.	
University of Liege, Liege, Prof. M. J. Bone chemistry.	
Dallemagne.	
University of Liege, Liege, Dr. J. Neurophysiology.	
Schlag.	

Denmark: University of Copenhagen, Dr. Neurophysiology of vision.
M. A. Lennox.

England:

University College of North Stafford-	Neurophysiology.
shire, Kelle, Dr. D. M. MacKay.	
System Research, Ltd., London, Mr. A. Behavior.	
G. S. Pask.	
University College, London, Prof. J. Z. Ethology.	
Young.	
University of Cambridge:	
Dr. B. A. Cross.	Neurophysiology.
Prof. L. Weiskrantz.	Physiology of vision.
Queen Mary College, London, Prof. C. Photosynthesis.	
P. Whittingham.	
University of Oxford, Oxford, Dr. Grant Pulmonary physiology.	
de J. Lee.	
University of Reading, Dr. D. M. Ethology.	
Vowles.	
University of Oxford,	
Prof. H. Blaschko.	Catecholamines.
Prof. Sir H. A. Krebs.	Acetate metabolism.
University of Cambridge, Cambridge, Ethology.	
Prof. W. H. Thorpe.	
Agricultural Research Council, London, Catecholamine-CNS.	
Dr. M. Vogt.	
Maudsley Hospital, London, Prof. H. CNS Chemistry.	
McIlwain.	

England—Continued

Subject

- Medical College of St. Bartholomew's Drugs and CNS.
 Hospital, London, Dr. J. P. Quilliam.
 Oxford University, Oxford, Dr. N. Tinbergen. Ethology.
 University of Oxford, Dr. E. Bulbring. Smooth muscle physiology.
 University of Birmingham, Dr. P. B. Bradley. CNS drugs.
 University of Sheffield, Prof. Q. H. Gibson. Enzyme kinetics.
 Maudsley Hospital, London, Prof. G. W. Harris. Neuroendocrinology.
 Institute of Laryngology & Otology, London, Prof. F. C. Ormerod. Ear function.

France:

- Salpetriere Hospital, Paris, Dr. A. Remond. Analysis of nervous functions.
 University of Marseille, Prof. J. Pailard. Motor functions.
 Hospital Henri Rousselle, Paris, Prof. P. C. Dell. Reticular formation.
 Naturalia et Biologia N.B.B., Paris, Prof. A. E. Fessard. Learning behavior.
 Faculte de Medecine, Lyon, Dr. M. Juvet. Sleep and consciousness.
 Faculte de Medecine, Marseille, Prof. H. Gastaut. Analysis of nervous functions.
 University of Toulouse, Dr. P. Montestruc. Atrial stretch receptors.
 Council for International Organizations, Paris, Dr. J. F. Delafresnaye. Brain mechanisms and learning symposium.

Germany:

- Max-Planck Institut fur Biologie, Tübingen, Dr. B. Hassenstein. Information processing. Biological systems.
 University of the Saarlandes, Saarbruecken, Dr. O. Spreen. Psychological-physiological reactions.
 University of Goettingen, Dr. R. von Baumgarten. Neurophysiology.
 Max-Planck Institut for Brain Pathology, Munich. Hypoxia, radiation—CNS.
 Bacteriological Institute, Freising-Weiherstephan, Dr. O. Kandler. Photosynthesis.
 Max-Planck fur Zellchemie, Munich, Prof. Dr. F. Lynen. Terpene chemistry.
 W. G. Kerckhoff Institute, Bad Nauheim; Dr. O. Gauer. Atrial stretch receptors.

