NATIONAL BUREAU OF STANDARDS REPORT

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BROOKS BILL ISSUE STUDY
OF THE
NATIONAL BUREAU OF STANDARDS

CENTER FOR COMPUTER SCIENCES AND TECHNOLOGY

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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NBS PROJECT		NBS REPORT
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BROOKS BILL ISSUE STUDY

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July, 1971

SUMMARY OF THE BROOKS BILL ISSUE STUDY OF THE NATIONAL BUREAU OF STANDARDS

1. Statement of the Issue

The role of the National Bureau of Standards in Federal automatic data processing operations was identified as a program issue by the Bureau of the Budget (now the Office of Management and Budget) in a letter to the Department of Commerce dated April 7, 1970. Specifically, a study of the following issue was requested:

> What can be done to make the contribution of the National Bureau of Standards more effective in achieving greater efficiency and economy in Government ADP operations, as envisioned in the Brooks Bill (P.L. 89-306)?

2. Background

The Brooks Bill was enacted on October 30, 1965, "to provide for the economic and efficient purchase, lease, maintenance, operation, and utilization of automatic data processing equipment by Federal departments and agencies." Under the law, the Office of Management and Budget was assigned responsibility for exercising fiscal control and providing policy guidance in the ADP area; the General Services Administration was made responsible for ADP equipment procurement and

maintenance functions; and the Department of Commerce was authorized:

(1) to provide scientific and technological advisory services to other agencies with regard to ADP equipment and related systems;

(2) to make appropriate recommendations to the President concerning the establishment of uniform Federal automatic data processing standards; and

(3) to undertake research in computer science and technology as needed to fulfill the above responsibilities.

The Secretary of Commerce has delegated to the National Bureau of Standards the responsibility for implementing these provisions, except for recommendations to the President on Federal ADP standards. Within NBS, this program is assigned to the Center for Computer Sciences and Technology (CCST). The Center reports directly to the Director of NBS.

In December 1966, the Bureau of the Budget supplied initial guidelines to NBS for specific activities to be undertaken in carrying out the Brooks Bill. The letter containing these guidelines divided NBS work into five programmatic areas: advisory and consulting services, development of voluntary commercial standards, recommendations for uniform Federal standards, research on computer sciences and techniques, and computer service activities. Within these areas the BOB

recommended that priority emphasis be given to (1) developing standards to provide for the compatible interchange of information and interoperation of systems and equipment; (2) standardizing computer programming languages; and (3) developing yardsticks for evaluating software and its effect upon the performance of the computer system. Since late 1966 this set of guidelines has played a major role in determining the main thrust of the NBS computer science and technology program.

3. The Need for and Objectives of this Study

Circumstances which have led to a re-examination at this time of the policy framework and program direction of activities aimed at implementing the Brooks Bill include:

° The rate of growth and of technological change which have characterized the computer field in recent years. For example, the total number of computers owned by the Federal Government rose from 3,007 to 5,277 between 1966 and 1970. Much of this growth is accounted for by "minicomputers," i.e., computers costing less than $50,000. An almost non-existent commodity in 1966, the Federal Government owned 1,061 minicomputers in 1970. By 1974, this number is expected to be in excess of 6,000. The most noteworthy developments, however, have come in the field of teleprocessing--the joining of computer technology with communications technology to allow access to a

computer from a remote terminal or to allow computers to converse with one another. In 1966, there were fewer than 20 operating teleprocessing systems in the Government. In FY 1970, 1,100 computers and over 10,000 data processing terminals were involved in teleprocessing-related operations. Current estimates call for 5,500 computers and 40,000 terminals (about 60 percent of the predicted Federal inventory) to be involved in teleprocessing by FY 1975.

° The broad domain of computer services is presently dominated by software and its management. Software, in this sense, is the schemata which permits the successful use of computing hardware and devices. Software management encompasses all the procedures and principles upon which computer services are dependent. Included among these are the serious and worthy problems of computer system acquisition, computer program production, control and transferability, the legal and proprietary rights of both buyers and sellers of software, the economics of computer services, controls over information in computer systems, criteria for computer utilization, and the like.

° The issuance, on September 4, 1970, of the Executive Order 11556 creating the Office of Telecommunications Policy. Because of the very close relationship of data processing technology to telecommunications technology already noted, it

is essential that NBS coordinate its responsibilities with those of OTP.

° The need for a review of the policy guidelines provided by the Office of Management and Budget (OMB) in the light of such new developments as those mentioned above. As no revisions or amendments to the original guidelines have been proposed or issued in the last five years, changes should be considered at this time.

° Major changes that have taken place in the NBS Center for Computer Sciences and Technology in recent months. These changes include the appointment of a new director for CCST, Dr. Ruth M. Davis, and a comprehensive reorientation of the Center's technical program and method of operation. These latter changes occurred subsequent to the initial request for this study.

With these circumstances as background, two objectives were established for this study:

(1) To identify problems in Government automatic data processing that affect objectives of the Brooks Bill; and related to these problems identify present practices, alternatives to present practices, resources required in and out of NBS to implement the alternatives, benefits to be derived from the alternatives, and risks or constraints involved in alleviating the problems.

(2) Determine whether NBS or other agencies need additional authority or policy guidance, and what fact finding studies, if any, are necessary to contribute to the reduction of problems identified in (1) above.

4. NBS Findings and Recommendations: Authority and Policy Guidance Problems

With respect to the question of whether NBS or other agencies need additional authority or policy guidance to achieve the purposes of the Brooks Bill, the following findings and recommendations are made:

(1) No additional legislation is needed. The existing provisions of the Brooks Bill are broad enough to permit a flexible response to new developments in the computer field as they occur.

(2) NBS effectiveness in implementing the Brooks Bill could be improved by certain actions on the part of the Office of Management and Budget, including:

(a) Transferring the responsibility for developing standards for data elements and codes from OMB to NBS. This change is already being contemplated by OMB as part of the process of revising Circular A-86 (Standardization of Data Elements and Codes). It would establish NBS as the single responsible computer standards organization in the Federal Government.

(b) Further revising Circular A-86 or issuing a new circular to cover agency responsibilities for computer equipment, techniques and software standards activities. Specifically, each agency should be assigned responsibility for ensuring compliance with Federal standards in these areas. The NBS role in this process should be explicitly stated, and a reporting system should be established. The existing Advisory Committee/Task Group system (FIPSCAP) for carrying out standards functions has not been adequate to permit NBS to meet its standards responsibilities under the Brooks Bill and it should be augmented. NBS plans to do this with OMB concurrence.

(c) Preparing an updated revision of the December 15, 1966 policy guidance letter. Substantive modification is needed to clarify and redirect the NBS role. The OMB is already preparing a revision, and NBS should work in concert with OMB to derive a mutually acceptable interpretive guidance paper.

(d) Establishing a reporting system under which agencies would regularly report the extent of standards implementation for each of their individual systems and installations. Such a procedure would provide the first real measure of agency conformance to Federal computer standards.

(3) NBS, in conjunction with the Office of Science and Technology, should arrange for annual reviews of Federal research

in computer sciences and techniques as part of the annual budget cycle. Provision was made for such reviews in the 1966 policy guidance letter, but none has been held. NBS recommends that they be scheduled within the framework of the OST spring reviews, with NBS organizing and sponsoring the process under OST and OMB policy guidance. The reviews would help to air problems of special concern to the Federal Government or to several different agencies, would supplement agency research efforts, and would identify continuing research and development requirements in this area.

(4) Policy guidance should be issued which delineates the relationships of the Office of Telecommunications Policy and NBS in teleprocessing. Effective coordination of teleprocessing efforts is needed. NBS has drafted a proposed Memorandum of Understanding which delineates such responsibilities within the Department and recommends issuance of this guidance. NBS also recommends the issuance of the already drafted letter from OTP to the Secretary of Commerce concerning the role of NBS in teleprocessing.

(5) No additional written authority or policy statements are needed to permit close working relationships between NBS and the General Services Administration.

(6) A special <u>de facto</u> relationship exists between NBS and the General Accounting Office with respect to GAO's

ADP-oriented reports. While no specific written guidance is needed, NBS plans to assume a more active and more formal supporting role in assisting the GAO in the preparation of its reports.

(7) Policy guidance should be issued by the Office of Science and Technology directing NBS and the National Science Foundation to develop coordinated planning and guidelines in the ADP area. The combined potential influence of NBS, with its Federally-oriented computer responsibilities, and NSF, with its academically-oriented responsibilities, is very great. This potential should be recognized and exploited. The directives to NBS and NSF should be promulgated to all agencies and should become an integral part of a Federal policy for computer science and technology.

(8) The Computer Science and Engineering Board of the National Academy of Sciences - National Academy of Engineering should play a large role in assisting the Federal Government to solve multi-agency computer problems. Inadequate resources and inadequate Federal liaison prohibits such action at present. NBS recommends that the Board be supported by the Computer Center at some continuing level of effort to be agreed upon by NAS-NAE, OMB and the Department of Commerce.

5. NBS Findings and Recommendations: Program Plans, Alternatives and Benefits

The program of the NBS Center for Computer Sciences and Technology, which has primary responsibility for the Federal computer customer, is oriented towards developing and putting into practice the procedures for quality control, operational effectiveness, measurement of performance and business-acceptable methods of costing out alternative means of computer application and utilization. It has been organized around six principal program areas:

- Computer utilization
- Selected computer applications
- Teleprocessing
- Supporting exploratory development
- Supporting scientific and technical advisory services
- Computer services

The most pressing Government ADP problems in each of these areas has been identified, a recommended NBS program aimed at meeting such problems has been formulated, and benefits which might be expected to result from NBS efforts have been estimated where it was possible to do so. These findings and recommendations are summarized below:

(1) Computer utilization: The most urgent problems in this area include (a) the development of means for measuring

the performance of computer hardware configurations and components; (b) software management, including determination of the accuracy of software-produced data and validation of software performance; (c) the development and implementation of urgently needed standards or guidelines for programming languages and input/output devices; (d) the development of better methods for analyzing the costs of computer services; and (e) improvement of the process used to select computer services in the marketplace.

The need for computer hardware performance monitors is a good example of the type of problem NBS hopes to solve. After 20 years, there are only five devices, all of recent origin, which can provide data on how various components of a computer system are performing. And yet, the first tentative findings indicate that a 25 percent improvement in computer utilization can result from the use of performance monitors. Given the current Federal computer inventory, this is the equivalent of nearly $200 million in cost avoidance. The CCST standards effort, another part of this program area, seeks to resolve problems of incompatibility that can be deterrents to effective utilization of computers. Standardization of programming languages, for instance, could help reduce programming costs. A 5 percent reduction would save the Government $32 million

annually. Likewise, a savings of $66 million annually could result from computer component standards that would permit a change in existing procurement practices.

In order to undertake new projects in the computer utilization area, NBS is recommending additional funding of $320,000 in FY 1973.

(2) Selected computer applications: The objective of this NBS program is to ensure that adequate technical support and developmental activities are available for those areas of computer applications most important to the Federal Government. Recommended projects in this area are characterized by a need for cooperative efforts between NBS and the appropriate mission-oriented agency. In particular, ADP problems are affecting the quality of Government service in the following areas: health care delivery services; welfare and medical payment services; educational services, both in formal education and in continuing education; law enforcement; mass transportation; and data management systems.

Recommended NBS projects in this area, for which an additional $170,000 has been budgeted in FY 1973, will attempt to improve productivity in specific computer service applications and to increase customer satisfaction with the service provided. Through such efforts, it may be possible to realize such benefits as saving 30 percent of the $6 billion spent on information

handling within hospitals each year (a savings of $1.8 billion); detecting crimes faster through computer-aided fingerprint recognition; and lowering the costs of computer-assisted instruction through the proper application of computer techniques.

(3) Teleprocessing: Teleprocessing technology involves the techniques by which a variety of computer systems and facilities might be joined through communications system and facilities to enable the attainment of new and different applications and the accomplishment of ADP services on a more cost-effective basis. It represents the most dramatic change in computer utilization in the last decade. The NBS program is comprised of research, measurement, testing, analysis, and evaluation projects directed toward (1) understanding and advancing teleprocessing science; and (2) applying new teleprocessing technology to make ADP facilities and systems more cost effective and to achieve higher levels of information management.

Major problems include the extensive demand for larger numbers of communications channels and wider ranges of service offerings; concern over the threat to individual privacy posed by the development of large data banks; and unresolved questions of redundancy for data storage locations, physical survivability, alternate communications routings, and interoperability requirements.

Program expansion of $250,000 is recommended for FY 1973. Unless NBS can establish itself quickly as the Federal Technical Coordinator for this area, a costly environment of uncertainty and permissiveness will result. Therefore, proper NBS involvement represents potential direct dollar savings to the Government that are immense. For example, a 10 percent reduction in current hardware or clock time costs through better communications would result in a saving of $60 million annually. Even greater opportunities exist in the non-hardware oriented problem areas.

(4) Supporting exploratory development: Projects in this program area are oriented toward anticipating and resolving problems which will be confronting Federal computer customers in three to five years. It provides the technical basis for future computer utilization, applications, and standards work.

Projects have been planned in the following problem areas: controlled accessibility to computer data banks; management of unbundled software (e.g., the practice of pricing separately a manufacturer's products and services); emulation software (e.g., the practice of using control programs on third generation computers to make them emulate second generation machines in order to utilize existing programs originally written for second generation computers); determination of software effectiveness; information control; and testing and evaluation of new computer languages.

Benefits in this area are difficult to pinpoint because most projects have long-term, rather than short-term, impact. The real objective of this work is to prevent the occurrence of costly and technically difficult problems. Additional funds amounting to $130,000 are recommended for FY 1973.

(5) Supporting scientific and technological advisory services: NBS has recently redirected much of its work in this area so as to put less emphasis on solving specific problems on an agency-by-agency basis. Instead, priority will be given to resolving Federal policy-making problems in ADP and to solving problems common to several agencies. Work in this program area falls into five general categories: support to the formulation of ADP policies; technology assessment and forecasting; support to U. S. international activities in ADP; support to other Federal agencies; and information services.

For the most part, NBS expects to be reimbursed for the services which it provides in this program area. Although many important opportunities exist, such as helping to formulate U. S. policies on exporting and importing computer products and services, it is generally not feasible to plan a scheduled program for undertaking the work. No funding increases are recommended in this area for FY 1973.

(6) Computer services: The purpose of this program is to provide computer and related services to NBS, DOC and other

Government agencies. Except for the initial costs of developing new services, this program is operated on a cost-reimbursable basis. Primary emphasis is placed on the support of scientific, experimental and developmental applications and on assistance during the development and early implementation of new systems.

In FY 1973, an additional $120,000 has been recommended for service improvements to NBS customers. These improvements include computer support for laboratory experimentation; internal data management applications; and better services to NBS users who are adopting "advanced" Federal Information Processing Standards.

6. Conclusion

In response to the Office of Management and Budget's request of April 1970, NBS has reviewed its computer science and technology program in the light of existing needs, authority, and guidance. Specific policy changes are recommended and NBS' 1972-73 program plans for meeting the highest priority needs are identified. Benefits have been estimated where it was possible to do so. Program expansion of $990,000 in FY 1973 has also been recommended.

In addition to the parts of the study summarized above, the full report contains an assessment of the Federal computer environment in 1971 (Chapter II) and highlights the major

accomplishments of the NBS Center for Computer Sciences and Technology during its five years of existence (Chapter VI).

II. THE FEDERAL COMPUTER ENVIRONMENT—1971

The computer field, more so than any other new technology in history, is characterized by explosive growth and rapid change. These characteristics intensify the problems that are the daily concern of the Center for Computer Sciences and Technology—problems of timely, meaningful research, policies, practices, guidelines, and standards.

The phenomena of growth and change are of course apparent in the Federal computer environment. In the five years since CCST was formed, the number of computers owned by the Federal government rose from 3007 to 5277, as shown in table 1, and the distribution of computers by size changed markedly, as shown in table 2.

Table 1

Government Agency	FY 1966		FY 1970	
	#	%	#	%
Atomic Energy Commission	256	8.5	754	14.0
Agriculture	28	.9	42	1.0
Commerce	47	1.6	73	1.0
Transportation	31	1.0	118	2.0
GSA	24	.8	27	1.0
HEW	45	1.5	96	2.0
Interior	27	.9	46	1.0
NASA	489	16.3	692	13.0
Treasury	58	1.9	77	1.0
VA	17	.6	41	1.0
Other Civilian	62	2.1	112	2.0
Air Force	869	28.9	1210	23.0
Army	507	16.8	927	18.0
Navy	439	14.6	894	17.0
DSA	83	2.8	125	2.0
Other DOD	25	.8	43	1.0
TOTAL	3007		5277	

TABLE 2

Category	FY 1966 1st GSA Inventory #	%	FY 1970 Latest GSA Inventory #	%
1. Less than $50,000	-	-	1061	20
2. $50,000-$200,000 (Less than $250,000)*	1405	47	1737	33
3. $200,000-$500,000 ($250,000-$450,000)*	715	24	1203	23
4. ($450,000-$750,000)*	288	9	-	-
5. $500,000-$1,500,000) ($750,000-$1,500,000)*	283	9	818	15
6. Greater than $1,500,000	326	11	458	9
TOTALS	3007		5277	

*Category applicable to FY 1966 only.

The Federal inventory of 5277 forms 8.4% of the estimated national computer population of 62,658 on June 30, 1971. On a value basis, the national inventory was estimated to be worth $20.8 billion, making the Federal inventory $2.8 billion 13.5% of this total.

Minicomputers

The introduction and steady increase in the number of minicomputers has been a significant factor in the past few years, as indicated by line 1, table 2. It is estimated that by 1974 there will be over 6000 minicomputers in the Federal inventory. During this period minicomputer prices are expected to drop at the rate of about 22% each year, while their performance should increase by about 40% per year. The advent and popularity of the minicomputer complicates the previous straightforward

procurement practices, since for more and more applications a minicomputer will suffice by itself or in conjunction with other computers.

Despite its many advantages, the minicomputer is not a cure-all. At present, software for minicomputers has dragged even further behind the hardware than has been the case for the larger computers. The software that is being produced, however, gives minicomputers the capacity to support a dozen or more time-sharing users concurrently, a task formerly requiring a much larger computer and higher cost. Because of the limitations of the smaller minicomputers, especially in terms of available peripheral equipment, extensive work is now underway to provide software support (including assemblers, compilers, and simulators) that are run on larger computers to produce minicomputer programs.

Manpower

The 1970 estimates of Federal and total computer personnel are:

	Federal	Total	% Federal
Computer operators	37,000	200,000	18.5
Programmers	19,000	200,000	9.5
Analysts	13,000	100,000	13.0
	69,000	500,000	13.8

The Federal manpower fraction of 13.8% correlates closely with the Federal value inventory of 13.5%.

The trained manpower base capable of contributing to the advance of computer science is a small but increasing fraction of the total shown above. Today there are 51 college/university computer science

programs leading to a bachelor's degree, 40 at the master's level, and 13 that award the Ph.D. The number of degrees granted over the past few years is shown below:

Degree	Year					Totals
	1964-65	1965-66	1966-67	1967-68	1968-69	
BA	87	89	222	459	933	1790
MA	146	238	449	548	1012	2390
Ph.D.	6	19	38	36	64	163
TOTALS	239	346	709	1043	2009	

Even though the number of graduates is increasing, the current ratio of applications manpower without formal education in computer sciences to those who have it is at least 100:1. This imbalance is producing a drag effect on computer application and utilization that will continue until a much larger percentage of the manpower receives formal training.

Computer Support

The computer is unique in that it requires intellectual, engineering, and administrative support of unprecedented magnitude. This support includes:

1. Procedures and regulations for accessing or using the computer
2. Software, hardware, communications, and data standards
3. Input procedures, protocols, and formats
4. The supporting programming staff
5. The supporting administrative staff
6. The information control system and/or procedure established in the organization
7. The computer services cost-accounting system
8. The common carrier transmission system interconnecting computer systems
9. Quality control procedures

Such support is expensive. A 1968 survey indicated that only 35% of the cost of data processing was spent on equipment, while the remaining 65% went for operations and programming. Efforts to increase the effective use of computers within the Federal community must necessarily consider as many of these support areas as possible.

Software

The 32,000 programmers and analysts in Federal service cost the Government an estimated $110 million in 1970. In addition, another $182 million was spent for contract produced software, excluding "program package" procurements. As the American ADP industry had estimated gross sales of $700 million for contract and package software, Government procurements form a significant fraction of the total. The dollar volume of the software industry is now greater than that of the hardware industry, and is growing at a faster rate. During the 1960's there were interesting--and opposite--trends in software/hardware costs. The cost of producing a line of code increased by as much as 50% during the decade, while the cost of performing a data processing calculation decreased by at least as much.

A large number of file and data management aids have been developed since 1966. These programming aids are designed to make a data base available to non-programmers, and to permit quicker, less expensive implementation of management processing systems than is possible with conventional languages.

An October 1970 survey identified 157 data/file management aids and systems, 85% of which were operational. Over 75% of the aids were proprietary, but only 25% of the systems had been implemented

on more than one manufacturer's line of equipment.

An effect that software--or rather the lack of adequate software--can have is that of nullifying advances in hardware technology. An example is the situation of many third-generation computers. Such computers, offering integrated circuits and more output at less cost, were introduced in 1964, creating a major market demand. But companion software to take advantage of the technology was not ready for any but the more routine applications. As a result, many of the third generation computers in the Federal inventory are emulating second generation machines, with obvious losses of efficiency, capability, and money.

In an attempt to simplify software procurement practices, GSA has already placed several programs or systems on their schedules; an example is Quick Query. Other agencies have purchased packages for their own use; HEW has purchased MARK IV and any branch of HEW may use the package upon payment of an installation fee. The Naval Medical Data Center recently contracted for the development of a COBOL compiler. Under terms of the contract, the Navy will be able to make the compiler available to any Government Agency having a suitable computer.

OMB is currently surveying 1600 Federal computer installations with regard to operating characteristics and software. Survey results are not yet available.

Teleprocessing

The development of time-shared or remote on-line systems is probably the most dramatic change in computer utilization in the last decade.

In 1966, there were fewer than 20 operating teleprocessing systems in the Government. In FY 70 there were estimated to be 1100 computers and over 10,000 data terminals in teleprocessing-related operations employing data communications facilities. By FY 75 it is predicted that at least 60% of the Federal computer inventory will be involved in teleprocessing operations—5500 computers and 40,000 data terminals.

The massive shift in the mode of operation of the majority of Federal computer installations will result in a significant increase in the complexity of both the hardware and software required and in the procedures necessary for effective ADP management. New means for measuring the effectiveness and efficiency of such systems must be developed to assist managers in maintaining control of their more complex installations. This very fast-moving technology coupled with the sharp increase each year in the number of systems necessary to support teleprocessing will require effective evaluation of new equipment very quickly and on a continuing basis.

Standardization

As would be expected of any enterprise that grew so rapidly, the computer field faces a number of major problems. Some of the problems (but by no means all) can be mitigated through standardization. The assigned responsibilities of the CCST include development of Federal Information Processing Standards (FIPS), and dissimination throughout government of information on all relevant standards. In fact, NBS, ANSI, and the Electronics Industries Association are the principal

groups in this country formulating computer standards. There are now 27 national voluntary computer standards, and FIPS. Of these, all the FIPS and 23 of the voluntary standards were developed since 1966. Fifty-seven FIPS and 54 voluntary standards are now under development, the adoption of which should lead to increased compatibility in Government ADP.

The selection of areas in which to pursue standardization requires sensitive judgements. If trivialities are standardized the effort is largely in vain, and care must be taken not to inhibit the growth of computer technology through overly stringent standards.

Computer standardization has impacted the changes occurring in the Federal computer environment, and the changes themselves have caused redirection of the standardization efforts. The American National Standard Code for Information Interchange was adopted as a Federal Standard in 1968 (FIPS Pub 1). This standard has had a direct impact on teleprocessing, and will be used increasingly as the standard code for data communications. The increasing use of teleprocessing, on the other hand, requires new and additional standards for information interchange with increased emphasis on standards for data management and conventions, as well as data elements and codes.

The American National Standard for Recorded Magnetic Tape for Information Interchange was developed with NBS participation and was adopted as a Federal Standard in 1968 (FIPS Pub 3). Using this standard, and in conjunction with ANSI, NBS developed the Amplitude Reference Tape Standard that has provided the basis for the more objective centralized

qualification of magnetic tape from multiple vendors with resulting increase in tape quality and performance for the Federal Government. The advent of unbundling, and the proliferation of software vendors has increased the emphasis on software programming and centralized validation and qualification of software packages, and has added new emphasis towards the development of application program standards. By the same token, the proliferation of independent peripheral equipment manufacturers, and the obvious cost advantages of competitive peripheral equipment procurements, have not only changed procurement practices, but have added new emphasis to peripheral equipment interface compatibility.

III. AUTHORITIES AND POLICIES TO IMPLEMENT THE OBJECTIVES OF PL 89-306 (THE BROOKS BILL) IN THE 1970's

This section reviews the authorities and policies governing the NBS in its relationships to other Federal Agencies and organizations and to the Congress under its Brooks Bill responsibilities. Background information is provided, accompanied by findings and recommendations. In some instances, the findings or recommendations are supported by discussions in other sections of the report. In these cases, reference is made to the appropriate section.

