AUTHORIZATION OF THE STANDARD REFERENCE DATA ACT AND REVIEW OF THE NATIONAL BUREAU OF STANDARDS

HEARINGS

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

UNITED STATES SENATE

NINETY-FIFTH CONGRESS

SECOND SESSION

ON

S. 2615

TO AUTHORIZE APPROPRIATIONS TO CARRY OUT THE STANDARD REFERENCE DATA ACT

FEBRUARY 15 AND APRIL 6, 1978

Serial No. 95–72

Printed for the use of the
Committee on Commerce, Science, and Transportation

U.S. GOVERNMENT PRINTING OFFICE
24–751 O WASHINGTON : 1978

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CONTENTS

AUTHORIZATION OF THE STANDARD REFERENCE DATA ACT AND REVIEW OF THE NATIONAL BUREAU OF STANDARDS

WEDNESDAY, FEBRUARY 15, 1978

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D.C.

The subcommittee met at 9:35 a.m. in room 235, Russell Senate Office Building, Hon. Adlai E. Stevenson (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR STEVENSON

Senator STEVENSON. This morning the Subcommittee on Science, Technology, and Space begins a review of the Nation's oldest national laboratory, the National Bureau of Standards (NBS).

This is the first such congressional oversight hearing for the Bureau in memory. We haven't been able to figure out when the last one was, if ever, in the Senate.

We aim to remedy that neglect. Our objective is a strong NBS which continues to contribute to the scientific and technical capabilities of the United States.

Our witnesses this morning are all from the Bureau. Our first is Dr. Ambler, who appears for the first time before the subcommittee in his capacity as permanent Director of the Bureau. They will, all of them, appear as a panel. In addition to Dr. Ambler we have Dr. John D. Hoffman, Director of the Institute for Materials Research; Dr. John W. Lyons, Director of the Institute for Applied Technology; and Mr. M. Zane Thornton, the Acting Director of the Institute for Computer Sciences and Technology. Thank you, gentlemen, for joining us, and welcome.

Can we start with your statement first, Dr. Ambler? Let me suggest that, if it's possible, that you all summarize, if you can, and we will enter the full statements in the record.

STATEMENT OF DR. ERNEST AMBLER, DIRECTOR, NATIONAL BUREAU OF STANDARDS, DEPARTMENT OF COMMERCE; ACCOMPANIED BY DR. JOHN D. HOFFMAN, DIRECTOR, INSTITUTE FOR MATERIALS RESEARCH; DR. JOHN W. LYONS, DIRECTOR, INSTITUTE FOR APPLIED TECHNOLOGY; AND M. ZANE THORNTON, ACTING DIRECTOR, INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY

Dr. AMBLER. Thank you, Mr. Chairman.

We will summarize the written statement that we have submitted to you.

The NBS certainly appreciates the interest you are taking in the broad fields of science and technology, and I personally appreciate the opportunity to describe to you the Bureau, its programs, and its impact on national concerns.

In my testimony I have tried to respond to the six questions in your letter of invitation to this hearing.

The Bureau was created by Congress in 1901. At that time, science, technology, and commerce were undergoing rapid growth. That growth brought into sharp focus the neeed for a central reference laboratory. Congress responded to that need by enacting an Organic Act establishing a National Bureau of Standards.

The first and second questions asked about the evolving role of the NBS, its relationship to the goals of the Department of Commerce, and the adequacy of the NBS Organic Act.

We believe the Organic Act to be most adequate. It is not so much the mission of NBS that is changing as it is the way in which we are called upon to respond to it.

These changes result from developments in science and technology, and from the changing needs and demands of our clients.

The Bureau has, since shortly after its founding, functioned in two major roles. First, it has function as the national central reference laboratory and as lead agency for the provision of measurements, standards, and data. Second, it has functioned as a technology problem solver through the application of our competences.

I illustrate that in my written statement, Mr. Chairman. I won't go into detail, now.

We would like to say that the two roles are complementary. The competence required to operate a successful central reference laboratory can be drawn on to solve more specific problems. On the other hand, by working on such problems, we maintain contact with many important areas that stimulate the work of the reference laboratory.

The basic reason for central reference measurements can be traced back to ancient times. It has always been important for equity in commerce, for example, that the measuring stick by which one buys be the same as that by which one sells. Everybody has a stake in uniform and accurate measurements.

With the industrial revolution and the increasing complexity of technology used by society came the need for more complex measurements in commerce. As a consequence, at the end of the 19th century central reference laboratories in all industrialized countries were established. Moreover, international compatability was provided through a treaty.

The growth and increase in complexity of science and technology during this century has accelerated, and so have the demands not only for measurments but also for a credible base of scientific and technical information.

Today's demands manifest themselves in areas such as realizing the second, and its reciprocal quantity, frequency to such an accuracy that one can design a standard clock with an accuracy of 1 second in 300,000 years, improving the measurement of ultraviolet radiation by a factor of 5, providing better measures for the thermal resistance of insulation, appliance efficiency, building codes and standards, liquefied natural gas, and consumer information. The relationship of these activities to the Department of Commerce's role of fostering U.S. commerce is clear.

Moreover, in view of the large numbers of people and institutions affected by these questions of equity and need for credible technical information, there is a need for a central focus, and that central focus—made clear in the Organic Act—is the NBS.

To describe the evolving role of the National Bureau of Standards, let me first quote from the Organic Act:

> The Bureau is authorized to exercise its functions for the Government of the United States, and for international organizations of which the United States is a member; for governments of friendly countries; for any State or municipal government within the United States; or for any scientific society, educational institution, firm, corporation, or individual within the United States. * * *

In my written statement, I illustrate our changing service to each of these clients.

For example, in our work with other Federal agencies, our largest sponsor 10 years ago was the Defense Department. Today, our largest sponsor is the Department of Energy.

In addition to the work for other Federal agencies, Congress itself has, since 1955, made some 17 assignments to the Bureau of Standards through legislation. In an attachment to my statement are our detailed responses to these pieces of legislation.

Our interaction with State and local governments for many years involved only weights and measures. Today the NBS services to State and local governments include law enforcement standards and aid to forensic investigations, services to aid in evaluating effects of earthquakes or other natural disasters—we have, for example, some of our staff members working on the underlying causes for the collapse of the Hartford, Conn., arena. In addition, the NBS helped create the National Conference of States on Building Codes and Standards.

Our support for industry's need for reliable measurements and data continues to be very broad. In recent years we have increased our activity to help industry demonstrate compliance with regulations.

The Bureau has an outstanding international reputation. Many NBS programs contribute to —and benefit—from international cooperation. Such cooperation involves support of U.S. treaty obligations, work supporting Agency for International Development AID programs, working with scientific societies as well as standards-making bodies, and via a number of bilateral agreements.

Our interactions with scientific societies and educational institutions are vital, not only in the development of the careers of all scientists and engineers at the NBS, but also in many institutional arrangements. I give an example of such interactions in my written statement.

In order to respond better to various interests of consumers, the NBS consolidated its work in this area in an NBS Center for Consumer Product Technology in 1974. One component of that work is the brochures we issue in order to provide consumers with useful and timely information.

Your third question refers to the factors influencing the NBS's ability to carry out its mission.

The most important factors are our staff, our facilities, and our resources. We have a full-tme permanent staff, as of December 31, 1977, of 3,040. We have concentrations of expertise in physics, chemistry, mathematics, computer sciences, and engineering.

The breadth of our programs, and of our deep involvement in current national concerns, also calls for broad expertise in such areas as architecture, psychology, economics, and law.

In addition, we use various authorities to bring people to the Bureau and send people to other institutions for a limited period. Such authorities are the National Research Council/National Bureau of Standards postdoctoral research program, the industrial research associates program, guest workers, and the Intergovernmental Personnel Act.

Under these and other programs, we have presently approximately 175 people at the NBS, and approximately 75 NBS people in other institutions. I cite this to indicate that, despite a relatively constant personnel ceiling for the past 10 years, we have made every effort to keep a flow of people and new ideas into the NBS.

Our physical facilities rank with the best in the world. Our headquarters are located in Gaithersburg, Md. on a 576-acre site. About 450 of our people are located at laboratories in Boulder, Colo., and we operate radio stations in Colorado and Hawaii that broadcast time and other information.

The funding for our various programs comes to us in three separate ways. Some $70 million this year is a direct congressional appropriation. For the work that we do for other agencies, we expect to receive this year about $55 million from 102 different agencies. Finally, we provide various services to both Government agencies and the public for which we charge a fee; and this year, we expect an income of $6.4 million from this source.

As to the adequacy of these resources, let me respond by answering your question No. 6. You asked me to comment on the Bureau's fiscal year 1979 budget.

The President's budget estimates, which have been forwarded to the Congress contain for NBS a budget of over $94 million, which consists of about $5 million for adjustments to base and built-in changes, and $19 million for program expansion. If appropriated, this will represent the largest dollar increase in NBS history. In addition, I will be working with the Office of Science and Technology Policy in the coming year to determine if any additional increases are warranted for NBS programs.

Your question No. 4 deals with the proposed reorganization of NBS. These plans is that have been approved by the President's Reorganization Task Force and OMB, and by the Secretary of Commerce. We expect to be operating under this new organizational structure on April 9.

In broad terms, the new structure will have three major operating units. These units are: a National Measurement Laboratory, a National Engineering Laboratory, and an Institute of Computer Sciences and Technology. I describe each of these in some detail in my written statement, and I won't repeat it at this time, Mr. Chairman.

I also indicate in the written statement some of the advantages of this reorganization: helping us organize along the major functional lines; consolidating the competences; and providing for greater flexibility.

In discussing the response of your question No. 5 concerning the future of NBS, I would first like to commend to you our role as the Central Reference Laboratory. Perhaps this role does not have the glamour of energy, medical research, or pollution control, but in my opinion, this aspect of NBS provides a fundamental factor in the operation of today's highly technological society.

The application of our expertise to the solution of national problems is already well focused on fire technology, building technology, energy conservation. The NBS role is developing in automation and electronic technology as well.

I see the need for NBS to respond to what I expect will be an increasing national concern—namely, the catalytic role the Federal Government can play in providing for a healthy environment for technological innovation and the development and use of technology in the private sector in order to strengthen the economy.

To this end, there is in the NBS fiscal year 1979 budget, some $2 million which is intended to be used in order to investigate the desirability and feasibility of a cooperative technology program which would advance critically needed technologies common to disaggregated industries or small independent firms in selected industry groups. The emphasis here is on the word "cooperative."

Also, NBS can play a growing role in the provision of consultation and services to state and local governments. I have already described how this NBS activity has been growing and changing over the past 10 years, and I expect that trend to continue.

The NBS will be faced, more than ever before, with making choices on how to respond to our mission and clients. Recognizing this, the President's fiscal year 1979 budget contains a $850,000 increase for our central planning function.

Thus, while it is too early to state specifically how we shall organize to do long-range planning more thoroughly, organization along the major sectors of our clientele—that is, among the Federal agencies, legislation, State and local governments, science and universities, international, industry, and the general public could well be a good way for us to set up.

Let me close, Mr. Chairman, on a personal note. I have been at the NBS for 24 years, at positions ranging from bench scientist to Director. I have always been proud of NBS and its reputation for technical accomplishment and integrity. I believe that reputation is a major factor in bringing about so many new demands for our services. It is true that these assignments have presented us with challenges, but the way we have responded is, in my view, correct not only in the interests of good government, but also for maintaining the reputation of NBS as an agency responsive to national priorities.

I am optimistic about the future. The administration supports a strong and vigorous NBS, and we appreciate the support shown by the NBS Statutory Visiting Committee. I truly appreciate the active interest shown by your committee, Mr. Chairman, in the NBS. We are pleased at the prospect of continuing dialog.

Finally, the proposed reorganization of NBS will improve our ability to respond to changing needs. In summary, I see in the coming years the opportunity to strengthen a fine institution that applies resources for public benefits.

Thank you very much, Mr. Chairman.

Senator STEVENSON. Thank you, Dr. Ambler.

[The statement follows:]

STATEMENT OF ERNEST AMBLER, DIRECTOR, NATIONAL BUREAU OF STANDARDS

Mr. Chairman and members of the subcommittee: We at NBS appreciate the interest you are taking in the broad fields of science and technology, and I personally appreciate the opportunity to describe for you the Bureau, its programs, and its impact on national concerns.

I would also like to respond to the six question in your letter of invitation to this hearing. With me today are Dr. John Hoffman, Dr. John Lyons, and Mr. Zane Thornton. They will describe for you the activities that will be conducted in the newly being formed National Measurement Laboratory, and National Engineering Laboratory, and also in the Institute for Computer Sciences and Technology.

The Bureau was created by Congress in 1901. At that time, science, technology, and commerce were undergoing rapid growth. That growth brought into sharp focus the need for a central reference laboratory. Congress responded to that need by enacting an Organic Act establishing NBS. The Organic Act assigns us responsibility for:

Developing, maintaining and disseminating standards of physical measurement.

Determining materials properties and physical constants.

Developing test methods for materials, mechanisms, and structures.

Establishing standard practices in cooperation with Government agencies and the private sector.

Providing advisory services to Government Agencies.

Your first and second questions ask about the evolving role of NBS, its relationship to the goals of the U.S. Department of Commerce, and the adequacy of the NBS Organic Act.

I believe the Organic Act to be most adequate. It is not so much the mission of NBS that is changing as it is the way in which we are called upon to respond to it. These changes result from developments in science and technology and from the changing needs and demands of our clients.

NBS has, since shortly after its founding, functioned in two major roles. First it has functioned as the National Central Reference Laboratory and as lead agency for the provision of measurements, standards, and data. Second it has functioned as a technology problem solver through the application of our competences. In our measurement role, we assure that such quantities as length, mass, time, temperature, luminous intensity, force, and many others are precisely defined, accurately, realized, internationally compatible, and accessible to a broad range of users. We are also concerned with the chemical measurement of trace impurities in foods and in the environment, and with the measurement of the fracture and corrosion behavior, and the electrical, mechanical, and magnetic properties of materials. In our problem solving role, we are broadly involved in such areas as energy conservation, building technology, fire research, cryogenic technology, electronic reliability, and automation. We are also deeply involved in solving problems related to the Federal use of computers. We do this by developing and issuing standards, and by providing advisory services and technical assistance to Federal agencies. The two roles are complementary; the competence required to operate a successful central reference laboratory can be drawn on to solve more specific problems. On the other hand, by working on such problems we maintain contact with many important areas that stimulate the work of the reference laboratory.

The basic reason for central reference measurements can be traced back to ancient times. It has always been important for equity in commerce, for example, that the measuring stick by which one buys be the same as that by which one sells. Everybody has a stake in uniform and accurate measurements. With the industrial revolution and the increasing complexity of technology used by society, came the need for more complex measurements in commerce. As a consequence, at the end of the 19th century, central reference laboratories in all industrialized countries were established. Moreover, international compatability was provided for through a treaty—the treaty of the meter—to which the United States was an original adherent in 1875.

The growth and increase in complexity of science and technology during this century has accelerated and so have the demands not only for measurements, but also for a credible base of scientific and technical information. Today's demands manifest themselves in areas such as realizing the second, and its reciprocal quantity, frequency to such an accuracy that one can design a standard clock with an accuracy of 1 second in 300,000 years, improving the measurement of ultraviolet radiation by a factor of five, providing better measures for the thermal resistance of insulation, appliance efficiency, building codes and standards, liquefied natural gas, and consumer information. The relationship of these activities of the DOC role of fostering U.S. commerce is clear. Moreover, in view of the large numbers of people and institutions affected by these questions of equity and need for credible technical information, there is need for a central focus and that focus—made clear in the Organic Act—is the National Bureau of Standards.

To describe the evolving role of NBS, let me first quote from the Organic Act: "The Bureau is authorized to exercise its functions for the Government of the United States, and for international organizations of which the United States is a member; for governments of friendly countries; for any State or municipal government within the United States; or for any scientific society, educational institution, firm, corporation, or individual within the United States . . ."

Let me take each of these constituencies in turn and describe, through example, how their needs have influenced our programs.

NBS competence has been drawn upon by other Federal agencies since the Bureau was established. As the national problems addressed by these agencies changed, so has the NBS response. For example, our largest sponsor 10 years ago was DOD; today, our largest sponsor is DOE. A decade ago, NBS had no other agency sponsored work involving the need to preserve the environment; now EPA (which itself did not exist in 1967) is our fifth largest sponsor. NBS became more heavily involved in aiding other agencies in areas such as health and safety, fire protection and prevention, and housing. All of these activities increased dramatically in the 1970's, while at the same time, other agency work, such as support for the space program declined.

In addition to the work for other Federal agencies, Congress itself has, since 1965, made some 17 assignments to NBS through legislation, covering many national problems including radiation protection, materials and energy conservation, and aid to consumers. These assignments and our responses to them are detailed in an attachment to this statement.

Our interaction with State and local governments for many years involved only weights and measures. Today, NBS services to State and local governments include law enforcement standards and aid to forensic investigations, services to aid in evaluating effects of earthquakes or other natural disasters. (e.g., collapse of the Hartford, Conn., arena).

NBS helped create the National Conference of States on Building Codes and Standards, acted as Secretariat during the formative years, and now provides technical support. This group provides a national focus for the task of removing barriers to the adoption of new technology in the building field.

Our support for industries' need for reliable measurements and data continues to be very broad. In recent years we have increased our activity to help industry demonstrate compliance with regulations. For example, in the past 10 years we have developed 76 standard reference materials, such as sulphur in coal, six mixtures of carbon dioxide with other gases for auto efficiency measurements, and sulphur dioxide and nitrogen dioxide permeation tubes.

NBS has an outstanding international reputation. Many NBS programs contribute to and benefit from international cooperation. Such cooperation involves treaty obligations, AID programs, scientific societies, standards making bodies, and bilateral agreements such as the US–USSR agreement for cooperation in Science and Technology.

A good example is provided by the International Organization of Legal Metrology (OIML), a treaty organization that this country joined in 1972 following recommendations of this committee. Current activity includes international consideration of uniform methods of measuring moisture in grain.

Our interactions with scientific societies and educational institutions are vital not only in the development of the careers of all scientists and engineers at NBS but also in many institutional arrangements. For example, the NBS Office of Standard Reference Data publishes with the American Institute of Physics and the American Chemical Society, the Journal of Physical and Chemical Reference Data. This journal, the only one solely dedicated to reliable reference data, is used by scientists throughout the world. We also work with the Committee on Data for Science and Technology, which represents 12 scientific unions, to maximize worldwide use of reliable data.

In order to respond better to the various interests of consumers, NBS consolidated its work in this area in the Center for Consumer Product Technology in 1974. We have joint programs with the Consumer Product Safety Commission, the Department of Justice, the Federal Trade Commisison, and the Department of Energy, and disseminate much of our work through an NBS Series of Consumer Booklets. E.G., "Making the Most of Your Energy Dollars in Home Heating and Cooling," has been distributed to over ½ million homeowners. The booklet, which is based on thermal engineering and economic studies provides the homeowner with a simple step-by-step procedure for determining cost-effective insulation requirements for his particular home.

Your third question refers to the factors influencing the Bureau's ability to carry out its mission. Let me now discuss staff, facilities, and resources.

We have a full-time permanent staff, as of December 31, 1977, of 3,040. Of this number, 626 have Ph. D. degrees, 302 have masters degrees, and 430 hold a bachelors degree. As you would expect, we have concentrations of expertise in physics, chemistry, mathematics, computer sciences, and engineering. The breadth of our programs, and our deep involvement in current national concerns, calls for broad expertise in such areas as architecture, psychology, economics, and law.

In addition, we use various authorities to bring people to the Bureau and send people to the institutions for a limited period. Such authorities are the NRC/NBS Postdoctoral Research Program, the Industrial Research Associates Program, Guest Workers, and the Intergovernmental Personnel Act, Under these and other programs, we have presently 255 people at NBS, and 188 NBS people in other institutions. I cite this to indicate that despite a relatively constant personnel ceiling for the past 10 years, we have made every effort to keep a flow of people and new ideas into NBS.

Our physical facilities rank with the best in the world. NBS headquarters are located in Gaithersburg, Maryland. This 576 acre site contains 27 buildings, including seven general purpose laboratories, a research nuclear reactor, a fire research facility, and facilities devoted to acoustics measurements. About 450 of our people are located at laboratories in Boulder, Colorado, and we operate radio stations in Colorado and Hawaii that broadcast time and other information.

The funding for our various programs comes to us in three separate ways. The largest amount, some $70 million this year, is a direct Congressional appropriation. This money is applied to our responsibilities under the Organic Act and subsequent legislation.

The work we do for other agencies is directly related to our mission and draws on our reputation for credibility in technical matters. This year, we expect to receive about $55 million from 102 agencies for our services.

Finally, we provide various services to both Government agencies and the public for which we charge a fee. These services include calibrations and tests, advisory services and the sale of standard reference materials. From these activities, we expect an income of $6.4 million this year.

As to the adequacy of these resources, let me respond by answering your question number 6. You ask me to comment on the Bureau's FY 1979 budget. The President's budget estimates which have been forwarded to Congress contain for NBS a budget of over $94 million which consists of about $5 million for adjustments to base and built-in changes and $19 million for program expansion. If appropriated, this will represent the largest dollar increase in NBS history, I will be working with the Office of Science and Technology Policy in the coming year to determine if any additional increases are warranted for NBS programs.

Your question number four deals with the proposed reorganization of NBS. The status of our plans is that they have been approved by the President's Reorganization Task Force and OMB, and by the Secretary of Commerce. I expect to be operating under this new organization on April 9th.

One of the most notable features of the plan is that we become organized along major functional lines. I have described the dual role of the NBS as the Central Reference Laboratory and as a contributor to the solution of specific national problems.

In broad terms, the new structure will have three major operating units. These units are a National Measurement Laboratory, a National Engineering Laboratory, and an Institute of Computer Sciences & Technology, which is also presently a part of the NBS structure.

The National Measurement Laboratory will provide the national system of physical, chemical, and materials measurement. This national system permits the scientific community, industry, and commerce to make accurate, uniform measurements. The Measurement Laboratory will also coordinate our measurement system with those of other nations, paving the way for the free flow of information and goods. The NML program, to be truly effective, must be support by fundamental research in the physical sciences. Some of the elements of such a program will be:

Development of National Measurement Standards.
Development of Standard Reference Data.
Materials Research.
Compositional Analysis.
Development of Standard Reference Materials.
Calibration Services Related to National Standards.

The National Engineering Laboratory will conduct a broad spectrum of programs in engineering and applied science. Each program will provide public benefits by supporting the technology needed to solve significant national problems. The work includes engineering measurements data, standards, codes, and practices. Research findings will be converted into forms suitable for the ultimate user, and institutional mechanisms for transferring results are developed when necessary. These programs must be supported by strong research in applied science. Some of the major programs and competences within the National Engineering Laboratory will be:

Building Technology.
Consumer Product Technology.
Fire Research.
Automation and Electronics Technology.
Experimental Technology Incentives Program.
Applied Mathematics.
Mechanical Engineering.

We have a third major group, the Institute for Computer Sciences and Technology, whose functions are defined by the Brooks Act. The Institute carries out its mission by managing the Federal Information Processing Standards Program, developing Federal ADP standards and Guidelines, and participating in ADP voluntary standardization activities. It also provides advisory services and assistance to Federal Agencies, and provides the technical foundation for computer-related policies of the Federal Government. Since the Federal investment in computers runs into billions of dollars, the potential impact of these programs is clear.

The detailed structure of the two laboratories is such that it greatly consolidates like competences and provides an excellent basis for building in the future. Dr. Hoffman and Dr. Lyons are prepared to discuss this further. A more detailed description of the new organizational structure is attached to this statement.

In addition, the new organization will provide for greater flexibility. For example, there are currently 249 formal organizational units at NBS. This number will be reduced to about 106 in the new plan. Our intent is to push detailed technical management as far down into the organization as possible, and to pull administrative support as high as we can. Reducing the number of units increases flexibility, as people will be able to change assignments without need for formal transfer and the paperwork that is usually involved.

In discussing the response to your question number five concerning the future of NBS, I would first like to commend to you our role as the Central Reference Laboratory. Perhaps this role does not have the glamor of energy, medical research or pollution control; but, in my opinion, it is a fundamental factor in the operation of today's highly technological society.

The application of our expertise to the solution of national problems is already well focused on Fire Technology, Building Technology, Energy Conservation and is developing in automation and electronic technology. I see the need for NBS to respond to what I expect will be an increasing national concern, namely the catalytic role the Federal Government can play in providing for a healthy environment for technological innovation and the development and use of technology in the private sector in order to strengthen the economy. To this end there is in the NBS fiscal year 1979 budget request $2 million in order to investigate the desirability and feasibility of a cooperative technology program which would advance critically needed technologies common to disaggregated industries or small independent firms in selected industry groups. The emphasis here is on the word cooperative.

Also NBS can play a growing role in the provision of consultation and services to State and local Governments. I have already described how this has been growing over the past 10 years, and I expect that trend to continue.

The NBS will be faced more than ever before with making choices on how to respond to our mission and clients. Recognizing this, the President's fiscal year 1979 budget contains a $850K increase for a central planning function. While I think NBS has used its resources well to respond to the many demands placed upon us, the intensity is now high across all of our clientele. Thus, while it is too early to state specifically how we shall organize to do long range planning more thoroughly, organization along the major sectors of our clientele; i.e., other Federal Agencies, legislation, State and local Governments, science and universities, international, industry and the general public, could well be a good way for us to set up.

Let me close, Mr. Chairman, on a personal note. I have been at NBS for 24 years, in positions ranging from bench scientist to Director. I have always been proud of NBS and its reputation for technical accomplishment and integrity. I believe that reputation is a major factor in bringing so many new demands for our services. It is true that these assignments have presented us with challenges. But the way we have responded is in my view correct not only in the interests of good government but also for maintaining the reputation of NBS as an agency responsive to National priorities.

I am very optimistic for the future. The Administration supports a strong and vigorous NBS and we appreciate the support shown by the NBS Statutory Visiting Committee. I appreciate the active interest shown by this Committee in NBS, and we are pleased by the prospect of a continuing dialog. Finally, the proposed reorganization of NBS will improve our ability to respond to changing needs. In sum, I see in the coming years the opportunity to strengthen a fine institution to continue and to apply its resources for public benefit.

Thank you, Mr. Chairman, and I will be pleased to answer your questions.

APPENDIX

The Funding Information Shown represents direct budget authority and reimbursable obligations for Fiscal Year 1977

1. BROOKS ACT - 1965 (40 USC 759 (f))

Provisions: "The Secretary of Commerce is authorized (1) to provide agencies, and the Administrator of General Services ...with scientific and technological advisory services relating to automatic data processing and related systems, and (2) to make appropriate recommendations to the President relating to the establishment of uniform Federal automatic data processing standards. The Secretary of Commerce is authorized to undertake the necessary research in the sciences and technologies of automatic data processing computer and related systems...."

Funding:	Direct	$4,055,000
	Reimbursable	1,089,000
		$5,144,000

2. FAIR PACKAGING AND LABELING ACT - 1965 (15 USC 1454 (d))

Provisions: "Whenever the Secretary of Commerce determines that there is undue proliferation of the weights, measures, or quantities in consumer commodity packaging .... and such undue proliferation impairs ability of consumers to make value comparisons, he shall request manufacturers, ... to participate in development of voluntary product standards ...."

Funding: Direct appropriations. - $61,000

NBS output: (1) Assisted in development of voluntary product standards in 50 categories, e.g., toothpaste

(2) Developed model laws for state and local government, e.g., model state unit pricing regulation

3. STANDARD REFERENCE DATA ACT - 1968 (15 USC 290)

Provisions: The Secretary (of Commerce) is authorized and directed to provide or arrange for the collection, compilation, critical evaluation, publication, and dissemination of standard reference data."

- o Authorized Secretary of Commerce to obtain copyright of standard reference data for United States.

Funding: Authorizing appropriations for three fiscal years, NBS authorization renewed through fiscal year 1978 (P.L. 94-49).

Direct	$2,922,000
Reimbursable	322,000
Total	$3,244,000

NBS output: J. Physical Chemistry Reference Data of 2,000 pages covering 20-30 subjects annually

4. RADIATION CONTROL FOR HEALTH AND SAFETY ACT - 1968 (42 USC 263b et seq.)

Provisions: Section 263d - "(a) The Secretary of (HEW) shall establish and carry out an electronic product radiation control program designed to protect the public health and safety from electronic product radiation. As a part of such programs he shall .... (6) consult and maintain liaison with the Secretary of Commerce, the Secretary of Defense, the Secretary of Labor, the Atomic Energy Commission, and other appropriate Federal departments and agencies on (A) techniques, equipment, and programs for testing and evaluating electronic product radiation, and (B) the development of performance standards pursuant to section 263 of of the Act to control such radiation emissions."

Funding:

Direct	$932,000
Reimbursable	268,000
	$1,200,000

NBS outputs: Voluntary standards which supplement or substitute for regulations are developed with NBS leadership and coordination, e.g., measurement assurance program for laser power and for radiation therapy devices using cobalt-60

5. FEDERAL COAL MINE HEALTH AND SAFETY ACT - 1969 (30 USC 804, 812)

This act directed the Director of the National Bureau of Standards or his designate to serve on the Advisory Committee of Coal Mine Safety and a companion Interim Compliance Panel. An NBS delegate served on these bodies from January 16, 1970 to April 17, 1976, at which time they were dissolved.

6. CONSUMER PRODUCT SAFETY ACT - 1972 (15 USC 2051)

Provisions: Consumer Product Safety Commission shall, ... , utilize the resources and facilities of the National Bureau of Standards, ... , to perform research and analyses related to risks of injury associated with consumer products ... to develop test methods, conduct studies and investigations, and to provide technical advice and assistance .... "

Funding: Reimbursable $1,405,000

NBS output:
(1) Flammability test methods for carpets, children's sleepwear and mattresses,
(2) Technical backup for standards on toys, bicycles, lawnmowers, etc.,
(3) Analysis of possible product defects, e.g., protective headgear

7. NOISE CONTROL ACT - 1972 (42 USC 4901)

Provisions: EPA is authorized to: .... develop .... improved methods and standards for measurement and monitoring of noise, in cooperation with the National Bureau of Standards ...."

Funding:

Direct	$882,000
Reimbursable	722,000
Total	$1,604,000

8. SOLAR HEATING AND COOLING DEMONSTRATION ACT - 1974 (42 USC 5501)

Provisions: The Secretary (of HUD), utilizing the services of the Director of the National Bureau of Standards, and in consultation with the Administrator and Director shall determine, prescribe and publish (A) interim performance criteria for combined solar heating and cooling components and systems to be used in residential dwellings, (B) interim performance criteria for such dwellings themselves ...."

o Authorized Director of the National Bureau of Standards to provide development and demonstration of technology for solar heating

Funding:

Reimbursable $2,575,000

NBS output: (1) Interim performance criteria for solar heating and hot water systems were developed,
(2) Draft standards for solar collectors and storage devices issued
(3) Technical work on heating and hot water systems completed

9. NATIONAL FIRE PREVENTION AND CONTROL ACT - 1974 (15 USC 2201)

Provisions: Secretary is authorized to conduct .... a fire research program, including:

(1) basic and applied fire research

(A) physics and chemistry of combustion processes
(B) dynamics of flame ignition, flame spread, flame extinguishment
(C) composition of combustion products
(D) early stages of fires in buildings and other structures
(E) behavior of fires involving all types of buildings, structures, contents
(F) biological, physiological, and psychological factors affecting humans in this area."

Funding: NFPCA Budget	$4,578,000
Reimbursable	$2,129,000
Total	$6,707,000

NBS outputs: Test home smoke detector design, evaluate fire resistance, toxicity of combustion products, produce standards under Flammable Fabrics Act

10. FEDERAL NONNUCLEAR ENERGY RESEARCH AND DEVELOPMENT ACT - 1974 (42 USC 5901)

Provisions: "The National Bureau of Standards shall give particular attention to the evaluation of all promising energy-related inventions, particularly those submitted by individual inventors and small companies for the purpose of obtaining direct grants from the Administrator. The National Bureau of Standards is authorized to promulgate regulations in the furtherance of this section."

Funding: Reimbursable $1,440,000

NBS outputs: Over 6,000 recommendations to DOE of which 53 inventions suggested for further funding (8 projects funded by DOE)

11. PRIVACY ACT - 1974 (5 USC 552a)

Provisions: "Commission shall (1) make a study of the data banks, automated data processing programs, and information systems of governmental, ... to determine the standards and procedures in force for protection of personal information ....

(C) examine standards and criteria governing programs, policies, and practices relating to the collection, soliciting, processing, use, access, integration, dissemination, and transmission of personal information."

- o Include provisions for the development of standards for safeguarding computer security.

(OMB directed NBS to provide technical guidance for Privacy Act.)

Funding: Included with Brooks Act

12. FY 1976 APPROPRIATIONS ACT (P.L. 94-121) (Corrosion Study)

Provisions: Senate Report #94-328 is direct in calling for NBS to initiate a study on the economic effects of corrosion.

Funding: Direct $369,000

NBS output: In 1975, corrosion cost U.S. $50-$90B. Over a period of time about $10B of this could be reduced through economically optimal application of corrosion control technology

13. ENERGY POLICY AND CONSERVATION ACT - 1975 (42 USC 6293 and 6363)

Provisions: The Administrator (of FEA) shall direct NBS to develop test procedures for determination of estimated annual operating costs of covered products (household appliances) and at least one other useful measure of energy consumption ...."

As soon as practicable after date of enactment of Act, the National Bureau of Standards shall develop test procedures for the determination of substantial equivalency of re-refined or otherwise processed used oil and new oil or additives with new oil for a particular end use."

Funding: Direct $1,519,000
Reimbursable $2,070,000
$3,589,000

NBS output: (1) Evaluation of used oil for use as fuel completed; results being compiled for FTC
(2) 12 categories of home appliances evaluated for operating costs and energy consumption
(3) Developing computer software for calculating energy use in buildings

No authorization or appropriation has been made in response to the Act at this time

14. METRIC CONVERSION ACT - 1975 (15 USC 205a)

Provisions: "Consultation by the Secretary of Commerce with the National Conference of Weights and Measures in order to assure that State and local weights and measures officials are appropriately involved in metric conversion and assisted in their efforts to bring about timely amendments to laws .... Financial and administrative services, ... needed by the Board, may be obtained by the Board from the Secretary of Commerce ...."

Funding: Direct $65,000

NBS output: Awaiting direction and coordination of U.S. Metric Board. OWM gathering information in anticipation of NBS responsibilities being assigned

15. ENERGY CONSERVATION AND PRODUCTION ACT - 1976 (42 USC 6833)

Provisions: The Secretary (HUD) after consultation with the Secretary of Commerce utilizing the services of the Director of NBS .... shall develop and publish in the Federal Reigster .... (energy conservation) performance standards for new commercial (and) residential buildings.

The Administrator (of FEA) shall direct NBS to develop an energy efficiency improvement target (for major houlsehold appliances).

Funding: Reimbursable $209,000
(Funding for appliance provision is included under P.L. 94-163)

NBS output: (1) Produced basis for first building energy standard
(2) Criteria for issuing energy saving materials to retrofit buildings
(3) Life cycle energy consumption detetermined for home appliances
(4) Assisting other agencies on safety and performance tests for building insulation

16. RESOURCE CONSERVATION AND RECOVERY ACT - 1976 (42 USC 6952)

Provisions: The Secretary of Commerce, acting through the National Bureau of Standards, ... shall .... not later than two years after .... enactment of this Act, publish guidelines for the development of specifications for the classification of materials recovered from waste which were destined for disposal."

Funding: Direct $41,000

NBS output: Developed detailed plan to carry out provisions of Act. The Administration has decided that the program will be funded with EPA appropriations. No funds received from EPA to date.

17. EARTHQUAKE HAZARDS REDUCTION ACT - 1977 (42 USC 7704)

Provisions: "The President shall establish and maintain, in accordance with provisions and policy of this Act, a coordinated earthquake hazards reduction program .... "

"(d) PARTICIPATION - In assigning the role and responsibility of Federal departments, agencies, and entities under subsection (b) (3) (B), the President shall, where appropriate, include Department of Defense, Department of Housing and Urban Development, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, National Bureau of Standards, Energy Research and Development Administration, Nuclear Regulatory Commission, and National Fire Prevention and Control Administration."

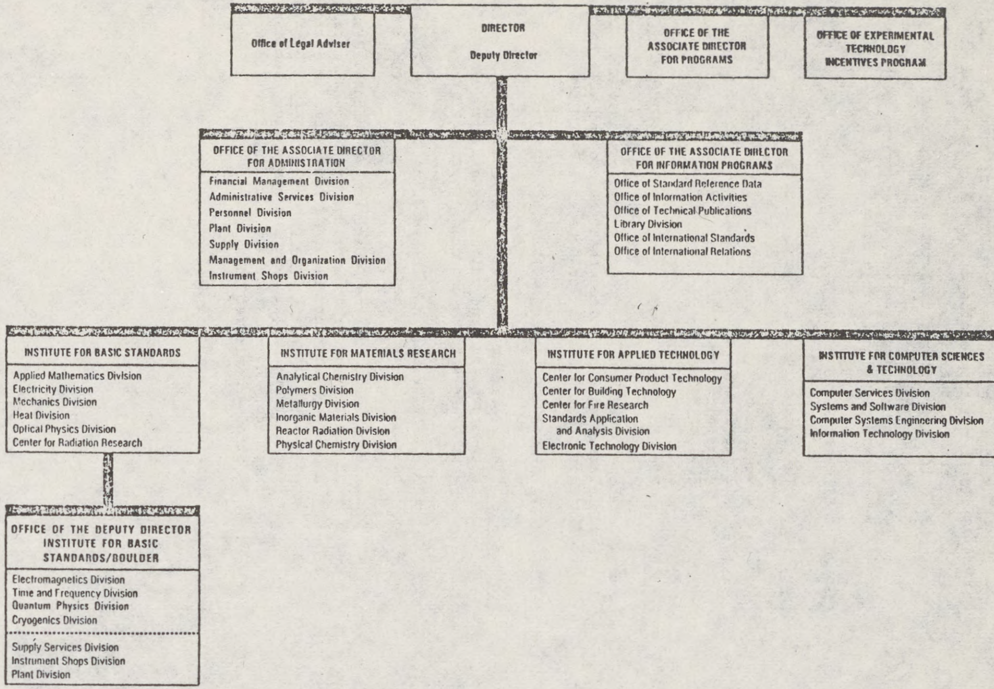
NBS output: Assisting in developing implementation plan

Attachment to DOO 30-2B
February 25, 1977

PRESENT ORGANIZATION

U.S. DEPARTMENT OF COMMERCE

National Bureau of Standards

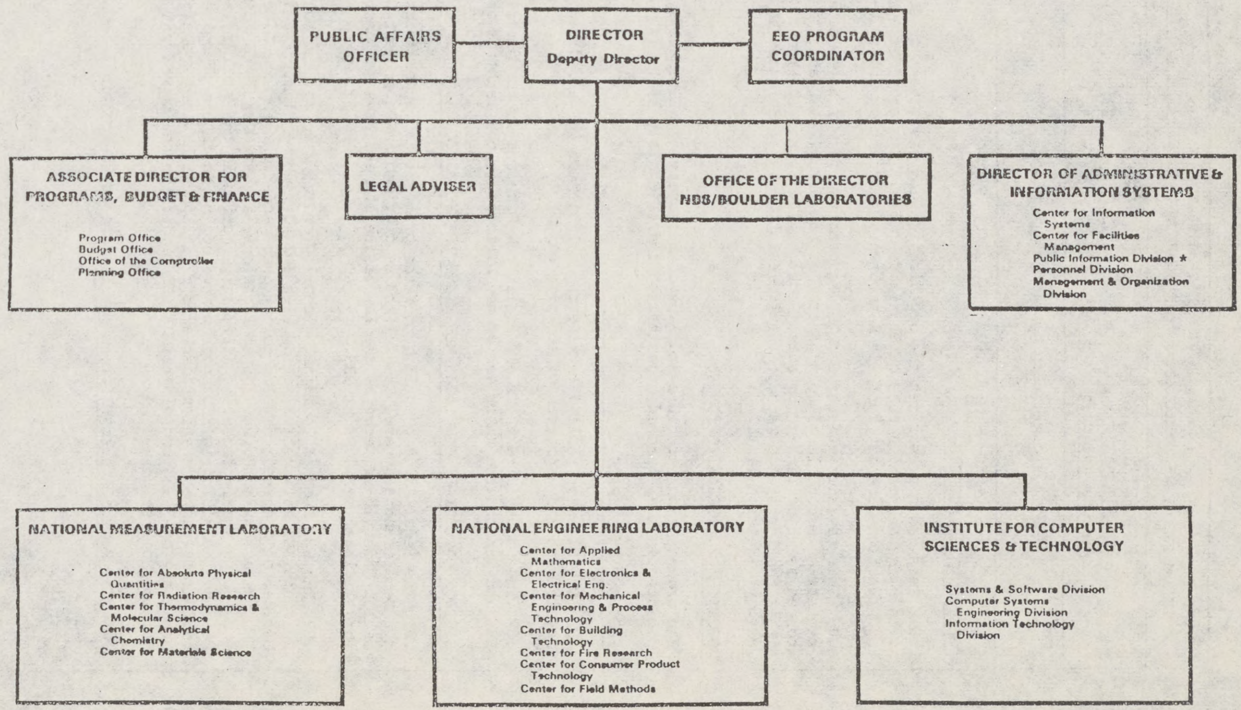


AMENDMENT 1

NEW ORGANIZATION

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS



TRANSMITTAL ____________

United States of America DEPARTMENT OF COMMERCE	DEPARTMENT ORGANIZATION ORDER 30-2B	
DEPARTMENT ORGANIZATION ORDER SERIES	DATE OF ISSUANCE PROPOSED NEW NBS ORGANIZATION	EFFECTIVE DATE

SUBJECT

NATIONAL BUREAU OF STANDARDS

SECTION 1. PURPOSE.

.01 This order prescribes the organization and assignment of functions within the National Bureau of Standards (NBS). The scope of authority and functions are set forth in Department Organization Order 30-2A.

.02 This revision effects a major reorganization which (1) establishes centers as second level components (Section 6.), (2) establishes laboratories as major line components (Sections 7., 8. and 10.), and (3) abolishes the Institutes (except Institute for Computer Sciences and Technology) (Section 11.).

SECTION 2. ORGANIZATION.

The organization structure and line of authority of NBS shall be as depicted in the attached organization chart (Exhibit 1).

SECTION 3. OFFICE OF THE DIRECTOR.

.01 The Director shall determine the policies of NBS and direct the development and execution of its programs.

.02 The Deputy Director shall assist the Director in the direction of NBS and perform the functions of the Director in the latter's absence.

SECTION 4. STAFF FUNCTIONS REPORTING TO THE DIRECTOR.

.01 The Legal Adviser shall, under the professional supervision of the Department's General Counsel and as provided in Department Organization Order 10-6, serve as the law office of, and have responsibility for all legal services at NBS.

.02 The EEO Program Coordinator shall prepare, develop, and monitor the Bureau's EEO Affirmative Action Plan and advise the Director and Personnel Officer of progress; develop policy recommendations for the Director on EEO issues having Bureauwide applications; assist MOU/EEO Coordinators in developing and implementing affirmative action in their MOU's; assist the Personnel Division in EEO program development to insure adequate minority and female representation; serve as a liaison with women and minority organizations; and coordinate NBS/EEO reports to the Department and Civil Service Commission.

.03 The Public Affairs Officer shall serve as the public information spokesman for the National Bureau of Standards, report to the Director of NBS, and work with the NBS Executive Board in developing communications strategies for the Bureau and use the information resources of the Public Information Division in implementing those strategies.

SECTION 5. ASSOCIATE DIRECTOR FOR PROGRAMS, BUDGET, AND FINANCE.

The Associate Director for Programs, Budget, and Finance shall plan, develop, and evaluate Bureau-level programs and formulate and carry out policies and strategies for programmatic, budgetary, and financial matters; develop techniques for and coordinate the review of technical and overhead programs; serve as the Director's staff for Bureau-level programmatic, budget formulation and execution, and finance matters; develop and maintain mechanisms to monitor planned and actual use of resources by providing integrated, evaluated information on program progress, opportunities, and resources to the NBS Director; advise management on significant changes and deviations; recommend program, budget, finance, and accounting priorities to the NBS Director; serve as the focal point of intelligence and feedback for Bureau-level programmatic issues; coordinate the formulation of the NBS budget and other Bureau-wide information packages and critique documents developed by line units; administer the NBS systems of accounting, financial management, travel, and payments; analyze resource and program proposals and investment levels; recommend distributions of the Working Capital Fund and Director's Reserve of funds, positions, and equipment to the NBS Director; and, through the comptroller, who shall report directly to the NBS Director on these matters, provide certification of official accounting records and reports and the control of funds.

a. The Program Office shall perform the functions of policy development, program analysis, and program development; sponsor, coordinate, and participate in issue studies and Bureau-wide information packages; develop analytical techniques for and coordinate the review of Bureau technical and overhead programs; generate strategies, guidelines, and formats for Bureau planning; articulate and document Bureal-level program plans and status for internal and external use; define alternatives for resource allocation and advise Bureau management on their implications.

b. The Budget Office shall provide advice and assistance to line management in the preparation, review, justification, presentation, and execution of the Bureau's budget, including financial management and resource allocation monitoring on the Bureau's total resources; interpret regulations and develop budgetary policy and procedures for the budget process; provide assistance in integrating program planning with the budgetary process using as a principal vehicle the Program and Financial Plan; maintain external liaison on budgetary matters; assist in the solution of budget and financing problems; design procedures for the resource monitoring system and review the execution of these procedures; perform analyses and continuing reviews of status of funds in relation to fiscal plans; advise on appropriate use of resources; and review other agency orders for conformance to policy and regulations.

c. The Office of the Comptroller shall manage a comprehensive accounting and finance program for the Bureau; administer the NBS system of accounting, payments, billings and collections, and financial reports; execute agreements for obtaining other agency funds; analyze and develop improved financial policies and practices; monitor the fiscal health of the NBS Working Capital Fund; monitor the overall fund controls and certify the official NBS accounting records and reports.

d. The Planning Office shall perform long-range program planning functions; maintain user liaison mechanisms; analyze external trends, opportunities, and user needs as they relate to program priorities; and provide economic benefit analyses.

SECTION 6. DIRECTOR OF ADMINISTRATIVE AND INFORMATION SYSTEMS.

The Director of Administrative and Information Systems shall direct the management of Bureau-wide facilities and information and administrative systems including information and office services, procurement, technical and public information functions, Bureau-wide computing, personnel, and management consulting services, health, safety, and security functions, and physical plant, facilities, space management and instruments shops functions; shall decide on policies and plans and direct implementation actions to assure the responsiveness of these services to the needs of the technical programs.

a. The Public Information Division shall serve as the focal point of Bureau communications with the public through interaction with the print and broadcast media, and by means of conferences, tours, and exhibits; advise on the public affairs impact and ramifications of program decisions; coordinate handling and dissemination of information for the public; and report administratively to the Director of Administrative and Information Systems, while operating as needed under the programmatic guidance of the Director, NBS.

b. The Personnel Division shall advise on personnel policy and utilization; administer recruitment, placement, classification, employee development, employee relations, labor relations and special programs activities; advise and assist operating officials and employees on these and other aspects of personnel management; and process employee security clearances.

c. The Management and Organization Division shall provide consultative services to line management in organization, procedures, and management practices; maintain the directives system; and perform reports management and committee management functions.

d. The Center for Information Systems shall provide computing and information processing services including operation of the central computing facility; design and maintain the automated administrative information systems; manage the publications program of NBS; provide library services; manage a network of administrative service centers and word processing centers for all Administrative and Information Systems Centers, and other organizational units in the Bureau as requested; manage support services for small purchase procurements, grants administration, and contract liaison with the Department of Commerce; manage office support services including visual arts, duplication, and forms and records management; provide consultative and advisory services on computer networking and related telecommunications requirements; coordinate the overall management and utilization of computing resources within the Bureau and provide liaison with the Department's Office of ADP Management; and establish mechanisms to assure compliance with applicable Federal ADP Standards.

e. The Center for Facilities Management shall manage and maintain NBS physical facilities including design and maintenance of the physical plant, roads, and utilities; provide for physical security, emergency planning, fire protection, and janitorial services; conduct the Bureau's energy conservation program; provide technical support services for NBS programs in the area of instruments design and fabrication; provide mail, messenger, communications, traffic and transportation services; furnish storeroom, property management, and warehousing services; provide logistical support for the Standard Reference Materials program; and manage the NBS occupational health and safety program.

SECTION 7. NATIONAL MEASUREMENT LABORATORY.

The National Measurement Laboratory shall provide the national system of physical and chemical and materials measurement; coordinate the system with measurement systems of other nations and furnish essential services leading to accurate and uniform physical and chemical measurement throughout the Nation's scientific community, industry, and commerce; shall conduct materials research leading to improved methods of measurement, standards, and data on the properties of materials needed by industry, commerce, educational institutions, and Government; provide advisory and research services to other Government agencies; develop, produce, and distribute Standard Reference Materials; provide calibration services; and collaborate with the National Engineering Laboratory in carrying out its responsibilities.

a. The Center for Absolute Physical Quantities shall develop and maintain the scientific competences and laboratory facilities necessary to preserve and continue to refine the base physical quantities upon which the Nation's measurement system is constructed; perform research, both experimental and theoretical, at the frontiers of physics in order to improve our measurement capability and our quantitative understanding of basic physical processes that underlie measurement science; improve, maintain and transfer the measurement base for time, frequency, electricity, temperature, mass and length; coordinate the National base standards with the Bureau International des Poids et Mèsures and national laboratories; measure at the highest level of accuracy the fundamental constants of nature; work closely with other centers of NBS in the interdisciplinary development of measurement science; and maintain scientific exchange programs with other measurement laboratories, including a continuing cooperative program with the University of Colorado.

b. The Center for Radiation Research shall develop and maintain the scientific competences and experimental facilities necessary to provide the Nation with a central basis for uniform physical measurements, measurement methodology, and measurement services in the areas of optical radiation, ultra-violet radiation, and ionizing radiation (x-ray, gamma rays, electrons, neutrons, radioactivity, etc.); provide government, industry, and the private sector with essential calibrations for field radiation measurements needed in such applied areas as nuclear power, health care, radiation processing, advanced laser development, and radiation protection for public safety; carry out research in order to develop improved radiation standards, new radiation measurement technology, and improved understanding of atomic and nuclear radiation processes; collect, compile, critically evaluate, and supplement the existing atomic and nuclear data base in order to meet the major demands of the Nation for such data; and participate in collaborative efforts with other Centers in the interdisciplinary applications of radiation.

c. The Center for Analytical Chemistry shall carry out basic and applied research in analytical chemistry; develop and improve methods for the separation, analysis, and characterization of materials, including Standard Referennce Materials; conduct fundamental investigations of the phenomena on which measurement of the composition and behavior of chemical systems is based; use these measurement methods to improve the accuracy of composition measurement and thereby the comparability among laboratories throughout the United States as well as ensuring measurement compatibility with other nations; use these techniques to assist in the solution of problems of national impact, e.g., in improving the accuracy of clinical analytical chemistry, air and water pollution analysis, and in providing advisory services in analytical chemistry to government agencies, scientific organizations, and industry; and participate in collaborative efforts with other Centers in the interdisciplinary applications of analytical chemistry.

d. The Center for Thermodynamics and Molecular Science shall develop and maintain the scientific competences and experimental facilities necessary to provide the Nation with uniform measurements, measurement methodologies, and measurement services in the areas of thermodynamics and transport properties, chemical kinetics, surface science, and molecular spectroscopy; provide government, industry and the scientific community with essential standards and certified Standard Reference Materials needed to maintain the integrity of the measurement system; develop standards and techniques of measurement, conduct theoretical and experimental research, and provide consultative services in the fields of thermodynamics, kinetics, surface science, and molecular spectroscopy; measure, compile, critically evaluate, and disseminate thermodynamic spectroscopic data, chemical kinetic data, and data on photochemistry to the industrial, governmental, and technological communities nationally and internationally; and participate in collaborative efforts with other Centers in disciplinary developments involving thermodynamics, kinetics, surface science, and molecular spectroscopy.

e. The Center for Materials Science shall characterize and conduct research on the structure of materials, key chemical reactions, and key physical and chemical properties which will lead to the safest, most efficient uses of materials, improve materials technologies, and encourage recycling; provide standards, measurement methods, data, concepts, and information concerning the properties and performance of metals, polymers, and inorganic materials, and disseminate this information to industry, Government, universities, and consumers; maintain and develop research reactor activities which provide precise information about these materials.

SECTION 8. NATIONAL ENGINEERING LABORATORY.

The National Engineering Laboratory shall provide technology and technical services to users in the public and private sectors to address National needs and to solve National problems in the public interest; conduct research in engineering and applied science in support of objectives in these efforts; build and maintain competence in the necessary disciplines required to carry out this research and technical service; develop engineering data and measurement capabilities; provide engineering measurement traceability services; develop test methods and propose engineering standards and code changes; develop and propose new engineering practices; develop and improve mechanisms to transfer results of its research to the ultimate user; and collaborate with the National Measurement Laboratory in conducting the National Engineering Laboratory's assigned responsibilities.

a. The Center for Applied Mathematics shall conduct research, collaborate with and provide support to all Bureau activities and to other Federal agencies in selected fields of the mathematical and computer sciences important in science and engineering; undertake specialized computational support and services for high technology science and engineering programs; develop tools for mathematical work such as mathematical models, statistical models and computational methods, mathematical tables, handbooks, and manuals, and advise on their use; and provide training in disciplines related to these functions.

b. The Center for Electronics and Electrical Engineering shall provide a focus in NBS for research, development, and applications in the field of electronic and electrical materials and engineering; maintain and develop competences in measurements and analytic methods, in fabrication processes, in performance evaluation, and in practical applications appropriate to a wide range of electrical and electronic materials, devices, instruments, and systems; identify technological barriers to the effective application of electrical and electronic technologies for the achievement of National goals; conduct responsive applied research to yield the requisite practical data, measurement methods, theory, standards, technology, and technical services; and provide national reference standards and engineering measurement traceability and deliver the results for the benefit of the Government, industry, the scientific community, and the consumer, either directly or through effective intermediarie

c. The Center for Mechanical Engineering and Process Technology shall provide, within the National Engineering Laboratory, competence in mechanics, mechanical engineering, materials engineering, industrial engineering, mechanical engineering metrology, and automatic control technology; manage these comp tences to provide technology, standards, and measurement traceability services to strengthen the manufacturing industries, public utilities, and Government agencies for the purposes of increased productivity, improved international competitiveness, and efficiency in regulatory compliance.

d. The Center for Building Technology shall perform analytical, laboratory and field research involving architecture, engineering, and physical and social sciences to produce performance criteria and methods of evaluation, and tests and measurements for codes and standards; serve building owners, occupants, designers, manufacturers, builders, regulatory authorities of State and local governments and Federal agencies with building programs; provide for demonstration, implementation and evaluation of improved building practices by means of cooperative programs with other research organizations, professiona societies, standards-writing organizations, State and local governments and oth Federal agencies; apply these methods and disciplines for the purposes of improving safety in building contruction and use, energy conservation in buildings, establishment of sound technical bases for the solar heating and cooling of buildings, more useful and economical new buildings, and effective use of existing buildings.

e. The Center for Fire Research shall perform and support research in all aspects of fire with the aim of providing scientific and technical knowledge applicable to the prevention and control of fires, including: (1) basic and applied research for the purpose of arriving at an understanding of the fundamental processes underlying fires, including the physics and chemistry of combustion processes and products, early stages of fires and structural influences in fire behavior, fire-safe design concepts for buildings, and specific fire hazards, (2) research into the biological, physiological and psychological factors affecting human victims of fire, and the performance of individual members of fire services, including the psychological factors leadin to arson and the prediction and cure of such behavior, and (3) operation tests, demonstration projects and fire investigations in support of such activities. The Center shall coordinate all activities carried out in NBS on behalf of the National Fire Prevention and Control Administration.

f. The Center for Consumer Product Technology shall perform research and development toward establishing and advancing measurement techniques and test methodology to evaluate the safety, energy efficiency, and other performance characteristics of consumer products and law enforcement equipment; apply the disciplines of mechanical and electrical engineering, consumer and behavioral sciences, economics, and operations research to programs involving consumer product technology and product-user interactions; develop the technical and analytical bases for performance standards and characterizing product attribute provide technical assistance, analyses, and evaluations related to consumer product technology to other agencies of Government; and produce descriptive literature and information for the public.

g. The Center for Field Methods shall investigate the effectiveness of various incentives and mechanisms to stimulate increased development and use of technology by industry. These investigations shall be designed to provide an experimental basis for the formulation of Government policy in this area.

SECTION 9. OFFICE OF THE DIRECTOR, NBS/BOULDER LABORATORIES.

The Office of the Director, NBS/Boulder Laboratories, located in Boulder, Colorado, shall provide administrative support to the technical programs of the NBS/Boulder Laboratories. These laboratories shall conduct research comprising work on measurement science for the National Measurement Laboratory in time and frequency, quantum physics, thermodynamics, materials science and the development of essential technical data in quantum physics, thermodynamics, and materials science; and conduct programs for the National Engineering Laboratory in electromagnetics and fluid dynamics. The following administrative divisions are located in the Boulder Laboratories:

Supply Services Division;
Instrument Shops Division;
Plant Division; and
Administrative Services Division.

SECTION 10. INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY.

The Institute for Computer Sciences and Technology shall conduct research and provide scientific and technical services to aid Federal agencies in the selection, acquisition, application and use of computer technology to improve effectiveness and economy in Government operations in accordance with Public Law 89-306 (40 U.S.C. 759), relevant Executive Orders and other directives. The Institute carries out this mission by managing the Federal Information Processing Standards Program, developing Federal ADP standards guidelines, and managing Federal participation in ADP voluntary standardization activities; providing scientific and technological advisory services and assistance to Federal agencies; providing the technical foundation for computer-related policies of the Federal Government; and assisting in the resolution of the issues of technology transfer and export of computers in international trade. The Organizational units of the Institute shall be as follows:

Systems and Software Division;
Computer Systems Engineering Division; and
Information Technology Division.

Senator STEVENSON. Dr. Hoffman, would you like to go next?

Dr. HOFFMAN. Thank you.

My name is John D. Hoffman. I am currently the Director of the Institute for Materials Research and the Director-Designate of the National Measurement Laboratory of the NBS.

I have submitted a written statement and respectfully request that this be entered in the record.

Senator STEVENSON. All the statements will be placed in the record.

Dr. HOFFMAN. In my summary statement I shall provide a picture of the mission of the National Measurement Laboratory, the kind of work we do, whom we serve, and some aspects of the future, including trends.

The National Measurement Laboratory is a reference laboratory for the United States for physical, chemical, and materials measurement.

Our business is measurement methods, standards and data.

Our role is to assure traceability—that is, to make sure that measurements refer to the same anchor points and are therefore compatible and correct throughout the United States.

We work in the technical areas of basic standards, materials research, chemical measurements, and radiation research.

I would now like to comment on the importance of measurements.

Measurements are used in decisionmaking in industry, and Government and such areas as health and safety. Our goal in this process is to foster reliable, consistent, and efficient measurement.

Let me illustrate the importance of measurements to decisionmaking by using the example of industry. Measurements are used in industry for quality control during manufacture, assuring equity in buying and selling, in materials selection, and for protection of workers.

I now mention a sampling of National Measurement Laboratory services relative to these items: NBS standard reference materials, are used for quality control in steel manufacture. We issue over 150 standardized specimens of steel of precisely known composition that permit rapid analysis of steel as they are being made. More than 90 percent of the steel made in the United States involves the use of these standards.

Another example relative to the industry relates to an experimental data on the properties of materials. Here the decisionmaking process requires data leading to proper selection of materials which is important, in emerging technologies such as coal gasification and magnetohydrodynamics.

On this same point—this selection—we provide the standard reference data that are carefully selected from the literature and evaluated complementing the new experimental data mentioned before.

Yet another example of measurement in decisionmaking in industry refers to nondestructive evaluations (NDE), which is a hierarchy of measurements and procedures whereby flaws can be detected during the manufacture and use of a product without destroying it. We provide measurements, methodology standards, and advanced concepts in this increasingly active field.

Calibrations are also used to insure accurate measurements for use in making decisions in industry. For example, calibration of personal radiation monitoring devices relates to worker safety and is also of interest to instrument manufacturers and users. Last, I remark that industry depends on our basic standards activities in length, mass, time, temperature, and related quantities. Time and frequency standards and measurements are widely used in decisions—for example, in power grid switching by electrical utilities. Parenthetically, I think it is worth observing that our calibration services are widely used by the Department of Defense in connection with weapons systems, since traceability of calibration to national standards is often required.

Let me now turn to how we interact with industry in regard to measurements.

We deal on a regular basis with standards organizations, trade associations, instrument manufacturers, and individual scientists in industrial research laboratories. In addition, we hold workshops which involve industry, university, and Government scientists on a planned and systematic basis. We held over 25 last year. Also, we have industrial research associates who come to the National Measurement Laboratory to work on problems of mutual interest.

Measurements and data are of course also widely utilized in decisionmaking in Goverment. Some key activities that we perform are as follows.

First, I note our measurement assistance to regulatory agencies. These agencies require a broad range of measurement services. Examples are provided by our standard reference material activity for the EPA and our study of welds in the Alaska pipeline carried out through the DOT. In each case, important decisions rest on accurate measurements and data.

Another function that we perform is consultation to other Federal agencies.

This is carried out both by the National Measurement Laboratory and the National Engineering Laboratory scientists are frequently called upon to give advice related to measurements and data. The NBS as a whole interacts with roughly 100 Government agencies.

I would now like to introduce a point of my own philosophy as regarding the National Measurement Laboratory. As a central reference laboratory, which is clearly one of broad scope, the role we play in the scientific and technical community is built around technical credibility. To me, this means that we must be aware of and involved in—and I mean very strongly involved in—scientific advances, and that we must build and maintain appropriate competences to do so. I truly believe that our job has room for and indeed requires, scientific creativity and imagination.

I have always been a proponent of basic research, and I feel that the Bureau cannot maintain its credibility or do its job without it.

Let me now turn to the future, certain trends concerning measurements in our technological society can be discerned, and they relate to our present work and future directions.

One major trend is an increased application of quantitative physical science measurements to health problems. National Measurement Laboratory's thrust in this area includes clinical standard reference materials and development of clinical analytical methods, and standards of measurement for radiation protection.

Another trend of importance to NBS in growing use is the dynamic measurements. Dynamic measurement are measurements on systems where the property being measured is rapidly changing or where the property must be measured quickly, usually by automated means. Some of the aforementioned clincal analyses are prime examples of this latter technique.

Standards for dynamic and automated measurements are needed. Challenges exist here in measurement assurance programs for automated weighing, rapid measurement methodology—for example, rapid temperature measurements in industrial processing—and standards for rapid, nondestructive evaluation measurements.

Turning to another trend, there's a strong trend to increase in efforts to attain higher industrial efficiency. This leads to measurement-related problems ranging from plant design data, process data, nondestructive evaluation measurements on products, to energy and materials conservation, including recycling.

Current National Measurement Laboratory activities in this area include predictive schemes for data for chemical processing, fracture and corrosion data, materials property data, and laser standards.

A trend associated with efforts to improve industrial efficiency trend which I think is evident is the increasing demand for measurements under extreme conditions, such as high temperature, high pressure, and intense radiation. Much of the National Measurement Laboratory thrust responding to this trend arises from our collaborative work on emerging technologies, such as coal gasification, and magnetohydrodynamics, and our nuclear power reactor design. Specific Laboratory work includes erosion data, neutron cross—sections, and plasma diagnostics.

Finally, we perceive a very strong trend to model complex systems. A model is a mathematical representation of a system—such as to the atmosphere—constructed so that some properties of the system can be predicted in the future. In the case of the atmosphere, modeling can tell us something of the fate and lifetime of ozone in the stratosphere or the change of carbon dioxide concentration with time. Many industrial processes are also modeled. My key points here are the following.

First, mathematical models require accurate input measurements and data, based on reliable measurements. The results from a model cannot be better than the input data. The second point is that models have to be based on physical laws and that the models require validation.

National Measurment Laboratory service related to modelling including the following: Evaluated standard reference data, key experimental data. Also we provide standards for measurements used to determine input data for the models; for example, SRM's carbon dioxide measurements in the atmosphere, and calibrations for ultraviolet rays that are impinging on the Earth.

We are now in the midst of planning the future of the National Measurement Laboratory. In formulating these plans, I think we should keep the question, "What happens if we're successful?", in mind. And I will close by endeavoring to answer it.

The time frame that I have in mind is around 5 years. If we succeed with what we plan to do; the following things will be possible.

First, we will, because of our measurement and data efforts, be able to asist industry to design plants and processes more efficiently, save energy, and control effluents better.

Second, we will be more confident of the accuracy of clinical analyses and hence the accuracy of the medical diagnoses deriving from them, and we will be more certain of the dosage of radiation treatments and chemotherapy.

Third, we will be able—better able to assist regulatory agencies better in the process of equitable and effective regulations, regulations based on accurate measurments systems. An example here is our nuclear safeguards program whose aim in measurements for accountability of fissile materials in power reactor and processing plants. This work is being done for the Nuclear Regulatory Commission, and the Department of Energy.

Fourth, we will be increasingly effective in providing the data base and the concepts to assist the development of new technologies.

Fifth, we will be able to aid ourselves and others to measure more accurately those chemical and physical effects that occur in our world that may affect our destiny. I'm thinking of such things here as ultraviolet light intensity, carbon dioxide concentration, and the stratospheric ozone question.

Sixth, we will, through better data and measurements, promote more effective and safer use of materials, including better design, better material selection, better processing and recycling, and more accurate lifetime predictions.

I am enthusiastic about the aforementioned prospects, and I think that in striving to attain them, we can at the same time forge a stronger institution in the scientific sense.

I have an optimistic view of the future, and look forward, together with my associates in the National Engineering Laboratory and the Computer Institute, I look forward to shaping a strong laboratory that serves the public intrest.

Mr. Chairman, I thank you very much for this opportunity.

Senator STEVENSON. Thank you, Dr. Hoffman.

[The statement follows:]

STATEMENT OF JOHN D. HOFFMAN, DIRECTOR, INSTITUTE FOR MATERIALS RESEARCH, NATIONAL BUREAU OF STANDARDS

Mr. Chairman and Members of the Subcommittee: My name is John D. Hoffman. It is both a privilege and an honor to appear before you today as Director of the Institute for Materials Research and Director-Designate of the National Measurement Laboratory of the National Bureau of Standards.

In my testimony today, I would like to convey a picture of our mission, the kind of work we do, whom we serve, and a sense of where we are heading as an institution. This last point—where we are heading—is particularly pertinent at this time because we are in the process of forging a new laboratory—the National Measurement Laboratory—to be responsive to the Nation's present and future measurement needs.

As Dr. Ambler mentioned, the National Measurement Laboratory (or the NML as we call it) is a reference laboratory that will provide the national system of physical, chemical, and materials measurement. As a reference laboratory, it is our role to tie together systems of measurement to assure that results of measurements made anywhere in the U.S. refer to the same basis or anchor points, so to speak. We call this feature *traceability;* measurements placed on a common base in such systems are said to be traceable to national standards. The national standards are developed and maintained by NBS.

The fields we work in are basic standards, materials research, chemical measurements, and radiation research. In simplest terms, it is our job in these areas to provide measurement methods, standards, data and the means for assuring measurement reliability for public benefit. By public benefit, I mean economic benefit as well as benefits derived from improved health, safety, and support of U.S. science.

The connection between measurement and public benefit is central to understanding the purposes and national value of the NML and to how we set our priorities. For this reason, I would like to illustrate why people measure and how reliable measurements serve the public.

Measurements are used in decisionmaking, for example, by industry, government, and medical practitioners. The use of measurements has been expanding rapidly in recent years not only because they have become more accurate and more widely applicable, but also because there are now more reasons to measure: to improve efficiency in industry, to monitor the environment, and to improve health care—are well-known examples.

Whatever the reasons for making measurements, the public interest requires a system that is reliable, consistent, and efficient. These goals—reliability, consistency, and efficiency—are goals of the NML. Let me give some examples to show you how NBS operates to achieve these goals.

Modern industries need to make millions of measurements daily; the reasons for measuring include:

Product quality control.
Buying and selling goods.
Selection of materials.
Design, construction and maintenance of production facilities.
Protection of workers and the environment.

NBS provides key measurement services in support of all of these everyday functions of industry. For example, we make standard reference materials—materials certified by NBS as to composition and physical state—that are used in quality control systems for the production of basic materials: steel, cement, aluminum, glass, copper and so on. More than 90 percent of the steel produced in the United States is made using NBS compositional quality control standards. These standards not only support productivity, but also allow minimum use of expensive and imported alloying elements—chromium, for example—and are used in specifications for buyer-seller agreements.

Over the years, we have developed about 1,000 different standard references materials in four categories:

Industrial.
Environmental.
Clinical.
Basic measurement science.

Last year, more than 32,000 units were sold to about 16,000 different buyers. The fact that many of these buyers are instrument manufacturers and producers of secondary standards, means that the impact of our standards reaches beyond the circle of our immediate buyers.

In support of another type of quality control, we have recently initiated a program in measurements and standards for an inspection technology called nondestructive evaluation of materials. Nondestructive evaluation of materials refers to methods for inspecting materials and structures for defects where the test itself does not damage the parts being inspected. One example is the use of high frequently sound waves to detect cracks in welded structures. In critical applications such as when public safety is involved—as, for example, with nuclear pressure vessels and aircraft parts—every part must be thoroughly inspected. In such cases, nondestructive testing offers the only possibility for safety evaluation.

Because of growing public and manufacturer concerns with product recalls and improved durability of goods, nondestructive testing of products is becoming increasingly important. In spite of its growing importance, lack of standards and incomplete understanding of the meaning of the measurements in terms of materials performance are hampering the more widespread and effective use of this technology.

NBS is working closely with the parties who have a stake in reliable nondestructive measurements:

Civilian agencies.
Defense agencies.
Standards bodies.
Professional associations.
Trade associations.
Industries.
Instrument manufacturers.

This involvement with all affected parties is a key to understanding how we operate. It means that the improved standards and measurements will be broadly utilized to improve reliability and safety in the manufacture and construction of pipelines, transportation systems, pressure vessels, bridges, and numerous consumer items.

In another aspect of industrial measurement, industry and labor are increasingly concerned with the safety of the work environment and, increasingly, measurements are relied upon for safety evaluation. We provide many services in this connection including calibrating systems used in the protection of workers exposed to radiation in the workplace. In fact, we have provided leadership and much development work to enable private testing laboratories to test commercial supplies of personnel radiation monitoring systems.

Let me briefly mention three other NBS reference services used widely in industry:

Time and frequency standards.

Standard reference data.

Calibration services.

NBS radio broadcasts of time—over radio stations WWV, WWVB, and WWVH in Hawaii—cover the continental United States and the Pacific and Atlantic Oceans. The broadcast services are used for safety on the oceans, regulatory compliance of broadcast frequencies, for switching operations in the U.S. electric power grid and more. A dissemination service that has become very popular is our telephone link to WWV. Last year, about two million calls to obtain accurate time were made to this station.

The NBS standard reference data program—established in response to the Standard Reference Data Act—collects data from the world's literature, evaluates them for accuracy and consistency and makes them available for general use. These data are used in almost every phase of manufacturing, engineering, and research. Our users include industrial designers, quality control engineers, and researchers in chemistry, physics, engineering, and biology. Applications include design of energy efficient and materials efficient processes, pollution control and energy utilization. Through a cooperative venture with the American Chemical Society and the American Institute of Physics, we publish the Journal of Physical and Chemical Reference Data that is subscribed to by most of the largest industrial corporations and universities in the U.S.