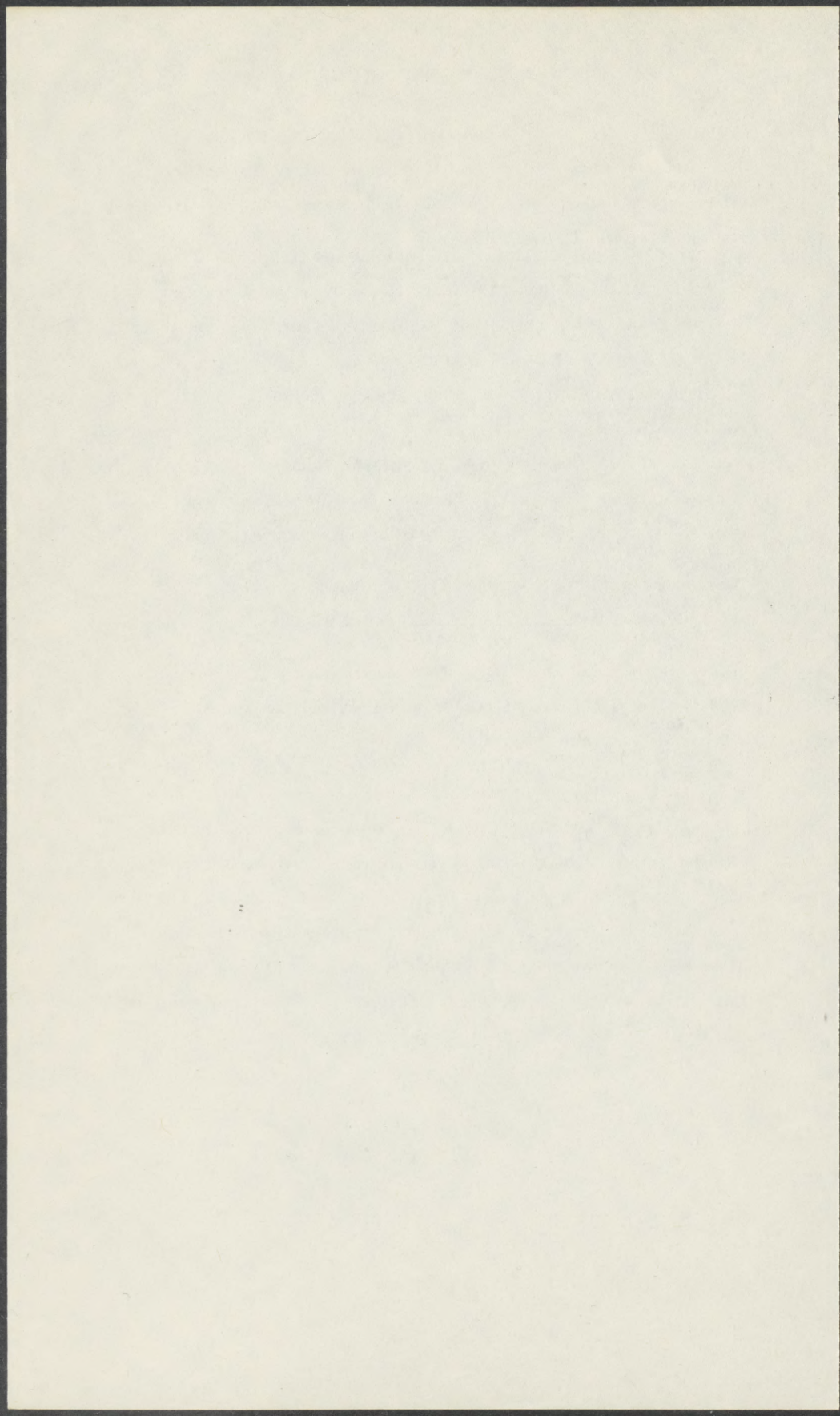
Ireland:

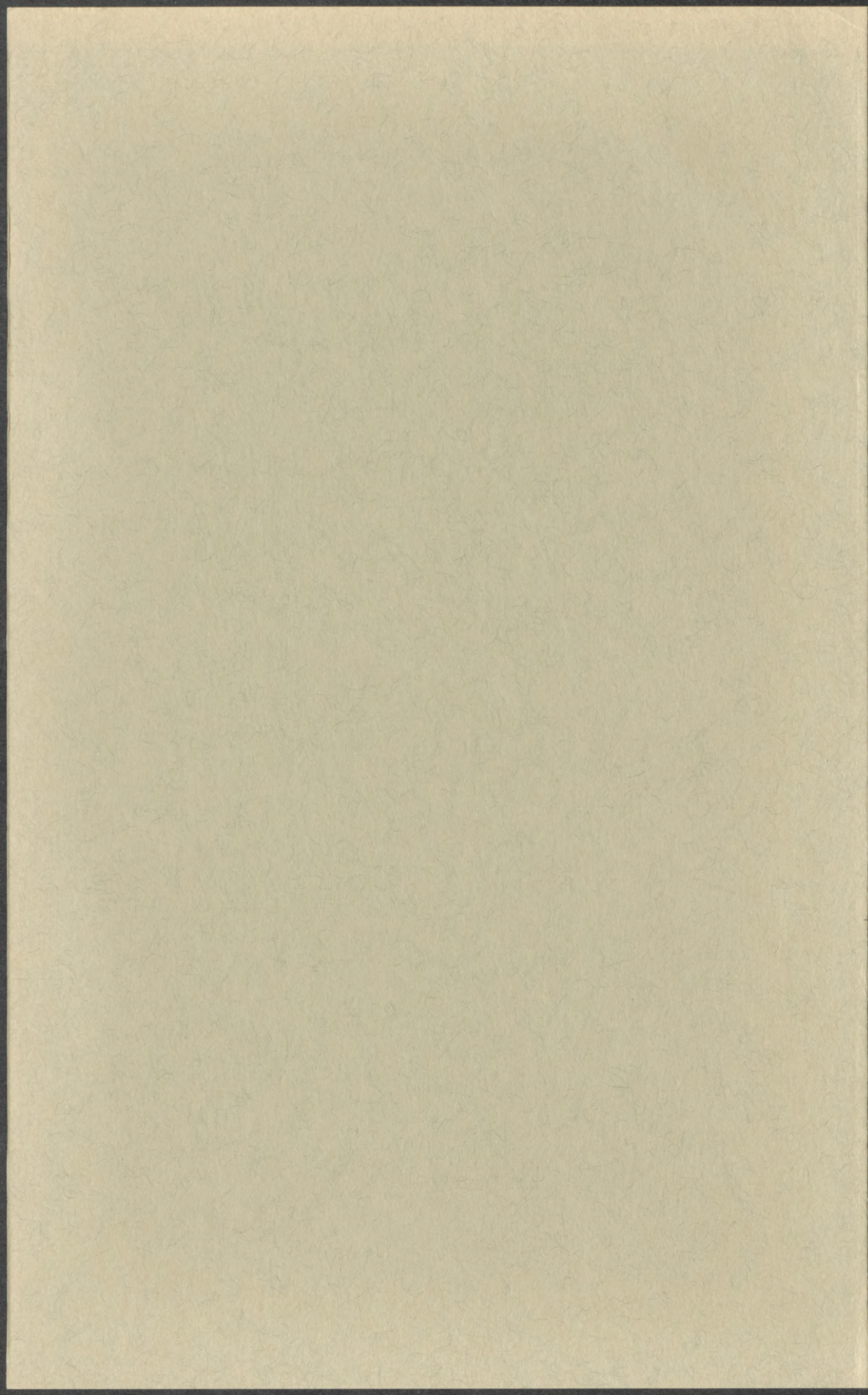
- Medical Research Laboratories, Dublin University College, Prof. E. J. Conway. Ion transport.
 University College, Galway, Eire, Prof. C. O hEocha. Photosynthesis.