A. Legislation

FINDING No additional legislative authority is needed to authorize NBS to provide scientific and technical services directed towards the "economic and efficient purchase, lease, maintenance, operation and utilization of automatic data processing equipment by Federal Departments and Agencies."(1) Section 111.(f) of PL 89-306 gives sufficient authority to the Secretary of Commerce to support the scientific and technical objectives of the Bill. In addition, it authorizes him to make recommendations ... "relating to the establishment of uniform Federal automatic data processing standards."

Support for this finding follows from the discussion in Section II, The Federal Computer Environment - 1971. In this section, a number of the significant changes which have occurred in the computer field since 1965 are identified. These include

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(1) Public Law 89-306 (Brooks Bill) dated October 30, 1965.

teleprocessing or computer networking, the spreading use of minicomputers and the proliferation of data management and management information systems. Although none of these could have been anticipated in the Brooks Bill, its wording permits interpretation which has allowed the NBS to address all of these changes in computer technology and computer utilization.

B. OMB Fiscal and Policy Control

1. General

Under the terms of PL 89-306, the authority vested in the Administrator of General Services and the Secretary of Commerce is made subject to "direction by the President and to fiscal and policy control by the Bureau of the Budget" (Section 111.(g)). The OMB has exercised its policy control through the issuance, as of January 1, 1971, of five policy letters, memoranda and circulars. These are:

1) Policy Guidance to the Department of Commerce (National Bureau of Standards) in the Implementation of PL 89-306, BOB letter dated December 15, 1966.

2) Policy Guidance to the General Services Administration in the Implementation of PL 89-306, BOB letter dated May 4, 1966.

3) BOB Circular A-54, Policies on the Selection and Acquisition of ADP equipment (October 14, 1961) and susequent transmittal memoranda dated June 27, 1967 and January 7, 1969.

4) BOB Circular A-71, Responsibilities for the Administration and Management of Automatic Data Processing Activities, March 6, 1965.

5) BOB Circular A-86, Standardization of Data Elements and Codes in Data Systems, September 30, 1967.

BOB Circular A-86 is currently in the process of revision. One contemplated change is of immediate import to this Issue Study. Under the terms of Circular A-86, the OMB (BOB) was directed to "provide leadership of a program for standardizing data elements and codes" for the Federal Government. The NBS has a supporting role (Section 7.C) of maintaining the several registers and reference files of data elements and codes. This was in addition to the NBS responsibility (BOB letter of December 15, 1966) for recommending Federal Standards relating to ADP equipment, techniques and computer languages. The contemplated change would give to the NBS the additional responsibility for recommending standards for data elements and codes, as a transfer of assignment from the OMB.

RECOMMENDATION

It is recommended that the contemplated change to BOB Circular A-86 be made, i.e., that the additional responsibility for developing standards for data elements and codes be transferred from the OMB to the NBS.

The initial retention by OMB in 1966 of this responsibility was based on the predicted need for senior level policy coordination within Federal Agencies of these data element and code standards. Sufficiently workable relationships have now been

established by the OMB within Federal Agencies to permit this standards activity to be carried out by the NBS. Six standards of this type have been issued as FIPS PUBS (4, 5-1, 6-1, 8, 9, 10) since 1966. A plan for assuming this responsibility at NBS including required resources is attached (Attachment 4).

The principal advantage to the transfer of this responsibility to NBS is the establishment of a single responsible computer standards organization in the Federal Government. The assumption of this new responsibility by NBS will be reflected first in the FY 74 budget. Its assumption prior to FY 74 will necessitate either reprogramming actions or supplemental budget requests although NBS has, since 1966, provided considerable support for this function to the OMB.

2. Policy Control in Federal Standards Activities

One of several means of achieving economic and efficient utilization of computers is through compliance with standards. In this way, compatability and interchangeability of data, programs, media and systems may be increased. The establishment of standards was singled out for special attention in PL 89-306. For this reason, it will also be addressed separately in this report.

The Brooks Bill authorizes the Secretary of Commerce to "make appropriate recommendations to the President relating to the establishment of uniform Federal automatic data processing standards"(Section 111(f)). The Policy Guidance to the Depart-

ment of Commerce (National Bureau of Standards)in the Implementation of PL 89-306, the guidance from OMB (December 15, 1966), recognized that standardization is a process which does not terminate with issuance of the standard. It specifically states, "Recommendations for Federal Standards will be transmitted through the Secretary of Commerce to the Bureau of the Budget. Such communications will include (1) a statement of purposes to be served by the standard, (2) an assessment of its probable economic and technological impacts, (3) a summary of agency and industry comments that were considered in the formulation of the recommendation, (4) a reference to applicable methods for measuring compliance with the standard, (5) areas for recommended application, and (6) planning guidance for development of implementation schedules in each agency." This same guidance directed the NBS "to the extent feasible and desirable, develop and recommend means for measuring compliance with Federal standards." Six standards have now been submitted to OMB under letters of transmittal. Experience shows that planning guidance for agency implementation schedules, areas of recommended application and assessment of probable economic and technological impacts are all client-oriented or agency-dependent subjects. Active agency participation and contributions are essential.

The mechanism established by NBS for performing its Standards functions under PL 89-306 was a FIPS Coordinating

and Advisory Committee and ad hoc FIPS Task Groups. The FIPS Coordinating and Advisory Committee serves as a vehicle for coordinating the work assignments to FIPS Task Groups on Information Processing Standards. The Task Groups review proposed NBS actions and deal with specific standards problems. This Committee structure was set up by the Center for Computer Sciences and Technology on May 12, 1969. As of January 1, 1971 there were seven such Task Groups.

FINDING This Committee/Task Group structure has not been adequate to permit the NBS to meet its Standards responsibilities cited in preceding paragraphs. As an advisory, coordinating and review mechanism, its environment is too permissive. Agencies are not bound by individual views of its representatives. Member agencies have no assigned responsibilities directed upon their use or compliance with Federal Standards. Neither do they have assigned responsibilities for providing the information needed by the NBS in carrying out its functions.

FINDING On the other hand, BOB Circular A-86 of September 30, 1967 did identify responsibilities for management of activities in the Executive Branch relative to the development and application of standard data elements and related codes in data systems. Responsibilities were assigned so that OMB could satisfactorily discharge its standards functions. The OMB function relative to standard data elements and codes is essentially equivalent

to that of NBS for computer equipment, techniques and programming language standards.

RECOMMENDATION

Since BOB Circular A-86 is in the process of revision, it is recommended that either (a) it be expanded to cover agency responsibilities for computer equipment, technique and software standards activities with the same degree of responsibility as assigned for data elements and codes, or that (b) a complementary OMB Circular be issued covering agency responsibilities for computer equipment, techniques and software standards activities. In either case, such an OMB issued Circular directive upon Federal Agencies and Departments is considered necessary for NBS to discharge its assigned Standards functions.

The principal omissions in present OMB policy statements which need to be addressed in the recommended new OMB Circular are a) assignment to Federal Agencies and Departments of specific responsibilities for ensuring compliance with Federal Information Processing Standards in computer equipment, techniques and programming languages; b) explicit statements of the NBS role (if any) in the measuring compliance with standards as well as the success of Federal Agencies in meeting their implementation schedules for standards; and c) the necessary reporting system to be established for measuring individual agency compliance with Federal standards.

3. OMB Policy Guidance for DOC (National Bureau of Standards)

FINDING The policy guidance issued by BOB to the Secretary of Commerce on December 15, 1966 is that under which the NBS is still operating. The guidance document treats a) basic policy, b) advisory and consulting services, c) development of voluntary commercial standards, d) recommendations for uniform Federal standards, e) research on computer sciences and techniques, and f) computer services.

An important statement clarifying the position of the Secretary of Commerce regarding the OMB interpretive policy guidance to him is in a letter from the Secretary to the Director, BOB, dated January 19, 1967. It reads: "I would like to emphasize my complete agreement with your thoughts that this policy guidance document should be subjected to continuing review and change when it becomes necessary. The Department of Commerce will make every effort to accomplish its responsibility in this matter and will not hesitate to suggest desirable changes."

This policy guidance of December 15, 1966 needs some substantive modification in terms of the role that NBS is assuming or wishes to assume in meeting its responsibilities under PL 89-306. Also, terminology of recent origin if introduced into updated guidance would clarify the NBS role. The organizational position of the Center for Computer Sciences and Technology (CCST) has changed since 1966. It is no longer in the Institute for Applied Technology. In addition, the Office of Telecommunications Policy (OTP) has been established in the Executive Office: there are relation-

ships planned between the CCST and OTP not covered in this guidance letter. These new policy relationships can be covered by separate memoranda modifying the OMB Guidance of 1966 or through issuance of a new letter of guidance.

FINDING The OMB is currently preparing its own revision of the policy guidance letter of December 15, 1966.

RECOMMENDATION

The DOC (NBS) should prepare an updated revision in line with its experiences and should work in concert with OMB in obtaining a mutually agreed-upon updated interpretive guidance paper. The target completion date should be September 1971 so as to fit into the FY 73-74 budget cycle planning.

4. Federal ADP Standards Reporting and Waiver Policy

FINDING A major problem in the Federal ADP Standards Process is the lack of an adequate reporting system in the implementation by Federal agencies of Federal standards. Currently, requests for waivers to Federal standards are coordinated with NBS prior to the granting of such by agency heads. This waiver procedure does not provide a real measure of conformance of Federal computer installations to standards.

RECOMMENDATION

What is needed is a reporting system in which agencies report the extent of standards implementation for each individual system and installation. Each Federal Agency would assume

responsibility for standards implementation by its constituent organizations. Reports would be submitted on a regular basis to the OMB. NBS would serve as an appeal mechanism for Federal agencies where technical problems are cited as a basis for requesting waivers.

The standards reporting system would provide sufficient information so that NBS can determine if standards are responsive to needs and what modifications or additional standards are needed.

The NBS (CCST) should develop with OMB the necessary Standards Reporting System within the next year.

C. Department of Commerce Policies

FINDING The NBS (CCST) under its Brooks Bill statutory authority has responsibilities in ADP that transcend those of individual Federal Agencies. It shares this special role with OMB and GSA. On the other hand, the Assistant Secretary (Administration) of the DOC has assigned responsibilities for ADP management within the DOC. These are distinct from those of NBS (CCST). This combined set of responsibilities places DOC in a unique position among Federal Departments. It is imperative that NBS (CCST) and the appropriate staffs of the Assistant Secretary (Administration) maintain close and cooperative contact in their complementary roles. The ability of the two organizations to do so has been demonstrated.

D. Office of Science and Technology (OST) Policies and Authorities

In the OMB policy guidance to the Deparment of Commerce (NBS) of December 15, 1966 one of the assigned responsibilities is stated as follows (Section D):

> "An annual review of the accomplishments of and programs for research in computer sciences and techniques should be conducted with the Bureau of the Budget, Office of Science and Technology, and other Government Agencies engaged in or sponsoring research in computer sciences to assess accomplishments and to provide guidance to programs."

FINDING No such review has been held in the four years which have passed. The OST has on several ocassions, on the initiative of individual staff members, held informal reviews. The success of such reviews is dependent upon a stated intent by OST and OMB to use them as part of their decision-making machinery in the annual budget cycle.

RECOMMENDATION

It is recommended that NBS (CCST) work with OST as lead agency and OMB as support agency in formulating an "all-agency" memorandum setting up these reviews as part of the annual budget cycle. NBS should act as organizer and sponsor of these reviews under OST policy guidance. They should be set up within the framework of the OST Spring Reviews: the first one should be held in the spring of 1972 and impact on the FY 74 budget.

An annual review is a necessary activity for NBS to accomplish certain other of its assigned responsibilities under its Brooks Bill authorization. Three of these found in the December 1966 BOB guidance are:

"1. To supplement agency research efforts ... or to provide solutions to problems of concern to several different agencies.

"2. To initiate efforts to solve large-scale and difficult problems sufficiently unique to special needs of Government that outside interests are not likely to undertake...action.

"3. To identify continuing research and development requirements... in planning and coordinating R and D programs in the area of the computer and information sciences and technology."

Thus far, neither the CCST nor the OMB nor the OST has had the necessary information on Government computer activities to recommend, approve or undertake these responsibilities.

E. Office of Telecommunications Policy (OTP) Policies and Authorities

Executive Order 11556 dated September 4, 1970 established the Office of Telecommunications Policy (OTP), in the Executive Office of the President, and delegated authority to OTP to:

"...Conduct studies and analyses to evaluate the impact of the convergence of computer and communications technologies, and recommend needed actions to the President and to the Departments and Agencies..."

PL 89-306 authorizes the Secretary of Commerce to "undertake the necessary research in the sciences and technologies of automatic data processing computer and related systems;" this is interpreted to include teleprocessing. BOB's December 1966 policy guidance to the Secretary of Commerce states that the research activities of the Center for Computer Sciences and Technology "will be directed primarily toward areas that give promise to satisfying widespread needs within the Federal Government and that offer prospects for significant improvements over existing capabilities". Again, this is interpreted as including teleprocessing. BOB's May 1966 policy guidance to the General Services Administration in implementing PL 89-306 directs GSA to explore various possibilities for enabling agencies to obtain needed data processing equipment and/or services at reduced cost, including "the establishment of central multiple-access computer facilities (or utilities), building upon the research and evaluation findings of the National Bureau of Standards..." Circular A-54, Policies on Selection and Acquisition of Automatic Data Processing (ADP) Equipment, dated October 14, 1961, includes under the scope of ADP equipment "data transmission or communications equipment that is selected and acquired solely or primarily for use with a configuration of ADP equipment which includes an electronic computer."

FINDING No formal policy guidance has been issued which relates OTP's teleprocessing authority and responsibility to those of the Department of Commerce, NBS (CCST) and GSA. Moreover, there is no formal policy guidance which treats teleprocessing directly

as a major new aspect of ADP management and utilization in the Federal Government. Such guidance will clarify effective coordination of efforts between the Office of Telecommunications Policy and the Center for Computer Sciences and Technology, and will provide an updated frame of reference in teleprocessing for all Federal Agencies. There is a general consensus already that the NBS (CCST) should assume responsibility for necessary teleprocessing activities as appropriate under its existing charters.

RECOMMENDATION

The NBS has formulated a Memorandum of Understanding delineating responsibilities for teleprocessing technology within DOC which could serve as a basis for such new policy (see Attachment 3). This Memorandum of Understanding should be officially promulgated by the Director, NBS, with the concurrence of the Assistant Secretary for Science and Technology, DOC.

In addition, the letter now in draft form from OTP to the Secretary of Commerce, delineating relationships between OTP and NBS, should be issued so as to further clarify responsibilities.

F. <u>The General Services Administration (GSA) Policies and Authorities</u>

The GSA and the NBS have special relationships under the provisions of PL 89-306. Further policy guidance to the GSA has been provided in a BOB letter dated May 4, 1966. In that

letter, GSA is asked to explore... "4. The establishment [under the ADP Revolving Fund] of central multiple-access computer facilities (or utilities) building upon the research and evaluation findings of the National Bureau of Standards, Department of Defense, and other agencies on the effectiveness of such systems."

In addition, in the December 1966 BOB policy guidance to the Secretary of Commerce, two specific guidelines identify special interrelationships between GSA and NBS (CCST). These are:

> "...direct working relationships will be maintained among the Center... and the Office of Automated Data Management Services of the General Services Administration. Among the means to be employed for extensive coordination with the using agencies are the Federal ADP Advisory Council and the Interagency Committee on ADP."
>
> The Center will: "5. Provide guidelines, criteria and techniques for evaluating and selecting equipment and related software, giving priority emphasis to criteria for measuring the effectiveness and efficiency of software. Data on this subject will also be furnished to GSA for consideration in the procurement of computers."

The Director, CCST, is a member of the Federal ADP Advisory Council. The Deputy Director, CCST, has been made (April 1971) an associate member of the "Interagency Committee on ADP." Committee membership for DOC is held by the ADP Planning Officer.

FINDING No additional written authority or policy statements are needed to permit needed close working relationships between GSA and NBS.

The NBS (CCST) is planning to assume new but authorized responsibilities for selected software validation services. Funding for these services when they become operational will be requested from other agencies and software/equipment suppliers. Initial funding for development of these validation services is a candidate for assistance from the ADP Revolving Fund of GSA. The Fund has not yet been used for such purposes. The NBS, GSA, and OMB should initiate such activities as soon as possible. If changes must be made in the rules governing its use to permit this funding, it is recommended that OMB and GSA authorize them. Initial contact was made on this subject by CCST in March 1971.

C. The General Accounting Office (GAO) Policies and Authorities

The General Accounting Office occupies a unique position in its responsibilities for informing Congress of the status of ADP activities in the Executive Branch. It further impacts heavily on ADP activities of the Executive Branch through its audits, surveys, findings and recommendations. Since passage of the Brooks Bill, major reports issued by GAO in ADP topics include:

a. Report to the Congress, Maintenance of Automatic Data Processing Equipment in the Federal Government, by the Comptroller General of the United States, April 3, 1968.

b. Report to the Congress, Study of the Acquisition of Peripheral Equipment for Use with Automatic Data Processing Systems, by the Comptroller General of the United States, June 20, 1969.

RECOMMENDATION

The NBS (CCST) also has an Executive Branch-wide responsibility under the Brooks Bill. As a result, GAO and NBS have a de facto special relationship. GAO generally singles out NBS in most of its ADP-oriented reports: in turn, it relies on NBS for technical support and advice in preparing many of its reports.

FINDING No specific statements of authority or policy governing the special relationships of GAO and NBS should be documented.

However, more formal correspondence should govern the supporting role NBS is attempting to assume with the GAO. This more active, formal role is exemplified by two recent activities accompanied by formal correspondence, i.e., the technical advisory role assumed by NBS at the request of GAO in reviewing the Undergraduate Navigation Training System procurement action of the Air Force, and the assigned responsibility of the NBS in determining the need for interface standards as a possible means for less costly procurement of peripheral ADP equipment. The referenced correspondence is available at NBS. The NBS intends to continue this more active formal interrelationship unless otherwise directed.

H. The National Science Foundation, the Office of Science and Technology and the National Bureau of Standards

The Director, NBS, has recently adopted a new, realistic and more comprehensive policy for working with the National Science Foundation (see Attachment 6). This policy is particularly important to the CCST because of the eminent role played by NSF in sponsoring computer sciences in the academic community.

The NSF, principally through its Office of Computing Activities, sponsors most of the computer science and technology projects in academia. The NSF program could be a major catalyst in the United States for accomplishing important objectives in computer sciences.

FINDING The NBS (CCST) with its federally-oriented computer responsibilities and the NSF with its academic-oriented responsibilities form a team with no peers in its potential influence on computer science and technology and computer utilization in this country. Thus far, relationships between NBS and NSF have been friendly and informal but with no joint planning or coordination efforts underway.

RECOMMENDATION

The NBS (CCST), with NSF concurrence, should request OST to formally recognize the combined potential of NBS and NSF in the computer field. This formal recognition should be in the form of policy guidance directive upon NBS and NST to develop coordinated planning and guidelines. It should be promulgated to all

Federal Agencies and should become one tenet of a Federal policy for computer science and technology.

I. The Computer Science and Engineering Board (CSEB) of the NAS-NAE and the National Bureau of Standards

The Computer Science and Engineering Board was established in 1969 to provide assistance to Federal Agencies in its domain of competence. Its funding has been primarily from the DOD (ARPA). Until 1971 no working relationships existed between the CSEB and the NBS. Now the NBS has provided funding to the Board and has asked for its assistance in several important areas. (See Attachment 5 for one of these areas.)

FINDING The CSEB with its members and consultants should play an important role in assisting the Federal Government in computer-oriented problems besetting more than one agency. It should be performing this role in close conjunction with the CCST and its assigned responsibilities. The CSEB is presently unable to work in this manner because of inadequate resources and inadequate liaison with Federal Agencies.

RECOMMENDATION

It is recommended that the CCST support the CSEB at some continuing level of support agreed upon by NAS-NAE, OMB and DOC. The CCST and CSEB should through OMB and OST select high priority problem areas for CSEB attention. The CSEB should then utilize avaiable funds (with additional requests to individual agencies as required) to address these high priority problem areas. The CCST should use its authorities to effect the suggested improvements in the Federal Government in conjunction with OMB, OST and GSA.

IV. GOALS OF THE CENTER FOR COMPUTER SCIENCES AND TECHNOLOGY

In broad terms, the goals of the CCST are to fulfill the requirements of the Brooks Bill and the NBS organic act of 1901. The specific purpose of the Brooks Bill (PL 89-306) is "to provide for the economic and efficient purchase, lease, maintenance, operation, and utilization of automatic data processing equipment by Federal Departments." In addition to the major role devolving on CCST as a result of this quotation, a subsection of the Bill deals directly with CCST responsibilities:

> The Secretary of Commerce is authorized (1) to provide agencies, and the Administrator of General Services in the exercise of the authority delegated in this section, 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, as may be required under provisions of this subsection.

In order to clarify the functions and responsibilities of CCST under this law, the Bureau of the Budget provided a Policy Guidance paper for the Secretary of Commerce in December 1966. This paper provided initial guidelines for actions to be taken in the areas of:

> Advisory and Consulting Services
> Development of Voluntary Commercial Standards
> Recommendations for Uniform Federal Standards
> Research on Computer Sciences and Techniques
> Computer Services

In recognition of the rapid change that is so characteristic of computer technology, the letter transmitting the Policy Guidance recognized the need for "continuing review" of the document.

Review is also an important process within the CCST, and has resulted in the recent formulation of a reoriented Center program having six major technical elements:

Computer Utilization
Teleprocessing
Computer Services
Specific Computer Applications
Supporting Exploratory Development
Scientific and Technological Advisory Services

Each element is the outgrowth of CCST responsibilities under the Brooks Bill and the 1901 organic act, amplified by both the Policy Guidance paper and the needs of the evolving Federal computer environment.

The acquisition of a computer, no matter its size, speed, and capabilities, is in itself no guarantee that it will serve a useful end. For a computer can operate perfectly as an electronic device and still not perform the function for which it was obtained. The program element arising from this fact, Computer Utilization, is a direct response to the purpose of the Brooks Bill. In its efforts to achieve "economic and efficient... utilization" of ADP equipment, the CCST will concentrate on the areas of standardization (another direct requirement of the Bill and the BOB directive), performance measurement, software management and cost analyses of computer services.

The rapid growth of teleprocessing is a major feature of the Federal computer environment. In order to achieve the economies inherent in teleprocessing, and required by the Bill, the CCST is concentrating on four major areas in teleprocessing: Federal teleprocessing technical management (formulation of policy and regulation recommendations); Teleprocessing system design; Teleprocessing system evaluation; and Teleprocessing system applications.

The provision of Computer Services to the rest of the NBS staff, and to other Government Agencies, is both a logical function of the Center and a requirement under the Policy Guidance paper. It is also required under the Brooks Bill for such services promote the efficient use of CCST computer facilities and capabilities. Activities to be pursued under this element include high quality computer and applications programming for other agencies; improved support for NBS laboratories; system modernization; support for standards development; and computer support for experiments in performance measurement, program validation, etc.

The Center will also concentrate on Specific Computer Applications. Again, work in this area is required by a specific citation in the Policy Guidance, and by the stated purpose of the Brooks Bill. Several areas have been identified for which the Government has a major share of the responsibility, within

which major problems do exist, and to which proper computer application can make a significant improvement. Examples are health care delivery, law enforcement, mass transportation, and many others.

The Policy Guidance paper also calls for the Center to "undertake research and development activities...oriented primarily toward Government application." This requirement led to development of the next program element, Supporting Exploratory Development. Within this framework, the Center will concentrate efforts on the removal of specific deterrents to the effective application of computer technology. Areas identified for attention are development of methods for insuring privacy and development of techniques for software management among others.

The last program element, Scientific and Technological Advisory Services, is also called for under the law and the Policy Guidance. A large number of agencies have been and will be served on a wide variety of problems. For example, the U.S. Office of Education was assisted in the evaluation of computer-related education research programs; the Post Office was helped with a time-sharing system used to direct mail to servicemen overseas; an automatic accounting system was developed for the Agricultural Research Service; and many agencies have been assisted in the development of procurement specifications for computer systems.

This type of assistance can only be expected to increase as more and more agencies turn to computer usage, and as the reputation of the Center for service of this type becomes more widely known.

V. THE CCST PROGRAM

One of the hallmarks of computer technology today is that it is a technology of services rather than of goods. The customers for computers are interested in the services their computer systems will provide. Their interest in computer hardware is secondary. So also is their interest in the individual programs written for computers.

In this context, the computer is atypical as a product of technology because in order to have widespread utility it must be integrally imbedded in a surrounding environment of supporting services. The computer is not free-standing. It can function perfectly as an electronic device and still not serve the function for which it was acquired. Satellites, missiles, and television have associated engineering and technician industries. But there is no satellite software industry and no missile programming field. If a viewer does not like the TV program he is watching, he does not turn in his TV set for another. But a customer who does not like the output of his computer system is likely to replace both his computer and his programs. As a result of these characteristics, computer science and technology have had to address the problems of the computer customer in a more intensive manner than have most other sciences and technologies which have concerned themselves primarily with their instruments or machines.