Calibration services ensure the accuracy of devices used to make or to check field measurements. For example, these services are used to link measurements of visible and ultraviolet light to NBS standards. The major users of our services include lamp industries, manufacturers of photographic materials, instrument makers, and Department of Defense standards laboratories. Many anti-ballistic missile defense systems use guidance devices which require calibrations traceable to these NBS standards. Some examples of new technologies that need these same standards are solar energy conversion, advanced materials processing, and laser manufacturing.

Although the NBS services just described are used primarily by industry, the benefits of these services accrue to the public in the form of support for improved productivity, materials conservation, public safety, and a more equitable marketplace.

I would like to emphasize another point about the nature of NBS services: as a central reference laboratory, the role we play in the technical community is built around technical credibility. Standards work is exacting and demanding. The acceptance of our standards depends upon people being able to rely upon our results. To do a thorough job, our work must be done by a highly competent technical staff. This means that we need the type of scientists who understand not only the techniques for careful measurement but also the underlying concepts of what is being measured and possible sources of error. It takes a long time to develop such scientists. I consider the strengthening and maintenance of a strong scientific foundation as one of my most important aims in making NML responsive to the Nation's needs.

Let me now turn to another important application of measurements—health. Each day millions of diagnostic measurements are made in clinics and hospitals; medication and therapy are administered in measured doses. Increasingly, medical practitioners rely upon measurement at every stage of patient care. Our role here is to help assure that these measurements are reliable.

This year, about 6 billion separate clinical measurements will be conducted in about 13,000 clinical laboratories in the U.S. The most common measurements are chemical or electrical in nature or involve some form of radiation—X-rays or radioactivity. In the future we must expect a continued increase in medically-related measurements and greater demands for reliability to facilitate earlier detection of disease and comparability of laboratories.

NBS has long been involved in improving the accuracy of medical measurements. For example, we have produced more than 30 clinical standards and a number of standards for radiopharmaceuticals to aid in the diagnosis and control of many different medical disorders. The multiple benefits—or leverage effect as I call it—provided by these standards is evident in the fact that NBS clinical standard reference materials are used by the manufacturers of more than 98% of automated and semi-automated clinical analyzers sold in the United States.

As is the case with all our measurement assurance work, we have been working closely with the user community: the College of American Pathologists, the American Association for Clinical Chemistry, and the Center for Disease Control.

In other health-related work, we provide services for accurate measurement of radiation dosage in cancer treatment. These services help to assure that patients receive exactly that radiation dose prescribed by their physicians; too much radiation could be harmful, and too little would be ineffective. We work with the Bureau of Radiological Health, the Nuclear Regulatory Commission, and with hospitals throughout the U.S. to assess the accuracy of radiation treatment units.

The need for reliability in health measurements and the public benefits that derive from it are, I think, clear. Again—achieving reliability depends upon doing careful scientific work.

Another measurement area of growing importance and increasing sophistication relates to assessing what I call the side effects of technology. The point I wish to make is that to ensure protection of the public from the known and potential hazards associated with a large and growing technology—the Nation needs reliable technical information for decision-makers and adequate controls—backed by good measurements.

Let me illustrate this point. Tens of thousands of chemicals and radioactive materials are now common items of commerce. These materials often find their way to regions remote from points of discharge. Accidental or deliberate spills of dangerous materials present still other possible side effects of technological growth.

On a more subtle level, some materials—harmless when released—may transform in the environment to toxic materials, perhaps when exposed to sunlight or bacteria. Low concentrations of materials in water or soil may concentrate in the food chain and pose unsuspected hazards. Scientists have warned of possible stratospheric modification and the possibility that dangerous levels of ultaviolet radiation might reach the earth, causing increased skin cancer and affecting crops. Questions are being raised regarding the long-term effects of low-level exposure to chemicals and to air-borne dusts and aerosols.

The fact that the Council on Environmental Quality estimates that 60–90% of cancer is environmentally induced provides a disquieting reminder of the stakes and subtleties involved. The Council's estimate of pollution abatement costs—$420B over the next decade—gives another dimension to the concern.

The public interest in balancing technological growth and technological impact is reflected in recent and pending legislation, the priorities of agencies of government, and the research and development programs of manufacturers and users of chemicals. The point that is of concern to me, however, is that today's measurement science and measurement assurance systems are simply not adequate to answer many of the *measurement-related* questions now being raised by those investigating the relationship between the environment and health.

For example, we cannot now measure ultraviolet radiation levels with accuracy sufficient to determine whether changes are occurring in amounts passing through the Earth's protective ozone shield and reaching the Earth.

Similarly, we do not know which features of small particles are responsible for specific health effects such as lung cancer or bronchial ailments. Though particle size, shape, and chemical composition must be considered, it is also possible that small amounts of chemicals adhering to mobile particles actually pose threats to the public health in particular instances.

The lack of measurement capability in these areas hinders the acquisition of the kind of data needed to shape public policy. The point I wish to emphasize then is that the protection of the public—without undue constraint of technology—requires two important measurement-related elements:

Reliable technical data—chemical and physical data, for example—to allow decision-makers to set reasonable national goals; and,

A quality control system to assist Federal agencies, manufacturers, State and local governments, and the Congress to *measure* progress in reaching these goals.

These elements are part of what we call the technical basis for fair regulation. Many of our services are now used by industries, EPA, other Federal agencies, and by State and local governments as part of this technical basis. In the environmental areas, for example, our standard reference materials are used as a common base. In fact, there are more than one dozen notices in the Federal Register calling for *traceability* of environmental measurements to specific NBS Standards such as the nitrogen dioxide standard reference material.

We have also provided key data needed to model the breakdown of the stratospheric ozone layer that protects plant and animal life from harmful ultraviolet radiation.

In summing up the contribution measurement makes to public benefit, I would stress two points:

(1) The number, type, and complexity of measurements used in decision-making in industry, government, medical practice, and in shaping public policy are increasing.

(2) Because protection of the public interest is increasingly involved in the decisions that are made, the need for reliability in measurement is becoming more important.

Before addressing the future of the NML, I would like to make a few comments on the processes we use to assess the measurement needs of the Nation and how we prepare to meet the measurement needs of the future.

In setting priorities for measurement services the most important factors we consider are:

The significance of a problem to the public, and

The degree to which the problem is amenable to solution through improved measurement.

In our anlyses of national problems, we seek a broad base of advice and other inputs from users and potential users of measurement services. The advice comes from industry, agencies of Federal and State and Local governments, professional and trade associations, universities and standards bodies. Our managers and scientists maintain close and regular contact with these groups through joint participation and sponsorship of workshops and other, less formal meetings. Our National Academy of Sciences evaluation panels—broadly constituted groups with experts representing every major sector in the U.S.—provide invaluable service to us by evaluating both our procedures and our technical capabilities. We also have a variety of formal and informal planning activities in which we analyze trends, monitor legislation, work with the Office of Technology Assessment, and conduct impact surveys and issue studies.

At the present time, we are in the process of completing a study of the economic effects of corrosion in the United States. This study—carried out by Congressional directive and conducted in part under contract to the Battelle Columbus Laboratories—concludes that in 1975, corrosion cost the U.S. economy from $50 to $90 billion. Of this amount, about $10 billion could be reduced—over a period of time—through economically optimal application of presently available corrosion-control technology. Further reductions would, of course, require technological advances such as new materials, improved coatings, improved tests, and corrosion research.

On the basis of our careful review of the findings of the corrosion study, we have an improved understanding of present and future needs in this area. We are taking steps to shape a long-term program in collaboration with key private sector and Government users.

Although our programs differ greatly, the general features of these programs are that they respond to problems that are significant at a national level and they serve multiple users. We work on problems for which measurement is a central issue or where inadequate measurement is a barrier that inhibits the solution to a problem. Moreover, we prove only those key services that are needed to establish a reliable measurement system and to keep it functioning.

I would like now to give a few specific examples that illustrate the factors that shape our programs and how we remain responsive to National needs.

Our programs change both to keep pace with technology and to capitalize upon advances in science and technology to improve standards.

For example, the voltage standard is now more accurately realized utilizing the superconducting properties of certain metals in specially constructed systems called Josephson devices. This is a scientific advance in that the volt is now maintained in terms of fundamental constants of nature. Moreover, the new system reduces NBS' cost and has the potential to simplify calibration systems used in industry and by the military.

Another example of the interaction of science, technology and standards is that of precision length measurements.

The unit of length was formerly defined by the distance between two scratch marks on a meter bar kept in Paris. It is now defined in terms of the constant wavelength of light emitted by a krypton light source. In recent years, NBS has developed stabilized lasers that have already, in practice, become the defined unit of length for the most accurate measurements. Lasers have overwhelming advantages; they have been used to measure gage blocks and to measure the distance between the Earth and the Moon. At the other extreme, they are used for measuring distances between atoms and for unifying length measures down to the wavelength of X-rays and nuclear dimensions. Our work in length standards, I think, illustrates both the impact of technology on standards and the impact of improved standards on new technology.

In areas where there are new needs or rapidly changing needs, we create new programs to meet them. Examples here are measurements for nuclear safeguards, recycled oil and nondestructive evaluation of materials—mentioned earlier.

NBS, in cooperation with the Nuclear Regulatory Commission, the Department of Energy and the nuclear industry has undertaken a new program to improve the quality of measurements made for safeguarding nuclear materials. These measurements are made in nuclear fuel cycle facilities to determine the inventory of plutonium and uranium, and thus provide sensitive methods for detecting diversion of nuclear materials.

The program in recycled oil was established in response to Public Law 94–163, the Energy Policy and Conservation Act. The purposes of the law were to reduce environmental damage caused by discarded oil and to foster energy conservation. Our responsibilities under the law are to develop test procedures to be used to determine the substantial equivalence of recycled oil with new oil. Potential users need to be assured that the recycled oil will not damage engines or machinery. Without test procedures for quality control, it is doubtful that widescale markets for recycled oil will develop. The expected impact of a quality control system, then, is twofold: it will facilitate the development of markets for oil that is now a major source of water pollution, and it will lead to energy conservation.

A very important avenue we use to anticipate future needs is our longer-term work on advanced techniques in measurement science. We regard this work as an investment in developing capabilities that will be needed more than five years from now.

Finally, I would like to make a few comments on the NML and its future. The scientific groupings in the proposed reorganization are considerably more flexible than the present ones. The combinations of physicists, chemists, materials scientists, mathematicians and statisticians will thus lend themselves to the kinds of broad-based research that we envisage as increasingly important over the next decade. Examples of such research areas are:

Surface science.

Fracture of materials.

Radiation research.

Research on the degradation of materials.

Within the NML, five entities called centers will conduct research in key areas of measurement science in support of U.S. science and technology and the mission of the newly-formed, National Engineering Laboratory at NBS.

At the present time, we are developing a long-range plan for the NML. The future to which we are responding is reflected—in broad aspect—in national trends that have significant implications to the future of measurement. Some of these trends:

Widespread automation of systems with controls linked to measuring sensors.

New industrial and energy systems operating at more extreme conditions of temperature, pressure, radiation levels, and chemical reactivity.

Increased surveillance, monitoring, and modeling of the atmosphere. waterways, and workplaces for chemicals, radiation, and small particles.

Increased efforts to improve the efficiency of industrial output through improved processes, design, and quality control.

Increased use o flasers and other radiation in monitoring, processing, and in health.

Continued increase in performance standards.

Continued rapid increase in the contribution of physical science techniques to health care.

The principal thrusts of the NML centers reflects the trends just mentioned. I would like now to summarize the functions of the centers and give you some of our current thinking on what these thrusts should be:

The *Center for Absolute Physical Quantities* is responsible for maintaining the base units of our measurement system that underlie all physical measurements upon which science and technology, industry, and commerce are based.

Some thrusts of this center will be:

Development of laser standards for precision length measurements in science and technology.

Development of new, fast temperature measurement technology applicable to energy system and materials research.

Establishment of an international coordinated time measurement system with an accuracy sufficient to permit precision position location on earth and in space.

The Center for Analytical Chemistry will provide the U.S. with measurement services and perform research in the areas of compositional analysis, chemical separation, and characterization of materials.

Two major directions of this center will be development of new methods and standard materials for:

Detection and measurement or organic chemicals in complex media such as plants, food, tissue, and water.

Characterizing small particles in terms of size, shape, and chemical composition to improve measurements of industrially important particles as well as particles found in the atmosphere, tissue, and water.

The Center for Materials Science will provide the nation with measurement services in the properties and performance of materials. It will perform research on the structure, physical properties, and reactions of materials related to stability and durability in service environments.

Major thrusts of this center will include:

Research on the degradation and failure of materials: wear, corrosion, fracture, and migration of chemical additives in plastics; lifetime prediction.

Development of quality control technology for measurements made at the separate stages in the materials cycle from raw materials, processing, fabrication to recycling.

Determination of properties of materials needed for effective utilization of materials in design, manufacture and use of products.

The Center for Thermodynamics and Molecular Science will provide the Nation with measurement services in the areas of thermodynamics, transport properties, chemical kinetics, surface science and molecular spectroscopy. It will conduct research in these areas and compile, critically evaluate, and disseminate data to users throughout the U.S.

Two principal thrusts of this center will be:

To develop and evaluate models and predictive schemes that involve the use of evaluated chemical reaction data used to optimize industrial processes and help provide a technical basis for regulating the emission of pollutants, and

To provide key chemical and physical data needed to validate models used by Government and industry.

The Center for Radiation Research will provide the Nation with measurement services in the areas of optical radiation, ultraviolet radiation, and ionizing radiation such as X-rays, neutrons, gamma rays, and radioactivity. It will carry out reesarch to develop improved radiation standards and improve understanding of atomic, molecular, and nuclear radiation processes.

Principal directions for this center include:

To improve methods for measuring high-energy X-rays, electrons, and fast neutrons providing bases for dosage standards used in radiation therapy of cancer, industrial processing, and nuclear fission and fusion power.

To improve methods for measuring ultraviolet radiation to meet the accuracy requirements in environmental monitoring, studies of solar radiation, and energy research.

In addition to the esearch activities of the centers, NML will have programs in several areas to focus outputs and to maintain close liaison with specific user groups. Some examples of this are: standard reference materials, nuclear safeguards, and measurement and calibration services.

In closing, I would like to say that I share Dr. Ambler's optimistis view of the future. I think that the National Measurement Laboratory will be faced with many challenges as measurement is called upon increasingly to improve technology, and to make it safer and more efficient. It is my aim to shape a responsive, technically-sound laboratory serving the public interest.

The National Measurement Laboratory (NML) has been assigned responsibilities under the following:

Standard Reference Data Act (P.L. 90–396)
Resource Conservation and Recovery Act of 1976 (P.L. 94–580)
FY 1976 Appropriation Act (P.L. 94–121)
Metric Conversion Act of 1975 (P.L. 94–168)
Energy Policy and Conservation Act (P.L. 94–163)
Federal Coal Mine Health and Safety Act of 1969 (P.L. 91–173)
Radiation Control for Health and Safety Act of 1968 (P.L. 90–602)

Specific responsibilities and NML actions under these assignments are summarized.

STANDARD REFERENCE DATA ACT (PUBLIC LAW 90–396)

Under this Act "The Secretary of Commerce is authorized and directed to provide or arrange for the collection, compilation, critical evaluation, publication, and dissemination of standard reference data." The Act authorizes the Secretary of Commerce to obtain copyright of standard reference data for the United States. The National Standard Reference Data System has been established at NBS and is administered by the Office of Standard Reference Data.

Projects supported by NBS are categorized in the following program areas: Energy and Environmental Data, Industrial Process Data, Materials Utilization Data, and Physical Science Data. In its management of the program, the Office of Standard Reference Data works closely with other Federal agencies, professional societies, industrial groups, and other appropriate organizations to determine and prioritize the needs for reference data. The average annual publication of tables of standard reference data is now about 2,000 pages covering typically 20 to 30 different subjects.

The program produces the Journal of Physical and Chemical Reference Data, which has more than 1,200 subscribers, including 32 of the top 50 U.S. industrial corporations.

FISCAL YEAR 1976 APPROPRIATION ACT (PUBLIC LAW 94–121)

Senate Report 94–328 directs NBS to carry out a study of the economic effects of corrosion in the United States.

The economic effects of corrosion include not only monetary losses suffered by users of products which corrode, but also consumption of materials (chromium, for example) and energy that would not occur were optimal corrosion control practice employed. Thus, a study to determine the economic effects of corrosion involves acquiring cost data, evaluating corrosion control options, and conducting economic analyses to convert cost data to economic effects. The economic analysis required in the study was placed under contract to Battlele Columbus Laboratories. The overall study is being conducted by Battelle and NBS.

The goals and objectives of the study were thus set as follows:

To determine the total cost of corrosion in the U.S., and

To determine the amount of capital goods, labor, energy, and materials required because of corrosion.

The corrosion study is nearing completion. The central conclusions of the study are that in 1975, corrosion cost the U.S. economy from $50–$90 billion. Of this amount, about $10 billion could be reduced—over a period of time—through economically optimal application of corrosion-control technology.

RESOURCE CONSERVATION AND RECOVERY ACT OF 1976 (PUBLIC LAW 94–580)

Section 5002 (42 U.S.C. 6952) specifically directs the Secretary of Commerce acting through NBS "to publish guidelines for the development of specifications for the classification of materials recovered from waste which were destined for disposal. The specifications shall pertain to the physical and chemical properties and characteristics of such materials with regard to their use in replacing virgin materials in various material, commercial, and governmental uses." In addition, P.L. 94–580 directs NBS to hold public hearings on these guidelines and to publish the guidelines not later than October 21, 1978. These guidelines will: (1) aid in conserving valuable material and energy resources, (2) increase the rate at which resource recovery from municipal soild waste will occur in the U.S., and (3) serve in the settlement of possible disputes involving the use of recyclables in terms purchased by the Federal Government (Sec. 6002/42 U.S.C. 6962/P.L. 94–580).

NBS plan under assignment

To carry out the program, NBS will conduct several projects to characterize recovered materials and establish the guidelines mandated in P.L. 94–580 and to evaluate existing, proposed and/or required specifications for these materials against the guidelines. The materials in question include ferrous metals, nonferrous metals (primary aluminum), glass, paper, rubber, refuse-derived fuels, and some construction wastes. The proposed projects include:

Investigations to determine whether existing or proposed specifications for materials reclaimed from waste are adequate for the intended use. Corollary to this will be the development of standrad test methods and testing procedures which can be used in the laboratory and in the field by buyers and sellers.

Development and transfer of information and data to the public and private sectors (in conjunction with existing specifications-setting groups) concerning the review, formulation, and promulgation of specifications for recovered materials.

Classification of recovered materials in terms of potential uses (such as a modified corrosion-resistant steel), based on market needs and specifications.

The administration has decided that this program will be funded with monies appropriated to the Environmental Protection Agency.

METRIC CONVERSION ACT OF 1975 (PUBLIC LAW 94–168)

Under this Act "there is established . . . an independent instrumentality to be known as a United States Metric Board." The Act states that there shall be "consultation by the Secretary of Commerce with the National Conference on Weights and Measures in order to assure that State and Local weights and measures officials are (1) appropriately involved in metric conversion activities and (2) assisted in their efforts to bring about timely amendments to laws. Financial and administrative services . . . needed by the Board may be obtained by the Board from the Secretary of Commerce."

NBS is awaiting the direction and coordination of the U.S. Metric Board. The NBS Office of Weights and Measures will coordinate the work to provide up-to-date information; modify model State laws and regulations and work for adoption by States through the National Conference on Weights and Measures.

ENERGY POLICY AND CONSERVATION ACT OF 1975 (PUBLIC LAW 94–163)

The NBS role under this Act is found in Section 383: "Develop test procedures for the determination of substantial equivalency of rerefined or otherwise procesed used oil . . . ," with new oil for a particular end use. The purposes of this legislation were to reduce environmental hazards associated with the disposal of used oil and to foster energy conservation.

The Resource Conservation and Recovery Act (P.L. 94–580) also affects NBS efforts in recycled oil. Recycled oils are end-use products and are therefore covered in Section 6002. "Federal Procurement" of P.L. 94–580, which states federal agencies ". . . shall procure items composed of the highest percentage of recovered materials practicable . . . ," and the NBS test procedures will be utilized. The procurement requirements set out under Section 6002 shall be followed beginning on October 21, 1978. NBS has completed the technical evaluation of test methods to be used for fuel oil—the first phone of the NBS program and this information is being compiled for transmission to FTC. The term used in the law, "for a particular end use," requires that NBS examine all major end use products which are made with recycled lubricating oils—e.g., waste oil used as fuel, industrial oils, hydraulic oils, engine lubricating oils.

The administration is proposing that this program be expanded in 1978 to enable NBS to evaluate and/or develop new or improved test procedures for other recycled oil products which will then provide the basis for FTC rulings for industry test prodedures and labeling standards for recycled oil.

FEDERAL COAL MINE HEALTH AND SAFETY ACT OF 1969 (PUBLIC LAW 91-173)

This act directed the Director of the National Bureau of Standards or his designate to serve on the Advisory Committee of Coal Mine Safety and a companion Interim Compliance Panel. An NBS delegate served on these bodies from January 16, 1970 to April 17, 1976 at which time they were dissolved.

An example of a service that NBS provided as a consequence of this act is the technical assistance that it provided to the General Accounting Office in preparing an overall evaluation of the mine dust monitoring system that was administered by the Department of the Interior's Mine Environment Safety Administration (MESA). At GAO's request NBS assisted in evaluating the ability of the personnel monitoring instruments and weighing laboratories to quantitatively sample and measure the level of respirable dust in operating coal mines. In its final report GAO concluded that the monitoring system could not measure the concentration of respirable dust with the accuracy specified in the Act. GAO also recommended that MESA obtain NBS assistance in effecting needed improvements in that system.

In November 1977 MESA engaged NBS to conduct research directed towards developing improvements in sampling statistics and measures of instrument performance under conditions actually encountered in the mine.

RADIATION CONTROL FOR HEALTH AND SAFETY ACT OF 1968 (PUBLIC LAW 90-602)

Section 356(a)(6) says the Secretary of HEW shall "consult and maintain liaison with the Secretary of Commerce . . . on (A) techniques, equipment, and programs for testing and evaluating electronic product radiation, and (B) the development of performance standards . . . pursuant to control such radiation emissions." NBS supports and assists the Bureau of Radiological Health (BRH) with measurement standards and procedures as necessary to protect the public from harmful effects of ionizing, electromagnetic, laser, ultrasonic, and ultravoilet radiation. NBS also reviews regulations and guidelines proposed by BRH with emphasis on measurement implications. Voluntary standards which supplement or substitute for regulations are developed with NBS coordination and leadership. The NBS activities include: development of basic measurement standards, instruments, and procedures; calibration of field instruments against these standards; and conduct of measurement assurance programs for manufacturers, users, and regulators of electronic products. Examples of the latter are MAP's for laser power and energy, and for radiation therapy devices utilizing cobalt-60.

Senator STEVENSON. Dr. Lyons?

Dr. LYONS. Thank you, Mr. Chairman. I am John W. Lyons, Director of the Institute for Applied Technology, and I am to become Director of the National Engineering Laboratory.

It's a pleasure for me to appear before this subcommittee to discuss the engineering and applied science programs of the NBS. I shall do this in terms of the National Engineering Laboratory.

In terms of disciplines, the Engineering Laboratory will have substantial programs in the following areas: electrical and electronics engineering, mechanical engineering, civil engineering, fire protection engineering, applied physicists, applied chemists, applied mathematicians, economists, architects, and behavioral scientists.

It is natural to think of the Laboratory as a series of clusters of these skills or competencies. The programs of the Laboratory will include development of measurements for process control in the electronics industry, studies of electromagnetic interference; standards for industrial automation and research on interactive computer-controlled manufacturing; noise control measurements; measurements and technology for commercial operations at very low temperature, as, for example, shipping and storing liquefied natural gas; measuring combustion processes for various industrial applications; research and standards in building science and technology; development of methods of measuring consumer product performance; a wide range of fire research activities; a series of measurements of standards activities related to energy conservation; technical support to the Department of Commerce on the long-term accreditation of testing laboratories and on the labeling of consumer products; research into the factors affecting technical innovation in our society—the ETIP program. We also have in the Engineering Laboratory the central NBS group working on applied mathematics.

Perhaps the most striking feature of all in this new laboratory is the breadth of its programs, as I have just indicated.

Let me now discuss one or two of the above programs. First, some of our work in electronics and electrical engineering. There are now serious problems with measuring the effects of electromagnetic radiation on people and with electromagnetic interference with electronically controlled devices.

For example, radiation levels in a normal environment have been known to prevent operation of electronically controlled truck brakes. Difficulties with EMI are expected to escalate. We are at work on improved techniques for measuring such radiation and for measuring the response of electronically controlled devices to it. We perceive a growing demand for results in this area and are increasing our efforts accordingly.

In electronics for many years the Bureau has worked on tests and measurements for the semiconductor industry. We have developed new methods of measurement and testing for processing and performance evaluation of semiconductor devices. As integrated circuits on semiconductor chips have become smaller and more complex, precision metrology has become more important on the production line. This work will be increasingly important as the industry moves to ever more complex, large-scale integrated circuits.

A second area is our comprehensive program of research in thermal insulation. The work draws on expertise across the Bureau in heat transfer, fire and electrical safety, durability, corrosion, consumer product labeling, and laboratory accreditation. We are developing an improved test apparatus for use with layers of insulation up to 12 inches thick.

We have developed two new fire tests. One of these defines the tendency of fire to spread over the surface of exposed insulation; the other is used to evaluate the propensity of an insulation material to sustain smoldering combustion given an accidental ignition.

We are studying the durability and corrosiveness of treatments applied to some forms of insulation.

We are working on the best way to display all or some of this information on product labels.

And, finally, thermal insulation is the first product category to have been selected by the Department of Commerce for voluntary accreditation of testing laboratories. Such accreditation will provide the Nation with a network of laboratories able to run the various tests required for labeling, for tax credits, and for building codes.

The National Engineering Laboratory will have responsibilities under nine specific legislative acts. In an attachment to my written statement there is a brief review of NBS's response to each of those.

At this point I should like to make a few observations on the Bureau's response to the fire safety and the energy acts.

The Federal Fire Prevention and Control Act of 1974 established a Center at NBS and gave it a very detailed charter. The act contains a separate authorization for this NBS Center. The budget for the Center is formulated at NBS in consultation with the administrator of the National Fire Prevention and Control Administration, and after consolidation with the budget of NFPCA is forwarded as a single document to the Congress. The center is a line item in this budget. NBS management is assured of continuity of funding and a voice in program planning. An appropriate portion of the funds are applied to building competence in the disciplines necessary for fire research programs. The Center for Fire Research is at once relevant and able to maintain its key competencies.

Now consider the situation in the energy area. There are four pieces of legislation. In the DOE budget request for appropriations for the Federal Non-Nuclear Research and Development Act, the NBS work on energy-related inventions is a separate line item. This is not the case with the other items. For these we are reimbursed by the other agencies. But we are not explicitly written into their appropriation requests.

The breakdown for the laboratory shows we have a $12½ million program, only $0.9 million of which is directly appropriated. $1.2 million shown in my testimony for energy-related inventions is clearly earmarked for this purpose and is not flexible. The reimbursible funds from other agencies come from specific projects, generally short range in nature. Other agencies are not particularly concerned with building NBS's scientific competence over the long range. NBS management has relatively little discretion in developing the competencies necessary to support applied energy work. This lack of flexibility is a serious problem for us in a number of program areas. As a result of this the President's fiscal year 1979 budget request includes a request of Congress for funds for competence-building and for funds to augment our long-range planning efforts.

Let me now turn to our thinking about the future. One cannot have excellence in technical problem solving without excellence in science. Future selection of problem solving areas will be governed at least in part by our choices now as to which competencies are to be exercised.

We propose to focus in a half-dozen areas in the National Engineering Laboratory with the first infusion of competence money in 1979.

These are fluid mechanics, heat transfer, phenomena occuring in electronic devices, and substantial strengthening in our ability to work with complex systems using computers.

We chose fluid mechanics and heat transfer because we are certain we shall have programs relying on these skills in the years to come. Examples are the need to describe the behavior of fire in a room; the flow of air in buildings; and to make engineering measurements on combustion processes in various kinds of furnaces.

Basic work in electrotechnology is important, because we receive very strong demands for developing measuring techniques in the new world of large-scale integrated circuits. The stress on handling large-scale problems in computers reflects our belief that the Bureau needs to improve its scientific computers very substantially.

During this calendar year we are to prepare a 5-year plan for the laboratory. From this exercise will come a rationale for management of the budgetary actions required in the years ahead.

The National Engineering Laboratory will be unique in its breadth of interest; its charter to serve many clients; its concern for engineering measurements and standards; and its ability to mount a variety of programs addressing national problems.

Thank you.

Senator STEVENSON. Thank you, sir.

[The statement follows:]

STATEMENT OF JOHN W. LYONS, DIRECTOR, INSTITUTE FOR APPLIED TECHNOLOGY, NATIONAL BUREAU OF STANDARDS

Mr. Chairman and members of the subcommittee: It is a pleasure for me to appear before this Subcommittee to discuss the engineering and certain applied science programs of the National Bureau of Standards (NBS). Dr. Ambler has discussed the dual role of NBS and his proposed reorganization which will place the problem solving role primarily into a new unit named the National Engineering Laboratory (NEL). I have served as head of a task force to give shape to this new entity and have spent several months thinking about the NEL, what it should be, what it should and should not do, and how it should relate to the National Measurement Laboratory (NML). I shall attempt today to set forth for you our views on these questions.

There are a number of ways to describe an organization—by its staff, its activities or programs, or its mission as enunciated by the organization itself and by its chartering body. For NEL, it is convenient to consider (1) the scientific and engineering disciplines, (2) the programs aimed at solving specific problems and (3) the context for these as given by various Federal Laws establishing the units, stating specific missions, or assigning tasks.

The National Engineering Laboratory of the National Bureau of Standards will be a Federal laboratory which will conduct technical programs to contribute to the solution of a broad spectrum of National problems. A distinguishing characteristic will be the breadth of our activities. In terms of disciplines we will have substantial groupings in the following areas:

Electrical and Electronics Engineers, Mechanical Engineers, Civil Engineers, Fire Protection Engineers, Applied Physicists, Applied Chemists, Applied Mathematicians, Economists, Architects, Behavioral Scientists.

Within these groups there will be many subdivisions; for example, the mechanical engineering group will include specialists in fluid flow and heat transfer; the applied physics group will include specialists in acoustics, electricity and magnetism and aerosols, to name but a few. When one views the proposed NEL in terms of its people and their training it is natural to think of the Laboratory as a series of clusters of skills or competences. As you know we are now engaged in assessing these competences as to which are essential and which need to be strengthened. The competences will be the scientific foundation on which effective problem-solving activities will be based.

The programs of the laboratory will include development of measurements for process control in the electronics industry, studies of electromagnetic interference, standards for industrial automation and research on interactive, computer-controlled manufacturing, noise control measurements, measurements and technology for commercial operations at a very low temperature as, for example, shipping and storing liquified natural gas, measurements on combustion processes for various industrial applications, research and standards in building science and technology, development of methods of measuring consumer product performance, a wide range of fire research activities, a series of measurement and standards activities related to energy conservation, technical support to the Department of Commerce on the voluntary accreditation of testing laboratories and on the labeling of consumer products, and research into the factors affecting technical innovation in our society (the ETIP program). We will have in NEL the central NBS group working on applied mathematics and providing skills in mathematics, statistics, and numerical computations to all NBS programs which require such support.

Let me now discuss a few of the above programs as they are now, programs which are done under the general authority of the NBS organic act. Our work in electronics and electrical engineering is remarkable for its breadth and the pervasiveness of its results. NBS is expert in making measurements across the electromagnetic spectrum. In recent years the Bureau has been the referee laboratory for measuring leaks of electromagnetic radiation from microwave ovens. There are now serious problems with measuring the effects of electromagnetic radiation on people and with electromagnetic interference (EMI) with electronically controlled devices; for example, radiation levels in the normal environment have been known to prevent operation of electronically controlled truck brakes. As the automobile industry turns to microprocessors for control of engines to achieve high efficiency in gasoline consumption and low exhaust emissions, difficulties with EMI are expected to escalate.

We are at work on improved techniques for measuring such electromagnetic radiation and for measuring the response of electronically controlled devices to such radiation. We perceive a growing demand for results in this area and are increasing our efforts accordingly.

For many years the Bureau has worked on tests and measurements for the semiconductor industry at the request of industry and other government agencies and under joint sponsorship with those agencies, principally the Department of Defense. We have developed key methods of measurement and testing for the processing and performance of semiconductor devices, procedures which have greatly improved the efficiency of production and reliability of products. These tests and procedures are used throughout the entire industry. As integrated circuits on semiconductor chips have become smaller and more complex, precision metrology has become more important on the production line. Recently our electronics experts have joined with our experts in length measurements to give the semiconductor manufacturers, and those who provide them with manufacturing and test equipment, new means of microscopic positioning of lines and patterns on semiconductor chips and ways of measuring and controlling line width in these patterns. These and related techniques will be increasingly important as the industry moves to ever more complex large-scale integrated circuits.

Because of the rapid development of automated, computer controlled machine tools, we are developing new concepts of dynamic, in-process measurement and control of part dimensions, surface finish and part integrity, and new traceability and calibration services to support that technology. In the most sophisticated of these concepts, a robot fitted with sensors is operated by a computer serving in the same control capacity as the human brain i.e., receiving sensory signals and responding with motor commands. We are working to develop the techniques, the instrumentation and the computer software to produce an economical production technique. NBS has a unique combination of skills which enable us to do this job.

We have for some years been making measurements of chemical and physical properties of liquids at very low temperatures and developing techniques for storing and transferring these materials. A recent application has been to liquified natural gas (LNG) a material shipped and stored at temperatures near $-160^{\circ}C(-256^{\circ}F)$. NBS has determined ways of calculating, from simple physical measurements, the heating value of the mixtures normally used in commerce, has developed ways of metering LNG, and has assisted with matters of safety.

As a final example, NBS has undertaken in collaboration with DoE a comprehensive program of research on insulation. NBS work on thermal insulation draws on expertise across the Bureau in heat transfer, fire and electrical safety, durability, corrosion, consumer product labeling, and laboratory accreditation. NBS maintains the standard engineering test apparatus for measuring the thermal conductivity of insulation.

We are developing an improved test apparatus for use with layers of insulation up to 12 inches thick. We have developed two new fire tests in the past year. One of these defines the tendency of fire to spread over the surface of exposed insulation, for example, in attics. The other is used to evaluate the propensity of an insulation material to sustain smoldering combustion given an accidental ignition such as from a dropped cigarette in a crawl space, an electrical short in a wall, or an overheated recessed lighting fixture. We are studying the durability and corrosiveness of treatments applied to some forms of insulation. We are working with other elements of the Department of Commerce and the FTC on the best way to display all or some of this information on product labels. And finally thermal insulation is the first product category to have been selected by the Department of Commerce for voluntary accreditation of testing laboratories. Such accreditation will provide the Nation with a network of laboratories able to run the various tests required for labeling, for tax credits, and for building codes. As you know, the subject of consumer equity in thermal insulation is of great concern in Government at this time; we are working very hard to find the necessary answers.

Of the legislation discussed by Dr. Ambler in his testimony, the NEL will have responsibilities under nine acts. In attachment A of this testimony there is a brief review of NBS response to each of these. At this point I should like to make a few observations of the bureau's response to the fire safety and the energy acts.

The Federal Fire Prevention and Control Act of 1974 established a Center at NBS and gave it a very detailed charter. The act contains a separate authorization for this NBS Center. The budget for the Center is formulated at NBS in consultation with the Administrator of the National Fire Prevenion and Control Administration (NFPCA), and after consolidation with the budget of NFPCA is forwarded as a single document to the Congress. The Administrator of NFPCA is assisted at hearings by the Director, Center for Fire Research, NBS. The Center is a line item in the budget. These funds are considered at NBS to be the same as direct appropriations since management is assured of continuity of funding and a voice in program planning. The Center has been able to develop long range plans and secure agreement for them from NBS and NFPCA management. An appropriate portion of the funds are applied to building competences in the disciplines necessary for a fire research program. By being written into the NFPCA budget by name, the Center for Fire Research is at once relevant and able to maintain its key competences.

Now consider the situation in our work on engineering measurements, test methods, and standards in the energy area. There are four pieces of legislation. (See attachment A for details.) Under the Solar Heating and Cooling Documentation Act of 1974 we are developing criteria and standards for devices and systems operating on solar energy. Under the Federal Nonnuclear Energy Research and Development Act of 1974 we are evaluating energy-related inventions as discussed by Dr. Ambler. Under the Energy Policy and Conservation Act and the Energy Conservation and Production Act we are developing criteria and standards for energy use in buildings and building components and test methods and efficiency improvement targets for a series of home appliances.

In the DOE budget request for appropriations for the Federal Nonnuclear Energy Research and Development Act, the NBS work on energy-related inventions is a separate line item. This is not the case for the other items. For these we are reimbursed by the other agencies but we are not explicitly written into their appropriation requests. We apply some of our own direct appropriations to the energy area to conduct basic research and studies needed to underpin the work done under the legislation. The breakdown for NEL is:

	Thousands
Reimbursables	$10.4
Appropriated to DOE for NBS	1.2
Directly appropriated to NBS	.9
Total	12.5

The money for energy-related inventions is clearly earmarked for this purpose. The reimbursable funds from other agencies come for specific projects, generally short range in nature. Other agencies are not particularly concerned with building NBS's scientific competence over the long range. NBS management has relatively little discretion in developing the competences necessary to support the short term applied energy work. This lack of flexibility is a serious problem for us in a number of program area. As a result of this the President's FY 1979 budget request includes a request to Congress for funds for competence building and for funds to augment our long range planning efforts. One of the prime functions of the planning effort will be to assess our needs and priorities for longer term fundamental work.

Let me now turn to our thinking about the future. We take it as axiomatic that one cannot have excellence in technical problem solving without excellence in science. We have already mentioned the new budgetary approach which enables us to single out important underlying disciplines or competences and request directly funds to develop and strengthen them. Future selection of problem-solving areas will be governed at least in part by our choices now as to which competences are emphasized. Our first set of choices are in connection with an increase of $1,000,000 for NEL for FY 1979. We propose to focus on a half dozen areas in the National Engineering Laboratory with this first infusion

24–751—78——4

of money. Examples are: studies in fluid mechanics, heat transfer, the physics and chemistry of phenomena occurring in electronic devices, and substantial strengthening of our abilities to work with complex systems using computers.

These decisions are based on the program areas we are likely to enter, the basic missions of the Bureau and the Laboratory, the degree to which NEL may be expected to fill a unique position, the current strength of the necessary competences, and our estimate of our ability to build an outstanding group with funds likely to be made available. We choose fluid mechanics and heat transfer because we are certain we shall have programs drawing on these skills for years to come. Examples are the need to describe the behavior of fire in a room, the flow of air in buildings, and to make engineering measurements of combustion processes in various kinds of furnaces.

Basic work in electro-technology is of interest because we see very strong demands developing for measurement techniques in the new world of very large integrated circuits. The stress on handling complex problems on computers reflects our belief that the Bureau needs to improve its scientific computing very substantially. We shall need specialists to formulate analytical models of complex phenomena, specialists to manipulate the sophisticated computer software needed to use these models, to convert results of modelling into graphical displays, to handle data reduction and optimization problems, and other difficult problems in mathematics and operations research. We also want to add to our existing base of competence in data analysis with emphasis on improved statistical techniques for use in regulatory processes.

In future years we shall want to strengthen additional areas. During this calendar year we are to prepare a five-year plan for the Laboratory. This planning process requires a searching assessment of each competence and each program area followed by a series of decisions: which areas are to be enhanced, which stay the same, which new ones are needed. From the exercise will come a rationale for management and budgetary actions required in the years ahead.

The NEL will be unique in its breadth of interests, its charter to serve many clients, its concern for engineering measurements and standards, and its ability to mount a variety of programs addressing National problems. I have indicated our immediate priorities in my testimony but I want to make it clear that there are many more opportunities for us. I am very excited about this proposed new Laboratory and am pleased to have had this opportunity to tell the Subcommittee about it.

I shall be pleased to answer any questions the Subcommittee may have.

ATTACHMENT A

The parts of NBS which will make up the National Engineering Laboratory have responsibilities under the following:

Fair Packing and Labeling Act (P.L. 89–755).
Consumer Product Safety Act (P.L. 92–573).
Noise Control Act of 1972 (P.L. 92–574).
Solar Heating and Cooling Demonstration Act of 1974 (P.L. 93–409).
Federal Fire Prevention and Control Act of 1974 (P.L. 93–498).
Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93–577).
Energy Policy and Conservation Act (P.L. 94–163).
Energy Conservation and Production Act (P.L. 94–385).
Earthquake Hazards Reduction Act of 1977 (P.L. 95–124).

In addition to the nine which remain in force, the NEL portion of NBS was also affected by the Flammable Fabrics Act Amendment of 1967, and the Fire Research and Safety Act of 1968. The Consumer Product Safety Act and the Federal Fire Prevention and Control Act superseded there two Acts insofar as NBS is concerned.

In the paragraphs that follow, NEL's responses to those assignments are summarized.

Fair Packaging and Labeling Act (P.L. 89–755)

Under this Act the Secretary of Commerce was charged with aiding in the development of voluntary standards to reduce undue proliferation of package sizes. The Bureau has assisted in the development of voluntary product standards in some 50 major product categories such as toothpaste and powdered milk. Model laws and regulations have been developed for use by State and local agencies. An example is the model State unit pricing regulation. The NBS effort is now at a maintenance level. The trend to unit pricing has mitigated somewhat the need for this Act. It should be noted that the Act requires package labels to state the quantity contained in English measures.

Consumer Product Safety Act (P.L. 92–573)

Section 29 (d) says "The Commission Shall, to the maximum extent practicable, utilize the resources and facilities of the National Bureau of Standards . . ." The Bureau formed a Center for Consumer Product Technology partially in response to this charge. The Center coordinates NBS activities for the Commission including research, test method development, and technical analysis and advice. Examples are development of flammability test methods for carpets, rugs, children's sleepwear, and mattresses (under the Flammable Fabrics Act now administered by the Commission); technical work for standards for toys, bicycles, lawnmowers, and miniature Christmas tree lights; analysis of possible product defects as reported under section 15(b) of the Act; and longer term research on questions relating to product safety including protective headgear, eye injuries, and combustion phenomena. The Commission funds most of this work. Certainly the product safety issue will be with us for a very long time to come. We believe the breadth of NBS technical expertise will and should be used in support of the Commission's technical work.

Noise Control Act of 1972 (P.L. 92–574)

The NBS role under this Act is found in Section 14 (1)(B): "development of improved methods and standards for measurement and monitoring of noise." This is actually an assignment to the Environmental Protection Agency but the Administrator is to carry out this particular job in cooperation with NBS. The Bureau has a team of specialists in the physics of sound, measurement of sound, and the effect of sound on people. This team has made measurements of noise emission for various products and environments such as railroads, trucks, buses, construction equipment, tires, motorcycles, and corona noise from high voltage electrical power lines. A variety of reports both formal and informal have been made on this work. The EPA sponsors by transfer of funds a small amount of this work ($\approx$\$1,000,000 a year). DOT is sponsoring the power line work at a higher level ($\approx$\$200,000 a year). NBS has \$815,000 base funds in this group. The group is being moved into the engineering laboratory and some of its priorities will likely change as a result. However, emphasis on noise measurement problems will continue.

Federal Fire Prevention and Control Act of 1974 (P.L. 93–498)

In Section 18 of this Act, the NBS organic act is amended to establish a Center for Fire Research and to authorize a detailed series of subjects for the Center to study directly and through contracts and grants. NBS consolidated activities previously handled in different units and, in 1976, added a program of research grants at universities from the NSF RANN operation. Today the Center has a variety of programs aimed ultimately at reducing the Nation's fire losses by half before the end of this century. Significant accomplishments include the research for a series of standards under the Flammable Fabrics Act research and test methods for home smoke alarms research and tests for evaluating fire resistance of interior finishes, structural members, insulation and; smoke control systems; home furniture and toxicity of combustion products. The priorities of the Center are agreed upon in consultation with the Administrator, National Fire Prevention and Control Administration. The budgets of the two units are presented to the Congress for a consolidated program. The outlook for the Center is excellent; we expect to continue to contribute to the technical basis for reducing fire loss and we believe the target of loss reduction can be achieved.

Energy acts

(Solar Heating and Cooling Demonstration Act of 1974 (P.L. 93–409), Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93–577), Energy Policy and Conservation Act (P.L. 94–163), and the Energy Conservation and Production Act (P.L. 94–385).)

In these four Acts, the Bureau has explicit or implicit responsibilities in the Nation's energy program. These include measurement and sandards work and the special case of evaluating inventions under the Federal Nonnuclear Energy Research and Development Act of 1974.

Under the Solar Heating and Cooling Demonstration Act of 1974, interim performance criteria for solar heating and hot water systems were developed within the 120 days specified, draft standards for collectors and storage devices were issued and later became two ASHRAF Standards, and technical work was completed on heating and hot water systems for HUD/FHA Minimum Property Standards issued July 1977. This work is expected to continue at an urgent pace in the year ahead.

The evaluation of energy-related inventions is conducted by a special office set up by NBS in response to the Federal Nonnuclear Energy Research and Development Act of 1974. Dr. Ambler has discussed this program in his testimony, the activity shows no sign of slackening.

Under the two conservation acts NBS has continued its work on energy conservation in buildings, work that earlier produced the basis for the first building energy standard called ASHRAE 90–75. In support of thees Acts, NBS has recently developed revised criteria for materials to retrofit buildings under the Weatherization Assistance Program and Life-cycle costing procedures for conserving energy in Federal buildings.

NBS has developed test procedures for determining the operating costs and energy consumption of twelve categories of home appliances and will complete this phase of the work when the procedure for fornaces is forwarded to DoE this month. NBS has assisted DoE in selecting energy efficiency improvement targets for these home appliances. Analysis of public comments and final targets are to be published by DoE this month. NBS has developed computer software for calculating the energy use in a building. NBS is assisting DoE, CPSC, FTC, GSA, and HUD on safety and performance tests for building insulation.

The future for much of this work seems clear, namely we shall continue to be funded by the other agencies to do measurement, test development and standards work. We are supporting DoE in research to improve performance based design standards for energy conservation in buildings. However, we are not directly involved in HUD's current program to develop building energy conservation standards in response to Title III of P.L. 94–385. We are now working on revisions to earlier interagency agreements which will make clear NBS' responsibilities in energy research.

Earthquake Hazards Reduction Act of 1974 (P.L. 95–124)

This new Act sets up a new Federal program to mitigate the effects of earthquakes. NBS has worked on standards for earthquake-resistant buildings in the past and is mentioned in the Act as one of several agencies which may be expected to participate in the new program. A lead agency is to be designated by the President by the end of this summer. NBS has assisted the Office of the President's Science Advisor in developing an implementation plan and the Director, NBS, is representing the Secretary of Commerce in further deliberations as to how the Act will be implemented. NBS expects to continue its work on building codes and standards in this area.

Senator Stevenson. Mr. Thornton.

Mr. Thornton. Thank you, Mr. Chairman.

I'm pleased to have the opportunity to describe to you the activity of the Bureau's Institute for Computer Science and Technology, which will remain an entity by that title in the Bureau under the Bureau reorganization.

The Institute is responsible for providing Federal computer standards and guidelines, and the scientific and technical advisory and research services that are aimed at helping achieve economy and effectiveness in the Government's acquisition, application, and use of computer technology.

Our job is a big one because we're attempting to gain leverage on the world's largest user of automatic data processing resources. These resources cost the Government over $10 billion a year; comprise more than 10,600 computers staffed with more than 150,000 technical personnel.

The problem of bigness that we face is compounded by the complexity and rapid change of computer technology itself. The Institute's mission is encompassed by Public Law 89–306 of October 1965. This law, more familiarly known as the Brooks Act, has the purpose to achieve economic and efficient purchase, lease, maintenance and operation and use of ADP equipment by Federal departments and agencies.

The law authorizes the Secretary of Commerce to recommend the establishment of uniform Federal ADP standards to provide computer, scientific, and technical advisory services to the Federal departments and agencies, and to undertake the necessary research to support both standards making and advisory services functions.

I would like to turn now to some of the specifics of what we do. The first activity I will discuss is our advisory services role.

For nearly three decades now the NBS has been a source of advice and technical assistance to Federal departments and agencies in their efforts to select and use computer technology. The Bureau achieve preeminence in the computer field by designing and building SEAC, or the Standard Eastern Automatic Computer, one of the world's first internally programed electronic computers.

This advisory work has been done mainly in the Institute for Computer Sciences and Technology and its predecessor organizations. Almost all of the advisory service and technical assistance work has been funded by reimbursements from the Federal agencies requesting help. And these reimbursements have averaged $1.8 million annually over the last 5 years.

We've tried to manage this advisory work so that in addition to benefiting the sponsoring or requesting agency, the end product will help other agencies and contribute to the Institute's standards making and research program.

Our technical assistance and advisory services role to other agencies covers a broad spectrum of ADP activities, including the assessing of the technical feasibility of automating a function or set of functions; designing ADP systems; evaluating vendor proposals for computer systems to be acquired; providing technical monitoring of systems development; and advising the agency on computer security and risk management.

I would like now to turn briefly to our research activities, the second of our responsibilities under the Brooks Act.

These research activities are oriented along two lines, namely, that required as a foundation for standards making; and second, that to support our advisory services role.

I can best describe the research area to support standards making with one example. One of our most important research efforts to support standards making is aimed at improving the quality of computer software, which is the most costly and complex aspect of computer usage.

Some have estimated that software-related activities account for as much as 80 percent of total ADP costs. The Institute is working to advance knowledge and understanding of the deficiencies and problems in the tools for developing software.

We are working currently on the theories and the methods for improving the correctness of software, and assuring that computer systems perform their intended functions accurately.

As I mentioned earlier, some of our research supports are our advisory services responsibility to keep Federal agencies abreast of developments in computer technology. During 1977 the Institute produced some 30 computer science and technology special publications reporting on our investigations into such topics as computer software; computer network interconnection; computer security and risk management; memory and storage technology; and auditing of computer systems.

Mr. Chairman, I would like to concentrate now on the biggest part of our mission, which is the development of Federal information and processing standards.

We're the only agency charged with the responsibility for developing Government-wide ADP standards. Since the passage of the Brooks Act, we have developed and promulgated 31 such standards. We have issued standards in the areas of high-level programing, languages, software, data encryption, data codes for information interchange, computer-magnetic storage media, and computer hardware.

The process of developing standards is a long one. I have described it briefly in my written statement and will not repeat it here.

In spite of our conscientious efforts, there have been criticisms of the Federal ADP standards program. And these criticisms have charged that we haven't produced enough standards; we haven't produced the right standards; and we have relied too much on voluntary commercial standardization activities.

We've taken these criticisms seriously. And we have taken stringent steps to overcome them. We've been strongly supported by the Department of Commerce and by the Office of Management and Budget.

We initiated a major effort in 1976 to strengthen the standards development program and achieve a more meaningful implementation of the Brooks Act. This effort produced a 5-year program plan centered on the standards development function.

This plan, covering fiscal years 1979 through 1983, was the basis for the President's significantly expanded budget request for the ADP standards program for fiscal year 1979.

I have, in the written statement, included a characterization of major features of the 5-year plan, and will pass it now.

The 5-year program plan places heavy emphasis on the standards in the computer software area. This reflects the overriding importance of software problems, and the growing ratio of software to hardware costs in Federal ADP expenditures. In fact, 75 percent of our expansion requests for fiscal year 1979 for developing standards is targetted on software-related problems. Our total expansion request for the Brooks Act program in 1979 is $13.4 million.

The planned development of high-level programing language standards is aimed at reducing the problems of converting software from one set of equipment to another; reducing the costs associated with program conversion; and eliminating software conversion as an obstacle to competitive procurement of competitive computer systems. In September, last year, the GAO reported to Congress, and estimated that software conversions cost the Government about $4.5 million each year.

These high-level programing language standards on which we are focussing, and their potential impact on software conversion costs, take on even more importance when viewed in the context of one estimate that over 80 percent, or about 8,500, of the general management computers in the Federal inventory will be replaced by 1985.

The 5-year plan that I have referenced and earlier described contains several provisions for strengthening the management of the overall ADP standards program. The particulars of this strengthening are described in my written statement.

The 5-year plan itself is focused on 10 priority families of standards to be developed. And again, I have those listed in my written statement, and will, in the interests of time, pass them here.

In summary, Mr. Chairman, the NBS 5-year program plan is a significant and necessary step toward a more meaningful and effective implementation of the Department of Commerce's Brooks Act responsibilities. In addition to constituting an action plan, the 5-year plan places a price tag on overcoming identified deficiencies in the Federal ADP standards program, and meeting the demand plans for a more meaningful implementation of the act.

We will update and extend this plan annually. We intend in the upcoming plannig cycle to broaden the plan; and to strengthen our research and advisory service program.

And finally, Mr. Chairman, I believe that it is entirely fitting that the NBS, which helped launch the era of the computer, should have responsibility for this program, which has such great potential to influence computer technology for public benefit. I believe that the Institute of Computer Sciences and Technology and its Brooks Act mission are well placed at the Bureau, and that in the coming years can make contributions to the Nation that are in keeping with the Bureau's tradition of service to the country.

Thank you, Mr. Chairman.

[The statement follows:]

Statement of Zane Thornton, Acting Director, Institute for Computer Sciences and Technology, National Bureau of Standards

Mr. Chairman and Members of the Subcommittee: I am pleased to have this opportunity to describe to you the activities of the National Bureau of Standards' Institute for Computer Sciences and Technology. The Institute will continue to exist as an entity in NBS under the reorganization. The Institute is responsible for providing the Federal computer standards, guidelines and scientific and technical advisory services aimed at helping achieve economy and effectiveness in the Government's acquisition, application and use of computer technology. Our job is a big one because we are attempting to gain leverage on the world's largest user of automatic data processing resources. These resources cost the Government over $10 billion annually and comprise more than 10,600 computers staffed with more than 150,000 technical personnel. The problem of bigness is compounded by the complexity and rapid change of computer technology.

The Institute's mission is encompassed by Public Law 89–306 of October 1965. This law, more familiarly known as the Brooks Act, has the purpose to achieve economic and efficient purchase, lease, maintenance, operation, and utilization of automatic data processing equipment by Federal departments and agencies. It authorizes the Secretary of Commerce to recommend the establishment of uniform automatic data processing standards, provide computer scientific and technological advisory services to Federal departments and agencies, and to undertake necessary research to support both the standards-making and advisory services roles.

I would like to turn now to some of the specifics of what we do.

For nearly three decades, the Bureau has been a source of advice and technical assistance to Federal departments and agencies in their efforts to select, acquire and apply computer technology. The Bureau achieved preeminence in the computer field by designing and building SEAC, one of the world's first internally programmed electronic computers. This work has been done mainly by the Institute for Computer Sciences and Technology and its predecessor organizations. Almost all of this advisory and technical assistance work has been funded by reimbursements from the Federal agencies requesting help; these reimbursements have averaged $1.8 million annually over the last five years. We have tried to manage this work so that, in addition to benefitting the sponsoring agency, the end product will help other agencies and contribute to the Institute's standards-making and research programs.

Our technical assistance to other agencies covers a broad spectrum of ADP activities, including assessing the technological feasibility of automating functions, designing ADP systems, evaluating vendor proposals for computer systems to be acquired, providing technical monitoring of systems development, and advising on computer security and risk assessment.

I would like to turn now to our research activities. These activities are oriented along two lines, namely, that required as a foundation for the development of standards and that to support our advisory services role.

I can best describe to support standards-making with a few examples. When we were getting ready to develop the Data Encryption Standard to protect sensitive information in computer systems and networks, we had to conduct research into cryptography, the criteria for selecting suitable encryption algorithms, and how to use such algorithms in a computer system.

One of our most important research efforts is aimed at improving the quality of computer software—the most costly and complex aspect of computer usage. Some have estimated that software-related activities account for as much as 80 percent of total ADP costs. We are working to advance knowledge and understanding of the deficiencies and problems in the tools for developing software. Concurrently, we are working on theories and methods for proving the correctness of software, and assuring that computer systems perform their intended functions accurately.

As I mentioned earlier, some of our research supports our advisory services responsibilities to keep Federal agencies abreast of developments in computer technology. During 1977, we produced some 30 computer science and technology special publications reporting our investigations into such topics as computer software, computer network interconnection, computer security risk management, memory and storage technology, and auditing of computer systems.

Mr. Chairman, I would like to concentrate now on the biggest part of our mission which is the development of Federal Information Processing Standards.

We are the only agency charged with responsibility for developing Government-wide automatic data processing standards. Since passage of the Brooks Act, we have developed and promulgated 31 Federal Information Processing Standards. We have issued standards in the areas of higher level programming languages and software, data encryption, data elements and codes for information interchange, computer magnetic storage media, and computer hardware.

The development of a standard is a protracted process because—

1. Obtaining a consensus position on a standard is time consuming.
2. Standards development task forces are frequently staffed by agency volunteers whose time must be divided between standards and their regularly assigned duties.
3. We have depended frequently upon voluntary commercial standards development efforts that are often prolonged by divergent industry views and interests. The recent General Accounting Office audit of the Federal Information Processing Standards Program cites an average of six years to develop a standard.

In spite of our conscientious efforts, there have been criticisms of the Federal ADP standards program. These criticisms have charged that:

We haven't produced enough standards.

We haven't produced the right standards.

We have relied too much on voluntary commercial standardization activities.

We have taken these criticisms seriously and have taken strenuous steps to overcome them. We have been strongly supported by the Department of Commerce and the Office of Management and Budget.

We initiated a major effort in 1976 to strengthen the standards development program and achieve a more meaningful implementation of the Brooks Act. This effort produced a deailed five-year program plan centered on the standards development function. This plan, covering the Fiscal Years 1979–1983, was the basis for the President's significantly expanded budget request for the ADP standards program for Fiscal Year 1979.

The major features of the five-year program plan include:

1. Expedited development of ten families of standards with expected high payoff in cost savings, cost avoidance, and improved productivity in the Government's acquisition and use of computers.

2. Annual updating of Federal ADP standards priorities through working arrangements between NBS, the Office of Management and Budget, General Services Administration, and Federal agencies.

3. Implementation of effective technical and administrative means for measuring and reporting on compliance with ADP standards by Federal agencies.

4. Production of technology forecasts to guide Federal agencies and particularly the central management agencies (NBS, OMB and GSA) in their Brooks Act responsibilities.

5. Development of technical impact assessments and cost benefit analyses for each standard.

The five-year program plan places heavy emphasis on standards in the computer sofetware area. This reflects the overriding importance of software problems and the growing ratio of sofetware to hardware costs in Federal ADP expenditures. In fact, 75 percent of the expansion request for Fiscal Year 1979 for developing standards is targetted on software-related problems. Our total expausion request for the FY 1979 Brooks Act Program totals $13.4 million.

The planned development of high level programming language standards is aimed at reducing the problems of converting software from one set of equipment to another, reducing the costs associated with program conversion, and eliminating software conversion as an obstacle to the competitive procurement of computer systems. In a Sepember 1977 report to the Congress, the General Accounting Office estimated that software conversions cost the Government about $450 million each year. These high level programming language standards and their potential impact on software conversion costs take on even more importance when viewed in the context of one estimate that over 80 percent or about 8500 general management computers in the Federal inventory will be replaced by 1985.

If funded, the five-year plan should lead to the more timely development of standards by strengthening management control of the development process and reducing reliance on purely volunteer, part time labor to staff standards development task forces. Moreover, the plan and adequate funding will give the Government the latitude to reduce dependence on voluntary commercial standardization activities whenever it becomes clear that those activities are not moving at a pace or in a direction that will satisfy essenial Federal goals and requirements. We plan to continue, however, an effective participation in voluntary commercial standardization activities wherever such participation will contribute toward achieving Federal ADP goals in a cost-effective and timely manner.

The five year plan contains a management mechanism for an annual updating of standards priorities. Equally important, the plan contains requirements for the development of technical impact assessments and cost-benefit analyses to accompany each standard. These assessments and analyses will strengthen the process of setting priorities and quantifying the benefits of Federal ADP standards.

Another key management feature of the five-year plan is the provision for an annual Federal-wide ADP standards assesment and program report. This report will serve as a principle vehicle for assessing the impact each year of the computer standards in place. The report will asses compliance by Federal agencies with each standard, thus filling a serious void in the present program.

I mentioned earlier that the five-year plan is focused on ten priority families of standards to be developed. I would like now to describe briefly some of those ten families:

1. We will develop software quality control standards against which to measure software quality at time of procurement and to improve quality in software development, and high level programming language standards to reduce the cost of software conversion.

2. We plan to develop a family of performance assurance standards to assure that computer systems perform their functions correctly and do not perform any unintended functions. These standards are aimed at eliminating the computer errors that waste Government resources or adversely affect the public's privacy, health, or safety.

3. We will establish computer system functional specification standards to permit agencies to procure computer systems and services on a fully competitive basis with regard to end use.

4. The family of computer system and network interface standards will permit the interconnection of competitively procured components in computer systems and networks. These interface standards will enable the Government to select among alternative suppliers and take advantage of competitive pricing.

5. We will develop data base management standards to reduce data conversion problems and permit the efficient use of files.

In summary, the NBS five-year program plan is a significant and necessary step toward a more meaningful and effective implementation of the Department of Commerce's Brooks Act responsibilities. In addition to constituting an action plan, the five-year plan places a price tag on eliminating identified deficiencies in the Federal ADP standards program and meeting the demands for more meaningful implementation of the Brooks Act. We will update and extend this plan annually. In addition, we intend in the upcoming planning cycle to broaden the plan to strengthen our research and advisory programs.

Finally, Mr. Chairman, I believe that it is entirely fitting that the National Bureau of Standards, which helped launch the era of the computer, should have responsibility for this program which has such great potential to influence computer technology for public benefit. I believe that the Institute for Computer Sciences and Technology and its Brooks Act mission are well placed at the Bureau and that in the coming years can make contributions to the nation that are in keeping with the Bureau's tradition of service to the nation.

Senator STEVENSON. Thank you, gentlemen.

Dr. Ambler, could you explain more about what the rationale is for this reorganization? It sounds, at least superficially, like changes in the names of institutes, job titles, creation of the new Center for Cooperative Technology, but otherwise cosmetic.

What's the effect of this reorganization really going to be? What's its rationale?

Dr. AMBLER. I think there are three substantial benefits that NBS will derive from this reorganization, Mr. Chairman.

The first is that we shall be organized along major functional lines. I have described the dual functions of the Bureau as the Central Reference Laboratory and as the Laboratory that applies its expertise to the solution of particular national problems. Reflecting those roles in the National Measurement Laboratory and the National Engineering Laboratory, respectively, and in clearly identifying the organizations responsible for the Organic Act responsibilities will enable our management to clearly focus on these basic functions of the Bureau of Standards.

Second, this reorganization gives us the opportunity to consolidate competences. We have been operating under the existing structure for many years now, and there is a need to consolidate our existing competences in appropriate parts of the Bureau of Standards. Such consolidation will also give us an excellent basis for building for the future and for adding competences.

The third effect that will be achieved is that we shall achieve a greater flexibility than we have in the present organization. The number of formal organizational units will be substantially reduced, from 249 to 106. The intent is to provide flexibility for changing programs, for changing assignments, without the need for formal transfers and becoming involved in a great deal of paperwork.

Thus, I see these three benefits as being much more than cosmetic, Mr. Chairman, in allowing us to manage the Bureau in a much more efficient way.

Senator STEVENSON. In your submission to OMB, it was stated that "sections will be eliminated as an organizational level within the reorganized Bureau." I also understand that internal Bureau documents state that sections are going to be retained.

Can you explain that apparent discrepancy?

Dr. AMBLER. Sections will not exist as a formal organizational unit, in the sense that many of the administrative functions that are presently performed in sections will be carried out at a higher level.

In some cases, sections will be retained, but the concept of the section will differ, that is, such a "section" will be technical working group. Indeed, in addition to the title "section," we expect to use "task forces" and other such titles that will constitute the section and equivalent groups more as a group of technical experts working on technical problems, and not an administrative unit within the Bureau.

The sections will be concerned with technical work, technical decisionmaking, and not with a great deal of administrative decisions.

Senator STEVENSON. You said, "competencies would be consolidated." How does that happen? And why should it? What's the advantage?

Dr. AMBLER. Well, if you've been operating for many years, programs change; the kinds of people that work on these programs change; the kind of expertise that's needed is changing; and you find that you have, throughout the organization, common expertise that is diffused throughout the organization.

And by "consolidating competencies" I mean bringing groups together that are concerned with similar scientific and engineering problems and making units that are bigger and more viable.

For example, we had in the old organization a group working on electronics—the kind of thing that Dr. Lyons was describing. We had, in the Institute for Basic Standards, a group working on electrical standards; a group in Boulder, Colo., working on electromagnetics, microwaves, radio; we had another group in Boulder working on cryoelectronics—that is, the use of very low-temperature circuits to make certain kinds of measurements.

These had developed very logically, according to the advances in science and needs for technology, but now there is a great advantage to pulling those activities together in a Center for Electronics and Electrical Engineering, which would be a center in the National Engineering Lab.

Senator STEVENSON. Can you explain how this fund for maintaining competencies in performing basic research will operate? It's to be build to a level equivalent to 15 percent of NBS's total resources, and is that interdisciplinary?

Does that cut across all of these labs? How does it work?

Dr. AMBLER. Yes. In the 1979 budget, there is a request for $2 million which is to help build competence in various areas.

Senator STEVENSON. Let me interrupt at that point. OMB says that: "For purposes of the 1979 budget, this fund will equal 15 percent of the NBS directly funded programs, plus a $2 million increase which wasn't in the NBS budget request."

So, the $2 million is just a part of it, isn't it?

Dr. AMBLER. Yes, sir; that's correct.

We interpret the OMB position as being that if we have, or if we had at the Bureau, 15 percent of our work that was supporting this, we could show it.

Our analysis shows that we do not have that amount at the present time, and that $2 million is one step in helping us build up to that level.

Senator STEVENSON. You say you don't have 15 percent supporting it?

Dr. Ambler. 15 percent of the work—the present work—of the NBS is not in place or available for building competencies.

Senator Stevenson. I guess that's what I don't understand. What is this fund—15 percent, or $2 million, whatever it amounts to—for? What do you mean by "building competencies"?

Dr. Ambler. Over the past 10 years, we have been responding to new demands placed on the Bureau. And, in my opinion and the opinion of the staff and visiting committee, in the opinion of the Department of Commerce, in doing so we have not been able to pay attention to those scientific and engineering skills that will be needed by the NBS to respond to future needs.

We have been responding to short-range problems, and not paying sufficient attention to the strength of the institutions, scientifically and technically.

The fund is to help us to do that; to look to the future and to establish skills at the Bureau of Standards that we do not have at the present time—either at all, or in sufficient strength.

Senator Stevenson. Is it for planning, then? Or is it for actually maintaining the competency?

Dr. Ambler. It's not for "planning," Mr. Chairman, no. It's to enable us to bring in new people, and to strengthen our scientific staff.

Senator Stevenson. But except for $2 million, it all comes out of funds that are programed for the laboratory. They're not additional funds.

Dr. Ambler. It is my understanding that if we can convince OMB that we do not have 15 percent of our funding available, that we can make our arguments to them, approach them again and try to convince them that other installments might be needed to build up to this level.

[The following information was subsequently received for the record:]

OMB determined during the fiscal year 1979 Budget review process to perform an overview study of NBS and to provide in the NBS a fund for maintaining competence and carrying out long-term activities in furtherance of NBS mission objectives. This fund is to be gradually built to a level equivalent to 15 percent of the NBS total resources, both direct and reimbursable. OMB assumed that the 15 percent share applicable to NBS directly funded efforts was essentially in place and recomended a $2 million increase aimed at beginning the funding of the share applicable to the reimbursable program. (Using estimates of total NBS resources for fiscal year 1979, this fund is equivalent to 15 percent of $155 million or $23.3 million; $13.7 million related to direct funds and $9.6 million to reimbursements) Funding levels at NBS in existing programs devoted to long-term activities which are aimed at building technical competence are not equal to the $13.7 million level. The overview study to be conducted with OMB will help to establish the level now in place and the short-fall that must overcome.

Senator Stevenson. I see.

Now, could you explain what the proposed National Center for Cooperative Technology is going to do? And, let me say that I'll probably be directing questions mostly to you, Dr. Ambler, but it's up to you all to decide how to answer them.

What is this National Center for Cooperative Technology? Why is it in the Bureau? It sounds as if it is aimed at supporting industry in ways that are foreign to the purposes of the Bureau.

Dr. AMBLER. I don't really take that position, Mr. Chairman.

It's true that, at the present time, there is little if any of our work that is of this nature, but this state of affairs has not always been true of the NBS.

The NBS has, in the past, been involved in the development of basic technology. Under wartime conditions, for example, worked on basic technologies such as glass manufacture, ceramics, rubber, and many others.

The Bureau has always maintained a close working relationship with industry. Most of our services at the present time are of a more basic infrastructure kind—but we have also been involved in this technology development in a cooperative mode in the past.

It seems to me that the merits of the program, intrinsically—irrespective of where the program is located—are very strong, and very timely. Furthermore it seems to me that an excellent place to try to develop this kind of program would be at the Bureau of Standards, in view of its borad range of skills and its broad connections with industry.

Senator STEVENSON. Well, what's it going to do? You say in your statement that the $2 million is "to investigate the desirability and feasibility of a cooperative technology program which would advance critically needed technologies common to disaggregated industries, or small independent firms in selected industry groups."

Now there's harly a word in that sentence that doesn't raise a question in my mind.

First of all, was this $2 million sought in your budget request by you, by the Bureau?

Dr. AMBLER. I think this request was incorporated later. Because, when the Bureau's budget went to the Department of Commerce, these ideas were just developing. Efforts in cooperative technology were in the discussion mode. This request was certainly included in the budget that was submitted to the OMB.

Senator STEVENSON. Well, is the $2 million to actually provide technical assistance? Or just to study the feasibility and to develop a cooperative technology program?

Dr. AMBLER. It's the latter, Mr. Chairman: To study the feasibility, and to try to design a way to achieve an appropriate program.

Senator STEVENSON. And the notion is to do what? "Advance critically needed technologies"—what are they? And who decides what is "critically needed"? Will this be the Bureau? Or will it be Mr. Baruch? Or somebody else?

Dr. AMBLER. Well, as I mentioned in my testimony, one of the crucial words in this program is "cooperative." We in the Government have had experience which has led us to the very definite conclusion that in working in the civilian technology area it is very important to have the interest of the affected industries. The industries themselves identify the kinds of problems that they have. At their request, we sit down with them and discuss what technology can do about these problems.

And so, one of the principal features of this program—one of the prinicpal ways in which I expect it will operate in fiscal year 1979 if funds are appropriated, is through a great deal of discussion with particular industries concerning their problems.

Certainly, no one within the Government—either the NBS or the Department of Commerce—will tell industries what we think they need. But we can extend an offer to work with them to see if there's anything industry and Government can do cooperatively to bring about the goals of a cooperative technology program.

Senator STEVENSON. Is this study of desirability and feasibility going to involve the shoe industry?

Dr. AMBLER. Yes, sir, it could involve the shoe industry. We already have two of our staff members working with the staff of the Assistant Secretary for Science and Technology Office and with other person's within the Department to see whether there is anything the concepts of cooperative technology can be doing to improve the U.S. shoe industry.