Israel:

- Hebrew University, Jerusalem, Prof. S. N. Eisenstadt. Sociology of role behavior.
 Weizmann Institute of Science, Rehovoth: Photosynthesis.
 Dr. M. Avron. Polypeptide chemistry.
 Dr. E. Katchalski.
 Israel Institute of Applied Social Research, Jerusalem, Dr. U. G. Foa and Dr. Guttman. Personality and human organization.

- Italy:
- Istituto di Fisica Teorica e Nucleare, Cerebellar function.
Naples, Dr. V. Braitenberg.
- University of Siena, Siena, Prof. C. Central nervous mechanisms in cir-
Bartorelli. culation.
- University of Genoa, Genoa, Dr. G. F. Brain stem electrocortical activity.
Rossi.
- Istituto Speriore di Sanità, Rome:
- Dr. V. G. Longo----- Drugs and CNS.
- Dr. F. R. Damer----- Pharmacology—benzodioxane.
- University of Rome, Rome, Dr. G. F. Neurophysiology (behavior).
Ricci.
- University of Pisa, Pisa, Prof. G. Reticular formation (behavior).
Moruzzi.
- Istituto Nazionale di Ottica, Arcetri- Vision.
Firenze, Prof. V. Ronchi.
- The Netherlands: Laboratory of Plant Photosynthesis.
Physiological Research, Wageningen,
Prof. E. C. Wassink.
- Norway:
- Gaustad Mental Hospital, Oslo, Dr. EEG in flight.
C. W. Sem-Jacobsen.
- University of Oslo, Oslo, Dr. B. Kaada. Lobe centers function.
- Scotland:
- University of Edinburgh, Edinburgh, Vascular hormone system.
Dr. M. Pickford.
- Sweden:
- Karolinska Institute, Stockholm, Prof. Chromaffin granules.
J. Adam-Ray.
- Prof. U. S. von Euler----- Catechol amines.
- University of Stockholm, Stockholm, Dr. Ethology.
E. Fabricius.
- University of Lund, Lund, Dr. S. Thes- Muscle physiology.
leff.
- University of Goteborg, Goteborg, Dr. A. Catechol amines—CNS.
Carlsson.
- Karolinska Institute, Stockholm:
- Dr. D. Carlstrom----- Bone crystal structure.
- Dr. H. Bjurstedt----- Acceleration.
- University of Uppsala, Uppsala, Prof. Membrane polarization.
T. Teorell.
- Gustaf Werner Institute, University of Proton beam lesions in CNS.
Uppsala, Dr. B. Larsson.
- University of Goteborg, Prof. H. Hy- Intraneuronal mechanisms.
den.
- Karolinska Institute, Stockholm, Dr. U. Brain stem autonomic activities.
Soderberg.
- University of Goteborg, Goteborg, Prof. Nervous control of circulation.
B. Folkow.
- University of Stockholm, Stockholm, Psychophysical relations—percep-
Prof. G. Ekman. tion.
- Karolinska Institute, Stockholm, Prof. Biophysical studies of nerve cell.
C. G. Bernard.
- Wales: University College of Wales, Abery- Photosynthesis.
stwyth, Dr. T. W. Goodwin.







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