Computer science and technology have thus polarized around two centers -- the computer and the customer. This polarization has highlighted the very difficult area of interface between customer and computer: and much of computer technology has had to be directed at this interface area. The formal focus of computer science and technology resultantly is three faceted: computer-oriented, customer-oriented, and man-computer problem-oriented. The direction of the technology is often set by the problems of linking customer to computer rather than by the objective of improving its product per se, namely, the computer.

The problem of linking customer to computer again highlights the services provided by computers. Computer services are dependent upon what has become known as the technological supporting system for computer technology. This system is made up of all the legal, economic, administrative, ethical, and intellectual arrangements through which a technology becomes available to its customers and is subjected to social controls.

The program of the Center for Computer Sciences and Technology (CCST) is directed towards the large objective of ensuring that computer services meet the needs of their customers and that the computer technology supporting system keeps pace with computer technology itself. The group for which the Center has primary responsibility is the Federal computer customer. The impact of the Center's program will also be

strongly felt by state and local governments and by customers utilizing computers for society-oriented projects; e.g., continuing education, patient care and diagnosis, improved safety in dangerous operations such as mining, electrical power network control, etc.

The program of the Center is thus not one which is directed towards laboratory benchwork, isolated innovation or enlightened tinkering. Rather, it is oriented towards developing and putting into practice the procedures for quality control, operational effectiveness, measurement of performance, and business-acceptable methods of costing out alternative means of computer application and utilization.

The broad domain of computer services is presently dominated by software and its management. Software, in this sense, is the schemata which permits the successful use of computing devices. Software management encompasses all the procedures and principles upon which computer services are dependent. Included among these are the serious and worthy problems of computer system acquisition, computer program production, control and transferability, the legal and proprietary rights of both buyers and sellers of software, the economics of computer services, quality control of computer services, controls over information in computer systems, criteria for computer utilization, and the like.

There is no question but that today in the United States, the world's greatest software producer, there is more quality control in the shoelace industry than in the computer service industry. Foresight and thought have been remarkably lacking in the adoption of computer procurement practices by the Federal Government. The use of standards as a means of rational bargaining for computer services by customer and seller has been diverted to "head counts" of the number of standards that can be developed in a given period of time. If automation is to continue to be one of the country's and the Federal Government's greatest sources of improvement in productivity and services, then computers, which epitomize the highest degree of automation, deserve serious and concentrated attention.

The program of the CCST has been organized around six principal program areas which are intended to reflect the more important facets of computer services as they can be impacted upon by computer sciences and technology. These are:

Computer Utilization
Selected Computer Applications
Teleprocessing
Supporting Exploratory Development
Supporting Scientific & Technical Advisory Services
Computer Services

The following six sections will treat each of these program areas individually. Emphasis is on a discussion of the most

relevant features of each area. Examples are provided and in many instances cost or utility benefits to the customers are cited. The description of the program area is tied to the FY 72 and FY 73 budget submissions through budget tables at the end of each section. In addition, selected products, levels of effort or services achievable in FY 72 and FY 73 are isolated for clarity.

The CCST prepared a comprehensive Program Review Document in February, 1971. It contains detailed descriptions and funding data for each project in the CCST Program. The contents of this document are not duplicated here. It is, of course, available from NBS. However, the following six sections, although less detailed than their counterparts in the Program Review Document, are self-contained as descriptions of the principal program areas of the CCST.

A. COMPUTER UTILIZATION

This area is comprised of the scientific and technological projects which are directed towards the effective provision of computer services per se and are generally independent of application and of customer.

For example, measurement of computer performance, software performance, and system performance is a function of the computer configuration, the software in use, and system operating practices. It is not significantly affected by whether the customer is the Social Security Administration or the Federal Highway Administration.

In this vein, the more important contributing factors to effective computer utilization can be identified as:

1. Means for measuring the performance of computer hardware configurations and components

2. Software management including the accuracy of software produced data and software validation

3. The development and implementation of standards

4. The analysis of costs of computer services

5. The process employed for selecting computer services in the marketplace

1. Hardware Performance Monitors

Presently, the computer industry has few meters or gauges for measuring hardware performance. After twenty years, there are only some five computer hardware monitors which can provide data on how various components of a computer system are performing. These have been built, generally, within the last five years. And yet, first tentative findings show that a 25% improvement in computer utilization can be expected from simple changes apparent from primitive analyses of the data produced by these hardware monitors. Grossly, this means a 25% decrease in the cost of computer services provided by a given installation. For an installation using a computer which sells for $1.5M, e.g., a UNIVAC 1108 or an IBM 360/65, with an annual operating cost of $1.68M, this could mean up to a $420K annual savings. There are about 458 of these computers in the Federal Government or 9.0% of all computers tallied in the GSA computer inventory. The total gross savings to the Federal Government through this type of performance measurement could thus amount to $192.3M.

There are no procedures, standards, evaluations nor comparisons of these means of computer performance measurement yet developed for Federal customers. Both by the NBS organic act of 1901 and its Brooks Bill Charter, the CCST has the responsibility for such functions. No other agency has related responsibilities

other than for its own mission-oriented applications: and this type of measurement should be application independent. If not assumed by the NBS, performance measurement practices yielding 25% savings in computer services will not be employed by Federal customers.

2. Software Management

Software management is a term of recent origin which has not been precisely defined. It may be broadly interpreted as the process of managing and controlling those discrete stages of sotware systems development, application and utilization known as selection, documentation, maintenance, validation, cost and amortization, and performance measurement. Software management involves production and technical control procedures of the same magnitude as has hardware management. No one has yet paid adequate attention to software management. However, it is through software management that a whole new dimension of efficiency is opened to customers of computer services. Software management is unfortunately becoming increasingly complex since, customers, along with having no experience, are now confronted with many alternatives in software products.

Until quite recently customers had few such alternatives available when it came to software. Most users with business applications had only COBOL and assembly-type programming languages from which to choose. Users with scientific and engineering applications had FORTRAN along with a number of high level language translators for selection.

Software is now being developed by computer manufacturers, computer users, independent software producers, research institutions, and universities among others. The customer's selection problems, utilization problems, costing problems, are complicated and are further compounded by lack of measuring sticks or product "guarantees" by the seller.

When one realizes that initial software costs invariably equal hardware costs for any application and that for a majority of applications initial software costs are estimated to run three to eight times hardware costs, the urgency of addressing problems of software management is underscored.

The aspects of software management considered in subsequent paragraphs include:

a. Accuracy of Software Produced Data

b. Software Validation

COBOL Validation
Other Validation Services

a. Accuracy of Software Produced Data

All customers of computer services want and generally assume that the numerical results produced by their computers

are accurate. Indeed, the determination of the accuracy of programs, such as, say, the widely used FORTRAN programs for computing the correlation coefficients for a given set of data, is independent of whether the application is analysis of aircraft traffic patterns or the distribution of crimes among cities in the United States. Because of questions concerning the accuracy of such numerical techniques the CCST and the Applied Mathematics Division in a combined effort have developed projects to test the accuracy of the many numerical analysis-type programs used by Federal customers as well as all consumers of computer services.

Results thus far have been dismaying in the sense of displaying inaccuracies in software produced and sold by industry and bought in good faith by computer customers. For example, validation tests on 27 computer programs for finding least square representations of data showed that all those based on elimination algorithms give poor results, some totally unacceptable. Four different computer systems were used and the programs tested were from the UCLA Biomedical Computer Programs collection, the C-E-I-R Computer Services Library, the IBM Share Library, the System 360

Scientific Subroutine Package, the UNIVAC Math-Pack and STAT-Pack collections, and MIT's Project MAC 7094 disc files.

As one Congressman who wrote to the Director of the Office of Management and Budget expressing his concern said, "In light of the fact that many important policy decisions within the Executive Branch are made on the basis of computer analyses utilizing sub-routines of this nature and that the Congress is asked to enact legislation or appropriate money in reliance upon such analyses, I believe it would serve a highly useful purpose ... to determine whether there is danger in the development of policy or in the making of important decisions based upon the results of such programs."

There is, of course, danger in using inaccurate data. The danger is not quantifiable in monetary units. Rather, the loss of confidence in computer-produced results could topple the entire existing structure of computer-based systems within the Federal Government. It is urgent that formal software validation procedures be developed and put into practice for assessing the accuracy of software-produced numerical data.

Only the NBS, as the nation's resource in measurements and with its responsibility for ensuring equity in the marketplace, has both the competence and the necessary liaison with the computer industry to perform this measurement task. Every one of the

approximately 5400 Federal computer installations is affected by this deficiency in software management -- and is affected on a daily basis.

b. Software Validation

Software validation services, in their totality, are an essential ingredient for effective computer utilization. None exist today. Software validation is the process of determining to what extent the given software conforms to certain stated conditions or requirements. Software certification is the result of a software validation process. It is the act of designating which stated conditions or requirements the software has met.

(1) COBOL Validation

Thus far, software validation has centered on validation of compilers for higher level programming languages. In particular, COBOL validation programs have been produced by the Department of Defense. Discussions are now underway as to the best means for instituting COBOL validation services for Federal customers. Presumably the NBS, with its Brooks Bill charter, is the one agency which has this responsibility.

In the case of COBOL, it is estimated that about 33 unique COBOL compilers are maintained by computer vendors. A selected analysis of the FY 1970 GSA ADP inventory shows that 180 systems (multiple procurements counted as one) entered the inventory for which a COBOL compiler is maintained by the vendor. Using the number four (4) as the average number of vendors that will bid

each procurement, one sees that 720 COBOL validations are required under current procurement practices. If a centralized COBOL Validation Service were provided by the CCST, only 33 validations would have to be made, reducing by some five-fold the present expenditure of resources. Using $3,000 as the cost of a single validation, based on in-house experience, the annual cost for a centralized validation service would be $99,000 versus $2,160,000 for the present decentralized practice. Thus, savings in excess of $2 million annually can be realized from validation services for COBOL compilers alone.

(2) Other Validation Services

Presently, there are some 157 Generalized Data Management Systems (GDMS) from which Federal customers must select. Only 25% have been implemented on more than one manufacturer's line of equipment. Here, a data management system is a set of software which will handle the agency's data without being tied to a particular set of data codes, data files, or computer application programs. The disparate set of documentation provided with different systems makes ready comparison impossible. The cost of operating the programs, the length of time for them to perform, and their ability to actually complete tasks is generally not known by the customer. Almost as frequently, these characteristics are not known to the seller.

As another example, there are over 80 payroll application packages available from software manufacturers. With no guidance and no validation procedures in effect, the selection

process is overwhelmingly wasteful in terms of duplicative expenditures of time and manpower resources.

Potential savings to the Government in the above two cited areas can easily run to more than eight times the annual realizable savings estimated for COBOL validation. This amounts to at least $16 million annually.

3. The Standardization Process

The objective of the standardization process is to make computer utilization more effective through resolving problems of incompatibility that exist among equipment, software, computer-generated data, and computer services.

Some illustrations of problems resulting from lack of standardization serve to highlight the motivations behind the pressures for increased efforts in this area by the CCST.

a. Data Interchange in Non-Standard Form

The use of the character code for information interchange, ASCII, allows any file using this code to be processed in all computer installations using the ASCII standard code without conversion from one character code to another. Conversely, continuation of use of non-standard character codes by different agencies necessitates the conversion of all data from one code to another before it can be processed as files or in other input form. This can cost four to six weeks of programming time per code conversion.

Without a standard code such as ASCII, interchangeability of component devices, such as printers, display and keyboard terminals, and tape and disk handlers is not possible without reprogramming the related computer system. Re-utilization of equipment is considerably restricted.

b. Standardization of Programming Languages

The orderly development and standardization of programming languages, e.g., COBOL and FORTRAN, responsive to the Government's needs are paramount to the reduction of programming costs within the Federal Government. There were an estimated 17,000 plus man-years spent in FY 1969 in programming in the Federal Government. A reduction of only 5% in this expenditure would result in an annual savings of some $32 million. This reduction could be achieved through agreement on standards for high level program languages.

c. Component and Device Standards

These standards are a means for solving the I/O interface problem. There is documented evidence that procurement of CPU peripheral units (tape and disc drives, printers, and card reader/punches) from peripheral equipment manufacturers would save the Federal Government $66 million annually. The present practice is to procure peripheral devices from mainframe manufacturers. But to achieve this potential savings, a solution to the interface problem is needed. If only half of the total potential savings is achieved

by the adoption of I/O interface standards, there will be a $32 million annual benefit, ($10 million for tape drives, $16 million for disc drives, $4 million for printers, and $2 million for card reader/punches).

d. The CCST Standardization Program

The CCST Standards Program reflects the tenet that ADP standards can usefully serve to resolve problems of incompatibility that can be deterrents to effective utilization of computers. Standards are consensus agreements on how the design performance, and other characteristics of computer products, processes, services and systems are to be described and, when possible, measured. The desired compatibility among computer equipment is achieved when one set of equipment can accept and process data prepared by another set without having to convert the data or modify its own program. The desired compatibility among software packages is achieved when the operating system of one computer can run programs written for another (compatible) computer and achieve the same results. Non-compatibility precludes the sharing of software and data among computer facilities.

Finding the remedy for computer hardware and software incompatibilities is not an easy task. The price for achieving increased compatibility must not be the stifling of opportunities for innovation nor the imposition of undue constraints on industry. The CCST Standards Program attempts these objectives through support and cooperation with the nation's voluntary ADP standardization activities, especially those of the American National

Standards Institute (ANSI) and the International Organization for Standardization (ISO). It is important that Federal computers and information systems be compatible not only with each other but also with those of state and local governments, the private sector, and those of other nations. Accordingly, standards developed to meet Federal requirements should, to the extent practicable, be consistent with corresponding ANSI and ISO standards.

In this regard, the CCST Standards Program continues the present level of 21 participants on ANSI Committees. There are approximately 170 Government representatives on these ANSI Committees (X3, X4, and Z39). The Program provides for consideration of twenty some ANSI standards as Federal Information Processing Standards and for their anticipated adoption as such. Three ANSI standards have already been adopted as Federal standards and five others have been recommended by the DOC to OMB for adoption. Some 70 other ADP standards are under development with ANSI Committees. The CCST Program envisions continued active technical participation in these standards activities.

In addition, the Standards Program has as an immediate objective the preparation of a "Federal Information Processing Plan" (FIPS Plan). This will be a detailed statement of the

Federal ADP standardization program, identifying and categorizing major technical areas and, within each such area, identifying all specific technical standardization efforts (projects) that are underway or contemplated. Each project will be assigned a priority as to its importance and impact upon the Federal Government, the major agency responsibilities, the resources by fiscal year necessary for completion, the correspondence to like national and international voluntary ADP standardization projects underway or contemplated, and the expected completion dates for approval and issuance of a voluntary ADP standard or implementation as a Federal standard.

This Plan will be reviewed with OMB and GSA and promulgated by NBS (CCST) to other Federal Agencies and Departments having a major role in the FIPS Program for comments, changes, or modifications. It will become the basis for the FIPS Program, be maintained and promulgated by NBS (CCST), and be updated annually.

4. Cost Analyses of Computer Services

The desirability of a computer service or product is highly dependent upon its cost. Choices between alternative computer services or products, all of them desirable or needed, are usually made on the basis of what can be afforded. Asking someone to choose between computer services or products without knowing initial or continuing costs is unrealistic and alien to assurances of equity in the marketplace. Presently computer customers are asked to do just that.

There are many ways of presenting costs. Similarly, there are many premises underlying statements concerning cost-effectiveness or cost-benefits of services or products. Some of the more important of these are:

. Cost should be stated in terms of funds, time, or manpower.

. Cost-benefits may be realized by shifting manpower requirements from a scarce skill to a more available skill. For example, health manpower is an extremely scarce skill. If services now demanding the time of health professionals can be satisfactorily provided, say, by using the skills and technologies of computer sciences then cost-benefits accrue.

. Cost-benefits may be realized through

1. Providing equivalent computer services or products at lower cost (dollars, manpower, or time).

2. Providing better computer services or products at a less than proportional increase in cost.

3. Providing computer services or products presently not available and which meet a known objective expressed as savings in dollars, time, or manpower.

. The continuing costs of maintaining services are significant and should be explicitly calculated. Computer services and computer products differ in concept in this respect. A "product" does not carry with it the implication of continuing maintenance.

. Recognized or expected improvements in quality of services are not readily translated into cost benefits. The results of changes in quality of services demand measurements which are generally statistical in nature and thus long-term. Few predictive techniques in this regard are presently applicable.

Computer service procurement and lease policies of the Federal Government as well as computer selection and replacement policies are dependent upon the introduction of standard pricing practices in the marketplace. An industry in which a 60% reduction in computer hardware costs has just been negotiated with one manufacturer cannot be termed a stable industry. The Federal customer needs assistance of a technico/economic nature. This is an assigned responsibility of the CCST working in conjunction with OMB and GSA.

5. Computer Selection Process

The problem of adequate selection of equipment, software, and services is an across-the-board problem for Federal computer customers. Present selection practices are unrealistic in that for more than 60% of Federal computer customers, selection is reported to take from eighteen months to six years. In this period of time, an entire computer equipment generation may have come and gone. Such selection processes are highly deterrent to the effective utilization of computers. It is obviously

cumbersome and burdensome to the computer industry in its entirety.

The CCST has responsibility for assisting in the technical facets of the Federal computer selection process. The GSA and the OMB have overall responsibility for it.

Portions of the computer selection process which are technical in nature include:

1. Estimation of the capability of proposed computer configurations to meet stated requirements. The five major techniques presently employed in order of their usage frequency are:

Evaluation of benchmark problems
Use of published hardware and software evaluation reports
Programming and execution of test problems
Computer simulation
Mathematical modelling

The suitability of any of these techniques depends upon the statement of requirements and the state of proficiency of the selection group in the application of the technique.

2. The initial statement of requirements which is part of the pre-selection process. These may take the form of functional specificiations, configuration specifications, performance specifications, job-effectiveness specifications, etc. The degree of subjectivity and measure of precision in statements of requirements is highly variable. It affects the ability of

bidders to adequately respond. It affects the evaluation of bids by affecting the types of possible comparisons and the time needed for evaluation.

3. The scoring system used in the selection process. Most computer selection processes employ scoring systems in an attempt to combine quantifiable factors with judgmental or nonquantifiable factors. Relevant considerations are enumerated and assigned weights. Each competing system is subjectively rated, scores are weighed, and the best system is selected on the basis of the overall score. Scoring systems are not subjected to the considerable scrutiny they deserve. Technically non-justifiable selections often result.

Technical guidance in the use of scoring systems, including sensitivity analyses, inconsistencies of cardinal and linear objective functions, indifference curves, etc., will eliminate inadequacies in scoring systems and concomitantly the time used by each selection group in deriving scoring systems.

6. Funding Data for the Computer Utilization Program Area

The allocation of RTS funding to the Computer Utilization program area is listed below for fiscal years FY 71, FY 72, and FY 73. The percentage of the total funding for CCST devoted to this Program Area is also presented.

Allocation of RTS Funding to Computer Utilization

	FY 71	FY 72	FY 73
Total $(000)	829.4	880.4	1198.4
% of total CCST Funding	42.5	42.6	39.2

A listing of the products or results achievable under this funding level is presented under major topical areas.

Hardware Performance Measurements

FY 72

a. Continue the development of the low performance digital tape cassette measurement system. Establish and maintain the NBS primary reference tapes and cassettes. Issue NBS secondary reference tape cassettes.

b. Continue to acquire and calibrate amplitude reference tapes at the applicable recording densities. Maintain the NBS primary reference groups. Continue issuance of NBS secondary standard reference magnetic tapes.

c. Continue the development of the disk measurement system and the related amplitude reference surfaces for 6-high disk pack applications.

d. Conduct required measurement services on magnetic disk, tapes and related transducers.

e. Initiate first use and experimentation with hardware performance monitors.

FUNDING

$180,000

FY 73

a. Develop a disk measurement system and related reference services for the higher performance one-high and 11-high disk applications.

b. Develop a digital tape cassette measurement system and related reference surfaces for the higher performance 250 ml tape cassettes.

c. Continue items a, b, and c of FY 72 list.

d. Analyze and prepare guidance material for the use of hardware performance monitors by federal agencies.

FUNDING

$220,000

Software Management: Accuracy of software produced data

FY 72-73

Performance measurement testing of programs run for CCST Computer Facility customers which use numerical analysis techniques or produce values of common mathematical functions will be done. No RTS funding has been allocated through FY 73 by the CCST. The Computer Services Division, CCST, supports approximately $90,000 of this work per year from its own funding sources. The Applied Mathematics Division, Institute for Basic Standards, allocates RTS funds to this project.

Software Management: Software Validation

. COBOL Validation

FY 72

a. Finalize plans for centralized COBOL validation services for federal agencies and other groups as directed.

b. Obtain OMB, GSA and other necessary approvals.

c. Develop procedures for centralized validation. Begin validation program check-out.

FUNDING

$18,000

FY 73

Initiate operational COBOL validation service

FUNDING

$400,000: (All of this is assumed to be billed back to suppliers and is therefore not funded from CCST RTS funds)

. Other Software Validation Services

FY 72

Initiate plans for centralized FORTRAN validation services.

FUNDING

$3,000

FY 73

Finalize FORTRAN validation service plans and obtain necessary OMB and GSA approval.

FUNDING

$3,000

FY 74 and later years

FORTRAN validation services may begin in FY 75

Development and Implementation of Standards

The funds in this area are allocated to projects leading to the development and implementation of standards of particular types. The table below summarizes these funding allocations by standard type or standards supporting efforts.

	FUNDS $(000) FY 72	FY 73
Measurements	20	40
Programming Languages	155	215
Policy, Procedures and Administration	65	65
Components and Devices	20	40
Data Communications and Teleprocessing	80	80
Character Sets and Related Topics	50	50
Media	50	50
Source Data Automation	40	80
Applications and Data	80	80
Systems Environment and Documentation	19.4	60
TOTAL	579.4	760

Computer Services Selection Process

FY 72

a. Develop technical projects for parametric analyses of the technical aspects of the selection process.

b. Gather vendor product statistics for publication in the Federal Supply Schedule. Establish the parameters to be reported, data collection procedures, catalog file format, maintenance and reporting procedures

c. Initiate work on an automatic analyzer for gathering and compiling statistics on COBOL application programs.

FUNDING

$ 50,000

FY 73

a. Continuation of FY 72 item b. In conjunction with GSA, collect and catalog vendor product data. Report in preliminary form, as appropriate.

b. Continuation of FY 72 item a. Implement program for determining user requirements by assisting other agencies in procurement actions.

c. Continuation of FY 72 item c. Complete COBOL automatic analyzer. Participate with other agencies in analyses of application programs and work load structures; this work to be closely coordinated with a related project concerned with installation evaluation and timing.

d. Initiate work on FORTRAN automatic analyzer.

e. Initiate work on standardizing evaluation criteria, measurement techniques, and selection procedures.

f. In conjunction with a related project concerned with performance evaluation techniques, develop benchmark module programs and "mix" techniques that can be employed to evaluate the ability of a given configuration to perform a specified workload.

FUNDING

$ 90,000

Cost Analyses

FY 72

Initiate the development of a methodology for costing computer services.

FUNDING

$ 25,000

FY 73

Apply costing methodology to computer utilization and services on an experimental basis at selected Federal computer centers

FUNDING

$ 30,000

B. SPECIFIC COMPUTER APPLICATIONS

This CCST program area is comprised of the scientific and technological projects which are dependent upon the specific applications as well as upon the specific requirements of the concerned customer group.

There are significant differences between the computer technology that creates a successful automated inventory system and that which creates a successful computer-based real-time satellite weather system. The automation of laboratory measurement systems varies substantially in its demands on computer technology from those of computer-assisted instruction systems.

By 1968, some 1200 different computer applications had been isolated. They can be grouped into the major subsets of administrative record-keeping, plant and production processing and maintenance operations, banking operations, educational management, instruction and curriculum development, financial record-keeping, state, local, and Federal government applications, hospital administration, patient records and clinical diagnosis, and insurance applications.

Other computer applications are in the fields of law, libraries, law enforcement, laboratory automation, military and intelligence operations, weather prediction, mapping and charting, space operations, and all areas of science and engineering.

Projects in this area of Specific Computer Applications are characterized by the necessity for cooperative efforts involving

the CCST and the appropriate mission-oriented organizations. Self-generated and self-evaluated work in computer applications is impossible. In many instances, portions of the funds expended by the CCST are obtained from other agencies. Generally, the posture of the Center is more healthy when the funding responsibility is shared with the concerned agency. Exceptions, however, are made on a case-by-case basis. One notable example in the Center's history is the fingerprint project, initially funded totally by the CCST and later jointly with the FBI. This project has also been one of the most successful application-oriented endeavors of the Center.

1. Objectives of the CCST Program

The objective of the CCST Program in Selected Computer Applications is to ensure that adequate technical support and developmental activities are available for those areas of computer applications most important to the Federal Government. This objective is met through several approaches, all within the assigned responsibilities of the CCST.

First, the CCST will, through its annual review of computer science and technology sponsored by Federal Agencies, obtain data as to the adequacy of the R&D support by agencies of their mission-oriented computer applications. (OMB Guidance Letter of December 15, 1966, Section D.) These data then permit the CCST to recommend to OST and OMB specific projects to be undertaken by the CCST or by other Federal Agencies. The problem associated

presently with this approach is that no such review has been conducted. The CCST budget as submitted will not support such a review prior to FY 74.