Senator STEVENSON. Any other industries in this initial phase?

Dr. AMBLER. There are a number of discussions going on between the Department and various industries. One such is with the apparel industry. Another is with the jewelry industry in Rhode Island. Those examples are all that I can call to mind at this moment, Mr. Chairman.

Senator STEVENSON. The jewelry industry, the shoe industry, and the textile industry: are these industries identified as a result of their initiative or some initiative of the Bureau or the Department? Do you know?

Dr. AMBLER. These industries have come to the attention of the Department, the shoe industry in particular, because, I think of the concern for so-called impacted industries.

Senator STEVENSON. Well, there are a lot of impacted industries, and some of them could be regarded as more essential to the public welfare than the jewelry industry, let's say, or even the shoe industry. The steel industry, for one. Or electronics generally.

I just question how in the world we focus on the shoe industry, which, according to GAO, isn't apparently impacted by foreign competition after all, or at least not seriously; or the jewelry industry. Maybe the textile industry is an appropriate one.

But my larger question is whether this activity is proper in the NBS. I'm not suggesting that the notion of identifying the industries, or better yet, identifying the markets for which products are needed, and then identifying an industry that may be capable of producing those products, isn't a legitimate, important activity for Government; though it seems to me there are many questions as to how you do that.

But the propriety of putting this activity in the Bureau, which is a neutral scientific and engineering body with a strong reputation, is doubtful to me, to my way of thinking. And the charter for the Bureau refers to assistance with respect to standards and basic measurements.

But does it authorize such activities as are contemplated for this Center? Can you cite the authority in the law?

Dr. AMBLER. I can't cite it at this moment, Mr. Chairman, but I certainly did have the attorneys at the Bureau and the attorneys at the Department of Commerce check the authority. They assured me that this activity is authorized under the Organic Act, and under the mission of the Department of Commerce of which NBS is a part.

Senator STEVENSON. If you have any opinions, or at least opinions of attorneys, or at least citations to provisions of the law which do arguably confer this authority on the Bureau, we'd be glad to have them for the record.

[The following information was subsequently received for the record:]

The citation for the proposed Cooperative Technology Program is as follows: 15 U.S.C. 1512; sec. 2, 31 stat. 1449, as amended; sec. 1, 64 stat. 371; (15 U.S.C. 272); 64 stat. 823 (15 U.S.C. 1152); Reorganization Plan No. 3 of 1946, Part VI: Reorganization Plan No. 5 of 1950.

The NBS budget for FY 1979 includes an increase of $2,000,000 and 18 positions to investigate the feasibility and desirability of a cooperative technology program and, if the program is determined to be warranted, to develop a plan for its operation. Once the study and planning phases are completed, one option is that the program be established organizationally as the National Centers for Cooperative Technology.

Senator STEVENSON. Dr. Ambler, you have previously said that you consider appointment of a Deputy Director for the Bureau to be of the highest priority.

When will a Deputy Director be appointed, and what responsibilities will be assigned to his or her position?

Dr. AMBLER. The paperwork connected with our being able to post a vacancy announcement and to recruit a Deputy Director is presently in the Department. One of the first things that I did after my confirmation was to initiate the process for recruiting a Deputy Director. I expect to have the position of Deputy Director filled within 2 or 3 months, allowing for proceeding via the civil service regulations, since this is a competitive position.

The dutes of the Deputy Director, principally, will be to assist me in the internal management of the Bureau. During the time I have been Acting Director I have spent a great deal of time on internal management functions—I considered it to be my responsibility—to make sure that the Bureau continued to function smoothly. Thus I paid a great deal of attention to what was going on inside NBS, with the feeling that I have neglected some of the external representation that is needed by the Director of the Bureau, not only in making presentations and speeches, but particularly in visiting and interacting with industries and universities.

This interaction is the something that I have greatly missed. Yet it is something that I very much want to do, to find out on my own the way that people are thinking about science and the way various industries see their problems.

So I expect the duties of the Deputy Director with respect to daily internal management to help me, most of all by allowing for more time for interaction with scientific and technological communities.

Senator STEVENSON. Now, returning to computer sciences, the fiscal 1979 budget provides for a $15.4 million increase in the budget of the Institute for Computer Sciences and Technology. The budget for those activities in fiscal 1978 was only $4.5 million.

Can you tell us how these additional funds are going to be used and assure us that that very substantial increase can efficiently and usefully be absorbed in such a short period of time?

Dr. AMBLER. Yes, Mr. Chairman.

Of that increase of $15 million there is a substantial amount intended for the use of contracts. The expertise available in computer sciences in universities and nonprofit organizations is considerable. Hence, we think NBS can make a more rapid yet accurate response to the Brooks Act mandates by making wide use of these outside resources.

There are funds for positions within NBS of course contained in this increase. By using NBS personnel and by judiciously recruiting and using outside resources, we expect to be able to use this additional money effectively.

Senator STEVENSON. I understand that GAO has been looking at this activity. Has it issued a report yet? Or have you seen the draft report? I have not.

Dr. AMBLER. Ask Mr. Thornton.

Mr. THORNTON. On the 22d of December, I believe it was, the GAO did put out to some agencies a draft of its report of audit or review of the Federal ADP standards program. And it is only a draft so far as I know; as of yesterday, it was.

The process is for the GAO to obtain review and comment by the agencies that are mentioned or involved, and then as appropriate to take those comments and make necessary changes in the draft. A final report to Congress can then be issued.

And to my knowledge, that has not happened yet.

Senator STEVENSON. Wasn't the draft report very critical, and isn't the final report likely to be?

Mr. THORNTON. Well, certainly, the draft of the report was very critical.

The final report, one would assume, would also be fairly critical.

Senator STEVENSON. Are the criticisms unjustified?

Mr. THORNTON. Given the way in which GAO levels criticisms, it would be hard to say that they are not justified.

But my belief is that allegations that NBS has not produced enough standards, or we haven't produced the right standards, written bare, or said without any elaboration, ignores the fact that, given the level of funding that we have had since the beginning of the Bureau's involvement, there is no way we could have produced enough standards, assuming that one knows what "enough" standards is. And I'm not sure that the GAO report says what "enough" is. They say what some of the right ones are, but not necessarily all of the right ones.

So it's been a matter of lack of resources within the Institute or within NBS to carry out a program that would produce a heavier level of standards.

Senator STEVENSON. Are the funds budgeted for fiscal 1979 adequate?

Mr. THORNTON. Well, they're certainly adequate to allow us to do a much more meaningful implementation of the act, "meaningful" being defined as a response to the criticisms and the guidance that we have had from the House Committee on Government Operations in October 1976, and also in other reports that the GAO have done in the Federal ADP area, exclusive of or in addition to the audit report.

Senator STEVENSON. Now check me if my figures are wrong, Dr. Ambler; but I understand that the NBS requested for 1979, a budget authority of $99.3 million, and was allowed $90.8 million. If so, that's $8.5 million less than it requested in budget authority. And that OMB increased—I'm not sure whether this means over requests or over the preceding year—funds for nondestructive evaluation; nuclear reactor modernization; oil recycling; automated technology; ADP standards just mentioned—over $13 million right there; planning and competency building, which we've discussed also.

Now if the overall request for budget authority was decreased, and these items were substantially increased, what happens to the other items? Didn't you take a bad beating on other subjects? What are they?

Dr. AMBLER. I don't have the figures here. I don't recall that such was the case with regard to most of the items that you mentioned.

Senator STEVENSON. I think I'm being a little unfair. I think that the items I mentioned to you are for funds increased over 1978. They may or may not be above or below what was requested, but if you're going up over $13 million just for ADP, over last year, and your budget authority is down $8.5 million from what you requested, you must have lost something.

Dr. AMBLER. We did enter requests with respect to these items, with OMB, including the one for the Brooks Act. However, NBS did lose funding in one area in the OMB budget process, namely, our base funding in the air and water pollution program.

Senator STEVENSON. And resource recovery.

Dr. AMBLER. No, sir, I don't believe that is correct.

No, sir, I think you were perhaps speaking about the program in recycled oil.

The 1979 budget does contain an amount for the annualization of the request with respect to our program involving characterization and uses for recycled oil. Funds for this program are being requested in 1978 as a supplemental appropriation.

[The following information was subsequently received for the record:]

The recovery and recycling of oil is covered by the Energy Policy and Conservation Act of 1975 (Public Law 94–163), which directs NBS to develop test procedures to establish the substantial equivalency of rerefined used oil with virgin oils for various end uses. The Administration has endorsed direct funding for NBS to carry on this work through a fiscal year 1978 supplemental budget request of $1,600,000 and 13 positions and continued of funding for fiscal year 1979. NBS activities in the area of resource recovery are mandated under the Resource Conservation and Recovery Act of 1976 (Public Law 94–580). The Administration has determined that funding for NBS activities in this area should be through reimbursement from EPA, and discussions have been initiated.

Senator STEVENSON. Well, I have a document from OMB which says the 1979 budget does not have funds for the requested research in the following areas: Air pollution, water pollution, and resource recovery.

Furthermore, the allowance does not include $1,920,000 of the requested base funding for environmental programs.

Is it your understanding that the activities that were to be covered by these funds are just being assumed by other agencies?

Dr. AMBLER. In the case of air and water pollution, we are presently negotiating with the EPA to obtain funding from them to carry out these efforts.

The negotiations seem to be going quite well at the present time.

With respect to resource recovery—if by that you mean recycled oil—NBS has been allowed to go forward with a supplemental budget request for fiscal year 1978 of $1.56 million and there is in the fiscal year 1979 budget a request to annualize that amount.

24–751—78——5

Senator STEVENSON. Now, Dr. Hoffman, in your prepared comments you referred to a contract with Battelle Columbus Laboratories to study the economic effects of corrosion in the United States.

It's our understanding that this contract was awarded on a sole-source basis.

Can you explain why it was awarded on that basis?

Dr. HOFFMAN. I was informed that Battelle had an input-output economic analysis technique there, thus, it would be very efficient to deal with them so that NBS could handle economic data in that manner.

That was the fundamental reason that was done.

Senator STEVENSON. Did you survey other potential contractors to determine whether that was also the case with him?

Dr. HOFFMAN. I didn't do so personally, but I believe that was done, to the best of my knowledge.

Senator STEVENSON. You believe that was done by the Bureau.

Does anybody know?

Dr. HOFFMAN. I don't happen to know the exact answer to that question, no.

Senator STEVENSON. Who would know?

Dr. HOFFMAN. I believe I could ask our legal counsel or our procurement people to find that out, sir.

Senator STEVENSON. Would you submit that information for the record?

Dr. HOFFMAN. I certainly would, sir.

[The folowing information was subsequently received for the record:]

The decision to award the contract to Battelle Columbus Laboratories to study the economic effects of corrosion in the United States was arrived at after careful study and deliberation by NBS scientific and Department of Commerce procurement and legal personnel. The NBS scientific staff members who were involved in these deliberations possessed considerable expertise in corrosion research and had a broad knowledge concerning which institutions had corrosion expertise germane to the intended study. In their professional judgment, Battelle Columbus Laboratories exclusively possessed the extensive knowledge of corrosion technology essential to the conduct of the study. In fact, the basis for concluding that Battelle should receive the award rested on the fact that Battelle previously had conducted a study on the "Technical Economic Evaluation of Air Pollution Corrosion Costs on Metals in the U.S." Further, in the opinion of the NBS staff, that study was one of the best done on the economic costs of corrosion, and amply demonstrated Battelle's superior competence in this area. The coupling of corrosion and economic expertise was imperative for the performance of the study. A copy of the detailed discussion which was submitted to the procurement sections of NBS and DoC in support of the sole source procurement action taken in this matter is attached.

SOLE SOURCE JUSTIFICATION

The work to be accomplished, as outlined in the attached prospectus, requires first and foremost an interdisciplinary research center with expertise in socio-economics, technical economics, materials economics, information handling and corrosion technology. In particular, the study requires that an evaluation be made of the extent to which the best available corrosion technology is being used in all sectors of American industry and other sectors of the economy. To meet this requirement, a deep and broad knowledge and involvement in all phases of corrosion technology must be the key characteristic of the institution carrying out the proposed study. Battelle Memorial Institute uniquely fits this requirement because the manager of its Corrosion Division, Walter K. Boyd, has developed unparalleled in-depth knowledge through his vast experience of over thirty years in the corrosion field at Battelle to interact with the corrosion problems of an extremely broad segment of American industry and other sectors of the economy. In meeting this responsibility he has assembled a staff that is the broadest and most competent in the U.S. from the standpoint of corrosion technology. Moreover, because Mr. Boyd and his staff provide corrosion expertise to Battelle's Metals and Ceramic Information Center, they have access to one of the most extensive store of corrosion information.

In addition, Battelle also has a world renowned group working on high temperature corrosion problems that is separate from Mr. Boyd's group. Mr. Boyd's very broad knowledge of corrosion technology derives not only from his access to all the resources of Battelle and his involvement in research on a multitude of corrosion problems from industries and other sectors of the economy such as the pipeline, chemical, defense, solid waste disposal (the corrosion of incinerators) industries, but also from his and his staff's continual involvement in failure analysis and interaction with the other companion group(s) at Battelle Memorial Institute. His preeminence in this activity, which requires unusually expert knowledge of corrosion technology, is attested to by the fact that he serves on failure analysis review boards of NASA and the Air Force. He has been very active in organizations concerned with spreading the best available corrosion technologies, e.g., internationally, AGARD (an arm of NATO), and nationally, the National Association of Corrosion Engineers (NACE). He has been a director of the latter organization since 1969, and he and his staff have chaired and served on key committees of that organization. These committees are concerned with disseminating the most advanced corrosion technology, over the whole gamut of American industry and other sectors of the economy. Also, he was recently chosen by NACE to represent independent not-for-profit research organizations on a U.S. delegation investigating corrosion technology in the Soviet Union.

Because the proposed study must produce a product that will be universally accepted by government and industry alike, the study must be carried out by the foremost expert in the application of corrosion technology to industrial problems and other sectors of the economy. Mr. Boyd and his staff at Battelle possess the highest expertise available as required by our program, along with an institution that has the required technical economics and socioeconomic abilities and a superb position in the materials information field (it is the home of a number of relevant information centers: Metals, Ceramics, Copper, Iron, Cobalt, Energy, Automated Search, Battery Information Centers).

Senator STEVENSON. Back again to computer sciences.

Does the Institute for Computer Science and Technology have any mission in addition to those under the Brooks Act?

Dr. AMBLER. No, sir. The Institute for Computer Science and Technology is responsible only for the Brooks Act, at least in the new organization. In the present organization, the Institute was responsible for operating the central computation facilities of the National Bureau of Standards, and we propose to move that to another group.

Senator STEVENSON. Dr. Lyons, under the new National Engineering Laboratory, what will be the role of the experimental technology incentives program which many people believe to be one of the most innovative in the Government?

Dr. LYONS. If I may, Senator, I'll refer that question to Dr. Ambler.

Dr. AMBLER. The function of the experimental technology incentives program will not be changed as a result of the reorganization. We do intend gradually to modify some of the ways that NBS has been carrying out the program.

We have found in working with the various Federal agencies with respect to their procurement regulations, that we have been getting rather deeply involved in administrative problems associated specifically with those agencies. We hope to eliminate that aspect insofar as possible so as to concentrate more on the basic thrust of the program, namely, the role of—or rather the kinds of policy changes that would—on the part of the Federal Government lead to encouragement of technological innovation.

We've been getting slightly away from technology while being drawn to an extent into administrative operations. We intend to make a correction on that account.

Senator STEVENSON. Dr. Hoffman, you referred to measurement services provided by the Institute for Materials Research in radiation.

This is a subject of particular interest to this subcommittee.

Given the proliferation of radiation-emitting devices, how adequate is our measurement capability for various types of radiation; and specifically, do we have adequate measurement capabilities for radiation in the microwave part of the spectrum?

Dr. HOFFMAN. Sir, if I may respectfully pass that one on to my colleague, Dr. Lyons, who just acquired that group.

Senator STEVENSON. Is this part of the reorganization?

Dr. LYONS. The test methods are not adequate, Senator, for much of the problem, and I described some of this in my testimony. We are at work attempting to do two things, really. First, to be able to measure stray electromagnetic radiation in the environment, to measure it precisely enough to take corrective measures, if possible; and second, to be able to determine the effect of such radiation on electronically controlled devices. And there we are particularly concerned with new microprocessors that we feel are going to be all around us in the future—microcomputers that may be on board our automobiles in another year or two, which may indeed be sensitive to this kind of interference.

And one of the greatest concerns that we can see now in industry is coming from the automotive industry. They want to know how to measure this, how to quantify the effects on these computers that they propose to have in their automobiles.

Senator STEVENSON. Are you involved in determining levels of exposure for human beings?

Dr. LYONS. We are involved only in the measure of the field itself. We are consulting with NIOSH and others who are involved in determining the effect of such radiation on human tissue.

Senator STEVENSON. Do you feel that the resources in the budget are adequate for all your activities in this field?

Dr. LYONS. Yes, sir.

Well, I should hasten to point out that I think it's an area that should grow, and we are putting our proposals in to devote some of our competence money in the future for building up our strength in this area.

I also expect we'll probably have a programatic initiative next time around.

Senator STEVENSON. Well, based on what I have heard in this committee—we have had a number of hearings on this subject now—it's a growth field, and we don't begin to understand what all the effects are going to be—of radiation, both nonionizing and ionizing, in all parts of the spectrum—on human safety, as well as equipment such as you have described.

I would hope that this would figure heavily in your 5-year planning and would get adequate attention in future budgets.

I'm not the expert, but I suspect we're going to need to devote far more resources in the future than we are now to this subject.

Do you disagree with that general proposition?

Dr. LYONS. No, I agree. It's going to grow. I think we have a good base. I think we do know how to get a handle on the problem. And I do expect it to grow.

Senator STEVENSON. Do you feel there is adequate coordination with the other agencies that are interested in this subject?

Dr. LYONS. I really can't answer that.

I've had some conversation with our people in Boulder—in fact this week they indicated that the coordination is good—but I can't give you my own judgment yet on that.

Senator STEVENSON. Do you do any work for DOD in this field?

Dr. LYONS. The same division at Boulder does do, I think, an extensive amount of research for DOD, but I don't know if they're working on EMI.

Dr. AMBLER. Yes, we do carry out some work for DOD, Mr. Chairman.

I would say that the connections we have established with various other agencies are good, not only with NIOSH but with the Bureau of Radiological Health and other regulatory agencies.

I would say that this illustrates one of the strong points about the Bureau of Standards; we do work rather well and rather extensively with other Federal agencies.

Senator STEVENSON. Could more dollars be spent usefully on this subject in fiscal 1979 than are budgeted?

Dr. AMBLER. We shall be, in the next few months, conducting extensive program reviews within the NBS. I'm sure that interaction with other Federal agencies is one of those areas that Dr. Lyons will raise as being an area in which the Bureau could well expand its activities. Before giving a definite answer to your question, I'd like to wait and see what the various other areas are that the program managers of the Bureau feel might be expanded. Only then can I assess the various priorities in the context of all NBS activities.

But I certainly do share your feeling that this is an important area for the Bureau to be providing a very strong response.

Senator STEVENSON. I understand the executive office of the President is planning a major study of the Bureau.

Can you tell us anything about this study, how it's going to be conducted and over how long a period of time, and how the results might change the Bureau in the future?

Dr. AMBLER. I don't know the details of how the Office of Science and Technology Policy proposes to go about this study.

I have had one conversation with a member of Dr. Press' staff who indicated that he plans to visit me at the end of February or the beginning of March.

Senator STEVENSON. It's his office that's conducting the study, OSTP?

Dr. AMBLER. Yes, sir, that's my understanding. I think OSTP is involved at the request of OMB.

To go on, I really welcome this opportunity—I look forward to displaying for OSTP the programs of the Bureau of Standards in depth. I intend to explain to the study team the increasing number of requests being made of the Bureau of Standards by its clientele. My goals are to convince the study team that the NBS can vigorously and efficiently respond to these demands and to make a convincing case that the NBS is an outstanding Federal laboratory that can be used more than it has been in the past.

Senator STEVENSON. Have you received any indication of the role the Bureau will play in this study?

Dr. AMBLER. No, sir.

It's my understanding that the first meeting will be aimed at discussing how OSTP proposes to go about this study.

I have every indication that they will take into account any suggestions I might have.

Senator STEVENSON. I'm going to have to wind up now.

You've been very helpful to us, and we may have some additional questions which I will take the liberty of submitting to you in writing, and we'd be glad to have your answers in writing for our record, along with other additional comments that you might wish to make.

As I think you know, this is the first of our oversight hearings. We'll be holding another on April 6 th in which the Assistant Secretary, Mr. Baruch, will testify.

Thank you very much gentlemen.

This hearing is adjourned until April 6th.

[Whereupon, at 11:20 a.m., the subcommittee adjourned, to reconvene Thursday, April 6, 1978.]

[The following information was subsequently received for the record:]

FISCAL YEAR 1979 BROOKS ACT INITIATIVE: EFFICIENT PROCUREMENT AND UTILIZATION OF COMPUTER RESOURCES BY THE FEDERAL GOVERNMENT

MANAGEMENT PLANNING CONSIDERATIONS

NBS plans to initiate in FY 1979 a significantly augmented and strengthened program in support of its Brooks Act (PL 89–306) responsibilities. This program will provide the needed standards to achieve increased economies through more competitive ADP procurement and improved ADP utilization by Federal agencies. Toward this objective, the program will:

1. Address the criticisms of the present NBS program as outlined in the House Government Operations Committee Report of October 1, 1976.
2. Address the criticisms of the several GAO Federal ADP audits conducted within the last five years and the findings of deficiencies by the on-going GAO audit of the Federal ADP standards program;
3. Carry out the responsibilities assigned to NBS by OMB in (a) the OMB (BOB) Letter of December 15, 1966, (b) Executive Order 11717, dated May 9, 1973, and (c) the OMB Letter to Congressman Brooks dated January 19, 1977;
4. Reflect the changing patterns of computer procurement and usage due to changing technology, e.g., minicomputers, microcomputers, and computer networking; and
5. Meet the requirements of new assignments to NBS, such as those resulting from the Privacy Act of 1974.

Although many criticisms were cited and deficiencies identified in the above references, the FY 1979 program addresses only those which NBS considers to have had the greatest negative impact on Government procurement and use of its highly complex computer resources. Major problems areas *not* addressed in the FY 1979 program include: (a) stated needs for computer scientific and technological advisory services to Federal agencies, and (b) identified research and development needs in areas not directly related to computer standards activities.

Deficiencies apparent in the first ten years of NBS' Brooks Act activities will be overcome by the program reorientation to be initiated in FY 1979 through planned efforts such as:

1. Expediting the development of *families of standards* with a high payoff in cost savings, cost avoidance, and improved productivity to Government. Ten such families of standards with these attributes have been singled out in this management plan;

2. An annual updating of *Federal priorities* through formal working arrangements between NBS and (1) OMB, (2) GSA, and (3) individual Federal agencies;

3. the implementation of effective technical and administrative means for measuring and reporting to OMB on *compliance* by Federal agencies with the NBS-issued standards;

4. The production of *technology forecasts* to guide Federal agencies and particularly the Federal ADP central management agencies of OMB, NBS, and GSA in their Brooks Act responsibilities;

5. The development of *technical impact assessment and cost benefit analyses* to accompany each standard;

6. A strong program in *high level programming language standardization* to reduce the costs of software conversion in the Government; and

7. A strong program in *software management* to improve quality control in software development, and to assure adequate marketplace mechanisms for software acceptance and cost reductions in software maintenance.

NBS has alreadly taken some important steps preliminary to and necessary for its major Brooks Act program reorientation of FY 1979. NBS has: (1) developed a five-year computer standards program plan structured for easy and responsible review by both the executive and legislative branches of Government (see Attachment), (2) identified the development, maintenance, technology impact assessment, and cost benefit analysis costs associated with each standard in its five-year program plan, (3) brought together senior policy officials from 16 agencies which together have over 95% of all Federal computers to review and comment on NBS' plans, and (4) prepared for the signature of the Secretary of Commerce a letter which was transmitted to heads of Federal agencies and departments informing them of DOC's intent to implement its computer standards compliance responsibilities, and initiated planning together with Federal agency representatives for compliance reporting.

These actions, accompanied by others underway and planned for FY 1978, will set the stage for the significantly different and improved UNBS computer sciences and technology program to commence in FY 1979.

HIGH PRIORITY FAMILIES OF STANDARDS

NBS has identified ten high priority sets (families) of standards as viewed by the House Committee on Government Operations, GAO, representatives of individual Federal agencies, and NBS. These are:

1. *High level programming language standards* to reduce the costs of software conversion and permit non-programmer specialists to use computers effectively: Such standards cover existing languages originally developed for business and scientific applications, improved languages to be standardized for general use and improved productivity, and standard protocols designed for cost-effective use of large and small computers and networks.

2. *Software quality control standards* against which to measure software quality at time of procurement and to improve quality in software development: Quality control standards cover the areas of management and control of software development projects, the analysis and design of software, software testing, and software documentation.

3. *Computer system and network interface standards* to permit the interconnection of competitively procured components in computer systems and networks: Computer system and network interface standards are required to permit the successful interconnection of competitively procured computer system and network components. It is only through the development and use of families of such interface standards that performance and cost advantages of competitive procurement of computer system and network components can be used to full advantage by Federal agencies while at the same time assuring reliable and efficient system operation.

4. *Data base management standards* to reduce data conversion problems and permit the efficient use of files: Data base management standards cover areas such as data entry; data translation; data management application system planning, design and conversion; and data management software design, evaluation and validation. These standards respond to Congressional and GAO demands to requests from other Federal agencies.

5. *Computer security and risk management standards* to protect information and reduce risks and vulnerabilities in computer systems and networks: Computer security standards cover such areas as computer system physical security, access controls, and data encryption to protect information in transmission between computers.

6. *Performance measurement and evaluation standards* to increase the efficiency of computer systems and networks: Standards for performance measurement and evaluation are essential both in the initial selection of computer systems and services as well as in assuring the most efficient continued operation of computer systems. When selecting systems, networks, and related services, performance measurement and evaluation standards permit requirements to be met in terms of performance a least cost. During system and network operation, performance measurement standards provide the basis for improving the efficiency of systems and networks such that the Government continues to receive maximum benefit for its ADP investment.

7. *Data standards* to facilitate the interchange of data in machine sensible form: Data standards cover the identification and definition of data elements and their representation and structure as required for the collection, processing and interchange of machine sensible data. These include both general and application specific data standards that reduce the costs of Federal computer operations by eliminating unnecessary duplication and incompatibilities. These standards respond to the expressed needs and recommendations of Congress, the Comptroller General, the Office of Management and Budget, Federal departments and agencies, state and local governments and industry.

8. *Computer system functional specification standards* for competitive procurement: Computer system functional specification standards are required to permit agencies to procure computer systems and services on a fully competitive basis with regard to end use. This contrasts to specification in terms of performance for a given configuration, or even design specification in which specific system components may be identified.

9. *Performance assurance standards* to assure that computer systems perform their functions correctly and do not perform any unintended functions: These standards deal directly with the problem of computer errors that waste Government resources or adversely affect the public's privacy, health, or safety. The standards will cover user requirements and control specific to various computer applications.

10. *Standards to improve management of Federal computerized models:* Standards to improve the management of Federal computerized models cover such areas as documentation, specification, development and procurement. This activity responds to a specific need cited by GAO in a report to the Congress.

In addition, technology forecasts will be made to aid in the updating of standards priorities and to assist agencies in long range planning of computer systems and networks. These forecasts will alert agencies to changing conditions that provide opportunities to better plan for future needs in computer systems and networks. This activity responds to requests for increased emphasis by the Office of Management and Budget and by the Department of Commerce.

PRODUCT DELIVERY SCHEDULE FOR THE NBS FEDERAL-WIDE ADP STANDARDS PROGRAM

The NBS program, reoriented to better meet its Brooks Act responsibilities and to meet the major cited deficiencies of its present program, will begin in FY 1979. Planning for the five-year period FY 1979-FY 1983 has been accomplished in terms of program deliverables or products which are principally standards and technology forecasts. Most such program products have important associated interim products, such as preliminary guidelines and accompanying validation services. These additional products are also separately identified in the Five-Year Plan (Attachment). The products for which activity is shown in FY 1979 and the delivery schedule for those products are based on the FY 1979 budget request as shown in Table 1.

Highlights of NBS Management Planning for the Fiscal Year 1979 (and Subsequent Years) Federal-Wide ADP Standards Program

Key management features of the strengthened Federal ADP Standards Program singled out for special attention include:

1. An Annual Federal-Wide ADP Standards Assessment and Program Report

This report—a new and critically significant product in NBS' program—will serve as the principal vehicle for assessing the impact each year of the computer standards then in place. This annual report will assess compliance by Federal agencies with each standard and will also present the priorities for standards development for the appropriate fiscal year budget, together with the need and economic benefits expected.

The report will comprise a Government-wide assessment of the Federal ADP standards program. This report will be included in DOC's budget transmittal to OMB and the Congress. The plans for the report have been discussed with OMB, the staff of the House Government Operations Committee, and GAO. The consensus view is that the report will fill a serious void in the present management of the Federal ADP standards programs.

The report will contain information on (1) benefits of past standards and cost/benefit analyses of planned standards, (2) compliance measurement and assessment of standards, (3) current standards priorities with the endorsement of Government policy officials, and (4) a detailed allocation plan of requested funds for all Federal ADP standards activities. NBS is requesting resources directed toward Federal-wide ADP standards needs. It will then allocate a portion of these resources to other Federal agencies, the private sector, and other organizations as appropriate. NBS will provide the management for the entire Federal-wide ADP standards development effort.

2. A Measurement and Reporting System for Federal-Wide ADP Standards Compliance

NBS has initiated the preliminary steps to develop a reporting system on ADP standards compliance within the Federal Government. The reporting system will lead to an assessment of standards compliance by Federal agencies. This assessment will be contained in the Annual Report. A letter has been approved by the Secretary of Commerce requesting the assistance of all agencies in developing this reporting system. This letter also has been discussed with OMB, GAO, and Congressman Brooks' staff.

3. Priority Setting Mechanism for Standards Development Based Upon Cost Benefit Analyses and Policy and Operational Considerations

Based upon inputs received from the Office of Management and Budget, the Comptroller General and senior ADP policy officials from Federal agencies, there is a recognized requirement for establishing a formalized priority setting mechanism for the development of standards. NBS, in cooperation with Federal agencies, will establish a process for updating current standards priorities based on recognized needs and policy considerations and supported by cost benefit analyses.

4. Review and Update of ADP Standards and Guidelines

NBS will review, periodically, all standards to assure that they continue to meet predetermined economic and operational objectives and continue to be technically and administratively sound. Review of standards will result in their reaffirmation, revision or withdrawal. Review of guidelines can result in their being converted to standards or in their updating and reissuance. Generally, standards will be reviewed once every five years and guidelines once every three years.

5. Policy Guidance on Technical Issues and Coordination for Government-Wide Specialized ADP Service Functions

NBS plans to extend its Brooks Act activity in providing increased coordination and policy guidance on technical issues for Government-wide specialized ADP service functions provided by other Federal agencies. This includes coordination between the service centers and NBS in order to implement an effective user supportive Federal standards program. Special ADP service functions include validation services for standards compliance, software support

24-751 O—78——6

services and other Government-wide specialized ADP services such as FEDSIM and the proposed software conversion center of the Department of Defense.

SUMMARY FUNDING REQUIREMENTS FOR THE FEDERAL ADP STANDARDS PROGRAM

The table which follows shows the ten (10) high priority families of standards as well as the two functions supportive of the standards program and the requested funding for each.

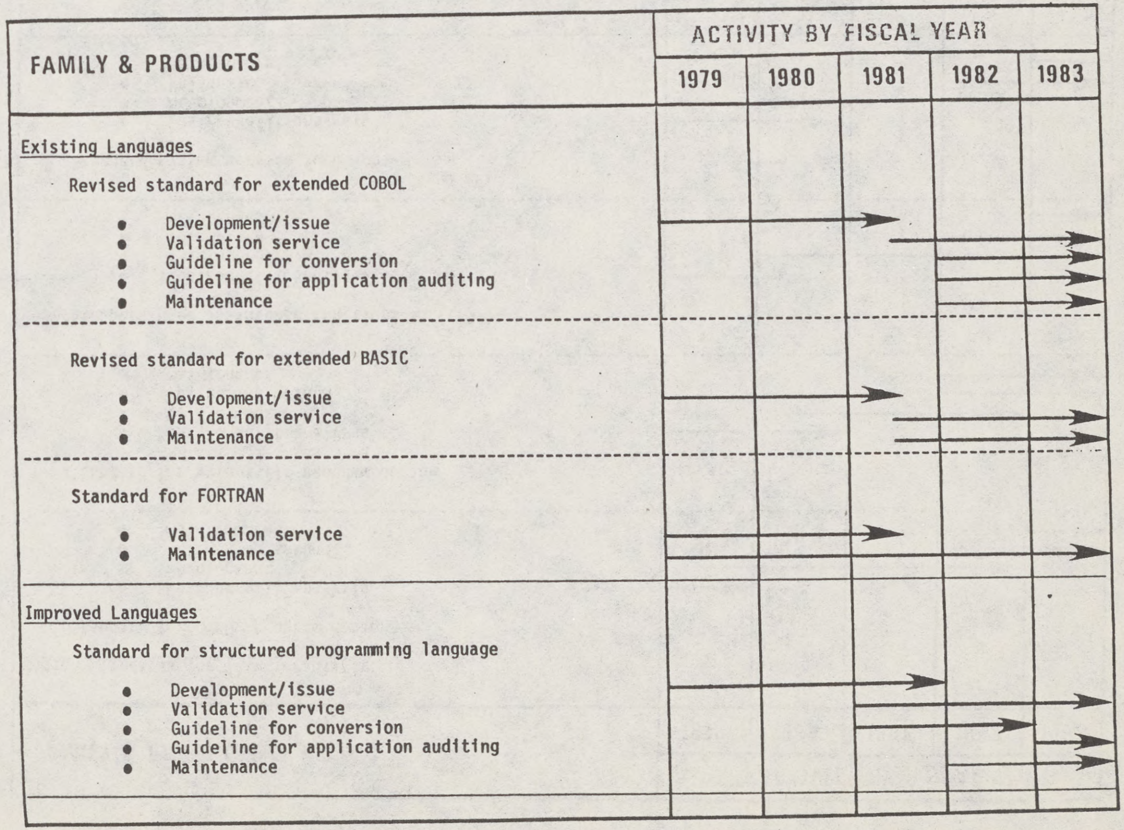
TABLE 1.—FISCAL YEAR 1979 REQUEST TO CONGRESS FOR THE FEDERAL ADP STANDARDS PROGRAM

[Dollar amounts in thousands]

Priority	Standards families	Fiscal year 1979 base	Fiscal year 1979 requested increase		Fiscal year 1979 total request
			Amount	Positions	
1	High-level programing language standards	$364	$1, 000	4	$1, 364
2	Softwa:e quality control standards	498	502	3	1, 000
3	Computer system and network interface standards	1, 077	3, 710	14	4, 787
4	Data base management standards	110	1, 500	3	1, 610
5	Computer security and risk management standards	720	250	0	970
6	Performance measurement and evaluation standards	370	130	0	500
7	Data standards	141	0	0	141
8	Computer system functional specification standards	141	1, 395	1	1, 536
9	Performance assurance standards		2, 985	2	2, 985
10	Management standards for Federal large-sacle computerized models		300	1	300
	Technology forecasts	705	495	1	1, 200
	Standards management	253	800	4	1, 053
	General purpose equipment		342		342
	Total	4, 379	13, 409	33	17, 788

ATTACHMENT—FIVE YEAR PRODUCT PLAN FOR A FEDERAL-WIDE ADP STANDARDS PROGRAM

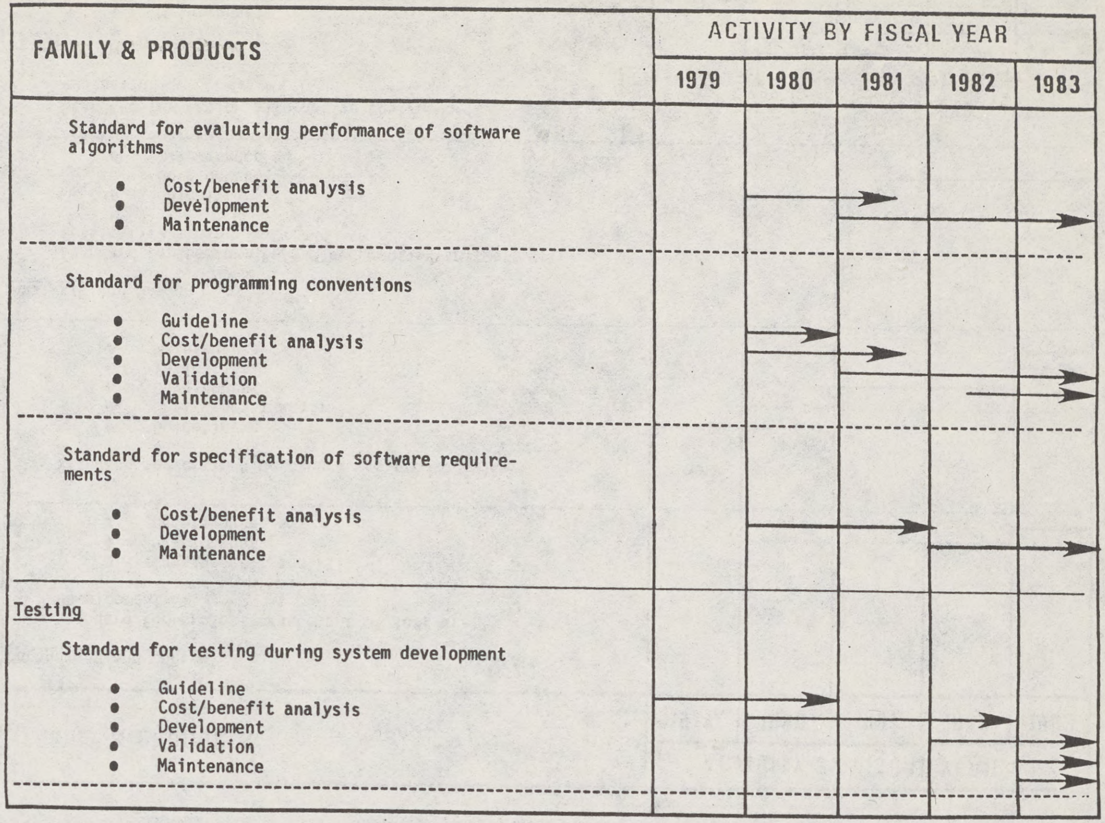
HIGH LEVEL PROGRAM LANGUAGE STANDARDS

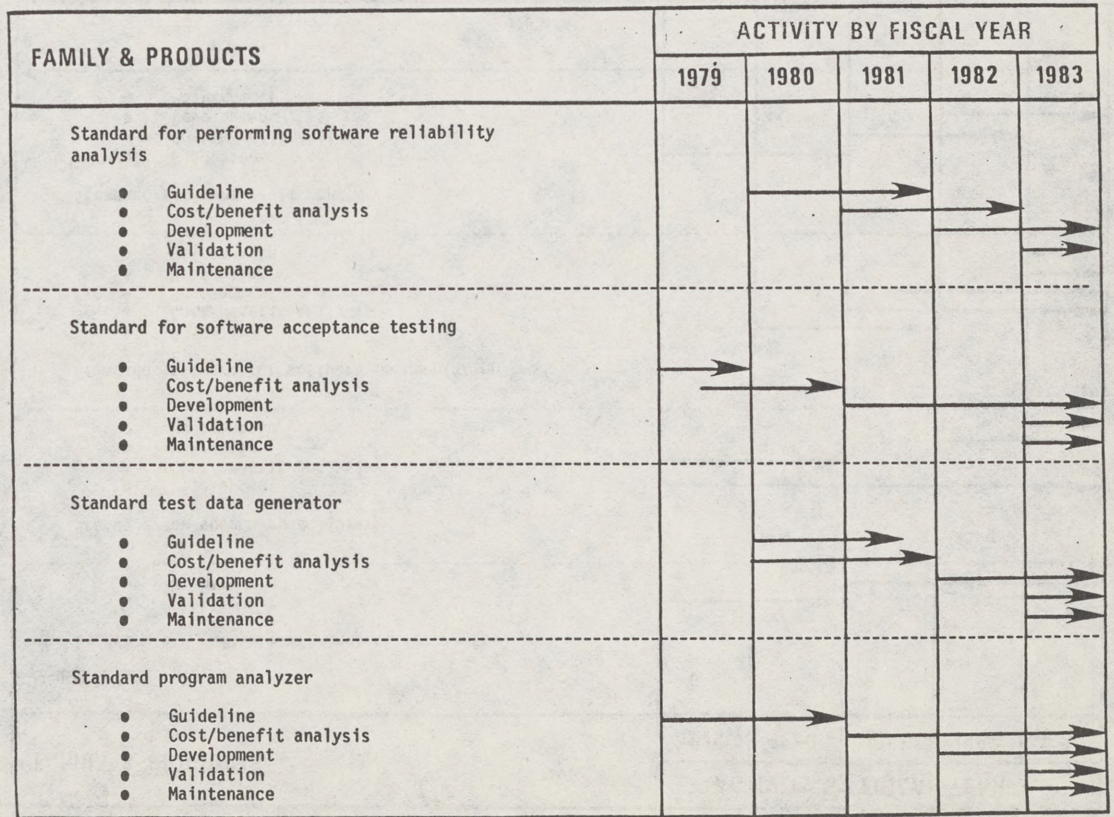


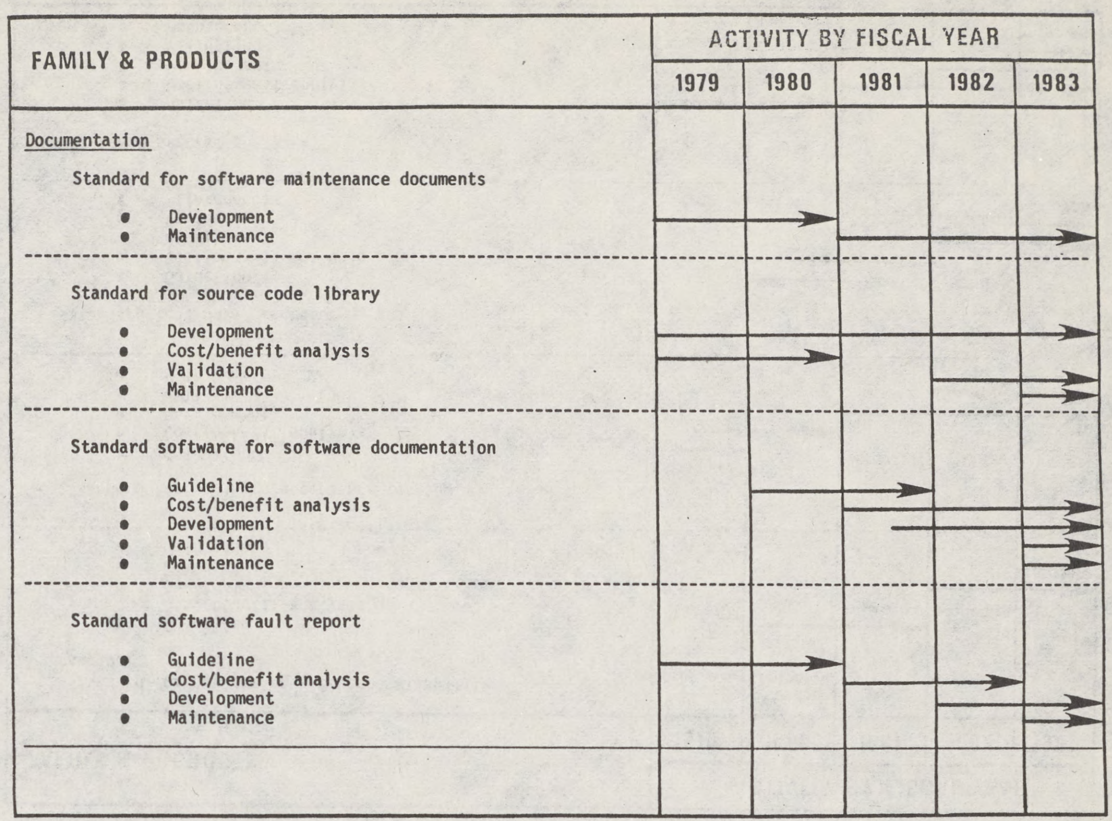
FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR				
	1979	1980	1981	1982	1983
<u>Design Standards for Transferability</u>					
Standard for COBOL program design					
• Cost/benefit analysis					
• Development					
• Validation method					
• Maintenance					
Standard for scientific program design					
• Cost/benefit analysis					
• Development					
• Validation method					
• Maintenance					
Standard user assistance functions					
• Cost/benefit analysis					
• Development					
• Validation					
• Maintenance					
Standard system service functions					
• Cost/benefit analysis					
• Development					
• Validation					
• Maintenance					

SOFTWARE QUALITY CONTROL STANDARDS

FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR 1979	1980	1981	1982	1983
Management and Control					
Standard for project management of software development					
• Cost/benefit analysis	→				
• Development		→	→	→	
• Maintenance					→
Standard for estimating programmer productivity					
• Guideline	→				
• Cost/benefit analysis		→			
• Development			→	→	
• Validation					→
• Maintenance					→
Analysis and Design					
Standard for performing and documenting software feasibility study					
• Guideline		→	→		
• Development			→	→	→
• Maintenance					
Standard for design alternative cost/benefit evaluation					
• Guideline		→	→		
• Development			→	→	→
• Maintenance					

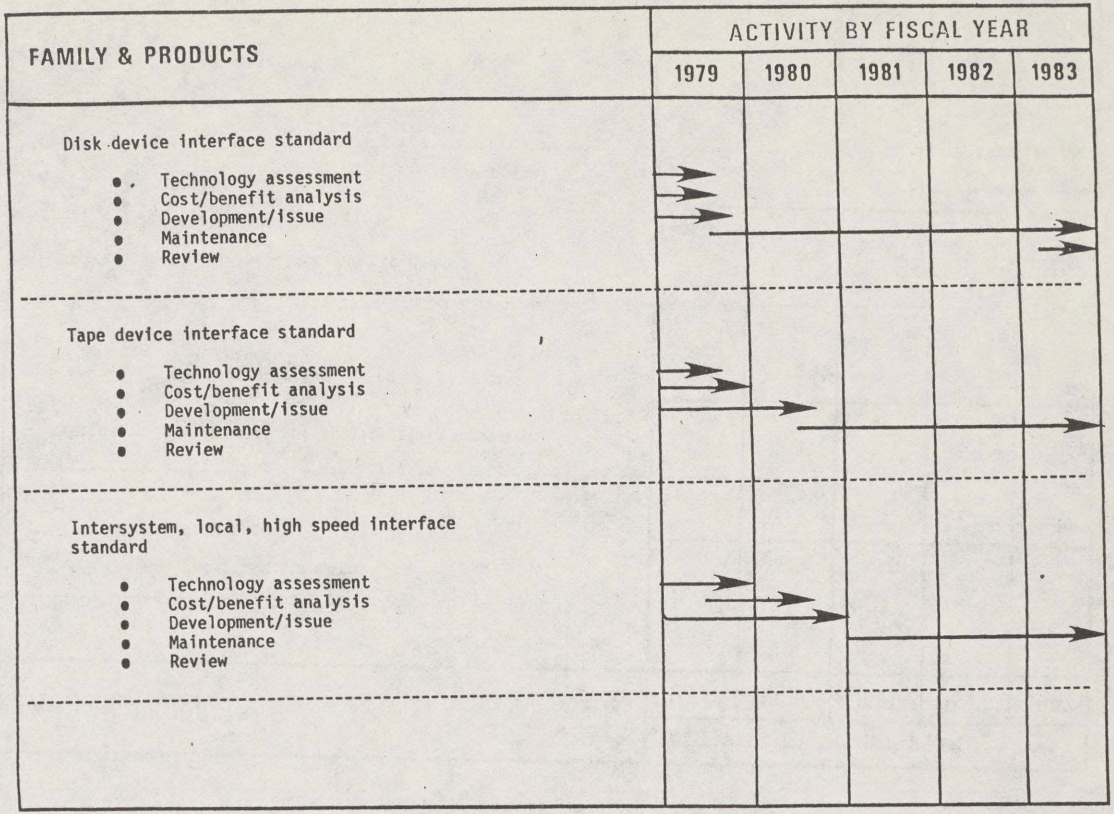

FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Standard for evaluating performance of software algorithms
• Cost/benefit analysis
• Development
• Maintenance
Standard for programming conventions
• Guideline
• Cost/benefit analysis
• Development
• Validation
• Maintenance
Standard for specification of software requirements
• Cost/benefit analysis
• Development
• Maintenance
Testing
Standard for testing during system development
• Guideline
• Cost/benefit analysis
• Development
• Validation
• Maintenance

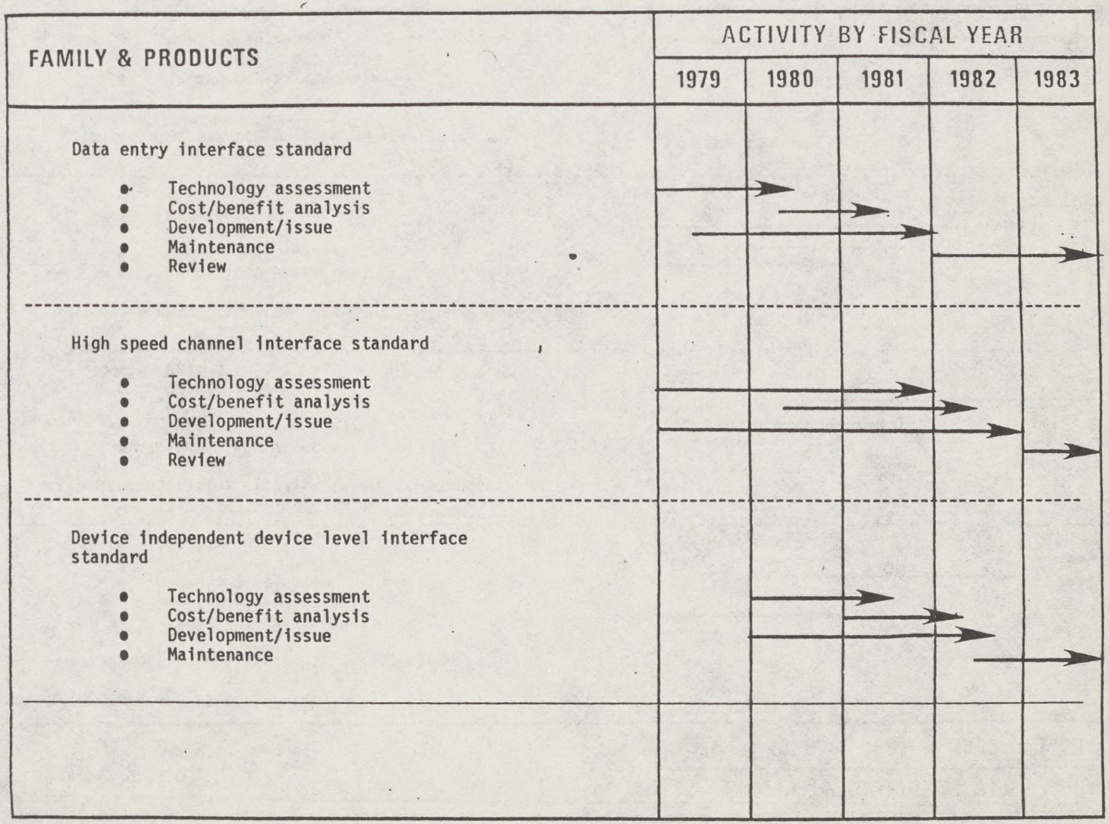

FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Standard for performing software reliability analysis
Guideline
Cost/benefit analysis
Development
Validation
Maintenance
Standard for software acceptance testing
Guideline
Cost/benefit analysis
Development
Validation
Maintenance
Standard test data generator
Guideline
Cost/benefit analysis
Development
Validation
Maintenance
Standard program analyzer
Guideline
Cost/benefit analysis
Development
Validation
Maintenance

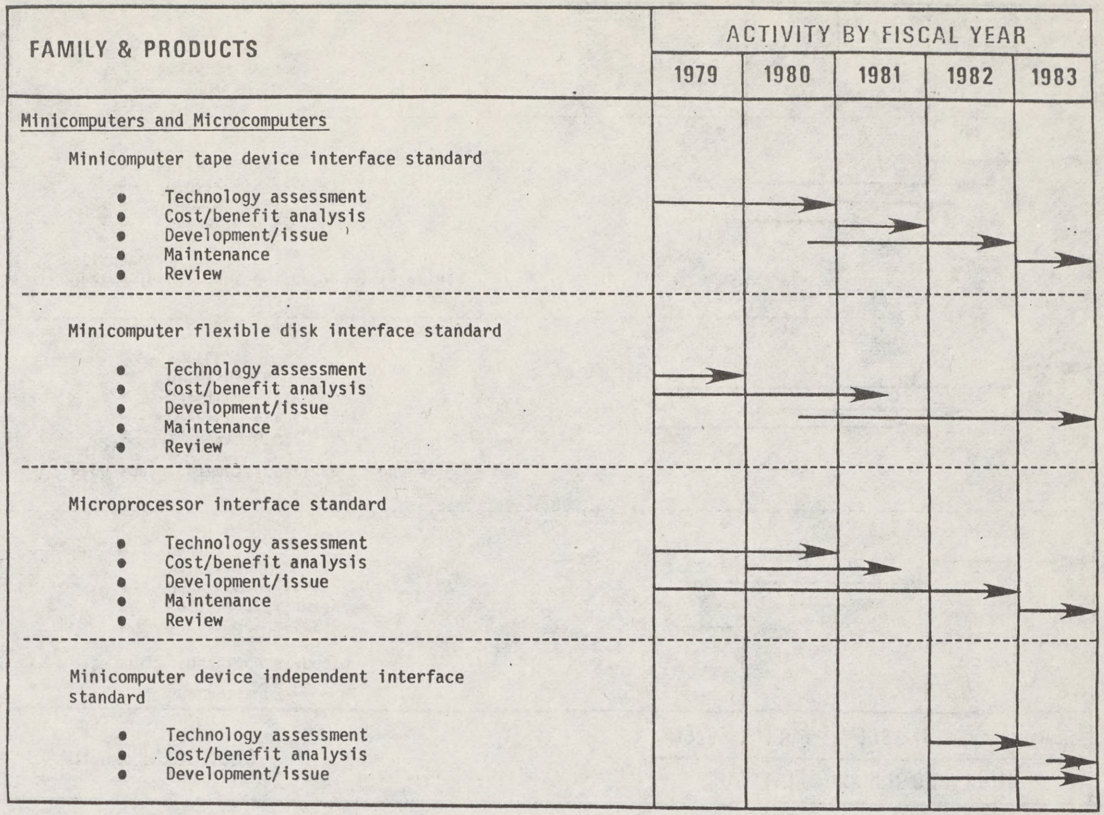

FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Documentation
Standard for software maintenance documents
• Development
• Maintenance
Standard for source code library
• Development
• Cost/benefit analysis
• Validation
• Maintenance
Standard software for software documentation
• Guideline
• Cost/benefit analysis
• Development
• Validation
• Maintenance
Standard software fault report
• Guideline
• Cost/benefit analysis
• Development
• Maintenance

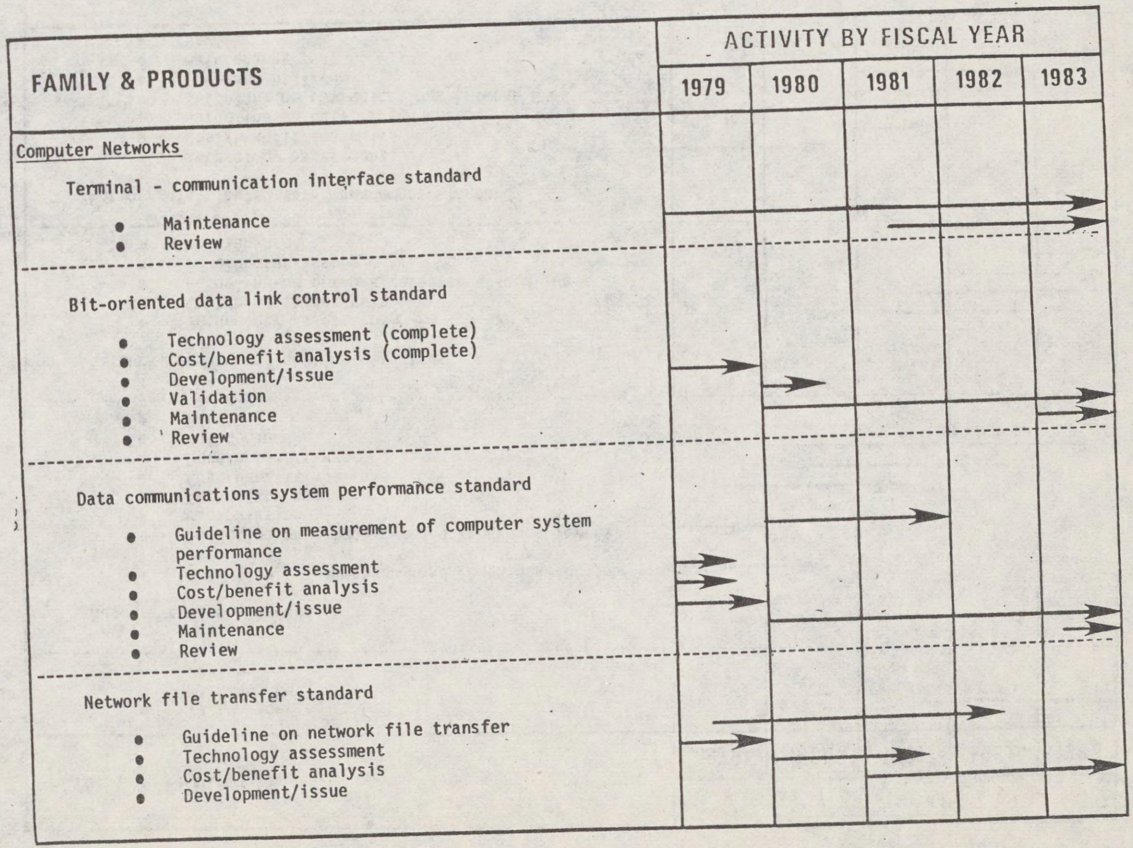
COMPUTER SYSTEM AND NETWORK INTERFACE STANDARDS

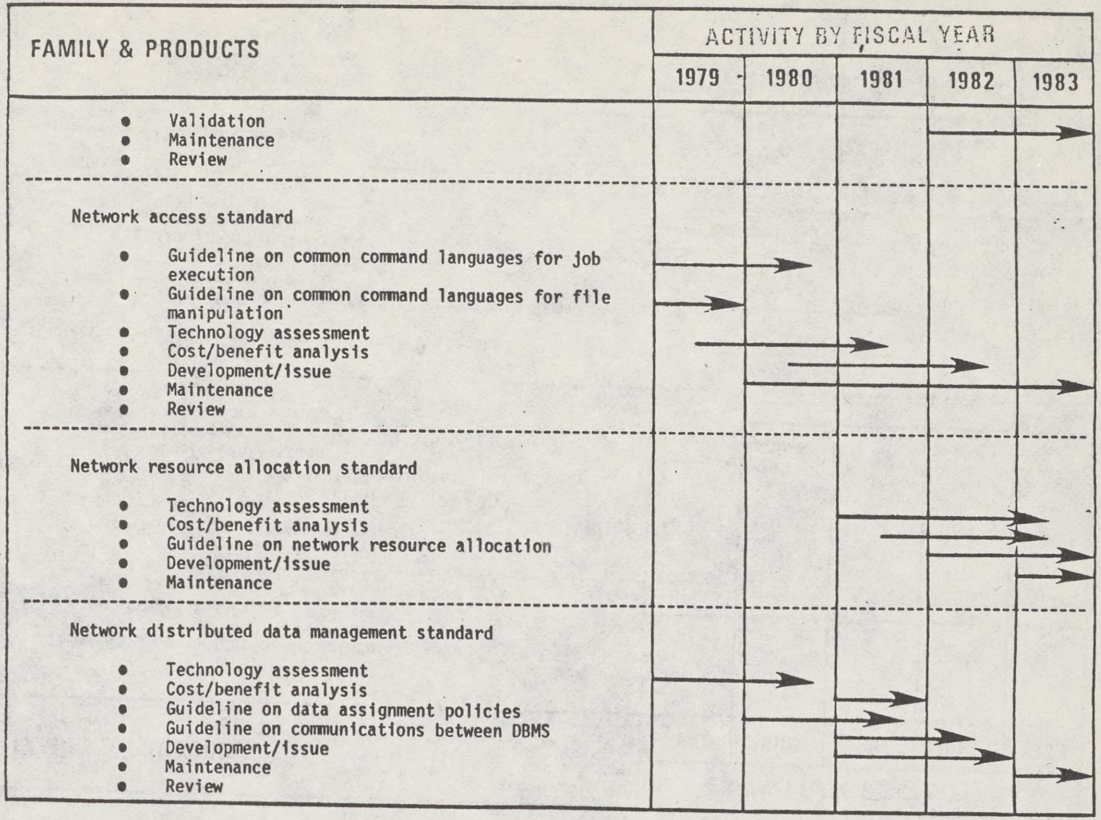
FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR				
	1979	1980	1981	1982	1983
<u>Large Scale Systems</u>					
I/O channel interface standard					
• Maintenance	→	→	→	→	→
• Review				→	→
Magnetic tape operational specification standard,					
• Technology assessment	→	→	→	→	→
• Development/issue				→	→
• Maintenance					
• Review					
Disk operational specification standard					
• Development/issue	→				
• Maintenance	→	→	→	→	→
• Review				→	→

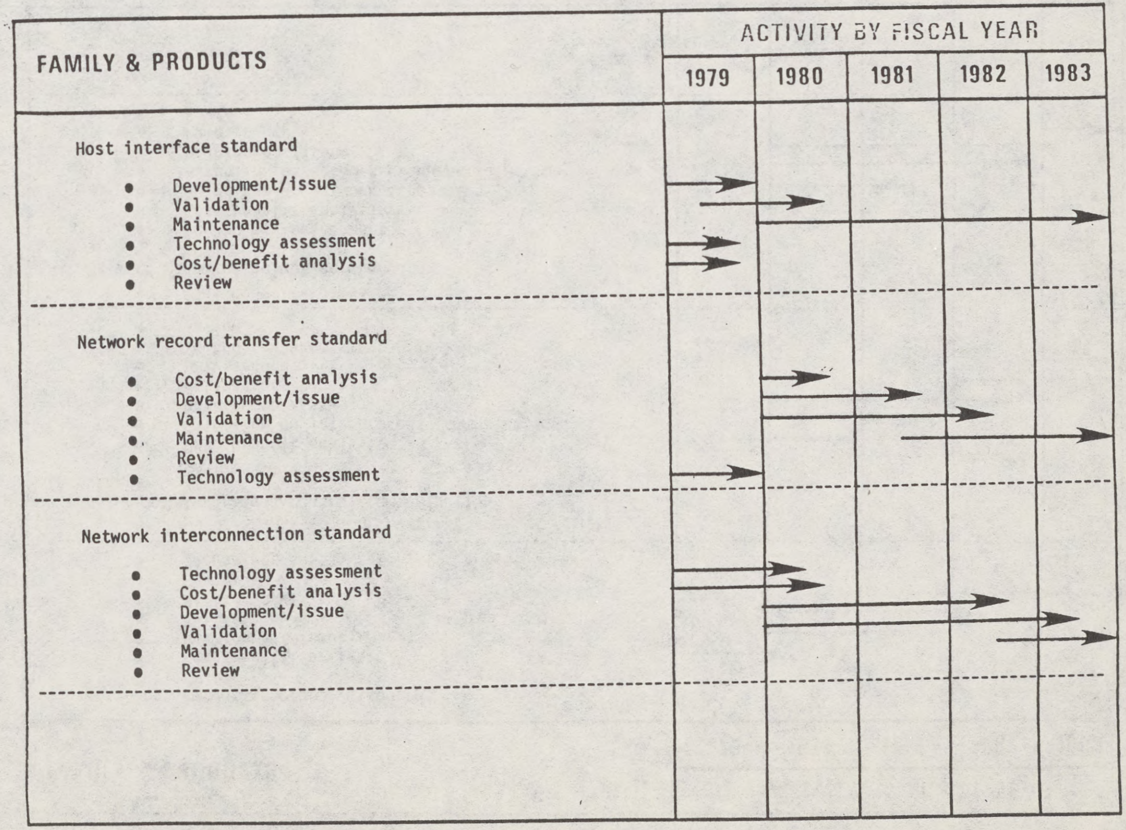

FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Disk device interface standard
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Maintenance
• Review
Tape device interface standard
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Maintenance
• Review
Intersystem, local, high speed interface standard
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Maintenance
• Review

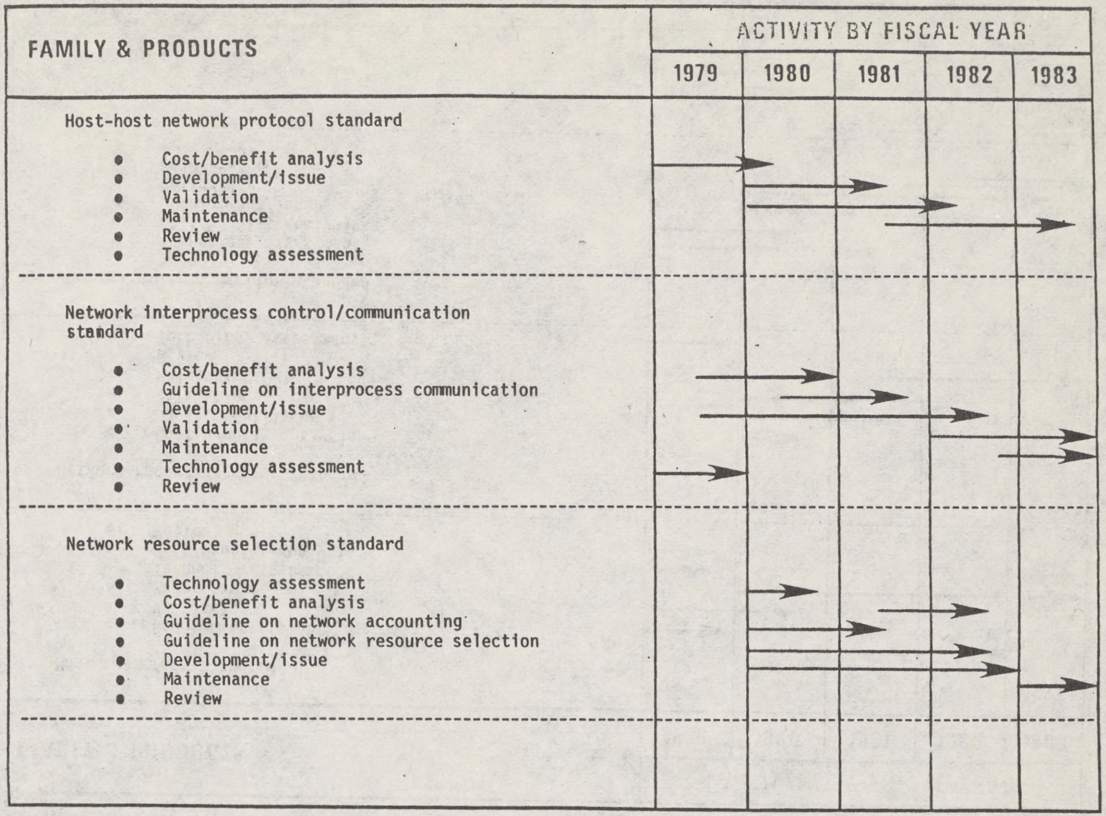

FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Data entry interface standard
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Maintenance
• Review
High speed channel interface standard
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Maintenance
• Review
Device independent device level interface standard
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Maintenance

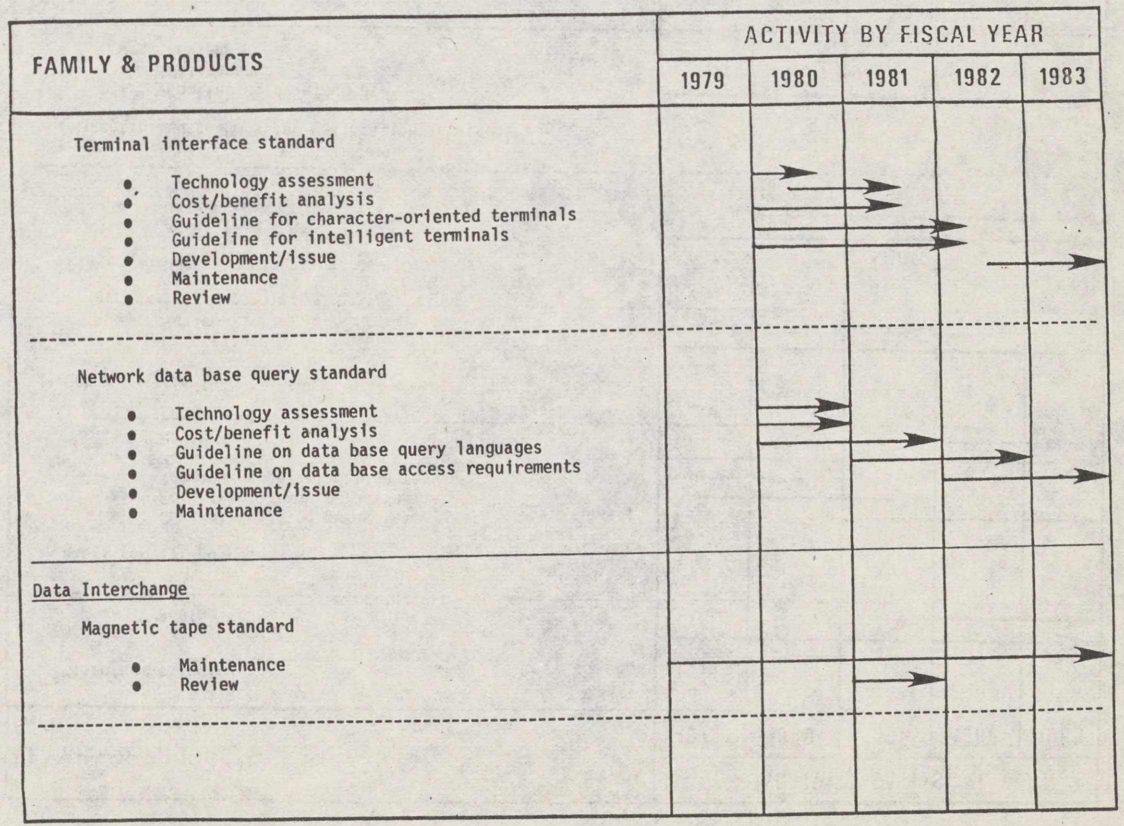

FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Minicomputers and Microcomputers
Minicomputer tape device interface standard
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Maintenance
• Review
Minicomputer flexible disk interface standard
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Maintenance
• Review
Microprocessor interface standard
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Maintenance
• Review
Minicomputer device independent interface standard
• Technology assessment
• Cost/benefit analysis
• Development/issue