Second, the CCST will concentrate its attention on computer service applications areas in which the government is presently confronted with problems. These areas will have the following attributes:

- Labor intensivity is high
- Increased costs are contributing significantly to increases in cost-of-living
- Demand has increased and will continue to do so
- There is widespread dissatisfaction with the quality and availability of the service

Initial findings have singled out several service areas for immediate attention:

- Health care delivery services
- Welfare and medical payment services
- Educational services, both in continuing education and in formal education
- Law enforcement, and
- Mass transportation

Finally, the CCST will, in conjunction with the appropriate mission-oriented agencies, use its technical expertise to improve productivity in the specific computer service application and to

increase the demand satisfaction of the customer population. Examples of benefits which can accrue from this Program or of problems which must be met follow for the three areas of Health Care, Law Enforcement and Education.

2. Health Care and Computer Technology

In 1969, the United States spent $63 billion on medical care. This exceeded defense outlays less Vietnam. Hospitals received 38% of this or $24 billion. A study on hospital costs reported that about 25% of hospital costs went into information handling or paperwork. This implies some $6 billion in 1969 were so spent. There appears little doubt that the computer can materially assist in the reduction of these costs associated with information handling.

A separate survey of the use of computers by industrial organizations showed that, in those companies most successful in their first years of using computers, for each dollar of current computer-systems outlay the annual return was $1.30. This, of course, occurred principally in their information-handling activities. If one permits optimism, one could hope that computers might save 30% of the $6 billion spent on information handling within hospitals. Assuming this cost to remain fixed (and, of course, its trend is actually upward), one might realize a $1.8 billion annual savings. This is almost equivalent to the total

amount spent on medical research in that year, i.e., $2 billion. Even if this prediction is 100% too optimistic, a saving of $900 million is worth attention and equates to almost half the total annual investment in medical research.

The computer applications which will make possible improved hospital care at decreased costs include patient management; reporting and billing systems which produce patient statements; claim forms for submission to third parties, e.g., MEDICARE, Blue Cross, etc.; patient treatment summary statistics and hospital supply inventories. Already the costs to hospitals and individual physicians for such services is comparable and in many cases lower than costs to produce the same material through traditional methods. Typical commercial costs for such services are proportional to the number of patient accounts handled. For example, one such service makes the following charges:

Active Patient Accounts	Monthly Fee
0-100	$115.00
101-200	$180.00
201-300	$235.00
.	.
.	.
.	.
1001-1100	$590.00
.	.
.	.
.	.
1301-1400	$710.00

It has been estimated that with improved computer application techniques and proper application-oriented software management, these prices could be reduced to 35% of this level.

This type saving would directly benefit Federal agencies such as the Veterans Administration, the Public Health Service of the HEW and the Medical Corps or Services of the three military departments. The indirect benefits are even more substantial through their impact on costs of MEDICARE, MEDICAID, and other Federally subsidized health care and insurance programs.

Additional computer applications which would benefit from CCST assistance include automated patient history-taking, automated multiphasic health testing, computer-assisted diagnosis, automated medical record-keeping and physiological monitoring and sensor analyses, e.g., EKG and EEG monitoring and analysis.

The CCST is working with the Army Medical Corps, the Health Services and Mental Health Administration (HSMHA) of the DHEW, and the Public Health Service in such applications of computer technology. It plans to continue and extend these efforts.

3. Law Enforcement and Computer Technology

A number of activities involving the application of automatic data processing to law enforcement problems are currently underway. Examples include the multi-state System for Electronic Analysis and Retrieval of Criminal Histories (SEARCH), the Florida Crime Information Center, the New York State Identification and Intelligence System (NYSIIS), Michigan Law Enforcement Information Network (LEIN), and the Los Angeles County ORACLE system. On a national basis, there are the National Crime Information Center (NCIC) and fingerprint automation programs of the FBI. These

programs are all directed toward the application of advanced data processing, information storage and retrieval, and communication technologies in support of law enforcement and criminal justice requirements which have been identified or defined and have been judged feasible from the technical, political, and economic points of view.

It is also possible to identify a number of potential new applications of ADP technology whose technical or economic feasibility is yet to be demonstrated. These include the possible computer-aided evaluation of physical evidence in criminalistics such as chemical analysis of evidence, latent fingerprints, ballistics, voiceprint and handwriting recognition and the analysis of marks left by tools, shoes, etc. Computer-aided handwriting recognition would have potential application in connection with the FBI's Fraudulent Check File and with forgery detection problems in the Postal Service.

Automated communications, control, and dispatch systems offer promise of better utilization of police resources, particularly when coupled with automatic vehicle locator capabilities. Computer-aided management of audio and video communications channels could help alleviate congestion through use of efficient, high speed data transmission between base stations and mobile units and could enhance the apprehension of criminals at the scenes of crime as well as facilitate the aversion of violence in mob action.

Over the years, the CCST has accumulated a considerable amount of ADP experience that could be of value to the Law Enforcement program. Potential CCST contributions are substantial.

For example, police organizations on local and state levels are being assailed by an array of technological concepts or products which have been designed to attract funding and which do not always meet the needs of law enforcement. There are several examples of this in the realm of automated fingerprint identification such as the proposed use of holography. The CCST is in a position to provide ways to measure the performance of such techniques. These measuring procedures are by-products of CCST work in developing an automatic fingerprint identification system for the FBI where it was necessary to measure progress and performance as the work proceeded. These measures are also readily applicable to other pattern recognition performance such as voiceprint and handwriting recognition.

As another example, the NBS has worked closely with the FBI during the last five years in automating its massive fingerprint identification system. It has assisted the FBI in the contracted development of a device for reading the minute details of fingerprints. At the same time, the

CCST has developed a technique whereby a computer can utilize this machine-read data to identify an unknown fingerprint.

4. Education and Computer Technology

Demand for education continues to expand in the United States. The education enterprise has an annual budget of more than $50 billion. Continuing education, the necessary updating of the formal education that all Americans acquire, is also becoming increasingly essential for adults.

Both continuing education and formal education are now being visibly altered by technological development in the form of computer-based education. Although the full impact of computer-based educational technology is still to be felt, it has been likened in its impact on society to the automobile.

The educational system is slow to improve its methods. It has been the computer scientist who has been the major innovator here. If computer-based education or computer-assisted instruction (CAI) is to have its purported impact, it must provide high-quality instruction at low cost and great convenience. One of its major advantages is the ability to provide individualized instruction so that the student can learn in his own way and at

his own pace. The advantage here is particularly apparent in those aspects of learning that require drill and practice. For example, competence in preforming arithmetical operations has been achieved through CAI in a third to a fifth the time required by conventional means. However, the computer technology for programming the techniques for teaching a variety of advanced courses is far from practical reality. Although development costs will be high, one important asset of CAI is that while the computer is "teaching" it records students' responses. These responses can determine what material is presented next and what improvements are needed in the curriculum.

Computer-assisted instruction equipment is presently too expensive per student hour and can only provide services to small classes. Present costs average about $7 per student hour with a maximum of around 100 students being served simultaneously. A teacher costs $.50 a student hour. Costs for the computer facility must decrease to $.25 per student hour with simultaneous instruction to over 1000 students to be cost-effective.

The Office of Education and the National Science Foundation have both expended hundreds of millions of dollars in grants supporting computer-based education projects. Informal estimates

compiled by NBS point up expenditures in this area by these organizations of over $150 million by 1971. Difficulties encountered in computer technology have hindered progress despite these large expenditures.

The overwhelming technological problems are in curriculum development and computer application. The CCST has the capability to contribute to the resolution of the latter problem area and plans to do so. Computer-based education is a technology that transcends the mission of any single government agency and demands a partnership of computer science with education.

The computer technology needed for simple computer-assisted instruction is formidable. Each student is assumed to be proceeding at his own pace and, therefore, each may be working at a point in the curriculum different from every other. Thus, the computer must track each student's status individually. To complicate the matter, the records on each student must be kept in real-time since the student's status must be available to the instructor. The computer system used needs an effective monitoring and evaluation scheme,

probably a combination of hardware and software. This is needed for scheduling each student as he begins his instruction period and for scheduling extra help for him. Extrapolation from some simulations of CAI systems suggests that with a population of 900 students, there would be some 30 to 40 changes between courses daily and about 300 mastery tests daily.

The computer system thus depicted has yet to be built. It is a major inventory control problem at the forefront of computer art just to keep an accurate real-time list of teachers, rooms, and media for today's schools. And yet a large portion of funding granted for computer-based education goes for repetitious starts towards the same unmet goals. An annual saving of 10% of the last five year's expenditure by OE would amount to $10 million. This is generally easily realizable through proper application of computer techniques.

The CCST plans to work with the Office of Education and the National Science Foundation in effecting improvements in educational processes through more effective computer applications.

5. Funding Data for the Selected Computer Applications Program Area

The allocation of RTS funding for the program area of Selected Computer Applications is listed below for fiscal years 71, 72, and 73. The percentages of the total funding for the CCST devoted to this program area is also presented. Funding from Other Agencies is essential for work in this area to continue.

Allocation of RTS Funding to Selected Computer Applications

	FY 71	FY 72	FY73
Total $(000)	22.0	22.0	272.8
% of total CCST Funding	1.1	1.1	8.9

The FY 71 and FY 72 funding allocation equates to less than one man-year for each of those years. This small effort will be used in FY 72 for in-house support of the FBI fingerprinting project.

In FY 73 the funding allocation will be utilized as follows: (In all cases, efforts involve cooperation from other agencies.)

FY 73

a. Determine performance measurement criteria and service cost criteria for hospital-based automated health care services.

b. Determine adequate models for automated ambulatory health care services.

FUNDING
(for a and b)

$100,000

c. Extension of computer applications in the law enforcement area.

FUNDING

$50,000

d. Initiation of directed efforts to stabilize the modalities of computer applications in education on the basis of benefits, costs, and widespread utility.

FUNDING

$50,000

e. Development of standards for the computer applications to computer-aided instruction, health care, legal information systems, information retrieval, and laboratory automation.

FUNDING

$72,000

C. TELEPROCESSING

This program area is comprised of those scientific and technical activities which have as their objective motivating, equipping, and assisting Federal agencies to pursue the most effective accomplishment of their Governmental functions through the use of Government-wide and nationally distributed ADP resources whose interconnection can be facilitated through teleprocessing technology, as well as contributing to sound, economical property acquisition and clock time management of ADP facilities.

Teleprocessing is a new synergistic technology emerging from the joining of computer and communications technologies for particular purposes. Just as water is qualitatively different from its component oxygen and hydrogen elements, so is teleprocessing qualitatively different from the computers and communications from which it derives. Teleprocessing is not a system in and of itself. Rather, it is a set of techniques by which a variety of computer systems and facilities might be joined through a variety of communications systems and facilities so as to enable the attainment of new and different applications and the accomplishment of ADP services on a more cost-effective basis. It is a means to achieving new systems of service--a way of doing things.

Teleprocessing Science is concerned with developing insight and understanding of the full range and scope of potentials and limitations inherent in the various methods and techniques by which computer facilities can be joined through communications facilities. Teleprocessing Technology is concerned with directing this knowledge toward useful needed purposes

through the design, measurement, testing, evaluation, and analysis of actual systems of service employing communications facilities to interconnect computer facilities.

The Federal Government is now incurring ADP costs upwards of $2 billion annually, giving consideration to both the acquisition, clock time, and disposal costs, as well as to the costs related to the effective use of the processed information and the establishment, maintenance, and exchange of ADP data bases. Historically, telecommunications and data processing have been and still are treated separately almost everywhere, including within the Federal establishment. However, the developing technology and new applications emerging within many agencies clearly demonstrate the increasing interdependence of the two, and the need to consider common management of both in the future, at least for purposes of computer resource sharing. Within the past half decade the new and rapidly evolving teleprocessing field has grown to multi-million dollar proportions within industry and Government.

The direct dollar savings to the Federal Government resulting from this CCST program are potentially immense. For example, in just the property management aspect of ADP facilities, which accounts for some 30 percent of the $2 billion plus cited above, a 10 percent reduction in hardware or clock time costs which can be made possible through communications interconnection would result in some $60 million savings per year. A way of gauging this potential value is to recognize that this savings could then be spent on communications instead of on computer facilities if such communications interconnections enabled the same services to be provided. This dollar amount is just about as large as the annual costs being proposed to,

and currently under consideration by the FCC for establishing an entire domestic communications satellite system for the nation. The opportunity for interconnection which such a satellite system could afford to the ADP community might in itself result in more than a 10 percent reduction to current Federal ADP property management costs.

By far the most important aspect of the CCST teleprocessing program however, is to bring the synergistic opportunities inherent in the new technology to bear upon the 70 percent of the $2 billion plus annual Federal ADP costs not concerned with property management. These opportunities are those relating to the effective use of distributed data bases and distributed information for Governmental management decision-making, planning, objectives formulation, resource allocation, and policy determination for more effective Government. Here the dollar pay-off ratio is highly leveraged, for any improvement in effective use directly impacts upon this larger (70%) segment of costs, currently some $1.4 billion annually.

The most comprehensive research effort thus far undertaken to assess the technical and operational factors deriving from synergistic interaction among computers is the teleprocessing network being established by ARPA. This network provides for the interconnection of some 20 major computers within academic, business, and government centers located from coast to coast throughout the country. The teleprocessing program of the CCST provides for direct interconnection of the Center into the ARPA network, and for the Center to serve as the hub for use of the network by Federal agencies located at the seat of Government in the Washington, D.C. area. This actual involvement in the ARPA teleprocessing

research network is expected to disclose new opportunities for operational use, and to provide an understanding of the full impact of computer network resources upon Federal agency activities.

It is now generally assumed that ADP complexes of the future will be comprised of devices offered by many different suppliers, with much larger distributed and interactive data bases and data processing serving a much broader spectrum of different users. Inherent to this assumption is the presumption that Teleprocessing Science will be ready with technological answers when needed to facilitate these complexes, and that these answers will have been effectively "conveyed" to planners and implementers within the using agencies, either through the availability of expert technical advisory services, or through standards, which may be regarded as a particular formalized type of advice, or both.

The teleprocessing program of the CCST is comprised of research, measurement, testing, analysis, and evaluation projects which are directed toward (1) understanding and advancing Teleprocessing Science, and toward (2) applying new Teleprocessing Technology to the purpose of making ADP facilities and systems more cost effective and to achieving higher levels of information management. The program is designed to enable the Center to fulfill its mandate under the Brooks Bill of "conveying" expert guidance and of providing to Federal agencies recommendations on whether and how to use teleprocessing to enhance the effectiveness of their activities. It further serves to equip the Center to serve as the technical and engineering hub for Federal agency use of experimental computer networks, and to maintain a close relationship to the complex of Government-wide policy issues and problem areas inherent to the Teleprocessing field.

The CCST program is organized so as to be capable of responding in a flexible way to changing policy guidance affecting the Teleprocessing Field. There are several problem areas and areas of emerging policy guidance which require the program response planned by the CCST.

One of these policy areas results from expanding pressures upon the established communications common carriers for larger numbers of communication channels and wider ranges of service offerings. These pressures have already resulted in the emergence of competitive "specialized" communications carriers, as well as in proposals for the establishment of services based upon new and different communications technologies, such as communications satellites. The policy issues surrounding the equitable regulation of even such simple matters as "from whom will it be possible to obtain communications services to interconnect computers?" are as yet unresolved.

Another problem is the growing concern that the synergistic interconnection of ADP data banks poses a threat to individual rights of privacy in a free society. While technology may offer a selection of safeguarding options as well as informed estimates of the costs and penalties incurred by incorporating such options, it is ultimately from the legal and legislative areas that the policy decisions will emanate, to which technology will need to respond.

Questions relating to the degree of redundancy for data storage locations; physical surviveability; alternate communications routings, and interoperability requirements loom increasingly larger in an environment where Federal managers will be as dependent upon teleprocessing as they now are upon typewriters and telephones. Again, while technology can disclose available options, it is consideration of broad national interests which ultimately must determine the degree to which teleprocessing techniques must respond in systems designs.

The present lack of a generally accepted set of supporting terminologies is a deterrent to the effective introduction and use of teleprocessing. This is due, in part, to the newness of teleprocessing, as well as to the variety of characteristics under which classifications and categorizations might be accomplished in this rapidly advancing science. For example, teleprocessing techniques can apply to "networks of terminals" communicating to a single computer at human data communication speeds, as well as to "networks of computers" operating in an interactive conversational mode at computer data processing speeds. The communications needed to support the latter are vastly different, both in quality, as well as in quantity than those needed for the former. They might, in fact be of so different a character as to require entirely different kinds of communications facilities.

Teleprocessing techniques can also relate to, and affect the degree of centralization or distribution of control established for any particular network of facilities which are interconnected, giving rise to a veritable spectrum of possibilities and combinations.

If the CCST does not serve as a focal point within Government for coordinating such technical aspects of teleprocessing, the resulting environment of uncertainty and permissiveness would be costly to the Government. There is currently no group relating these technical aspects to ongoing policy and regulatory actions within Government, and promoting and guiding teleprocessing applications as a new resource to provide better service to the public through improved agency performance through reduced ADP costs. This problem is widely recognized within Government and Executive Branch attention is currently being directed to this matter.

Because the Teleprocessing program of the CCST must work within this "milieu" of multiple technologies and divided authorities and responsibilities, the program has been structured so as to relate to activities embedded within these fields and authorities according to the following principal subelements:

1 Teleprocessing Technical Management and Coordination (TPR/TM&C)

2 Teleprocessing Research, Engineering and Design (TPR/RE&D)

3 Teleprocessing Measurement, Testing and Evaluation (TPR/MT&E)

4 Teleprocessing Applications and Services (TPR/A&S)

5 Teleprocessing Support Facilities (TPR/SF)

1. Technical Management Functions

In pursuing its teleprocessing functions the CCST program must provide for the timely and positive identification of potential policy decisions and regulatory actions which might affect teleprocessing activity within the Government; for advising the affected agencies; and for coordinating with the responsible Governmental policy and regulatory units in respect to those aspects of existing and projected teleprocessing technology as may impact upon, or be impacted by such policy decisions or regulatory actions.

The CCST plans to provide for the documentation of pending and projected regulatory and policy actions throughout the Federal Government, assessing the adequacy and timeliness of technical support for such actions, advising with respect to technical impacts, and recommending supporting technical activity in areas determined to be deficient. Principal issues of current concern relate to the controlled accessibility (security and privacy) aspects

of information being handled within systems employing teleprocessing techniques, and to the degree of specialization of communication services which will be allowed within the telecommunications industry. Related concerns are the relative costs, rate structures, and tradeoff economics of the technologies which might apply and the communications services which might be required to satisfy the principal issues.

It is likely that the regulatory and policy-making agencies acting without sound technical advice will underestimate the impact of problems associated with teleprocessing over the next several years. Failure of the CCST to transmit the knowledge and experiences gained through its activities pursued in conjunction with other Government agencies to the overall problems related to teleprocessing in the Federal community would severely reduce the effectiveness of ADP management within the Federal Government.

Coordination with the Office of Management and Budget, the Office of Telecommunications Policy, the Office of Telecommunications, and the General Services Administration has disclosed that accurate and comprehensive information on teleprocessing activity in the Federal Government is virtually nonexistent. Accordingly, the GAO, with the concurrence of OTP, is undertaking an initial survey within Government in order that other Federal agencies as well as the CCST may plan programs to evaluate such uses, with a view toward enhancing and extending the effective utilization of teleprocessing capabilities within the Government. The program is directed towards the development of guidelines for identifying and classifying teleprocessing systems, and for refining the information to include not

only teleprocessing use by and for the Federal Government, but also by directly-related state and local government activities. The information base will include current and projected usages and costs, correlation of the information with possible revisions of OMB circular A-82 annual inventory of Government ADP equipment, and a summary of survey results in a manner meaningful to Government management and policy-making personnel.

The program involves close cooperation by the CCST with OMB, OTP, GAO, and GSA, to assure the development of meaningful classification, usage, and cost data upon which to base Federal Government policy decisions affecting the teleprocessing area.

2. Research and Engineering Functions

It is clear that very significant changes in computer system organization will take place as Teleprocessing makes possible the sharing of ADP resources. Some of these changes will occur rapidly--within, perhaps, the next 5 years. Others will take perhaps a decade to mature. These changes will span the range from the saving of dollars by participation in computer networks instead of independent acquisition and operation of large general purpose ADP facilities, to the sharing of large data bases without need for data base duplication, to the sharing of "one of a kind" software for specialized applications. The program is directed toward extending teleprocessing science and contributions to the state of the art of teleprocessing technology in the areas of network resource sharing, network cost optimization, data exchange and conversation techniques, and data transmission technologies.

a. Network Resource Sharing.

There is presently minimal understanding of how to control and make available the resources within a network of computers. While much is known about the scheduling of resources within simple individual time-shared computer networks even here 50% to 70% of the total resources of the system frequently go unused because of ineffective operating control. With the advent of numerous computer networks in which resources and users are widely distributed geographically, such as are found in the ARPA network, an understanding of the problems involved in sharing resources and techniques between networks is also required.

The CCST is making a thorough study of the ARPA IMP (Interface Message Processor) system networking efforts with emphasis on the network information center concept. The project will contribute to the study of the organization of data for storage in a distributed computer network and of techniques for optimally distributing data in a network based on projected and measured usage patterns. The techniques of the ARPA network will later be compared with the techniques used in other networks such as the GSA RAMUS (Remote Access Multiple Users System), the National Library of Medicine AIM-TWX (on line bibliographic retrieval) system, the NASA RECON (REmote CONsole) system, the FBI NCIC (National Crime Information Center) system, and other pertinent systems.

An example of the kinds of dollar savings realizable through resource sharing is to compare the cost of copying a data base, as against the cost of accessing the data base through a communications network (Teleprocessing). The current cost of copying a billion bit data base is about $2000. However,

the cost of accessing this same data base through the ARPA network is expected to be at most only $300, even if all of the billion bits of data were accessed. Beyond the direct cost savings aspect is the factor of convenience, especially for data bases which must be used periodically. For a "once per month" access, the savings could amount to over $20,000 per year for this single simple operation alone.

b. Network Cost Optimization

The increasing cost of telecommunications services and equipment together with their expanding use by the Federal Government warrants a careful study to determine how greater cost-effectiveness can be attained for teleprocessing networks. The CCST will develop a capability to estimate performance of proposed new configurations, the identification of potential areas for standardization, and an assessment of the advantages to be realized by standardization. Continuing studies need to be made of telecommunications services available to the Federal Government to determine capabilities, options, costs and other teleprocessing network design considerations. Construction of a model suitable for analyzing alternative configurations of telecommunication networks may be required and the model utilized with parameters collected from real telecommunications configurations. The results obtained from simulations will be used to determine optimum sets of parameters in response to various requirements and to formulate guidelines for the design of teleprocessing networks.

Even at the present level of communications utilization for ADP, a reduction of only a few percent in communications costs as a consequence of better network design would produce savings equal to several times the cost of this program.

c. Data Exchange and Conversation Techniques.

Effective inter-computer communication (Teleprocessing) requires the establishment of procedures and conventions at several levels. At the hardware level problems arise in the selection of telecommunications facilities and interfacing to them via appropriate modems or special communications equipment units. At the data level problems arise with bit sequencing and character codes as well as error detection and correction, formats for transmitting strings of characters between systems, and procedures for delineating message boundaries and for overall control of the communication line between two systems. At the control level, consideration must be given to the meaning of the character strings, or messages, and to an overall protocol which accounts for the activity within the participating computer systems that are placed into communication with each other and which is meaningful with respect to the applications desired. There is also widespread need for alternative protocols for communication among computer systems at the process-to-process level between systems, and the development of techniques for describing protocols for the use of interactive processes potentially available through computer networks, as well as the format mechanisms for describing language protocols.

d. Data Transmission Techniques.

Wide band and digital communications techniques for data transmission are evolving rapidly in response to the demands imposed by the expanding use of teleprocessing. The transmission of data by wire, coaxial cable, microwave links, satellites and even lasers is assuming an increasingly larger role in the operations of many Government agencies such as the National Oceanographic and Atmospheric Agency (NOAA), NASA, DOD, State Department,

the Justice Department, FBI, GSA, and AEC. The development of standards for interoperability has lagged in this rapidly evolving field, resulting in incompatibility among and between different communication systems, terminal devices, and computer systems.

Communications services for data transmission which would match the needs of computer systems as satisfactorily as the telephone service matches the needs of humans will need to exhibit different technical parameters than those required for voice communications. Whereas voice communication is a rather continuous constant data rate process, communications to and between computers requires intermittent bursts of transmission, at data rates very much higher than the average rate.

By way of illustration, statistics on teletypes, graphics consoles and remote batch stations show that the burst rate of data flow is approximately 100 times as great as the average rate of data flow. This means that if a conventional communications line is established for computer conversations, the average utilization of that line will be only about 1%, and its cost from 10 to 100 times higher than the raw cost of "moving" the bits of data. Further, the connect time to establish a conversation (switching) must be short enough that the computer and its users are not held up unduly. For normal voice conversations, some 20 seconds or so are commonly required to switch to a connecting circuit. By contrast, for computers, this switching connect time must be considerably less than a second. The maximum data rates must also be considered. It is known that for useful comprehension by a human, a peak data rate is on the order of 250 words per minute, or 20,000 bits of information per second. This suggests a

minimum meaningful communications bandwidth for console to computer communications, and provides a basis for assessing the communications bandwidths which would be useful for meaningful computer to computer communications. Finally, the error rates inherent in data communications services must be far lower than for voice communications, and the service reliability must be very high if a user is to rely upon remote resources.

CCST activity in this project involves direct participation in the development of preferred techniques for use in Federal teleprocessing networks, as well as the design of useful experiments employing new communications technologies, such as data transmission via communications satellites. Inherent to this project is a continuing assessment of the economic tradeoffs posed by the rapidly changing technological capabilities.

3. Measurement and Evaluation Functions

The effectiveness of ADP systems employing teleprocessing techniques depends both upon how the systems are used, and how they respond to that use. At present, acceptable methods for measuring and evaluating network effectiveness have not been evolved. Network performance measurement has direct applications to system selection and improvement and to validation of models for hardware and software design. The program of the CCST is directed toward the development of methods and equipment to measure, test and evaluate such system effectiveness.

An important technique for this purpose is the measurement of the dialogues carried on between and among users and computers in teleprocessing networks. Data resulting from a few such measurements are already being used by the CCST for the development of simulation and analytic models leading to accurate

qualitative and quantitative predictions of how teleprocessing networks react to changes in system configurations and to changes in user group characteristics. An important part of the program is the development and testing of performance criteria for both hardware and software employed in teleprocessing networks. The measuring equipment developed under this program is known as the CCST Dialogue Monitor.

Conservative estimates place the number of simple interactive teleprocessing systems in use by Federal agencies at well over fifty systems. Assuming each of these consists of a computer costing some $200,000 per year and about 25 terminals located throughout the country which each average 2 hours "connect-time" per day, potential savings of about one third of the computer costs and one-half of the communications costs might be realizable as a direct consequence of the better understanding of teleprocessing operations obtained by this program. This would yield annual savings of some $3 million in computer costs and $3.6 million in communications cost, or potentially over $6 million a year for these symple systems alone. On the other hand, teleprocessing costs in the Federal Government may rise well beyond expectations if the present lack of understanding of how these systems work and how they can be used most effectively persists.

a. Categorization of Teleprocessing Usage

The CCST is developing user simulation programs using playbacks of useage histories collected by the CCST Dialogue Monitor. Repeated simulations of the same users will be made on the same system to measure and classify the various types of teleprocessing usage patterns, to identify variations in system performance, and to develop models of user behavior.

b. Teleprocessing Behavior under Controlled Conditions

Through the use of the CCST Dialogue Monitor, the Center will have accumulated a large store of user behavior data. This data will be used for simultaneous interactivity with selected actual ADP teleprocessing networks in order to record system response, and to develop measures of system behavior.

c. Teleprocessing Control Software

Teleprocessing control programs and language processors are quite complex because of the necessity of handling constantly changing conditions in real-time while concurrently supporting many processing activities. The development of teleprocessing software is still mainly an art largely because the analysis and documentation of procedures for measuring the effectiveness and efficiency of this type of software has not yet been undertaken. The CCST program, will investigate techniques for measuring software performance and for improving software effectiveness.

Savings of at least a factor of two in computer clock time and communications costs should be possible as a result of changes in the design of operating systems and language processors expected to result from this project activity.

d. Teleprocessing Terminals Evaluation

The CCST can render an immediate and important service to the Federal teleprocessing community by providing advice and assistance in the selection and adaption of the multitude of terminal devices which are available for systems used by the Federal agencies. By promulgating standards and conventions for certain common teleprocessing functions such as logging on and off, requesting assistance, and controlling output performed by terminal devices,

great simplifications could be achieved which would facilitate the interchangeability of data. This project includes work directed toward the development of conventions, procedures, and standards for "touchtone" telephones used as computer terminals, and for experimentation with CRT editing displays using keyboard and full ASCII character set, and with magnetic tape cassettes and speed changing recorders, and a Model 37 teletype with full ASCII character set plus graphic symbols.

This project area can be highly effective in reversing the trend of continued proliferation of conflicting practices, conventions, and standards among Federal agencies, and will greatly facilitate the interchange of computer programs and data required for the eventual interconnection of various Federal agency teleprocessing systems into a government-wide computer network.

e. Modem Modulation Evaluation

During the past 5 years a profusion of modems for use in teleprocessing have been developed for the marketplace. As of December 1970, at least 117 models, from at least 39 manufacturers were available. Although there tends to be some standardization in signalling speeds, there is little standardization with respect to the modulation techniques at any given speed. For example, 2400 bit-per-second modems are listed which use the following modulation techniques: AM(SSB), AM(VSB), FM, FSK, PM, PM(diphase), PM(4 phase) and PSK. This inhibits free intercommunication across product lines and impedes the development of teleprocessing networks.

The types of modulation employed in modems used for digital data communications influence both system performance and system cost. Performance is influenced because in a circuit with a given signal-to-noise ratio

the bit error rate depends in part upon the modulation scheme employed. Use of more sophisticated and noise resistant modulation techniques may result in a lower bit error rate but may carry along possible penalties in the form of increased cost and complexity of the modem.

With the recent development of a proposed standard for determining the performance of data communications sytems, it is now feasible to quantitatively assess the performance of alternative modulation techniques and to establish meaningful relationships between performance and cost. This, in turn, would permit identification of the most cost-effective configurations which would be recommended for use in Federal Teleprocessing networks.

The adoption of preferably one, or at most two, modulation techniques for each of the standard signalling speeds would enhance the capability to interconnect teleprocessing networks using switched circuits and offer a potential for benefits similar to those which have resulted from the adoption of ASCII, the standard character code.

4. Applications and Services Functions

It is important that teleprocessing network design and evaluation activity be put into a frame of reference directly related to intended useful applications of ADP systems. Within the CCST program there are opportunities for useful in-house applications in support of overall National Bureau of Standards activities, as well as opportunities to support other Federal agencies. As an adjunct to the direct services provided under the "Computer Services" and "Effective Applications" elements of the overall CCST program, the "Teleprocessing" element provides specific assistance for laboratory automation within the NBS using state-of-the-art teleprocessing technology.

The CCST program seeks to extend this support for experimental activities within NBS and other agencies through networking of minicomputers, use of interactive computer graphics, operational participation in the ARPA network as the point of entry into the network for Federal agencies, and the incorporation of existing research and development information in the computer sciences into Federal time-sharing system data banks.

a. Laboratory Automation Experiments

The design and development of overall configurations of computers in support of laboratory activity is now changing rapidly to take advantage of the new teleprocessing technology. Use of mini-computers in laboratories and the sharing of central computer facilities has become essential to the efficient and effective conduct of laboratory research

In the laboratory, however, minicomputers frequently are not adequate to support experiments unless connected to larger facilities. Large shared computers by themselves generally are not adequately available to support laboratory experiments directly in real time. The CCST program is directed towards solution of the various problems associated with the networking of computers to support laboratory experiments and toward the development of techniques for data acquisition and storage, data formatting and display, experiment control, data reduction, and software preparation for minicomputers.

b. Interactive Computer Graphics

Interactive computer graphics is emerging as a powerful, although still expensive, technology for a wide range of applications such as computer-aided design for buildings, ships, and electronic circuits, and for the development of management charts and the anaylsis of experimental data

in graphical form. The CCST program has its graphics activity focused on the evaluation of interactive graphics systems and the rendering of assistance to other agencies in the application of such graphics systems.

Graphics computer programs will be developed as necessary to test new ideas and to demonstrate new graphics concepts. Cost and performance trade-off studies will be undertaken to assess factors influencing system designs, and to evaluate the effectiveness of multiple graphical displays connected to single computer systems.

c. Data for Federal Time-sharing Systems

The CCST now has available, in a file on a DOD computer, some 6000 resumes of active Federal projects involving research and development in the computer sciences. In order to make this information immediately accessible to government managers, the CCST will undertake to transfer this information to a Federal time-sharing system. This project will include a study of the GSA "RAMUS" time-sharing system as a candidate government wide time-sharing service, and will assist other Federal agencies in making wider use of this and other time-shared systems.

Failure to make such resumes on Federal R&D work in computer sciences available in an on-line system would mean that management will continue to lack quick access to this information as a basis for R&D decision making. This in turn will lead to overlapping and duplication of effort. Failure to assess the GSA time-shared system will mean a potential delay in the development of more-efficient government-wide time-sharing services.

d. ARPA Network Participation

A few years ago no communications system existed which even came close to providing the type of service which is integral to the experimental

ARPA network. This network currently interconnects more than 20 computers at 15 locations across the country. By 1972, expansion to 25 locations is expected. The computers at each of these locations interconnect with computers at the other locations through communication lines capable of handling some 50 thousand bits of information a second. Each location has an Interface Message Processor facility which accepts messages from the Host Computer, breaks the message into thousand-bit packets, and sends each packet toward its destination over whichever communication routing is then optimal. Each interface processor along the route, upon receiving the bit packet, checks for errors, and if it checks, routes the packet on to the next processor along the way. At the destination, the bit packets are assembled back into the original message, and delivered to the computer at the destination. Since each communications line is being used for traffic between many pairs of locations simultaneously, the load on the lines can be quite efficient.

At the present time, the actual cost of the total network communications ranges up to about $6,000 per month per location. It is estimated that for the 1972 network of 23 nodes, this will decrease to about $4,800 per month. One of the principal aspects of the CCST participation in the network is to evaluate the cost implications of Federal agency participation in the network on an operational basis.

The CCST will serve as focus for Federal agency use of the experimental ARPA Teleprocessing network. The program provides for an extensive study of the resources which will be available to Federal users through the ARPA network, and for advising selected agencies as to how these resources can usefully be applied in their ADP operations. An evaluation of the resources

will be accomplished through utilization and testing by the CCST operating as one of the 20 some nodes of the ARPA network. The Interface Message Processor facility required by the CCST for access to the ARPA network is funded under the teleprocessing support facilities portion of the CCST program.

5. Teleprocessing Support Facilities

Computer and terminal facilities are an essential part of the CCST teleprocessing program. These facilities support the experimental work and measurements necessary to evaluate computer networks, terminals, and modem equipments, and to study and test new techniques for effective design of systems employing teleprocessing techniques. The kinds of facilities required include on-line computing (not necessarily in-house) using full-capability time-sharing computer systems; various types of terminals, including teletypewriters, alphanumeric full graphics CRT's; in-house computing capabilities adequate for interfacing terminals and for evaluating devices requiring specialized interfaces such as touchtone input units, automatic calling units, and flying spot scanners; and specialized equipment necessary to the performance measurement activity. In addition, provisions for direct access to a variety of remote computing systems are required for computer networking experiments, performance measurement activities, and data communications studies.

In particular, the CCST project provides for the planning, installation, maintenance, operation, and demonstration of facilities which include a variety of terminals for access to the ARPA network and various time-sharing systems and for use on a stand-alone basis, a terminal interface message

processor for access to the ARPA computer network, a PDP-11 minicomputer to support experimental performance measurement activity in conjunction with the ARPA network, specialized terminal support, and other teleprocessing-oriented equipment.

The CCST facilities are available to other NBS projects which can make effective use of the teleprocessing capabilities provided by the Center and to other agencies having a direct working relationship with the CCST's scientific and technical activities.

FUNDING DATA FOR THE TELEPROCESSING PROGRAM AREA

The allocation of RTS funding to the Teleprocessing Program Area is listed below for fiscal years FY71, FY72, and FY73. The percentage of the total funding for CCST devoted to this program area is also presented.

ALLOCATION OF RTS FUNDING TO TELEPROCESSING

	FY71	FY72	FY73
Total $ (000)	337.0	402.0	723.9
% of Total CCST Funding	17.3	19.5	23.7

A listing of the results achievable under this funding level is presented under major topical areas.

TECHNICAL MANAGEMENT AND COORDINATION

FY72

a. Provide advice to the OTP, FCC, and other agencies regarding teleprocessing data communications technical requirements, in relation to data communication services proposed to be established by the common and specialized communications carriers.

b. Provide guidance to the GAO, GSA, and OMB for the development of guidelines for the identification, classification, and inventory of Federal Teleprocessing systems.

FUNDING

$10,000

FY73

a. With specific reference to data communications services, assess alternative proposed communications rate structures with a view to providing guidance for the fair allocation of costs within Teleprocessing networks.

b. Advise regarding technical options available in connection with the study of the problems associated with controlled access to data about individuals as stored and used in systems employing teleprocessing techniques. Provide guidance to the executive and legislative branches regarding the impact of proposed Federal data banks and specific teleprocessing networks.

FUNDING

$50,000

RESEARCH, ENGINEERING AND DESIGN - NETWORK RESOURCE SHARING

FY72

a. Complete a thorough study of the ARPA network information center concept, and initiate a compilation of useable resources which can be accessed through the network.

b. Study other Federal Teleprocessing networks, with particular emphasis on the GSA RAMUS system and methods of organizing data for storage.

FUNDING

$30,000

FY73

a. Complete the study of major Federal Teleprocessing networks, and the compilation of data resources available within these.

b. Perform comparative analyses of selected Federal teleprocessing systems, with recommendations for possible system improvements and means for interconnection between systems.

c. Initiate experimentation with adaptive network control techniques.

d. Investigate techniques for sharing human resources by means of interpersonal communications through computers in teleprocessing networks.

FUNDING

$60,000

RESEARCH, ENGINEERING AND DESIGN - NETWORK COST OPTIMIZATION

FY72

a. Initiate a comprehensive study of telecommunication services available to and within Federal Government Agencies, and provide assessments of these services for teleprocessing network use.

b. Study analytical approaches for construction of network analysis models leading to network performance evaluations.

FUNDING

$30,000

FY73

a. Complete the Federal Telecommunications services study, and catagorization of capabilities, costs, and other design parameters of these services, including cost/effectiveness comparisons.

b. Construct at least one model suitable for analyzing alternative configurations of telecommunications, and initiate application of the model for network simulations and performance predictions.

c. Identify areas of potential standardization in Telecommunications systems and services used for data transmission, with a view toward possible cost reductions for teleprocessing network use.

d. Prepare preliminary guidelines for Federal agency use in planning for telecommunications services needed to support agency teleprocessing network activities.

FUNDING

$45,000

RESEARCH, ENGINEERING AND DESIGN - DATA EXCHANGE AND CONVERSATION TECHNIQUES

FY 72

a. Continue development of standards relating to communication bit sequencing, error detection and correction, and character structure.

b. Initiate study of computer intercommunications at the process to process level, and the development of suitable protocols and means for describing these protocols.

c. Participate in applicable FIPS and ANSI standards committees.

FUNDING

$45,000

FY73

a. Continue the development of intercomputer process protocols for use in teleprocessing networks.

b. Design a language for describing language protocols.

c. Perform experiments in the area of Host to Host Computer communications utilizing the ARPA network.

d. Continue participation in applicable FIPS and ANSI standards committees.

FUNDING

$60,000

RESEARCH, ENGINEERING AND DESIGN - DATA TRANSMISSION TECHNIQUES

FY72

a. Initiate studies of the transmission, modulation, switching, and error control methods inherent to current and projected data communications services.

b. Develop a methodology for quantitative assessment of performance of data communications services to be used in teleprocessing networks.

c. Initiate preliminary categorization of communication service characteristics required for teleprocessing networks.

d. Participate with NASA in the design of formal experiments in data communications via satellite.

FUNDING

$20,000

FY73

a. Continue the data communications services technical study, with emphasis upon economic/technical tradeoffs which may be available to teleprocessing network designers.

b. Develop an initial telecommunications quality specification standard for Federal teleprocessing networks.

c. Conduct an experimental program in information transfer and teleprocessing using available operational or experimental satellite communication links for network interconnection.

FUNDING

$50,000

MEASUREMENT, TESTING AND EVALUATION - TYPE CATEGORIZATION OF TELEPROCESSING USEAGE

FY72

a. Apply the Dialogue Monitor to selected systems of teleprocessing for the accumulation of data on system responses, communications utilization and user characteristics.

b. Apply the Dialogue Monitor histories for the development of user simulation models.

c. Define pertinent terminology for descriptive measurement and classification of teleprocessing network features.

FUNDING

$45,000

FY73

a. Extend the monitoring and data collection to a wider range of teleprocessing applications, and to multiple users in teleprocessing networks.

b. Develop and refine multiple user simulation models.

c. Initiate development of models for user group behavior.

d. Investigate the hardware and software for measuring "internal" behavior characteristics of teleprocessing networks, such as channel utilization, interrupt frequencies, etc.

FUNDING

$65,000

MEASUREMENT TESTING AND EVALUATION - TELEPROCESSING BEHAVIOR UNDER CONTROLLED CONDITIONS

FY72

a. Apply user simulation models to selected systems to measure variations in system performance and system responsiveness to controlled variations in user behavior.

b. Initiate identification of possible hardware, software and communications services modifications which might improve teleprocessing network performance.

FUNDING

$15,000

FY73

a. Extend the user simulation activity to include application of

multiple user models to selected systems for measurement of systems responses.

b. Identify potential quantitative measures of system performance and initiate the specification of criteria for evaluating system performance.

FUNDING

$43,900

MEASUREMENT, TESTING AND EVALUATION - TELEPROCESSING CONTROL SOFTWARE

FY72

a. Initiate analyses of representative operating time-shared systems.

b. Investigate techniques for measuring software performance.

FUNDING

$10,000

FY73

a. Extend analyses to include study of conversational languages and language processors.

b. Analyze the cost/performance tradeoffs for representative control software configurations.

FUNDING

$30,000

MEASUREMENT, TESTING AND EVALUATION - TELEPROCESSING TERMINALS EVALUATION

FY72

a. Develop criteria for type classification of teleprocessing terminal devices.

b. Prepare a FIPS on user procedures for touchtone telephone terminals.

c. Initiate experimentation with representative terminal types connected to various time-sharing systems.

FUNDING

$20,000

FY73

a. Continue experimentation using a wide range of terminals on various time-sharing systems.

b. Develop conventions, procedures and standards for typewriter like devices and for text-oriented keyboard duplex devices.

c. Prepare a FIPS on user procedures for the operation of typewriter-like terminal devices.

FUNDING

$40,000

MEASUREMENT, TESTING AND EVALUATION - TELEPROCESSING MODEM MODULATION EVALUATION

FY72

a. Develop criteria for type classification of teleprocessing modem devices.

b. Initiate experimentation with representative modem types, and define quantitative measurements for assessment of performance of alternate modulation techniques.

c. Continue support of pertinent ANSI standards group.

FUNDING

$20,000

FY73

a. Continue the measurement and assessment of representative modem modulation techniques.

b. Analyze the cost/performance tradeoffs available to teleprocessing network designers.

c. Initiate the identification of preferred modulation techniques applicable to each of the standard communications signalling speeds, for use in Federal teleprocessing networks.

d. Continue the support of pertinent ANSI standards groups.

FUNDING

$40,000

APPLICATIONS AND SERVICES - LABORATORY AUTOMATION EXPERIMENTS

FY72

a. Initiate the investigation of problems associated with interconnection of minicomputers to central computer facilities.

b. Assess the particular problems inherent to NBS laboratory automation.

FUNDING

$15,000

FY73

a. Investigate the software support requirements for Intra-Lab minicomputers using larger computer systems.

b. Develop specific NBS laboratory applications for the CCST minicomputer.

c. Study the data handling and data reduction alternatives available to the laboratory minicomputer teleprocessing network.

FUNDING

$20,000

APPLICATIONS AND SERVICES - INTERACTIVE COMPUTER GRAPHICS

FY72

a. Extend the studies of the performance requirements and costs of computer system configurations to support graphics terminal operations.

b. Develop computer programs to demonstrate new graphics concepts.

FUNDING

$20,000

FY73

a. Continue experimentation using a wide range of terminals on various time-sharing systems.

b. Develop conventions, procedures and standards for typewriter like devices and for text-oriented keyboard duplex devices.

c. Prepare a FIPS on user procedures for the operation of typewriter-like terminal devices.

FUNDING

$40,000

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b. Initiate experimentation with representative modem types, and define quantitative measurements for assessment of performance of alternate modulation techniques.

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c. Study the data handling and data reduction alternatives available to the laboratory minicomputer teleprocessing network.

FUNDING

$20,000

APPLICATIONS AND SERVICES - INTERACTIVE COMPUTER GRAPHICS

FY72

a. Extend the studies of the performance requirements and costs of computer system configurations to support graphics terminal operations.

b. Develop computer programs to demonstrate new graphics concepts.

FUNDING

$20,000

FY73

a. Extend the studies to include factors and problems associated with multiple graphical displays connected to one computer system, and to computers accessible through teleprocessing networks.

b. Experiment with interactive computer graphics operations through the ARPA teleprocessing network.

FUNDING

$20,000

APPLICATIONS AND SERVICES - DATA FOR FEDERAL TIME-SHARED SYSTEMS

FY72

a. Initiate the programming and data entry for at least one Federal time-sharing system to utilize the available resources on Federal R&D projects in computer sciences.

b. Study the GSA "RAMUS" system as a candidate time-shared system for such data banks.

FUNDING

$7,000

FY73

a. Continue the programming and data entry of time-sharing systems to include entry of all pertinent NBS project resumes.

b. Evaluate additional selected time-sharing systems in other Federal agencies as candidates for such data banks.

c. Provide advice and assistance to Federal agencies with respect to more effective use of available time-sharing systems.

FUNDING

$20,000

APPLICATIONS AND SERVICES - ARPA NETWORK PARTICIPATION

FY72

a. Complete the preparations for the terminal interface message processor facility enabling the CCST to serve as a nodal point for Federal use of the ARPA network.

b. Study the resources available to Federal agencies through the ARPA network.

c. Advise and assist other agencies preparatory to use of the ARPA network by such agencies.

FUNDING

$20,000

FY73

a. Extend awareness of resources applicable to Federal agency use which can be accessed through the ARPA network.

b. Evaluate selected resources through utilization and testing by the CCST.

c. Evaluate the ARPA teleprocessing network as a potential operational facility for Federal agency use.

d. Continue providing advice and assistance to other agencies regarding the ARPA teleprocessing network.

FUNDING

$40,000

SUPPORT FACILITIES

FY72

a. Complete the detailed planning and development of interfaces

FUNDING

$20,000

FY73

a. Extend awareness of resources applicable to Federal agency use which can be accessed through the ARPA network.

b. Evaluate selected resources through utilization and testing by the CCST.

c. Evaluate the ARPA teleprocessing network as a potential operational facility for Federal agency use.

d. Continue providing advice and assistance to other agencies regarding the ARPA teleprocessing network.

FUNDING

$40,000

SUPPORT FACILITIES

FY72

a. Complete the detailed planning and development of interfaces for the ARPA network interface message processor and the minicomputer and initial preparation of software required for these facilities.

b. Continue the interfacing activities for new terminal devices.

c. Initiate the detailed planning for a research computer facility.

d. Procure required communications modems and communications devices.

FUNDING

$95,000

FY73

a. Operate and maintain the teleprocessing research facilities comprising: the ARPA network Interface Message Processor (IMP), the PDP-11 minicomputer, the MOBIDIC time-sharing facility and in-house research computer facilities.

for the ARPA network interface message processor and the minicomputer, and initial preparation of software required for these facilities.

b. Continue the interfacing activities for new terminal devices.

c. Initiate the detailed planning for a research computer facility.

d. Procure required communications modems and communications devices.

FUNDING

$95,000

FY73

a. Operate and maintain the teleprocessing research facilities comprising: the ARPA network Interface Message Processor (IMP), the PDP-11 minicomputer, the MOBIDIC time-sharing facility and in-house research computer facilities.

b. Finalize the plans for the research computer facility.

c. Continue the interfacing activities for additional terminal devices.

d. Procure the required communications services and modems to support current teleprocessing activities.

FUNDING

$130,000

D. SUPPORTING EXPLORATORY DEVELOPMENT

This CCST program area is comprised of the scientific and technological projects which are directed towards 1) resolving the urgent problems deterring the effective application of computer technology, 2) resolving the problems of computer utilization unduly constraining the customer, 3) providing the technical foundations for standards activities, 4) the technical problems resulting in prohibitive costs to the Federal computer customer, and 5) the technical problems resulting in inequities in the computer service marketplace. The resolution of these problems is the objective of this CCST Program.

A very important attribute of an adequate Directed Exploratory Development Program is that it be oriented towards resolving the problems which will confront customers for computer services in three to five years. The CCST does not presently have afforded to it the luxury of such a program. The one currently underway and being planned through FY 73 is attempting to simultaneously resolve yesterday's problems, today's problems, and those of tomorrow.

Another characteristic of Directed Exploratory Development projects is an often-lacking short-term tangible product. The products which are highly visibile to customers are manifestations of better computer utilization or of useful computer applications. And yet, the basis for reducing the time of

operation of a payroll system, for instance, probably rests upon a data structuring technique which permits more rapid access to data on disks. The data structuring project, however, is hidden in the shadow of the more tangible product.

Illustrations of representative Directed Exploratory Development projects planned for the CCST follow. They are Unbundled Software, Controlled Accessibility to Data Banks, Emulation Software, Software Effectiveness, Pattern Classification and Processing, Information Control and Language Development.

1. Unbundled Software

The term "unbundling" describes the separate pricing of products and services provided by the manufacturers of computer hardware. Until 1969, it had been general policy for the manufacturers to supply programs (software) and certain installation and maintenance services under the original purchase or lease price of the system. The products and services which can now be priced separately from the computer itself under the terms of the "unbundling" anti-trust decision are 1) computer programs, 2) education of the customer's personnel, 3) consultation and programming support for specific customer applications, and 4) maintenance.