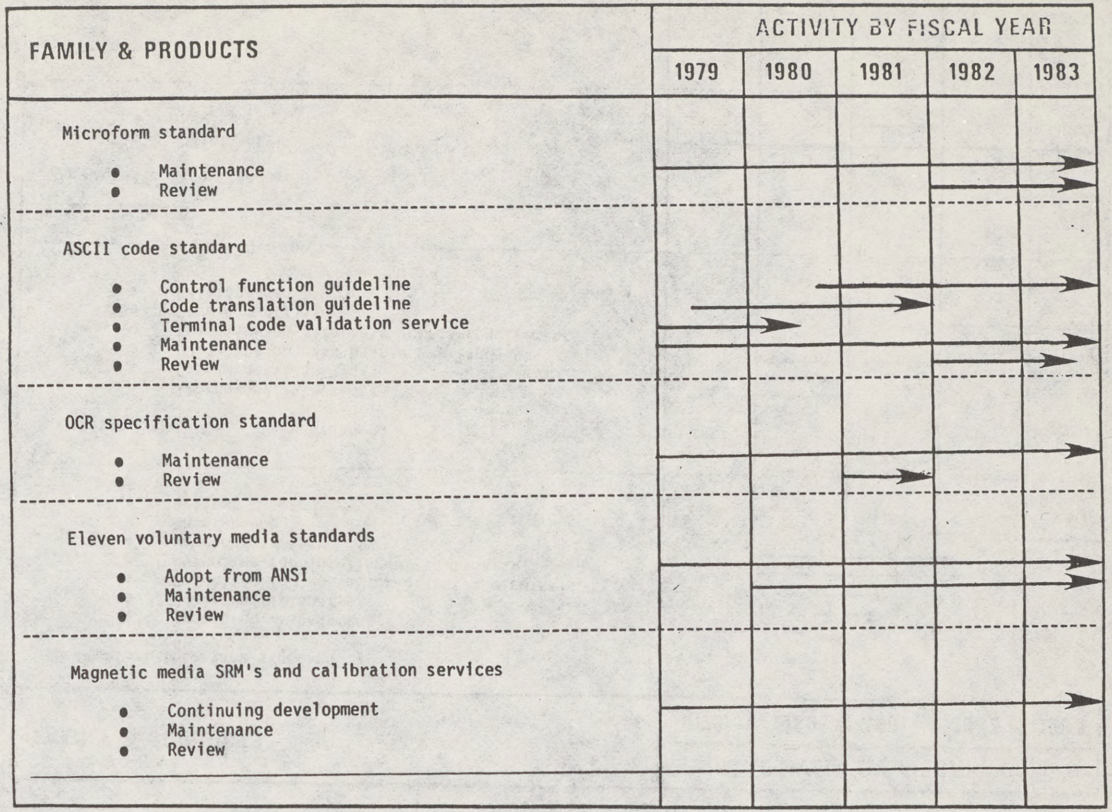

FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Computer Networks
Terminal - communication interface standard
Maintenance
Review
Bit-oriented data link control standard
Technology assessment (complete)
Cost/benefit analysis (complete)
Development/issue
Validation
Maintenance
Review
Data communications system performance standard
Guideline on measurement of computer system performance
Technology assessment
Cost/benefit analysis
Development/issue
Maintenance
Review
Network file transfer standard
Guideline on network file transfer
Technology assessment
Cost/benefit analysis
Development/issue

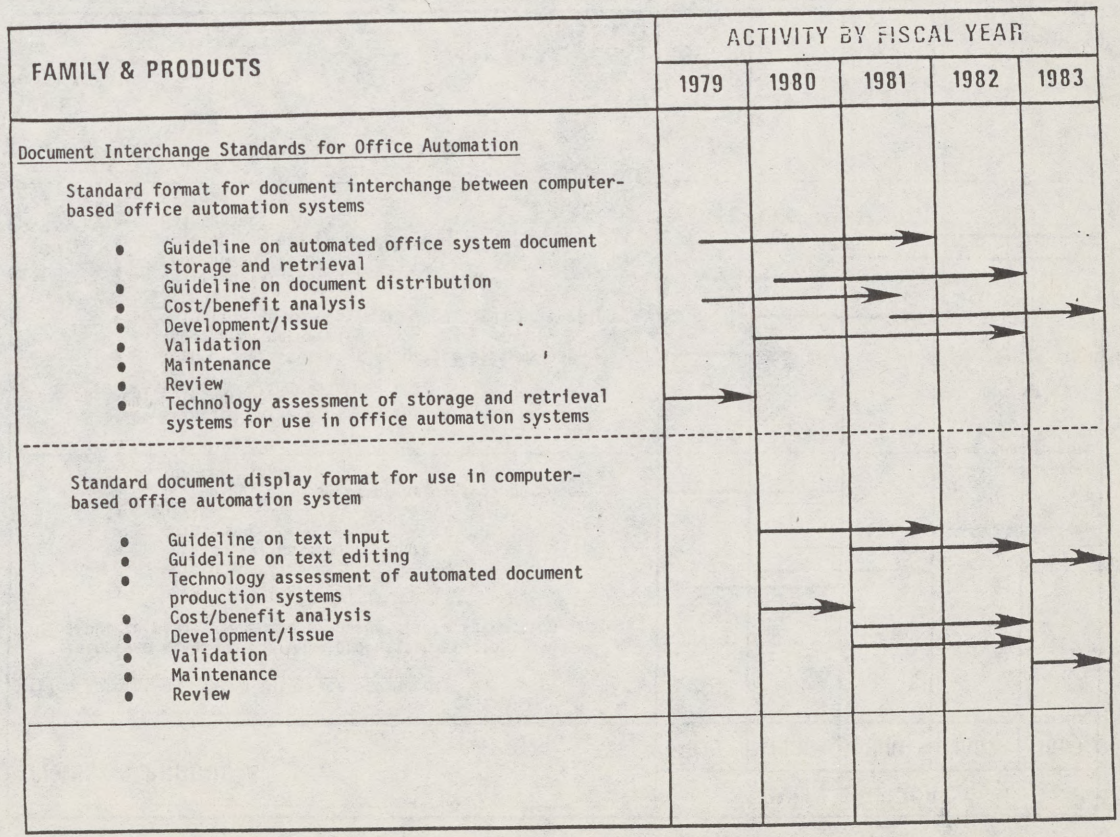

FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979 - 1980
1981
1982
1983
• Validation
• Maintenance
• Review
Network access standard
• Guideline on common command languages for job execution
• Guideline on common command languages for file manipulation
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Maintenance
• Review
Network resource allocation standard
• Technology assessment
• Cost/benefit analysis
• Guideline on network resource allocation
• Development/issue
• Maintenance
Network distributed data management standard
• Technology assessment
• Cost/benefit analysis
• Guideline on data assignment policies
• Guideline on communications between DBMS
• Development/issue
• Maintenance
• Review


FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Host interface standard
Development/issue
Validation
Maintenance
Technology assessment
Cost/benefit analysis
Review
Network record transfer standard
Cost/benefit analysis
Development/issue
Validation
Maintenance
Review
Technology assessment
Network interconnection standard
Technology assessment
Cost/benefit analysis
Development/issue
Validation
Maintenance
Review


FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Host-host network protocol standard
Cost/benefit analysis
Development/issue
Validation
Maintenance
Review
Technology assessment
Network interprocess control/communication standard
Cost/benefit analysis
Guideline on interprocess communication
Development/issue
Validation
Maintenance
Technology assessment
Review
Network resource selection standard
Technology assessment
Cost/benefit analysis
Guideline on network accounting
Guideline on network resource selection
Development/issue
Maintenance
Review


FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Terminal interface standard
Technology assessment
Cost/benefit analysis
Guideline for character-oriented terminals
Guideline for intelligent terminals
Development/issue
Maintenance
Review
Network data base query standard
Technology assessment
Cost/benefit analysis
Guideline on data base query languages
Guideline on data base access requirements
Development/issue
Maintenance
Data Interchange
Magnetic tape standard
Maintenance
Review

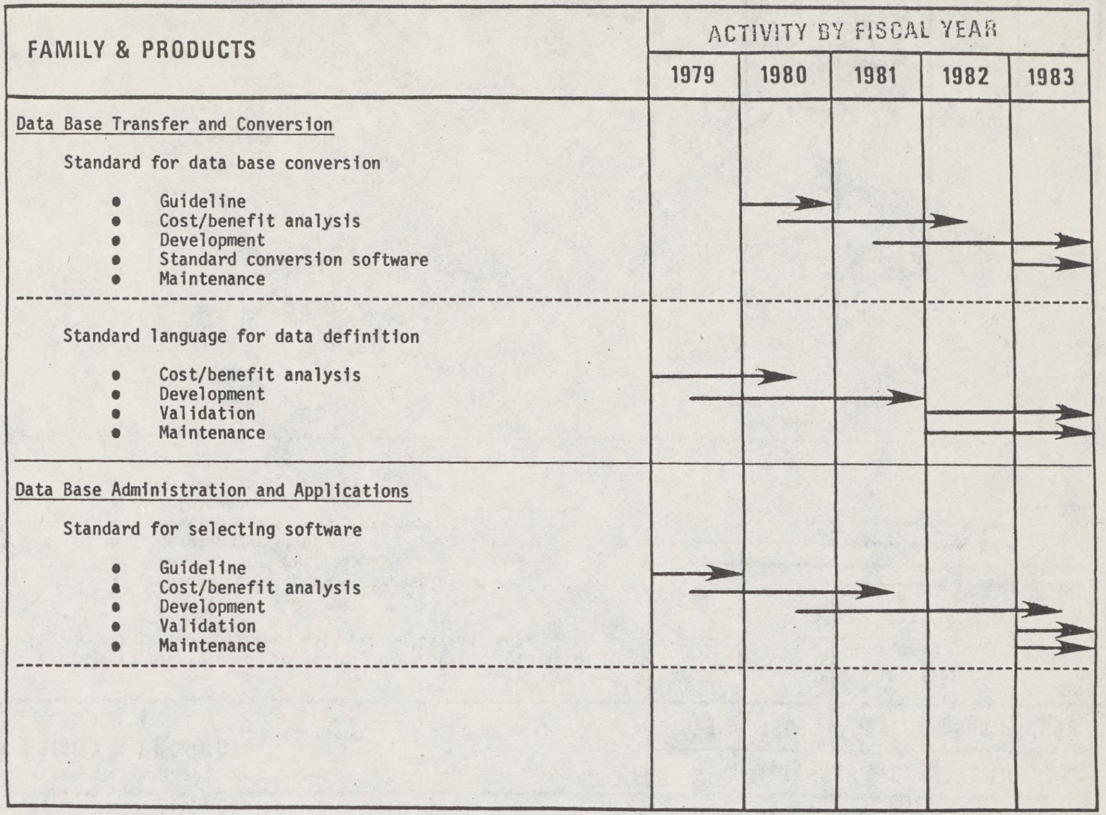

FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Microform standard
• Maintenance
• Review
ASCII code standard
• Control function guideline
• Code translation guideline
• Terminal code validation service
• Maintenance
• Review
OCR specification standard
• Maintenance
• Review
Eleven voluntary media standards
• Adopt from ANSI
• Maintenance
• Review
Magnetic media SRM's and calibration services
• Continuing development
• Maintenance
• Review

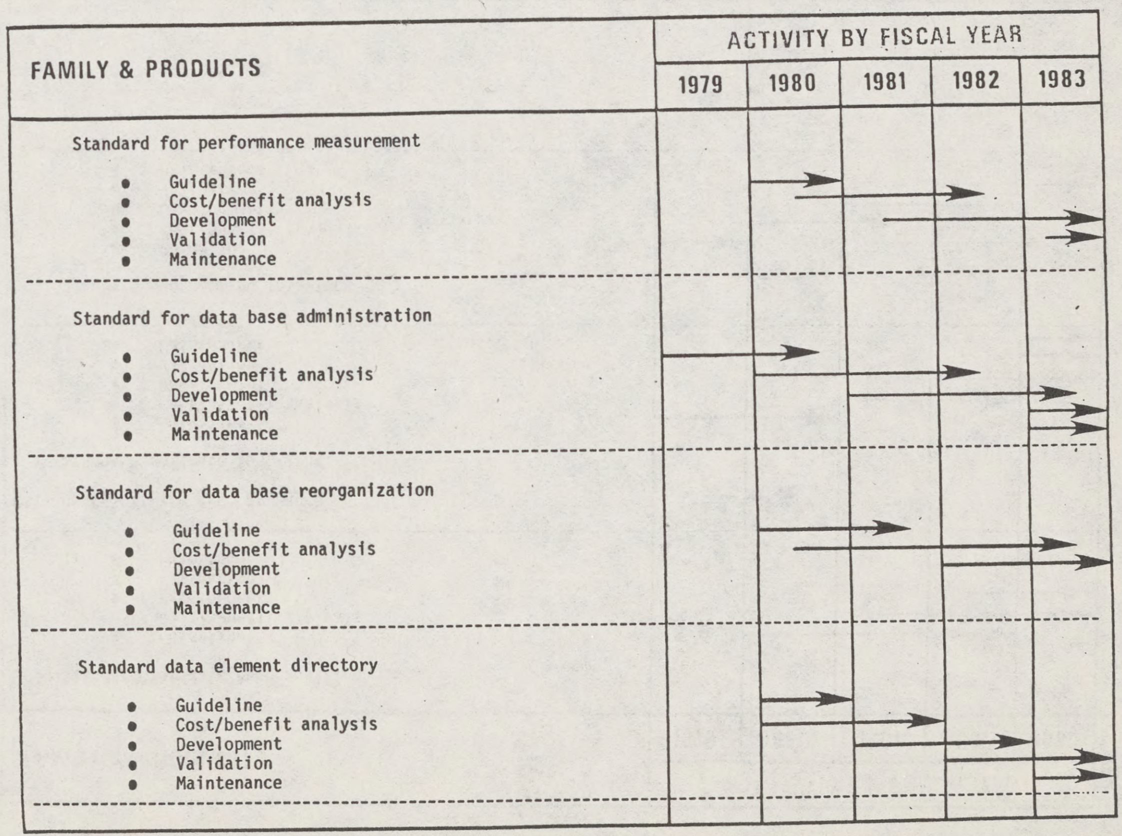

FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Document Interchange Standards for Office Automation
Standard format for document interchange between computer-based office automation systems
• Guideline on automated office system document storage and retrieval
• Guideline on document distribution
• Cost/benefit analysis
• Development/issue
• Validation
• Maintenance
• Review
• Technology assessment of storage and retrieval systems for use in office automation systems
Standard document display format for use in computer-based office automation system
• Guideline on text input
• Guideline on text editing
• Technology assessment of automated document production systems
• Cost/benefit analysis
• Development/issue
• Validation
• Maintenance
• Review

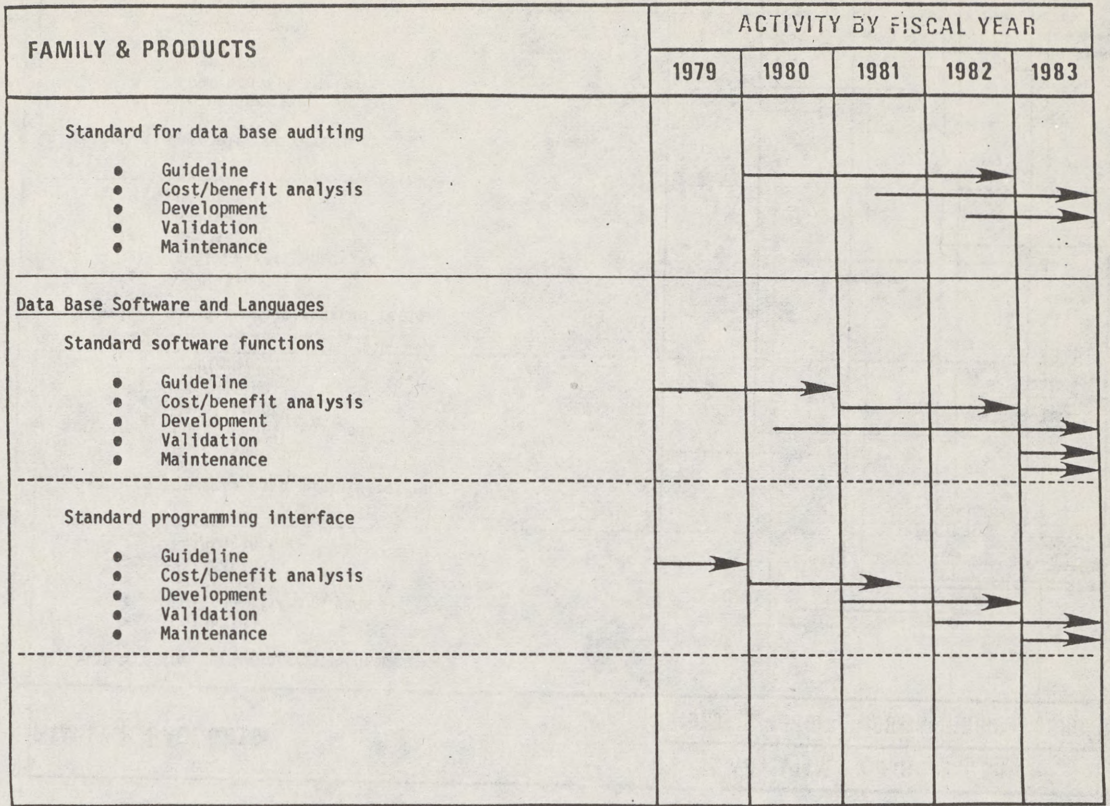
FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR 1979	1980	1981	1982	1983
<u>Office Automation System Interface Standards</u>					
Interface standard for word processing stations used as input terminals in computer-based office automation systems					
• Cost/benefit analysis	→	→			
• Development/issue		→	→		
• Develop validation procedure		→	→		
• Maintenance				→	→
• Review					
• Technology assessment of automated procedures for text input	→	→			
Interface standard between office automation terminals and local data networks					
• Technology assessment of office systems and local area networking	→	→			
• Guideline on selection of local area networking technology		→	→		
• Cost/benefit analysis	→	→	→	→	
• Development/issue			→	→	→
• Develop validation procedure			→	→	→
• Maintenance					
• Review					

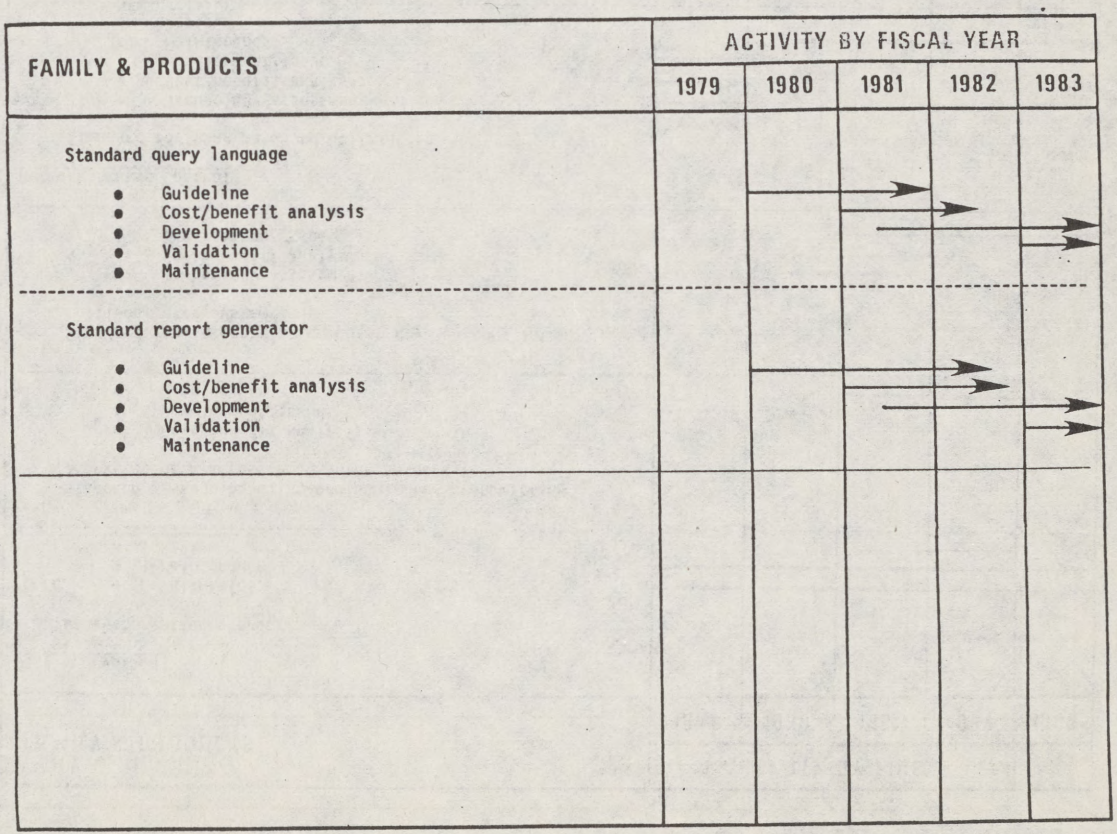
FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR				
	1979	1980	1981	1982	1983
Standard for interconnection of local office automation network to long distance data communications networks					
• Guideline on document transmission			→	→|	
• Cost/benefit analysis	→	→	→|		
• Development/issue	→	→	→	→|	
• Develop validation procedure		→	→	→|	
• Maintenance					→|
• Review					

DATA BASE MANAGEMENT STANDARDS

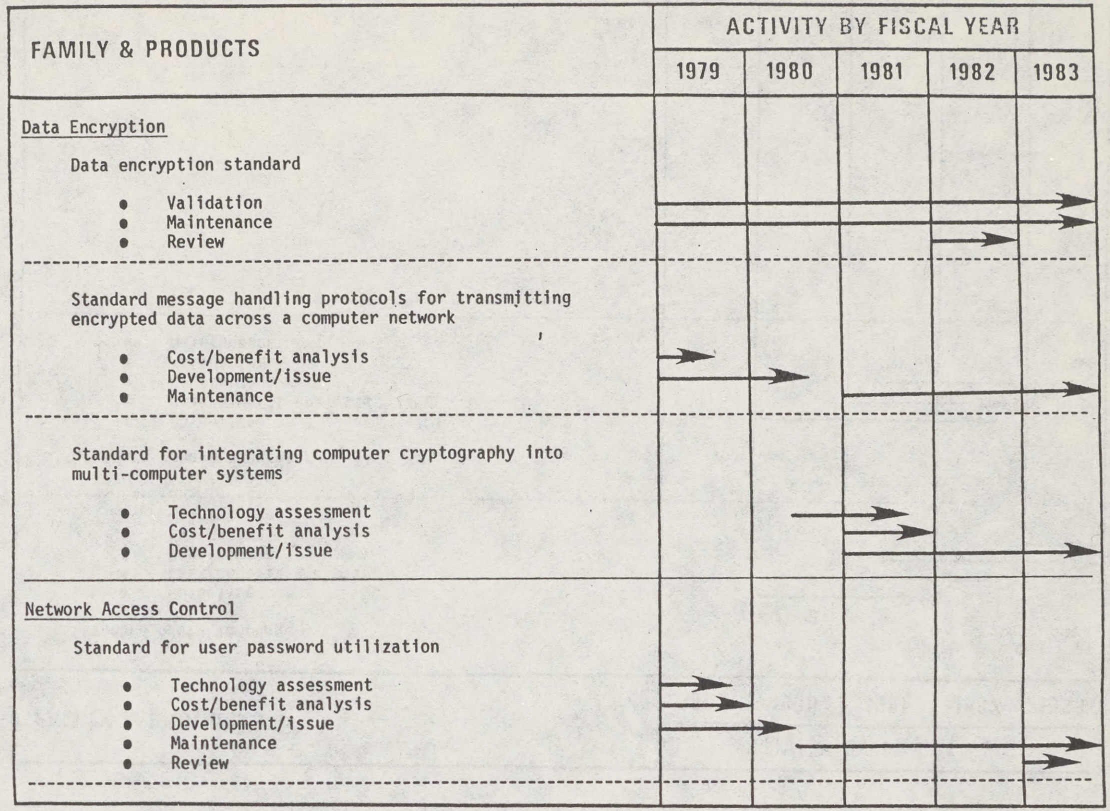



FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Standard for performance measurement
Guideline
Cost/benefit analysis
Development
Validation
Maintenance
Standard for data base administration
Guideline
Cost/benefit analysis
Development
Validation
Maintenance
Standard for data base reorganization
Guideline
Cost/benefit analysis
Development
Validation
Maintenance
Standard data element directory
Guideline
Cost/benefit analysis
Development
Validation
Maintenance


FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Standard for data base auditing
• Guideline
• Cost/benefit analysis
• Development
• Validation
• Maintenance
Data Base Software and Languages
Standard software functions
• Guideline
• Cost/benefit analysis
• Development
• Validation
• Maintenance
Standard programming interface
• Guideline
• Cost/benefit analysis
• Development
• Validation
• Maintenance


FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Standard query language
Guideline
Cost/benefit analysis
Development
Validation
Maintenance
Standard report generator
Guideline
Cost/benefit analysis
Development
Validation
Maintenance

COMPUTER SECURITY AND RISK MANAGEMENT STANDARDS

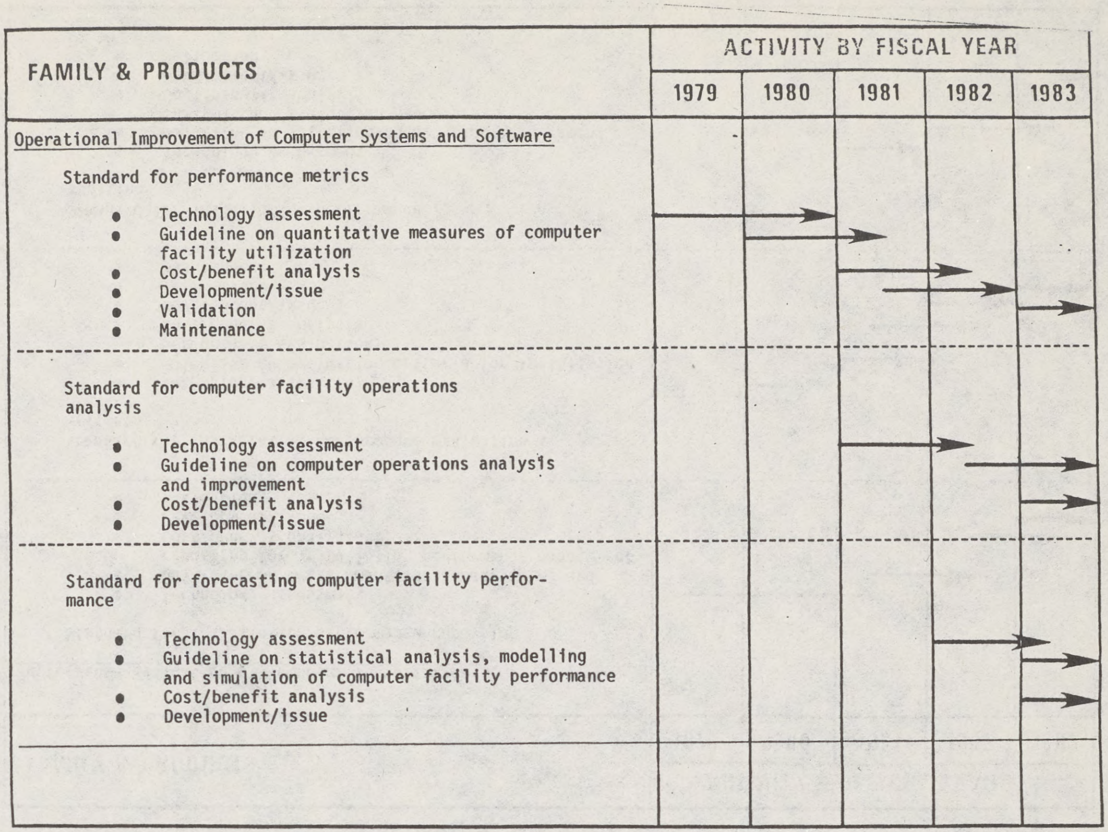


FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR 1979	1980	1981	1982	1983
Standard for personal identification device evaluation					
• Technology assessment	→	→			
• Cost/benefit analysis		→			
• Guideline on combined personal identification devices		→	→		
• Guideline on signature verification	→	→			
• Development/issue		→	→	→	
• Maintenance					→
• Review					
<u>Risk Management</u>					
Standard for evaluating the security status of Federal computer installations					
• Cost/benefit analysis	→				
• Development/issue	→	→	→		
• Validation			→	→	
• Maintenance			→	→	→
Standard for certification of security controls					
• Technology assessment	→				
• Guideline on certification methods		→	→		
• Cost/benefit analysis			→		
• Development/issue			→	→	→

FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR				
	1979	1980	1981	1982	1983
<u>Access Controls</u>					
Standard for secure data management systems					
• Technology assessment			→		
• Cost/benefit analysis				→	
• Development/issue					→
Standard for computer user access authorization mechanisms					
• Guideline on data management system authorization mechanism	→	→			
• Technology assessment	→	→			
• Cost/benefit analysis		→			
• Development/issue			→	→	
• Validation				→	→
• Maintenance				→	→

PERFORMANCE MEASUREMENT AND EVALUATION STANDARDS

FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR 1979	1980	1981	1982	1983
Performance Evaluation of Computer Installations					
Standard for installation performance reporting					
• Technology assessment					
• Guideline on measurement, data management and reporting for installation performance management					
• Cost/benefit analysis					
• Development/issue					
• Validation					
Standard for installation performance evaluation criteria					
• Technology assessment					
• Guideline on evaluation criteria for installation performance evaluation					
• Cost/benefit analysis					
• Development/issue					
• Validation					
• Maintenance					
Standard for installation performance auditing					
• Technology assessment					
• Guideline on installation auditing measurement, analysis and evaluation procedures					
• Cost/benefit analysis					
• Development/issue					
• Validation					


FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Operational Improvement of Computer Systems and Software
Standard for performance metrics
• Technology assessment
• Guideline on quantitative measures of computer facility utilization
• Cost/benefit analysis
• Development/issue
• Validation
• Maintenance
Standard for computer facility operations analysis
• Technology assessment
• Guideline on computer operations analysis and improvement
• Cost/benefit analysis
• Development/issue
Standard for forecasting computer facility performance
• Technology assessment
• Guideline on statistical analysis, modelling and simulation of computer facility performance
• Cost/benefit analysis
• Development/issue

FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR 1979	1980	1981	1982	1983
<u>Computer Installation Workload Management</u>					
Standard for optimization of production software					
• Technology assessment		→			
• Guideline on the application of software optimization techniques to production systems			→	→	
• Cost/benefit analysis			→	→	
• Development/issue				→	
• Validation					→
• Maintenance					
Standard for capacity planning for development software					
• Technology assessment			→	→	
• Guideline on methods for estimating the impact of development systems on the production environment				→	→
• Cost/benefit analysis					→
• Development/issue					
Standard for installation user site conventions					
• Technology assessment			→	→	
• Guideline on the development of site conventions to modify workload demand and user behavior				→	→
• Cost/benefit analysis				→	
• Development/issue					→
• Validation					

FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR				
	1979	1980	1981	1982	1983
Standard for computer system hardware measurement instrumentation					
• Technology assessment					
• Guideline on minimum requirements for hardware instrumentation/probe points					
• Cost/benefit analysis					
• Development/issue					
• Validation					
Standard operating system interface requirements for hybrid hardware/software monitors					
• Technology assessment					
• Guideline on hybrid monitor/operating system interface characteristics					
• Cost/benefit analysis					
• Development/issue					
• Validation					
Standard Federal requirements for installation tuning manuals and documentation					
• Technology assessment					
• Guideline on content and objectives of tuning manuals and documentation					
• Cost/benefit analysis					
• Development/issue					
• Validation					

FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR 1979	1980	1981	1982	1983
Standard functional procurement specifications for total instrumentation, software documentation for Federal computer installation performance management requirements					
• Technology assessment					
• Cost/benefit analysis					
• Development/issue (1985)					
Network Performance Measurement					
Standard for network service performance measurement					
• Guideline on interactive service measurement					
• Guideline on remote batch service					
• Technology assessment					
• Cost/benefit analysis					
• Development/issue					
• Validation					
• Maintenance					
Performance Measurement of Office Automation Systems					
• Guideline on economic analysis of office automation					
• Guideline on application of office automation techniques					
• Technology assessment					
• Cost/benefit analysis					
• Development/issue					

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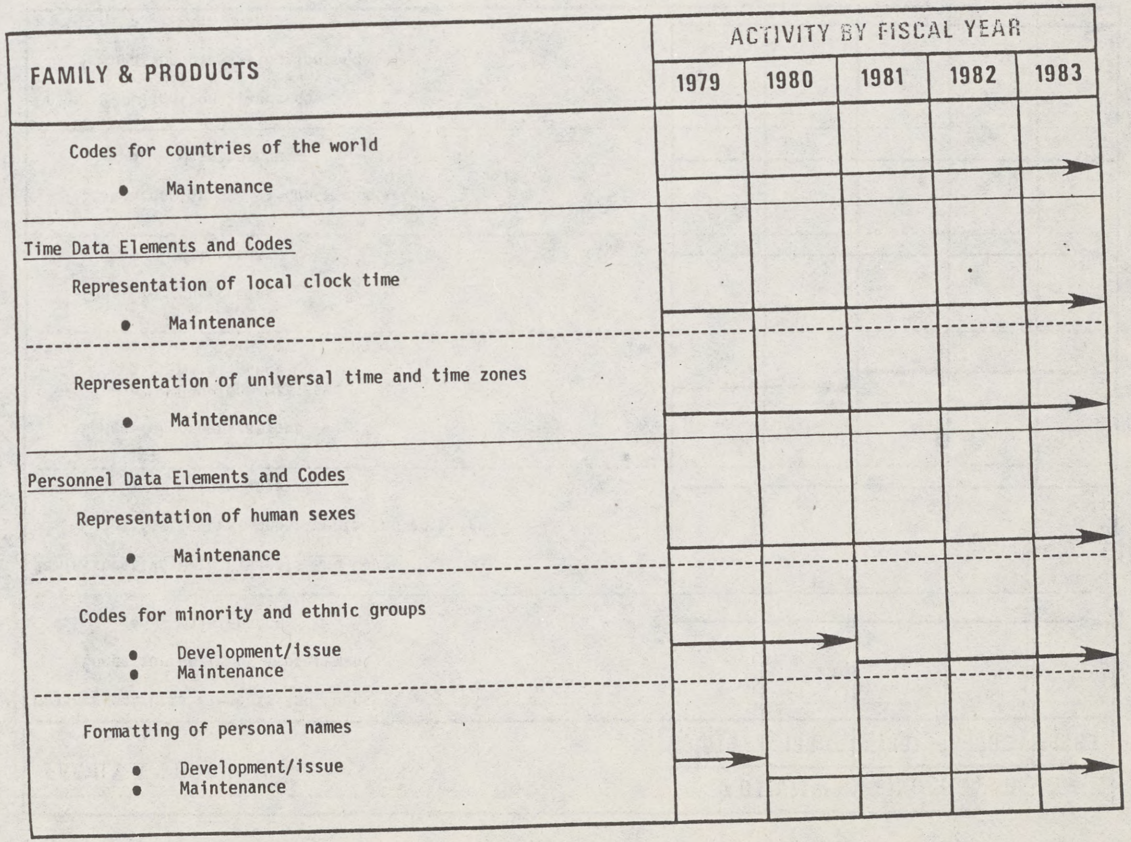
DATA STANDARDS

FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR				
	1979	1980	1981	1982	1983
Geographic Data Elements and Codes					
Codes for cities, towns and places					
• Maintenance	→	→	→	→	→
Codes for first order subdivisions of countries					
• Maintenance	→	→	→	→	→
Codes for water bodies					
• Maintenance	→	→	→	→	→
Codes for geographic point locations					
• Maintenance	→	→	→	→	→
Codes for major geopolitical divisions of the world					
• Maintenance	→	→	→	→	→
Codes for counties of the states of U.S.					
• Maintenance	→	→	→	→	→
Codes for standard metropolitan statistical areas					
• Maintenance	→	→	→	→	→

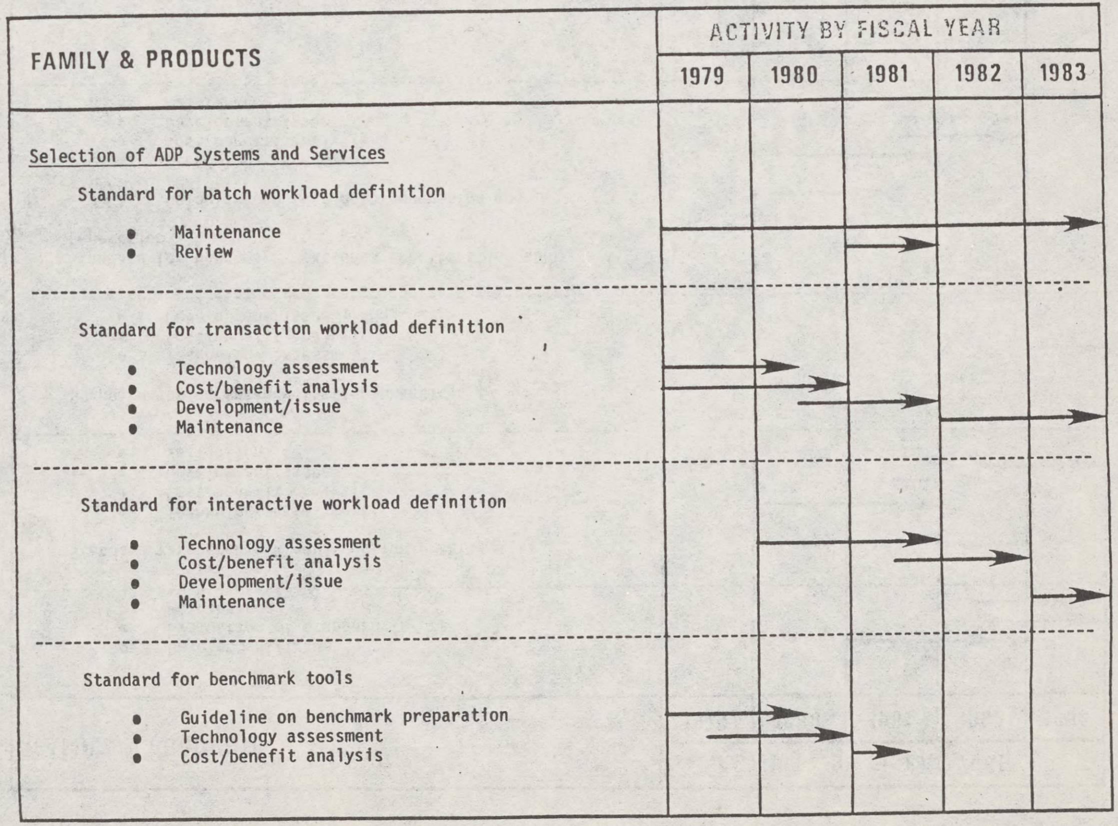

FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Codes for countries of the world
• Maintenance
Time Data Elements and Codes
Representation of local clock time
• Maintenance
Representation of universal time and time zones
• Maintenance
Personnel Data Elements and Codes
Representation of human sexes
• Maintenance
Codes for minority and ethnic groups
• Development/issue
• Maintenance
Formatting of personal names
• Development/issue
• Maintenance

FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR				
	1979	1980	1981	1982	1983
Measurement Data Elements and Codes					
Codes for units of measurement					
• Maintenance	→	→	→	→	→
Administrative Data Elements and Codes					
Codes for Federal departments and agencies					
• Maintenance	→	→	→	→	→
Codes for organizations					
• Development/issue	→	→			
• Maintenance			→	→	→
Codes for currencies					
• Maintenance	→	→	→	→	→
Standards for use of check characters					
• Maintenance	→	→	→	→	→
Program/Application Standards					
Occupation classification codes					
• Maintenance	→	→	→	→	→

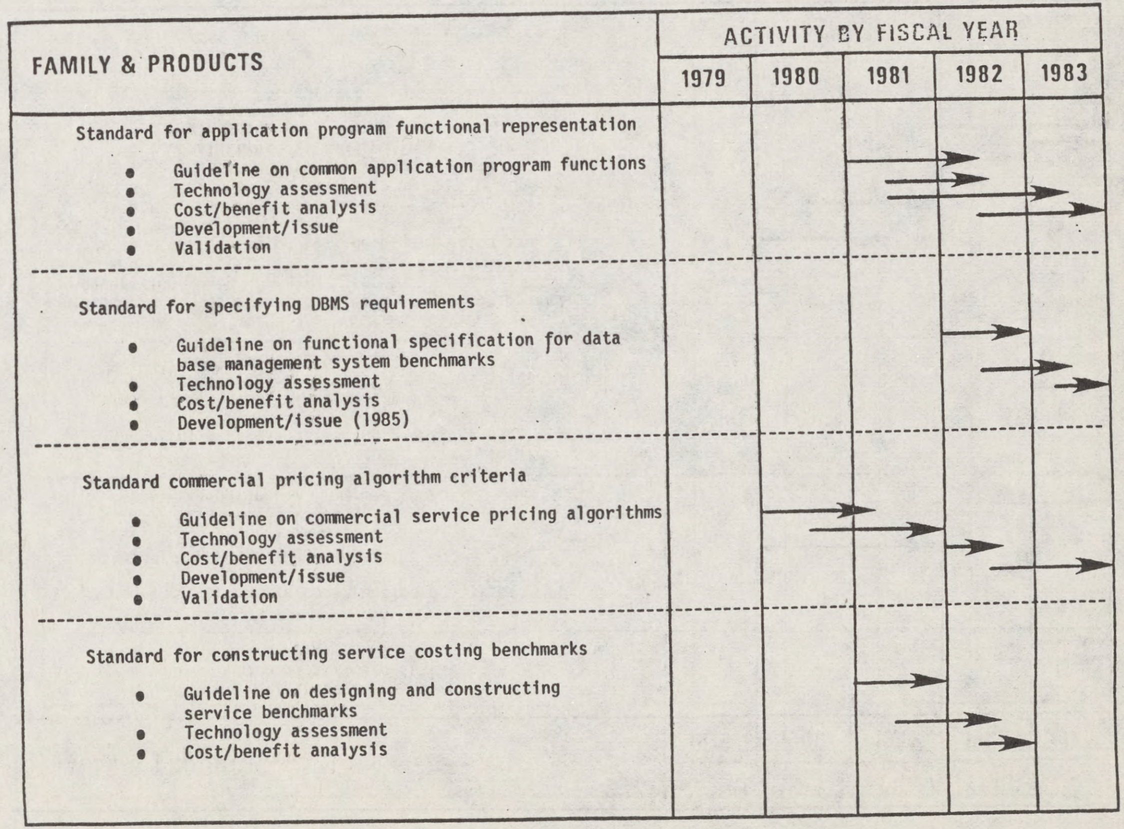
FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR				
	1979	1980	1981	1982	1983
Industry classification codes					
• Maintenance	→	→	→	→	→
Data standards for automated civilian personnnel systems					
• Development/issue	→				
• Maintenance		→	→	→	→
Data standards for Federal energy data systems					
• Development/issue	→				
• Maintenance		→	→	→	→
Data standards for transportation freight movement systems					
• Development/issue	→	→			
• Maintenance			→	→	→
Data standards for communications management data systems					
• Maintenance	→	→	→	→	→
Data standards for Federal procurement data systems					
• Maintenance	→	→	→	→	→

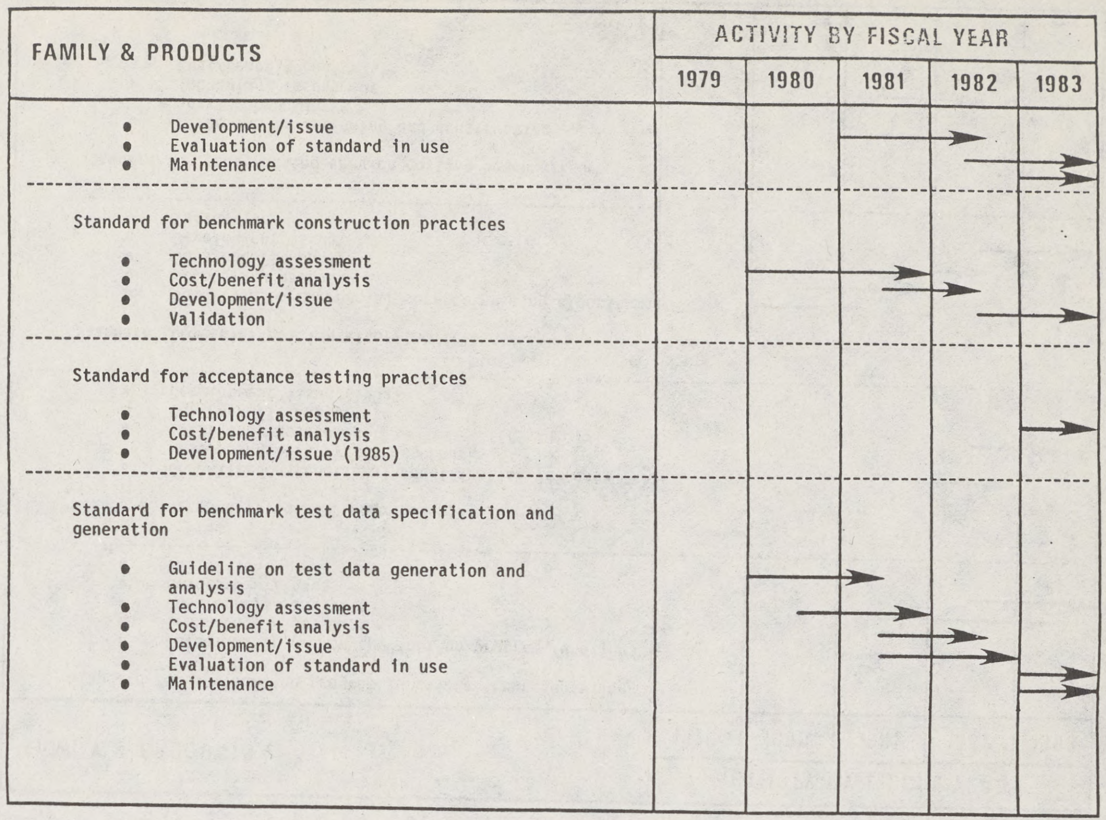
FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR				
	1979	1980	1981	1982	1983
<u>Standards for Management of Data Resources</u>					
Standard for development, maintenance and use of data element directories					
• Development/issue	→	→			
• Maintenance			→	→	→
Standard for registering data standards					
• Maintenance	→	→	→	→	→

COMPUTER SYSTEM FUNCTIONAL SPECIFICATION STANDARDS



FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR 1979	1980	1981	1982	1983
• Development/issue • Evaluation of standard in use • Maintenance					
Standard for benchmark construction practices • Technology assessment • Cost/benefit analysis • Development/issue • Validation					
Standard for acceptance testing practices • Technology assessment • Cost/benefit analysis • Development/issue (1985)					
Standard for benchmark text data specification and generation • Guideline on test data generation and analysis • Technology assessment • Cost/benefit analysis • Development/issue • Maintenance					


FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Standard for application program functional representation
• Guideline on common application program functions
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Validation
Standard for specifying DBMS requirements
• Guideline on functional specification for data base management system benchmarks
• Technology assessment
• Cost/benefit analysis
• Development/issue (1985)
Standard commercial pricing algorithm criteria
• Guideline on commercial service pricing algorithms
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Validation
Standard for constructing service costing benchmarks
• Guideline on designing and constructing service benchmarks
• Technology assessment
• Cost/benefit analysis


FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
• Development/issue
• Evaluation of standard in use
• Maintenance
Standard for benchmark construction practices
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Validation
Standard for acceptance testing practices
• Technology assessment
• Cost/benefit analysis
• Development/issue (1985)
Standard for benchmark test data specification and generation
• Guideline on test data generation and analysis
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Evaluation of standard in use
• Maintenance

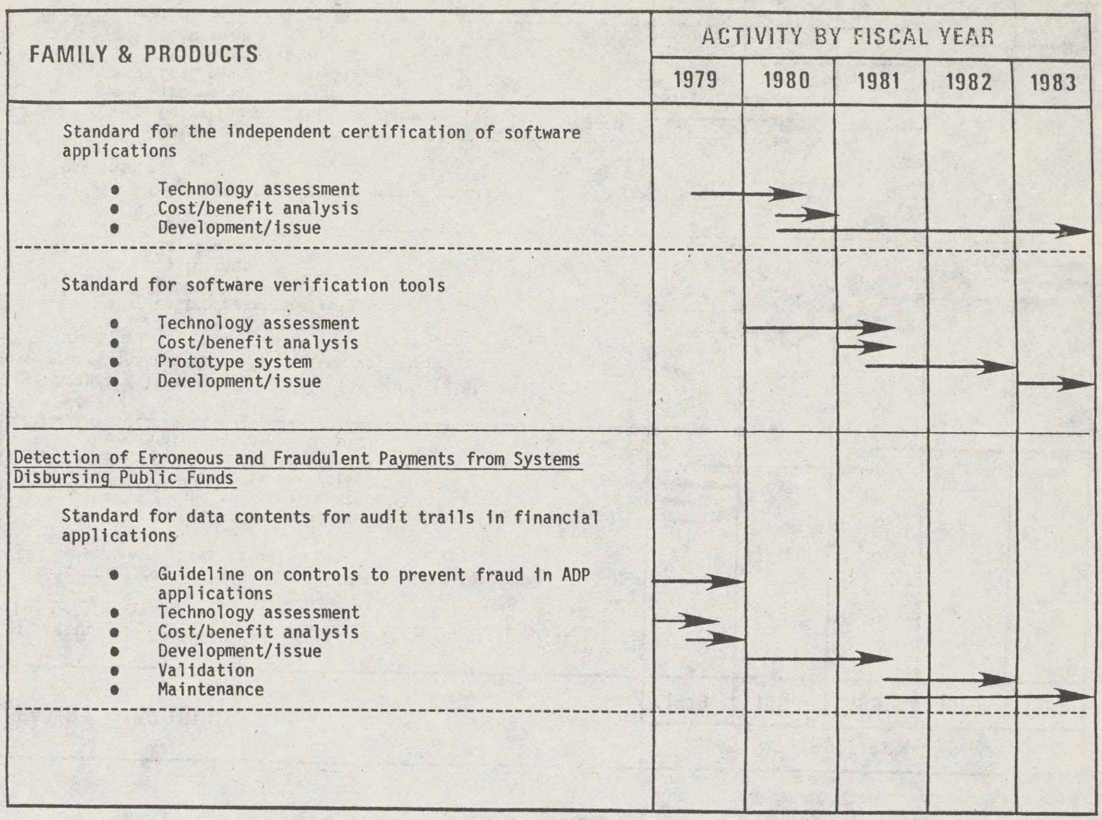
FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR 1979	1980	1981	1982	1983
• Development/issue					→
• Validation					
Standard for performance assessment and cost evaluation of non-priced, commercial service facilities					
• Guideline on functional capability testing (security, audit capability, fail/safe, error recovery, system failure recovery, usability/accessibility/availability)				→	→
• Technology assessment				→	→
• Cost/benefit analysis					→
• Development/issue					→
Specification of System and Services					
Standard for functional specification for procurement of ADP systems and processing services					
• Guideline for performing ADP functional requirements analysis	→	→	→		
• Technology assessment	→	→			
• Cost/benefit analysis		→			
• Development/issue			→	→	
• Maintenance					
Standard for evaluating conformance of ADP systems capabilities against procurement specifications					
• Guideline on comparative evaluation of alternative configurations		→	→	→	

FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR				
	1979	1980	1981	1982	1983
• Technology assessment • Cost/benefit anlysis • Development/issue • Review • Maintenance					
Standard for ADP equipment and processing services documentation • Technology assessment • Cost/benefit analysis • Development/issue • Maintenance					

PERFORMANCE ASSURANCE

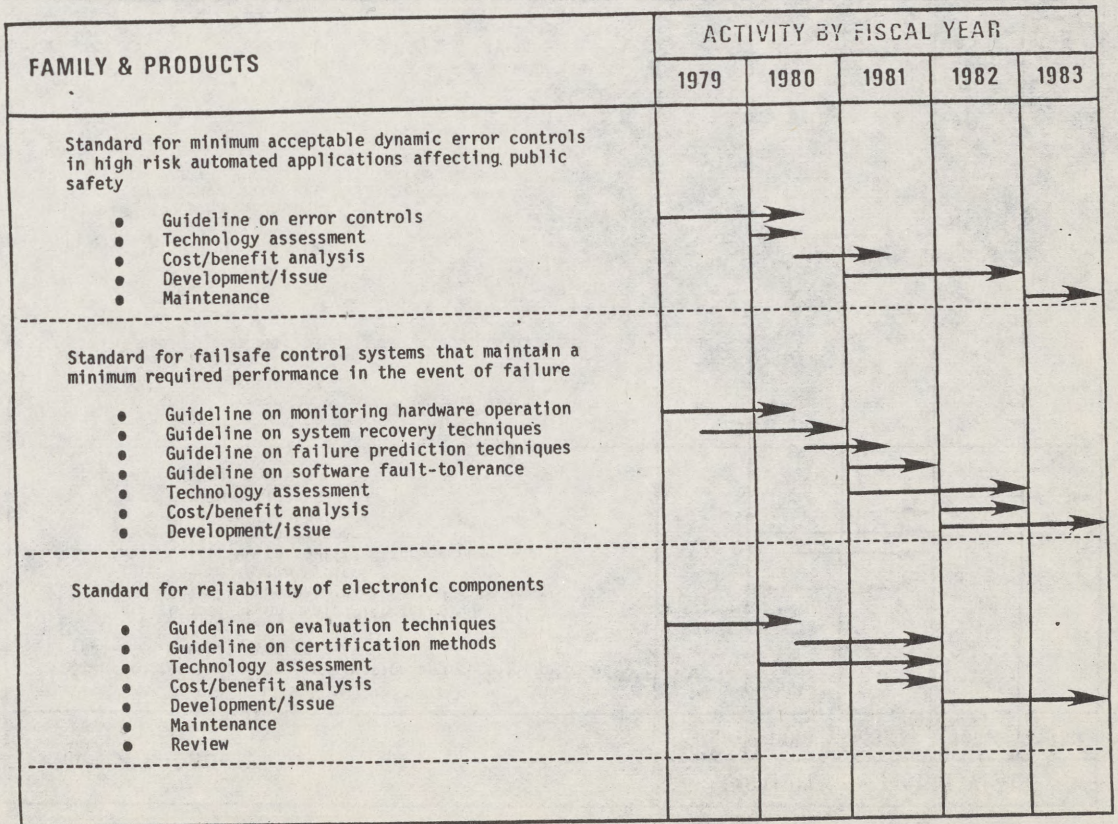
STANDARDS

FAMILY & PRODUCTS	1979	1980	1981	1982	1983
Validation and Certification of the Performance of Specific Application Systems					
Standard for defining user-visible system functions necessary for system validation					
• Guideline on requirements definition methods	→				
• Technology assessment	→				
• Cost/benefit analysis	→				
• Development/issue	→	→	→		
• Maintenance			→	→	→
Standard language for specifying user-visible systems functions necessary for system validation					
• Technology assessment	→	→			
• Cost/benefit analysis			→		
• Development/issue			→	→	→
• Validation					→
• Maintenance					→
Standard for application system design specifications					
• Guideline on design specification methods	→	→			
• Guideline on data base design	→	→			
• Technology assessment		→			
• Cost/benefit analysis		→			
• Development/issue		→	→	→	
• Maintenance				→	→


FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Standard for the independent certification of software applications
• Technology assessment
• Cost/benefit analysis
• Development/issue
Standard for software verification tools
• Technology assessment
• Cost/benefit analysis
• Prototype system
• Development/issue
Detection of Erroneous and Fraudulent Payments from Systems Disbursing Public Funds
Standard for data contents for audit trails in financial applications
• Guideline on controls to prevent fraud in ADP applications
• Technology assessment
• Cost/benefit analysis
• Development/issue
• Validation
• Maintenance

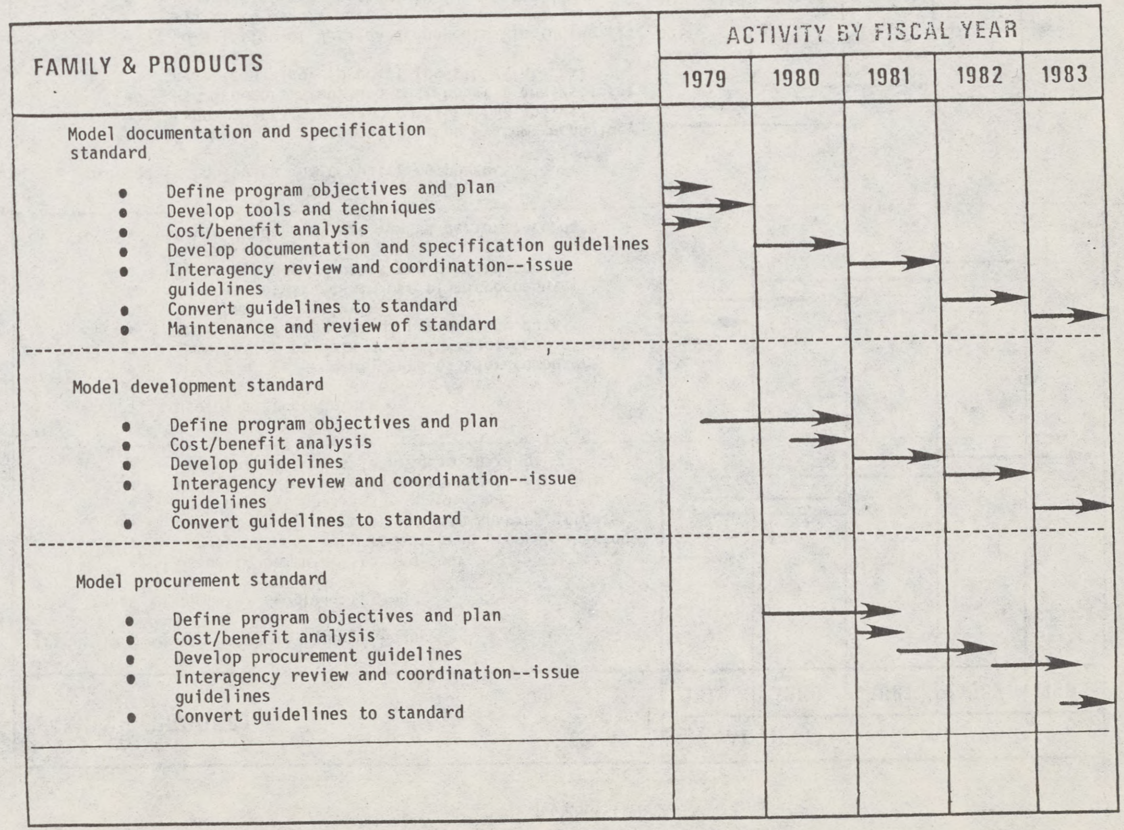
FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR				
	1979	1980	1981	1982	1983
Standard for dynamic error control in financial applications					
• Guideline on controls to reduce errors in the automatic payment of public funds					
• Technology assessment					
• Cost/benefit analysis					
• Development/issue					
• Maintenance					
Data Accuracy and Confidentiality for Highly Personal or Economically Valuable Data					
Standard for data integrity audit					
• Guideline identifying information system vulnerabilities and controls					
• Technology assessment					
• Cost/benefit analysis					
• Development/issue					
• Maintenance					
Standard for dynamic data protection and validation in application systems					
• Guideline on data limit and consistency checks					
• Technology assessment					
• Cost/benefit analysis					
• Development/issue					
• Maintenance					

FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR				
	1979	1980	1981	1982	1983
Standard for assuring data integrity during data capture and data entry					
• Guideline on the use of advanced devices for human mediated data input					
• Guideline on the use of sensor based devices for data capture and entry					
• Technology assessment					
• Cost/benefit analysis					
• Development/issue					
• Maintenance					
• Review					
<u>Public Health and Safety When Computers are Used for Real-Time Control of Aircraft, Rapid Transit Vehicles, Nuclear Power Plants, and Medical Diagnostic and Monitoring Systems</u>					
Standard for audit and evaluation of real-time control systems					
• Guideline to identify vulnerabilities and controls					
• Technology assessment					
• Cost/benefit analysis					
• Development/issue					
• Validation					
• Maintenance					


FAMILY & PRODUCTS
ACTIVITY BY FISCAL YEAR
1979
1980
1981
1982
1983
Standard for minimum acceptable dynamic error controls in high risk automated applications affecting public safety
Guideline on error controls
Technology assessment
Cost/benefit analysis
Development/issue
Maintenance
Standard for failsafe control systems that maintain a minimum required performance in the event of failure
Guideline on monitoring hardware operation
Guideline on system recovery techniques
Guideline on failure prediction techniques
Guideline on software fault-tolerance
Technology assessment
Cost/benefit analysis
Development/issue
Standard for reliability of electronic components
Guideline on evaluation techniques
Guideline on certification methods
Technology assessment
Cost/benefit analysis
Development/issue
Maintenance
Review

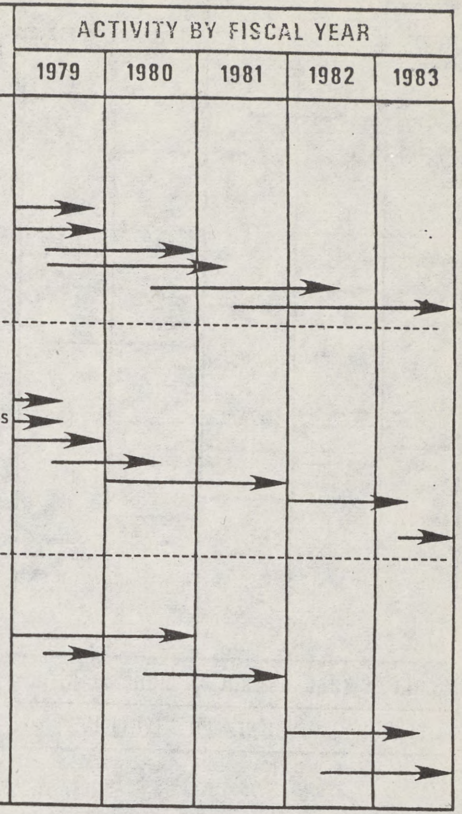
FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR				
	1979	1980	1981	1982	1983
Standard for independent evaluation and certification of real-time control systems • Guideline on evaluation techniques • Guideline on data capture and data entry for real-time systems • Guideline on certification methods • Technology assessment • Cost/benefit analysis • Development/issue					

MANAGEMENT OF FEDERAL LARGE SCALE COMPUTERIZED MODELS



FAMILY & PRODUCTS

ACTIVITY BY FISCAL YEAR



Trends in Computer Usage in Federal Government

Trends in computer program sharing

- Guide to computer sharing sources
- Survey of user requirements for program sharing
- Evaluation of computer program sharing efforts
- Cost/benefit analysis
- Guidelines for effective program sharing
- Forecast of trends in program sharing

Trends in use of microcomputers

- Survey of government users of microcomputers
- Compilation of data on performance characteristics
- Analysis of user versus performance data
- Cost/benefit analysis
- Forecast of trends in use of microcomputers
- Review/update of users and performance characteristics
- Review/update of use versus performance data

Advanced technologies for computer components

- Forecast of telecommunications system technology
- Requirements study and cost/benefit analysis
- Requirements study and cost/benefit analysis for next technology forecast (possibly internal memory)
- Compilation of data on components (including site visits to manufacturers)
- Forecast of next technology (possibly internal memory)

FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR 1979	1980	1981	1982	1983
Effective Use of Emerging Computer Technology In Government					
Forecasts of impact of technological change on priorities for Federal ADP standards					
• Requirements study					
• Cost/benefit analysis					
• Forecast for impact at component technology level					
• Forecast for impact at system development level					
• Forecast for impact at related technologies level					
• Forecast review and update					
Guidelines for effective use of rapidly emerging technology in Government					
• Requirements study					
• Guideline for identification of technology users					
• Cost/benefit analysis					
• Guideline for definition of technology applications					
• Review and validation					
• Guideline for implementation of technology					
• Review and validation					
• Guideline for management of technology use					
• Review and maintenance					

FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR 1979	1980	1981	1982	1983
<u>Formulation of Computer Export Control Policy</u>					
Compilation and maintenance of performance data bases on various kinds of computer equipment					
• Requirements studies for performance criteria	→	→	→		
• Initial compilations of performance data	→	→	→		
• Maintenance (including periodic updating and redistribution of tables) of data bases on various kinds of computer equipment	→	→	→	→	→
• Periodic cost/benefit analyses of performance data bases			→	→	→
Development of new computer safeguard methodologies					
• Theoretical studies of new methodologies	→	→	→	→	→
• Experimental testing of safeguard methodologies	→	→	→		
• Cost/benefit analysis of new methodologies			→		
Studies of technological advances and their relationship to computer export controls					
• Analysis of export license applications in terms of the computer technologies involved	→	→	→	→	→
• Studies of emerging computer technology and their potential impact on computer export controls	→	→	→	→	→

STANDARDS MANAGEMENT

FAMILY & PRODUCTS	ACTIVITY BY FISCAL YEAR				
	1979	1980	1981	1982	1983
Management of the Federal-wide ADP Standards Program	→	→	→	→	→
Annual Federal-wide ADP Standards Assessment and Program Report	→	→	→	→	→
Measurement and Reporting System for Federal-wide ADP Standards Compliance	→	→	→	→	→
Priority Setting Mechanism for Standards Development Based Upon Cost/Benefit Analyses and Policy and Operational Considerations	→	→	→	→	→
Management Support to the Review and Update of ADP Standards and Guidelines	→	→	→	→	→
Policy Guidance on Technical Issues and Coordination for Specialized ADP Service Functions	→	→	→	→	→

AUTHORIZATION OF THE STANDARD REFERENCE DATA ACT AND REVIEW OF THE NATIONAL BUREAU OF STANDARDS

THURSDAY, APRIL 6, 1978

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D.C.

The subcommittee met at 9:40 a.m. in room 5110, Dirksen Senate Office Building, Hon. Adlai E. Stevension (chairman of the subcommittee) presiding.

Senator STEVENSON. The subcommittee will come to order. This morning we continue our review of the oldest national laboratory, the National Bureau of Standards. After hearings on NBS, we will turn to S. 2615, a bill to authorize—reauthorize the Standard Reference Data Act for a period of 3 years.

[The bill follows:]

[95th Congress, 2d Session S. 2615]

A BILL To authorize appropriations to carry out the Standard Reference Data Act

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there is authorized to be appropriated to the Department of Commerce not to exceed $3,152,000 for fiscal year 1979 and such sums as may be necessary for each of fiscal years 1980 and 1981 to carry out the purposes of the Standard Reference Data Act (15 U.S.C. 290–290f; 82 Stat. 339).

Senator STEVENSON. Our first witness is Dr. Jordan Baruch, the assistant Secretary of Commerce for Science and Technology.

I apologize to you and the other witnesses for keeping you waiting, Dr. Baruch.

If you prefer to summarize, we would be glad to enter your full statement in the record.

STATEMENT OF JORDAN BARUCH, ASSISTANT SECRETARY OF COMMERCE FOR SCIENCE AND TECHNOLOGY, DEPARTMENT OF COMMERCE

Dr. BARUCH. Thank you, Mr. Chairman. I would like to enter my statement for the record.

Senator STEVENSON. That will be done.

Dr. BARUCH. I would also like to express my gratitude for the committee holding oversight hearings on the NBS. I think it plays an important part in insuring that our activities are relevant to the country's needs. Rather than summarize my written testimony, I think I would like to expand on certain parts that I think are critical.

The President's budget submission to the Congress this year includes a net programmatic increase for NBS of $19,016,000 over the 1979 adjusted base. That's almost exactly a 25 percent increase in the Bureau's budget. Such increases have been unheard of in the recent history of the Bureau; and while this is not, strictly speaking, an appropriation hearing, I assume the Bureau's oversight committee wants to be assured that the increase will be well and effectively spent; second, that the programs arising from it will be well manned; and third, that the Bureau is in no danger of suffering incapacitating financial indigestion from such an infusion of funds.

To address these questions, Mr. Chairman, I would like to address briefly each of the major program areas on which those funds will be spent. The first of those program areas is the Brooks Act. The largest portion, 70 percent of our increment, $13,409,000, is earmarked for use by the Institute of Computer Science and Technology (ICST) toward implementing its standards setting mandate under the Brooks Act.

Primarily, that mandate is described in item 2 of my written testimony. The Brooks Act was passed over 12 years ago. The GAO estimated that compliance under that act would save the Federal Government some $440 million a year by 1983. Despite this clear and pressing need, it had been impossible under past administrations to secure the funding and personnel resources for the Bureau to perform its mission.

Mr. Chairman, as you are well aware, business decisionmakers, even relatively conservative business decisionmakers, consider an investment well worthwhile if it has a potential for a 4-year payback. Even if we were to cut the GAO's estimate arbitrarily in half to a savings of $220 million per year, it would make sound business sense to invest up to $880 million over the next 5 years to secure those benefits.

On that scale, Mr. Chairman, the amount we requested in the President's current budget represents only 2 percent of that warranted investment.

I would now like to discuss our list of standards that will be developed under that budget in order that you may better understand what we intend to do specifically and why we intend to do it.

The first and most critical group of standards are targeted at the software area. Over the life of any isolated computer installation, software costs far outweigh the costs of hardware. Insofar as Federal ADP Installations act in isolation, the same is true of them. Applications programs, despite their general applicability to problems of many agencies, simply are not portable. Existing high-level languages such as Cobal, Fortran, APL and basic, while tagged with the same name in fact behave very differently. As a first step in securing portability or the useful sharing of application programs among agencies, it is imperative that high-level language standards be developed that will make the Fortran at DOD identical to that at HEW, Commerce, or HUD. That's our first priority, Mr. Chairman. It is reflected in our designation of high-level standards as our first priority item under the Brooks Act.

Second, for applications programs to be portable, they must use those high-level languages without resorting to jump-outs to machine specific instructions or other exceptions. Third, to make them worth transporting, especially when used frequently, they must be reasonably efficient and effective. They must do what they say they do.

Our second priority item under the Brooks Act addresses these needs. It is what we call software quality control standards.

Software is not the only factor that determines the economy of using a large number of computers. There are times when a computer at one agency is underutilized while a computer at another agency is overloaded. If we were indeed to have a Federal ADP system rather than a group of isolated installations, such a system would have to provide for load sharing under those conditions.

Mr. Chairman, your electric bill, high as it is, would be at least 50 percent higher were there not load-sharing provisions among the utility companies. Each utility, without load sharing, would have to design its individual system for peak demand. With load sharing, each utility only has to design for the peak demand of the overall system. The same applies to computer installation. If a computer load-sharing system is to work, the interconnections among the computers must be effective, and that requires the existence of detailed network interfacing system standards.

That, Mr. Chairman, is our third priority under our Brooks Act responsibility.

In a load-sharing network, data is required to be transferred from installation to installation effectively and securely. Program transfer alone is insufficient. It is for that reason that our fourth and fifth priorities address the question of data transfer. Data base management standards and computer security and risk management standards are required.

Now, I could go on with the remaining 5 of the 10 families of standards that we have proposed in our budget submission. Performance and assurance standards, for example, are necessary to eliminate the very costly practice of sole-source or brand-name procurement, et cetera.

I will stop here, however, to reiterate that we are proposing to spend next year only 2 percent of what a rational businessman would spend when faced with the potential payoff.

A serious question has been raised as to whether the ICST can in fact effectively manage the proposed $17.8 million budget given its performance in the past. In the past, it only had a $4 million budget. I think the answer is probably that ICST cannot manage the new budget as it is currently constituted, but I am not sure. You know, I would be very reluctant to give a man a 2-foot crowbar, ask him to move a big boulder, and based on his performance with a 2-foot crowbar, say I am not going to give him an 8-foot crowbar to try the same task.