Unbundling has posed severe problems to most computer customers. The OMB believes its impact has been serious on the Federal customer. It has shifted the burden of responsibility

from the seller to the customer for assuring that his total computer system will provide its services efficiently. Most customers do not have the technical sophistication to understand or deal with the problems of software management or computer service management. One of the assigned responsibilities of the CCST is to assist Federal computer customers in these rather complex considerations.

Major difficulties introduced by unbundling are the lack of inventories of software product characteristics to guide customers in their selection and the uncertain status of program protection, including copyrighted software, patented software, and software protected through licensing and contract arrangements. The lack of descriptive data about software including time for running programs and costs of producing output as well as the lack of any performance criteria to assist the buyer or to help the seller accredit or certify his product are major deterrents to adequate customer protection. These have all been highlighted by unbundling.

The CCST plans to emphasize the assistance it can supply the Federal customer in overcoming these types of problems.

2. Controlled Accessibility to Computer Data Banks

A rational approach to the problem of security, privacy, and confidentiality of information contained in computer data banks is both feasible and necessary. The subject is a highly

visible one today frought with emotion, fear, and political pressures. One Senator has recently (1971) advocated a stop to computer procurement by the Government until adequate protection of computer data banks is assured.

This problem cannot be resolved in the abstract or in generality. The means of controlled accessibility is dependent upon the data in question. This is because the constraint, regulations, legal decisions, and the like which now control accessibility of data vary with the data. Copyrighted material must be handled differently than non-copyrighted material. Medical records have different constraints on their use than do criminal records. Information possessing a military security classification is subject to different regulations than is proprietary drug-house experimental data.

It is necessary in each such case to translate the different information controls into hardware and software terms, to determine alternative approaches for meeting imposed controls, to cost them out, to have them validated by proper legal and regulatory groups and then to implement them.

The computer in these instances becomes an information repository and the logical control machinery for controlling access. The computer technological supporting system includes the personnel and means for operating the information repository and its control machinery, handling the information as it is

received and disseminated and the rules governing accessibility. The computer and its supporting system must be separately treated.

Consider the case very much in the spotlight today -- that of medical records.

Privacy assumes individuals have the right to keep certain information about themselves to themselves.

The Supreme Court has addressed this in only one full case. The subject was birth control. Connecticut law says that it is unlawful for married couples to use contraceptives. The Supreme Court accepted the constitutionality of privacy and rules that this Connecticut law violated the allowed privacy of individuals.

Confidentiality assumes sensitive information has been passed from one person to another with whom the first person has a relationship of trust. This relationship of trust can be protected by law. Information so passed can only be used for the personal benefit of its originator -- not for any other person.

Both privacy and confidentiality of information assume patient consent to its release. Medical practice is based upon the assumption that medical records do not belong to the patient but to the institution, clinic, or physician that produced them.

Privacy might be detrimental to medicine. Confidentiality of information is common in medicine. It is generally accepted that confidential information about patients may be exchanged

among medical personnel without further specific permission of the patient. This is because the law assumes that this exchange is in the best interests of the patient. The law also assumes the exchange of confidential information is for treatment not research.

Computer technology can now provide four types of patient control over computer systems. All are expensive and difficult to implement. In brief they are:

1. The patient must consent to the release of all/ any patient-related information.

2. The patient signs an initial blanket consent for release of information entering the system on the basis of standards for information control.

3. The patient gives blanket consent but distinguishes between named release and un-named release.

4. The patient has some form of personal surveillance on who has accessed the information and for what purpose: he has right to correct errors.

Similar examples peculiar to other fields of computer application can be equally well formulated.

In designing computer systems with adequate control to information, one must be careful not to require so much additional "control" information as to impose new problems of invasion of privacy or to increase system costs to an important level.

Imposed accessibility controls must vary based on the type of information: thus, several sets of control procedures may have to be implemented in a single computer service center if it provides a multi-customer community service.

The CCST is giving this area of Directed Exploratory Development the highest priority.

3. Emulation Software

A grave problem facing the government is the practice its computer customers have adopted of emulating second generation computer software on third generation computer hardware. Emulation, as used here, is a process whereby one computer is set up to permit the execution of programs written for another computer. This is done through a combination of hardware features and software packages. The present problems arose when customers bought third generation hardware and found that the software available soonest consisted of programs that would allow applications packages developed for their old computers to run on their new ones. This is highly wasteful of newly procured computer hardware.

The technical problem which the CCST must address on behalf of the entire government is whether to make large scale investments in software for third generation equipment or to call the third generation of computers a "lost" generation and concentrate on

the future. Annual investments in software of over $100 million by the Federal Government will ride on the technical inputs made.

It is estimated that 17% of the IBM 360 series computers in the Federal inventory are using emulation software. This implies that a significant fraction (over 11%) of the latest generation computer hardware is using emulation software to run "old" programs written for older computers.

The problem is not one-time but is self-compounding. If not faced up to now similar problems will cascade as computer customers move to new equipments, minicomputers, and time-sharing computer configurations.

4. Other Illustrative Exploratory Development Projects

a. Software Effectiveness

This project will define the parameters of software products in a consistent manner using systems concepts; that is, by treating a software product as a "black box" whose internal characteristics are to be established by imposing standard inputs and measuring the resulting outputs. In this way, competing products should be able to be compared and potential users can more accurately specify their requirements and more closely satisfy their needs. This project also proposes to provide specialized types of users (e.g., scientists) with languages for data acquistion, querying, and manipulation specifically suited to their needs. It also seeks to develop data and storage definition languages to facilitate mutual file access and transferability.

b. Pattern Classification and Processing

In this project, better tools and techniques are sought to automatically classify, manipulate, describe, and interact with two dimensional or graphic information, signals, and large non-numeric sets. Tools needed are specialized languages, and semi-automatic computer input methods and classification methods. The techniques to be employed include computational linguistics and artifical intelligence.

Clients for improved manipulation and interaction with curves, patterns or signals, are agencies performing physiological and environmental monitoring, and agencies performing chemical analysis, or voiceprint or fingerprint analysis.

c. Information Control

Initially through simulation, and later through actual multi-computer implementation, priority control methods, resource allocation methods and fail-soft controls will be studied and appropriate ones developed for specific uses. Access to an operational network will be essential by FY 73.

d. Language Development

Languages for data manipulation and definition to improve file accessibility and transferability will be evaluated for utility. Query and retrieval systems for specialized users, and aids to problem-solving and diagnostics, will be evaluated and changes recommended.

5. Funding Data for the Directed Exploratory Development Program Area

The allocation of the RTS funding to Directed Exploratory Development projects is listed below for fiscal years 71, 72 and 73. The percentage of the total funding for CCST devoted to this program area is also presented

Allocation of RTS Funding to
Directed Exploratory Development

	FY 71	FY 72	FY 73
Total $(000)	261.2	261.2	390.8
% of total CCST Funding	13.4	12.6	12.7

A listing of the allocation of funds for FY 72 and FY 73 in terms of project areas is presented below:

FY 72

Software Management, e.g., unbundling, emulation, software, effectiveness, and software inventory projects.

FUNDING

$126,000

Controlled Accessibility to Computer Data Banks

FUNDING

$75,000

Computer Network Design and Economic Analysis

FUNDING

$31,200

Graphic Display Processing

FUNDING

$30,000

FY 73

Software Management

FUNDING

$175,000

Controlled Accessibility to Computer Data Banks

FUNDING

$100,000

Information Control

FUNDING

$40,000

Graphic Display Processing

FUNDING

$45,800

E. SUPPORTING SCIENTIFIC AND TECHNOLOGICAL ADVISORY SERVICES

This program area is composed of projects directed towards satisfying the requirements of that part of PL 89-306 which assigns the Secretary of Commerce responsibility for providing scientific and technological advisory services relating to automatic data processing to Federal agencies. These projects are also responsive to the portion of the BOB policy guidance letter of December 1966 which delineates specific guidelines for providing ADP advisory and consulting services.

The current CCST technical program reflects the changing character and emphasis of the Center's scientific and technological advisory services. Since its establishment, the Center has directed the majority of these services toward helping Federal agencies solve specific ADP problems; only a small part of the effort was aimed at supporting those few Federal agencies which have broad policy-making responsibilities in the area of automatic data processing. Starting in FY 1972, CCST has reoriented its scientific and technological advisory services program to put more stress on support to such Federal policy-making and policy-influencing agencies as the Office of Management and Budget, General Service Administration, Office of Science and Technology, Office of Telecommunications Policy, National Science Foundation, National Academy of Science, General Accounting Office, Federal Council on Science and Technology, Department of State, and the Civil Service Commission. In spite of this change in emphasis,

however, ADP consulting and advisory services will continue to be made available to other agencies to assist in solving specific ADP management and application problems.

The CCST Scientific and Technological Advisory Services program is made up of five general areas of activity:

1. Support to the formulation of ADP policies
2. Technology assessment and forecasting
3. Support to U.S. international activities in automatic data processing
4. Support to other Federal agencies
5. Information services

1. Support to Policy Formulation

The formulation of Federal policies affecting both the development and utilization of computer technology is an increasingly important part of Federal ADP management. The Federal Government, with some 5300 computers valued at $2.8 billion is easily the largest single user of computers in the United States. Clearly, a wide range of policy formulations are required to insure effective management of these resources from the point of view of acquisition, application, operation and eventual disposition. At the time of their formulation, Federal ADP policies must be assessed not only in terms of their impact within the Fedral environment but also in terms of the supporting computer technology, the national economy, the private sector's

use of computers, and the international environment.

The policy formulation process itself has become exceedingly complex because of the rapid growth and rate of change in computer technology and the extent to which automatic data processing is being used both in the Federal Government and the private sector. This is due in part to the increasing number of Federal agencies now taking an active role in ADP policy-making and, in part, to the growth of interdependence of computer technology with other technologies, e.g., communications. For these reasons, ADP policy-making is creating heavy demands for high quality scientific and technical support over a wide range of ADP topics. In many cases, this support must be in the form of extensive research in computer science and technology of the type described in earlier sections of this report. Moreover, the organizations charged with responsibility for formulating ADP policy do not have their own computer science and technology resources and, therefore, must seek scientific and technical advice from other organizations. The CCST, under PL 89-306, is the Federal focal point for providing the technological base for the development of ADP policies.

Some of the prominent areas where scientific and technical advisory services are needed are general Government-wide ADP management policy, ADP product acquisition, teleprocessing and computer networking, development of new computer science and technology, technical assessment of automation opportunities,

and ADP manpower. Each of these areas has associated with it unique demands for a technological base to support effective policy-making. Some illustrative examples follow.

a. General Government-wide ADP Management Policy

Under PL 89-306, the Office of Management and Budget has responsibility for overall policy control of automatic data processing. In carrying out this responsibility, OMB needs a sustained, high level of scientific and technical advice and assistance in identifying and exploring ADP management problems, developing technically sound solutions, evaluating alternative solutions, estimating the cost-benefits associated with specific alternatives, and determining compliance with promulgated policies. As the technological arm of the Federal ADP management mechanism CCST must maintain data bases, conduct research and development, develop ADP standards, keep abreast of new developments and provide technology forecasts, and conduct a wide range of technical and economic analyses in order to provide the scientific and technical foundation for ADP management policy formulation. Similarly, CCST must provide high quality technical support to other Federal agencies such as the General Services Administration and the General Accounting Office.

A specific example of CCST's scientific and technological support to ADP policy formulation occurred recently when OMB asked the Center to provide technical answers to several questions

concerning potential damage to computer magnetic recording media (i.e., magnetic tapes, films, disks and drums) from various kinds of magnets. The Center quickly reviewed the research that has been done in magnetic recording and degaussing, summarized some of the basic laws of magnetism, and conducted some tests and experiments using small magnets and large electromagnetics. Within a few days, the Center provided OMB with a brief but comprehensive technical paper which answered the specific questions posed and proposed a set of general guidelines for protecting magnetic recording media against damage. This paper will serve as the technical basis for a policy issuance to assist computer installation managers in guarding against intentional (or unintentional) attempts to use magnetic devices to destroy information on computer magnetic media.

Similarly, the Center is involved in providing technical advice and assistance in formulating Federal ADP policies for the validation of computer software. In this case, CCST is providing technical inputs on the validation process itself, and has developed a plan for implementing a central COBOL validation service.

b. Computer Product and Services Acquisition

Under PL 89-306, the General Services Administration is responsible for formulating policies affecting the acquisition of ADP equipment, products and services. The entire area of ADP acquisition has been growing rapidly and increasing in

complexity. GSA ADP procurement policies must deal effectively with very difficult problems which are deeply rooted in computer science and technology itself. To insure maximum cost-effectiveness in the procurement of ADP equipment, product and services, GSA requires a high level of expert scientific and technical advice and assistance in such difficult areas as performance measures for computer systems, product validation and certification, establishment of criteria for effecting interface compatibility between the components that comprise a computer system, technology assessment and forecasting as an adjunct to effective procurement management, development of effective methods for determining the real worth of used computing equipment, development of methods for calculating the trade-offs between computer and communications in teleprocessing systems, the maintenance of hardware and software directories of what is already available in the Federal inventory as an adjunct to improved resource sharing arrangements, etc. CCST's research program includes work in all these areas and will provide the technological base for supporting GSA in formulating specific procurement policies. CCST will also provide scientific and technical inputs to the General Accounting Office to support its role of advising the Congress on ADP procurement practices.

In the area of computer products and services acquisition, the Center is currently involved in providing technical assistance

in the area of ADP equipment interface standards or plug-to-plug compatibility. The Center has made two recent contributions in this area. First, it has prepared a policy-oriented paper which discusses the need for interface standards for automatic data processing systems. The paper discusses the kinds of interfaces, the device controller/adaptor, and the hardware markets, and recommends courses of action. Second, the Center has prepared a technical paper which outlines a new approach to developing solutions to the problems of interchangeability of components in computer systems. The approach emphasizes deriving documentation of design and/or performance specifications for device interfaces. First efforts in this area would be directed at magnetic tape interfaces including both reels and cassettes -- reels because of their current widespread use and cassettes because of their importance to teleprocessing. This work will lead to Federal ADP procurement policies which will require all computer equipment bids to contain precise interface descriptions. These policies would forewarn industry of the Government's intent in the interface standards area and insure that unintentional impacts of interface standards on industry are minimized.

Another area where CCST scientific and technical support of policy formulation is needed concerns the problem of the Federal Government's large inventory of second generation computer equipment. A real question is whether to invest in improved software for equipment that is essentially obsolete; another is

whether to impose "interface" standards that will require this older generation of equipment to be plug-to-plug compatible with newer peripherals. Another similar problem is the practice of emulating second generation computer software on third generation hardware. This problem arose when customers bought third generation hardware and found that the software closest at hand consisted of programs that would allow applications packages developed for their old computers to run on their new ones. This is a highly wasteful use of computer hardware. The technical problem is whether to invest in new third generation software or to call the third generation a "lost" generation and concentrate on the future. The problem demands a technological assessment and forecast. CCST will emphasize work in this area as a part of its technical program in Scientific and Technological Advisory Services.

2. Technology Assessment and Forecasting

Technology is a "codified way of deliberately manipulating the environment to achieve some material objective". Technology assessment is "a systematic planning or forecasting process that delineates options and costs, encompassing economic, environmental, and social considerations (both external and internal) and with special focus on technology-related 'bad', as well as 'good' effects."

Computer technology assessment and forecasting in the Federal environment are particularly important because of the pervasiveness of computer usage, the high cost of ADP products and services, and the disruption and expense associated with effecting changes in operational systems and computer usage practices. Adequate forewarning of major advances or important changes in the technology can smooth the introduction of new technology and minimize the costs and disruptions associated with such introductions,

The CCST program in technology assessment and forecasting has two primary objectives: to prepare Federal customers for anticipated changes, and to prepare the Center itself for the resolution of problems associated with the new technology. In the former case, CCST will provide assessments and forecasts to such agencies as OMB and GSA to initiate and support the formulation of new or revised ADP policies which, being issued in advance of the arrival of the new technology, can prepare Federal agencies to deal effectively with the technology. Further, CCST will engage in a wide range of technological assessments and forecasting to assist specific Federal Agencies in making decisions regarding the acquisition of new ADP hardware, developing new software, exercising lease vs purchase options, etc. The CCST program in teleprocessing or computer networking will be particularly valuable as a basis of advising Federal agencies in the areas of computer services, trade-offs analysis involving computing capacity versus communications capacity, privacy or controlled accessibility of information, network design

and cost optimization, teleprocessing software effectiveness, and performance measurement.

3. Support to U.S. International Activities

ADP scientific and technical advisory services play an important role in U.S. international activities in the automatic data processing area. Such services are needed as inputs to the formulation of U.S. policies on exporting and importing computer products and services; they are also needed to provide the capability for assisting foreign governments in solving specific technical problems in the acquisition and utilization of ADP systems. These CCST scientific and technical advisory services bear directly on U.S. economic well being and the balance of trade. In 1970, the computer industry accounted for 38% of the total U.S. foreign trade balance. Department of Commerce statistics show that total U.S. exports for 1970 amounted to $42.731 billion and total imports were $39.948 billion leaving a favorable trade balance of $2.783 billion. Computer exports were $1.105 billion and imports were $33 million. The computer industry, therefore, accounted for $1.072 billion or 38% of the total balance of $2.783 billion.

CCST scientific and technical advisory services constitute a significant input to the formulation of U.S. ADP export-import policies, and to the shaping of U.S. positions for participation in international meetings and conferences involving such groups as the United Nations and the Organization for Economic Cooperation and Development (OECD). An example of this latter type of support

involves CCST inputs to the formulation of a U.S. position regarding the proposal by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Council of Scientific Unions to develop a World Science Information System. Another example concerns proposals to develop international programs to handle information to support actions relating to environmental quality control.

Over the last few years, CCST has provided technical representation on special U.S. teams assisting foreign governments in solving specific problems in automatic data processing. The Center recently provided two computer professionals to a team which assisted the Greek Government in analyzing and developing solutions ADP systems problems. Currently, a senior member of the CCST staff is detailed to the U.S. Agency for International Development (AID) Mission in Kabul to assist the Royal Government of Afghanistan in analyzing automation proposals, formulating systems designs and preparing for the acquisition of computer hardware and software. These types of scientific and technical services not only help recipient countries but also are of significant benefit in shaping U.S. computer export policies.

4. Support to Other Agencies

CCST has a basic responsibility under PL 89-306 and the NBS organic act to provide scientific and technical consulting and advisory services to assist Federal agencies in solving their ADP oroblems. During FY 1971, CCST provided such services to some 45 organizations in 16 Departments and Independent Agencies.

These services, provided on a cost-reimbursable basis, cover a wide range of activities including systems analysis, system specifications and requirements definition, system design, computer programming, preparation and analysis of automation proposals, and equipment selection. Specific examples of the assistance provided to other agencies are provided in Section V.C.5 of this report.

The CCST recently provided a unique type of scientific and technological advisory service to the General Accounting Office. In this instance, the GAO asked the Center to assist in resolving technical issues related to bid protests involving the award of a contract for the design and development of an Undergraduate Navigation Training System. The Center provided three expert consultants who worked with GAO lawyers, USAF technical and procurement personnel, and industry personnel to determine the merits of the technical issues of protest. Based on this work, the Director, NBS, provided a report of findings to the Comptroller General of the United States. The new program of the Center emphasizes these kinds of service to Federal agencies.

5. Information Services

In the performance of its mission and functions, CCST must necessarily be a broker of information services. It must collect, organize and maintain significant quantities of

information in the ADP and computer sciences and technology areas both for its own consumption and for delivery to Federal customers. The types of information to be collected include directories, inventories and listings of ADP software, hardware systems, and services, state-of-the-art surveys and reports, research and technical reports, product specifications, etc.

The scientific and technical information services program poses some difficult problems. The half-life of information is currently about 3-5 years; therefore, state-of-the-art surveys can no longer be done in the traditional leisurely manner. New methods must be derived to facilitate conducting such surveys and provide for their maintenance. Similarly, improved methods for preparing and maintaining current inventories and directories of relevant ADP information must be developed. In this regard, CCST will provide technical assistance and recommendations to OMB, GSA, OST, OTP and other policy-making agencies to develop the techniques and reporting mechanisms necessary to insure the timely availability of the scientific and technical information required to support the CCST mission and the activities of other agencies.

The CCST has a responsibility to provide easy accessibility to its own technical information holdings and to refer customers to other sources of information. This area also requires improved procedures and techniques in whose development CCST must participate.

6. Funding Data for the Scientific and Technological Advisory Services Area

The allocation of RTS funding to the Scientific and Technological Advisory Service Area is listed below for FY 1971, FY 1972 and FY 1973. The percentage of the total CCST funding devoted to this program area is also shown.

ALLOCATION OF RTS FUNDING TO
SCIENTIFIC AND TECHNOLOGICAL ADVISORY SERVICES

	FY 71	FY 72	FY 73
Total $ (000)	357.7	357.7	200.0
% of Total CCST Funding	18.4	17.3	6.5

F. COMPUTER SERVICES

The Center for Computer Sciences and Technology operates a specialized service bureau as a profit-and-loss enterprise, providing computer and related services to NBS and other government agencies on a cost-reimburseable basis. Primary emphasis is placed both on support of scientific, experimental and developmental applications and on assistance during the development and early implementation of systems in which the user anticipates conversion to his own computer within a specific period. Access to the main computer system, an intercoupled UNIVAC 1108/418 is provided to both on-site users and those at remote terminals connected via telecommunications.

1. Planned Service Improvements for NBS Customers

In the Center's new program for improving computer services to its NBS customers, primary attention will be focused on four general areas of activity, each of which will be discussed in subsequent paragraphs:

a. laboratory support,

b. computer facilities,

c. ADP standards implementation,

d. experimental computer facilities for the specific needs of CCST.

The highest priorities will be placed on those services and facilities which cannot be obtained economically and effectively through commercial sources.

The CCST is proposing these new initiatives in its computer services to place major emphasis on the specific needs of NBS. This emphasis will result in the development of in-house capabilities to augment and facilitate the use of the computer in support of NBS technical and management programs. Without this central computer support, particularly for exploratory research, development and measurement technology in its various programs, NBS may fall far behind other Federal laboratories that are already making extensive and sophisticated uses of computers. This concern is evidenced in the May 1970 report by the "Ad Hoc Study Group on ADP Policy for NBS".

a. The need for computer support in laboratory experimentation has been documented in the interim report of the CALM survey dated January 12, 1971. Forty-five visits have been completed, of over 100 planned, to various laboratories in the NBS. Thus far, the survey reveals that significant improvements in the Bureau's laboratory experimentation can be obtained through (a) more reliable paper tape handling, (b) direct data and program interchange between laboratory experiments and the central computer, and (c) development of 1108 processors for laboratory mini-computers. The latter development would

substantially reduce the overhead programming expended in each laboratory to program its own mini-computer. The Center plans to hasten its efforts to improve paper tape handling with emphasis on both the reliability of paper tape conversion/input and the "one-job" concept; i.e., a single computer job may consist of a program deck, a length of paper tape and/or other media such as data cards and magnetic tape. Centralized data logging will be supported by developing a system capability that allows a laboratory experiment to be directly connected to the central computer system as a remote batch terminal. It is also planned to develop a system facility that will allow an experimenter to interactively edit his centrally logged data from a remote keyboard terminal. Future improvements to this basic facility will also allow interactive compilation, computation and text processing. To improve access to the central batch processing environment as well as job turnaround time, it is also planned to place up to ten remote batch terminals at strategic locations in the Bureau's various laboratory buildings. Finally, the development of an 1108 processor to support laboratory mini-computers will not only reduce the cost of overhead programming, but will also greatly enhance the use of such computers throughout the NBS laboratories.

b. Improved computer facilities are urgently needed in support of on-line inquiry, interactive problem-solving and data management applications. A specific example here is the Bureau's

management information system which is currently being developed in a batch processing environment. The present mode of operation severely restricts the effective development of these kinds of applications and feasible modifications to the present operating environment have produced only marginal stop-gap measures. The Center plans to upgrade the 1108/418 facility to a multi-programming, expanded core system with augmented input/output facilities, all of which it considers essential to meet its service objectives. The augmented I/O facilities will include an on-line extended character train printer to support computer-aided text preparation and a full complement of ASCII input/output devices. The overall responsiveness of the batch processing system would be improved for both on-site and remote users through faster job turnaround and increased reliability; i.e., fewer system failures and less reruns. Add-on facilities to this basic system will permit the orderly development of on-line and interactive applications. An additional benefit of such system modernization will be increased utilization of system resources.

c. An important element in planning these system modifications is attention to the requirements of those users who have and are adopting Federal Information Processing Standards (FIPS) and their associated American National and International Standards. It is necessary to note that some "information processing standards" now endorsed as FIPS were deliberately

written to cover categories of information and processing not routinely handled by "standard computer centers" at the time the standards were written. There is a growing class of users and potential users of computer services which requires implementations of the anticipatory features embodied in FIPS. In recognition of this, the Center's plans for improved hardware and software are made with a view toward supporting the necessary standards. Users with "advanced" requirements will be advised of the potentialities of existing and developing standards and encouraged to take these into account at an early stage in planning long-term projects.

d. The fourth area of activity for major emphasis in service improvements arises from the Center's overall program. Achievement of the Center's new objectives implies a significant and increasing demand for computer support, particularly in order to conduct initial experiments in performance measurement, computer networks, COBOL and FORTRAN validation systems, management information systems design and data communications. While some of this support can be obtained commercially, the remaining substantially new workload will require specialized in-house computer services. Pending acquisition of a minimum set of hardware systems to support the Center's proposed technical actions, interim support will be provided by the 1108/418 complex and its immediate successors. Installation and/or development of specific hardware and software capabilities

will be implemented within this complex as required and funded to meet the experimental and computational needs of the Center's other program elements. Such modifications will be controlled so as not to disrupt or degrade normal computer service to other components of NBS.