As I say, I am not sure ICST can manage the proposed program as it is currently constituted. What I am sure of, however, is that if the ICST has the resources commensurate to its task, we, meaning my office and the Bureau, can organize ICST, structure its management, and staff it to do the job in a way that will be effective and efficient.

Let me address that management question at the Bureau for a moment.

As you are aware, Mr. Chairman, I didn't forward Dr. Ambler's name to the President for nomination until I had worked with him for 6 months. When I did forward it, it was because I had developed a confidence in both his managerial skills and in his ability to grow in those skills. The ICST knows what it has to do. The management of the Bureau and my office know how to insure that that job gets done.

That accounts for 70 percent of our budget increase.

Let me turn now to what is frequently considered the most unusual item in our budget—competency building. Our budget submission contains $2 million for this task, about 10 percent of our requested net programmatic increase. Competency building in an organization like NBS is the most ephemeral of tasks. In reality, of course, it is no more ephemeral than the investments industry makes in new equipment to keep them au courant.

Unfortunately, in the Bureau and in industry, it is the kind of investment that can be put off for years. Our steel industry has clearly demonstrated that that kind of investment can be put off for years. Tragically, it has also shown us the price of doing so.

Our immediate need in the area of competency building is one of playing catchup ball. In 1969 we propose to spend our $2 million in three areas: advanced measurement science, mathematical modeling, and materials durability. Let me give you a few reasons why we have chosen those.

I will first turn to the area of frequency metrology. Why does the Bureau need to increase its competence in frequency metrology? It has the world's standard in that area. The answer is straightforward: the existence of satellities and new navigation systems make it possible with improved frequency metrology for a vessel to measure its position on the ocean and for an aircraft to measure its position any place on Earth with an accuracy of about three meters.

The importance of that, particularly when sailing in uncharted waters, is clear.

In advanced measurements science, we plan to tackle trace organics. We do not know enough about the analysis of trace organics to cooperate effectively in the pollution area. Electrotechnology is another area in which we need further competence in order to participate in the rapidly developing field of very large-scale integrated circuits.

I could go on: mathematical modeling, durability of materials. Under durability of materials, I would like to stress wear and fracture theory and lifetime prediction. We have a whole new class of materials coming into being in this country called composites. They have been used in making boats, golf club handles, and cars; and the degree of ignorance that we have about the behavior of those materials under wear and fracture is striking. If the Bureau is going to maintain its role, it needs to build up competence in that area.

The third area I would like to mention, and one discussed at great length in my written statement is the cooperative technology study that we are proposing. Incidentally, I must apologize for the length of my written statement and pedantic tone of some of it. When an ex-professor starts writing, it is often hard to stop. Its target is disaggregated industries, as you know, but I would like to mention why we see a reason for a study instead of a program. Three questions must be answered in the affirmative before going forward with a program. First, will industry consider it worthwhile to participate in such a program? Second, do the potential benefits of such a program warrant the effort? Third, is there sufficient evidence that industry won't do the job without the assistance of Government?

Personally I feel there is reasonable evidence in the literature and in the history to answer questions 2 and 3 in the affirmative, but No. 1 is still troubling to me. When I was at General Electric I had a boss who delighted in telling the story about the nutritionist who developed a new dog food. He had done a superb analysis of all the requirements for nutrition that dogs had, had formulated a food that exactly met all those requirements, and proposed the building of a new plant and starting of a new business.

His boss, however, asked: Will the dogs eat it? The nutritionist, unfortunately, was forced to confess that he had never tested that question. I do not want to be in the same position with a cooperative technology program. We have a new product; but we do not know whether our target market will like it.

Despite that, let me describe for you what we, or the Bureau, will actually be doing in the coming year under this study. It is an experimental study. We are not going to do simple surveys. We are going to do a market test. First, we will be constituting a road show and putting articles in a wide range of trade publications to describe a cooperative technology program and how the Government proposes to interact with industry.

Next, we will be receiving—since we will have solicited them—letters of request from various disaggregated industries with low productivity. We will then do short analyses of those industries to determine if full-scale proposals are warranted.

For those that are, we expect to receive proposals which will then be reviewed both by the staff and by representatives of the public and private sector. From that set of proposals, we will be selecting a series of high value proposals as examples of what we would do if we had the resources. Should that selection show high benefits for the costs involved, should it fit in with the Secretary's and the President's desires as to a way of approaching the problem, we will then come back to request resources to actively engage in those projects.

We have made estimates as to what the cost would be. We estimate it will cost between $1 million and $5 million for 3 years for each significant proposal that we get, that we chose to fund. We are estimating that we will probably get about 100 proposals. This is based upon the Bureau's experience in other areas. We estimate of that 100, 6 to 10 projects will in fact be high value targets. If we combine those, we can see that we are talking about a program that starts off at rate of about $20 million to $30 million per year; and that will level off in time at 3 to 4 times that amount.

If we add to that activtiy the work we are already doing under EDA's authority on impacted industries, we may be talking about a program that is double that amount or more.

One of the questions that has ferquently been raised is what is NBS's authority for doing that? We have received a decision from our counsel that indicates that we probably have sufficient authority based on one part of our organic act to go ahead and do the cooperative technology study, that we probably have authority to go ahead if the study proves positive.

Assuming we will want to establish a program that could grow to $100 million or more a year, it is questionable to me whether such a program should be based on an interpretation of probable authority in turn based upon one part of a major organic act. That's a question we are going to have to be addressing. I am sure this committee will also want to address it over the coming year.

Unfortunately, without the results of this study, I would have no idea of how to draft legislation to do the job of assisting disaggregated industries and impacted industries.

Mr. Chairman, I tried to expand a little bit on the rather narrow focus I took in my written statement. I appreciate your taking the time to listen; and I would be glad to answer any questions you have to ask about the Bureau. Dr. Ambler is here today to assist me if we get into too much detail.

Senator STEVENSON. Thank you, Dr. Baruch.

As you mentioned at the outset, NBS has an open authorization and, therefore, gets an annual appropriation. OTA has suggested that we consider annual or biannual or periodic authorization as one means of focusing more congressional attention on the Bureau and ending the neglect which has, I think, been harmful for it in the recent past.

How would you feel about periodic authorizations instead of the historical method?

Dr. BARUCH. Personally, I would be happy with such a setup. I think it would give this committee the opportunity to really focus in on the activities of the Bureau.

Senator STEVENSON. Well, that's a refreshing answer from someone in the executive branch. Ordinarily the objective is to elude us to the extent possible; but I think the consequences of such attitudes has been demonstrated in the case of NBS. It may well be right for a periodic review and—there is no reason for me to think it wouldn't be a sympathetic review. It might produce more congressional support than the Bureau has received in the recent past.

That's something we will want to give very serious attention to.

Let's go to the last subject you discussed, which I believe was the cooperative technology matter. Could you explain orally what you mean by "impacted and disaggregated industries"?

Dr. BARUCH. Yes, sir. Impacted industries are those industries that have suffered a significant dislocation in the way they do business because of intense foreign competition or because they are short of raw materials or energy or because the Government has passed new regulations or changed old ones that dictate major changes in their behavior. Those are the industries that usually come to EDA, to other agencies for help.

Frequently technology can play a large part in helping those industries; and, as you would expect under that kind of pressure, the industry is very willing to work on those technological solutions.

The disaggregated industries are another matter. They are the small industries. I shouldn't say that. They can be large industries. They are however made up primarily of small firms. As a result, they don't have the corporate laboratory of the kind represented by Bell Laboratories, for example, in the communications industry. The result is that it is very hard for such disaggregated industries to develop technologically in any significant fashion. They are small, they don't have the resources, they can't get together; and, if one looks at their productivity performance over a period of years, we find that in general it falls well below the productivity performance of industry as a whole.

That reduced productivity contributes to inflation, contributes to lack of competitive position, and it seems reasonable to expect that the Government, which represents society, can play some role in aggregating those small firms in addressing the problem of technological development within such industries. But it is a difficult job because the firms in the industries have been working for years, they are not accustomed to technological change, and there is a real question as to whether or not they want to participate. Can you get a bunch of machine shops worrying about a new technology and addressing itself to that problem?

Senator STEVENSON. And the cooperative technology program is aimed at the latter, the disaggregated industries?

Dr. BARUCH. I can't call it a program yet.

Senator STEVENSON. Study?

Dr. BARUCH. The study is aimed at those industries primarily to determine whether or not they will work with Government. Are they interested? Can they work with Government? Can Government work with them in an effective way to increase their productivity?

Senator STEVENSON. And as I recall, if I recall correctly, you indicated once before to us that this study had already identified certain or targeted certain disaggregated industries for the cooperative technology program. Is that correct?

Dr. BARUCH. Senator, we found that there were certain industries that were going to be easier to work with; but those turned out largely to be disaggregated industries that were impacted. Now we want to look at those disaggregated industries that are not yet in acute trouble, but that manifest this chronic problem of maintaining their productivity increase.

Senator STEVENSON. Could you give me an example?

Dr. BARUCH. Of the kind of industries?

Senator STEVENSON. Yes.

Dr. BARUCH. Sir, they range from the manufacture of books, where we have a very disaggregated industry, with a very low productivity growth, to the women's apparel industry.

Senator STEVENSON. The women's apparel? Is that disaggregated? It sounds impacted or at least disaggregated and impacted?

Dr. BARUCH. Well, I don't know yet. They haven't come through the normal route that an impacted one would come through. They are certainly disaggregated according to our census figures.

Incidentally, we define disaggregated, in order to pick industries out of the standard classification, as any industry in which the eight largest companies have less than 50 percent of the market share. It is that kind of industry where you are unlikely to get significant collaborative developments of new technology.

The reason we have not picked target industries, Mr. Chairman, to the extent that many people would like us to is that if innovation is going to take place in these industries, those industries have to be self-selecting as targets. We are speaking to industry. For instance I spoke yesterday in Atlanta to the textile industry. We will be speaking to the machine shop industry, to the machinery people. We will be speaking to a large number of industries to assist them in deciding whether they would like to self-select—to select themselves for this program.

Senator STEVENSON. Have you studied the Japanese experience with Japan's cooperative technology?

Dr. BARUCH. Yes, sir. I am quite familiar with the MITI program. It is a different kind of program. They are one step ahead of where we are even talking about.

Senator STEVENSON. Oh, at least.

Dr. BARUCH. For example, we are talking about impacted industries, industries already in trouble. We are talking about disaggregated industries. They form a nexus that acts as a drag on our economy. What we have never decided in government is where would we like to be? What would we like to have as our lead industries over the next 20 years? How can government and industry work together to insure that we attain and maintain a preeminent position in those industries? That's a very tough problem. It is one that I was talking with Dr. Baker about just before this hearing. It is a tough problem, but one we are not going to ignore.

Senator STEVENSON. Well, I am glad to hear you are not going to ignore it, but I have the impression that far from catching up with the Japanese, there is a possibility that we are stepping back from the Japanese.

Let me try to articulate my concern and get a response from you.

This subcommittee has been studying, in cooperation with the Subcommittee on International Finance—which I chair—the industrial competitiveness of the United States in the world with emphasis on export policy and emphasis on technology, and what is happening to our technological position in the world.

My impression of the Japanese is that instead of focusing on so-called disaggregated or impacted industries, with all that that implies to me about subsidizing industries that are confronted with the surplus capacity such as textiles, such as steel, and industries in which a highly developed country cannot expect to compete successfully with the low cost of labor in foreign countries, that they move ahead and don't look at such industries except to the extent they offer large potentials for shifting—for becoming different industries; and with the provision of which a government should be capable of identifying the markets of the future; and in cooperation with industry, the products with which to supply those markets.

Instead of differentiating between large and small, disaggregated and the Mitsubishi's, they will make the resources available for the development not of textiles to be exported by a great power in competition with the Indians or the Taiwanese or the South Koreans. but a fifth generation of computers or optical fibers; moving the nation into industries of high technology in which there will be markets where they can compete and out of those where others can do the job better, more effectively, taking advantage of their low-cost labor.

Now the last examples you gave me, as I recall, were textiles, shoes, and jewelry. Now I am glad to see you shifted a little. We have gone from textiles to women's apparel, which doesn't strike me as offering the greatest opportunity for the resources of a highly developed country, nor all of the social benefits that might be associated with.

let us say, a new generation of aircraft, not Boeing, but general aviation. The Government ought to be in a position to perceive the consequences of its own acts before taking such steps as deregulation of the aviation industry, which may mean an entirely different route structure in the United States with a few hubs served by the Boeings and everybody else served by commuter aircraft, services for which existing aircraft aren't really adequate. I pull that example out of the air.

Next year IBM gets hit by that next generation of computers. Why aren't we hitting them, and not with textiles? Or jewelry? Or shoes? What else? Books?

Dr. BARUCH. Yes.

Senator STEVENSON. That is an interesting possibility, although it might be better to start in the schools than with the printing, if the publication of books is to be a major priority. Any reaction?

Dr. BARUCH. Indeed. I could not share your concerns more specifically and more thoroughly. This committee has been told about the Japanese efforts in very large-scale integrated circuits, fiber optics, and flat screen television. I went through an exercise with some people in my office. Assuming that those activities of the Japanese were in fact to pay off, we postulated the creation of a beautiful little instrument about the size of a current hand calculator with a flat screen that folds down over the keyboard. You open it up and you can work on the keyboard in a higher-level language, get your outputs in numbers, or in letters, or in graphics, and in color. We look at that and ask who is going to buy a current Texas Instrument calculator when the Japanese produce something like that?

We have no mechanism in this country at the present time for saying where we want to go industrially. Basically that is left to the private sector. That system has worked for hundreds of years. It has worked because other countries have not made industrialization a matter of national commitment.

Now they have. There is serious question whether our old mechanisms of leaving it to private industry alone, at best providing them with benign neglect, frequently providing them with hostility from the Government, is really the best way to compete with countries that have made industrial development—particularly in the new and significant industries—a major goal.

We have cultural problems. We have cultural problems that go back to the days of the robber barons and the monopolies in the 19th century. We have a Justice Department that has very properly acted as a guardian against monopolistic practices. We have a great deal to overcome before the Government and industry can effectively participate in an industrialization plan of the kind that you are suggesting.

Having said that, since there is a great deal to overcome, that process cannot be started too soon. And I suspect others in the executive branch would be happy to work with the Congress. I think we would have excellent cooperation from people in industry to try to think through a process that would not be at great variance with our cultural background and our associated political system, that would enable industry and Government to work together, without the threat of an industrial state, to bring the kind of benefits of that kind of development to the public in general.

However, I think the Japanese are making a mistake. I think they are making a mistake because they are not looking at textiles. I think they are making a mistake because they are not looking at apparel. I don't agree with the hypothesis that textiles are not something to look at technologically because we can let the cheap labor people do that. We say let the cheap labor people do that because we see the making of apparel as a labor-intensive activity. I think there are other possibilities that need exploration.

Senator STEVENSON. If I can interrupt at that point, we also see it as important because our own welfare depends upon external markets. If they can't use their own labor, put their own people to work and export, whether it is textiles or some other product, those countries are going to suffer severe economic distress.

We will suffer severe economic distress and that may be the last of the distress.

Dr. BARUCH. Now that is a very good point, the fact that we need the economic vitality of other nations. If we decide not to work on textiles for that reason, it ought to be explicit that we are not working on textiles for that reason rather than because there is nothing that can be done. That is the part I want to get clear. I think the kind of decision that you are talking about is a very appropriate political decision; and I do not think it is for a technologist to make. I do think that if we were to put our minds to it, we would address the textile business somewhat differently. We would ask about three-dimensionally formed fabrics as opposed to woven, cut and stitched fabrics. That is of importance to the upholstery industry and to the textile industry. We would think about things like using the ink jet technology that was developed for printing outputs from computers. It has been developed in color. We would now ask if that is an appropriate technology for the dyeing of fabric as piecework so you can get great variability of design, thus providing a different type of product.

Senator STEVENSON. Can I interrupt again? If it is a technology that is appropriate for textiles in the United States, is there any reason to think it wouldn't be a technology appropriate to the industries in the foreign producers and adapted by them as well?

Dr. BARUCH. Yes, sir. The kind of technologies we tend to look at are those that take advantage, for the United States, of the difference in our factor prices; that take advantage of the fact that in the United States, capital is relatively cheap and labor is relatively dear, whereas in other countries, labor is relatively cheap and capital is relatively dear. We also look at technologies that require a basic technical support system which is generally not available in those other countries, the infrastructure.

When we can identify technologies that meet both of those criteria, we use a term they are "less swipable"; they are less transferable to the less-developed countries.

Whether this is a wise thing to do, whether we should engage in this at all, whether the structural unemployment that is taking place in our textile and apparel industry is important enough, compared to our foreign policy considerations, that I can not answer.

Senator STEVENSON. Well, I am suggesting there is a convergence of economic and political and moral considerations. Plus there is the—I would have thought—obvious fact that we can't call upon everybody to subsidize everybody else. There have to be priorities. If all those considerations can converge in a way that suggests that high technology, office equipment, information processing—which you have already talked about—optical fibers, new generation of aircraft, whatever is——

Dr. BARUCH. New basic materials

Senator STEVENSON. New materials. That's extremely interesting and an important subject and even more so because as they come onstream, they will create more problems for the steel industry. I am digressing, but you suggested an example of something that could be done within the steel industry and probably is being done in other countries, namely to shift it from a commodity for which there is an excess supply already into the production of new commodities such as composites.

In any event, there ought to be priorities, I would have thought. What concerns me a little is that this cooperative technology program seems to invert the priorities. Instead of aiming at the technologies that can be put to work in the United States in a way that simply isn't realistic in other countries, and as other countries are doing, highly developed countries such as the Japanese where they are focusing on women's apparel, not jewelry, we are taking a step backwards.

I think you are wrong. On this, Dr. Baruch, I have to claim the greater expertise about public attitudes and public opinion and cultural hangups. I think the country is ready for new ideas. It is ready for cooperation as opposed to continuing controversy between segments of our system, including Government and industry, and more ready than the Government is. The qualification is about the media. The media feeds on the adversarial relationship. The country, I think, would be very supportive of a new major cooperative approach between Government and industry on technology and its application and the experience we have had in the case of NASA, I think already bears me out.

There is one way to find out. That takes a little leadership.

Dr. BARUCH. Sir, first of all, I am happy to cede to you the higher authority in knowing the public. As of today, I have been in public service for exactly 1 year. I hope you are right. We have asked a group of the Commerce Technical Advisory Board to start looking at this question. As you are also aware, Dr. Press' office and mine will be doing a study on innovation in industry. That study will heavily involve members of the public sector and the private sector. I hope we find the kind of readiness that you say is there. Were it a desire on the part of the public for this kind of change, I would be happy to exercise the leadership I have.

Senator STEVENSON. Did I hear you say you are polling the public?

Dr. BARUCH. No.

Senator STEVENSON. That is good. Somebody has to lead the public one of these days.

Dr. BARUCH. What?

Senator STEVENSON. Somebody has to get out and lead the country someday.

Dr. BARUCH. What we are doing is looking at what resources there are in the Government for this kind of innovative stimulation and what kind of attitudes there are in the private sector for participating. It is a tough problem. We are not ignoring it.

Senator STEVENSON. Do you have a detailed study plan for the cooperative technology project?

Dr. BARUCH. Yes. We can submit that for the record.

Senator STEVENSON. Could we have a look at that?

Dr. BARUCH. Yes.

Senator STEVENSON. Thank you.

I have taken so much time on one of my favorite subjects that I don't have time for the others. I may have to follow up with some questions in writing.

Dr. BARUCH. I will be away for 10 days, Mr. Chairman, but I hope we can work out a schedule.

Senator STEVENSON. Very good. There may be a few more questions. Thank you very much, Dr. Baruch. You have been very helpful as usual.

Dr. BARUCH. Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF DR. JORDAN J. BARUCH, ASSISTANT SECRETARY FOR SCIENCE AND TECHNOLOGY, DEPARTMENT OF COMMERCE

Mr. Chairman, members of the Committee, I want to express my thanks for being invited to testify here today. Dr. Ambler and I have both expressed our appreciation for your interest in holding periodic oversight hearings on the National Bureau of Standards. The present hearings, however, are especially welcome. First, the Bureau is undergoing a reorganization; second, it is becoming active in new industry-related areas; and third, it is developing a powerful synergy with other parts of the Department of Commerce. That dynamism can lead to difficulty in understanding the rationale behind what is going on and the rationale connecting such apparently disjointed activities. I hope that my testimony here today can dispel those concerns and contribute to an understanding of what we are doing and why.

Because I would like to expose our thinking carefully, I am afraid that this testimony may be somewhat longer than usual. I hope that you will bear with me, however, because I believe that the Bureau has a unique contribution to make to our Nation's present and future industrial health. Let me first provide some background for my task.

For 77 years the National Bureau of Standards has made major contributions to American science, industry, commerce, government, and the general public. That an institution created in 1901 is still a vital force is a tribute to its management and staff who, over the years, have adapted NBS programs to the changing needs of our society.

In 1901 the Bureau's concerns were rather narrowly focused. For example, one of the major challenges then facing NBS was the need for uniform weights and measures for the states. Today, the Bureau, consistent with its organic act, is involved in a host of concerns, such as energy conservation, fire research, computer security, environmental measurements, and electronic reliability. Fortunately, NBS has demonstrated over the years an ability to focus on timely topics without sacrificing its reputation for integrity, independence, and high quality output.

The Bureau is and has been, first of all, the Nation's central reference laboratory. It provides the measurement standards, techniques, and data that are needed by almost every area of society. For example, science uses measurements in developing an understanding of our physical universe. Industry needs reliable data for the design of products and processes, and uses measurement as a major element in quality control. In commerce, accurate measurement assures fairness to buyer and seller alike. I think it's safe to say that measurement directly affects the lives of all Americans.

Measurement is both important and pervasive, yet we hear very little about it. That we don't, reflects credit on NBS and their ability to understand their constituents and respond to their needs. It means that the Nation's needs for accurate, reliable measurements are largely being met. I say largely because science, industry, and society encounter new problems, NBS must continue to respond. Let me give just a few examples. In 1962, a British physicist named Josephson made a theoretical prediction concerning electrical phenomena in coupled superconducters. Ten years later, after extensive laboratory work, a device based on the Josephson effect was adopted as the means of maintaining the legal volt in this country. It is a more accurate, more stable voltage reference than the standard cells that were used before, and, being based on a constant of nature, is reproducible at any time.

Such development work has effects that reach beyond the legal volt. During that decade of effort, a decade whose early years were marked by no assurance that a new standard would eventuate, the Bureau's competence in this new area was growing. Regardless of the outcome of the investigation into that new standard, it was evident that the Josephson junction marked a critical transition in solid state devices. Its potential for packing density, the speed of its transitions and its uniformity clearly indicated potential in electroncis.

Even now, industry is vigorously working on the Josephson junction. When they need the metrology and the basic technological support to facilitate its manufacture, the Bureau's competence in that area will be there to support them. Indeed, the Bureau's competence and its developments constitute a part of the infratechnology which will form the basis for our industries' product and process developments in this promising area.

The establishment of the National Measurement Laboratory under the new reorganization of the NBS is in explicit recognition of the Bureau's central responsibility for measurement and for the conduct of supporting research. It is in the NML that much of the basic competence will be housed and developed in the future.

Let me cite a more prosaic, yet very important NBS project. Many homes in this country waste a great deal of energy. The energy shortage of 1973, coupled with rapidly rising energy costs, focused attention on the need for energy conservation in buildings.

The average homeowner, however, is not equipped to judge what combination of insulation, storm windows and doors, and weatherstripping represents a sound investment. An economist at NBS provided guidelines with which homeowners can determine, in terms of weather conditions, costs of fuel or electricity, and cost of improvements, the best combination for their situation. This information has been distributed to hundreds of thousands of households in very useable format, and is helping people reduce energy consumption, fuel bills, and environmental pollution.

Even such a prosaic area of investigation as home heating, when coupled with the interdisciplinary skills that the Bureau can bring to bear, has the potential for extended impact. The Bureau's work in thermophotography, an effort originally directed at detecting heat leaks in those same houses, is now used effectively by state and local governments for surveying entire areas. Its influence is even spreading into the cancer detecting area of mammography.

Of considerable importance to the Bureau's own development, is the synergy that is to become increasingly important to the new activities of the Bureau as I will demonstrate later in my testimony.

NBS has long been a first-rate institution. Its staff is exceptional and creative; its management is competent, growing in strength and dedicated to excellence. Together they continue to make valuable—indeed essential—contributions to our national well-being.

But we've been lucky, Mr. Chairman. We've been lucky while we've been mortgaging the future of the Bureau. For many years, I have watched the Bureau change. As a member of its evaluation panels and as a colleague, I have had close and frequent contact with the NBS management and staff. For the past year, that contact bordered on the continuous. What I have found is disturbing.

NBS has been stretched thin in recent years by a variety of new assignments and the lack of commensurate resources. We have mortgaged our future by avoiding investment in many areas of science and technology that will clearly become critical in the rapidly approaching future. We have met most of these requirements albeit with varying degrees of satisfaction both to us and others.

Now, however, there is no slack left; no slack for developing our needed competence, no slack left for meeting new assignments and, most critically, no slack left for applying capabilities of the Bureau to the Nation's rapidly growing need for technological help in its industrial development. The mortgage has come due. The President's budget request to the Congress addresses itself to this problem.

We recognize that to utilize these additional resources effectively and without waste imposes different requirements on the Bureau's management than does either the maintenance of the status quo or conservation in the face of shrinking resources.

The NBS reorganization, which becomes effective on Sunday, is a major step towards that task. Grouping of competences along functional lines, reducing the number of organizational units, and providing focal points for development will lead to an increase in the Bureau's efficiency and effectiveness, provide an atmosphere for the development of our competence and the leadership for guiding that development.

So far, Mr. Chairman, I have spoken of the Bureau's special role in measurement, some of the past spinoffs from that role and our drive to rebuild our competence. I have also alluded to our shrinking ability to contribute meaningfully to our Nation's rapidly growing need in industrial development. That last was not a casual comment. On February 14, I and several other witnesses testified before joint hearings of your Subcommittee and the House Subcommittee on Science, Research and Technology as to our concerns about this country's vitality in industrial innovation and its place in the world's industrial development. We were a diverse panel—a professor, a labor specialist, an industrialist and a Federal employee. We were diverse; our approaches were diverse; but our concerns were remarkably uniform. We agreed that many signs point to trouble in the aea of innovation.

At the very time when shortages of raw materials are developing, when foreign competition is increasing, and when we need exports to help pay for the oil we import—at this critical time the private sector in America seems more detached than ever from the productive innovative process. While there are valid economic reasons for such growing detachment, the bottom line spells trouble.

This Committee's witnesses testified that the Federal Government has a significant impact on the process of innovation. Tax laws, patent policy, procurement, pollution regulations, support for R&D, and many other actions of the Federal Government affect the process of innovation. As you know, the OSTP and my office will be trying, over the next year or so, to quantify and localize the impact of these various options in an effort to answer the fundamental question: What integrated Federal policies can best encourage and assist industrial innovation while minimizing the social costs of those policies?

The answers to that question will be vital to the establishment of a rational long-term strategy but even now we are seeking an approach that will be effective. Mr. Chairman, let me spend some time describing the approach that we are considering.

When my colleagues, my students, and I studied the process of innovation in industry, we found two elements—ability and opportunity—were needed if it were to proceed at all. When a third element—imperative—was also present, however, innovation tended to proceed with great rapidity. Ability is easy to understand. A firm or organization either can innovate or it can't. To possess what we call ability, it needs both the knowledge—composed of technology and business skills and the financial and other resources that permit the organization to bring that knowledge to use. Many organizations try to innovate without one of those two components of ability, most fail.

Opportunity is a bit harder to pin down. For the decision makers along the line in an organization to be willing to undergo the risks and stresses of innovation—risks and stresses that are often sizeable—they must perceive a commensurate future return. For firms, that return is often expressed by simple measures such as pay-back-period or return-on-investment. For the individuals in the firm, however, the question of opportunity is more complex. Marketing managers often measure their return in increased share of market, engineers often in terms of peer plaudits and even chief executive officers—above some level of profit that will keep the stockholders happy—are often sensitive to such seemingly extraneous rewards as community reaction, status, and their firm's growth. These internal rewards are often uncorrelated with the economic rewards and help to explain why firms with the same external opportunity may differ in their willingness to innovate.

In the non-profit sector, such non-economic rewards often serve to explain most of the variability in innovative behavior among organizations.

Despite that variability, however, on the average the perceived economic opportunity is the surest predictor of reaction to a potential innovation. In estimating the response of an industry as a whole then return-on-investment swamps out virtually all other factors. Just as ability determines whether a firm can, the level of opportunity determines how hard it will try.

Imperative, our third element can be the strongest. It biases the willingness to try to an extent often bordering on panic. We're familiar with this phenomenon in other areas.

Termnial cancer patients will try Laetrile; uncertainties about the potential benefits are overridden by their imperative. Doctors, however, will not in general try Laetrile; they perceive a negligible opportunity and share virtually none of the patient's imperative. As does the patient faced by death, a firm threatened with extinction often shows much of the same extreme behavior. Internal reluctances often disappear and innovative change may become the firm's most pressing business. Not all imperatives, of course, are so extreme. Pilkington Brothers' extraordinary investment in the eventually successful Float Glass process was partly justified by the threat of French and American invasion of their market—an invasion made palpable by Pilkington's earlier experience with the Belgians.

Our studies thus tell us that Ability and Opportunity together—in an innovation-accepting firm—are enough to produce innovation. When they are both present. Imperative is an effective spur.

If it is necessary and fruitful for the Department to help industry through the support of innovation, it may be appropriate that we first choose those industries in which an imperative clearly exists. That choice is doubly motivated. Such industries—if the imperative is strong—are also a natural concern of government. Industry degradation or failure implies damage to our balance of payments, structural unemployment, deterioration of regions in which such industries are concentrated and a waste of productive facilities. Such industries aren't hard to find. We can easily identify three classes of industry that have such an imperative:

1. Industries experiencing severe foreign competition;
2. Industries which are threatened by sudden, gross or unexpected changes in the price of their raw materials or energy supply; and
3. Industries whose processes or products run counter to new government regulation.

The Federal Government has long provided assistance to such industries. Financial assistance and worker retraining assistance have been made available through such agencies as Commerce's Economic Development Administration (EDA). Such assistance has often, however, been provided with a sense of inevitability shared by both government and industry. Indeed, it is often wryly referred to as "burial assistance."

Since the presence of an imperative is such a strong force for innovation, there is a better way to provide assistance. The presence of imperatives offers industry and government an opportunity to bring their joint resources to bear on innovations strategically focused on lessening or removing those imperatives.

Mr. Chairman, to demonstrate some of the functional reasons behind the Bureau's reorganization and to clarify one facet of the relationship of the Bureau with the Department of Commerce, I would like to take a few moments more to review how we work with these impacted industries.

As the request of EDA, it is anticipated that NBS will provide technical support to various impacted industries to prevent conditions of excessive unemployment. As appropriate, funds are transferred to NBS for such undertakings.

In working with these impacted industries, our first task has been to determine what particular function of that industry would, if modified through innovation, serve to reduce its imperative. Sometimes that task is easy. In the case of an industry hurt by a new or changed EPA pollution regulation, for example, it may only be necessary to find a process modification that brings it within EPA limits. In other cases the task requires all the business, economic and technical skills we can bring to bear on it.

For a foreign-trade impacted industry the opportunity may be in the industry's management techniques, in marketing, in its production process, in a shift in its product line, in a change in scale or in various other areas. Because we are today focussing on the role of the National Bureau of Standards, I will restrict my remarks to those industries where the opportunity lies in a shift in product or process technology. That restriction is in no way meant to imply that the Department is impotent when the opportunity lies elsewhere. The Industry and Trade Administration, EDA, the Office of Minority Business Enterprise and my office all have capabilities that can play an effective role in those cases. The Bureau's skills, coupled with the resources of the rest of the Department, shine, however, when a technological innovation is needed.

Each impacted-industry project starts with a microeconomic analysis of the industry. That analysis isolates what industry segments are impacted and why. Based on that analysis we can then determine specific loci within those industry segments where a technological change can have the necessary impact.

After the necessary microeconomic analysis points to a potentially useful technological innovation, we establish a set of starting specifications for that technology. Next we have to determine whether that technology already exists—perhaps in some totally unrelated industry, in unfinished form in some research institute, or in a Federal Laboratory. Ideally, for this task, one would like an engineering group closely coupled to the forefront of research and familiar with the technologies used in a wide range of industries. Ideally, such a group would have a record of industry cooperation and a wide range of contacts throughout the industrial world. Ideally, such a group would have the necessary mathematical skills to model the impact of any new technology in the target industry and to monitor the effects as the technological change takes place.

All of those skills, albeit in somewhat scattered form, have existed at NBS for years. Under the Bureau's reorganization, however, they have been brought together under the National Engineering Laboratory. Of course, the NEL does far more than work on the technological problems of impacted industry. They are constituted generally to ensure a smooth flow from research to industrial use. More important, perhaps, they are also constituted to ensure that the researchers at NBS are aware of the general progress of applied technology and the future needs that such progress generates. This synergy between the National Engineering Laboratory and the National Measurement Laboratory will be both powerful and bi-directional.

Once we have identified either an existing technology that can be adapted or a new technology that requires development, estimates are made of the economic needs and effects of that technology. This latter is vital to success if the innovation is to presist on a self-sustaining basis. If the costs are large, other activities are started in parallel with the development program. EDA may be brought in for financing, OMBE may be brought in if there is the potential for the development of minority business enterprises, the Regional Affairs Office may be called on to work with the locality if a local development plan is needed, etc.

While that is going on, a technical team made up largely of industry representatives and either Bureau engineers and scientists or engineers and scientists on contract from outside, tackles the technical problem. The industry representatives, supported by their firms as a form of "earnest money," are critical to this process. Not only do they ensure that the efforts of the engineers remain relevant to the industry's needs and constraints, but they serve as the basic technology transfer medium. Upon completion of the project, they return to their firms—not with written reports alone—but with the new technology imbedded in their minds and with a personal commitment to its use.

This work with impacted firms has often been confused with the specific study on the feasibility of an effort in cooperative technology proposed in the President's budget. That confusion is understandable because the technique—the collaborative, cooperative development of new technology—is the same in both cases. The critical differenec between the two is the question of the applicability of that approach to two very different kinds of industry. The impacted industry program I have just been describing is relatively easy. Not only are the industries relatively easy to select in terms of the structural dislocations they are responsible for, but they also have that special ingredient—imperative—that provides the incentive for their participation. Our cooperative technology study focuses on a class of industries in which both of those ingredients are missing. In fact, that is why it has been set up as a study.

The special class of industries that the study addresses are the disaggregated industries (currently defined as industries where the 8 largest firms do less than 50 percent of the business) that have chronic productivity improvement problems, that provide many of our jobs and a sizeable fraction of our gross national product but, because of their structure often lack the ability to innovate. Indeed, because of the way innovation and subsequent copying takes place in those highly competitive industries, even the potential for financial benefit—opportunity—may be small compared to the risks involved. Such industries, in manufacturing alone, run a wide gamut from women's clothing through machine-shops, printing, and foundries to the fastener industry. In the service industries ranging from health care to retail distribution, the gamut is even wider.

For many reasons the Federal Government has a major stake in the development of these disaggregated industries:

They contribute significantly to the general economic health of the country.
They are chronically susceptible to incursion from foreign competition.
Cost reductions in such industries are counterinflationary.
Expansion of such industries creates new jobs and new export potentials.

Secondary incentives for government involvement run from the potential for energy conservation to pollution abatement in advance of regulation. The government has a stake, but does its involvement with such industries make sense in light of our economics and our culture? Moreover, do the industries have a stake—will they have the motivation to participate?

It is easier to answer the first question than the second. Economists such as Arrow, Mansfield, Solow, and Denison have demonstrated the discrepancy between the level of investment in innovation that takes place under motivation solely internal to the firm and that which would take place if the public benefits were also considered. Traditionally, when such market failure occurs, the government tries to compensate for that market failure through such means as tax incentives, procurement set-asides, etc., all of which address "opportunity". Rarely, except through the mission agencies does the government address the question of "ability", yet for many of the disaggregated industries there is a lack of the ability to respond to opportunity—no matter how many government programs provide such opportunity. It is to this problem that our study seeks to address itself—and if the study warrants it is here that the NBS will again have a major role to play.

Two aspects of this study will be proceeding simultaneously. The first will be academically oriented. It is necessary, before committing the Federal Government to any major effort in this area to determine whether industry alone can do the job and whether there are other, less expensive, modes of federal intervention. This study, a part of a much larger study that we and the OSTP will be doing, will rely heavily on economic analysis and analyses of the decision making process in firms that are part of disaggregated industries. We already have clear indicators from Olsen's work that, for disaggregated industries served by oligopolistic supply industries, other forms of help to such suppliers may be a more effective way of spurring innovation. Even if that academic study indicates that theoretically there are good reasons for government participation in the innovative activities of some disaggregated industries, a major question remains. Do the industries themselves perceive a need? To answer that question we will be performing a parallel field study.

During fiscal year 1978 and fiscal year 1979 we will be publicizing our concern to a wide range of disaggregated industries. With them, once we have received an expression of interest, we will proceed as with the impacted industries. There will, however, be two salient differences. First our work with them can only proceed through identification to the point of designing an appropriate attack on their technological need. This is, after all, a study and we have neither the funds nor the authorization to go further. Second, we will try to array our potential target industries for selection. It is essential that we be able to select, from among the many disaggregated industries, that set with which it is important to collaborate. Based on such criteria as achievable benefits, cost, ease of securing the technology and others, we will, in collaboration with representatives of the private and public sector, make an appropriate selection of industries. That selection, the response of industry in general and our academic analyses will form the basis of any budget proposal to the Department and to the President to initiate an appropriate program.

Such a direct approach is sometimes considered at variance with the concept of a "study", yet in this case it is appropriate. Cooperative technological development based on strategic business analysis would be a radically new "product" for the Federal Government. Other organizations, from soap companies to photographic firms have discovered that, in the case of a radically new product, survey results are essentially worthless. For minor modifications, such surveys work; for major ones they don't. In the light of this fact, most firms "test market" when they have a major innovation; that is what we are doing at Commerce. In a year or so we should be able to tell whether we are in a position to meet a well perceived need or whether we have another Edsel.

In sum, Mr. Chairman, both our on-going work in the area of impacted industries, and the proposed cooperative technology study which focus on disaggregated industries share a basic approach. Its essential element is to cooperate with industry and academia in the development of technology supportive of the industry. Cooperation for mutual benefit is the key to success. There will be no joint efforts unless the users and developers of technology identify the problems and opportunities and collaborate in the search for a solution. The objective of both efforts is, broadly stated—the preservation of jobs and the growth of our economy.

I see the National Bureau of Standards playing a lead role in the impacted industry program and a similar role if our study leads to an additional program. The Bureau will manage the feasibility studies that precede initiation of tasks, identify and assemble resources, and manage a responsive technical program. In cases where NBS has unique resources, these tasks might be performed internally. In general, however, work would be done under contract to outside institutions. NBS will monitor the progress of all technical studies, and play a large role in the transfer of the resulting technology.

I believe NBS is a logical choice for the functions I have mentioned—indeed it is the best choice I know of—because NBS has cooperated with industry and academia for 77 years. This new program would not be a radical departure for NBS; it would be a logical extension of its role and actions in providing technical services to industry and commerce. The Bureau understands the subtleties involved in the development and use of infratechnology as a result of its long experience in developing and providing infrastructure services.

The Bureau is already coupled to the industrial, academic, and government communities and has their respect and confidence. NBS people are now collaborating with many of the scientists and engineers who will participate in this program.

Many of the Bureau's outstanding scientists and engineers have had careers in industry too. This program could allow multiple use of their talents and provide all NBS researchers with new and exciting challenges.

NBS already has in place a variety of mechanisms for collaboration. For example, under the research associate program over 75 people from industry are working at NBS on problems of mutual interest. Other interchanges take place through the postdoctoral program, the Intergovernmental Personnel Exchange Act, visiting scientists, and executive interchange programs. My point is that interactions, leading to diffusion of technology, are an everyday occurrence at the Bureau.

The last sector of the NBS that I would like to address is the Institute for Computer Science and Technology (ICST). The ICST faces an immense task—nothing less than bringing to the Federal Data Processing system the economies of scale that it should be enjoying. In order to do that job—and do it right—will require an ICST that looks and acts very differently from the ICST of the past. To clarify that point let me just include here our internal tasking memorandum. It outlines the major activities that are necessary if the Federal Government is indeed to get all the mileage out of standardization that it can, and it indicates our view of those activities.

INTERNAL TASKING MEMORANDUM—TASKS REQUIRED FOR THE EFFECTIVE IMPLEMENTATION OF THE BROOKS ACT

1. Program Development and Evaluation (under Institute Director)

a. Conduct impact analyses to determine potential benefits of standards families and individual standards.

b. Conduct analyses to determine projected costs for standards families and individual standards.

c. Analyze technological forecasts to evaluate potential for future standards (see 7e below).

d. Collect and review (in coordination with OMB) operating costs to evaluate performance of standards and families.

NOTE: This separate and independent office is necessary for two reasons: 1. it requires a set of business analysis skills not generally found in the technical centers; 2. it directly supports the institute director in the establishment of standards development priorities.]

[NOTE: From our work with the ISETAP panel and others, it is likely that

2. Establishment of hardware and software standards for the procurement and use of computers in the Federal Government

these standards will also be adopted by state and local governments.]

a. Standards are to be mandatory and binding;

b. Deviations (exceptions or waivers) from these standards must be centrally approved upon review and recommendation of the ICST;

c. Standards must be pro-competitive; and

d. ICST will use the voluntary system where practical and timely.

3. Enforcement

a. Secretary of Commerce to approve deviations;

b. On-site audit (including inspection and tests);

c. Higher level language validation;

d. Applications package validation; and

e. Sanctions by GSA (procurement) and OMB (budget).

4. Assistance to agencies

a. Adaptation, maintenance and operation of the Federal Software Exchange. The current GSA system is voluntary. It is our intent that application program submission (in standard language and with standard documentation) be made mandatory as is the case with publications under the G.P.O. There will be some minimum level on such programs. Such a procedure is also necessary for compliance determination.

b. Training of other agency personnel in standards use and library use.

c. Training of other agency management personnel in the management of facilities under the standards and in the procurement of new standard facilities.

d. Consultation to other agencies on standards implementation, facilities specification and operation (OA funds or appropriations not yet decided).

e. Establishment and maintenance of a capacity-smoothing facility (if necessary; see f below) to meet temporary peak needs of agencies or to serve agencies whose needs are too small to warrant a dedicated installation.

f. Maintain inventory of predicted demands and capacity availability of other agencies to "broker" services where networking or transportation is appropriate.

g. Conduct a simulation service to assist in procurement and software development.

h. In cooperation with the Center for Applied Mathematics, develop models and general purpose statistical packages for other agency use. Such models must be requested and, depending on their generality, be cost shared by the other agency.

i. Conduct validation and conversion centers as appropriate internally or on contract.

j. Assist other agencies in evaluation and use of new types of equipment.

5. Research and Development

a. Develop prototype hardware or software technology to prove feasibility of proposed standards where necessary.

b. Procure, adapt or develop—on request from other agencies special purpose equipment that can be connected to standard installations.

c. Procure, adapt or develop the necessary software to permit standardized operation of the above.

d. Develop and establish privacy-protecting and security protocols to facilitate networking among standard facilities (see 4f above).

e. Coordinate with the Center for Electronic and Electrical Engineering, the Center for Applied Mathematics and the Center for Mechanical Engineering and Process Technology (automation) see 6d below.

f. Conduct in cooperation with OMB and other appropriate agencies an annual review of the accomplishment of and programs for research in computer services and techniques to assess accomplishments and to provide guidance for programs.

6. Diffusion

a. Assist State and local governments in the adoption and use of Federal Standards.

b. Assist State and local governments (via NACO, NLA, USCOM, etc.) in establishing a central applications program library for their use (similar to

4a above) and provide library interchange services with the central library.

c. Publish and publicize the results of impact analyses (see 1a) to encourage maximum comment on some and maximum use of Federal standards.

d. Review Federal Computer Science and Technology and maintain a computer-based inventory of same to assist in diffusing it through the public and private sector.

7. *Research*

Conduct research as needed to:

a. Develop test and standardization methodologies.

b. Open areas for new or revised standards as in the onset of new equipment architectures, new software developments or new protocols.

c. Support specific standards under development or to be developed.

d. Evaluate the potential and usage factors of new equipment or software.

e. Perform technological forecasts in both the hardware and software areas.

f. Maintain competence and ties with the outside.

I think it is clear that while some of these activities may be done outside of ICST, whatever remains is large. To ensure its accomplishment, the ICST has been established as an organization on a par with the NML and NEL within the Bureau. Whether this structure is sufficient, time will tell.

Mr. Chairman, I have gone on too long. Clearly the Bureau is on the move along several fronts. Such motion, of course, causes some strain but the overall effect looks very promising. With everyone's help this major national resource can be counted on to attain new levels of greatness.

U.S. DEPARTMENT OF COMMERCE,
ASSISTANT SECRETARY FOR SCIENCE AND TECHNOLOGY,
Washington, D.C., May 8, 1978.

Hon. ADLAI E. STEVENSON,
Chairman, Subcommittee on Science, Technology, and Space, Committee on Commerce, Science and Transportation, U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: Enclosed is the study plan for our Cooperative Technology Program which you requested that I furnish the Subcommittee during my testimony of April 6, 1978.

Please note that this study, although it represents our current thinking, may be modified.

Sincerely,

FRANCIS W. WOLEB,
(For Jordan J. Baruch).

Enclosure.

GUIDE TO FISCAL YEARS 1978 AND 1979 ACTIVITY ON THE COOPERATIVE TECHNOLOGY PROGRAM STUDY PLAN

The Department has requested $2 million for fiscal year 1979 which will support a study to determine:

the potential of a cooperative program with the private sector,

the feasibility of effective cooperation, and

the policy and management issues necessarily involved in organizing and designing a program.

Work has already begun along several interrelated tracks on the above tasks and sufficient results should be available by August of 1978 to present a sound justification for an fiscal year 1980 submission. These tracks involve:

intensive work with the private sector to determine both its support for the program and opportunities for significant cooperative projects;

systematic review of similar programs, both domestic and foreign, to define key issues and impacts;

management of programs with a similar thrust that are part of the existing mandate of the Department; and

comprehensive analysis of the governmental policy system affecting industrial innovation.

TRACK I: SURVEY OF PRIVATE SECTOR SUPPORT

Introduction

The Office of the Assistant Secretary for Science and Technology has actively contacted organizations representing the private sector concerning their interest in a cooperative program. Meetings have been held and will continue with a wide variety of industrial associations, universities, public interest groups, and companies concerning projects which would make significant contributions and which require appropriate government action. This outreach effort to the private sector constitutes a quasi-experimental study to determine the potential impact of such a program. That is, interactions start with the question: If a cooperative program were available, what specific needs could it fill?

In coming months, the Office of the Assistant Secretary for Science and Technology will focus interactions on leaders from one or two specific industries (e.g., machine tools and textiles, and areas of technology (e.g., composite materials, corrosion, and lubrication). An intensive schedule of visits to factories, research laboratories, technical institutes, key spokesmen, labor leaders and academics will provide the depth of mutual understanding needed to identify creative projects which will provide both significant results and realistic prospects of success.

Activity in fiscal year 1979 should continue on both the general and specific surveys of technologies with the aim of obtaining:

a full range of prospective projects across the broad spectrum of U.S. industry;

guidelines on policy and procedure abstracted from the analysis of prospective opportunities; and

indications of the depth, breadth and conditions of private support for a cooperative program.

Milestone Plans

Select sample fields for test market analysis by consultation with private sector organizations (May 1978).

Assess, with participation of the selected industries:

Technology opportunities and corresponding business strategies for meeting market needs,

Capacity to develop and use technology,

Shortfall in the capacity of private organizations to produce and use technology, and

Extent and feasibility of possible impact by a cooperative program (July 1978).

Analyze, integrate and report on results (August 1978).

Indentify industries and technical fields requiring special interaction in developing proposals for cooperative projects (September 1978).

Assess the opportunities for cooperative projects proposed across the full range of technical fields (April 1979).

Assess the potential impacts of cooperative technologies on the operations of state and local governments (May 1979).

Analyze, integrate and report results (June 1979).

TRACK II: REVIEW OF PROGRAMMATIC EXPERIENCE

Introduction

The concept of the Cooperative Technology Program is an outgrowth of an analysis of past programs of the U.S. and other governments in support of industrial technology. Efforts have continued to locate, describe and analyze these programs to:

identify policy options for providing governmental assistance on critical technologies;

define specific issues, problems, and strengths of programs; and

evaluate the success and impact of programs.

While a more rigorous review will extend into fiscal year 1979, sufficient analytical work should be complete by late summer of fiscal year 1978 for a sound submittal for a fiscal year 1980 budget request.

Two meetings are planned for the summer of 1978 to validate and integrate the preliminary findings of the above studies. These meetings will be held with academic, governmental and industrial experts in (a) the econmics of industrial technology and (b) the management of the innovation process.

Funds requested for fiscal year 1979 will be allocated to a systematic plan to continue the above process of location and analysis. In particular, efforts will be made to study the programs of:

other industrial nations in the free world,

other mission agencies of the U.S. government,

state governments within the U.S., and

private organizations organized into cooperative consortia.

The review of these programs will include published and unpublished program reviews, interviews with key personnel associated with the programs, analyses of theoretical literature dealing with general principles relevant to the programs, analytical comparisons of key characteristics, and systematic collection of descriptive and evaluative data.

Milestone Plans

Select primary examples of Federal and state government programs which have similar goals and structures (June 1978).

Select primary examples of foreign government programs which have similar goals and structures (May 1978).

Evaluate the effectiveness of exemplar programs in promoting balanced growth (July 1978).

Specify and assess the strengths and weaknesses in order to develop procedural and policy options in cooperative programs (July 1978).

Conduct conferences with economists, industrialists and experts on innovation to air, synthesize and validate conclusions about other programs (July 1978).

Complete the search of similar programs and of alternative options for influencing the advancement of critically needed technologies (October 1978).

Evaluate alternatives to cooperative R&D for accomplishing the goals of the program (December 1978).

Evaluate the effectiveness of other programs (March 1979).

Specify and assess the strengths and weaknesses for procedural and policy options on cooperative technology programs (July 1979).

TRACK III: MANAGEMENT OF COOPERATIVE PROGRAMS

Introduction

Existing missions of the Department of Commerce (namely those focused on providing industry-wide, technical assistance to impacted industries) require the Office of the Assistant Secretary for Science and Technology to be involved in the management of government/industry cooperation on specific technologies. For example, throughout fiscal year 1978, the Office of the Assistant Secretary for Science and Technology has been actively involved in a cooperative analysis of the trade impaction problems of the American footwear industry. This analysis will assist the footwear industry and the Department to specify a technical program which will encourage technologies capable of supporting a competitive advantage for American industry.

During the summer of fiscal year 1978, cooperative projects will be organized to provide the needed knowledge for industry to undertake subsequent commercial projects. This effort and others like it will provide many lessons of general value to the Cooperative Technology Program, such as:

delineation of the need for, and the structure of, a business analysis process necessary to relate technologies to viable, long-term strategies;

indication of the willingness for, and capability of, government and industry to cooperate together;

definition of the policies, procedures and assurances necessary to obtain full and effective cooperation;

clarification of the constraints of other agency policies (e.g., Department of Justice) on cooperative, technical work; and

projections of the value of cooperative projects.

Milestone Plans

Preliminary analysis, integration and reporting of lessons from cooperative projects (July 1978).

Evaluate the early response of the industries dealt with (July 1978).

Analysis, integration and reporting of lessons from the full set of cooperative projects to date (February 1979).

Evaluate the response of the private sector to the cooperative projects initiated (March 1979).

TRACK IV: POLICY ANALYSES ON INDUSTRIAL INNOVATION

A comprehensive analysis of the impact of Federal policy and program activities upon industrial innovation is being initiated by the Department of Commerce in conjunction with the Office of Science and Technology Policy. It is anticipated that the study will be conducted as a part of the Domestic Policy Review System.

Work on the policy review memorandum has already begun and first order assessments of the impact of Federal policy and programs upon industrial innovation should be well along by Fall and will continue throughout the Fall and winter months. The policy review activity and output will be factored into the analytical activity described in Track II thereby reinforcing the analytical evaluation being developed for the CTP. In sum, it will facilitate an assessment of the merit of a Cooperative Technology Program in the context of a review of other Federal policy and program options.

PRELIMINARY DESIGN OF A COOPERATIVE TECHNOLOGY PROGRAM

Introduction

All of the work described to this point is meant to specific the context, need for, and feasibility of a cooperative program. Given the successful completion of these tasks, we shall need to integrate the information obtained into an operational design for a program.

During the summer of fiscal year 1978, sufficient work will be completed to formulate a preliminary program design. This prototype will be valuable both in a systematic effort to obtain feedback from industry executives and others and in the design of final information search efforts. This latter work, culminating in a formal operating structure, will be the agenda for fiscal year 1979.

Milestone Plans

A. *Preliminary Design.*—Structure the preliminary design of the CTP:

Specify a process selecting specific fields of technology as the focus for special efforts on the generation of cooperative projects (July 1978)

Determine appropriate roles of industry groups, universities, Federal and state governments (June 1978)

Systematize criteria for selecting tasks (August 1978)

Determine preliminary policies for CTP on property rights (July 1978)

Design a preliminary strategy for promoting the utilization of technologies (July 1978)

B. *Initial Feedback.*—Solicit reaction to the pro-forma program through intensive, private sector interaction to:

Determine, with selected test cases, how CTP would affect private R&D activities and levels of funding (January 1979)

Determine preliminary response to CTP's preliminary design (November 1978)

C. *Formal Design.*—Evaluate responses to:

Refine program goals and statements of need (February 1979).

Specify program structure, policies and procedures (April 1979).

Assess potential impacts of cooperative projects (May 1979).

Define potential level of industry participation (June 1979).

D. *Final Feedback.*—Solicit reaction to the program through intensive private sector interactions to:

Determine with selected test cases how CTP would affect private R&D activities and levels of funding (July 1979).

Determine industry's response to CTP design (July 1979).

E. *Final Design.*—Evaluate responses to:

Assess potential value of the projects submitted to CTP (June 1979).

Finalize program goals, structure and procedure (July 1979).

Define potential level and nature of industry cooperation (August 1979).

Select projects, if warranted, as basis for a fiscal year 1980 funding request (September 1979).

Senator STEVENSON. Our next witness is Dr. W. Dale Compton, Vice President of Research, Ford Motor Co.

Dr. Compton, I will suggest to you also that if you would like to summarize your statement, we would be happy to enter it in the record.

STATEMENT OF DR. W. DALE COMPTON, VICE PRESIDENT OF RESEARCH, FORD MOTOR CO., DEARBORN, MICHIGAN

Dr. Compton. Mr. Chairman, my remarks are rather brief. With your permission, I would like to read through them.

Senator Stevenson. Very well.

Dr. Compton. If you would bear with me.

I am very pleased this morning to have the opportunity to participate in these hearings on NBS. My comments are based primarily upon opinion derived through participation on the NBS statutory Visiting Committee.

NBS has long been recognized as a truly outstanding national laboratory. It has been respected for the quality of its research, for the service it has rendered to commerce and industry, and for the intellectual integrity it has maintained in providing technical support to other governmental agencies. NBS is indeed a national resource. If it did not exist today, much of what it does would have to be carried on by other Government agencies.

The Organic Act of the National Bureau of Standards (1901) provided that the Bureau maintain and develop national standards of measurements and the means and methods for making measurements consistent with those standards. While this has continued to be a central function for the Bureau throughout its 77 years of service, recent legislation has substantially expanded and broadened its responsibilities. This broadening of responsibility has brought with it some real difficulties. I would like to spend a few minutes discussing some aspects of these problems.

Legislation subsequent to the Organic Act has often assigned specific tasks to the Bureau in areas that require immediate responses. Frequently, this assignment of responsibility has not been accompanied by adequate resources. As an example, I would like to mention the Brooks Act which Dr. Baruch has spoken of in considerable detail.

Let me say if the requested increase of $13.409 million for 1979 is allowed, this will substantially improve the situation; however, even this increase is probably insufficient to accomplish the task called for under that act.

The Standard Reference Data Act authorized and directed the Secretary of Commerce to provide, in part, for the collection, compilation, critical evaluation, publication, and dissemination of standard reference data. This program has regularly been authorized at $3 million, but was budgeted at $2.85 million in fiscal year 1978 and is requested at $3.15 million in fiscal year 1979.

The needs of many segments of industry, particularly in energy related areas, for carefully evaluated data are particularly great at this time. The level of support for this program is of serious concern to many of us in industry.

Other legislative actions have assigned the Bureau responsibilities that, in retrospect, appear ill-advised. The Federal Non-Nuclear Energy Research and Development Act directed that NBS give particular attention to the evaluation of all promising energy-related inventions, particularly those submitted by individual inventors and small companies. While I do not quarrel with the need for someone in the Government to perform this function, I question whether this is a proper role for the NBS.

Some of the legislation has stipulated that the funding be provided by other Federal agencies. OMB has been particularly aggressive in denying funding increases for the Bureau for those programs where another agency has the lead responsibility. While the rationale for these actions is reasonable, considerable problems have resulted.

Even in those cases where a transfer of funds is accomplished, it is seldom accompanied by an adjustment in personnel ceilings. Thus, the Bureau is called upon to perform the additional tasks for other agencies within its existing headcount ceiling. The Bureau has estimated that in fiscal year 1979, 180 additional positions would be required to support the high priority reimbursable programs of other agencies. The proposed fiscal year 1979 budget would provide for partial correction of this situation with an allowed increase of only 66.

What has been the impact upon the Bureau of these various actions? It has demanded that some very difficult decisions be made about program priorities. The long-range research that is the foundation of the next generation of measurement technology has been reduced in many cases in order to support the mandated programs.

Personnel have been shifted from longer-range programs to those having shorter-range objectives. As a result of this perceived shift in program priorities at the Bureau, morale has reached a low point. The reputation of the Bureau has suffered to the point that the best graduating students no longer consider the Bureau high on their list of employment considerations. In short, the view has been expressed that the Bureau is becoming a "job shop" and that it is no longer a research institution. This is undoubtedly an overstatement; however, the perceived situation is often as important as is the actual situation. Thus, there is real cause for concern.

Can anything be done about it? The answer is "yes" and, in fact, the proposed fiscal year 1979 budget represents a significant step toward helping correct this situation. Significant budget increases for the Bureau have been recommended by the Department of Commerce and OMB.

As was noted earlier, some headcount relief has been granted for the support of programs supported by other agencies. A particularly important contribution to correcting the situation is the requested budget increase for developing and maintaining basic research efforts in the scientific and engineering areas that support all NBS programs. Dr. Baruch referred to this as "competence building."

It is hoped that similar additional increases can be provided in future years. The NBS Visiting Committee has applauded these various budget actions. In addition, the committee is pleased that the capital equipment modernization program is proceeding as planned, with completion scheduled for 1981. This is a necessary move in the continuing effort to update the research facilities of the Bureau.

24-751—78——11

The budget and personnel relief offered by these actions is expected to start the rebuilding of the basic research competency at the Bureau. But it will take time and effort to restore full confidence in the ability of the Bureau to sustain a sound research effort. Stability of research support is essential if the Bureau is to regain its preeminence in the scientific world. It must be demonstrated that the long-range research will not always be sacrificed for the shorter-term research.

The proposed reorganization at the Bureau may be of some help in this. As you know, the proposed reorganization would concentrate much of the more basic, longer range research in the National Measurement Laboratory, with much of the more applied work and the support for other Government agencies being concentrated in the National Engineering Laboratory.

Since this organizational structure would concentrate the work that supports the basic measurement function within one unit, it will be easy to see how much budget and how many people are devoted to this function. The organization change will only help solve the Bureau's problems, however, if the Congress, OMB, and the Department of Commerce agree that budget demands of the National Engineering Laboratory will not be solved by transferring funds from the National Measurement Laboratory.

This means that future legislation should provide proper levels of funding and adequate personnel headcount, and it must assign tasks that are appropriate for and can best be done by the Bureau. If this is done, it would appear that both the basic and the applied programs of the Bureau can flourish. This is not to suggest that the legislative of executive branches should not request a reprioritization of work at the Bureau.

What is suggested is that reprioritization should not always require the Bureau to sacrifice its own fundamental mission in order to support the mission of other governmental agencies. This suggests that care should be taken not to require that funds be regulatory or randomly shifted from the National Measurement Laboratory to the National Engineering Laboratory.

Finally, I would like to comment on one other aspect of the proposed reorganization of the Bureau. A cooperative technology program is being studied. This program would assist disaggregated industries in developing basic technologies that are believed essential to providing products and processes necessary for their survival. This is a noble objective. But I must express some serious skepticism about the likely success of the Bureau in being able to do this; not because the problem doesn't exist, but because it is very difficult for any activity that is not an integral part of industry to determine what the real problems are, to determine when a given direction of work should be dropped, or to determine when the work has been successful and should be terminated.

These remarks are not specifical to the Bureau's programs. They apply to any Government agency that attempts to influence civilian commerce by development of solutions to problems that they perceive to be critical to that industry. I would observe that generally they have been unsuccessful. Thus, I am not optimistic that the Bureau can solve these problems through a cooperative technology program.

A number of my comments have been critical of actions taken by or on behalf of the Bureau. I would like to close by noting that the Bureau has many highly talented and devoted people. It has contributed greatly to the scientific and technological base of this Nation. It has a first-rate administrative group which has moved aggressively to improve the capability of the Bureau.

And the present Department of Commerce administration has demonstrated a sensitivity to the problems of the Bureau and a willingness to help correct them. This is most refreshing and suggests that optimism in the future is appropriate. The visiting committee of NBS notes that these recent trends are very positive. It believes that the Bureau will undoubtedly again achieve the excellence that is necessary if it is to fulfill the objectives that are required of it.

Speaking on behalf of the visiting committee, we wish to thank this committee for its interest in the well-being of the Bureau and for the opportunity to express our views on the issues that we feel are critical to the future of this great institution.

Senator STEVENSON. Thank you, Dr. Compton.

I agree that we ought to make certain the Bureau in the future isn't forced to subordinate its fundamental and long-range objectives to immediate objectives and mandated programs. That's a tendency which is chronic in the Government and the consequences are obvious in this agency. Maybe with annual or periodic authorizations for the Bureau, we can be more conscious of what we do to it and would thereby afford ourselves an opportunity to transfer out of as well as into the agency various responsibilities.

Do you have any opinion on that possibility? Periodic authorization?

Dr. COMPTON. The only comment that I would feel qualified to make on this issue, Mr. Chairman, is that the greater the visibility that the Bureau has at the highest levels of the Government, the more successful I think it will be. It has much to gain from a greater awareness of its programs.

Senator STEVENSON. Let's assume that contrary to your opinion, the Government did decide that the national welfare did require a cooperative program, that is one that is different than that contemplated through the Bureau, but one that did contemplate Federal assistance for R. & D. in industry, and not have development of the traditional defense-related objectives, but commercial products. Is the Bureau the appropriate place for such a program, or let's put it a different way.

Let's say your opinion is not accepted by the Government and it does go ahead with the present cooperative technology programs, shouldn't it be in some other agency? Aren't we getting apples and oranges mixed up again?

Dr. COMPTON. If one looks only at the basic mission of the Bureau, then it is somewhat removed from this type of function. But if one asks what other activity within the Department of Commerce, has the responsibility to be concerned with the health of U.S. industry, what other activity within the Department of Commerce could assist in this, I think one is led to the conclusion that it would be the NBS.

Senator STEVENSON. Of course, it doesn't have to be in the Department of Commerce at all?

Dr. COMPTON. Then I would question the viability of the role of the Department of Commerce in overlooking the health of industry in this country, if the program you describe were to be located elsewhere.

Senator STEVENSON. My proposition is the health of the Nation, and maybe it is not much of an exaggeration to say the survival of the Nation as the preeminent industrialized power of the world. Such programs are scattered throughout the Government. They are in the National Institutes of Health, in the Department of Energy, the Department of Agriculture, Commerce. Offhand, I can't think of one that doesn't have related programs.

I don't know how you would recognize it. I don't have a thought in mind. I just question whether this sort of thing is appropriate, if you want to maintain the integrity of the Organic Act and those fundamental missions of the Bureau, which you have already talked about.

Dr. COMPTON. There is a danger of diluting the principal function that the Bureau has been given in the Organic Act by bringing in a program which—as has been described—could be quite large. But I say—if the program as contemplated is truly a technical program for assisting industries in developing new ways of doing business, it will require a very technically oriented activity. If you look through the Federal Government at its technical capability, I think one is struck with the fact that most of this capability resides in the Department of Defense laboratories and in the National Laboratories of the Department of Energy. Putting aside, of course, health and the National Institutes of Health.

So the capability exists for the Bureau to contribute substantially to this kind of a problem. I think it would be well to look seriously at whether that capability would have to be built up someplace else, if it is not placed in the Bureau. This is an organization that is highly regarded by industry. It has a long history of working with industry.

I think a case might very well be made that they would have a credibility with the industrial sector that is probably unequaled elsewhere in the Government. That is a great advantage in the early stages of creating a program like this.

Senator STEVENSON. Yes. You are taking a fairly narrow view of the kind of technology that would be developed in cooperation with industry, but let me move on.

Do you think the Bureau can effectively use the $13.4 million requested increase over the current $4.2 million for implementation of the Brooks Act?

Dr. COMPTON. It is a large chunk to swallow. I have not looked in detail at what their plans are in terms of managing that increased effort. Neither has the Visiting Committee. I think it would be inappropriate for me to comment that it is either prepared or unprepared to do that task.

The issue boils down to whether you can attract the high-caliber people that you need to expand the program rapidly.

I believe the Bureau is sensitive to that, Mr. Chairman. I would be inclined to think that they have given their careful judgment to that and to its appropriateness.

Senator STEVENSON. You mention your concern about the level of support for the Standard Reference Act. Could you explain that concern?

Dr. COMPTON. Although I was unaware that that was to be discussed at the hearing later this morning. I am pleased to be able to respond to this question.

When that act was passed, I recall that there was a recommendation that it should be budgeted at a level of roughly $10 million or, at least, projected to that level.

I believe that was the thrust of the recommendation that Mr. Weisner made at the time of the presentation.

The needs are so great for industry in that area that it seems to me very important that that activity grow at a regular rate over the next several years to a level that approaches something like the originally planned $10 million. That growth can be slow, it can be gradual, but it needs to be expanded to meet the kind of needs that exist in the industry.

Senator STEVENSON. Could you hazard a suggestion as to an appropriate level of this fiscal year, fiscal year 1979?

Dr. COMPTON. Well, I have a rule of thumb in my own organization, Mr. Chairman, that for large programs it is difficult to grow more than about 10 percent per year.

For a program of the current size of the standard reference program—which is a rather small—I would think a 25-percent growth for the next couple years would be quite appropriate.

Senator STEVENSON. It was 2.9, I believe, for fiscal year 1978?

Dr. COMPTON. And it is proposed at 3.1 for fiscal year 1979.

Senator STEVENSON. That is proposed for fiscal year 1979?

Dr. COMPTON. Yes, and a certain part of that would be considered to be economics, I believe.

Senator STEVENSON. You would need 25?

Dr. COMPTON. Real growth should be about 25 percent.

Senator STEVENSON. Twenty-five percent in real growth over the 1978 level would be appropriate for 1979?

Dr. COMPTON. Yes.

Senator STEVENSON. More or less.

How about the adequacy of the NBS Organic Act? Do you have any suggestions as to how it should be changed, improved?

Dr. COMPTON. No, sir. I do not. I would only comment that, if it is changed, I would hope that it would retain as a key objective for the Bureau its continued service in the standards and measurement area.

Senator STEVENSON. How do you feel about the experimental technology incentive program and the Bureau's proposal to reorganize it into an experimental methods activity?

Dr. COMPTON. Within any program I think you can likely find areas which one would like to see strengthened and others that are already quite strong. In all honesty, things are no different for this particular program. It is a new experimental program and, thus, will likely need continuing review for some time to come. As a general comment I would note that it is a problem to determine what a governmental laboratory should be doing in the applied research area. This relates directly to the critical issue of commercialization. How should the Government assist the private sector in commercializing products; how does it provide the necessary incentives?

The experimental technology incentives program suffers from some of the same problems.

Their greatest contribution will come, in my view—in those areas in which they can develop ne methodologies, new measurement techniques, and a better understanding of phenomena that can be broadly applied by the industry, rather than in attempting to develop solutions to specific industrial problems that may exist.

Senator STEVENSON. Now, Dr. Compton, an unfair question. How is the Ford "Fiesta" doing?

Dr. COMPTON. We would always like to sell more of those Ford "Fiestas," Mr. Chairman.

Senator STEVENSON. It is doing well, isn't it?

Dr. COMPTON. Yes.

Senator STEVENSON. Where is it manufactured?

Dr. COMPTON. In Europe.

Senator STEVENSON. Why?

Dr. COMPTON. It is a European car. It was developed and built for the European market and is being imported into this country now in a limited volume to determine the acceptance of that type of vehicle to the American public.

Senator STEVENSON. Is it getting accepted?

Dr. COMPTON. It is meeting the expectations that we had for it. We are pleased with the acceptance so far. This is the first year. It's only been on the market a few months.

The import level will only be about 120,000 units this year. But we are pleased with its acceptance today.

Senator STEVENSON. And if industry had had a little more vision, it might have been onstream about, what, 1973, when the oil price was quadrupling? Earlier than that?

Dr. COMPTON. I don't know whether it is vision or not. Clairvoyance, maybe.

Senator STEVENSON. I think vision. It didn't take a prophet to foresee the energy crisis.

Dr. COMPTON. It is hard to predict a dramatic change in anything, Mr. Chairman, including, of course, an oil embargo. But I agree with you. We wish we had more fuel-efficient cars on the market and we are making a virgorous effort to accomplish this. I'm sure you are aware of this effort.

Senator STEVENSON. Any other questions? Thank you very much, Dr. Compton.

Dr. COMPTON. Thank you, Mr. Chairman.

Senator STEVENSON. Our next witness is Dr. William Baker, president of Bell Laboratories.

STATEMENT OF DR. WILLIAM O. BAKER, PRESIDENT, BELL LABORATORIES

Mr. BAKER. Good morning, Mr. Chairman.

Senator STEVENSON. Good morning, sir.

Once again, if you would like, we would be happy to enter your full statement into the record.

Mr. BAKER. Thank you, sir. We are reporting today the position of the panels of the National Academy of Sciences, National Research Council, which are invited annually by NBS and the Department of Commerce to review the scientific and technical work at the Bureau.

This has been done since 1959 by these groups. There are about 6 of them in major review capacities, and many subpanels, involving more than 200 people who are expert in the whole range of science and technology covered by the Bureau and who represent a whole range of American enterprises: universities, Government agencies, and, very especially, industry.

We have submitted in our prepared statement conclusions of that group in current reviews. We feel the need for NBS is more compelling than ever in its 75-year-plus history.

We have remarked in our notes for you the way it has and continues to contribute to the strength of industry and of other scientific and technical enterprises. I put it that way because NBS has a very large and important constituency among the scientists and engineers of the United States. This extends through many other activities such as particular industries, particular institutions: universities, educational systems, and the like.

It's clear from your perceptive exchanges with the witnesses already today, Dr. Baruch and Dr. Compton, that you are especially aware of the challenges to our economy and industry that we are finding now and are aware of the role the Bureau may play in them.

I might take the next few minutes, rather than reviewing the prepared statement, to pick a case which may be particularly timely and indicate how the judgments of these Panels are applied to the affairs of the Bureau and how we believe they are useful in your assessments of how the Bureau should be supported in its role in our national resources.

Namely, as Dr. Baruch has said, the Institute for Computer Science and Technology, the activities in the Bureau that are concentrated on the mastery of computers and of automations, is an area where a major increase in funding has been recommended. This is in full accord with the studies of the panels of the past several years.

One of the reasons for those recommendations from the Panels has been that we felt that American industry as well as Government and other enterprises not only had a world leadership in the use of automations, but could enhance the productivity in our ecnomy most effectively by that means better than by any other means that we know. This means, as you know, is already closely associated with many of the specific high-technology industries that are leaders in the country.

Dr. Compton's whole realm of automotive technology is a very heavy and skillful use of computers, of automations for machine-controls, and the rest.

In the field of electronics, we find such advances—that I could not have reported even last fall—as a single silicon disk here, containing 2.8 million transistors on this one disk of single crystal silicon, which has a whole series of completely functional computer memories on it. There are 142 memory sites there, capable of 2.3 million bits of memory.

Now, it's not only that this technology provides America with a strong leadership—strong leadership challenged, as you pointed out, by other countries such as Japan, but nevertheless a very strong leadership in the creation of these kinds of resources for automations. But also, the creation of these resources itself requires an exercise of automatic machinery and of skills in production which are beyond anything we have seen before.

To come to the Bureau's part, we can simply report that it is a source of authentication, of standardization, of measurement skills, from the most scientific to the most technological, that are absolutely essential to this kind of productivity and this kind of industry.

For example, here the dimensions that are significant in these circuits are dimensions of hundred-millionths, verging on billionths, of a meter, whereas a few decades ago—in fact, not more than one or two—relatively small subdivisions of a meter were what you had to worry about in measurements in industry and in technology generally. So we have come many orders of magnitude beyond what was long thought to be essential in producing a piece of hardware for the American economy.

Now, the Bureau of Standards is vital and is the world leader in the measurement schemes and the understanding of how to determine those parameters. But I wanted to pursue a little further your theme of what the Bureau's role properly is in the broader context of assuring industry progress widely.

The Institute for Computer Science and Technology is a good example. We have said these automatons are the basis for major industrial advances around the world today, events of all kinds: steelmaking, shoemaking, as well as for computers and electronics themselves.

The Panels advisory to the Institute for Computer Sciences and Technology in the Bureau are convinced that a major role remains in that Institute and in the Bureau to contribute to this advance in automatons in our country. It is the following kind of mission, in order of importance, and things which are not being done adequately anywhere else in the country or anywhere in the world.

The first involves the software engineering and quality control. It may interest you to know that although the programing of computers, generally known as software engineering, is a major technical activity in this Nation and around the world, there do not exist adequate quality controls. The quality assurance we happened in our industry to have introduced in the manufacture of products in the early 1940's and through the 1940's, which is now universal throughout the world in hardware production, has not been extended to software engineering or the production of software for automatons.

Second, the security of computers as proprietary elements of government, industry, wherever, is demanding strong attention.

Third, the network access controls, and the computer system accountability and audit ability and fidelity, and authenticity, are things that are not being dealt with in any part of industry adequately, although the computer industry has made a good start. It is necessary for an agency with the traditions of accuracy and objectivity of NBS to resolve the important issues there and to master that technical need.

Further, it is clear—along the lines that Dr. Compton pointed out generally—that the Bureau's mission is being spread too thinly and that the Bureau has not had the resources that are essential to do some of these absolutely essential jobs, such as this one on computer documentation, software standards, and quality assurance that I am talking about; it is clear that the deficiencies in the Bureau's work in this field up to date are very significant.

The interface—matter of interface standards has struck our Panel as being the most serious; and Dr. Baruch has referred to this, that we are in this Nation developing a lot of fragmented computer systems, fragmented capabilities in industry and Government, that are not interconnected; and this doesn't have to be that way.

We talk about combinations of government and industry and other resources in Japan—Japan, Inc., or whatever else—in advancing new capabilities as a nation. Here we have an opportunity for magnificant national advances in automatons through all our components of the United States which we are missing by not having this transferability, this portability that Dr. Baruch talked about, and what we generally call interface standards. It is very much an appropriate mission for NBS.

We mentioned software quality control, which our Panel thought was the next most essential thing for the Bureau to do. We mentioned software validation. Data standards, the actual formating of data upon which American industry and American Government must eventually depend, are needed. The automation and "manufacture" of data bases is not being standardize and made transferable in the form that is essential.

It is almost as though instead of using a decimal system for arithmetic, we use three or four convenient and quite different bases.

The standard programing language deserves much more attention; the computerized model development deserves a modest amount. That is something that is extremely useful, for these smaller industries that have been referred to as well as for the very large technological ones.

By essential computer model development, industries can estimate markets, estimate the relationship of their products to the needs of this Nation, the consumer interest, and, of course, to their marketability.

I hope this is a little example of the breadth of utility that a proper support of the Institute of Computer Science and Technology in the NBS can lead to.

I could take your time to illustrate similar roles and functions in a variety of other industries, in a variety of the other sections of the Bureau's work, but it would come out rather similar to this. My real point of the report is that in the judgment of these citizens who worked on the panels for NBS, the enhanced funding that has been proposed is absolutely essential. And furthermore, to answer your query specifically, we believe that NBS in its present form, with its present leadership and the action that has been taken in this Senate to assure that leadership, will manage effectively the resources that are being requested and will manage effectively the meeting of some of these technological needs.

I should add that in the opinion of the panels, while we have not looked deeply into the proposed reorganization—there hasn't been time—we judge these things by results and not by postulates. Nevertheless, the feeling is that there will be a very ample and very compelling mission for the Bureau in the main organization roles of the National Measurements Laboratory, the National Engineering Laboratory. We believe there is a basis for the concerns that Dr. Compton has expressed about whether there are really appropriate resources for other things.

However, we will be anxious to report on that as the new organization evolves.

I believe, Mr. Chairman, that we have summarized the current findings of the panels but we would be very glad to expand on any of these or to explicate them.

Senator STEVENSON. Thank you, Dr. Baker. You have an opinion, you say, on the reorganization plan?

Dr. BAKER. We really do not have much of an opinion.

Senator STEVENSON. You do not?

Dr. BAKER. No. We will seek to judge that and react on it in terms of the outputs, as we do annually. And it is really too early to see how this new arrangement is going to go.

Senator STEVENSON. You probably heard Dr. Compton suggest that $13.4 million was a rather large increase for the Bureau to swallow for implementation of the Brooks Act. Do you disagree with that?

Dr. BAKER. We share the concern, of course, about how rapidly any scientific or technical body can absorb such an increase, but it is modulated, as I think he implied, by the fact that the Bureau has needed to do this work for a long time. They have been grasping for it, they have been struggling to get some of it done.

Therefore, the issue is not quite so much a completely new set of operations to carry out, rather being able to carry out some that they have been half doing, or not doing, for some years already.

They really are more prepared than one might expect.

Senator STEVENSON. Do I take that to mean that you do disagree and feel that the $13.4 million is a reasonable figure?

Dr. BAKER. I do really disagree, and think it is appropriate.

Senator STEVENSON. What are your views on the proposed cooperative technology program for the Bureau?

Dr. BAKER. Well, sir, I would have to say that that is a vital new element in the reorganization and, therefore, it is early for us to be able to judge anything about it. We haven't had the chance to see the outputs.

We do feel, as we noted, that the other missions of the Bureau, which have much needed expanded support, are so compelling, along the lines

I reported to you, for example, in automata, in computers, that it is going to be a full-time job to get those things done well. Therefore, we will look with interest but with reservation on whether a quite different program, such as the one in cooperative technology, will find the appropriate attention.

The Bureau's management is very competent, is highly committed to doing these important things for the country. You can only do so many things at once.

Senator STEVENSON. I believe you were here during Dr. Baruch's testimony? You heard him indicate that his program was directed toward cooperative technology for women's apparel as opposed to automation. Would you care to respond to his suggestions about the directions of this program, for disaggregated industries?

Dr. BAKER. I think he very wisely emphasized that we are much worried in the country about the science and technology, research and development, available to the so-called disaggregated industries. I believe, on the one hand, we must heed very keenly Dr. Compton's point that it is those industries themselves that know what they need, and it will be very hard to do their research and development for them. But, on the other hand, we have to agree with Dr. Baruch's implication, at least that maybe we can get something out of their way.

That is the hand of regulation, of control, of the dealing with questions of intraindustry communication, that is, being able to have exchange of information within an industry. Those things are very serious constraints on the research and development for those smaller industries.

For example, in the high technology part of electronics, where there are many small industries, it is necessary to clean the materials that you use—which are semiconductors, metals, all sorts of things. Industry, for generations, has had methods of degreasing, cleaning by certain solvents. The Toxic Substances Control Act will make it practically illegal—nobody is quite sure of what—to use a beaker of benzene in removing contaminants from vital parts of the raw materials from which the smaller industries make the components that we are dealing with.

Now, nobody knows whether this is good or bad. If you grow up inside of a tank full of benzene there are certainly dangers. But one has not got a set of scales of hazard, which is to adequately enable us to keep research and development and to keep process technology moving in industry.

By the way, even the matter of mere demonstration of the quantities of these alleged toxic materials that are present in processes is something NBS can contribute a great deal to, by its analytic techniques and measurement techniques.

Then to turn all the way around and say that Government can do research and development for disaggregated industries which are being inhibited in their own solution of technical problems by unmeasurable, uninterpretable regulations, I think is of very serious concern.

Senator STEVENSON. Do you have any suggestions for changes in the Organic Act of the Bureau?

Dr. BARKER. No. sir, I believe that it has proven to be effective and versatile. It has met the needs that I have described to you, which I think are samples of needs which will still be coming on at the end of this century. It is a good act.

Senator STEVENSON. You and others have cited the personnel problems at the Bureau. In addition to supporting the fiscal year 1979 budget request for competency building, what else should be done?

Dr. BAKER. I am not quite sure I follow you.

Senator STEVENSON. In addition to supporting the request for competency building, what if anything should be done to help solve that personnel problem?

Dr. BAKER. Specifically, some relief in the matter of personnel positions that the Bureau has been held to. It has—it needs——

Senator STEVENSON. There is some relief contemplated.

Dr. BAKER. Yes.

Senator STEVENSON. Are you familiar with the ceilings proposed in the budget for personnel?

Dr. BAKER. I have looked very quickly at the budget.

Senator STEVENSON. Should it be higher?

Dr. BAKER. I think it should be higher soon. If—particularly in the area of funds which the Bureau can manage experimentally and use for supporting the basic work that will permit these measurement techniques we are talking about, I do think that should be higher. I do think there are specific——

Senator STEVENSON. Should there be any ceilings at all?

Dr. BAKER. I am sorry?

Senator STEVENSON. This is a somewhat theoretical question. Why not make money available and forget about the ceilings. Leave it to the Bureau to determine for itself how best to make use of the funds made available.

Dr. BAKER. I would hope there would be a strong tendency in that direction. They are able to do this. The legislation is already very good, as we have indicated about defining a mission. The demonstration over 75 years really is that the Bureau management has been highly realistic about this.

They have tried to relate consistently to the intentions of the Congress. Therefore, the point you are making is really very vital for maintaining technical excellence.

They should be able to dispose of these funds. An interesting thing about their reorganization is that they have reduced the fine structure. They reduced some of the subdivisions in their own internal organization. It is a good thing, because they are going to be able to move people and move programs more readily than before.

They removed, I think the thing they called sections. I think this puts them in a good position to do what you are implying, that they should have a little more internal autonomy.

Senator STEVENSON. Anything else you would suggest?

Dr. BAKER. What?

Senator STEVENSON. Anything else you would suggest for coping with the personnel problem?

Dr. BAKER. No, thank you, sir. I think this has been a very useful exchange.

Senator STEVENSON. Nothing more?
Thank you very much, sir.
[The statement follows:]

STATEMENT OF DR. W. O. BAKER, BELL LABORATORIES

I am pleased to appear here today to discuss with your Subcommittee the strengths, problems, and needs of the National Bureau of Standards.

Since 1959, the Department of Commerce and the National Bureau of Standards have annually invited the National Academy of Sciences to provide an external evaluation of the technical work of NBS. This is accomplished through a series of Evaluation Panels. There are currently six major Panels and a number of Subpanels. The National Academy of Sciences selects and appoints the Panel members, of which there are at present over 200 people who give freely of their time. In recent years I have been pleased to serve as the Chairman of the Steering Committee of the Evaluation Panels.

Today I speak on behalf of the Panels, who are charged with the responsibility of evaluating the technical functions and operations of NBS, and also as a private citizen and industrial scientist with a keen interest in the vital functions that the Bureau performs.

As a member of the U.S. industrial community, I can report that the need for the National Bureau of Standards appears to be more compelling than ever. The Department of Commerce and the National Bureau of Standards have worked coopertively with industry in this country for many years, and it is incumbent on the Congress and this Subcommittee in particular to ensure that the Bureau is able to continue to make valuable contributions to the scientific and technological health of the nation. I believe that the Bureau has performed its role with distinction and that it can continue to do so.

I have sressed the importance of the Bureau to industry, but my colleagues on the Evaluation Panels from universities and also from other government agencies attest to the fact that the Bureau is vitally needed by these other segments of the nation.

During the many years that I have been aware of its activities, the Bureau has been a forum for the exchange and dissemination of scientific and technical information, and it has been a major force in the encouragement of innovation. It not only has furnished an accepted language for science and technology—the language of measurement—but it also has become a scientific conscience of these communities. It has set high standards for research. Scientists have become accustomed to expect that they can visit the Bureau to obtain new ideas and to confirm the validity of their work. My overall assessment is that, through the National Bureau of Standards, Congress has provided the science and technology of this nation with invaluable support.

Since the Bureau was founded in 1901, the needs of science and technology have changed considerably and I must emphasize that the needs of the very near future are quite beyond those with which we have been familiar. There is an evolving role of the National Bureau of Standards in its relationship to national science and technology goals. As the reputation and prestige of the Bureau has grown, additional responsibilities and tasks have been entrusted to its care. I want to stress that the role of the Bureau is quite pervasive. It covers many fields of science and engineering, and it is a crucial base of support for programs of many other federal agencies.

Because the Bureau furnishes the legal as well as operational bases for many measurements in this country, it is important that sufficient resources be made available to the Bureau to maintain the competences necessary to ensure the quality of measurements and measurement methods on which the nation depends. Since its beginning, the Bureau has been involved with standards for weights and measures in the marketplace that are necessary to ensure equity in trade, both within this country and internationally.

Let's look at one type of standard—the standard of length. A century ago, this standard consisted merely of the space between two scratches on a metal bar. Today, you will find such a metal bar in the NBS museum, but not in the laboratory. Today, the Bureaus is called upon to furnish standards and standard measurement methods for length that range from astronomical distances to interatomic spacing. Optical effects of highest precision are nowadays the principal length meter.

The Bureau has made technical contributions to the Global Positioning System of the U.S. Air Force. In this System, precisely timed signals from a group of satellites will be used to accurately locate the position of an object on the surface of the earth or even in the air to within a few feet. The precision of the instruments required in this System are at the forward state of the art.

At the other end of the range of length measurements required in today's technology, the Bureau has recently been able to measure absolutely rather than relatively the distance between atoms in a silicon crystal. This has far-reaching effects because until now, these atomic distances had to be expressed in arbitrary x-ray units because the exact relationship to the standard of length was not known.

In between these two extremes of length are many other examples of much-needed work that is being carried out by the National Bureau of Standards.

Everyone is familiar with the revolutionary advancements in the field of electronics; advances that are now providing a myriad of consumer products such as calculators, digital watches, home video games, and many other devices. It is now possible to construct device, such as a microprocessor, that is smaller than a postage stamp but contains literally thousands of transistors and associated components. This device is in fact the working part of a computer. Devices like this one have to be calibrated and are subject to manufacturing controls that are orders of magnitude greater than before. This nation leads dramatically in applying such controls, and the National Bureau of Standards has provided the necessary precision standards.

For electrical measurements, the Bureau provides calibration services by which many types of electrical measurements throughout the country are coordinated. A dramatic example of the need for these calibration services occurred last year on the Evaluation Panels. The Bureau proposed a cutback in the number of electrical calibrations. Such a cutback was vigorously protested by Evaluation Panel members from both the military services and the defense contrctors. Both stressed the need for such callibrations to be done by a recognized authority such as the National Bureau of Standards in a third-party role.

Continual improvement in measurements is vitally important to industry, but at the same time, there are many challenges in new areas that the National Bureau of Standards must tackle if our nation is to remain internationally competitive. One such area is dynamic metrology, which could greatly enhance our ability to compete as a manufacturing nation. Already tremendous advances have been made in the manufacture of discrete parts through numerically controlled machine tools. The next step is to measure the work in progress dynamically without slowing down the machining process. This technique can result in a significant increase in manufacturing productivity. Even greater increases can be made by providing computer-controlled, continuous adjustment of the machining process based on these dynamic measurements. This is the kind of anticipatory research that the National Bureau of Standards is doing and should be doing. Inspection by automatic pattern recognition is another oncoming need that is capable of lifting productivity.

In recent years, regulatory agencies have issued a large number of regulations in health, safety, environment, energy, and so forth. In many cases, the legal enforcement of these regulations depends on the work of the National Bureas of Standards for calibration, standard measuring methods, and Standard Reference Materials. Sometimes, new technologies of measurement have had to be developed. For example, pollutants in the atmosphere often must be measured to parts per billion, and this requires the highest type of technology. Of course, it is not the Bureau's mission to determine the maximum allowable level of pollutants in the air—that is done by another agency. However, it is the mission of the National Bureau of Standards to provide the calibrations and standards to enable these measurements to be made.

As you know, the National Bureau of Standards is now in the final stage of an extensive reorganization. The Evaluation Panels of the National Academy of Sciences have not been active participants in the planning of the reorganization, but nevertheless they are extremely interested in any management action that might affect the technical programs of the Bureau. All organizations find it necessary to reorganize from time to time, and one always hopes that some of the problems of the organization will be solved thereby. Although Dr. Ernest Ambler was only recently sworn in as the new Director of the Bureau, his association with that organization covers a quarter of a century, and he is well known to us. Therefore, it is to be expected that the reorganization is being done with a very thorough knowledge of the mission and operation of the Bureau.

In some cases, specific organizational problems pointed out by the Evaluation Panels have been addressed. For example, it has been previously necessary to have three separate Subpanels to evaluate the work of the Electricity Division, the Electromagnetics Division, and the Electronic Technology Division, because these parts of the Bureau were in separate institutes and separate locations. The Panels have pointed out the need for improved coordination of these activities, and in the new organizational structure we find them grouped together. Included with these three divisions will be a small group in cryoelectronics that was formerly part of the Cryogenics Division. This move is also viewed as a positive step by the Panels. And there are other examples.

One of the management problems that cannot be wholly solved by reorganization is the difficulty of having a part of the Bureau located in Boulder, Colorado, which is 1,500 miles from Gaithersburg, Maryland. It might seem that the obvious solution is to move the entire operation to Gaithersburg, but this is neither necessary nor desirable. The technical quality of work in Boulder is high and is enhanced in some cases by the location. For example, the recent discovery of a new type of molecule important in atmospheric chemistry resulted from a joint project between NBS and NOAA, another large Department of Commerce laboratory located in Boulder. Also, the Joint Institute for Laboratory Astrophysics (JILA), a joint venture between NBS and the University of Colorado, is world renowned for its scientific excellence. The work done by the NBS portion of the JILA is directly related to the mission of NBS, but it is immeasurably enhanced by interactions with experimentalists and theorists in the university portion of JILA.

I might point out that one of the original justifications for moving a part of the Bureau to Boulder was to obtain a better location from which to broadcast the much-used time and frequency signals from WWV. There is now also a transmitter in Hawaii. In the not-too-distant future, the time signals will probably be broadcast from satellites, and the ground location of the Time and Frequency Division could be anywhere, but the ground-based transmitters must be maintained for another decade or so.

The Evaluation Panels were not happy with the original reorganizational plan for the Cryogenics Division in Boulder, but the difficulties appear to have been resolved satisfactorily. This is one example of how the Bureau has been very responsive to the findings and recommendations of the Evaluation Panels.

I have discussed the NBS Boulder laboratories in some detail in order to illustrate that the inherent problem of managing an organization with a smaller portion located at some remote distance has not resulted in work of any less significance or quality from that remote location.

The main concern of the Evaluation Panels at this time is that the Bureau is spread too thin. It has too many responsibilities for the resources available to it. In many cases, the expertise of the Bureau in a particular field is now only one person deep.

Over the past few years, the number of short-term tasks assigned to the Bureau has increased while the ceiling on the number of personnel has remained essentially constant. It appears that this situation has compromised the Bureau's ability to maintain a balance between short-term applied work and long-term fundamental research. There is a general impression, both within and outside NBS, that the amount of fundamental research undertaken by the Bureau has decreased within the last few years. It is generally believed that this is primarily due to the fact that additional, short-term, applied responsibilities assigned to the Bureau do not carry concomitant additional personnel slots, and consequently, the required positions must be generated within a constant-size staff by reducing the amount of long-range fundamental research. It would be desirable to find mechanisms to maintain and protect the level of long-term fundamental research so that it is no lower than about 15 percent of the total NBS program. It is vital that the necessity of maintaining the ability to do fundamental research within NBS be formally recognized in the federal budget approval procedures.

It is important that the National Bureau of Standards do both short-term applied work and long-term fundamental research. In fact, the ability to do today's short-term applied work is based largely on the long-term fundamental research that was done in the past, and there is no doubt that today's long-term fundamental research will be useful in the applied work of the future. Adequate long-range planning can determine those areas of fundamental research that are most likely to give results that will be needed in the future. We must protect the ability of the Bureau to be able to respond quickly to the short-term needs that will arise in the future.

The quality of the science and technology at the Bureau is, for the most part, excellent, but constant vigilance is required in order to make sure that the expertise and equipment available at the Bureau are sufficient to meet the evolving needs. Several years ago, the Evaluation Panels called attention to serious deficiencies in the equipment of the Bureau due to reduced equipment funding. At that time, the Secretary of the Department of Commerce began an equipment modernization program that has done a great deal to relieve the situation. However, there will continue to be equipment needs because the Bureau needs state-of-the-art equipment in order to maintain and disseminate the national standards of measurement.

The Evaluation Panels have called attention to deficiencies in the central computing facility at the Bureau, and I understand that plans are under way to modernize this facility.

In general, the Evaluation Panels have no complaints about the technical work of the Bureau or the productivity of the staff. In one case involving the Bureau's nuclear reactor, which is used heavily by other agencies, the Panel believes that the productivity is actually too high. That is to say that the reactor is being used to the maximum exen possible, and only minimum time is available for reactor operator training and routine safety maintenance. In order to relieve this, it is proposed in the fiscal year 1979 budget of the Bureau to install equipment that would allow the maximum power of the reactor to be doubled to 20 MW, and this is fully endorsed by the Evaluation Panels. The additional power of the reactor would allow individual irradiations to be accomplished more quickly and thus a greater number of them could be done.

The current assessments of the Evaluation Panels highlight three points:

1. The technical work of the Bureau is excellent;
2. The managerial talent at NBS is of high quality; and
3. NBS is being stretched beyond its resource limits.

It appears that new assignments are given to NBS because of the great trust than can be placed in an institution with such a strong reputation. What the Bureau is able to do with resources available, it does well. The National Bureau of Standards continues to provide, as it has in the past, the standards, the measurement technology, the critical standard reference data, the Standard Reference Materials, and the information processing standards that are necessary for increased productivity, equity in trade, continued innovation, and more efficient government operation.

Senator STEVENSON. We now have been joined by Congressman Brown. I apologize for keeping you waiting, Congressman.

I thank you for joining us this morning.

STATEMENT OF HON. GEORGE E. BROWN, JR., U.S. REPRESENTATIVE FROM CALIFORNIA

Mr. BROWN. I apologize for being late. I intended to be here a little earlier. I was unable to do so.

Senator, I am taking the liberty of appearing and offering testimony before your subcommittee because of my own interest in this area, and because of earlier hearings which we held on the House side which led me to feel that perhaps I could offer some suggestions or raise some questions that might be helpful.

I have a prepared statement which I hope that you can see fit to insert in the record. I will try to briefly cover as much of it as I think is necessary.

Senator STEVENSON. The full statement will be entered in the record.

Mr. BROWN. I want to pay tribute to the work that you have done in this subcommittee, Senator, in a number of different areas which I won't belabor.

I have been involved cooperatively in many of the efforts that have come before your subcommittee for legislation, such as the earthquake and climate bills; and I know of the very excellent work that you have been doing.

I note that the subcommittee shares jurisdiction with the House Science Committee over NBS, OTA, NASA, and a number of science policy issues. These may very well enlarge in the future.

As I mentioned, we had in the House oversight hearings on the Bureau last October. I have been giving some thought to the matter which you are considering here. I want to pose several questions; and I wish I could pose the answers to all of them, but I can't.

Briefly, the questions that I think need to be answered—and I hope will be as a result of these hearings—include, first, what is the mission of the Bureau, and what forces shape that mission?

The core of that mission, of course, has been to develop and maintain national standards of measurements over the years; but bits and pieces of additional responsibilities have been added, so that we now have a rather wide variety of activities within the purview of the Bureau.

These are continually being changed and modified by the capabilities of the staff; by changes in the Department of Commerce policies; by congressional action, both legislative and oversight. I think we need to continually focus in on what is it exactly that we want the Bureau to do.

I would suggest that we perhaps ought to monitor more closely new legislation affecting the Bureau so that we insure that any mandates are consistent with the—with its own abilities and with past legislative directions. It is conceivable that the Organic Act possibly should be amended in order to give cognizance to some of these changes that have been added more recently; and it is, of course, possible—and on the House side we have tended to make a point of this business of annual authorization of appropriations as a way of helping the agencies under our general jurisdiction, to keep them a little closer tuned with the feelings of the Congress as a whole.

I don't know whether it will be possible to reach agreement on the central focus or mission in any precise terms, but I always consider that this is indispensible to answering most any other questions that arise in connection with an agency.

The second question that has come to my mind is that of what can we do to make NBS a part of an integrated network of Federal Laboratories? In fact, what can we do to create that integrated network, a rationally functioning network, out of the hodgepodge of multimission laboratories that we have throughout the Government?

I know this is a question that you have been interested in, Senator; and it is a tremendously complex and important kind of a question.

In thinking about it as far as the Federal establishment as a whole, NBS, of course, has to play a key role in any such concept.

What I am really interested in is an evaluation of how well the structure and focus of our laboratories permits them to respond to changing national needs for a national network of talent and laboratory facilities that can serve our national purpose.

I, of course, see this as being an indispensible tool this network of laboratories, in any process of planning for the future in this coun-

24-751 O—78——12

try. I have come to feel that we are missing a great opportunity in not devoting the kind of integrated thought to this laboratory capacity that we should.

I would suggest in that connection—and it applies to NBS—that there are several things that can be done to maximize our use of the labs. There should be a freer exchange of personnel capabilities and information among the laboratories. There should be a greater opportunity to make these exchanges between the various levels of Government, between the Federal Government, State and local government, for the mutual benefit of all of the levels of government.

Of course, the role of the Congress should be in helping to remove any barriers that exist in terms of that greater capability for the exchange of people, and resources to meet changing needs.

I gather you have had some discussion of the role of NBS in encouraging innovation in American industry. We feel that this is an important question which needs to be dealt with.

The systems that we have, such as the patent system and the various provisions in the Small Business Administration legislation should be contributing to this goal, but don't seem to be doing it as well as it should. I don't have good suggestions as to how we can increase this innovation capability, but in connection with the industrial—major industrial development in my own area of California, I find that our steel industry is lagging behind foreign steel development, because of this failure to innovate.

I know there are many other industries in the same position. I think that the Bureau should have an important role in assisting in doing that.

You have already raised questions about the budgetary and staff levels of the Bureau, and I have come to the conclusion last year that we had provided more responsibility and less resources than the Bureau needed.

I hope that this year's budget will rectify that. I do want to indicate that certainly the increases are in the right direction. Possibly they could be modified, but I have strongly felt that we did need an increase in both personnel and financial resources for the NBS, and I think that is developing.

I am sure you have thought about this problem of needs for maintaining a so-called critical mass of research capability and whether the various programs in the Bureau do have that. This needs to be constantly analyzed, and the problem of the aging of the Bureau's research staff needs to be looked at in terms of maintaining its historical excellence. As we fail to draw in new blood at the Bureau, we are missing the opportunity, of course, to bring new insight, people who have a different training.

There are generational differences in approach.

I am very much concerned that the personnel management at the Bureau and the level of personnel be such as to encourage this turnover and the attraction of younger scientists.

Mr. Chairman, I think this, in a very brief way, indicates the kind of questions that I thought needed to be raised and, therefore, very little in the way of answers, as I indicated.

My longer statement elaborates on some of the points I made. I think in the interests of time I will confine myself to these remarks.

Senator STEVENSON. Thank you, Congressman Brown.

You have been one of the leading figures in the country on the activities of the Federal Government in this whole area of science technology, and your opinions are valued by all of us as is your continued cooperation.

We have had a good relationship in the past. I am certain it will continue in the future.

I am hopeful that together we can answer the important questions that you have raised. I think you have raised the right ones.

Let me ask one question, if I might. Do you think we would be helped in the Congress to answer those questions and to better monitor the legislation, as you suggested which assigns a task to the Bureau, if the Bureau was subject to a periodic authorizing legislation? As you know, it is open ended.

Mr. BROWN. Yes, Mr. Chairman, I think it is a matter more of custom and precedent on the House side, in our committee, to use the annual authorization. We found that it worked very well with the National Science Foundation, with NASA, with some of the other agencies. I am not at all sure that it is an indispensable tool or that it needs to be annual instead of, say, biannual. Our concern is that there be some method by which frequent oversight is promoted. These regular authorization procedures do promote close oversight.

It does not solve all the problems. It can become routine and perfunctory. In considering the tremendous load that exists on the members of the Senate, perhaps an annual authorization would be too much of a burden, but the overriding goal is to make sure that the agency is responsive to the needs of the public as reflected in the Congress and that the Congress is aware on a continuing basis of their problems, and we think that it helps to do that.

Senator STEVENSON. Well, I am glad to hear you say that. I agree with what you say about annual authorizations.

I don't know—we don't have a period to suggest, whether it is 2 years, 3 years. Maybe it would be a good idea for us to develop some legislation that would begin a periodic authorizing process and perhaps include other measures, some, for example, which again slough off a few of the assignments which the Bureau has taken on or been given in recent years, which aren't directly related to its fundamental purposes and might better be taken care of in other agencies.

Mr. BROWN. If I might comment, Mr. Chairman, I think every agency tends to develop by accretion funds which should be evaluated and considered as to whether they are still necessary.

Apply the so-called sunset thinking to it. I am not saying this is true in the case of the Bureau, but I have run into many programs where there are laws that sometimes go back 50, 100 years that are still on the books, but no longer even observed.

The opportunity to go back and restructure this authorizing legislation, if that's what it is, to simplify it, to combine it may be a process of fundamental importance to this whole business of simplifying the structure of government.

I would hope that it might be and is well worth doing in many situations.

Senator STEVENSON. I understand that OSTP is reviewing NBS. Maybe we ought to work with OSTP to come up with a process for periodic reviews, as well as beginning now a review of all of the assignments which the Bureau has accumulated over the years.

In any event, we look forward to cooperating with you on that, and we are grateful to you for coming over this morning.

Before you leave, we have reported our climate bill. Would it be too soon to start reconciling the fairly insignificant differences?

Mr. BROWN. I am very pleased to hear that, Mr. Chairman. We will do everything possible to facilitate the expeditious agreement on some version that will meet both of our needs.

Senator STEVENSON. Now that we have taken care of earthquakes, we can take care of weather.

Mr. BROWN. Right.

Senator STEVENSON. Thank you, Congressman Brown.

Mr. BROWN. Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF HON. GEORGE E. BROWN, JR., U.S. REPRESENTATIVE FROM CALIFORNIA

Chairman Stevenson and Members of the Subcommittee on Science Technology and Space, I am delighted to appear before you today to testify regarding the National Bureau of Standards. Your Subcommittee and the Committee on Science and Technology of the House, particularly the Subcommittee on Science, Research and Technology, have enjoyed close and harmonious relations ever since you, Senator Stevenson, assumed the chair at the outset of your Subcommittee's existence. It was a pleasure to co-chair with you the recent joint hearings on the Office of Science and Technology Policy. I would like to thank you and your staff, also for your work with the House Science Committee on the Earthquake and Climate bills, legislation that was of particular interest to me. As you know, your Subcommittee additionally shares jurisdiction with the House Science Committee over the National Bureau of Standards, the Office of Technology Assessment, NASA, and science policy issues of recombinant DNA. I hope and anticipate that our areas of common interest will be larger in the future.

The House Subcommittee on Science, Research and Technology held an oversight hearing on the National Bureau of Standards last October. In connection with NBS oversight I have been thinking about issues that deserve consideration. I would like to discuss with you six questions about the National Bureau of Standards which I believe to be important.

First, what is the mission of the National Bureau of Standards, and what forces shape that mission?

Second, how can the National Bureau of Standards best be made part of an integrated network of Federal laboratories?

Third, what should be the role of NBS in encouraging innovation in American industry?

Fourth, are the resources assigned to NBS proper for the execution of the Bureau's mission?

Fifth, what needs and characteristics of the Bureau's staff are important, and are they now adequately considered?

Sixth, is the current reorganization of the Bureau conceptually and practically sound?

I intend to amplify on each of these questions and to suggest partial answers to some.

MISSION

To reiterate, my first question is: What is the mission of the National Bureau of Standards, and what forces shape that mission?

The core of the Bureau's mission, as you well know, has been to develop and maintain national standards of measurement. Over the years, especially since 1965, bits and pieces of additional mission have been added to that core, so that now a wide variety of activities is undertaken at the Bureau: fire research, the evaluation of inventions, development of labels revealing energy efficiency, furthering metric conversion, risk analysis for consumer products, and so forth. There is no current NBS activity that seems to me inappropriate to the Bureau, but the variety of activity is so great that it is not obvious how it all fits under one blanket.

Several forces continually mold the Bureau's mission. The abilities and proclivities of the NBS staff, the policies and priorities of the Department of Commerce, the needs and desires of other agencies which pay for Bureau services, and Congressional pressure through legislation and oversight are probably the principal forces. Legislation has definitely been responsible for much of the variety in Bureau activities. Bureau work is currently authorized by over fifteen Acts. Legislation can also play a role in determining the success of NBS programs funded by other agencies.

Actions that might be beneficial—and let me emphasize that I am not now endorsing these but only recommending they be considered—include (i) closer monitoring of new legislation affecting the Bureau, (ii) overhauling the Bureau's organic act—it hasn't been revamped in nearly thirty years, (iii) requiring the Bureau to obtain periodic reauthorization of appropriations (iv) making the Bureau an independent agency, and (v) amending the authorizing legislation of agencies using Bureau services.

FEDERAL LABORATORIES

My second question is: How can the National Bureau of Standards best be made part of an integrated network of Federal laboratories?

I understand, Senator, that your Subcommittee is interested in the general question of Federal laboratory utilization and is undertaking studies directed at getting answers. I, too, am convinced of the importance of this issue, and I applaud your efforts.

Collectively, the Federal laboratories cover a wide spectrum of sizes and subjects. The expertise housed in the laboratories has tremendous depth and breadth. Additionally, these facilities range from the development oriented laboratories, such as NASA's to those that are mission oriented like DOD laboratories, and further to completely unique national facilities, such as the National Bureau of Standards. This complex montage of organizations should be networked into a rational harmonious system if this Nation is to have the optimum benefit of this excellent pool of scientific, engineering, and technical facilities and talent.

I am suggesting a re-evaluation of how well the structure and focus of laboratories can allow for the proper response to changing national needs, and for a national networking of talent and facilities. I am not proposing that the laboratories should all be integrated into one organization. In fact, I feel that such an integration into one organization might be counter-productive to the breadth of our scientific enterprise by causing a narrowing of administrative viewpoints. What I am suggesting is that we try to reach a better understanding of the relative place and capabilities of all the facilities; and further that we use this understanding in conjunction with medium and long range planning to optimize the whole system and avoid actions which, by being either too narrowly focused or short sighted, optimize one part of the laboratory system at the expense of the whole.

Our nation is facing problems in several areas which can only be solved through the scientific and technological input of two or more disciplines. We frequently hear calls for programs similar in scope to the space program to solve problems of urban decay and pollution clean-up. We are currently adding problems such as environmental health threats and one imagines that the future will add yet more. I question whether the present structure of our laboratory system is best designed to respond to the challenge.

To respond to such cross-cutting problems we regularly ask the agencies to cooperate with one another and coordinate their efforts. In spite of these attempts at joint-effort research, I feel that presently our laboratories are too constricted and narrowly focused on agency missions, and not adequately networked, to optimally respond to such interdisciplinary or interagency challenges. As long as the labs are primarily agency labs, and accountable in terms of the success or failure of the agency's mission, there is an understandable, but counterproductive, tendency to solve the agency mission first and undertake joint efforts second.

Three measures should be considered to maximize the use of our Federal laboratories.

(a) There should be freer exchange of personnel, capabilities, and information among the laboratories.

In the course of scientific research, whether basic or geared towards solving a particular problem, it is not unusual that an investigator explores the fringes of his own specialty and even researches in a field not immediately pertinent be of direct value to other researchers.

(b) There should be similar exchange of personnel, ideas and technology among the several levels of Government and private concerns.

The Federal Laboratory Consortium currently provides for such exchanges. The list of examples of how the Consortium has assisted State and local governments is impressive; including such notable ones as protective body armour for our civilian police forces and decompression chambers that have already saved the lives of many diving accident victims.

To simply transfer a piece of equipment or a technical report, however, is often insufficient and leads to frustration and dissatisfaction of local officials who must cope with an unfamiliar topic. Technology transfer works best when the scientists are actively reaching out into the community, identifying those areas where technology can play a role, and consulting with administrators to gain a firmer grasp of the nontechnical aspects of the problems.

(c) There should be a concerted effort on the part of Congress to remove institutional barriers to the types of exchanges which I have mentioned.

It is likely that the Congress and the administration would have to relax constraints on agency budgets and operations and provide for and encourage pass through funding and subcontracting. Scientists and engineers could then more freely move to where their expertise can be best used. Perhaps these practices would be more easily performed (and the problems of joint research mentioned earlier reduced) if our laboratories and research centers were considered not as agency but as national facilities. They would be temporarily assigned to solve specific tasks. This concept of national labs needs to be considered as a possible solution to our crosscutting problems.

There are other problems in using Federal laboratories for non-Federal purposes that deserve the attention of Congress and the administration before our laboratory structure can be more broadly used. These potential problems include the relationship of regulatory agencies to the entities they regulate; military secrecy; public-private competition and others.

INNOVATION

My third question is: What should be the role of NBS in encouraging innovation in American industry?

This question should be addressed as part of an approach to the broader question of how the Federal government can encourage innovation in American industry.

I understand, Senator Stevenson, that you have been interested in the broader question. I agree with you that this issue is emerging as one of the most important matters with which the nation will have to deal in the near future. My own reasons for coming to this conclusion include several factors. First, the percentage of U.S. patents issued yearly to foreign inventors has been increasing steadily while the U.S. percentage has been decreasing. Second, in other countries governments are beginning to cooperate with industry in fostering innovation; Germany has a national program in automated parts manufacture, for example, and Japan is investing in large-scale integrated circuits. It is not clear that U.S. industry can compete wtih entire governments without the assistance of its own government. Third, the United States balance of trade is heavily dependent on exports of high-technology equipment. Fourth, in certain industries—steel, for example—foreign countries clearly lead the United States in innovation. The long-range fate of these industries may depend upon policies which rekindle innovative spirit. Fifth, there are indications that U.S. industrial research is turning toward immediate needs for minor products changes and toward environmental and health research for mitigating harmful effects of industry. Such research is essential but generally does not lead to the invention of new or improved products. Sixth, although the rate of innovation per unit of investment is highest in small R&D firms, the United States effort to encourage such firms is weak. Public financing of new small technical companies declined from about $350 million in 1969 to almost nothing in 1975.

A number of threads of Federal activity exist. The patent system is an effective spur to innovation. The Small Business Administration could be contributing, but seems not to be. The National Science Foundation has an Office of

Small Business Research and Development, a small business set-aside in the Applied Research directorate, and a special small business innovation program. At the National Bureau of Standards there are the Office of Energy Related Inventions, the Experimental Technology Incentives Program, and, just beginning, the National Centers for Cooperative Technology. The actual effectiveness of all these programs combined in encouraging innovation may well be dwarfed by the effectiveness of tax policy. I have not tried to evaluate these programs, but whatever their individual effectiveness, there is obviously great fragmentation of effort and lack of coordination.

The Bureau's role in the overall national effort needs to be more clearly analyzed and defined. I hope our committees will be able to contribute to the analysis and definition. Your committee has the advantage of jurisdiction over both commerce and science which we do not enjoy.

RESOURCES

My fourth question is: Are the resources assigned to NBS proper for the execution of the Bureau's mission?

During the NBS oversight hearings held by the House Subcommittee on Science, Research and Technology last October we focused on this question and discussed it at length. A strong case was made that NBS funding had been inadequate to carry out fully all the Bureau's missions, especially those assigned by recent legislation. In the President's budget for fiscal year 1979 the request for NBS was significantly higher than the 1978 appropriation, as I am sure you are aware. Increases are slated both for NBS for responses to legislation and for supporting basic competence at the Bureau. I am heartened by these increases, but I would suggest that our committees continue to monitor NBS funding.

Just as the definition of the Bureau's missions must be viewed in relation to the missions of other Federal laboratories, so must the funding of those missions be considered in relation to the funding of other agencies. This is true both in the small—for example in fire research and environmental monitoring—and in large—meaning that NBS must be viewed as part of the overall national research effort.

STAFF

My fifth question is: What needs and characteristics of the Bureau's staff are important, and are they now adequately considered?

Does the Bureau maintain a "critical mass" of talent in its mission areas? That is to ask, are the working groups of the right size and do they contain enough first-rate researchers to maintain high intellectual power output? The competency funding requested by the President should allow the Bureau to deal with this question. Because the intellectual life of the Bureau is essential to its success and because the competency funding program is new, our committees should follow its progress with care to determine its effectiveness.

Associated with the "critical mass" question is the problem of aging of the Bureau's staff. The average age of the staff has increased every year since 1961 and is still increasing at the rate of half a year older each year. The average age of Bureau employees is now about 44 years old. New blood is needed at the Bureau at a reasonable rate. NBS is working to attract younger scientists and visiting scientists to the Bureau for permanent or temporary positions. These efforts should be encouraged.

For the post of Director and for other high-level positions NBS needs to find and keep the best talent available. The last two Directors of the Bureau were drawn away after short terms by jobs they considered better; both received pay increases. Clearly one major factor in the quality of a job is its salary level. In the last Congress Representative James Symington recognized that salaries may be a problem at NBS and introduced a bill that would have raised the pay level of the NBS Director. Perhaps a similar bill should be introduced now. Serious consideration should be given to raising the pay of the principal Bureau administrators.

REORGANIZATION

My sixth and final question is: Is the current reorganization of the Bureau conceptually and practically sound?

I understand you investigated this question in some detail in your hearings earlier this year, Mr. Chairman, so I will not labor the point. My brevity is not meant to downplay the importance of the issue. Two particulars with which I am concerned are: first, will the reorganization in fact add another layer of bureaucracy to the Bureau. In terms of funtioning the question may be rephrased: Will papers have to cross one more desk for additional approval and will chains of command and reporting get longer? The second particular is the apparent concentration of other agency funding in the National Engineering Laboratory of the reorganized structure.

I have been told that the units which will be made part of the National Engineering Laboratory obtain eighty percent of their funding from other agencies. If this is indeed the case, the ability of that Laboratory to maintain a stable program must be questioned.

That completes my prepared remarks, Mr. Chairman. Let me offer my compliments to you again for the performance of your Subcommittee. These hearings on the National Bureau of Standards are very much needed. I hope the questions I have suggested will be helpful to you.

Senator STEVENSON. Now we will turn to S. 2615, the authorization bill for the Standard Reference Data Act. Our final witness this morning is Dr. Ambler, the Director of the Bureau.

You might start by identifying the persons that you brought with you, Dr. Ambler.

STATEMENTS OF ERNEST AMBLER, DIRECTOR, NATIONAL BUREAU OF STANDARDS, AND DONALD R. JOHNSON, DEPUTY DIRECTOR FOR PROGRAMS (DESIGNATE), NATIONAL MEASUREMENT LABORATORY; ACCOMPANIED BY DAVID R. LIDE, JR.

Dr. AMBLER. Thank you, Mr. Chairman.

I am accompanied today by Dr. Donald Johnson, immediately on my right, who will provide details of the standard reference data program after I conclude my statement. I am also accompanied by Dr. David Linde, who is chief of the standard reference data program.

As I have testified previously before this committee, NBS conducts a broad variety of scientific, technical, and engineering investigations. The product of much of our work, and the work of scientists in laboratories around the world, is new information. A great deal of this information involves data, data that often is published in the open literature so that others may use them.

So many papers are published each year that it is practically impossible for scientists to keep abreast of the new data in their field of interest. The mere publication of data is no guarantee that it is accurate, and in most cases individual readers are unable to make a sound judgment concerning the reliability of published data.

In 1968 Congress provided NBS with a specific mandate through passage of the Standard Reference Data Act. That act calls for the "collection, compilation, critical evaluation, publication, and dissemination of standard reference data." That is a charge that we take most seriously, Mr. Chairman, for we are convinced that standard reference data are of great value to American scientists, engineers, and decisionmakers.

Such important activities as basic scientific research, industrial quality control, development of new and improved processes, development of new materials, and measurement and correction of environmental pollution depend on standard reference data of the highest quality. At this point, let me cite one example of the importance of standard reference data.

The chemical known as ethylene represents a $3 billion industry in the United States; many companies produce it and many more companies, both large and small, buy it as a raw material. It is used in the manufacture of plastics, automotive antifreeze, and many other products. Despite the usefulness of ethylene, its properties were not well known over a broad range of temperature and pressure. This lack of data led to problems in custody transfer through pipelines, in underground bulk storage, and in design for a multitude of processes in which ethylene is used.

At the request of industry, we undertook a two-step response to the data problem. First, we analyzed the world literature and for interim use selected the best available data. Then, we initiated measurement projects to produce data needed in selected areas. This program, in which seven ethylene producers are sharing the costs with us, will result in a data base that should satisfy industrial needs for many years.

Our total standard reference data program serves an extremely broad and diverse community. For example, engineers in chemical plants, technicians in hospitals, and research students in universities use the data that we produce. In carrying out this program, we work closely with other Federal agencies, scientific and engineering societies, industrial trade associations, and international organizations. In passing the Standard Reference Data Act, Congress intended that NBS become the national focus for all of these institutions which are concerned with physical property data. I feel that we do provide such a focus, and I personally support the continuation of a strong program.

The Secretary has transmitted to the President of the Senate, and to the Speaker of the House, a draft bill together with a statement of purpose and need to authorize appropriations for fiscal years 1979, 1980, and 1981 for the standard reference data program. This bill authorizes appropriations of $3.152 million for fiscal year 1979. I support this bill and urge its favorable consideration by the committee. The House Committee on Science and Technology has amended the bill, adding specific authorizations of $3.75 million for fiscal year 1980, and $4.5 million for fiscal year 1981.

Dr. Donald Johnson will now review for you the operation of our program, the progress made since our last hearing, and our plans for the future.

Senator STEVENSON. Fine. Thank you.

Please proceed, Dr. Johnson.

Dr. JOHNSON. Thank you, Mr. Chairman.

I welcome the opportunity to testify before you today. I have been personally very close to the standard reference data program for many years and with the new NBS organizational structure I now have management oversight for this program.

Mr. Chairman, I would like, with your permission, to make a brief oral statement and submit a more extensive statement for the record.

Senator STEVENSON. The statement will be entered in the record.

Dr. JOHNSON. Thank you, sir.

Let me begin by clarifying the term "data" for you. Data in the context of the Standard Reference Data Act of 1968 refers to numerical values for physical or chemical properties of well-characterized materials. The measurements which generate this kind of information are made as part of the normal scientific research and development work performed daily by scientists and engineers around the world. The data are reported along with other research results in thousands of journals and technical papers each year.

Unfortunately, data in the form available in the primary scientific literature varies widely in quality and often does not cover the range needed for a given application. Potential users of data are hard pressed to find the specific numbers they seek or, having found them, to assess their applicability.

Our job starts with the retrieval of data in a specified subject area from the primary scientific literature. We evaluate these data for accuracy and consistency, supplement the data to cover the full range which users require and finally prepare and distribute tabulations for general use.

This kind of analysis requires considerable experience and it is an expensive time-consuming process. It goes far beyond the mechanical operation of collecting the data. It involves detailed comparison of experimental values with theory in order to develop techniques for prediction or extrapolation into new regions. Occasionally a limited number of measurements must be made to test the theory or the quality of the predictions.

The final product of such an effort is a complete set of data, well documented and of known accuracy, which can be used for a wide variety of applications in research, engineering, and industry. Typical users will include industrial engineers, quality control engineers, and researchers in chemistry, physics, engineering, and biology. Applications are as esoteric as plasma diagnostics in energy production and as commonplace as the design of street lights.

In passing the Standard Reference Data Act, Congress recognized the traditional role of NBS as the Nation's foremost measurement laboratory, where responsibility for the quality and reliability of technical data could best be placed. It was also recognized that NBS could help consolidate the results of the Federal Government investment investment in research and make those results more useful to science and technology. In accomplishing that end, the SRD program has been very successful and we feel we can be justifiably proud of our achievements over the past 10 years.

Our own Journal of Physical and Chemical Reference Data is now in its sixth year of publication and has evolved into a major outlet for SRD compilations. The journal currently has 1,200 subscribers, including subscriptions in 44 foreign countries, and has sold over 19,000 individual offprints of articles in the past 6 years.

It is interesting to note that the journal has gained wide acceptance in libraries in the academic community; 54 of the 55 leading physics departments in the United States currently subscribe to the journal and at least one State university in each of the 50 States is now a subscriber. On the industrial side, 9 out of the 10 top corporations of the Fortune 500 list subscribe to the journal; 18 of the 20 chemical companies whose sales exceeded $1 billion in 1976 also subscribe. And I think most importantly, the librarians tell us that the Journal of Physical and Chemical Reference Data is one of the most frequently used journals on their shelves.

During the last 10 years a unique management style has evolved for the SRD programs. We have found that critical evaluations are most successfully carried out by experts who are able to keep up to date in their own specialty. We have therefore physically located our data projects in active research environments in a variety of different institutions. This allows us to take advantage of the available talent and also assures that the knowledge of the most advanced laboratory techniques can be factored into the evaluation process.

The core of the program is a set of 22 countinuing data centers; 14 of them are located in the technical divisions of NBS, and 8 are located at universities and other private institutions. Each has a well-defined technical scope, in an area where we can foresee a long-term demand for data.

We also have short-term projects that permit us to respond rapidly to newly emerging needs for data. Such projects have a more narrow scope than the continuing centers and often produce a single compilation or critical review on a 1- or 2-year time scale. Most of our contracts are small, ranging from $5,000 to $100,000. In many cases we obtain appreciable contributions in kind from the institution involved, which greatly increases the leverage of our directly appropriated funds.

A list of the 22 continuing data centers and the 31 currently active short-term projects has been attached for the record. Together, these projects which include work at 27 universities and private institutions are referred to as the national standard reference data system, and they are managed through the Office of Standard Reference Data at NBS. This Office arranges for publication of all of the products of the NSRDS efforts. A complete listing of these publications has also been included in the record.

One of the most difficult tasks that we face in managing NSRDS is to assess needs for data compilations and to allocate resources to meet these needs. Clearly, the amount of data reported worldwide each year is many times larger than we can handle, and we therefore must establish priorities.

Projects which address needs in important national programs are given highest priority. We also favor projects whose outputs will be useful to several different user groups. The availability of an appropriate theoretical framework upon which to base the work is another important factor. Of course, the willingness of other parties to help support the work, either by joint funding or assistance in kind, gives us a good indication of the urgency. In this context we are currently collaborating on a number of projects with other Federal agencies, professional societies, industrial trade associations, and a variety of international organizations. These organizations provided a total of $2 million in fiscal year 1977 to help support our standard reference data efforts.

Using these general guidelines to set priorities, we have looked at the needs for new data activities in a wide range of the economy. We have identified five areas that we consider to be highest in priority. Thermal data for the organic chemical and fossil fuel industries, physical reference data for medicine and biology, data on stability of alloys and ceramic materials, data on fracture properties of structural materials, and data for chemical modeling of water pollutants.

Let me give you some detail on the first two of these areas to convey the flavor of what might be possible. The organic chemicals and fossil fuel industries are among the most energy- and materials-intensive industries in the American economy. These industries include 40 percent of all chemical processing and the bulk of our gas and electric industries. They share common resources and common problems: Feedstock shortages, rising energy costs, and increasingly stringent pollution restrictions.

A broad base of material properties is essential for these industries to respond effectively to the challenges. We believe that direct industry support can be obtained for a portion of this work; however, the diverse character of the users—large companies and small, suppliers and consumers, plant construction firms as well as production companies—makes it appropriate to build from a broad base of Government funding.

The specific data needed here are thermochemical and thermophysical data on coal, coal liquids, celluloses, and a variety of fluids both pure and mixed. Much of the effort of the planned program will be spent developing procedures for predicting the properties of these substances over wide ranges of temperature, pressure, and composition.

The ethylene project that Dr. Ambler mentioned earlier serves as an excellent model for what we are planning in this broader program. As Dr. Ambler indicated, ethylene has a production worth $3 billion annually. It is the starting point for the production of plastics, synthetic fibers, antifreeze, solvents, and many other products. Yet the physical properties of this pure fluid were so poorly known when we began our study 3 years ago that the resulting uncertainties were unacceptable when ethylene was bought or sold.

To remedy these problems, the SRD study is assembling and evaluating existing data and providing certain key measurements. A formula is being developed to generate a value for any desired property of ethylene at the temperature and pressure of interest. SRD will then package ethylene data from this generalized base in a variety of different ways to meet the specific needs of end users. Clearly, a very broad range of producers as well as consumers of ethylene will benefit from these efforts. The total cost of the 5-year project will be $490,000, of which 52 percent will come from industrial sponsors and 48 percent from NBS-appropriated funds.

We can identify at least 16 other industrial fluids that demand the same kind of attention as ethylene. We believe that a critical SRD evaluation of these materials will have a significant impact on the affected industries.

Now, in the second area, a serious need has been identified for reference data from the physical sciences for application in medicine and biology. The whole range of techniques now used for therapy, diagnosis, and research in these areas require quality data to determine proper application and to interpret results.

For example, the delivery of the proper radiation dose to a patient undergoing radiation therapy requires quantitative data on the absorption of the radiation in the various layers of tissue through which it must pass. This absorption is a physical process, and it can be calculated from the information on the interaction of the radiation with each type of tissue. Hospitals now depend on incomplete and poorly evaluated tables of reference data to check and to control their radiation therapy procedures.

We believe that better data can be made available and that extrapolation techniques can be developed to extend the existing data into the appropriate ranges. A new SRD project in this area would have significant impact on the quality of health care.

In each of these areas we are equally confident that the SRD efforts can have broad impact.

In summary, Mr. Chairman, let me emphasize that the generation of standard reference data involves a creative effort, and it adds value to the enormous U.S. investment in research and development. It pulls together the results from many diverse research activities, and it organizes these results into a more useful form. Once an SRD evaluation has been completed, the whole is definitely greater than the sum of its parts.

We are enthusiastic about continuing the standard reference data program, and we are proud of its accomplishments. We urge you to continue to support these important activities.

I would like to thank you, Mr. Chairman and members of the committee, for this opportunity to address you. I have Dr. David Lide, who manages the SRD program, seated here at the table with we. We shall be happy to attempt to answer any questions that you may have.

Senator STEVENSON. Thank you, Dr. Johnson and Dr. Ambler.

How much does a subscription to the Journal of Physical and Chemical Reference Data cost?

Dr. JOHNSON. Sir, the subscription for the current year is $100.

Senator STEVENSON. That seems awfully low if it is as valuable as you indicate. Wouldn't the subscribers be willing to pay more?

Dr. JOHNSON. Sir, our publication and subscriptions for the Journal of Physical and Chemical Reference Data are handled through an agreement with the American Institute of Physics and the American Chemical Society. We have a joint arrangement with them.

They are the primary professional societies in physics and chemistry. They have had considerable experience in this area of publishing technical journals. They assure us that this price is an appropriate price for journals of this type on the market.

Senator STEVENSON. You take their word for it? They do have an interest in a low price, do they not? Don't they represent groups interested—certainly they would have no interest in paying a higher price?

Dr. JOHNSON. Well, sir, I guess we do have to take their word for it, since they do have the experience in the market.

The price of the journal is based, in addition to the average market price, to some extent on the cost of the publication. We do recover an appreciable portion of the total cost of publication.

Senator STEVENSON. Where does the money go from the subscription payments received?

Dr. JOHNSON. Sir, the Standard Reference Data Act authorizes us to use that money to the benefit of the program.

Senator STEVENSON. That's not quite what I was asking. How is it used for the benefit of the program?

Dr. JOHNSON. Well, it is applied toward the expenses of publication, sir. I guess that's the most direct answer to your question.

Senator STEVENSON. I will address these questions to all of you. I don't know who the appropriate answerer is.

Can you describe the Bureau's procedure for setting priorities for work to be done under the standard reference data system?

Dr. JOHNSON. Well, sir, I outlined those procedures in my full statement and I shall be happy to expand on them briefly for you.

We have our program divided roughly, sir, into four areas. Those areas deal with energy and the environment, with industrial process design, with materials utilization, and with physical sciences.

We have program managers in each of these areas, and our program managers are in contact with users of the data and with trade organizations. They assess the needs in that way from actual users of the data.

We also have the National Academy of Science Evaluation Panel, which Dr. Baker was representing for you here today. The evaluation panels give us advice on priorities. In addition to that, there is a National Academy Panel on Data which assesses the needs for data in the country.

We take advice from those sources. Then we follow the priority procedures that I outlined.

I am not sure I answered your question completely, sir.

Senator STEVENSON. Well, my objective is not to get answers that are already covered in the statement. I had understood from the staff that the statement we received yesterday did not have a full answer to that question.

Let me ask the staff at this point: Is the question now answered?

The question is now answered. Thank you.

What indicators do you use to determine how extensively the products in the standard reference data program are used and its value to the users?

Dr. JOHNSON. We get advice in that respect from users in the field through our program managers. They are also in constant contact with professional societies, trade associations, and other federal agencies. We also get some advice from the National Academy panels that we are involved with.

We have on occasion in the past sent out questionnaires asking subscribers to our information how they use the information and how extensively it is used.

Senator STEVENSON. What guidelines do you employ for deciding on a cost-sharing between the Bureau and other agencies and industry?

Dr. JOHNSON. Sir, it is our general feeling that the development of a broad data base to begin with is a development that is for the benefit of the country as a whole, and has a fairly substantial uncapturable benefit.

Once that data base is developed, the specific packaging that is necessary to meet the needs of an end user, if we can identify the end user in a direct way—such as another Federal agency—are paid for totally by the user.

If we are publishing a general compilation, as we do through our journal, then we use the copyright authorization to return some of those publication costs.

If we are doing a special project for another Federal agency which is aimed directly at its mission, we expect that Federal agency to pay for the entire cost for that special project.

Senator STEVENSON. You and Dr. Ambler have cited ethylene as a case where the Bureau and industry have worked together. Is that a typical mode of operation between the Bureau and industry?

Dr. JOHNSON. Well, it certainly is—I hope it to be typical of the kind of mode of operation that we will be in in the future and it is an example of our current operation as well. We are developing more and more into this style of operation.

It has been difficult in many areas where the industry is represented by many different firms to get the firms together sufficiently to acquire the kind of resources to engage in a joint project of this kind.

As Dr. Ambler indicated, there are seven different producers of ethylene sharing the expenses here with us.

Senator STEVENSON. You said there are five areas of future expansion in the standard reference data program. What kind of impact do you expect this expansion to have on the budget in the future?

Dr. JOHNSON. We are currently reviewing program plans in certain of these areas, and we are at a less mature State with program plans in other areas; but we do hope that there's going to be an opportunity for expansion into these areas.

The five areas that I listed for you were indicated to you in priority order. It is our intention to attempt to follow that priority order in the budget process.

Senator STEVENSON. I don't know if you were here earlier, but Dr. Compton suggested getting up to a level of $10 million over about 4 years. The evaluation panel has recommended $15 million; and SRD is now at $3.15 million; is that adequate?

Dr. JOHNSON. Is that adequate for the current year, sir?

Well, the value that has been approved by the House, $3.152 million, of course, tracks the value that is currently in the President's budget. It does cover existing pay raises, that sort of thing, but it does not anticipate any programmatic growth for fiscal year 1979.

Senator STEVENSON. What does it do, realy, cover inflation with no real increases?

Dr. JOHNSON. Well, in fact it covers only the existing or trackable portion of the inflation. It does not cover, for example, any anticipated pay raise that may be coming through in the fall.

Senator STEVENSON. Well, I would assume the pay raise was inflation, that's 5.6 percent. That's keeping up with inflation. It doesn't even track inflation, is that what you are suggesting? It allows no real growth?

Dr. JOHNSON. It allows no real growth.

Senator STEVENSON. Does it do the opposite? Is there a real decrease?

Dr. JOHNSON. If there is a pay raise in the fall, we estimate that that pay raise will cost us about $150,000. That, in effect, will be a decrease in the program if the fiscal year 1979 level is fixed at $3.152 million.

Senator STEVENSON. At $3.152 million?

Dr. JOHNSON. That is the number that is to the present fiscal year 1979 ceiling from the House bill, sir.

Senator STEVENSON. Now, Dr. Ambler, I am going to digress, if I might. Is the Bureau working with NASA and the Department of Energy to analyze the dangers of airborne carbon filaments in composite structures; and in particular, the possibility that they can short-circuit power generators and other electrical circuits?

Dr. AMBLER. Yes, sir. We have been doing some work with both of those agencies on that subject.

Senator STEVENSON. How is that work coming?

Dr. AMBLER. Our work has been an assessment of experimental work that was done elsewhere. We have not actually done any experimental work of our own.

I believe that NASA and I think another Federal agency have done extensive experiments on this problem; and we have been able to look at their data and give advice to them and to other parts of the Federal Government as to the effects of using carbon fibers.

Senator STEVENSON. Well, this is a subject that we have an interest in. We also have the jurisdiction over NASA. If you could give us a little bit more information on your relationship with NASA and DOE, and also on the progress of this work and any findings, we would be grateful for it. I don't mean now.

Dr. AMBLER. Yes. Our relationship with NASA generally, or on this particular subject?

Senator STEVENSON. On this particular subject, and DOE, plus the results of the work, the progress, and what you are concluding. Then I guess after that, we would be interested in the final results.

[The following information was subsequently received for the record:]

U.S. DEPARTMENT OF COMMERCE,
NATIONAL BUREAU OF STANDARDS,
Washington, D.C., April 17, 1978.

Hon. ADLAI STEVENSON,
Chairman, Subcommittee on Science, Technology, and Space, Senate Commerce, Science and Transportation Committee, Washington, D.C.

DEAR MR. CHAIRMAN: In response to your request at the recent oversight hearings of the National Bureau of Standards requesting information on the details of NBS research on the dangers of airborne carbon filaments in composite structures, the following information is submitted.

The National Bureau of Standards participated in a White House Interagency Task Force under the auspices of Frank Press, the President's Science Adviser. This Task Force met during the period June to December 1977, and issued a report of study on January 20, 1978. The report and press release provided summary information on the findings of the Interagency Task Force on Carbon Fibers. Also the NASA Report entitled "Carbon Fiber Study," provides extensive additional information on the entire carbon fiber question and the individual agency responsibilities.

In response to the findings of the Interagency Task Force, an interagency program plan was proposed and accepted by the White House for future work by the numerous Federal agencies participating in the Task Force. The specific assignment given to NBS involved commercial and household equipment. Quoting from the action plan of the Interagency Task Force, "Communication and computer equipment are particularly important. Failure modes must be studied, design standards for future equipment must be developed in conjunction with industry, and protective procedures for installed equipment must be worked out. DoC (NBS) will take the lead. The program will run for two years with the aim of transferring the lead to industry." NBS has initiated its program in the above mentioned areas. We are cooperating with NASA, the Department of Defense, and other Federal agencies in this endeavor. The action plan requires that individual agency responses be prepared for transmittal in August 1978.

I trust that the above information will be of use to you and your Committee and I remain available to provide any additional information and answer any further questions which you may have.

Sincerely,

ERNEST AMBLER, *Director.*

Senator STEVENSON. Let me ask you also, Dr. Ambler—I raised with the other witnesses the possibility of periodic authorizations. I noted the standard reference data program has a 3-year authorization. How do you feel about subjecting the Bureau to periodic authorizations, and perhaps conforming that period to the standard reference data program?

Dr. AMBLER. I would be very much in favor of it, Mr. Chairman.

Senator STEVENSON. Do you have any suggestions as to the length of the period?

Dr. AMBLER. Two or three years, I think, would be appropriate.

Senator STEVENSON. As a matter of curiosity, why isn't the Bureau subject to periodic authorization? Does it reflect disinterest on the Hill, or is there some historical reason?

Dr. AMBLER. There is certainly a historical reason. We never have had regular authorization hearings.

Senator STEVENSON. What is it?

Dr. AMBLER. I don't think we have ever had an authorization hearing in the Senate at all. Since I have been at the Bureau, there's been one authorization—no. I am mixing up authorization and oversight hearings in the House. There have been no authorization hearings at all. Oversight hearings have been held rather infrequently.

Senator STEVENSON. Why is that? What's the reason? Most every agency is subject to periodic authorization.

Dr. AMBLER. I think it is historical. In my opinion, perhaps the reason that this is now being very seriously considered is that because the Bureau has not been communicating regularly with oversight committees, that it was in the danger of being neglected in several respects.

It is a source of great gratification to me that this committee is taking an interest in the Bureau. Efforts of the visiting committee and Dr. Baruch to draw attention to the state of affairs of the Bureau is perhaps one reason why the Congress is now focusing attention on the subject. Attention that is very much welcome.

Senator STEVENSON. Well, I agree. I think the failure to subject the Bureau to periodic authorization is one of the reasons for its neglect; but I still don't understand the reason for the history, how it began and what the rationale was for not subjecting the Bureau to an authorizing process.

It is not particularly important, although if there is a rationale for it, I guess we ought to know what it is. I was mostly curious.

You don't know?

Dr. AMBLER. No. I would be glad to try to find out. I suspect that there isn't a reason for it.

Senator STEVENSON. Well, I think there ought to be some changes; and that's one of them.

Any questions?

That's all. Thank you very much, gentlemen.

Dr. AMBLER. Thank you.

[The statement follows:]

STATEMENT OF DR. D. R. JOHNSON, DEPUTY DIRECTOR FOR PROGRAMS (DESIGNATE), NATIONAL MEASUREMENT LABORATORY, NATIONAL BUREAU OF STANDARDS

Mr. Chairman, members of the subcommittee, I welcome the opportunity to testify before you today on the subject of Standard Reference Data. I have had considerable personal experience in this area, having spent 9 years out of the past 10 as a bench-level participant in a National Standard Reference Data System data center. In the new NBS organizational structure I am responsible for management oversight of the Standard Reference Data Program among others.

As the members of this Committee know well, this country faces an array of economic and technical challenges—dwindling energy sources, precarious materials supplies, environmental problems, crises in many areas of health care—which can be solved only through the vigorous application of science and technology. The ready availability of reliable technical information is a major factor in the efforts to solve these problems. And reliable technical information is what the Standard Reference Data Program is all about.

I. INTRODUCTION

I would like to spell out a bit more explicitly just what kind of technical information we will be discussing today. In the present context, "data" refers to quantitative information on measurable properties of substances of known composition and structure. These are, for example, the strength of metals data used by engineers in designing bridges, the spectroscopic and crystallographic data used by chemists analyzing new drugs, and the superconducting materials data used by physicists working on the transmission of electric power. The measurements which generate these data are made as a part of the normal scientific research and development work performed daily by scientists and engineers around the world. The data are reported in thousands of scientific journals and technical reports.

This reservoir of data is an essential element in both the progress of science and the translation of scientific discoveries into useful technology. Unfortunately, potential users of data are often hard pressed to find the specific numbers they seek, or, having found them, to assess their reliability. As a result there is a very real and continuing user demand for a focussed effort through which this reservoir of data can be systematically organized, checked for accuracy, and made accessible in a directly usable form. The Standard Reference Data Program serves precisely this function. Our job is to retrieve all pertinent reports and papers in specified subject areas from the world scientific literature, compile the data, evaluate these data for accuracy and consistency, develop techniques for prediction and extrapolation into new regions, and finally to prepare and distribute tabulations which NBS can endorse for general use.

Let me say a bit more about the evaluation process itself, because that is the creative and scientifically demanding part of the work. It is the key reason for the formal existence of this program and for NBS leadership of it. The data available in the world scientific literature vary widely in quality and often do not cover the range needed for a given application. As I indicated a moment ago, a scientist or engineer who goes to the original literature for data often fails to find exactly what is needed and, even more often, is unsure of the reliability of what he does find.

Only by analyzing all the data available, including data on other properties, other materials, other temperature ranges, etc., is it possible to make an intelligent estimate of the desired numbers and to assess their reliability. This analysis requires considerable experience and is an expensive, time-consuming process. It goes far beyond the mechanical operation of collecting the data. It involves detailed comparison of experimental values with theory in order to develop evaluated mathematical formulations which in turn are used to find data values in regions that have not been experimentally measured. There is a clear advantage in carrying out such analyses systematically and making the results available to the technical community at large. The Standard Reference Data Program carries out such analyses. It should be emphasized that this is a creative effort which extends the value of the enormous U.S. (and worldwide) investment in research and development. It pulls together the results from many diverse research projects, and it organizes these results into a form from which more complete sets of useful information can be generated. Once such an evaluation has been completed, the whole is definitely greater than the sum of its parts.

The project on ethylene which Dr. Ambler mentioned serves as a good illustration of this process. Ethylene is one of the major commodities in the U.S. chemical industry with an annual production estimated at $3 billion. It is the starting point for production of plastics, synthetic fibers, antifreeze, commercial solvents, and many other products. There are many properties of ethylene of practical interest—density, thermal properties, and others. Different applications require these properties to be known at various temperatures and pressures. For example, the density must be known very accurately in order to determine how much ethylene has been transferred from seller to buyer in a commercial transaction. To measure everything of interest would be extremely expensive, tedious, and clearly impractical. In our study of ethylene, certain key measurements are being made to supplement the data retrieved from the scientific literature. The complete set of data is then being correlated, utilizing well-established theory, to yield a formula which will generate a value for any desired property of ethylene at the temperature and pressure of interest. This new, comprehensive data base will then be packaged in a variety of different ways to meet the specific needs of each type of end user. The total cost of the five-year program will be $490,000 with roughly half of this amount supplied by the industry and the remainder from NBS funds.

In passing the Standard Reference Data Act, Congress recognized the traditional role of NBS as the Nation's foremost measurement laboratory, where responsibility for the quality and reliability of technical data could best be placed. Congress also recognized that NBS could help consolidate the results of the Federal Government investment in R & D and make them more useful to U.S. science and technology.

As the Act specified, the NBS Standard Reference Data Program is focussed on physical and chemical properties of well-characterized materials. But let me emphasize that the products of this program find broad utility in almost every phase of research, engineering, and manufacturing. Our users include industrial designers, quality control engineers, and researchers in chemistry, physics, engineering, and biology. Our data are used in projects as esoteric as plasma diagnostics for fusion energy research and as commonplace as the design of street lights.