The expected success of these planned improvements in the Center's computer services to its NBS customers depends largely upon the experience and competence of its technical staff. Recent additions of senior personnel to the staff of the Computer Services Division have greatly enhanced the prospects for a successful program. In addition, the Center will draw on staff of other divisions in NBS to supplement its own expertise in specific areas.

2. Funding Data for the Computer Services Program Area

The allocation of RTS funding to the Computer Services program area is listed below for fiscal years 71, 72, and 73. The percentage of the toal funding for CCST devoted to this program area is also presented.

Allocation of RTS Funding to Computer Services

	FY 71	FY 72	FY 73
Total $(000)	93.8	93.8	213.8
% of total CCST Funding	4.8	4.6	7.0

A listing of the service improvements achievable under this funding level is presented under major topical areas oriented primarily to the Center's NBS customers.

Service Improvements -- NBS Lab Support

FY 72

a. Continue support to RTS-funded projects in the area of programming services, software assistance, advice on hardware and assistance in converting old programs to new systems as provided for by NBS ADP policy dated August 5, 1970.

b. Continue the definition and analysis phases of the requirements study begun in FY 71 for automation of NBS laboratory work. Complete documentation of financial support capability, and complete evaluation of alternative remote batch devices at terminal ends.

c. Implement improved handling procedures to reduce user time involved in punched paper tape processing. Complete modifications to the 418 to reduce 1108 time required to process punched paper tape data.

d. Investigate and define specific 1108 software processors to support operation of mini-computers in NBS laboratories.

FUNDING

$93,800

FY 73

a. Continue support to RTS-funded projects in the area of programming services, software assistance, advice on hardware and assistance in converting old programs to new systems as provided for by NBS ADP policy dated August 5, 1970.

b. Complete procurement and install remote batch terminals at selected sites.

c. If feasible (technically and financially), lease and install small time-sharing system for use of NBS only.

d. Develop selected 1108 software processors for mini-computers used in NBS laboratory automation. Initial efforts will be concentrated on support of those mini-computers already installed.

FUNDING

$213,800

VI. ACCOMPLISHMENTS OF THE CENTER FOR COMPUTER SCIENCES AND TECHNOLOGY

A. INTRODUCTION

The Center, in the five years since it was established, has many accomplishments in which it takes pride. Its predecessor organizations within the National Bureau of Standards earned much of their reputation on the innovative and pioneering contributions they made to computer hardware design. This was especially true in the 1950's.

The growth of the computer industry and the unpredicted widespread use of computers both in the public and private sectors made it inevitable that the Federal Government would find it necessary to establish a substantial base of competence not only in the technology of computer hardware but in the increasingly important technologies of computer utilization and application. These latter technologies form the core of what shall be referred to as the technology of computer services.

The Brooks Bill (PL 89-306) of 1965 explicitly recognized the importance of computer services in their entirety as a new integral part of the operations of the Federal Government. Through the foresight of its creators, it provided the impetus and primary statutory authority for the establishment of the Center for Computer Sciences and Technology.

Under the direction of the Brooks Bill and the more detailed BOB guidance of December 1966, the efforts of the Center

have focused on the extremely complex areas of software management, systems management, computer utilization, computer applications, and computer standardization. Only peripheral attention has been directed towards computer hardware, per se. The computer hardware industry has demonstrated the ingenuity, production capability, and quality control necessary for excellent hardware products. The software industry has not yet done so.

In the context of this emphasis, the Center's accomplishments are discussed in subsequent sections under the general topics of:

1. Standards Program
2. Scientific and Technical Information Services
3. Computer Services
4. Hardware Design and Implementation
5. Scientific and Technical Advisory Services to Other Agencies
6. Software

Two excellent NBS pamphlets also describe technical highlights of the CCST for FY 69 and FY 70. They are reprinted from "NBS Technical Highlights Fiscal Year 1969" and "NBS Technical Highlights Fiscal Year 1970" NBS SP 340. The accomplishments as discussed here address the problem or responsibility generating the accomplishment, present a brief background, and then describe the accomplishment in terms of specific products or results, benefits, and those customers who are assisted by the work.

B. SUMMARY OF ALLOCATIONS OF EFFORT

The OMB Policy Guidance letter separates, for its purposes, the responsibilities of the CCST into four major areas. The funding records of the CCST have been examined and a rough estimate of funding resources allocated to these four areas from FY 1965 - FY 1971 is presented in the table below.

Responsibility	Funding: $(000) FY 1965 - FY 1971
1. Advisory & Consulting Services	1658.2
2. Standards (Federal and Voluntary)	4238.6
3. Research	2803.6
4. Computer Services	646.2
TOTAL	9346.6

Before presenting the accomplishments, it should also be asserted that the resources available to the Center have forced it to focus on exceedingly modest, short-term goals. Its ability to assist and when necessary to influence other Federal Agencies has been similarly limited. Some of the projects which the CCST has felt to be important and which it has not been able to undertake or to complete in a responsive manner include:

1. The timely issuance of a COBOL standard.

2. Development of the following FIPS Standards given high priority by Federal Agency consensus:

FORTRAN
Interface Standards for Telecommunications
Signal Quality Interface Standards
Computer Software Performance Monitors
Analytic Performance Techniques
Application Packages
Systems Documentation

3. Software Product Management. This includes adequate documentation, selection criteria, performance measurement, and utilization procedures. In this context, software products include:

Systems Software
Software Packages (proprietary and in-house)
- Application oriented
- Non-client oriented

Software Services

4. Generalized Data Management Systems: Analysis and Technical Guidance Services.

5. Management Information Systems (MIS): Analysis and Technical Guidance Services.

6. Engineering Analysis in the Hardware Interface Problem Area: This involves detailing feasible means of achieving component interchangeability in a competitive marketplace.

7. Information Accessibility Controls in Computer Systems: Work in this area could have decreased the amount of emotionalism currently present in information privacy and confidentiality discussions.

8. Determination of Means for Measuring Compliance of Federal Agencies with Standards.

9. Improvement of the Technical Aspects of the Computer Selection Process.

10. Development of Software Validation and/or Certification Services.

11. The "annual review of the accomplishments of and programs for research in computer sciences and techniques [to be] conducted with the Bureau of the Budget, Office of Science and Technology and other Government Agencies engaged in or sponsoring research in computer sciences to assess accomplishments and to provide guidance to programs." This was a responsibility assigned to the OMB Policy Guidance letter of December 15, 1966.

C. ACCOMPLISHMENTS MATCHED AGAINST ASSIGNED RESPONSIBILITIES

The accomplishments of the CCST are presented in the following sections.

1. The CCST Standards Program

A major function of the CCST is that of administering the Federal Information Processing Standards (FIPS) Program. This is in accordance with the provisions of Public Law 89-306 (the Brooks Bill) that authorizes the Secretary of Commerce to make appropriate recommendations to the President relating to the establishment of uniform Federal automatic data processing standards. In a letter to the Secretary of Commerce of December 15, 1966 policy guidance was provided in the implementation of this law by the Office of Management and Budget.

The Federal Government is the largest single user of information processing equipment. Since the introduction of the first general purpose computer in 1951, use has increased to where there were approximately 5300 computers in the Federal Government in July 1970. The establishment of information processing standards was not recognized as a significant factor in the early years of Government computer use since there were only a small number of manufacturers and a limited selection of available equipment. Information systems were generally independent of other systems and those standards that were established were done so on strictly a local basis. However, as the technology advanced and as the

number of applications of information processing systems increased, the need for standardization became more apparent. Large systems now being acquired by the Government include complex networks of peripheral devices and central processing units and frequently these interface with extensive systems of world-wide telecommunications.

A practice used by some agencies in the past in acquiring multiple computer systems has been to procure these from a single manufacturer. Acquisitions of this type provide a certain amount of standardization and compatibility within a given environment. In many cases the manufacturer provided nearly all the system components including communications hardware. However, this type of "single vendor" procurement did not provide compatibility with other systems acquired from other manufacturers. Furthermore, this approach to establishing standards by procuring equipment and services from a single manufacturer resulted in unbalanced competition.

Standards Produced

To date three standards have resulted from the CCST program, and six from the OMB program. There are published by NBS in a series of publications entitled FEDERAL INFORMATION PROCESSING STANDARDS, commonly referred to as FIPS. The publications issued are listed below. Those that are standards are noted with an asterisk.

FIPS PUB 0 General Description of the Federal Information Processing Standards Register.

*FIPS PUB 1 Code for Information Interchange, (Hardware Standard, Interchange Codes and Media).

*FIPS PUB 2 Perforated Tape Code for Information Interchange, (Hardware Standard, Interchange Codes and Media).

*FIPS PUB 3 Recorded Magnetic Tape for Information Interchange (800 CPI, NRZI), (Hardware Standard, Interchange Codes and Media).

*FIPS PUB 4 Calendar Date, (Federal General Data Standard, Representations and Codes).

*FIPS PUB 5-1 States and Outlying Areas of the United States, (Federal General Data Standard, Representations and Codes).

*FIPS PUB 6-1 Counties and County Equivalents of the States of the United States, (Federal General Data Standard, Representations and Codes).

FIPS PUB 7 Implementation of the Code for Information Interchange and Related Media Standards, (Supplement to FIPS PUB 1, 2, and 3).

*FIPS PUB 8 Metropolitan Statistical Areas, (Federal General Data Standard, Representations and Codes).

*FIPS PUB 9 Congressional Districts of the United States, (Federal General Data Standard, Representations and Codes).

*FIPS PUB 10 Countries, Dependencies and Areas of Special Sovereignty, (Federal General Data Standard, Representations and Codes).

FIPS PUB 11 Vocabulary for Information Processing (Software, Documentation).

FIPS PUB 12 Federal Information Processing Standards Index.

Standards Submitted for Approval

Additionally, the following proposed standards have been submitted to OMB for approval as FIPS:

. Bit Sequencing of the Code for Information Interchange in Serial-by-Bit Data Transmission.

. Character Structure and Character Parity Sense for Parallel-by-Bit Data Communication.

. Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in the Code for Information Interchange

. Hollerith Punched Card Code

. Rectangular Holes in Twelve-Row Punched Cards

. Subsets of the Standard Code for Information Interchange.

Approval of these by the Director, OMB occurred on 18 June 1971

Time Required to Standardize

A chart which reflects the time taken to develop the nine standards and proposals for which NBS has primary responsibility is reflected below:

	NBS/FEDERAL GOVERNMENT (dates, year-month)							
TITLE OF STANDARD OR PROPOSED STANDARD	Joined Industry Committee	Decision to Process as Federal Standard	Coordinated with Gov't Agencies	NBS forwarded to Dept. of Commerce	Dept. of Commerce Forwarded to OMB	Approved as FIPS (President or OMB)	Promulgation of Implementing Inst.	Implemented in Procurement Act'n
FIPS 1, Code for Information Interchange	60-11	65-09	65-11	66-05	66-06	68-03	69-03	70-04
FIPS 2, Perforated Tape Code for Info. Interchange	62-06	65-09	66-01	66-11	66-12	68-03	69-03	70-04
FIPS 3, Recorded Magnetic Tape (800 CPI, NRZI)	62-06	65-11	67-04	67-11	67-12	68-03	69-03	70-04
Bit Seq of the Code for Info. Interchange	63-02	69-03	70-02	70-03	70-04			
Char. Stru. & Par. Sense for Parallel-by-Bit Data C.	63-02	69-03	70-02	70-03	70-04			
Char. Stru. & Par. Sense for Serial-by-Bit Data C.	63-02	69-03	70-02	70-03	70-04			
Hollerith Punched Card Code	62	67-12	68-02	70-07	70-07			
Ret. Holes in 12 Row Punched Cards	62	67-12	68-02	70-07	70-07			
Subsets of the Standard Code for Info. Inter.	69-07	69-05	69-11	70-07	70-08			

Standards Objectives

The objectives of the FIPS Program have been defined as follows:

Data, Programs and Components

. To facilitate the interchange of machine sensible data within and among data processing installations.

. To facilitate the interchange of computer programs among computers of different makes and models.

. To facilitate the interchange of computer components and devices across product lines.

Data Communications

. To establish, where applicable, common standards for both information processing and data communications.

. To facilitate the interfacing of information processing and data communications systems.

Computer Performance

. To provide objective measures of performance for Federal computing systems, components and software packages.

Applications and Data

. To eliminate unnecessary reinvention of like computer applications throughout Government departments and agencies.

. To facilitate the interchange of data at the data element level.

Personnel and Environment

. To maximize the productivity of technical personnel working with Federal information processing systems.

. To reduce the need for retraining in programming, operations and maintenance due to differences in manufacturers' products and systems.

. To develop guidelines for ADP and telecommunications site preparation and environment.

Acquisition and Reassignment of ADP Products

- To provide tools for optimizing computer selection.
- To facilitate and speed-up the mechanics of acquiring information processing systems, components, software and related material, supplies and services.
- To protect current investments in computer programs, data files and personnel when acquiring new equipment.
- To facilitate the procurement of portions of multiple CPU systems from different suppliers.
- To facilitate the procurement of components of a single CPU system, particularly peripheral devices, from different suppliers.

Priorities

In March 1970, NBS queried Federal Departments and establishments as to their needs and priorities for ADP standards. The results of this query generally indicated that highest priority be given to programming languages, documentation, telecommunications interfaces, data elements, and optical character recognition. Some fifty areas have been identified for which standards are needed. Work is currently underway or is planned within CCST to develop these for Federal implementation.

COBOL

One of the major standardization efforts has been that of the COBOL programming language. The demonstrated Government interest in having a COBOL standard prompted NBS, in July 1968,

to solicit comments and views, from both Government and industry, on plans for the adoption of the ANSI COBOL as a Federal Standard. The Federal COBOL Standard will become effective on July 1, 1972.

Revisions have been made to the draft FIPS PUB to resolve these major issues. Coordination has been completed with selected agencies and concurrences have already been received. The proposed FIPS PUB for Federal Standard COBOL will be published in the Federal Register for the purpose of obtaining industry comments. Following the review of industry comments, a recommended FIPS PUB will be forwarded to OMB through the Department of Commerce. The COBOL standard will become effective in the Federal Government in July 1972.

Software Validation Service

CCST in cooperation with the Department of Defense is developing procedures and tests for validating the COBOL programming language. A software validation service is envisioned with initial funding being requested from the ADP revolving fund. Barring unforeseen difficulties, the validation service should be operational in the last half of FY 72 or early FY 73.

Interface Standards

The need for interface standards has been another major concern of the CCST. Shipments of plug-to-plug compatible devices by independent peripheral manufacturers have been increasing in

both volume and variety. Expanding adoption of de facto interface standards is largely responsible for the increase of annual shipments to approximately 560 million dollars in 1970 and an expected rate of 720 million dollars in 1971. De facto device interface standards result when various application requirements become generally satisfied by the capabilities of equipments whose performance was prescribed through the voluntary standardization of ADP supplies such as tapes, disk packs, cassettes, and forms. In addition to compatible devices, the larger independents have begun shipping subsystems that meet de facto interface standards at the channel level. Also, there is an expressed requirement for greater uniformity in the direct connection of major system components (such as mass memories), which must presently be individually fitted and remain sensitive to variabilities in system software.

If the volume of shipments cited above (combined sales and rentals) derives from underpricing the main frame manufacturers by as little as 15%, customer cost savings are currently in excess of 1000 million dollars per annum, of which the Federal Government should be realizing a proportionate share. Further economic benefits of competition are being realized through market reactions of the principal system manufacturers, which have included significant price reductions as well as new performance features.

Performance standards for retail products are rarely written voluntarily. Further, such standards do not necessarily insure

interchangeability of complex ADP components. The alternative to product standards is de facto interface design and performance standards, whose development and utilization require, in addition to maturing of the market, the same urgency of demand from "general interest" and "government" groups normally needed in voluntary standardization processes.

The following recommendations have been made concerning future standardization of interfaces:

- De facto standards for reel type tape handler and disk handler interfaces should be reviewed and those appropriate for selective use in Federal procurement of the related devices should be identified. Identification should be in terms of equivalent performance, since design specifications, however detailed, cannot be expected to assure functional interchangeability of components.
- After some pre-announced date, such as the first of Fiscal Year 1974, supplier bids for main frame hardware should be required to describe certain kinds of interfaces (to be enumerated) in sufficient detail to permit competitive procurement of related system components.
- Field engineering changes in major ADP components for the purpose of improving system operation either should not alter significantly the functioning of system interfaces, or should prescribe peripheral modifications required to maintain compatibility.

- CCST should actively participate in the work of ANSI subcommittee X3T9 in developing an input/output interface standard at the channel level as being fundamental to most applications, but providing exceptions such as process control computers and minicomputers.
- CCST should continue its active support of ANSI in the standardization of ADP supplies, including magnetic tapes, disk packs, tape cassettes and forms, in order to help define the performance of interfaces for the corresponding peripheral devices. Such definition is viewed as a significant benefit in addition to those relating directly to the standardization of supplies.
- A program should be undertaken to collect complete information on device level interface specifications for all computer peripheral equipments having existing or potential economic significance. These data should be considered in the development and application of additional device level interface standards which may become economically and technically feasible. Such new standards may have to be developed because of recent developments in integrated circuit technology and its application to general-purpose interface adaptors by equipment manufacturers.
- Finally, but perhaps most urgently, performance criteria in terms of job effectiveness for types of applications should be identified and classified, so proper weights may be assigned to them in determining the cost-effectiveness of various

combinations of interchangeable ADP components for any particular installation. The relative values obtained may be expected often to differ greatly from those currently obtained from consideration of the hardware performance figures in the manufacturers' manuals.

Magnetic Tape Standardization

Government Agencies, industrial producers of tape and tape handling equipment, the American National Standards Institute (ANSI), and the International Standards Organization (ISO) had requested standard computer tape references since the establishment of CCST.

In 1969, the NBS (CCST) began issuing secondary standard magnetic tape computer amplitude references, referred to as Standard Reference Material (SRM) 3200.

This Standard Reference Material consists of 600 feet of reference tape wound on an 8 1/2 inch diameter precision reel, applicable test and calibration data, and a description of the equipment and procedures employed for the calibration. Each tape is calibrated against the Master Standard Magnetic Tape kept in repository at NBS.

The primary purpose in issuing these secondary reference tapes is to provide industry and Government with a common signal level reference source for calibrating computer tape recording and reproducing equipments. Thus far, the major customers have been tape and tape equipment manufacturers and testing laboratories.

In addition, the secondary reference tape serves as the common reference for production control and is used in the qualification and acceptance testing of all computer tape available to Federal Agencies from the GSA Schedule. The secondary reference tape is also of significant value to Federal ADP installations and tape rehabilitation centers which are employing industry produced working reference tapes. Specifically, the SRM 3200 can be used for measuring the signal amplitude stability of these working references because it serves as the primary reference in the calibration and certification process used by industry in the production of these working references. Widespread use of the NBS secondary reference tapes by computer installations and testing facilities substantially contribute to error-free tape recording and reproduction in using installations.

The issuance of the secondary reference tapes by NBS directly supports the June 1966 Presidential memorandum to all Departments and Agencies which directed the employment of all possible means to provide better computer utilization at the lowest cost.

This capability and function of the CCST is unique both nationally and internationally. Thus far fifty-eight secondary reference tapes have been distributed as follows:

U.S. Industry	38
U.S. Government	5
Foreign Countries	15
TOTAL	58

The NBS (CCST) developed its Master Standard Magnetic Tape as a result of research on tape characteristics, in the course of which the NBS performance measurements laboratories had to develop new instrumentation for a tape evaluation system that measures the amplitude of signal pulses read from the tape. This instrumentation is now used in calibrating the secondary reference tapes issued by the NBS.

Voluntary Standards Participation

It has been the policy of CCST to support the voluntary standards activities especially those of the American National Standards Institute (ANSI) and the International Standards Organization (ISO). It is important that Federal computers and information systems be compatible not only with each other, but also with those of State and local governments, the private sector of the economy and those of other nations. Accordingly, standards developed to meet Federal requirements should, to the extent practicable, be consistent with corresponding ANSI and ISO standards. This has not, however, prevented the Government from (1) adopting standards on its own in cases where ANSI and ISO standards do not exist or are inadequate, nor from (2) modifying ANSI and ISO standards where they do not completely meet Federal requirements, nor from (3) embarking on independent standards development efforts in cases where ANSI and ISO efforts do not exist or are too slow, or are leading to results which will not satisfy the Government's needs.

In this regard, there are some 167 Government representatives from the various Federal Departments and Agencies participating on voluntary standards groups, particularly on the ANSI Committees concerned with Computers and Information Processing (X3), Office Machines (X4) and Library Work, Documentation, and Related Publishing Practices (Z39). NBS provides 21 participants on these groups.

As a result of these cooperative efforts, some 30 voluntary standards have been adopted. Four of these have been adopted for Federal use and five others have been recommended. The remainder of the ANSI standards are in various phases of consideration or coordination as Federal standards. There are some 70 other standards under development within the technical groups of ANSI.

FIPS Coordinating and Advisory Committee and Task Groups

The CCST in performing its functions in developing proposed Federal Information Processing Standards under the Brooks Bill (PL 89-306) needed to obtain advice and assistance from other Federal Agencies. A FIPS Coordinating and Advisory Committee was established in May 1969 by the CCST. It provides coordination of the work assignments to such task groups, and serves as a general advisory group to NBS on Information Processing Standards. It has members from all concerned Federal Agencies.

The FIPS Coordinating and Advisory Committee consists of (1) the Chief of the Office of Information Processing Standards, Center for Computer Sciences and Technology, NBS, as Chairman,

(2) the Chairmen of FIPS Task Groups, (3) the Chairman of the Interagency Committee on ADP, and (4) such other members as the Chairman of the FIPS Coordinating and Advisory Committee may designate. The composition of the Committee also includes members from NBS, OMB, and GSA, the three agencies principally responsible for carrying out the provisions of the Brooks Bill.

CCST recognizes that it must coordinate the standards program on an interagency basis. It is the purpose of the FIPS Task Groups to assist NBS to provide better coordination of the Federal ADP standards program. Technical personnel with a knowledge of each agency's requirements assist NBS in matters regarding development, adoption, and implementation of standards.

This participation by agencies enables NBS to gain greater insight into their respective agency problems and requirements. Such participation also allows NBS to more effectively evaluate its own standards program, and focus efforts on agency needs.

To date ten FIPS Task Groups have been established as follows:

Task Group 1 - Objectives and Requirements for Standards

Task Group 2 - Data Terminals and Data Interchange Systems Requirements

Task Group 3 - Character Subsets, Sign Conventions, and Packing Techniques

Task Group 4 - Subsections on Standards for Use in Requests for Proposals

Task Group 5 - Vocabulary

Task Group 6 - Computer Magnetic Tape

Task Group 7 - Magnetic Tape Labels

Task Group 8 - Format Description for Information Interchange

Task Group 9 - COBOL

Task Group 10 - Computer Systems Performance Evaluation

The three major benefits resulting from the standards program as expressed by Congressman Jack Brooks (D - Texas), the sponsor of Public Law 89-306, are:

1. The free interchange of data

2. The interchangeability of programs

3. Increased competition among computer manufacturers resulting in better computers at lower cost.

Congressman Brooks has also stated:

"There is no question that ultimately optimum compatibility among computers will be attained. The real question is when. At this time, we have the opportunity, through meaningful problem definition, to determine with greater exactitude the true nature of this problem. With greater interest among those participating in the effort we can speed up the process. Optimum compatibility among computers is the key to their fullest exploitation. We must do more than we have done in the past, and we must give compatibility the highest priority. In terms of the benefits computer techniques can bring to our society, we can move this nation forward decades in but a few years."

CCST has supported these objectives and statements and is doing all within its available resources to assure that they are realized and implemented.

2. Scientific and Technical Information Services Provided by the CCST

The NBS (CCST), under its Brooks Bill mandate, is responsible for providing scientific and technological advisory and consulting services to Federal Agencies in the area of ADP. The BOB policy guidance in its letter of December 15, 1966 cited specific tasks in support of this mission. The Department of Commerce Department Order 90-B of May 1966 highlighted the importance of information services in that one of the five Divisions of the CCST was given the mission of operating a specialized information center for the computer sciences and technology.

The initial information base for the CCST was the documentation that had been acquired by the organizational units that preceded the establishment of the Center, primarily the collection of the Information Technology Division. This contained not only the computer literature that had accrued since the mid-1940's but also the holdings of the Research Information Center and Advisory Service on Information Processing, a special project co-sponsored by the National Science Foundation and NBS beginning in 1958 with emphasis on research and development and the personnel involved in what is now termed the information sciences. Since Public Law 89-306 effectively gave specific legislative legitimacy

to NBS's on-going function of providing technical and scientific advisory services to agencies in their utilization of computers to perform their missions, there already was a pattern of their making use of the services now provided by the Center. It was the Center's objective to be able to provide them even better and thus to increase the effective and efficient utilization of ADP in the Federal Establishment.