II. HISTORICAL BACKGROUND

Historically the National Bureau of Standards has always been a data-generating and data-evaluating organization. The Organic Act 1901, under which we operate, specifically authorizes both determination of the properties of materials and concern for their accuracy.

As early as 1913, NBS undertook an extensive study of the thermodynamic properties of ammonia in a program authorized by an Act of Congress. The program was responsive to a request from the then-budding refrigeration industry, and culminated in the publication of NBS Circular 142, "Tables of Thermodynamic Properties of Ammonia." At that time, ammonia was the most important heat-exchange medium for refrigeration, especially for large-scale applications such as meat-packing, cold storage plants, and refrigerated freight cars. Circular 142 clearly filled a vital need. It remained a standard reference work for fifty years and went through six GPO printings totalling 30,000 copies. Because parts of the tables were also reprinted in many engineering texts and trade journals, the actual distribution has probably been several times higher than the sales total.

The principal technological application for Circular 142 was for data relevant to the use of ammonia as a refrigerant. Today this application is dwarfed by the growth in uses for ammonia in agriculture and industry. These new applications, which were almost unknown in 1913, now require enormous quantities of ammonia (production in 1973 was 15,200,000 tons compared to 11,700 tons in 1923). Present and proposed uses for ammonia require data in temperature and density regions much beyond the range covered by Circular 142. An NSRDS-sponsored update of Circular 142, scheduled for publication in June, 1978, should meet needs which are just as important as those which evoked the earlier work.

Overlapping the work on ammonia was the monumental International Critical Tables (ICT) project, in which NBS was deeply involved. The enterprise was first recommended in 1919 by the International Union of Pure and Applied Chemistry, and became an active undertaking in 1923 under the patronage of the National Research Council. U.S. industry contributed heavily to the cost of this effort. Dr. Edward W. Washburn, Chief of the NBS Division of Chemistry, was the Editor-in-Chief, and the list of contributions to the seven volumes includes 33 NBS-affiliated items.

The first volume appeared in 1926, the seventh in 1930, and the comprehensive index in 1933. From that time until 1964, the ICT were recognized as the essential critical reference data sources for an English-language scientific library. In its commitment to both critical evaluation of data and breadth of coverage, the ICT were the direct precursor of the NSRDS.

Systematic compilation of thermodynamic data continued at NBS with the establishment in 1940 of a data project on selected values of Chemical Thermodynamic Properties, and with a companion effort, dating from 1942, on the properties of hydrocarbons and related compounds. The latter project was sponsored by the American Petroleum Institute. Both of these undertakings, which remain active parts of the NSRDS today, were originally directed by Dr. Frederick D. Rossini, who led the work at NBS until his resignation in 1950. He has recently (1977) been awarded the National Medal of Science by President Carter for this and associated achievements.

Comprehensive compilation of atomic spectral data began at NBS in 1946, when Dr. Charlotte Moore Sitterly joined the organization. Although she retired several years ago, she is still active in this work. Her volumes of Atomic Energy Levels are among the most widely used compilations and have brought her international recognition and many awards. The NBS Atomic Energy Levels Data Center continues this activity, whih finds important applications in energy research and development programs, especially plasma diagnostics for nuclear fusion research.

While these early data projects were well recognized for the contributions they made in their special areas, there was no early across-the-board concern for meeting national needs for reliable data.

In May, 1963, the Federal Council for Science and Technology issued a Federal Policy statement recommending that a coordinated system to supply reliable data to the scientific and technical community, to be called the National Standard Reference Data System (NSRDS), be developed by the National Bureau of Standards. This recommendation, together with the existing authorities provided in the NBS Organic Act, served as the basis for the start of a formal program. Full-time professional staff members were hired, and existing NBS data projects were linked to the newly-established Office of Standard Reference Data (OSRD). Initial support consisted of $800,000 transferred to NBS by the Department of Defense, the Atomic Energy Commission, the National Aeronautics and Space Administration, and the National Science Foundation, plus internal funding for on-going data work. Standard reference data activities were first formally included in an NBS budget submission in January, 1964, and Congress appropriated funds for that purpose for Fiscal Year 1965.

In the four years which followed, OSRD built an active, productive program, covering six categories of data: nuclear, atomic and molecular, solid state, thermodynamic and transport, chemical kinetic, and colloid and surface properties. By April, 1968, sixty data projects were active at NBS and elsewhere, and 51 reports had been released. Almost all of these reports were published through the GPO, a source of information not completely familiar to most working scientists. As a result, dissemination of the output of the system was not altogether satisfactory.

In 1968 the Standard Reference Data Act (Public Law 90–396), was passed by Congress endorsing the NSRDS efforts and providing authority for utilizing alternate publication channels. On the basis of this authority, the OSRD has developed an effective and productive system for retrieving and evaluating data, and for preparing and disseminating compilations in forms which are convenient for users. It has become, as the Congress intended, a coordinating force for similar data activities throughout the Federal Government. Data centers supported by the Department of Defense, the Department of Energy, and the Department of the Interior are affiliated with the NSRDS. The Department of Health, Education, and Welfare, the Department of Transportation, the Environmental Protection Agency, and Natiotnal Aeronautics and Space Administration have all called on our centers for technical help, and collaborate with us in data dissemination projects.

One of the principal features of the Act provides the Secretary of Commerce with authorization to copyright publications which result from the program and to assign this copyright to others. Several contracts have been negotiated under this authority. In particular, OSRD has contracted with the American Chemical Society and the American Institute of Physics to publish the quarterly Journal of Physical and Chemical Reference Data. The Journal has now completed its sixth year of publication and has been widely accepted as a source of reliable reference data. With the appearance of the last issue of Volume 6, 109 data compilations have been disseminated to users through this medium; in addition, three major compilations have appeared as Supplements.

While the Journal is now the major outlet for NSRDS-derived data, other dissemination channels continue to prove useful. The table below summarizes the published output of the program for the period 1964–1977. A copy of the NSRDS Publication List (LP81) is appended to this statement. This List provides more complete information on our published products.

NSRDS DATA OUTPUT, 1964–77

Category	Titles	Number of pages
JPCRD	109	6,877
JPCRD supplements	3	1,999
NSRDS-NBS series	68	7,963
Coblentz Society spectral data	6	5,250
Crystal data tables	2	2,596
Wiley-Interscience series in atomic and molecular collisional processes	4	1,292
Metallic shifts in NMR (Pergamon Press, 4 volumes)	1	2,350
Miscellaneous monographs, circulars, technical notes, etc	27	4,829
Total		33,056

(In addition to these data publications, the NSRDS has provided 69 critical bibliographies and indexes to data sources, 12 reports providing computer programs for handling data, 8 magnetic tapes, and 24 translations of products of the USSR standard reference data system.)

III. ORGANIZATION AND MANAGEMENT OF THE NATIONAL STANDARD REFERENCE DATA SYSTEM

The many years of experience with critical evaluation of data at NBS have demonstrated that these activities are intellectually very demanding and that they are most successfully carried out by experts who are up-to-date in their own specialty. Since the program covers a very wide scope of technical activities, a continuing effort must be made by our management to seek out the appropriate experts to carry out data evaluations. A decentralized system of data projects located in the laboratory environment has been developed to take advantage of the technical talent in a variety of institutions. Physically locating these projects in an active research environment also assures that knowledge of the most advanced laboratory techniques can be factored into the evaluation process.

The core of the program is a set of 22 continuing data centers; 14 of them are located in the technical divisions of NBS, and the remainder at universities and other private institutions. Each has a well-defined technical scope. These data centers collect all relevant information within that scope from the world scientific literature, catalog the data, and carry out critical evaluations. Thus, each center builds up a data base in its area of responsibility, and draws on this data base for constructing applications-oriented special compilations, for answering specific data questions, and for more comprehensive multi-use tables. The data base is revised and expanded as new research results appear.

The work of the continuing data centers is supplemented by short-term projects which permit us to respond rapidly to newly emerging needs for data evaluation. Such projects have a narrower scope than the continuing centers and produce a single compilation or critical review on a one- or two-year time scale. They are generally established to meet a clearly defined need for a compilation of modest scope, and they frequently receive back-up support from a related data center.

A list of the 22 continuing data centers and the 30 currently active short-term projects is appended to this statement. There are 27 universities and other private institutions represented on this list. Most of our contracts are small, ranging from $5,000 to $100,000, but the leverage that we obtain with these resources is very large. In many cases we obtain appreciable contributions-in-kind from the outside institution involved, thereby supplementing our directly appropriated funds.

These data centers and other projects are tied together through the Office of Standard Reference Data at NBS, which acts as the program management office and arranges for dissemination of the output. The entire set of activities is referred to as the "National Standard Reference Data System," or NSRDS. The links among the components of the system vary in character, depending upon the location of the center and the contractual relationships, but the net result is a coherent mechanism for delivering data of certified accuracy to the user. The systems concept also helps avoid unnecessary duplication of work and provides users with a mechanism for gaining access to data on a variety of subjects through a single point of contact.

Early in 1976, the management of the program was restructured along application lines rather than by scientific disciplines. Our activities are now categorized under four subprograms designated as Energy and Environmental Data, Industrial Process Data, Materials Utilization Data, and Physical Science Data. Briefly, the programs have the following content:

Energy and Environmental Data—Projects dealing with data that have an important application in some aspect of energy R. & D. or environmental quality improvement. Projects in chemical kinetics, nuclear properties, spectroscopic data, and interaction of radiation with matter are currently incorporated in this program. The output of these projects is particularly important in R. & D. on new energy sources, environmental monitoring techniques, and prediction of the effect of pollutants introduced into air, water, or land.

Industrial Process Data—Projects dealing with thermodynamic, transport, colloid and surface, and physical properties of industrially important substances. Such data have particular application to design of new processes in the chemical and metallurgical industries, optimization of currently used processes, and general productivity enhancement.

Materials Utilization Data—Properties required for materials selection and R. & D. on new materials. The structural, optical, electric, magnetic, and mechanical properties of solid materials are included.

Physical Science Data—Projects which involve basic data of very broad applicability, or which are associated with an important frontier field of science. Examples are fundamental physical constants, data on fundamental particles, and data relevant to radioastronomy.

The users of NSRDS outputs and services present a very broad spectrum of interests. Analysis of the distribution of our publications shows that we fulfill needs for data in basic research, applied research and development, engineering design, and education. The Journal of Physical and Chemical Reference Data goes to over a thousand technical libraries which are interested in the full range of our outputs. A breakdown of the 1163 subscribers in 1977 is displayed in the following table:

Subscribers to the Journal of Physical and Chemical Reference Data

	Percent
Industry (United States)	20
University (United States)	30
Government (United States)	5
Foreign (all categories)	36
Miscellaneous (United States) (general libraries, individuals, etc.)	9

It is of interest to note that 9 out of 10 top industrial corporations on the Fortune magazine list subscribe to the Journal; these 10 companies had combined sales totalling about 250 billion dollars. Eighteen of the 20 chemical companies whose sales exceeded one billion dollars in 1976 subscribe to the Journal.

On the university side, we find that 54 of the 55 leading physics departments in the U.S., which granted 70 percent of the Ph.D. degrees in physics in 1976, subscribed to the Journal. At least one state university in each of the 50 states is a subscriber.

In addition to these institutional subscriptions to the Journal, 5,000 to 10,000 copies of individual compilations and monographs (including off-prints from the Journal) are sold in a typical year. A breakdown of purchasers of off-prints in calendar year 1977 is shown below:

Sales of individual compilations from the Journal of Physical and Chemical Reference Data (1977)

	Percent
Industry (United States)	17
University (United States)	27
Government (United States)	22
Foreign (all categories)	30
Miscellaneous (United States) (general libraries, individuals, etc)	4

With the broad range of the NSRDS user community in mind, it is appropriate for me to say a few words about cost recovery policy. As I mentioned earlier, the Standard Reference Data Act gives NBS the authority to obtain copyright on data compilations and receive income from their sale. NBS follows the general guidance provided to all agencies of the Government by the Office of Management and Budget in Circular Number A–25: "No charge should be made for services when . . . the service can be primarily considered as benefitting broadly the general public."

The evaluation process through which the broad data base is developed is such an activity. This is also the most expensive portion of the total NSRDS program and is analogous to research costs in the sense that it results in new or improved knowledge which has broad national benefits. On the other hand, the dissemination costs—that is, the costs required to supply previously evaluated data to a user in the exact form he needs—can fairly be charged to the specific user who benefits. The Circular states: "A reasonable charge . . . should be made to each identifiable recipient for a measurable unit or amount of Government service or property from which he derives benefit." Our pricing policy is based on this statement and is designed to recover as much as possible of these dissemination costs, commensurate with keeping prices at a level which does not discourage use of the output. Current prices for Standard Reference Data compilations are toward the high end of the range of prices charged by private publishers for comparable technical information. In Fiscal Year 1977 income from royalties and licenses amounted to $59,392, and an income of $75,000 is projected for FY 1978. By contracting outside for publication, some of the printing and distribution costs are also avoided which otherwise would be paid by Government funds.

IV. EXAMPLES OF CURRENT ACTIVITIES

Operation of a system of data centers under the management of OSRD offers a number of unique advantages. For example, NSRDS data centers can provide a quick and effective response to a specific need of another Government agency. The Department of Energy's (DOE) Office of Waste Isolation has recently contracted with the Office of Standard Reference Data to assemble and publish a handbook on the physical properties of salt.

As you know, the disposal of wastes from nuclear power plants is a matter of great national concern. Prominent among the techniques being considered is the storage of encapsulated nuclear fuel wastes in underground salt dome formations. However, the introduction of such wastes into this otherwise stable environment may cause changes which would affect long-term stability. A handbook in which are assembled the pertinent data on salt properties will be important in selecting the most effective and safest storage strategy. The Office of Standard Reference Data has called on three data centers to participate in this effort. They are the Molton Salts Data Center at Rensselaer Polytechnic Institute, the U.S. Geological Survey's National Center for Thermodynamic Data of Minerals, and the Center for Information and Numerical Data Analysis and Synthesis at Purdue University.

The handbook will contain the physical, chemical, and mineralogical properties of common salt and of salt mixtures characteristic of those found in nature; it will serve as a sourcebook for data on the basic properties of salt and as a guide in designing nuclear waste disposal systems in salt deposits. Plans are being made to distribute this handbook to contractors of the Department of Energy who are active in waste disposal, and to scientists and engineers who are concerned with mining, manufacturing, and the occurrence of salt in the environment. The preparation of the handbook is being funded entirely by DOE; however, the NBS support of the data centers at Rensselaer and Purdue provided the necessary competence—the comprehensive data files and the expertise in evaluation methods—for the job to be done promptly and thoroughly.

NSRDS data centers in an entirely different technical area are providing evaluated data used in the design of new energy sources. The Department of Energy and the Office of Standard Reference Data are jointly supporting this work in the Atomic Transition Probabilities Data Center and the Atomic Energy Levels Data Center, both located at NBS. These centers are compiling and evaluating information on highly ionized states of atoms, the kind of information that is needed for diagnostics of the plasma in a fusion reactor.

The data are used to determine the temperature, density, and other parameters of the plasma while the device is in operation. They are also crucial in the calculation of energy losses from the plasma, the factor which ultimately will determine whether magnetic fusion energy is a feasible source of power. The data centers involved have developed their competence through long-term support by OSRD and are recognized worldwide as the primary source of data in these areas. As in the previous example, they have been able to respond quickly and effectively to the needs of the DOE program. The data centers involved in this example, as well as those in the previous example, are continuing NSRDS centers. Each has a clearly defined disciplinary expertise which, when they are combined, offers a unique ability to contribute to the solution of a major national problem.

The flexible management style of the NSRDS also allows rapid response to needs for data by establishing short-term projects. The results of one such effort, supported entirely by OSRD, will soon be published in the Journal of Physical and Chemical Reference Data under the title "Critical Review of Hydrolysis of Organic Compounds in Water under Environmental Conditions." This work, which was carried out at the Stanford Research Institute in California, will provide chemical kinetic data which are necessary to predict the fate of specific compounds, such as pesticides and plasticizers, in our rivers and lakes.

Short-term projects clearly offer an advantage in cases where the demand is immediate and a suitable evaluator can be found. On the other hand, the continuity of the long-term data centers is often an important consideration. For example, a trade association for the copper industry, the International Copper Research Association (INCRA), has recently undertaken to print and distribute a monograph of evaluated data on Diffusion in Copper Alloys, a text based upon five review articles prepared with OSRD support by the NSRDS Diffusion in Metals Data Center from 1973 to 1976. These data describe how fast a material will diffuse into, or intermingle with, a particular metal alloy with which it is in contact. It is a key property, for example, in the design of cladding processes to protect base metals from corrosion and in the selection of materials for cutting tools. INCRA will make this monograph available to the 250 member companies of the association, and there will be additional distribution to industries which use cooper. As part of the agreement with INCRA, NBS will receive royalties on the sale of these monographs. In addition, INCRA plans to supplement the OSRD support of the Diffusion in Metals Data Center, in order to permit more rapid evaluation of data on other copper alloys.

PRIORITY SETTING AND FUTURE DEMANDS

Since the amount of data reported worldwide each year is many times larger than can be handled at the level of the program, one of the major management tasks of the Office of Standard Reference Data is to assess needs for data and set priorities for allocating resources. We obtain information on data needs from many sources: informal ones, such as laboratory visits, conferences, and consulting with program managers in other agencies; and formal ones, such as advisory committees and workshops. We make use of the National Academy of Sciences-National Research Council through both the NBS Evaluation Panel structure and the Numerical Data Advisory Board. In this way we identify application areas where reliable data are needed now or will be needed in the future. Specific programmatic decisions take into consideration the urgency of the needs and the importance of having highly reliable, certified data. Projects which address needs in important national programs are given highest priority. We also favor projects whose output will be useful to several different user groups—which is frequently the case, since data on inherent physical properties often have quite diverse, multiple applications.

A good test of the importance of a proposed project is the willingness of other parties to help support the work, either by joint funding or assistance in kind. For this reason, many of our data evaluation projects are jointly supported by other organizations that are interested in some part of the output. We are currently collaborating on a number of projects with agencies such as Department of Energy, Department of Defense, Environmental Protection Agency, National Institutes of Health, U.S. Geological Survey, National Aeronautics and Space Administration, Maritime Administration, and National Science Foundation.

We work with professional societies such as the American Institute of Physics, the American Chemical Society, and the American Society for Metals; with industrial trade associations such as the International Copper Research Association and the American Gas Association; with National Laboratories such as Lawrence Livermore and Oak Ridge; and with a variety of international organizations. These organizations provided a total of $2 million in FY 77 to help support our standard reference data efforts.

Our analyses have pointed up needs for future NSRDS activities in a variety of areas including the following five which we consider to be of highest priority:

Thermal data for organic chemical and power industries;
Physical reference data for medicine and biology;
Stability of alloys and ceramic materials;
Fracture properties of structural materials; and
Chemical modelling data for water pollution.

We also see a need to improve our procedures for disseminating data via computers. I will discuss each of these areas in somewhat more detail.

First, we have documented a growing need for a reliable data base and predictive capability for use by the organic chemical and power industries in chemical engineering design calculations. The chemical and power industries are both facing a complex set of problems brought about by changing sources of raw materials, environmental constraints, and the necessity to reduce energy consumption. A broad data base on materials properties is essential for the industry to respond effectively to these challenges. We believe that direct industry support can be obtained for a portion of this work; however, the diverse character of the users—large companies and small, suppliers and consumers, plant construction firms as well as producing companies—makes it appropriate to build on a base of Government funding. The specific data needed here are thermochemical and thermophysical data on coal, coal liquids, celluloses, lignins, gaseous and liquid fuels, and fluids (pure and mixed) commonly encountered in industry. Much of the output of the program will consist of procedures for predicting the properties of these substances over pertinent ranges of temperature, pressure, and composition. These procedures will be developed and validated in a coordinated program of data evaluation and measurements on key materials.

In the second area, a serious need has been identified for reference data from the physical sciences for application in medicine and biology. The whole range of techniques now in use for therapy, diagnosis, and research in these areas require evaluated data to determine the proper application and to interpret results. For example, the delivery of the proper radiation dose to a patient undergoing radiation therapy requires quantitative data on the absorption of the radiation in the various layers of tissue through which it must pass. This absorption is a physical process, and it can be calculated from information on the interaction of the radiation with the atoms and nuclei in each type of tissue.

Hospitals now depend on incomplete and poorly evaluated tables of reference data to check and control their radiation therapy procedures. The introduction of new types of radiation (e.g., neutrons) for cancer therapy, as well as the increasing use of automated procedures, is making the demands for reliable reference data of this type even more intense.

In the third area, we are considering a new activity on the phase stability of metals and ceramics, a characteristic which is crucial in development of new materials, extraction of metals from ores, and production of new alloys. At present the United States needs to develop alternate materials to replace conventional materials which are in short supply. Equally essential are new materials required by technological changes; for example, those resulting from efforts to exploit alternative sources of energy. These new uses subject materials to extreme or corrosive environments. At the same time pollution control and safety requirements place additional restrictions on materials production and on in-service performance. The mechanical behavior of materials depends on their exact composition and morphology, and the behavior of materials in a given environment depends on their chemical and phase equilibria with the substances in their environment.

Phase diagrams contain data pertinent to both types of performance. They give the exact composition that a mixture of substances will have at equilibrium at a given temperature and pressure, plus information on the structure of each solid phase present. Phase diagrams are of major importance for both ceramics and alloys. The affected industries now support or have indicated a willingness to support SRD activities in each area. A comprehensive, up-to-date, reliable compendium of existing phase diagrams is needed in each area, as well as a capability for predicting additional information in a reliable, timely fashion.

Fourth, advanced data on the performance limitations on structural materials is badly needed. Theoretical developments in the field of fracture mechanics in recent years have provided a firm basis for greater understanding of the mechanical strength of structural materials in actual-use situations, and this understanding needs to be translated into better design. Here we are referring to structures such as highway bridges, railroad track, suspension systems, pressure vessels for nuclear reactors, and bodies of automobiles. What is needed is a compilation of data on the pertinent mechanical properties of the materials used to build these structures, which will serve as input to the analytic procedures used by engineers as they design them.

We are also considering extending the activities of existing data centers and initiating additional projects to provide data for the characterization and understanding of water quality. The Council on Environmental Quality estimates that the United States will spend $110 billion for water pollution clean-up for the period 1975–1984. The ability to use reliable physical properties data to extend the measurement capability by modelling the effects of water pollutants is an important contribution to bringing pollution under control. Such data are fundamental to understanding how substances enter water bodies, how long they reside, and how they ultimately interact with other dissolved materials.

As I indicated earlier, we see a definite need to improve our procedures for disseminating data via computers. Users of technical information are beginning to shift from traditional books and journals to modern computer-based methods for day-to-day acquisition and use of the data they need. Computer delivery of data offers several advantages over traditional methods, *e.g.*, (1) ability to search large files for a substance whose properties met a number of specified conditions; (2) rapidity and low cost of up-dates and corrections; and (3) facility for direct interfacing of data files with manipulation or design programs which utilize the data. Computer-based dissemination of numerical data presents a number of difficult developmental problems which require solution before a viable delivery system can be installed. Suitable procedures for analytical representation of various types of data and for interpolation and extrapolation must be developed. Flexible search and retrieval programs are required, and a sufficiently general data base management system will be needed. Once the developmental phase is completed, the operational costs of the computer-based delivery system will be financed by user charges, in accordance with our usual policy.

Mr. Chairman, I hope that these examples of potential areas for future program activity will serve to illustrate the vitality of our program and the continuing need for specific reference data. We ask your continued support for these creative activities so that the evaluated results of research can be moved reliably and efficiently into technological improvements which will benefit our country, our society, and our quality of life.

National Standard
Reference Data System

Publication List

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PREFACE

The National Standard Reference Data System was established in 1963 as a means of coordinating on a national scale the production and dissemination of critically evaluated reference data in the physical sciences. Under the Standard Reference Data Act (Public Law 90-396) the National Bureau of Standards of the U. S. Department of Commerce has the primary responsibility in the Federal Government for providing reliable scientific and technical reference data. The Office of Standard Reference Data of NBS coordinates a complex of data evaluation centers, located in university, industrial, and other Government laboratories as well as within the National Bureau of Standards, which are engaged in the compilation and critical evaluation of numerical data on physical and chemical properties retrieved from the world scientific literature.

The primary focus of the NSRDS is on well-defined physical and chemical properties of well-characterized materials or systems. An effort is made to assess the accuracy of data reported in the primary research literature and to prepare compilations of critically evaluated data which will serve as reliable and convenient reference sources for the scientific and technical community.

This Publication List includes NSRDS data compilations, critical reviews, and related publications which are available from various sources. Prices and ordering instructions for publications listed are given on pp. 17-25. Further information may be obtained from

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CONTENTS

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NBS Tech. Note 291 — A Bibliography on Ion-Molecule Reactions, January 1900 to March 1966
F. N. Harllee, H. M. Rosenstock, and J. T. Herron (1966)

NBS Tech. Note 554 — Annotated Accession List of Data Compilations of the NBS Office of Standard Reference Data
H. M. Weisman and G. B. Sherwood (1970)

NBS Tech. Note 848 — A Bibliography of the Russian Reference Data Holdings of the Library of the Office of Standard Reference Data
G. B. Sherwood and Howard J. White, Jr. (1974)

NBSIR 76-1061 — Annotated Bibliography on Proton Affinities
K. Hartman, S. Lias, P. J. Ausloos, and H. M. Rosenstock (1976)

NBS-OSRDB-70-1 Vol. 1 — High Pressure Bibliography 1900-1968, Volume I, Section I - Bibliography, Section II- Author Index
Leo Merrill (1970)

NBS-OSRDB-70-1 Vol. 2 — High Pressure Bibliography 1900-1968, Volume II, Subject Index
Leo Merrill (1970)

NBS-OSRDB-70-2 — The NBS Alloy Data Center: Author Index
G. C. Carter, D. J. Kahan, L. H. Bennett, J. R. Cuthill, and R. C. Dobbyn (1970)

NBS-OSRDB-70-3 — Semiempirical and Approximate Methods for Molecular Calculations Bibliography and KWIC Index
George A. Henderson and Sandra Frattali (1969)

NBS-OSRDB-70-4 — Bibliography of Photoabsorption Cross Section Data
Robert D. Hudson and Lee J. Kieffer (1970)

NBS-OSRDB-71-1 — Bibliography on Properties of Defect Centers in Alkali Halides
S. C. Jain, S. A. Khan, H. K. Sehgal, V. K. Garg, and R. K. Jain (1971)

NBS-OSRDB-71-2 — A Bibliography of Kinetic Data on Gas Phase Reactions of Nitrogen, Oxygen, and Nitrous Oxides
Francis Westley (1970)

Bibliography of High Pressure Research
Leo Merrill, Compiler
Volume X (1977) Bimonthly

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Provo, Utah 84602 USA

VII. Critical Bibliographies and Indexes from Other Publishers

Binary Fluorides, Free Molecular Structures and Force Fields, A Bibliography (1957-1975)
Donald T. Hawkins, Lawrence S. Bernstein, Warren E. Falconer, and William Klemperer (1976)
IFI/Plenum, New York $25.00

Bulletin of Chemical Thermodynamics, Vol. 20
The annual index, bibliography, and review for published and unpublished research in the intersecting areas of thermodynamics and chemistry
Robert D. Freeman, Editor (1977)
Prepared under the auspices of IUPAC Commission I.2 on Thermodynamics and Thermochemistry
With Volume 20/1977, this publication returns to its original name, found on Volumes 1 (1958) to 4 (1961). Volumes 5 (1962) to Volume 19 (1976) were the Bulletin of Thermodynamics and Thermochemistry.
Subscription prices: Vol. 20, 1977 $25.00
To: Bulletin of Chemical Thermodynamics
Department of Chemistry
Oklahoma State University
Stillwater, OK 74074 USA

A Compilation of Volumes I-IV of the Bibliography on High Pressure Research with Author and Subject Indexes, Volumes I and II
J. F. Cannon and L. Merrill (1972)
Published by and available from the
High Pressure Data Center
Brigham Young University
Provo, Utah 84601

Equilibrium Properties of Fluid Mixtures, A Bibliography on Fluids of Cryogenic Interest
M. J. Hiza, A. J. Kidnay, and R. C. Miller (1975)
IFI/Plenum, New York $25.00

A Guide to Sources of Information on Materials
Robert S. Marvin and Gertrude B. Sherwood
Chapter 10, pp. 603-627 in
Handbook of Materials Science, Volume III
Nonmetallic Materials and Publications
C. T. Lynch, Editor
CRC Press, Cleveland (1975)

Liquid-Vapor Equilibria on Systems of Interest in Cryogenics, A Survey
A. J. Kidnay, M. J. Hiza, and R. C. Miller
Cryogenics 13 (10) 575-599 (October 1973)

VIII. Indexes to Radiation Chemistry Literature from the Radiation Chemistry Data Center

Semiannual Cumulations of the Weekly List of Papers on Radiation Chemistry have been prepared for Volumes IV to VI, 1971-1973, and are available from NTIS as listed below:
Weekly List of Papers on Radiation Chemistry, Index and Cumulation,
Vol. IV, Nos. 1-26, Jan. through June 1971
COM-71-01103
Vol. IV, Nos. 27-52, July through Dec. 1971
COM-72-10266
Vol. V, Nos. 1-26, Jan. through June 1972
COM-72-10621
Vol. V, Nos. 27-52, July through Dec. 1972
COM-73-10281
Vol. VI, Nos. 1-26, Jan. through June 1973
COM-73-11878/8AS
Vol. VI, Nos. 27-52, July through Dec. 1973
COM-74-10899

Annual Cumulations of the Biweekly List of Papers on Radiation Chemistry have been prepared for Volume VII (1974) to the present and are available from NTIS as listed below:
Biweekly List of Papers on Radiation Chemistry, Annual Cumulation with Keyword and Author Indexes,
Vol. VII, 1974
COM-75-11475
Vol. VIII, 1975
PB 257 025
Vol. IX, 1976
PB 268 699
Vol. X, 1977
Available from the Radiation Chemistry Data Center

Subscriptions to the Biweekly List of Papers on Radiation Chemistry (Vol. XI, 1978) and the Annual Cumulations for the previous year are available on a subscription basis from the:
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Radiation Laboratory
University of Notre Dame
Notre Dame, Indiana 46556

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Annual Cumulation only (1977)	$15.00
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Biweekly List (1978)	$24.00
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Biweekly List (July-Dec. 1978)	$11.00
Biweekly List (July-Dec. 1978) and Annual Cumulation (1977)	$18.00
Overseas Airmail (Biweekly List, July-Dec. 1978)	$12.00

UND-RCDC-1 Thesaurus for Radiation Chemistry, March 1977
Alberta B. Ross (1977)

IX. Other Non-Data Publications from NSRDS-Related Projects

NBS Spec. Publ. 463 — Materials Information Programs, An Interagency Review of Federal Agency Activities on Technical Information about Materials (Proceedings of a Conference held at the National Bureau of Standards, Gaithersburg, Maryland, April 16-17, 1974)
S. A. Rossmassler, Editor (1977)

NBS Spec. Publ. 496 — Workshop on Applications of Phase Diagrams in Metallurgy and Ceramics
G. C. Carter, Editor (1978, in press)

NBS Tech. Note 464 — The NBS Alloy Data Center: Function, Bibliographic System, Related Data Centers, and Reference Books
G. C. Carter, L. H. Bennett, J. R. Cuthill, and D. J. Kahan (1968)

NBS Tech. Note 947 — Critical Evaluation of Data in the Physical Sciences - A Status Report on the National Standard Reference Data System, January 1977
Stephen A. Rossmassler, Editor (1977)

NBSIR 75-910 — The Role of Chemical Kinetics in Energy Conservation
H. M. Rosenstock, D. Garvin, J. T. Herron, and W. Tsang (1975)

NBSIR 76-1002 — Industrial Process Data for Fluids: A Survey of Current Research at the National Bureau of Standards
Howard J. White, Jr., Editor (1976)

NBSIR 76-1130 — Program and Abstracts, Symposium on Nonbiological Transport and Transformation of Pollutants on Land and Water: Processes and Critical Data Required for Predictive Description, May 11-13, 1976, National Bureau of Standards, Gaithersburg, Maryland
L. H. Gevantman, Editor (1976)

NBSIR 76-1147 — A Combined Least Sums and Least Squares Approach to the Evaluation of Thermodynamic Data Networks
D. Garvin, V. B. Parker, D. D. Wagman, and W. H. Evans (1976)

JILA Report No. 12 — Proceedings of the Workshop on Dissociative Excitation of Simple Molecules, Appendix B. Line and Band Emission Cross Section Data for Low Energy Electron Impact
L. J. Kieffer (1972)

The Compilation and Evaluation of Chemical Kinetics Data; A Descriptive Survey of Current Efforts
Lewis H. Gevantman and David Garvin
International Journal of Chemical Kinetics V, 213-230 (1973)

Cooperation Between Professional Societies and A Government Agency: The Journal of Physical and Chemical Reference Data
David R. Lide, Jr.
IEEE Transactions on Professional Communications PC 18 (3) 127-129 (September 1975)

The NSRDS Experience
David R. Lide, Jr.
CODATA Bulletin No. 14, pp. 6-8 (Feb. 1975)

Reaction Rate Data Compilation and Evaluation Activities
Robert F. Hampson, Jr. and David Garvin
Journal of Physical Chemistry 81 (26) (December 29, 1977) In press.

The Standard Reference Data System
David R. Lide, Jr.
Chemical Engineering Progress 67 (11) 77-78 (November 1971)

Status on Critical Compilation of Physical Chemical Data
David R. Lide, Jr. and Stephen A. Rossmassler
Annual Review of Physical Chemistry 24, 135-158 (1973)

Survey of Analytical Spectral Data Sources and Related Data Compilation Activities
Lewis H. Gevantman
Analytical Chemistry 44 (7) 30-48 (June 1972)

X. Computer Programs for Handling Technical Data

NBS Tech. Note 444 — Reform: A General-Purpose Program for Manipulating Formatted Data Files
R. C. McClenon and J. Hilsenrath (1968)

NBS Tech. Note 470 — Edpac: Utility Programs for Computer-Assisted Editing, Copy-Production, and Data Retrieval
C. G. Messina and J. Hilsenrath (1969)

NBS Tech. Note 500 — Edit-Insertion Programs for Automatic Typesetting of Computer Printout
C. G. Messina and J. Hilsenrath (1970)

NBS Tech. Note 700 — COMBO: A General-Purpose Program for Searching, Annotating, Encoding-Decoding, and Reformatting Data Files
Robert McClenon and J. Hilsenrath (1972)

NBS Tech. Note 740 — SETAB: An Edit/Insert Program for Automatic Typesetting of Spectroscopic and Other Computerized Tables
Robert C. Thompson and Joseph Hilsenrath (1973)

NBS Tech. Note 760 — Description of the Magnetic Tape Version of the Bulletin of Thermodynamics and Thermochemistry, No. 14
R. McClenon, W. M. Evans, D. Garvin, and B. C. Duncan (1973)

NBS Tech. Note 820 — Complete Clear Text Representation of Scientific Documents in Machine-Readable Form
Blanton C. Duncan and David Garvin (1974)

NBS Tech. Note 903 — The NIRA Computer Program Package (Photonuclear Data Center)
H. J. Vander Molen and Henry M. Gerstenberg (1976)

NBS Tech. Note 928 — Computer Programs for the Evaluation of Activity and Osmotic Coefficients
Bert R. Staples and Ralph L. Nuttall (1976)

NBS Handbook 101 — OMNITAB, A Computer Program for Statistical and Numerical Analysis
J. Hilsenrath, G. G. Ziegler, C. G. Messina, P. J. Walsh, and R. H. Herbold (Revised January 1968)

NBS Handbook 125 — OMNIDATA, An Interactive System for Data Retrieval, Statistical and Graphical Analysis, and Data Base Management. A User's Manual
Joseph Hilsenrath and Bettijoyce Breen Molino (1978, in press)

NBS Spec. Publ. 424 — A Contribution to Computer Typesetting Techniques: Table of Coordinates for Hershey's Repertory of Occidental Type Fonts and Graphic Symbols
Norman M. Wolcott and Joseph Hilsenrath (1976)

XI. NBS Magnetic Tape Series

NBS Magnetic Tape 1 — OMNITAB II Magnetic Tape and Documentation Parcel
David Hogben, Sally T. Peavy, and Ruth Varner (1970)

NBS Magnetic Tape 2 — Fortran Programs for Text Editing File Manipulation and Automatic Typesetting
C. G. Messina, R. McClenon, and J. Hilsenrath (1973)

NBS Magnetic Tape 3 — Bibliography and Index to the Literature in the NBS Alloy Data Center
G. C. Carter and D. J. Kahan (1973)

NBS Magnetic Tape 4 — Magnetic Tape Version of the Bulletin of Thermodynamics and Thermochemistry No. 14 (1971)
Robert McClenon and Blanton Duncan (1973)

NBS Magnetic Tape 9 — Crystal Data Tape, Derived from the 3rd Edition of Crystal Data Determinative Tables
H. M. Ondik and A. D. Mighell (1975)

NBS Magnetic Tape 10 — Atomic Spectral-Line Intensities
W. F. Meggers, C. H. Corliss, and B. F. Scribner (1975)

NBS Magnetic Tape 12 — Tables of Coordinates for Hershey's Repertory of Type Fonts and Graphic Symbols
Norman M. Wolcott and Joseph Hilsenrath (1977)

NIH/EPA/MSDC Mass Spectral Data Base
Stephen R. Heller, G. W. A. Milne (1977)

Requests for Information and Orders should be sent to the
Office of Standard Reference Data
National Bureau of Standards
A537 Administration Building
Washington, D. C. 20234
Telephone: (301) 921-2229

XII. Translations from the Russian

A number of products of the Russian standard reference data system have been translated with support of the National Science Foundation at the request of the National Bureau of Standards.

Electric Conductivity of Ferroelectrics
V. M. Gurevich (1969, translated 1971)
TT70-50180

Handbook of Hardness Data
A. A. Ivan'ko; G. V. Samsonov (editor) (1968, translated 1971)
TT70-50177

Handbook of Phase Diagrams of Silicate Systems, Vol. I. Binary Systems, Second Revised Edition
N. A. Toropov, V. P. Barzakovskii, V. V. Lapin, and N. N. Kurtseva; N. A. Toropov (editor) (1969, translated 1972)
TT71-50040

Handbook of Phase Diagrams of Silicate Systems, Vol. II. Metal-Oxygen Compounds in Silicate Systems, Second Revised Edition
N. A. Toropov, V. P. Barzakovskii, I. A. Bondar, and Yu. P. Ulalalov; N. A. Toropov (editor) (1969, translated 1972)
TT71-50041

Handbook of Thermodynamic Data
E. B. Naumov, B. N. Ryzhenko, and I. L. Khodakovsky (1971, translated 1974)
PB 226 722

Heavy Water, Thermophysical Properties
Ya. Z. Kazavchinskii, et al.; V. A. Kirillin (editor) (1963, translated 1971)
TT70-50094

Isochoric Heat Capacity of Water and Steam
Kh. I. Amirkhanov, G. V. Stepanov, B. G. Alibekov; M. P. Vukalovich (editor) (1969, translated 1974)
TT72-52002

Properties of Liquid and Solid Hydrogen
B. N. Esel'son, Yu. P. Blagoi, V. N. Grigor'ev, V. G. Manzhelii, S. A. Mikhailenko, and N. P. Neklyudov (1969, translated 1971)
TT70-50179

Rate Constants of Gas Phase Reactions, Reference Book
V. N. Kondratiev, translated by L. Holtslag and R. Fristrom (1970, translated 1972)
COM 72-10014

Surface Ionization
E. Ya. Zandberg and N. L. Ionov (1969, translated 1971)
TT70-50148

Thermodynamic and Thermophysical Properties of Combustion Products, Vol. I. Computation Methods
V. E. Alemasov, A. F. Dregalin, A. P. Tishin, and V. A. Khudyakov; V. P. Glushko (editor) (1971, translated 1974)
TT74-50019

Thermodynamic and Thermophysical Properties of Combustion Products, Vol. II. Oxygen-Based Propellants
V. E. Alemasov, A. F. Dregalin, V. A. Khudyakov and V. N. Kostin; V. P. Glushko (editor) (1972, translated 1975)
TT74-50032

Thermodynamic and Thermopnysical Properties of Compustion Products, Vol. III. Oxygen- and Air-Based Propellants
V. E. Alemasov, A. F. Dregalin, A. P. Tishin, V. A. Khudyakov, and V. N. Kostin; V. P. Glushko (editor) (1973, translated 1975)
TT75-50007

Thermodynamic and Thermophysical Properties of Combustion Products, Vol. IV. Nitrogen Tetroxide-Based Propellants
V. E. Alemasov, A. F. Dregalin, A. P. Tishin, V. A. Khudyakov, and V. M. Kostin;V. P. Glushko (editor) (1973, translated 1976)
TT76-50007

Thermodynamic and Thermophysical Properties of Helium
N. V. Tsederberg, V. N. Popov, and N. A. Morozova; A. F. Alyab'ev (editor) (1969, translated 1971)
TT70-50096

Thermodynamic and Transport Properties of Ethylene and Propylene
I. A. Neduzhii, et al. (1971, translated 1972)
NBSIR 75-763

Thermophysical Properties of Air and Air Components
A. A. Vasserman, Ya. A. Kazavchinskii, and V. A. Rabinovich; A. M. Zhuravlev (editor) (1966, translated 1971)
TT70-50095

Thermophysical Properties of Freon-22
A. V. Kletskii (1970, translated 1971)
TT70-50178

Thermophysical Properties of Gases and Liquids, No. 1
V. A. Rabinovich (editor) (1968, translated 1970)
TT69-55091

The other volumes of this series have the English title "Thermophysical Properties of Matter and Substances."

Thermophysical Properties of Gaseous and Liquid Methane
V. A. Zagoruchenko and A. M. Zhuravlev (1969, translated 1970)
TT70-50097

Thermophysical Properties of Liquid Air and Its Components
A. A. Vasserman and V. A. Rabinovich (1968, translated 1970)
TT69-55092

Thermophysical Properties of Matter and Substances, Volume 2
V. A. Rabinovich (editor) (1970, translated 1974)
TT72-52001

Volume 1 of this series has the English title "Thermophysical Properties of Gases and Liquids, No. 1."

Thermophysical Properties of Matter and Substances, Volume 3
V. A. Rabinovich (editor) (1971, translated 1975)
TT73-52009

Thermophysical Properties of Matter and Substances, Volume 4
V. A. Rabinovich (editor) (1972, translated 1975)
TT73-52029

XIII. Ordering Instructions

The National Standard Reference Data System publications are available from a variety of sources, including the American Chemical Society (ACS); American Institute of Physics (AIP); the Superintendent of Documents, U. S. Government Printing Office (GPO); the National Technical Information Service (NTIS); the Office of Standard Reference Data (OSRD); as well as private publishers and societies. Ordering information for publications listed previously is included in Section XIV. It provides the following information for each publication: the publication number; date of publication; number of pages; hard copy source code, order number, and price or price code; microfiche source code, order number, and price code. The source codes used in the table are explained below.

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AIP	American Institute of Physics Department S/F 335 East 45th Street New York, New York 10017 Write for price quotes and further information.
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Japan

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Chiyoda-Ku, Tokyo 100
Japan

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Administration Building - Room A521
National Bureau of Standards
Washington, D. C. 20234

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XIV. Price List

Journal of Physical and Chemical Reference Data (JPCRD)

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99	1977	675-829	ACS	8.00
100	1977	831-869	ACS	4.50
101	1977	871-917	ACS	4.50
102	1977	919-991	ACS	5.50
103	1977	993-1102	ACS	6.50
104	1977	1109-1132	ACS	4.00
105	1977	1133-1166	ACS	4.50
106	1977	1167-1180	ACS	3.00
107	1977	1181-1204	ACS	4.00
108	1977	1205-1252	ACS	4.50
109	1977	1253-1330	ACS	5.50

Journal of Physical and Chemical Reference Data (JPCRD)

Supplements

Volume	Date	Pages	Source	Type	Price
Vol. 2, No. 1	1973	420	ACS	Hardcover	$33.00
			ACS	Softcover	30.00
			AIP	Microfilm	*
Vol. 3, No. 1	1974	796	ACS	Hardcover	60.00
			ACS	Softcover	55.00
			AIP	Microfilm	*
Vol. 6, No. 1	1977	783	ACS	Hardcover	70.00
			ACS	Softcover	65.00
			AIP	Microfilm	*

* Microfilm copies of the supplements are available as an addition to the microfilm for the entire volume. Write to AIP for details.

Reprint Packages

Package	Parts	Price	Source
A	10 parts	$25.00	ACS
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E	3 parts	25.00	ACS
F	8 parts	20.00	ACS
G	13 parts	35.00	ACS

National Standard Reference Data System (NSRDS) Series

			Hardcover			Microfiche		
Publication No.	Date	Pages	Source	Order No.	Price	Source	Order No.	Price
1	1964	12	GPO	SN003-003-06627-1	$0.55	Not available		
2	1965	68	NTIS	NSRDS-NBS-2	A04	NTIS	NSRDS-NBS-2	A01
3, Sec. 1	1965	31	NTIS	NSRDS-NBS-3	A03	NTIS	NSRDS-NBS-3	A01
3, Sec. 2	1967	22	NTIS	NSRDS-NBS-3-2	A02	NTIS	NSRDS-NBS-3-2	A01
3, Sec. 3	1970	73	NTIS	COM 72-50056	A04	NTIS	COM 72-50056	A01
3, Sec. 4	1971	46	NTIS	COM 71-50346	A03	NTIS	COM 72-50346	A01
3, Sec. 5	1975	80	GPO	SN003-003-01444-3	$1.80	NTIS	COM 75-10953/AS	A01
3, Sec. 6	1972	32	GPO	SN003-003-00998-9	1.15	NTIS	COM 72-50994	A01
3, Sec. 7	1976	33	GPO	SN003-003-01558-0	0.85	NTIS	PB 253 231	A01
4	1966	153	NTIS		A08	NTIS		A01
5	1966	87	NTIS	NSRDS-NBS-5	A05	NTIS	NSRDS-NBS-5	A01
6	1967	56	Superseded by NSRDS-NBS-39					
7	1966	38	OSRD	NSRDS-NBS-7	$0.85	Not available		
8	1966	68	NTIS	PB 189 698	A04	NTIS	PB 189 698	A01
9	1967	129	NTIS	NSRDS-NBS-9	A07	NTIS	NSRDS-NBS-9	A01
10	1967	49	NTIS	NSRDS-NBS-10	A03	NTIS	NSRDS-NBS-10	A01
11	1967	38	Superseded by NSRDS-NBS-39					
12	1968	98	NTIS	NSRDS-NBS-12	A05	NTIS	NSRDS-NBS-12	A01
13	1968	62	GPO	SN003-003-00622-0	$3.00	Not available		
14	1967	66	NTIS	NSRDS-NBS-14	A04	NTIS	NSRDS-NBS-14	A01
15	1968	140	NTIS	NSRDS-NBS-15	A07	NTIS	NSRDS-NBS-15	A01
16	1968	146	NTIS	NSRDS-NBS-16	A07	NTIS	NSRDS-NBS-16	A01
17	1968	39	Superseded by NSRDS-NBS-39					
18	1968	49	GPO	SN003-003-00628-9	$1.15	Not available		
19	1968	10	GPO	SN003-003-00629-7	0.65	Not available		
20	1968	49	OSRD	NSRDS-NBS-20	0.95	Not available		
21	1970	645	NTIS	PB 191 956	A99	NTIS	PB 191 956	A01
22	1969	268	NTIS	AD 696 884	A12	NTIS	AD 696 884	A01
23	1968	65	NTIS	NSRDS-NBS-23	A04	NTIS	NSRDS-NBS-23	A01
24	1968	271	OSRD	NSRDS-NBS-24	$6.10	Not available		
25	1968	116	NTIS	NSRDS-NBS-25	A06	NTIS	NSRDS-NBS-25	A01
26	1969	289	Superseded by J. Phys. Chem. Reference Data 6, Supplement 1 (1977)					
27	1969	153	GPO	SN003-003-00637-8	$1.80	Not available		
28	1969	116	NTIS	NSRDS-NBS-28	A06	NTIS	NSRDS-NBS-28	A01
29	1969	85	NTIS	NSRDS-NBS-29	A05	NTIS	NSRDS-NBS-29	A01

24-751 O - 78 - 15

Publication No.	Date	Pages	Hardcover Source	Hardcover Order No.	Hardcover Price	Microfiche Source	Microfiche Order No.	Microfiche Price
30	1969	27	NTIS	NSRDS-NBS-30	A03	NTIS	NSRDS-NBS-30	A01
31	1970	48	NTIS	PB 189 028	A03	NTIS	PB 189 028	A01
32	1970	79	GPO	SN003-003-00729-3	$1.15	Not available		
33	1970	37	NTIS	PB 192 183	A03	NTIS	PB 192 183	A01
34	1970	22	GPO	SN003-003-00770-6	$1.65	Not available		
35, Vol. I	1971	358	GPO	SN003-003-00949-1	9.25	NTIS	COM 72-50282	A01
35, Vol. II	1971	263	GPO	SN003-003-00935-1	7.95	NTIS	COM 72-50216	A01
35, Vol. III	1971	289	GPO	SN003-003-00950-4	8.30	NTIS	COM 72-50283	A01
36	1971	222	NTIS	COM 71-50203	A10	NTIS	COM 71-50203	A01
37	1971	1141	GPO	SN003-003-00872-9	$15.60	NTIS	COM 71-50363	A01
38	1971	114	NTIS	COM 71-50351	A06	NTIS	COM 71-50351	A01
39	1972	167	GPO	SN003-003-00845-1	$5.10	NTIS	COM 72-50742	A01
40	1972	261	NTIS	COM 72-50439	A12	NTIS	COM 72-50439	A01
41	1972	57	NTIS	COM 72-50849	A04	NTIS	COM 72-50849	A01
42	1972	27	NTIS	COM 72-50886	A03	NTIS	COM 72-50886	A01
43	1973	69	GPO	SN003-003-01083-9	$1.05	NTIS	COM 73-50537	A01
43, Suppl.	1975	53	GPO	SN003-003-01429-0	1.10	NTIS	COM 75-10737/AS	A01
44	1974	41	NTIS	COM 74-50175	A03	NTIS	COM 74-50175	A01
45	1973	29	GPO	SN003-003-01165-7	$0.65	NTIS	COM 74-50060	A01
46	1973	72	NTIS	COM 73-50623	A04	NTIS	COM 73-50623	A01
47	1974	161	GPO	SN003-003-01125-8	$2.25	NTIS	COM 74-50641	A01
48	1974	44	GPO	SN003-003-01166-5	0.80	NTIS	COM 74-50310	A01
49	1974	140	GPO	SN003-003-01190-8	1.70	NTIS	COM 74-50715	A01
50	1973	120	NTIS	AD 771 200	A06	NTIS	AD 771 200	A01
51	1975	66	GPO	SN003-003-01414-1	$1.20	NTIS	COM 75-10617	A01
52	1974	55	GPO	SN003-003-01262-9	1.15	NTIS	COM 74-50696	A01
53	1975	55	GPO	SN003-003-01426-5	1.15	NTIS	COM 75-11437	A01
54	1975	33	GPO	SN003-003-01406-1	0.85	NTIS	COM 75-10625	.A01
55	1975	21	GPO	SN003-003-01431-1	0.85	NTIS	COM 75-10917/AS	A01
56	1975	37	GPO	SN003-003-01396-0	0.85	NTIS	PB 248 991	A01
57	1976	24	GPO	SN003-003-01609-8	0.55	NTIS	PB 255 004	A01
58	1976	23	GPO	SN003-003-01627-6	0.70	NTIS	PB 254 470	A01
59	1977	126	GPO	SN003-003-01731-1	1.90	NTIS	PB 263 198	A01
60	1978		GPO	In press	Not set			
61, Part I	1978		GPO	In press	Not set			
62	1978		GPO	In press	Not set			

NBS Circular (NBS Circ.)

Publication No.	Date	Pages	Hardcover Source	Hardcover Order No.	Hardcover Price	Microfiche Source	Microfiche Order No.	Microfiche Price
488, Sec. 1 & 2	1950-1952	200	NTIS	PB 252 093	A09	NTIS	PB 252 093	A01
488, Sec. 3, 4, 5	1962	196	NTIS	PB 252 094	A09	NTIS	PB 252 094	A01

NBS Handbooks (NBS Hdbk.)

Publication No.	Date	Pages	Hardcover Source	Hardcover Order No.	Hardcover Price	Microfiche Source	Microfiche Order No.	Microfiche Price
101	1968	256	NTIS	NBS-H-101	A12	NTIS	NBS-H-101	A01
125	1978		GPO	In press	Not set			

NBS Interim Reports (NBSIR)

Publication No.	Date	Pages	Hardcover Source	Hardcover Order No.	Hardcover Price	Microfiche Source	Microfiche Order No.	Microfiche Price
75-763	1972	206	NTIS	COM 75-11276	A10	NTIS	COM 75-11276	A01
75-910	1975	122	NTIS	PB 248 646	A06	NTIS	PB 248 646	A01
75-968	1975	358	NTIS	PB 250 845	A03	NTIS	PB 250 845	A01
76-1002	1976	55	NTIS	PB 257 469	A04	NTIS	PB 257 469	A01
76-1034	1976	73	NTIS	PB 254 460	A04	NTIS	PB 254 460	A01
76-1061	1976	51	NTIS	PB 256 328	A04	NTIS	PB 256 328	A01
76-1130	1976	181	NTIS	PB 257 347	A09	NTIS	PB 257 347	A01
76-1147	1976	41	NTIS	PB 259 637	A03	NTIS	PB 259 637	A01
77-860	1977	239	NTIS	PB 272 355	A11	NTIS	PB 272 355	A01
77-1300	1977	93	NTIS	PB 273 171	A05	NTIS	PB 273 171	A01

NBS Monographs (NBS Mono.)

Publication No.	Date	Pages	Hardcover Source	Hardcover Order No.	Hardcover Price	Microfiche Source	Microfiche Order No.	Microfiche Price
70, Vol. I	1964	171	NTIS	PB 168 072	A08	NTIS	PB 168 072	A01
70, Vol. II	1964	349	NTIS	PB 189 714	A15	NTIS	PB 189 714	A01
70, Vol. III	1969	275	NTIS	COM 74-10794	A12	NTIS	COM 74-10794	A01
70, Vol. IV	1968	419	NTIS	COM 74-10795	A18	NTIS	COM 74-10795	A01
70, Vol. V	1968	533	NTIS	COM 74-10796	A23	NTIS	COM 74-10796	A01
94	1965	116	NTIS	N65-32001	A06	NTIS	N65-32001	A01
115	1970	54	NTIS	PB 192 874	A04	NTIS	PB 192 874	A01
134	1973	177	NTIS	COM 73-50582	A09	NTIS	COM 73-50582	A01
153	1976	123	GPO	SN003-003-01651-9	$1.35	NTIS	PB 256 586	A01

NBS Office of Standard Reference Data Bibliographies (OSRDB)

Publication No.	Date	Pages	Hardcover Source	Hardcover Order No.	Hardcover Price	Microfiche Source	Microfiche Order No.	Microfiche Price
70-1, Vol. 1	1970	692	NTIS	PB 191 174	A99	NTIS	PB 191 174	A01
70-1, Vol. 2	1970	748	NTIS	PB 191 175	A99	NTIS	PB 191 175	A01
70-2	1970	413	NTIS	COM 71-00722	A18	NTIS	COM 71-00722	A01
70-3	1970	293	NTIS	AD 705 110	A13	NTIS	AD 705 110	A01
70-4	1970	47	NTIS	COM 71-00025	A03	NTIS	COM 71-00025	A01
71-1	1971	293	NTIS	COM 71-00248	A13	NTIS	COM 71-00248	A01
71-2	1971	140	NTIS	COM 71-00841	A07	NTIS	COM 71-00841	A01

NBS Miscellaneous Publication (NBS MP)

Publication No.	Date	Pages	Hardcover Source	Hardcover Order No.	Hardcover Price	Microfiche Source	Microfiche Order No.	Microfiche Price
281	1967	155	NTIS	NBS MP 281	A08	NTIS	NBS MP 281	A01

NBS Special Publications (NBS SP)

Publication No.	Date	Pages	Hardcover Source	Hardcover Order No.	Hardcover Price	Microfiche Source	Microfiche Order No.	Microfiche Price
306, Sec. 1	1968	80	NTIS	NBS SP 306	A05	NTIS	NBS SP 306	A01
306, Sec. 2	1969	57	NTIS	NBS SP 306-2	A04	NTIS	NBS SP 306-2	A01
306, Sec. 3	1969	37	NTIS	PB 264 245	A03	NTIS	PB 264 245	A01
306, Sec. 4	1969	48	NTIS	COM 73-10870	A03	NTIS	COM 73-10870	A01
320	1970	104	NTIS	AD 701 614	A06	NTIS	AD 701 614	A01
320, Suppl. 1	1971	70	NTIS	AD 730 356	A04	NTIS	AD 730 356	A01
320, Suppl. 2	1973	65	NTIS	COM 74-50034	A04	NTIS	COM 74-50034	A01
324	1971	683	NTIS	COM 71-50070	A99	NTIS	COM 71-50070	A01
349	1972	43	NTIS	COM 72-50807	A03	NTIS	COM 72-50807	A01
362	1972	75	GPO	SN003-003-01000-6	$1.15	NTIS	COM 72-50466	A01
363	1972	109	GPO	SN003-003-00962-8	1.45	NTIS	COM 72-50676	A01
363, Suppl. 1	1977	190	GPO	SN003-003-01673-0	2.50	NTIS	PB 263 199	A01
366	1972	168	GPO	SN003-003-01044-8	2.80	NTIS	COM 72-50943	A01
366, Suppl. 1	1974	76	NTIS	COM 74-50063	A05	NTIS	COM 74-50063	A01
366, Suppl. 2	1975	79	GPO	SN003-003-01544-0	$1.35	NTIS	PB 246 714	A01
369	1974	180	GPO	SN003-003-01124-8	1.85	NTIS	COM 74-50302	A01
371	1973	93	NTIS	COM 73-50245	A05	NTIS	COM 73-50245	A01
371, Suppl. 1	1975	91	GPO	SN003-003-01422-2	$1.45	NTIS	COM 75-10687	A01
380	1973	134	GPO	SN003-003-01109-6	2.10	NTIS	COM 73-50244	A01
380, Suppl. 1	1978		GPO	In press	Not set			
381	1973	71	NTIS	COM 73-50932	A04	NTIS	COM 73-50932	A01
392	1974	84	GPO	SN003-003-01272-6	$1.30	NTIS	COM 74-50348	A01
396-1	1974	90	GPO	SN003-003-01274-2	1.25	NTIS	COM 74-51060	A01
396-2	1975	56	GPO	SN003-003-01457-5	1.10	NTIS	PB 248 989	A01
396-3	1976	42	NTIS	PB 250 844	A03	NTIS	PB 250 844	A01
396-4	1976	96	GPO	SN003-003-01572-5	$1.35	NTIS	PB 258 537	A01
424	1976	177	GPO	SN003-003-01599-7	2.90	NTIS	PB 251 845	A01
426	1976	222	GPO	SN003-003-01465-6	3.30	NTIS	PB 252 687	A01
428, Part I	1976	2414	GPO	SN003-003-01541-5	28.50	NTIS	PB 249 160	A01
Part II	1976		Available from GPO only			NTIS	PB 249 161	A01
Part III	1976		as 3-part set			NTIS	PB 249 162	A01

Publication No.	Date	Pages	Hardcover Source	Hardcover Order No.	Hardcover Price	Microfiche Source	Microfiche Order No.	Microfiche Price
449	1976	142	GPO	SN003-003-01677-2	$2.00	NTIS	PB 263 122	A01
454	1976	71	GPO	SN003-003-01666-7	1.65	NTIS	PB 257 765	A01
463	1977	275	GPO	SN003-003-01701-9	3.25	NTIS	PB 262 887	A01
478	1977	58	GPO	SN003-003-01824-4	2.00	NTIS	PB 270 972	A01
485	1977	57	GPO	SN003-003-01812-1	2.00	NTIS	PB 270 367	A01
496	1978		GPO	In press	Not set			

NBS Technical Notes (NBS Tech. Note)

Publication No.	Date	Pages	Source	Order No.	Price	Source	Order No.	Price
270-3	1968	264	GPO	SN003-003-00406-5	$3.25	Not available		
270-4	1969	152	GPO	SN003-003-00407-3	2.10	Not available		
270-5	1971	49	NTIS	COM 71-50171	A03	NTIS	COM 71-50171	A01
270-6	1971	124	GPO	SN003-003-00932-6	$1.90	NTIS	COM 71-50608	A01
270-7	1973	84	GPO	SN003-003-01139-8	1.25	NTIS	COM 73-50435	A01
291	1966	40	NTIS	NBS-TN-291	A03	NTIS	NBS-TN-291	A01
438	1967	139	NTIS	AD 665 245	A07	NTIS	AD 665 245	A01
444	1968	25	NTIS	NBS-TN-444	A02	NTIS	NBS-TN-444	A01
464	1968	163	NTIS	NBS-TN-464	A08	NTIS	NBS-TN-464	A01
470	1969	76	NTIS	NBS-TN-470	A05	NTIS	NBS-TN-470	A01
474	1969	22	NTIS	AD 681 351	A02	NTIS	AD 681 351	A01
484	1969	62	NTIS	AD 692 231	A04	NTIS	AD 692 231	A01
500	1970	47	NTIS	PB 191 352	A03	NTIS	PB 191 352	A01
554	1970	196	NTIS		A09	NTIS		A01
700	1972	72	NTIS	COM 73-50015	A04	NTIS	COM 73-50015	A01
740	1973	32	GPO	SN003-003-01210-6	$0.55	NTIS	COM 73-50986	A01
760	1973	54	GPO	SN003-003-01112-6	0.90	NTIS	COM 73-50242	A01
820	1974	58	NTIS	COM 74-50140	A04	NTIS	COM 74-50140	A01
848	1974	23	NTIS	COM 74-50934	A02	NTIS	COM 74-50934	A01
866	1975	127	GPO	SN003-003-01441-9	$1.85	NTIS	COM 75-10958/AS	A01
903	1976	34	GPO	SN003-003-01578-4	0.85	NTIS	PB 249 541	A01
928	1976	60	GPO	SN003-003-01711-6	1.10	NTIS	PB 262 600	A01
947	1977	88	GPO	SN003-003-01776-1	2.20	NTIS	PB 268 513	A01

Joint Institute for Laboratory Astrophysics (JILA) Reports

Publication No.	Date	Pages	Source	Order No.	Price	Source	Order No.	Price
No. 6	1969	104	NTIS	PB 189 127	A06	NTIS	PB 189 127	A01
7	1969	176	NTIS	AD 696 467	A08	NTIS	AD 696 467	A01
12	1972		NTIS	AD 745 417	A08	NTIS	AD 745 417	A01
13	1973	150	NTIS	COM 74-11661	A08	NTIS	COM 74-11661	A01

University of Notre Dame, Radiation Chemistry Data Center (UND-RCDC) Reports

Publication No.	Date	Pages	Source	Order No.	Price	Source	Order No.	Price
Vol. IV, No. 1-26	1971	283	NTIS	COM 71-01103	A13	NTIS	COM 71-01103	A01
" No.27-52	1971	276	NTIS	COM 72-10266	A13	NTIS	COM 72-10266	A01
Vol. V, No. 1-26	1972	315	NTIS	COM 72-10621	A14	NTIS	COM 72-10621	A01
" No.27-52	1972	334	NTIS	COM 73-10281	A15	NTIS	COM 73-10281	A01
Vol. VI, No. 1-26	1973	414	NTIS	COM 73-11878/8AS	A18	NTIS	COM 73-11878/8AS	A01
" No.27-52	1973	352	NTIS	COM 74-10899	A16	NTIS	COM 74-10899	A01
Vol. VII	1974	553	NTIS	COM 75-11475	A24	NTIS	COM 75-11475	A01
Vol. VIII	1975	670	NTIS	PB 257 025	A99	NTIS	PB 257 025	A01
Vol. IX	1976	707	NTIS	PB 268 699	A99	NTIS	PB 268 699	A01
Vol. X	1977		RCDC	Volume 10, 1977	Available March 1978			
UND-RCDC-1	1977		NTIS	PB 267 655	A06	NTIS	PB 267 655	A01

U. S. Bureau of Mines Bulletin

Publication No.	Date	Pages	Source	Order No.	Price	Source	Order No.	Price
668	1976		GPO	I28.3:668	$2.70	NTIS		A01

Translations from the Russian

Publication No.	Date	Pages	Hardcover Source	Hardcover Order No.	Hardcover Price	Microfiche Source	Microfiche Order No.	Microfiche Price
COM 72-10014	1972	434	NTIS	COM 72-10014	A19	NTIS	COM 72-10014	A01
NBSIR-75-763	1972	206	NTIS	COM 75-11276	A10	NTIS	COM 75-11276	A01
PB 226 722	1974	340	NTIS	PB 226 722	A15	NTIS	PB 226 722	A01
TT69-55091	1970	214	NTIS	TT69-55091	A10	NTIS	TT69-55091	A01
TT69-55092	1970	255	NTIS	TT69-55092	A12	NTIS	TT69-55092	A01
TT70-50094	1971	273	NTIS	TT70-50094	A12	NTIS	TT70-50094	A01
TT70-50095	1971	402	NTIS	TT70-50095	A18	NTIS	TT70-50095	A01
TT70-50096	1971	260	NTIS	TT70-50096	A12	NTIS	TT70-50096	A01
TT70-50097	1970	251	NTIS	TT70-50097	A12	NTIS	TT70-50097	A01
TT70-50148	1971		NTIS	TT70-50148		NTIS	TT70-50148	A01
TT70-50177	1971	69	NTIS	TT70-50177	A04	NTIS	TT70-50177	A01
TT70-50178	1971	72	NTIS	TT70-50178	A04	NTIS	TT70-50178	A01
TT70-50179	1971	126	NTIS	TT70-50179	A07	NTIS	TT70-50179	A01
TT70-50180	1971	366	NTIS	TT70-50180	A16	NTIS	TT70-50180	A01
TT71-50040	1972	730	NTIS	TT71-50040	A99	NTIS	TT71-50040	A01
TT71-50041	1972	329	NTIS	TT71-50041	A15	NTIS	TT71-50041	A01
TT72-52001	1972	395	NTIS	TT72-52001	A17	NTIS	TT72-52001	A01
TT72-52002	1974	215	NTIS	TT72-52002	A10	NTIS	TT72-52002	A01
TT73-52009	1975	212	NTIS	TT73-52009	A10	NTIS	TT73-52009	A01
TT73-52029	1975	179	NTIS	TT73-52029	A09	NTIS	TT73-52029	A01
TT74-50019	1974	453	NTIS	TT74-50019	A20	NTIS	TT74-50019	A01
TT74-50032	1975	505	NTIS	TT74-50032	A22	NTIS	TT74-50032	A01
TT75-50007	1975		NTIS	PB 248 719		NTIS	PB 248 719	A01
TT76-50007	1976	540	NTIS	TT76-50007	A23	NTIS	TT76-50007	A01

NBS Magnetic Tape Series

Tape 1	1970	NTIS	NBS Magnetic Tape 1	T05
2	1973	NTIS	NBS Magnetic Tape 2	T05
3	1973	NTIS	NBS Magnetic Tape 3	T05
4	1973	NTIS	NBS Magnetic Tape 4	T05
9	1975	NTIS	NBS Magnetic Tape 9	T99
10	1975	NTIS	NBS Magnetic Tape 10	T05
12	1977	NTIS	NBS Magnetic Tape 12	T10
NIH/EPA/MSDC	1977	OSRD	NIH/EPA/MSDC Mass Spectral Data Base	$500.00

CARBON FIBER STUDY

EXECUTIVE SUMMARY

Carbon fibers were produced nearly a century ago in the search for an incandescent lamp filament. During the 1950's and 1960's, experimentation resulted in stronger fibers and the use of their special strength properties in new materials called composites. These materials, which are composed of carbon or graphite fibers (the difference being the temperature of pyrolysis during manufacture) embedded in a resin binder, have opened a wealth of new structural engineering and consumer product opportunities. In the next decade, composites may become as important to the United States economy as the steel and aluminum they replace. No other materials now in prospect offer equivalent advantages.

The potential benefits of composites are manifold. Higher strength, lighter weight military and commercial products portend energy savings and increased safety. Unfortunately, these benefits are not realized without risk. The carbon (or graphite) fibers used in the present generation of composite materials are finer than human hair, extremely good electrical conductors, and virtually indestructable. They are so light that millions are contained in a gram mass. If released into the air, they can easily be transported by winds or currents. In contact with electrical devices, they can create resistive loading, short circuits, and arcing, resulting in stoppages or destruction. A variety of actual incidents can be cited supporting the hazards the fibers pose to electrical equipment. Their health impact is not fully known and requires careful research and analysis before any firm conclusions can be reached. But at current manufactured diameters and lengths, based upon currently available information, they are primarily an irritant to the eyes and skin, like fiberglass, rather than carcinogenic or destructive to lung tissue.

In July 1977, the Director of the Office of Science and Technology Policy was directed by the President to conduct a study of graphite composite materials analyzing the potential problems and providing a plan for possible Federal action.

The study revealed that current uses of carbon/graphite fibers worldwide entail about 700,000 pounds of material. At least six countries are currently producing composites and fabricating them into products. Major uses today are in military and commercial aircraft, with a growing list of consumer products, e.g., skis, fishing rods, golf clubs, etc. The major anticipated use is in automobiles where weight reductions necessary to realize fuel economies can only be achieved by replacing steel and aluminum with composite materials. Worldwide use, by 1990, could reach one billion pounds.

Inadvertent fiber release, during manufacture or by destruction of the resin binder in fire, is the major hazard associated with composites. Major manufacturers are aware of the unique problems associated with these materials and have successfully applied controls to avoid the in-plant problems. With the expected rapid growth in the use of these materials in aircraft and automobiles, however, vehicle accidents followed by fire could become a substantial possible source of fiber release. Further, the uncontrolled incineration of industrial waste and of discarded consumer products could create serious problems.

In some cases, protection might be realized by seclusion of equipment through protective covering or air filtering. New generations of electrical and electronic equipment can be manufactured with added protection at relatively modest cost.

Three courses of action are open to the Federal Government: (1) do nothing at this time, (2) support further investigation of effects and solutions, or (3) impose regulatory restraints on all or parts of the life cycle of composite materials. The study supports further investigation and coordinated action by a number of Federal departments and agencies with existing relevant responsibilities.

Action Plan

Carbon Fibers

I. Introduction

This paper presents a coordinated Federal Government action plan for dealing with the potential problems arising from the increasing use of graphite-fiber-reinforced composite materials in both military and civilian applications. The plan addresses the required dissemination of declassified information and outlines near-term and continuing Government actions to minimize the social and economic consequences of proliferated composite material applications. The plan includes budget, organizational, and scheduling considerations.

II. Agency Actions and Responsibilities

A. Information Dissemination

Several goals must be met by the overall information program, without stimulating unwarranted and undesirable reactions in any part of the public. Government agencies and both operating and producing industries must be aware of the hazards and the need to develop and use protective measures; the technical community must start to work on means to cope with the problem.

The hazardous effects under consideration are insidious and, though hopefully incidents will be rare, they would affect many sectors of society. In order to reduce the likelihood of a serious incident, there must be widely disseminated information about the potential hazards and means to protect against them. While technical means for protection have been devised, they are at the laboratory stage and not yet ready for commercial development. Work is also underway on the development of alternative composite materials which will not present an electrical hazard, but this effort is now in the earliest exploratory stages. To promote further technical alternatives and to develop inexpensive and effective means of protection, the scientific community must be thoroughly informed. All possible information will be declassified by the government.

The DOC, assisted by NASA, DOE, DOS, DOT, and DOD will review and make a selection of elements of Congress, Federal agencies, state and local jurisdictions, major industrial firms, specialized constituencies (e.g., professional societies, labor organizations, environmental organizations, etc.) to receive information. DOS will determine which foreign Governments and international bodies must be informed of the technical facts and projections. Typical industries are:

Aircraft operations
Aircraft equipment
Power generation and distribution utilities
Heavy electrical equipment
Surface transportation
Consumer electrical equipment

Communications: radio, TV, telephone operations,
equipment manufacture
Computers
Electronic components.

Examples of professional societies and industrial associations are:

AIAA, IRI, EPRI, IEEE.

NASA will prepare technical information in a "technical note" form that can be used initially to lay out the pertinent facts in a low-key and authoritative manner.

NASA, assisted by other Federal agencies as required, will prepare briefing strategies and necessary material, and will help coordinate the various agency briefing terms.

The above actions will be completed within 30 days after action plan approval.

B. Near-Term Responses

The present and projected near-term use of carbon fiber composites is limited, but increasing. A USG program must be developed to deal with the possibility of incidents which might occur before long-term solutions are developed in order to limit the possible harmful side effects of the materials.

An incident created by accidental release is thought likely to occur first through aircraft crash and fire. Aircraft are a current and projected major user of composites and an aircraft crash often involves conditions favorable to fiber release. DOT, supported by NASA and DOD, shall develop a procedure for identifying and reporting all aircraft accidents which could result in carbon fiber related incidents.

For incidents arising through other applications of composite materials, it will be necessary to have a field organization that is ready to assist local government bodies, at least until the phenomenon is more widely understood. Defense Civil Preparedness Agency is well-suited in that its offices exist throughout the country, it is well-organized, it is accepted readily by local authority and it is experienced in helping with disasters. DCPA assistance would presumably be required only during the early years when use of the composite material has become more widespread than at present, but technical methods of protection are not yet widely in use. The DCPA will prepare a plan to render such assistance by March 1, 1978.

The DCPA shall maintain records and shall provide written analyses of incidents which may occur, including information on sources, damage, effectiveness of clean-up, etc. DOD and NASA shall support the DCPA with laboratory analysis as required.

C. Continuing Efforts to Minimize Material Effects

Research and Development - There are three facets of approach that must be pursued simultaneously: (1) understanding the details of damage mechanisms to equipment and personnel and what protective measures can be employed; (2) prevention of introduction of fiber into the atmosphere; and (3) modification of material so that the damaging effects can be avoided. Specific programs in each of these areas are listed below.

Commercial aircraft equipment. Studies of vulnerability of commercial grade avionics and control equipment, and other systems essential to the safety of flight, including ground-based equipment, has been started, but data are inadequate to permit assurance of protection or accurate assessment of vulnerability. Assisted by consultation with and advice from DOT (FAA), NASA has responsibility for establishing a suitable test program and design of protective measures in concert with the aircraft industry. This program will include studies of crash plus fire scenarios and will be reviewed after one year to establish a completion date.

Surface transportation equipment. Virtually no data have been generated on the vulnerability of typical civilian surface transportation equipment. DOT will take the lead with assistance from NASA. This program will include studies of surface transportation crash plus fire scenarios. The program will take two years, and will be reviewed at that time for possible continuation.

Power generation and distribution equipment. Little work has been done in this area, although DOD has a limited data base. Examination of the failure modes of typical equipment and the design of suitable protective features for new equipment and backfit measure for existing equipment is essential. DOE will take the lead in working with the power industry. The program will take at least three years. Detailed annual review for progress is required.

Other commercial and household equipment. Communication and computer equipment are particularly important. Failure modes must be studied; design standards for future equipment must be developed in conjunction with industry; and protective procedures for installed equipment must be worked out. DOC (NBS) will take the lead. The program will run for two years, with the aim of transferring the lead to industry.

Monitoring Equipment. Instruments for continuous environmental monitoring and for site surveys must be developed. EPA will take the lead, with assistance from the DOD.

Health-related Effects. There is strong clinical correlation between inhalation of certain fibrous material, such as asbestos, and illness. The clinical effects of other materials, such as fibers of glass or carbon, are not equally clear. In all cases, the specific mechanism of insult is not well understood. Lacking such understanding, exposure standards can be developed only by analogy and such standards may either fail to protect or be needlessly restrictive and expensive. HEW (PHS) will undertake a three year program to elucidate the specific mechanism of damage by fibrous materials in order to improve treatment and to provide a solid base on which to establish safety standards.

DOL (OSHA) will prepare and promulgate regulations necessary for the protection of industrial workers handling carbon fiber material. These will include prescription of safe industrial practice, and will be based on a prudent extension of available clinical evidence on the deleterious effects of fibrous materials.

Environment. Uncontrolled disposal of discarded consumer goods and of industrial scrap generated during the manufacture of fiber and the fabrication of objects from the material could be a major source of release to the atmosphere. EPA, in concert with industry, will conduct a two-year study of means to control such disposal, including establishing identification of effective methods.

The most dangerous method of disposal is incineration, which may burn away the binder of the fiber material without necessarily destroying the fiber. EPA, in concert with industry will conduct a three-year study of safe methods of incineration, will develop the control technology necessary for this purpose, and will determine what methods may be suitable. At the end of that study, if required, EPA will issue regulations governing the disposal of carbon fiber material. Within the same period necessary atmospheric monitoring systems will be set up in the vicinity of major manufacturing facilities, and carbon fiber will be included in the monitoring of the effluent of major incinerators. Essentially nothing is known about the ecological effect of carbon fiber invasion of the natural water system and long-term accumulation in the environment. EPA will conduct a modest study of observation of concentrations of carbon fiber in the vicinity of manufacturing facilities, where free carbon fiber can be expected.

Alternative Materials. Since hazards arise from the high conductivity, general indestructability and ease of airborne transport of present carbon fibers, desired characteristics of alternative materials are clear: the substitute fibers should be of comparable cost and strength, but should not be able to produce the electrical effects feared unless conductivity is required for special applications. A complementary approach is to arrange that the fibers do not become airborne, or settle out so quickly that the problem is purely local. Given the desired strength and cost characteristics, investigators can look for fibers that are larger and thus settle out, are poorly conductive, or have an insulating coating. Research can seek a binder that does not burn below the ignition temperature of the present fibers, or seek a way of igniting the present fibers at temperatures characteristic of the disintegration of the present matrix. Finally, the technology program can seek a binder resin that chars and does not release fibers into the atmosphere when there is a fire. The technical history of development of composite materials indicates that between the introduction of a new fiber or a new matrix, when found, and the development of adequate engineering design data is a period of several years. Thus, an alternate material is not considered an early solution to the problem addressed here. It would seem that the earliest success is likely to appear in the form of a matrix binder material that will char rather than disintegrate.

NASA will take the lead in investigating alternative materials, with DOD assistance. Work will be aimed at larger diameter fibers, reduced conductivity, insulating coatings, and lower ignition temperatures for the fiber. Work on organic matrices will aim at non-combustible higher ignition temperatures and char characteristics. Work on charring matrices should produce results in two years; the other programs will take from three to five years. Development of engineering design data on candidate alternatives will not be complete before five years.

Composite Material Data Monitoring and Analyses. DOC shall undertake a continuing responsibility for maintaining the available data base, current industry practices, in-service protection procedures, etc., in order to assess the likelihood of incidents. The resulting analyses will provide the basis for continuing evaluation by OSTP/NSC and OMB as to budget requirements and priorities.

Assessment of Regulatory Requirements. Methods and necessary rules are to be developed by OSHA for the protection of industrial workers exposed to carbon fiber and by EPA for the control of release into the atmosphere during the ultimate disposal of carbon fiber composite materials. If present regulatory authorities are not adequate, draft legislation will be prepared by the cognizant agency.

International Considerations. Foreign production of carbon composite materials will increase, and there will be continuing sales of material or finished products to the U.S. Attempts to exclude importation of such material are inappropriate until we are assured either of a satisfactory alternative or that regulatory controls are necessary. DOS will prepare suitable advisories to governments of other countries producing or using large amounts of carbon composite material to inform them of U.S. actions in this area.

III. Budget Issues

Lead agencies for actions are responsible for preparing reprogramming plans for FY 1978 and budget requirements for FY 1979-82 in time for the President's decisions on the FY 1979 budget. OSTP, NSC, and OMB will collaborate in reviewing and approving those plans.

IV. Organizational

The execution of the broad aspects of this plan are agency responsibilities. Coordination and central monitoring for consistency, effective dates, etc. are required. OSTP, assisted by NASA, will assume this responsibility during the early stages. Continuing lead responsibility will pass to DOC in three to five years or at a time when commercial applications have increased to the point of being the dominant source of inadvertent release. To reduce duplication and confusion in dealing with local jurisdictions, states, cities, police departments, fire departments, etc.:

- DOC will develop and coordinate all contracts with industry except for research and development projects.

- NASA will coordinate Federal research and development projects.

- EPA will develop and coordinate all contacts with local governments and their substructures.

An annual report of progress, problems, and budget recommendations is to be submitted to OSTP in August of each year. NASA will assist OSTP in the consolidation and review of the total program and in judging the progress made and the work remaining.

V. Schedule

Completion of various functions is indicated in the sections above. Key targets are as follows:

- Agency R&D plans for assigned work are to be submitted to OSTP in time for the President's budget review. Budget requirements for FY 79-82 will be shown, along with planned allocations from FY 78 appropriations.

CARBON FIBER STUDY

I. INTRODUCTION

Carbon graphite composites are a family of important, new, lightweight and high-strength materials finding very rapidly growing use in military and civil aircraft, in space systems, and in a variety of consumer products ranging from sporting goods to automobiles. Carbon graphite composites may become as important to the United States and the international economy as the steel and aluminum they replace.

In a letter to the President, the Deputy Secretary of Defense and the Administrator, National Aeronautics and Space Administration (NASA), recognized the benefits and increasing usage of composite materials. They also worried that the carbon fibers if inadvertently released into the atmosphere posed a potential hazard to electrical equipment and possibly to the health of individuals.

The President directed the Office of Science and Technology Policy (OSTP) to review these matters and recommend an action plan. To accomplish this task, an interdepartment/interagency committee was formed under OSTP aegis to prepare a report and develop the action plan. The carbon fiber study presented below is the result of the OSTP sponsored review.

II. BACKGROUND

A. History of Composite Materials

The history of carbon fibers and filaments extends back for many years. In his classic work on the incandescent lamp, Edison made carbon filaments before 1880 by carbonizing natural cellulose fibers, such as cotton and linen. A further development occurred in 1909 when Whitney patented a process for coating carbon fibers from cellulose with pyrolytic graphite by flashing at temperatures up to 4,000° C. However, after the introduction of tungsten filaments, interest in carbon for lamp applications declined.

In the 1950's, the search for new materials for structural composites generated an upsurge of interest in carbon fibers. Early work at this time on pyrolyzed viscose rayon, sponsored by the Air Force Materials Laboratory (AFML) at Wright-Patterson Air Force Base, produced relatively strong flexible fibers by stretching the fiber during carbonization at 2,000° C. Although the process for producing high strength fibers was not very reproducible, reliable low-strength carbon and graphite yarns and fabrics could be manufactured. These low-strength fibers found application in tape configurations for strategic missile re-entry vehicle heat shields and rocket nozzles in the early 1960's.

A significant breakthrough in carbon fiber technology occurred in the period 1963-1965 when it was discovered that very high strength carbon filaments could be obtained by subjecting the precursor fiber to a rigidly controlled continuous tensile stress during the high-temperature treatment. It is the high values of the specific modulus and specific strength that make these new carbon fibers attractive materials as structural reinforcing agents.

Commercial carbon and graphite fibers are made from any carbonaceous, fibrous, raw material that pyrolyzes to a char, does not melt, and leaves a high carbon residue. The physical properties of the final carbon fiber materials are extremely sensitive not only to the type of precursor material, but also to such manufacturing variables as rates of heating, maximum baking temperature, time at maximum baking temperature, the baking environment, and the strain applied to the fiber during pyrolysis. Technically, the term "carbon fiber" is applied correctly to fibers that have been pyrolyzed at temperatures of 1,100° C. to 1,200° C. and consist essentially of amorphous carbon networks. The term "graphite fiber" is applied to the carbon fibers that have been heat treated at temperatures on the order of 2,200° C. to 2,700° C, resulting in a crystalline fiber structure. (For purposes of this report, the two terms will be used interchangeably, since the hazards under consideration are generally common to both.)

The starting material, called the precursor, for carbon fibers is usually continuous and may be a single fiber or a multistrand filament. Prior to 1973, most major U. S. producers of carbon fibers preferred rayon precursors; however, by 1976, most major producers in the U. S. and abroad preferred a polyacrylonitrile (PAN) precursor. Production of carbon and graphite fibers from a low cost pitch or tar precursor has received considerable attention recently, primarily from Union Carbide Company in the United States, and Taiyo Kaken in Japan. Union Carbide has its pitch-based process well along in development and Taiyo Kaken is expected to be producing this type of fiber during the next few years. The fibers derived from pitch precursors will probably be considerably less expensive to produce than those derived from PAN.

Very high modulus (of elasticity) graphite fibers in the form of a continuous yarn have been developed through the application of stress to a carbon fiber yarn during heat treatment at temperatures exceeding 2,200° C. This procedure creates a more ordered microstructure in the fiber, leading to a 10-fold increase in the elastic modulus and a simultaneous increase in the electrical and thermal conductivity in the direction of the fiber axis.

The outstanding mechanical properties of carbon fibers only become of practical interest when they can be efficiently translated into a visible structural form, such as a carbon fiber composite. To this end, significant effort has been expended in developing compatible matrix materials (to bind the fibers together), composite manufacturing methods, and optimized design configurations. The present generation of carbon fiber composites has unique combinations of properties which result in a significant capability for reduction in structural weight of both aerospace and nonaerospace transportation systems. Moreover, these same properties make possible significant economy of certain industrial operations with accompanying increases in safety for both static and rotating machinery. Finally, carbon fiber composites provide entirely new capabilities to consumers in the areas of sporting goods, medical equipment, electronic components, etc.

Studies based on experience gained from R&D programs and production of advanced composite aerospace structures indicate that extensive utilization of carbon fiber composites in the next generation of aerospace systems will provide significant benefits in the form of either reduced weight, size, and cost or in improved performance.

(1) Improved Performance (structural and aerodynamic):

o More efficient structure/lighter weight (higher specific stiffness and strength);

o Greater ability to dynamically tailor the structure; and

o Greater ability/flexibility relative to advanced geometric shapes and structural concepts.

(2) Improved Safety and Survivability:

o Improved fatigue characteristics;

o Greater damage tolerance;

o Improved flight safety (characteristically a redundant structure) -- slow, soft failure with advanced warnings; and

o Satisfactory ballistic tolerance.

(3) Reduced Cost:

o Acquisition - fewer parts, greater automation of fabrication (less labor intensive), less scrappage of basic materials, less testing required.

o Life cycle - improved performance - improved mission effectiveness - reduced maintenance (improved repairability) inherent corrosion resistance.

Commercial aircraft have begun to use carbon fiber composites and are expected to use more significant amounts of these materials with the introduction of the next generation of new or derivative aircraft. Weight reductions made possible in commercial aircraft are expected to be realized by improved fuel economy with a full fleet fuel savings of about 200 million gallons of gasoline per year projected on the basis of the quantities of graphite composites expected to be used in commercial transports by 1990.

The Federal automobile average fuel economy standards are expected to cause automobiles to be by far the largest user of graphite fiber by 1990. In this time period, the U. S. automotive industry alone may use more than 1,000 times the volume of graphite fiber used by the nonmilitary aerospace industry. Use of graphite composites in automobiles could result in full fleet fuel savings of as much as 2 billion gallons of gasoline per year based on the projected estimates for graphite usage in the 1990 automobile. If the automotive industry does substitute even a relatively small amount (90 lb./auto) of graphite composites for structural steel in automobiles, this will sufficiently reduce the cost of graphite fibers and sufficiently enhance the technology base that the trucking industry likely will apply large amounts of composites to new trucks. This should result in an approximate 15% increase in either fuel economy or load capacity. Likewise, the rail freight industry will apply composites in an amount which is likely to result in a 7% increase in rail freight capacity.

Future projections indicate that as the price of carbon fibers decreases, there will be an increase in other industrial uses of carbon fiber composites due to weight and cost savings as well as to increased safety. Also, the reduced cost will lead to a rapid expansion of use by the general public in the form of sporting goods and other recreational articles, due to the increased performance capability that carbon fiber products will offer to the consumer.

B. Nature of the Hazard

There are two categories of potential hazards that must be recognized and dealt with in the use of carbon fibers. These are: (1) accidental interference with electrical equipment, and (2) health impacts.

(1) Accidental Interference with Electrical Equipment

The only proven hazard of working with graphite fibers lies in their effects on unprotected electrical and electronic equipment. Release into the atmosphere of even a few grams of these fibers (actually millions of fibers) may damage unprotected electrical equipment. High electrical conductivity of the carbon fibers is a prime factor in causing the electrical hazard; however, other properties such as small fiber diameter (8 μm), generally short length (6-10 mm), and low density (1.5-1.9 gm/cm^3) are also important contributing factors. These fiber characteristics permit any small movement of air to cause free fibers to become airborne. The nominal fall rate of the fibers is 1 m/min. in still air. Therefore, fibers which are accidentally released can be transported over very long distances by normal atmospheric motion. Moreover, fibers which have settled out of the atmosphere are easily resuspended by minor atmospheric turbulence or mechanical agitation. As can be seen, therefore, depending on prevailing atmospheric conditions, localized release of a small quantity of carbon fibers can lead to contamination of a very large geographical area. As an example, it has been estimated that an accident involving burning of an aircraft containing 1,300 pounds of composite material can result in atmospheric exposure levels at distances 5 km away from the accident site which are equivalent to those which have produced electrical damage.

Because of their high conductivity and their physical inertness, carbon fibers which settle on or across electrical contacts or circuits can cause one of three types of electrical effects. They can cause: (1) resistive loading; (2) temporary, but possibly damaging, shorts; or (3) electrical arcing.

Single fibers of the type used in structural composites do not normally cause resistive loading in low voltage, solid state circuits. However, two

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or more such fibers in parallel can provide a sufficiently low resistance to adversely affect even these circuits. This effect, which is obviously somewhat dependent on the circuit impendence and voltage as well as the terminal or circuit board surface material, can lead to malfunctions of the equipment containing the circuit. These effects are most commonly associated with low voltages.

Single carbon fibers of the type normally used can cause shorts at voltages below 30 volts. The specific voltage at which such shorts begin is somewhat dependent on contact spacing and the surface of the contacts. (The existence of a contact potential is often the largest contributor to the overall resistance of the short circuit created by the fiber. However, for carbon fibers, even this contact resistance drops to a very low level at quite low voltages.) Due to the high conductivity of the fiber, it will carry quite high currents at relatively low voltages. The fiber will, however, burn out in the manner of a fuse because of its fine diameter. Nevertheless, even the momentary short formed can blow fuses in the equipment or can cause stressing of electrical and electronic components so that they no longer operate within specification.

Single fibers can also initiate arcing (air breakdown) between contacts either by effectively narrowing the air gap between contacts or by vaporizing (or causing the conductor material to vaporize) and producing ions to initiate air breakdown. Once the arc is initiated, it will often lead to extensive destruction of the equipment through fire. Even if the arc is not self-sustaining, the initial arcing can lead to vaporization of the carbon fiber which may recondense as a "carbon streak" on associated insulating surfaces. This highly conductive carbon deposit will then maintain the short circuit even in the absence of the arc.

Research has been conducted on various types of carbon fibers possessing a range of mechanical properties. In general, the electrical conductance increases with increasing modulus of the fibers. Therefore, the present commercial trend to higher modulus (and higher strength) fibers will, if anything, make the electrical hazards more severe. However, it should be noted that the carbon and graphite fibers presently being used for structural applications all have such high conductances that, except for very low voltage effects, all carbon and graphite fibers should be considered to cause nearly equivalent hazards.

The specific effect of fiber length in determining hazard severity has not been completely identified. Neither has the distribution of lengths which is likely to be produced in a typical accidental release scenario. Short fiber lengths favor easy distribution and penetration while long fiber lengths might be expected to cause more incidents by bridging wider gaps. However, it is not necessary for an individual fiber to bridge a gap in order to cause an incident since the fibers are polarizable in strong electrical fields, and the dipoles created can link up to bridge a gap which is wider than an individual fiber length. Whether or not this will actually occur in any particular case is dependent on the competition between electrostatic force and other external forces (e.g. wind).

As will be discussed later, protection methods are available; these include insulating circuits and/or contacts with a variety of insulating materials. However, preliminary research indicates that electrostatically charged carbon fibers may, in some cases, actually penetrate polymeric or resin type insulations leading to an electrical incident in a supposedly "protected" circuit.

The electrical hazard is a poorly correlated and an unpredictable phenomenon. However, the research done to date and the limited number of documented incidents are sufficient to prove that the hazards are real. Limited test data indicate that electrical equipment tolerance to free carbon/graphite fiber interference can be characterized in terms of exposure, or (fibers/m^3) x sec; electrical interference seems to begin in the exposure range of 10^4 - 10^7 (fibers/m^3) x sec.

(2) Health Implications

The carbon fibers of concern are often approximately 8 micrometers (μm) in diameter and typically 6-10 mm. in length. Tests conducted by the U. S. Army Environmental Hygiene Agency did not show a significant number of fibers with diameters of less than 6μm, but it is known that exposure to fibers of smaller diameter (such as asbestos) can produce severe respiratory problems.

While at the present time available information does not provide a basis to conclude whether man-made fibers (as opposed to asbestos) are or are not carcinogenic in man, smaller fibers can penetrate more deeply into the lungs than larger fibers. Until more definite information is available, the possibility of potentially hazardous effects warrants special consideration.

The fiber itself (not the carbon from which it is made) would appear to create the principle health significance, based on an extrapolation from other fiber materials, namely, asbestos, fiberglass, etc. The maximum permissible occupational exposure levels for carbon fibers is comparable to that for other fibers. For example, the Department of Labor, Occupational Safety and Health Administration (OSHA), has a current asbestos permissible exposure limit of 2.0 x 10^6 fibers/m^3 for an 8-hour time weighted average and has proposed to lower that level to 0.5 x 10^6 fibers/m^3 for an 8-hour time weighted average for asbestos fibers greater than 5μm in length because of the known human carcinogen risk associated with asbestos fibers. The National Institute for Occupational Safety and Health, DHEW, has recommended a level for asbestos of 0.1 fibers greater than 5 μm in length per m^3 on an 8-hour time weighted average with peak concentrations not exceeding 0.5 fibers greater than 5 μm in length per m^3 based on a 15-minute sampling period.

NIOSH recently recommended a maximum occupational exposure level of 3.0 x 10^6 fibers/m^3 for up to a 10-hour workshift in a 40-hour workweek for fibrous glass, as well as other man-made mineral fibers, having a diameter equal to or less than 3.5 μm and a length equal to or greater than 10 μm.

The discussion of asbestos fibers is only to provide general background data and should not be extrapolated to apply to carbon fibers on the basis of any existing toxicologic or epidemiologic data.

The potential health hazards associated with exposure to small diameter fibers may include:

(a) Acute skin and eye irritation;
(b) Skin sensitization;
(c) Chronic lung disease;
(d) Carcinoma of the lung; and/or
(e) Pulmonary and abdominal mesothelioma.

Of principle health concern are possible human exposures resulting from the manufacture, formulation, and rework (cutting, grinding, etc.) of such fibrous material, particularly as increased production occurs and as new commercial applications are developed. Another concern, although not yet observed, is the potential degradation or breakdown of the existing 8 μ m diameter fibers thus resulting in a significant respiratory hazard, or a change in current manufacturing processes which would allow greater use of smaller diameter (less than 3.5 μ m) fibers.

Acute human exposures from accidental release of carbon fibers into the environment will be less than occupational exposure during manufacture of various carbon fiber-containing products when considered as a time-weighted average exposure. It is unlikely that a significant risk to human health would occur from an acute exposure following an environmental incident.

(3) Biological Studies

An extensive literature review and evaluation of the biological effects of exposure to fibrous glass was recently completed by the U. S. Public Health Service, National Institute for Occuptational Safety and Health, in its "Criteria for a Recommended Standards --- Occupational Exposure to Fibrous Glass," DHEW (NIOSH) Publication No. 77-152. These recommendations also relate to all man-made fibers and, therefore, by analogy are important to this project.

Carbon fibers like other fibers (including man-made and mineral) would appear to have carcinogenic potential if smaller fibers (both diameter and length) were produced, or if currently produced fibers were to break up into smaller units. At the present time, no carbon fiber is reportedly being produced with diameters less than 5 μm. Smaller diameter carbon fibers would have less desirable structural and electrical properties. Therefore, production of smaller diameter carbon fibers seems unlikely at this time. Industrial hygiene evaluations conducted to date have failed to demonstrate any significant breakup into smaller diameter fibers, even though breakup into shorter lengths occurs in both occupational settings and following environmental release. Additional studies of possible breakup of different types of carbon fibers under various occupational and environmental conditions appears to be highly desirable. However, considering the lack of demonstrated breakdown into smaller diameter fibers in occupational and environmental settings, and the relatively small amount that would be released into the environment following an incident, any potential carcinogenic risk to man from fibers of currently produced diameters seems exceedingly small.

Human exposures to man-made fibers have indicated few reported health changes except those related to skin and respiratory tract irritation. The absence of such reports may be due to the short time that small diameter man-made fibers have been in commercial production, along with the short duration of exposure of adequate study groups. (Effects from asbestos exposures often are not indicated for 20-30 years after exposure.)

Large diameter fibers have been demonstrated to exhibit different effects in biological systems than small diameter fibers. Studies indicate that 3.5 μm approximates the diameter of the thickest long fibers observed in lungs of rats following inhalation exposure and that 90% of the fibers in lungs of deceased fibrous glass workers were less than 3.5 μm in diameter.

Previous exposures to humans have been mostly to large diameter fibrous glass and the health effects that have been observed include skin, eye, and upper respiratory tract irritation; a relatively low frequency of fibrotic changes, and a very slight indication of an excess mortality risk due to nonmalignant respiratory diseases.

An epidemiologic study of the mortality experience of 12,000 workers, sponsored by the Thermal Insulation Manufactures Association (TIMA), is now in progress on occupational exposures to manufactured (man-made) mineral fibers. The study, consisting of 3 groups of workers, is scheduled to be completed in phases between June 1977 and May 1978. Another current study, also sponsored by TIMA, will provide additional information on environmental concentrations, fiber characterizations, and durations of exposure.

(4) Industrial Environmental Data

In 1974, the U. S. Public Health Service reported on investigations of airborne particulates in 10 fibrous glass production facilities. The study consisted of four facilities producing fibers used in standard home insulation (designated as large diameter fibers) and six facilities producing or using fibers measuring less than 1 m in diameter (designed as small fibers).

In facilities where large diameter fibers were produced or used, mean airborne fiber counts ranged from 60,000 to 130,000 fibers/m^3 (0.06 to 0.13 fiber/cm^3). The highest single concentration was 830,000 fibers/m^3 (0.83 fiber/cm^3). Mean total dust concentrations ranged from 0.34 to 2.73 mg/m^3. The highest concentration was 14.5 mg/m^3. The median diameter of the fibers found in the various plants ranged from 1.1 to 4.3 μm. In most operations sampled, over 50% of the fibers were less than 3.5 μm in diameter.

In facilities where small diameter fibers were present, fiber diameters ranged from less than 0.1 to 2.0 μm with the majority being less than 1.0 μm and 40% to 85% less than 0.5 μm. Mean airborne fiber counts for these facilities ranged from 1,000,000 to 21,900,000 fibers/m^3. (1.0 to 21.9 fibers/cm^3);

the single highest concentration was 44,100,000 fibers/m^3 (44.1 fibers/cm^3). In bulk handling operations, four of six facilities had a mean concentration in excess of 5,000,000 fibers/m^3. (5.0 fibers/cm^3). All operations studied had mean gravimetric concentrations less than 1.0 mg/m^3 with the single highest observed concentration being 2.0 mg/m^3.

C. Fiber Release

Waste disposal by incineration of either industrial scrap or discarded composite products represents a source of carbon fibers capable of causing hazardous effects. Those who have responsibility for disposal are generally unaware of the hazardous potential of the fibers, thereby increasing the probability of inadvertent occurrence of a fiber releasing event.

Another possible fire-related accident which could cause fiber release is a crash plus associated fire of either an aircraft or surface transportation vehicle containing carbon fiber composites. Since the major near term use of carbon fiber composites for structural application is expected to be in military and civilian aircraft, the possible crash and burning of composite containing aircraft represents one of the immediate threats for release of carbon fibers. Most crashes of military aircraft involve fire followed by an explosion, and preliminary test data indicate that up to 15% of the carbon fibers contained in a composite undergoing this sequence of events may be released in a hazardous form; i.e., as single fibers or lint.

D. History of Incidents

The discovery of the damaging effects of the impingement of carbon fibers on electrical equipment came about quite accidentally. In 1968, the Air Force was conducting electronic interference experiments. Test personnel noted that electronic equipment exposed to the carbon fibers malfunctioned. Laboratory tests substantiated the effects of carbon fibers on electrical equipment.

On May 12, 1972, during a clean-up of an area in the Union Carbide's Carbon Fiber Production building at Fostoria, Ohio, a cardboard carton containing untwisted filaments of fine strands or carbon fibers 6 to 42 inches long was inadvertently placed in the plant incinerator rather than going to land fill. Subsequently, fibers were emitted from the stack, and conveyed by air over the plant and surrounding areas. The loose fibers were experimental material from development work; carbon fiber composite material was not involved. The electrically conductive strands settled on several electrical substations at the plant, causing short-circuits and power outages in three of the substations. The carton of fibers was placed on a burning pile of wood in the incinerator with a stack about 125 feet high and five feet in diameter at the top. The incineration occurred at 9:00-9:15 a.m., on May 12, 1972, a Friday. Within minutes, fiber strands were being discharged from the stack top. Strands (both single and in tumble-weed like clumps) were observed floating around in the air, settling on wires, roofs, and in the yard area. Some unburnt fibers were pulled from the fire and the fire was extinguished. The fibers were probably in the incinerator for 20 to 40 minutes.

Between 9:25 a.m. and 10:00 a.m., the 4000-volt circuits in two substations at the Union Carbide plant about a half mile downwind from the stack were shorted out. Power was restored in these substations by 2:00 p.m. A third substation nearby shorted out at 5:15 p.m. on the same afternoon. Startup of this substation was delayed until the following day pending an inspection of temporary repairs. Eight other open air substations and a metering station at the plant which were downwind from the stack did not short out. A newspaper account in the Fostoria Review Times on May 12, 1972, reported the Union Carbide power failure and also quoted a spokesman for the Ohio Power Company as indicating that three or four power outages were reported in the city at 9:10 a.m. The Ohio Power Company spokesman also said failures occurred within 15 minutes of each other at Ohio Power's east end substation, which is adjacent to the Union Carbide plant, and its west end substation which is some 3 miles to the west (downwind) of the plant. A power outage was also reported on Saturday, May 13, 1972, from 1:25 p.m. to 3:17 p.m. which darkened most of the downtown area of the city east of Main Street. Ohio Power's east end substation adjacent to the Union Carbide plant was reported as losing six 4000-volt line insulators.

E. Interests of the United States Government

There is a considerable range of Federal interest in the widespread use of graphite composite materials and potential hazards therefrom. Composites may offer the transportation industry the only economically viable means of meeting the automotive fuel consumption standards established for the 1980's. Composites are now integral to a number of key aeronautical and space systems being developed and procured by the military and civil agencies of the Government; in certain cases (F-18, Space Telescope), the mission objectives cannot be met without its use.

Composite materials are of growing importance to the entire national industrial economy as they find use in many different applications; they offer an improvement in performance and weight in comparison to the metals they replace. The Federal responsibilities for the public welfare encompass the full range of the possible threats posed by graphite fiber release, including environmental protection, human health, public safety, and degradation of such basic services as power and communications. Federal responsibilities for informing the public as to the positive and negative implications of new developments may not be explicit in every case but are nonetheless real, especially in light of the Government's dual promotional and protective interests. Considerable foreign use is being made of graphite composites and a significant amount, both as raw material and in finished consumer products, is being imported by the United States.

Federal R&D programs, notably within NASA, have focused on expanding the use of composites in the civil aviation field; Federal procurement programs, notably within the military, have specified these high-performance, lightweight materials; and Federal automotive fuel consumption standards virtually require conversion from present metals to new lighter materials. The role of the Federal Government, therefore, has included both the promotion of economically and socially beneficial new materials and the protection of the society from deleterious side effects.

III. PRESENT PRODUCTION AND APPLICATION

A. Production

Worldwide production capacity of carbon fibers was over 900 tons in 1976, and will probably be more than 1,500 tons in 1977. The industry as a whole, however, was operating at only about 40% of full capacity in 1976 with total sales of about 300 tons. Six of the leading carbon fiber producers accounted for about 80% of the world capacity and about 85% of the total carbon fiber sales in 1976. Producers of significant quantities of carbon fibers are listed in Table 1, along with estimated production capacity and some sales statistics. Marketing experts are currently predicting more than a 400% increase in the worldwide carbon fiber demand and production by 1980. Such increases will depend, in part, on further development of lower cost continuous, high-modulus, pitch-based graphite fibers; the utilization of carbon fiber technology in the automotive industry; the availability of Government aerospace and defense contracts; and the ability of producers to reduce the price of PAN-based graphite fibers below $10/lb.

B. Applications

The consumption of carbon and graphite fibers in the free world, by the general industrial and sporting goods industries, accounted for over 75% of the total output in 1976, with the remainder being consumed primarily by military and aerospace applications. By 1985, all sectors of the industry will be consuming larger volumes of carbon fibers with the automotive industry expected to consume a sizeable fraction of the total. Applications of carbon fibers in the aircraft and aerospace industries will continue to increase, especially in the area of structural load-bearing applications. Significant carbon fiber applications are listed in Table 2. There are over 250 fabricators using carbon fiber materials in the United States alone and probably as many more in the rest of the world. Hundreds more may be attracted to the field in the next 10 years as the market expands.

IV. POTENTIAL USAGE

A. Projected Military Usage

Of materials technologies which have emerged during the past ten years, the graphite composite technology appears to have the most significant across-the-board impact on future military systems. For this reason, the military is projecting the use of graphite fiber composites in virtually all new aircraft being considered. Table 3 lists these aircraft along with the anticipated weight and location of the graphite fiber components. Of the aircraft listed, two are worthy of special note.

The Navy F-18 aircraft is being designed for extensive use of graphite fiber composites. The use of this relatively large amount of graphite fiber composites will enable this aircraft to achieve mission and performance capability that could not presently be obtained with any other carrier-based aircraft designed without the extensive use of composites. Similarly, the VTOL aircraft, AV8B, is dependent on the use of large amounts of graphite fiber composites to provide this aircraft with adequate range and payload.

Table I

CARBON FIBER MANUFACTURERS AND ESTIMATED PRODUCTION CAPABILITIES
(Metric Tons)

Country	Company	Trade Name	Total Capacity 1976	Total Capacity 1977	Sales 1976
United States	Union Carbide	Thornel			
	Hercules	Magnamite			
	Stackpole	Panex			
	Morganite	MODMOR			
	Great Lakes Carbon	Fortafil			
	Celanese	Celion			
	Total United States		282	170[1]	126
United Kingdom	Courtaulds	GRAFIL			
	Hyfil (BCM)	HYFIL			
	Morganite-Modmor	MODMOR			
	Total United Kingdom		112	172	21
Japan	Toray	Torayca			
	Taiyo Kaken	Kureha			
	Toho Rayon	Beslon			
	Nippon Carbon	Carbolon			
	Mitsubishi Rayon	N/A			
	Nitto Boeski	Wonderfil			
	Total Japan		372	912	164
France	Le Carbone Lorraine (Serofim)	RIGALOR			
	GEPEM (SEP and Fibre-Mica)	N/A			
	Total France		22	22	N/A[2]
Federal Republic of Germany	Sigri Elektrographite	SIGRAFIL			
	Total F.R. of Germany		4-10	4-10	4

[1]Firms that reported 1976 capacity did not report in 1977

[2]N/A = Not Available

Table 2

APPLICATIONS OF CARBON AND GRAPHITE FIBERS

Structural components for commercial airlines

Antenna for Jupiter flyby satellite

Equipment section for third stage of TRIDENT missile

Space Shuttle cargo doors

Rocket motor combustion chambers and nozzle components

Access doors, empennage parts and speed brakes for fighter aircraft

Helicopter tail boom

Sporting goods, such as: fishing rods, shafts for golf clubs, CB antennas, tennis racket frames, javelins, bats, hockey sticks, etc.

Experimental automotive parts, such as: drive shafts, spring leaves, side intrusion beam, bumper parts, frame rails, valve trrain pushrods, gears, bearings, brake linings

Lightweight oil field derrick

Textile equipment

TABLE 3

GRAPHITE FIBER COMPOSITE USE ON MILITARY AIRCRAFT

A/C	Location	Weight (lbs)
F-18	Tail, Slats, and Fairings	1300
AV8B	Wings	900
CH-46	Rotor Blades	30
S-3	Spoilers	6
A-7	Wing Tips	50
YF-17	Tail, Slats/Flaps	1000
F-15	Speed Brakes	165
F-111	Fairing over Doubler	20
CH-47 Mod	Rotor Blade	150
UTTAS	Tail Drive Shaft Rotor	50

B. Projected Civilian Aerospace Usage

As for all other segments of the nonmilitary marketplace, the projected use of graphite composites cannot be determined with a high degree of certainty since the anticipated volume of use is dependent on price, which is likewise dependent on volume. However, since the benefits of lightweight structures to aerospace applications are so great, this segment of the market will likely continue to grow quite rapidly even if the optimistic estimates of price reductions are not realized. The relatively wide ranges given below, of projected weights of graphite fiber to be used, are due primarily to price uncertainties. Since the aerospace industry is expected to be a relatively minor user of graphite composites as compared to the ground transportation industry in the time period beyond 1985, decisions of the aerospace industry, in this time period, should not have a significant impact on price.

The major use of graphite fibers, in the commercial aerospace market, will be in airframe structures. A significant fraction, however, will be in engines and miscellaneous commercial aerospace components including civilian rockets and spacecraft, aircraft brakes, interior components, etc.

The Aircraft Energy Efficiency (ACEE) Program estimate for volume of graphite fiber usage in 1990 is plotted on Figure 1. As can be seen, volume of nonmilitary aerospace use is expected to increase by about a factor of 5 each 5 years until at least 1990.

C. Potential Usage in Surface Vehicles

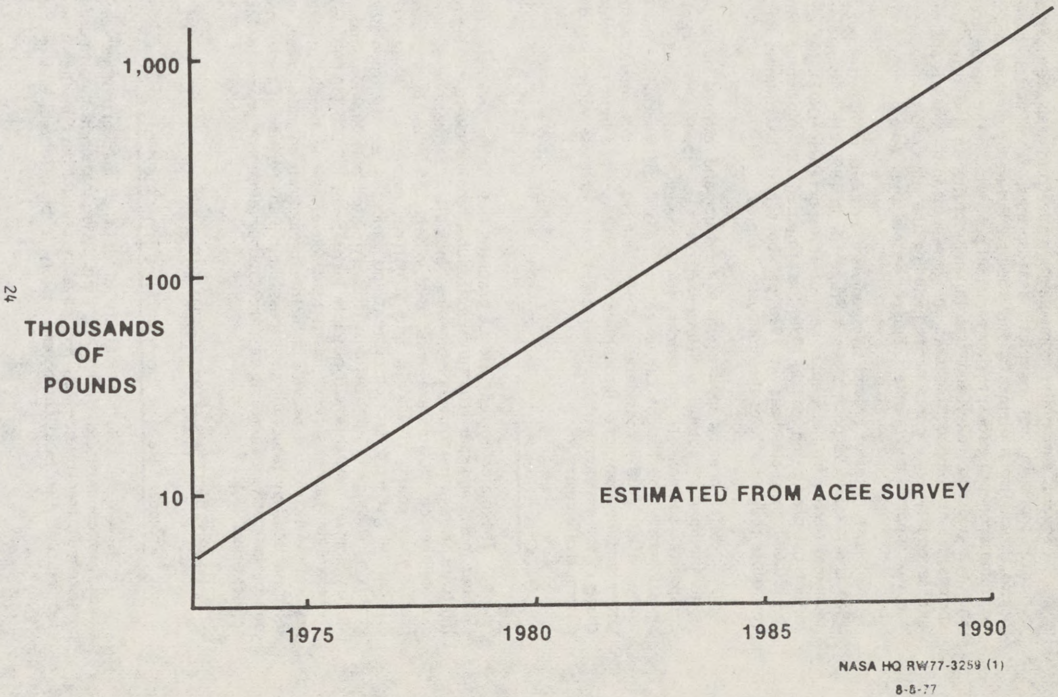
The interest in graphite composites for automotive manufacturing has risen largely because of the pressure to conserve energy in accord with national policy. The truck and freight car industries are also motivated by their interest in means of reducing vehicle weight to increase maximum useful load carried. Their usage will be based on cost effectiveness.

The achievement of automotive fleet average fuel economy standards set for 1985 (27.5 mpg) by Congress does not necessarily depend upon the use of graphite composites. These objectives are now being met by downsizing, improved engine efficiency, and light metal substitution. By 1990, however, the need for even greater fuel economy will require further alternatives such as smaller cars, lower performance, and higher efficiency engines and power trains, or more emphasis on exotic lightweight structures. Government specifications provide only performance requirements; therefore, it can be expected that decisions to use new materials such as CF composites will be dependent on materials costs.

There is general agreement, based on references from industry sources and the literature, that the price of fiber composites will be down to $5 - $10 per pound by 1985. At these lower prices, they would move into a range where they would be competitive with metals.

FIGURE I

ESTIMATED USE OF GRAPHITE FIBER FOR NON-MILITARY AEROSPACE APPLICATIONS



Several automotive components made from graphite fiber composites are currently found in test vehicles: leaf springs, drive shafts, car-door intrusion beams, truck frame elements, and wheels. Future application potentials are for: push and connecting rods, rocker arms, oil pan, etc., in the engine area; shafts, axle and axle-housing, yoke, and transmission-housing in the drive train area; leaf springs, frame components, brake linings, wheels in the chassis and suspension area; and secondary body components including the air conditioning, transmission and radiator supports and brackets, bumper beams, and whole bumper systems.

Estimates of around five pounds of graphite composites per average car in 1985 and possibly 90 pounds per average car in 1990 are reasonable, based upon a technical review by the Department of Transportation (DOT). At an estimated 10 million car production rate in 1990, the projected consumption of composites would be 450,000 tons per year in 1990 or about half that number in fibers, which constitute roughly 50% of the composite weight.

References on applications to the truck and railroad industries are sketchy as to the market potential. However, one can expect the market for graphite composite components in trucks to be second only to the automotive in significance. The freight car usage will be a small fraction of the passenger car usage based on the considerably fewer number of units manufactured annually. Other surface transportation applications, in buses and light rail vehicles, will also share in the development but the market share of these vehicles is dwarfed by the automotive industry.

D. Other Uses

The major current use of graphite fiber is in consumer products such as sailboat masts and spar structures, golf clubs, tennis rackets, fishing rods, oars, and lightweight, high-performance bicycles. In addition to these consumer applications, carbon fiber composites are being used in selected industrial applications for such products as gears, flywheels, and structural members. While it is extremely difficult to get hard data on current and projected use of carbon fiber composites in this wide range of applications, it is estimated that 50,000 pounds are currently in commercial use; this will possibly increase to 100,000-150,000 pounds by 1980. There are no market surveys in existence covering commercial utilization of these materials which could provide a further breakdown on uses. Also, manufacturers seem particularly reluctant to discuss their plans for use of these materials which may be indicative of ongoing research and development programs for new market applications.

V. CONSIDERATIONS FOR THE FUTURE

A. Projected Rate of Electrical/Electronic Incidents

Given the relative scarcity of data on inadvertent release of graphite fibers from composite materials, on their dissemination in the atmosphere, on their persistence after release, on the ways in which fibers in the atmosphere reach electronic or electrical components likely to be affected, and on the severity of damage likely to be produced, it is nearly impossible to currently project the rate of future graphite fiber induced electrical incidents. Both NASA and DOD are currently involved in experimental test programs and risk analyses to improve the capability to make such assessments. Nevertheless, in order to provide some quantification of the near-term and far-term risks involved in the civilian use of graphite composites, NASA has carried out two very preliminary calculations to provide a basis for discussion. The first deals with the near-term risk due to the use of small amounts of graphite composites in commercial transport aircraft, and the second deals with the projected far-term risk due to their use in automobiles.

Commercial aircraft applications were selected for assessment since they are expected to be the second largest nonmilitary use of graphite composites in the near time frame, and since the small amount of data available for the risk assessment calculation are most suitable for this application. (The largest nonmilitary user in the near time frame will be consumer products such as sporting goods, but assessment of incidence rate for this application cannot be done now due to a complete lack of data on disposal by incineration which is the only significant fiber releasing scenario applicable to these products. Moreover, since these products are currently quite costly and durable, substantial disposal of them does not appear to be likely for the next several years. Automobiles, of course, present an entirely different situation, but their disposal will not involve a carbon fiber issue in the near term.)

In the context of the following discussion, a graphite fiber induced electrical incident refers to a single electrical anomaly. This would include any small or large electrical short or component failure which would cause the malfunction of an electrical instrument or appliance. An incident is then clearly differentiated from a graphite releasing accident which could cause either many incidents or none at all depending on the various factors to be discussed below. At present, the incident rate can be discussed only in statistical terms with very little account given to the possible consequences of a particular incident. Some attempt will be made, however, to illustrate examples of consequences of the two examples used below.

In general, the way in which the incidence of graphite fiber induced electrical hazard can be evaluated is to determine: the number of fiber releasing accidents which are likely to occur; the number of fibers released in each accident; the integrated exposure of all areas due to the accident; the density of equipment in the affected area; the site; and the probability that the exposure at the damage site will cause damage. Based on the available data base, assumptions or statistics can be used to place a value on each of these factors. However, a high to very high degree of uncertainty must be placed on each of these values because of the very limited amount of data currently available. Table 4 lists the assumptions used to assess the incidence rate due to near term commercial aircraft use of graphite composites and provides judgmental remarks concerning their certainty. Table 5 shows some factors which were not evaluated.

The following calculations are included for illustrative purposes only and only relative significance can be attached to the actual numbers developed. In most cases, the values assigned to the various factors represent highly conservative

Table 4

KEY FACTORS IN AIRCRAFT INCIDENCE CALCULATIONS

Factors	Valued Used	Remarks
Exposure	$10^4 - 10^7$ (fibers/m^3) seconds	See NASA Technical Memorandum 78652
Accident Rate (AC)	0.004 fire related commercial accidents for 10^6 miles	Accident statistics from NTSF and unpublished NASA study. (Average over lifetime.)
Flight Miles/AC/Yr.	1.2×10^6 miles/yr.	Average for narrow bodied jet.
Population Density	3,340/km^2	U. S. Census, Norfolk, Virginia. Assume one electronic device/person.
Fiber Fraction Released from Fire and Explosion	15%	Limited data, chamber tests. Probably worst case. Need full scale tests.
Fiber Exposures	$10^1 - 10^5$ (fibers/m^3)x(seconds)	Integrated exposures calculated downwind for worst case release heights and atmospheric conditions.
Transfer Coefficient	1.0	Transmission factors for buildings, filters ducts vary from 1.0 to 0. worst case.
Probability of Damage	$P = 1-e^{-E/\bar{E}}$	E is the actual exposure and $\bar{E}$ is the critical exposure.

Table 5

FACTORS NOT EVALUATED

Factor	Remarks
Turbulence, Additional Energy Sources	Mechanisms which keep fibers airborne increase risk. Washout mechanisms decrease risk.
Equipment Concentration	
Major Power Generating and Transmission Equipment	
Washout, Fog, and Rain	
Material Life and Redeposition	
Material Length Distribution	Effects of material length, life, and redistribution are unknown.

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(worst case) conditions. No account was taken of natural protection offered by buildings, containers, filters, etc. (This will be discussed more extensively below.) Accidents were assumed to occur exclusively in populated areas and only worst case atmospheric conditions were considered. No account was taken of actual fire failure modes as opposed to "worst-case" fire plus explosion.

A calculation of possible near-term incidence rate was made for the case of a fleet of 40 narrow bodied (Boeing 737) aircraft each containing 10 lbs. of graphite fiber in a composite form. This scenario closely approximates the actual use of graphite composites in NASA-sponsored flight demonstration projects at present. The results of the calculation show that this usage produces the possibility of between 35 and 50 incidents of graphite fiber induced electrical failure per year, arising from one expected aircraft accident involving fire every five years in a fleet size of 40 aircraft. This value is undoubtedly very conservative (high, perhaps by several orders of magnitude) because of the assumptions discussed earlier and because of the assumption that each fire related accident would involve and consume all the composite material. This same statement cannot necessarily be made for aircraft use of graphite composites in the future. The quantities of material per aircraft may increase by a hundredfold and the number of aircraft involved may also increase by the same factor.

A similar calculation can be made for the case of incidents caused by graphite composites used in the 1990 automobiles. For this calculation, many of the same factors can be used. It should be cautioned, however, that for this case, the values assigned to the various factors are even less certain because of a total lack of test data directly applicable to automotive crash scenarios. However, for purposes of illustration, such a calculation was done.

Statistics from the National Highway Safety Council provide a "best estimate" that 0.1% of the 17 million automotive accidents occur each year involve fire in various degrees of severity. Using a value of 10,000 fire accidents per year to account for the severity, it is possible to show that if the average automobile in 1990 contained 90 pounds of graphite fiber, the rate of fiber induced electrical incidents might be very high based on the factors of population, transfer coefficient, etc., in Table 4.

An additional factor which should be considered in a more extensive risk assessment, but one which is difficult to quantify at this time, is related to the possible consequences of a given incident. Two electrical incidents which may cause approximately equal damage to a given piece of equipment may have vastly different consequences. Using the two examples given above, it is easy to imagine that an accident at a commercial airport which caused temporary or permanent failure of a critical communications component could have a much more severe impact in terms of both safety and costs than would equivalent damage to a personal radio or television set. The failure of the communications link could result in the requirement to close the airport entirely resulting in a large economic loss, or, in the worst case, could result in the crash of other aircraft. The auto accident, however, would be more likely to result in "nuisance failure" of consumer products which would result in inconvenience to individuals and businesses accompanied only by minor economic loss unless major structural fires resulted. These sorts of factors must be evaluated in future studies when more source and vulnerability data are available.

As indicated in Table 4, the transfer coefficient describing the ratio between fiber exposure levels in the free atmosphere to those at site of electrical hazard can vary from 1 to 0. The value used for the above calculations was 1. However, relatively simple protection methods such as providing well sealed cabinets and consoles for electronic assemblies, using fitted filters with all chassis ventilation fans, conformally coating all circuit boards, and either increasing the spacings between terminal strips or covering the terminals themselves have been shown to decrease the transfer coefficient and thereby decrease the incidence rate. Reductions in the coefficient of one or two orders of magnitude should not be difficult to achieve with equipment for which it is possible and practical to provide sealed cabinets and filter protection.

B. Future Health Implications

Future health implications relate to three primary areas of consideration:

(1) Lack of definition of size and shape and other factors related to carbon fibers.

(2) The implications of controlled and uncontrolled incineration, from occupational considerations as well as general waste disposal, related to air, water, and soil contamination.

(3) Future increases in production and distribution as related to manufacturing, commercial products, and other composite matrixes.

If total composite material recycling could be developed and inititated now, many of the occupational and environmental health implications could be significantly reduced. In addition, this would enhance conservation of resources and provide for increased energy savings through utilization of lighter and stronger materials for secondary structural applications.

Overall health implications of the carbon fiber can also be reduced when the fibers are incorporated into a stable composite matrix. Other steps, such as coating of the fibers, may reduce possible health implications.

Care must be taken during the development of any alternate materials so that a more significant health risk is not developed.

In summary, we need to know more about carbon fibers, including their interaction with the human body, industrial hygiene and environmental considerations, and future implications of an expanded commercial usage. The U.S. Public Health Service may inititate efforts to better determine sampling and analytical methods, fiber size and shape determinations, fiber transport mechanisms, control technologies, and toxicological and epidemiological studies to better define the nature of any associated health risks to both workers and the general public.

C. Protective and Remedial Measures

The electrical hazards created by carbon fibers could be protected against or remedied by a number of methods. Obviously, one method would be to regulate or terminate the manufacture and sale of the fibers, the composite material, or certain end-products. The following discussion assumes that the anticipated benefits to the U. S. of continued use of composite materials preclude consideration of such action at this time.

(1) Protective

A partial list of possible methods of protecting against electrical incidents is given in Table 6. These fall into three broad classifications: (1) protection of equipment; (2) limiting dissemination of hazardous fibers; and (3) modification of the hazard causing material. Limited test data suggest that all of the listed methods of equipment protection can be very effective. However, more research of the type to be discussed later in this section is needed to quantify the potential of each method. The added cost of protecting equipment will depend very significantly on the degree to which the electronics industry has already begun to move in a direction which will provide some measure of protection to electronic circuit boards and terminal strips. They have, for some time, been conformally coating circuit boards for aerospace applications which might be subject to contamination from debris in either short- or long-term weightless conditions. Some companies now indicate that they are applying similar coatings to boards for consumer applications to increase reliability. The cost of such coatings is apparently small compared to other production costs. This would probably hold true for production of protected or redesigned terminal strips for new equipment. Improved sealing and filtered ventilation for consoles and chassis could probably be used on new equipment at only a small fraction of the overall product manufacturing cost.

(2) Remedial

Existing electrical and electronic equipment would be much more difficult and costly to protect than would new equipment. Such costs cannot be reasonably estimated at this time. However, based on the number of years before the use of graphite composites reaches the large volume projected for 1990, it is likely that most of the equipment now being produced will be obsolete and out of service before a significant problem exists. Therefore, if manufacturers were made aware of the potential problem now and if they introduced improvements in new product lines, it is likely that only a small fraction of equipment existing in the 1990's would have to be retrofitted with protective materials and devices.

One area of uncertainty regarding costs of hazard prevention in the future is tied to the unknown persistence and redistribution of graphite fibers in the environment. If liberated graphite fibers retain their high conductivity and persist as individual particles for long periods of time, it is possible that they could represent a continually increasing background capable of electrical contamination and hazard throughout the country. If this occurred, it is conceivable that it would be necessary to use "clean room" procedures whenever producing or repairing any

Table 6

METHODS OF PROTECTION

Protection of Equipment:

- o Conformal Coating
- o Filters
- o Sealed Cases
- o Clean Rooms

Limiting Dissemination:

- o Safety Regulations for Transport, Storage, and Use
- o Warning Labels Against Burning and about Storage, and Use
- o Safety Regulations for Handling During Manufacturing
- o Firefighting Techniques
- o Disposal Techniques
- o Precipitators on Incinerators
- o Burial of Waste

Modification of Material:

- o Changes in Conductivity, Fall Rate, Fiber Length, Clumping Characteristics
- o Improved Matrix Materials
- o Containment of Residue

equipment containing open electrical circuitry. The costs for establishing this much higher degree of cleanliness for the electronics industry and for society in general would undoubtedly be enormous.

(3) Material Modification

Of the three classes of protective methods shown in Table 6, only material modification holds the promise of elimination of the electrical hazard entirely. Modifications which could dramatically reduce the conductivity of the fibers or could drastically reduce the potential for atmospheric dissemination could reduce the risks sufficiently that the hazard would be effectively eliminated. However, while some approaches which might lead to such amelioration have been identified and will be discussed later in this section, there are no proven technical means currently existing.

(4) Repair and Cleanup

Very little is known concerning the cost and complexity of repair and cleanup of either accident sites or affected electrical equipment. A joint NASA/Navy full scale test program is to develop methods to neutralize or minimize the release of graphite fibers in the case of an aircraft crash and fire. It will include studies of the best ways to fight crash-related aircraft fires, the containment of graphite fibers and lint, decontamination of the affected area, and disposal of debris.

The cost of cleanup and repair of electrical equipment which has been contaminated by fibers is also under investigation by both NASA and DOD. Preliminary DOD data indicate a wide variation in both time required and effectiveness of known decontamination procedures. Standard cleanup procedures involve vacuum cleaning the affected equipment, washing with a detergent solution which is harmless to electronics, and air drying. The estimated time for cleanup of specific equipment has been reported to be as little as one-half a manhour to many manhours. Sometimes the cleanup procedure has been reported as being very effective; in other cases, a new failure has been noted immediately after the equipment is re-energized. Considerably more data must be acquired before the cost and effectiveness of cleanup procedures can be determined.

Similarly, the cost of repair of affected equipment is widely variable depending on the specific component or circuitry involved. Incidents which involve shorts across low voltage circuits or on the "load" side of a power supply may be repaired by either decontaminating the equipment alone or by replacing a minor circuit component after decontamination. Incidents which are caused by fiber induced shorts on the high voltage or power generating portion of the equipment may lead to massive destruction of the electronic circuitry and may require replacement of the equipment. Due to the random nature of the specific events which can occur within any particular piece of electrical equipment, a conservative estimate of the cost of repair of affected equipment would be equal to the cost of replacement of the equipment.

D. Good Work Practices and Protective Measures to Safeguard Human Health

(1) Users of carbon fiber materials should be made aware of the potential health hazards.

(2) Engineering controls should be installed in work areas to minimize exposure to the fibers.

(3) Properly designed local exhaust systems should be used in manufacturing processes where possible to prevent the dispersion of airborne fibers. Where exposures may occur, proper protective clothing, gloves, respirators, etc., may be advisable, depending on fiber size and degree of exposure.

(4) Appropiate protective equipment (coveralls, gloves, eye shields, and respirators where necessary) should be made available to workers as well as adequate wash and shower facilities.

(5) Hand wash and shower facilities should be available to exposed persons. General good housekeeping procedures such as vacuum cleaning, washdown procedures, and wet sweeping should be followed. More extensive recommendations are provided in Appendix A.

E. Research and Technology Development Needs

Many of the characteristics and effects associated with carbon fibers are incompletely known. The relative newness of the problem, and the limited resources thus far devoted to addressing the problem all have led to the relative scarcity of data related to: understanding the details of damage mechanisms to equipment and people, and what protective measures can be employed; prevention of introduction of carbon fibers into the atmosphere; and modification of material so that the damaging effects can be avoided.

Further research is needed in the following areas:

(1) Sources of Free Fibers - How they are released or disseminated from the material in question:

(a) Aircraft/Spacecraft

Small scale and large scale tests are currently underway to determine release rates, dispersion characteristics, etc., in the case of aircraft crashes accompanied by explosion. Testing involving aircraft accidents involving large pool fires (not involving explosion) and in-flight fire plus explosion is needed. The possibility of accidental release from graphite fiber composites on spacecraft which might suffer an explosion and/or fire on the launch pad or might undergo burn-up as a result of an unplanned reentry also needs investigating.

(b) Surface Transportation

Small scale and full scale tests are needed on graphite/polyester composite automotive components under a wide range of conditions to simulate the various accident scenarios representative of automobiles, trucks, and freight cars. The tests should provide data on both chopped fiber composites and continuous fiber composites of the types expected to find application.

(c) Handling/Disposal

Tests are needed to determine proper handling and disposal procedures for both carbon-fiber-containing scrap and discarded products containing carbon fibers. The effectiveness of current filters/precipitation of commercial incinerators requires assessment. Economical methods for separating carbon fibers from other scrap materials need to be investigated.

(d) Persistence

The likelihood of previously dispersed fibers being a source for continuing incidents at future times requires study. Data are needed on the degradation of fibers, their tendency to cluster into less hazardous forms, possibilities of transport on water, etc. Such data, and data on the cumulative buildup of released fibers will permit assessment of the statistical incidence of threat due to this background as a source.

(2) Vulnerability - The degree of susceptibility of electronic and electrical equipment to damage by the graphite fibers.

(a) Airport/Aircraft

Tests are currently underway to develop an understanding of vulnerability (i.e., critical exposure levels, transfer functions, etc.) for both critical airport navigation and communication equipment as well as essential aircraft electronics.

(b) Consumer/Business

The vulnerability of a wide range of civilian consumer and business equipment requires study: home and building electrical circuits, home appliances, business machines, computers.

(c) High-Power Generation and Distribution Systems

A test program to determine the statistical vulnerability of utility power generation and distribution equipment is needed to identify the susceptibility of power turbines, power substations, high voltage transmission lines and insulations, etc., to fibers of various lengths and from various sources, and to assess the consequences of various types of incidents.

(3) Protection and Alleviation - Procedures designed to protect equipment from damage by exposure to the fibers, as well as possible modification of composite materials to minimize the damaging effect:

(a) Firefighting, Cleanup, and Disposal

Large scale tests, under a variety of conditions, are needed to develop methods to minimize the release of carbon fibers in the case of various accident scenarios. Because of the different equipment available and various degrees of control possible, many different accident scenarios need attention. These are listed below:

- o Aircraft crash at airport
- o Non-airport aircraft crash
- o Automobile crash plus fire
- o Incinerator release

Such tests should identify optimum firefighting techniques, containment of residue, decontamination of the affected area, and disposal of residue.

(b) Equipment/Building Protection

The possibility of devising economical techniques for protecting specific electrical equipment and for "hardening" entire buildings from intrusion by carbon fibers needs investigation. These might include: packaging techniques, filters, conformal coating of components, component redesign, improved ventilation filtering systems, and building (door and window) sealing techniques.

(c) Safety Regulations

Methods for reducing the threat from accidental release by defining safety regulations and containers for transport, storage, and use of graphite fiber containing material, using warning labels on products containing graphite fibers, and by promoting user education require consideration.

(d) Material Modification

A substantial national effort is required to develop modified materials which eliminate or reduce the threat of graphite-induced electrical incidents. Approaches to material modification which have been identified to date fall into the following three categories:

- Fiber modification to reduce the conductivity or to modify the dispersement characteristics of released fibers. Approaches to modifying the conductivity include "doping" the precursor fiber in some way which reduces the conductivity without affecting the mechanical properties, developing surface treatments which reduce the conductivity, or developing alternative fibers. Methods of modifying the dispersement characteristics include developing "fatter" fibers, bundling fibers together, etc.

- Matrix modification to provide a much greater degree of containment of the fibers in the case of a fire related accident. Methods for accomplishment of this include development of more resistant matrices, development of matrices which degrade to a stable char rather than melt or vaporize etc.

- Containment of the entire composite residue by wrapping the laminate with a single ply of stable, fire resistant material such as a thin, metallic coating or a layer of ceramic fibers.

Many other materials modification techniques may be identified in addition to those listed above when a broader spectrum of the scientific community is made aware of the problem.

(4) Risk Assessment - To enable trade-off decisions between anticipated benefits of and risks inherent in extensive use of graphite composite materials:

(a) Near-term Risk

Analytical risk analyses are currently underway to assess the immediate threat to airport environs and urban population centers from the crash of both military and civilian aircraft containing graphite composites. These analyses are being developed from available data on sources of graphite fiber applicable to the crash plus fire scenario, measured vulnerability of representative equipment and from atmospheric dispersion models developed in related studies. These studies do not yet deal with spacecraft accidents and other fiber release scenarios, with methods of disposal of consumer products (including industrial scrap), with characteristics of commercial incinerators, or with product "wear-out" rates.

(b) Future Risk

Continuing studies to redefine the overall risk associated with the widespread future use of graphite composites in all projected commercial applications would guide the direction of, and the need for, future research activities and budget requirements.

(5) Health Hazards

(a) Fiber Effects

Although preliminary test data show graphite fibers to not pose a significant health hazard, this is an area of obvious public concern which requires much fuller understanding.

(b) Resin Toxicity

Laboratory tests and statistical analyses are needed to determine the additional risk to humans from toxic products formed by burning of composite matrix materials, including both conventional resins and modified resins which might be developed under a materials modification program.

VI. COURSES OF ACTION FOR UNITED STATES GOVERNMENT CONSIDERATION

The spectrum of responses to the graphite fiber situation open to the Federal establishment, at this time, appears to range from taking limited actions to immediate recognition of the potential threat through regulation of composite material producers and users. A key factor in selecting a course of action appears to be the amount of factual information available at the moment.

A. To take no action at this time would presuppose that the data in hand support a position that no present or future risks of any magnitude exist at either current or estimated usage levels of graphite fibers. The current state of knowledge, as noted in Sections IV and V, does not offer a sufficiently categorical assurance that the public welfare might not suffer from governmental inaction at this time.

B. A number of intermediate or preliminary steps are open to the Government in response to the perceived problem of minimizing the social and economic impacts of useful graphite fiber materials. These include:

(1) Informing potentially affected sectors of society (importers, manufacturers, processors, users, disposers, and the general public at large) of the potential hazards.

(2) Encouraging private sector solutions to questions of vulnerability, alternative materials, and disposal techniques.

(3) Developing a broad data base on material sources and usage, on fiber effects across a full range of facilities and equipments, and on incidents related to carbon fibers and their analogues.

(4) Focusing Federal R&D on defensive measures, alternate and modified materials, and disposal techniques.

C. Regulatory measures up to and including a ban on the manufacturing, fabrication, or end-use of carbon/graphite composites in the United States require careful consideration of technical data and legal authority. In the absence of evidenced health effects, unilateral regulatory actions by the United States Government could be challenged as restraint of commerce; legislation might be required. The paucity of analogous precedents dealing largely with hazards to property and equipment, but of uncertain or second order public health impact, warrants further development of information before regulation can be contemplated. It is not clear that existing legal authorities would permit a substantial ban on a structural material which is not hazardous in its fabricated form, but which may become so if released through accidents which are beyond Governmental control.

Nevertheless, various Federal agencies do have existing authorities to regulate the use of certain hazardous materials. Specific controls over clearly dangerous (e.g., toxic) materials and products governing their production, fabrication, waste disposal and product disposal has been effected by rule making.

To date, some "self-regulation" over graphite composites has been realized as a result of information disseminated to some material producers and fabricators: (1) earlier processing techniques which put plants at risk and posed potential liabilities to their operators are being corrected; (2) manufacturing waste is being disposed of voluntarily by burial rather than incineration. However, because of the Government's inability to prevent accidents or effectively control actions of individual consumers, regulation short of a ban would seem of little value in coping with the fully developed array of composite material applications foreseen for the future. Regulation, therefore, should be looked to, if needed, to insure compliance in the highest risk activities of the material life cycle, e.g., production, fabrication, and disposal.

At the moment, the hazards to neither equipment nor human health and safety appear to support a total ban on graphite composites. The potential energy savings, safety, and other benefits are sufficient to warrant continued exploration of positive approaches to minimizing adverse effects. There is no evidence of restraints abroad against use of the material, and their general advantages make it unlikely that other governments would follow suit domestically if a U.S. ban on import or manufacturing were imposed. However, if safe fiber manufacturing techniques, safe composite applications, post-accident controls, and nonhazardous disposal methods cannnot be developed, nor nonhazardous alternative materials developed, selective (use-oriented) or total bans remain possible Federal courses of action for the future.

APPENDIX A

Protective Measures to Minimize Exposure to Mineral Fibers

The areas of the body most susceptible to hazards from fibers are the skin, eyes, and respiratory system. Prevention of contact with these areas can be accomplished by the interposition of protective equipment and protective clothing.

Respiratory protection is necessary in those operations where high volumes of dust are generated and where adherence to environmental exposure limits cannot be achieved by engineering controls. While the primary concern is for fibers having diameters of 3.5 μm or less, larger diameter fibers are also potentially deleterious to the nasopharngeal region. Fibers capable of causing laceration in the nasopharnx can be prevented from entering the nose by disposable respirators.

Respirators are recommended where engineering controls cannot be applied in operations involving fibers 1 μm or less in diameter, because of the extreme respirability of such fibers. To insure that very small fibers (those less than 1 μm in diameter) will not penetrate the lungs, respirators should be used even if engineering controls are present.

The observance of good personal hygiene is of primary importance if dermatologic problems are to be avoided or minimized. Conveniently located hand washing facilities should be provided and persons should be instructed as to the importance of their proper use. In addition, exposed people should shower at the end of the exposure period.

Special consideration should be given to the laundering of contaminated clothing. Contamination of other clothes that came in contact with these clothes in laundry machines has been observed. In operations where clothes are laundered under contract, it is important to inform contractors of the hazards of laundering clothes contaminated with fibers.

Most skin problems arise from direct contact with fibers through handling rather than from airborne fibers or dust. Decisions on whether to use gloves or other protective clothing will depend on the nature of the work as well as the nature of the materials involved. Where the exposure is limited to fibers, experience has generally demonstrated that the use of gloves is not always indicated. Some people regularly exposed seem to become toughened to the fibers and may not need to wear gloves. Those with only intermittent exposures may not become "hardened" to the fibers.

Good housekeeping practices are essential for minimizing exposures. Vacuum cleaning, washdown procedures, and wet sweeping should be used where practical to control or reduce airborne concentrations of fibrous glass dust. Dry sweeping or the use of compressed air to remove dust should be prohibited. Scrap materials should be placed in suitable, covered storage containers located as close as possible to the point of origin of the waste. Disposal should be by methods which will ensure that fibers will not disperse into the atmosphere.

The feasibility of engineering control methods such as dilution or exhaust ventilation and enclosure will vary, depending on whether operations are being performed at fixed locations or in the field, including construction sites.

Respiratory protective devices are generally not needed for fiber exposures below recommended environmental limits. For situations where airborne concentrations may exceed the limits recommended, respirators could be used but not as a substitute for feasible engineering controls. When feasible, exhaust ventilation of the enclosure should be used to provide general room air changes and limit the need for wearing respirators. The air should not be exhausted into other work areas. Respirators are not recommended to be used as primary control measures in lieu of appropriate environmental engineering controls during routine, ongoing operations.

Eye protection, consisting of safety goggles or face shields and goggles are recommended for use in work necessitating tear-out, or blowing, or at any time when there is the likelihood of getting large quantities of airborne fibers in the eyes.

Well-designed and properly maintained local exhaust systems with appropriate capture velocities can minimize contamination of workers' breathing zones in production facilities. Manufacturing operations are often conducted at fixed locations where established principles of engineering control (e.g., ventilation, enclosure, or isolation) of operations could be applicable. In the majority of applications of fibers, certain operations are performed which have the potential for dispersing fibers into the air. These operations include cutting, sawing, grinding, sanding, and polishing. As with any other material subjected to such particulate dispersing operations, the basic engineering objective should be to prevent the particles from entering the general workplace air. The most generally applicable control measure is local exhaust ventilation, including high velocity, low tool attachments. Such ventilation should follow the principles presented in Industrial Ventilation, a Manual of Recommended Practices, published by the American Conference of Governmental Industrial Hygienists, or in Fundamentals Governing the Design and Operation of Local Exhaust Systems, Z9.2 (1971), published by the American National Standards Institute. Other control measures, including enclosure, isolation, or change of process could be useful in many situations and should be given consideration.

The use of compressed air to clean off various cutting surfaces or machinery often results in increasing airborne dust. Appropriate capture hoods should be used when compressed air is used.

Senator Stevenson. With that, the hearing is adjourned.

[Whereupon, at 12:16 p.m., the hearing was adjourned.]

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