To this end, the task of systematizing the total information base in order to be more responsive to requests was undertaken, building on the tools already available, through the use of a set of index-creating programs. A major problem encountered immediately was the derivation of a classification scheme for computer information. There were as many such schems as there were collections. Two of the professional societies with commensurate problems being the Association for Computing Machinery and the Computer Group of the Institute of Electrical and Electronic Engineers, collaborative efforts were undertaken with these and other activities on information management systems problems, including the development of a mutually acceptable computer information classification scheme, the definition of a universal set of descriptive data elements and their respective codes, and the realization of a standard format for recording bibliographic information on magnetic tape to facilitate interchange (utilizing such standards as ASCII). Over the first three years this type of effort took as much manpower as that of continuing tasks of acquisition, descriptive cataloging, including analysis

and recording of data, and searching the data base for selecting and retrieving information to meet the requirements of users of the services. In addition, in changing from an IBM 7094 to a UNIVAC 1108 as the NBS service computer, the index producing programs had to be rewritten so they were made machine independent by using COBOL as the programming language. The system used for file preparation and manipulation has been named CHAOTIC, for Computer- and Human-Aided Organization of a Technical Information Center, and can be utilized for any collection of information.

As to the information maintained by the Center, it includes but is not limited to the following types: books, proceedings, reports journals and other serials, update services, program catalogs and documentation, descriptions of hardware, software and services, house organs, brochures, manuals, course and conference announcements, some Requests for Procurement and suppliers responses, and so forth. The magnetic tape file containing the FY 70 Index of Computer Sciences and Technology Project Resumes is available but of limited usefulness. The supply of Federal Information Processing Standards Publications (FIPS Pubs), published by the Center, is also maintained for regular distribution and for responding to additional requests.

Services range from alerting individuals regarding availability of information of known concern to them or their organizations to indepth searches with analysis on specific aspects of the computer field, in addition to the obvious one of providing documents on demand to the Center staff. An analysis of services provided over

the first nine months of FY 71 indicates that the number of requests for technical and scientific advice averaged about 50 per month (other than simple requests for identifiable documents) and that the clientele served could be categorized as follows: approximately 60% were employees of Federal agencies (some 50 agencies in 17 departments and independent agencies); 30% came from industry; and the remaining 10% were evenly divided between students and staff of high schools, colleges and universities, and private individuals (not otherwise identifiable). Of the requests received, slightly less than two-fifths consisted of requests for general information or for location or identification of a source from which to get information, one-fifth could be answered by reasonably easy referral to references, and the remaining two-fifths required detailed search and analysis, along with compilation of a selective bibliography and/or document collection.

A sample of requests received and responded to include such topics as the use of computers in real estate, identification of program optimization packages, history of computing at NBS, economics of the computer industry, number and types of computer personnel by size of installation, forecasts of technological advances in computers, early publications on data input devices, statistics on teleprocessing terminals used in the U.S. Government, status of and information on computers in various foreign countries, information center management at the local, national and international levels, computer programs for engineering departments in universities and computer selection criteria. Special bibliographies

are typied by such subjects as management information systems, operational medical information systems, software development and manpower requirements, centralized vs decentralized computer operations, memories, data communications, and software catalogs and indexes. The tape files and printouts of data on domestic and foreign computer installations, obtained from the International Data Corporation for use by the Government, have also been utilized for searches, both manual and by special computer runs, an example of the latter being to produce a report of the relevant market share by manufacturer for the Department of Justice.

The costs to the Center for the establishment of a management system for the computer sciences and technology information base and for providing scientific and technological advisory services for the period FY 67 through FY 71 are approximately $1 million, including costs of labor, information resources, computer time and NBS overhead. The provision of this type of analytical service requires professional staff as well as support staff for file preparation and maintenance. The computer-produced indexes provide necessary search tools for the present; however, the computer data files will be cumulative on tape for eventual use for batch processing and/or on-line when it becomes economically advantageous.

3. Computer Services

The Computer service activity operated by the Center for Computer Sciences and Technology is included in the December 15, 1966 policy guidance to the Department of Commerce in the implementation of the Brooks Bill. Its mission, as provided in paragraph E. of the guidelines, is "...to meet the needs of the National Bureau of Standards and upon request to furnish services including problem diagnosis, systems design, programming, and related support activities to Federal Agencies on a reimbursable basis."

In January 1964, the Bureau of the Budget Bulletin 64-9 announced the establishment of a Computer Sharing Exchange and a Computer Service Center at the National Bureau of Standards to serve Government Agencies in the metropolitan Washington, D.C., area on an experimental basis. The sharing experiment was successfully concluded, and in August 1966, responsibility for the Sharing Exchange was transferred to the General Services Administration (GSA). Subsequently, the Service Center experiment was evaluated and, in July 1967, GSA delegated to the Department of Commerce authority to operate a permanent ADP Service Center at the National Bureau of Standards.

On February 27, 1967, the Assistant Secretary of Commerce for Science and Technology advised the Assistant Director for Management and Organization of the Bureau of the Budget that "...the National

Bureau of Standards proposes to concentrate its efforts towards those tasks requiring professional input on the part of NBS staff, on those which deal with the experimental use of computers, and on those which represent the development of a new computer application. The Service Center will continue to provide raw computer time to other agencies, but only to the extent this does not interfere with the ability to be responsive to service requests under any of the above circumstances."

Most recently, in a statement of new ADP policy, dated August 5, 1970, NBS assigned authorities to the Center for Computer Sciences and Technology for providing central computer services primarily oriented to meeting the technical and administration needs of NBS. One of the major policy conclusions reached by the ad hoc study group on ADP policy for NBS was that "...The Center for Computer Sciences and Technology should take a more positive role in advancing the state-of-the-art of ADP utilization at NBS."

In meeting these responsibilities, the Center operates a computer facility that provides computer and related services to NBS and other Government Agencies on a cost-reimbursable basis. Primary emphasis is placed both on support of scientific, experimental and developmental applications and on assistance during the development and early implementation of systems that the user anticipates converting to his own computer within a specific

period. Access to the main computer system, an intercoupled UNIVAC 1108/418, is provided to both on-site users and those at remote terminals connected via telephone lines. The following examples illustrate some of the Center's more significant accomplishments in Computer Services.

Several agencies have made use of the remote access capability of the NBS central computer system to develop large-scale applications and data bases prior to installing their own computer or in connection with evaluating the feasibility of installing their own computer. For example, assistance was provided to the Economic Development Administration, which began using the NBS facility from a remote terminal in the summer of 1967 and, as planned, converted to its own computer in January 1970. This assistance permitted the orderly development of a broad economic data base and information-handling techniques at a minimum cost. More recent examples include the Edgewood Arsenal and the Social Security Administration. A terminal was installed at the Edgewood Arsenal in July 1969, and in May 1971, they installed their own computer system at the Arsenal. Staff members of the Computer Services Division provided consultation and advice preceding and during the conversion and furnished a substantial number of programs and software packages originally developed for the NBS computer. This enabled Edgewood to become fully operational in a minimum period of time. The Social Security Administration installed remote terminals in their Baltimore (October 1968) and Washington (March 1969) offices to gain access to the NBS computer for support of research and development activities. A new computer system has now been installed in

Baltimore (October 1970) which already supports the work from the Washington, D C., terminal, and it is expected that most of the Baltimore terminal workload will be supported in the near future. As a final example of this type, terminals at U.S. Forest Service offices in Washington, D.C., Atlanta, Milwaukee, Denver, and Albuquerque were connected to the system, enabling the Forest Service to experiment with centralized road design computations and collaborative development of new design techniques. At the same time, a saving was achieved by the Forest Service by not having to acquire additional computer equipment to support the decentralized operations.

A comprehensive set of computer programs called SPEED (Systematic Plotting and Evaluation of Enumerated Data) has been developed for the Structures Section of the NBS Building Research Division to automate the recording and processing of experimental data on either magnetic or paper tape. The computer programs interpret and transform these data, print the transformed data, and also produce graphs. The scientist is able to control the exact form of the output through the use of a few input parameters. Following a presentation of SPEED at an ACM symposium in June 1970 and subsequent publication in "Computer Graphics," there have been about 30 inquiries and requests for copies of the programs.

Cost/benefit analyses of results obtained from experimentation with various terminal equipments and various communication facilities

were used in selecting equipment and facilities. Benchmark tests showed a marked improvement in performance of selected terminal devices when using a Milgo 4800 bps modem as compared to both the 201B modem (2400 bps) over the same leased line and the dial-up 201A (2000 bps) service. As a result, five sets of Milgo modems have been purchased and placed in service to take fullest advantage of the capability of the terminal. This has produced a saving of about $1200 per terminal and a performance improvement of 12 to 25 percent over leased modems. In addition, the Coastal Engineering Research Center has independently installed Milgo modems to replace their 201Bs and to achieve similar economies and increased performance. As a further test, a direct communications cable was installed between the NBS Supply Division's terminal and the 418 in order to achieve the full rated capability of the Noller Corporation DTS-114 terminal using a pair of 14.4 kilobit modems. The resulting improvement was impressive enough that the Bureau has placed a pair of these modems in full time operation for the Supply Division.

The Computer Services Division has established several channels of communications with its users in an effort to keep them up to date on both policy and technical matters affecting computer utilization. The computer itself is used to (1) print notices of current interest at the end of each printed output; (2) produce a comprehensive user's manual and maintain an up-to-date version

in on-line mass storage, and (3) maintain a list of known software bugs and tips on how to avoid them. In addition, frequent newsletters are issued containing technical information and advance notice of proposed system changes, enabling users whose programs are affected to plan accordingly. Most recently, an automatic response telephone was installed which provides recorded messages of current interest to users of the facilities. Occasional seminars presented by the systems staff serve to pass along "tricks of the trade," stimulating users to think about more efficient ways of using the computer. These communications are aimed both at better service to the users and at freeing systems programmers for more effective use by reducing demands on their time for one-to-one user counseling.

The Quick Query information retrieval system was obtained from the Economic Development Administration and implemented on the NBS UNIVAC 1108 for use by the NBS Office of Flammable Fabrics in constructing and interrogating a data base of fire accident cases. Subsequently, the Office of Fire Research and Safety and the Metric Study's Industrial Survey team were introduced to Quick Query as a relatively inexpensive and flexible approach to maintaining and interrogating data files.

For over three years, the Office of the Secretary, U.S. Department of Commerce, has received continual support from Computer Services Division in the operation and maintenance of

the Uniform Personnel System which is used to maintain a file of personnel records for the Office of the Secretary and 16 other Commerce bureaus and commissions. One programmer has recently been representing the Office of the Secretary in meetings at Civil Service Commission concerned with implementation of the Federal Personnel Management Information System.

For some time, Computer Services Division has been promoting the use of microfilm produced in lieu of computer listings for voluminous information that must be retained on file for lengthy periods. Several programs have been developed to assist users in using the S-C 4020 Computer Recorder for the preparation of microfilm,and a UNIVAC 1004 plug board has been made available to allow off-line printing of magnetic tapes which have been formatted for microfilm production. The NBS Supply Division was one of the initial benefactors of these efforts, switching to microfilm recording of some property management and standard reference material information. The Applied Mathematics Division is the most recent user of one of the print-to-microfilm programs, replacing large listings representing the results of mathematical library testing.

The Harry Diamond Laboratories' (HDL) Office of Technical Information has received programming and analysis support for the past five years. One of their most recent achievements was the introduction of a Selective Dissemination of Information (SDI)

system which is dependent upon computer programs designed and developed (in part) by Computer Services Division. The SDI system is currently furnishing HDL's technical staff with references to bibliographic information from the Defense Documentation Center, Engineering Index and INSPEC (Science Abstracts). The main program of the system was furnished to the NBS Office of Computer Information for possible use in information retrieval projects.

Programs were recently completed which processed data obtained from the Bureau of the Census and then used the results as a basis to calculate state and local shares under the Administration's Revenue Sharing Proposal. The method of calculation was suggested by the Treasury Department. The computer output was photo-reproduced and published by the Treasury Department for distribution to the Congress and other interested parties.

Installation of a paper tape reader on one of the NBS terminals and modifications to the 418 software provide a service not previously offered, allowing the labs to use data from their experiments logged on paper tape, as direct input to the computer without conversion. This is the first step in several improvements that are planned in support of NBS laboratory automation.

Significant contributions have been made by users in improving the quality of performance of the central facility. The Applied Mathematics Division, for example, has improved both the transferability and capability of OMNITAB, a scientific, numerical, and

statistical analysis program system. With the financial support and assistance of the Computer Services Division, they have started the effort on performance measurement of mathematical algorithms. This joint effort has already produced improved and validated mathematical subroutines with known accuracies and several linear programming routines with known characteristics. This early work will be the basis for more extensive work in performance measurement of mathematical software.

Thus far, data processing services during fiscal year 1971 have been provided to 45 divisions of NBS and to 50 organizations including eight executive departments, 12 agencies of the Government, the Congress, state and local governments, quasi-government organizations and universities. Total revenues and costs for FY 1971 are estimated to be $2,140,000. The revenue includes $14,000 from the CCST RTS base for training of applications programmers, and $60,000 from the NBS Director's RTS base to provide programming support to NBS RTS-funded projects. The FY 1971 costs and revenues for computer services are estimated to be $2,000,000. The revenue received supports a $105,000 effort in system modernization, $11,000 for implementation of FIPS, and a $15,000 effort in applications programming services for customer support but does not include the $30,000 from the Director's RTS base for improved NBS laboratory support. The remaining $140,000 revenue is directly billed for applications programming.

4. Hardware Design and Implementation

Public Law 89-306 (Brooks Bill) authorizes the Secretary of Commerce to undertake necessary research in the sciences and technologies of automatic data processing computer and related systems. The BOB guidance letter of December 15, 1966 advised the NBS/CCST to sponsor, monitor and undertake research and development activities in the computer and information sciences and technologies, including system design, oriented primarily toward Government applications.

During the fifties and early sixties, NBS was very active in the actual development of computers and logical elements. SEAC, DYSEAC, PILOT, AMOS, ACCESS and FOSDIC are all vivid examples of early accomplishments of NBS. Since the establishment of the CCST, its technical resources have redirected from innovatiion to application. By hardware application, we mean the process of employing computer marketplace components to implement a system design which is either not available, or for which the performance of system components cannot be determined by paper analysis alone In this case, working models have proven to be a most effective way to achieve confidence and acceptance of the new system. The CCST has pioneered in this application area.

a. High Altitude Nuclear Test Detection Studies (HANDS) Station

In collaboration with the ESSA research laboratories, CCST provided system design and actual hardware implementation of an

advanced computer controlled multi-sensor geophysical background monitoring station. A geophysical background consists of many different events that occur in the atmosphere and the ionosphere, such as lightning strikes, effect of sunrise and sunset on the propagation of VLF-UHF radio energy and solar flares which can create hazardous conditions in upper air for both high altitude aircraft and manned space vehicles.

The data collected by the station designed and implemented by CCST served to improve and also validate techniques employed by DOD in monitoring the occurrence of nuclear events on a world-wide basis. Total sponsorship was provided by the Advanced Research Projects Agency of DOD. Solar flare detection and warning service is provided to NASA and the Weather Services on a continuing basis by the station. Work began on this project in 1964 and continued through 1968 and was known as the High Altitude Nuclear Test Detection Studies (HANDS).

b. Automated Control of Sensing Instruments

As a result of findings from the HANDS project, the Air Force asked NBS/CCST to undertake a large task to apply procedures and system design for the development of a computer-based experimental field station to automatically control sensing instruments and perform correlation and analysis of events that occur in the geo-physical background.

A medium sized computer ($250,000) was procured and installed in the CCST Field Site at Ft. Belvoir, Va. Hardware necessary to

connect the output and control signals between complex sensing instruments and the computer was designed and fabricated utilizing off-the-shelf components.

The field station has been semi-operational for approximately one year and has demonstrated the capability to provide unattended control and collection functions. The automatic features of this system will be installed in the world-wide network of operational stations which will result in less need for manpower with a greater improvement in the quality and confidence in the data collected by these stations.

Design and implementation of this computer controlled station was initiated in 1969 and work will continue as previously planned and scheduled through 1971 and 1972.

c. MOBIDIC Computer Effort

Upon the deactivation of PILOT (a large vacuum tube computer), the CCST was left without a computer to use in its research and development, and without funds to procure a replacement. To fill a void, a 1960 vintage solid-state, van-installed computer was obtained from the Army at no cost.

After moving to the present site at Gaithersburg, Maryland, this computer known as MOBIDIC was augmented by interfacing two high capacity, high speed memory units, and four large disk files to the input/output channel. As an interesting sideline, the computer was made by Sylvania, disk files by Telex, disk controller

by RCA, and memory units by Ampex -- a good example of interface design using multiple source components. Concurrent with the augmentation, MOBIDIC was modified from a batch type computer to a time-shared configuration which could accommodate keyboards, CRT displays, and direct dial-up of communications lines.

Even though MOBIDIC does not have the speed and power of present generation machines, it has provided CCST researchers with access to a computer for investigating new concepts. Early work on fingerprint identification was done on this computer. It was connected, through a specialized interface, to a laboratory experimental set-up located in another part of NBS to provide real-time control and data collection and analysis. MOBIDIC is now employed in measuring the performance of time-shared computer systems located anywhere within the U.S. In essence, this computer monitors the dialogue between the user at a keyboard terminal and a remotely located computer, such as the GSA remote access computer in Atlanta, Georgia. This is one of the Center's first endeavors in the field of performance measurement related to the high priority Teleprocessing Program.

MOBIDIC has enabled us to build our competence in teleprocessing and control system design and will be gracefully retired when a node of the ARPA computer network is established in the Center during 1971-1972.

d. Machine for Automatic Graphics Input to Computer (MAGIC)

A large screen display (15" diameter CRT) complete with its own computer and memory was designed and constructed for use in the study of graphics, text editing, command and control, computer-aided design and other fields where large display areas and manipulated controls are desired. The console contains a joystick to position data points on the CRT, a keyboard for data entry, a light pen for spot identification, and a stylus-platten graphical input device known as a RAND tablet.

This display known as MAGIC (Machine for Automatic Graphics Input to Computer) was designed and assembled during 1966-1968 and is available for use by any researcher in the computer sciences and technology. The decision to embark on its development was made within CCST and RTS funds were used for implementation.

e. Computer-Assisted Calibration of Fluid Flow Test Benches

The Fluid Mechanics Division of NBS was requested by the Navy to improve the operation of fluid flow test benches used in calibrating and adjusting fuel flow controllers for jet aircraft engines. CCST provided engineering and construction assistance for selecting a minicomputer and interfacing it to the sensors and controllers on the test bench.

A prototype model has been completed and during acceptance tests, it has shown the capability to do more accurate calibration than the manual method and requires only 50 man-hours as against each previous 150 man-hours in the manual mode. As a result of

the excellent performance of this model, the Navy is procuring eight systems for installation in its Norfolk maintenance depot.

CCST became involved in this project in 1969 and will continue to assist the Navy and the Fluid Mechanics Division through 1971-1972.

f. Laboratory Automation

The predecessor of the Center, the Information Technology Division, initiated a program to foster the application of data processing techniques to scientific experiments within NBS laboratories. A series of modular data logging and control building blocks were designed and stocked for use by interested scientists at NBS.

Some of the early applications of digital techniques in experimental control were made possible by this program. The Center has continued to support and improve the hardware and design services to a growing number of requests for assistance by various NBS laboratories. Since 1966, CCST has both directly designed laboratory automation systems and assisted ten scientists in automating specific laboratory measurement processes. This spectrum of use ranges from pure physics research to chemical reactions and structure analysis in building research.

Other agencies have called upon us for assistance in employing automated measurement procedures in their laboratories. We have been approached by EPA and FDA to participate in the planning to perform specific engineering tasks related to the measurement processes needed in those two mission-oriented agencies.

g. Computer Tape Measurement Equipment

The measurement of the magnetic qualities of computer magnetic tape necessitated the development of a new precise electronic system to control a digital tape recorder and analyze the signals generated at the reproduce/record heads. Basically, the system consists of comparators, a precise power supply for reference voltages, current measuring circuits, and time history recorders.

At the request of GSA, an identical measurement system was constructed and calibrated for use in their facility where GSA now measures the magnetic qualities of computer tape submitted by industry for testing to determine its eligibility to be placed on the Qualified Products List of the GSA Purchasing Schedule.

With NBS and GSA both using the same equipment and procedures to produce the secondary standard reference tapes and also test for quality acceptance, the industry and government are using an identical "yardstick."

This system was delivered in 1970 to the GSA Magnetic Surfaces Testing Facility.

The accomplishments presented in this section are indicative of the nature of our hardware activities since 1965. This review portrays an orderly transition from component design to the application of hardware and related systems in solving unique problems within NBS and government. As the computer technology continues to grow and produce new devices, such as the versatile

minicomputer, the CCST looks forward to involvement with many agencies in the utilization of new principles and techniques offered by the marketplace and design houses.

5. Scientific and Technical Advisory Services to Other Agencies

The Brooks Bill authorized the Secretary of Commerce to provide Federal Agencies and GSA with scientific and technological advisory services relating to automatic data processing and related systems. The BOB Guidance Letter of December 15, 1966 instructed NBS to provide scientific and technological advisory and consulting services to executive agencies on automatic data processing. Upon request of Federal Agencies, the Center has, to the extent possible, provided direct assistance on specific projects and monitored the technical performance of commercial consulting contracts.

NBS has traditionally assisted agencies of the executive branch under the provisions of its basic organic act and subsequent modifications. During the early part of the 1950's, the Bureau assisted agencies in the solution of relatively simple problems (by today's standards) in computer utilization using the SEAC. One of the first applications of a digital computer in data management systems was the demonstration project sponsored by the old Bureau of Supplies and Accounts, now the Navy Supply Systems Command. When the Center was formed in 1965, requests for assistance increased, and in the last two years a noticeable increase in the demand for services had occurred.

a. ADP Management Advisory Services

In 1966 an extensive study was undertaken by a study team jointly sponsored by NBS-OMB-GSA upon request of the Assistant Secretary for Administration, Department of Health, Education, and Welfare. The purpose of this study was to determine department-wide future ADP requirements and to develop a plan for department-level policy, management, organization, and control which would best provide for the efficient continuing evolution of information systems and the provision of data processing services for HEW's constituent agencies and the Office of the Secretary. This study was particularly sensitive since it dealt with organization and responsibility at the Assistant Secretary office level.

Similar problems on a smaller scale are represented by studies of the ADP organizations at the Agency for International Development and the Office of Business Economics in 1967. Both of these studies dealt with ADP organizational responsibilities, methods of operation, and general ADP policy. Consultative assistance was given to the Labor Department the same year in a general Department systems planning and review study.

b. Automated Fingerprint Identification for the FBI

From time to time, other Government Agencies request NBS (CCST) to determine feasibility, perform exploratory research, and develop prototypes for special applications that are usually unique and for a specific Government need. An example of this was a

request from the FBI for assistance in automating its massive fingerprint identification system.

In 1965 the FBI asked NBS for advice on the possibility of automating its manual identification system which currently processes over 30,000 inquiries a day against a fingerprint file containing the arrest records of more than 19 million individuals. After experimenting with fingerprints for two years (NBS supported research), NBS concluded that it seemed feasible to automate the system.

Since then, as a consultant to the FBI, NBS has assisted the FBI in the contracted development of a device for reading and digitalizing the positions and directions of minute details (ridge endings and forks in the ridges) directly from inked fingerprints. The minute details which are used by fingerprint technicians for positive identification can be machine read in approximately one second. A prototype reader, being built by the Cornell Aeronautical Laboratory, will be installed at the FBI in early 1972.

The National Bureau of Standards has also developed a technique whereby a computer or special device can utilize this machine read minutiae-data to identify an unknown fingerprint. Identification is accomplished by comparing the patterns of the minute details of an unknown fingerprint with the patterns from the fingerprints in a large file. While the match processing is currently performed by a general purpose computer, it is expected

that the FBI workload requirements can be more economically met by a special purpose processor whose design is optimized for the matching process. NBS has conceived a design approach for such a processor. This can serve as the basis for a developmental contract at the appropriate future time.

It has been estimated that an automated fingerprint search will cost less than a third of the present cost for a manual search. The work by NBS (CCST) will assist the FBI Identification Division in handling heavier workloads and will lead to advances in detecting the perpetrators of crimes through fingerprint identification. In particular, it will become possible to automatically search a latent fingerprint found at the scene of a crime against the file of all recorded fingerprints and thereby reduce the percentage of hitherto unsolvable crimes.

c. System Design for the Immigration and Naturalization Service

In 1967, CCST assisted the Immigration and Naturalization Service with a short study to determine the economic and program accomplishment feasibility of automating the Service's large name-index files. This was followed later by a one-year effort to more fully define system characteristics for design purposes. During this portion of the study, more than 12,000 requests for searches were evaluated for degree of match on name parts and other identifying attributes. Approximately 100,000 records were subjected to these type analyses. As a part of this analysis, rules for handling certain foreign name characteristics were

determined and a program was written for Soundex Coding based upon the rules. The end product of this joint effort was a conceptual systems design with sufficient system specifications for vendors to bid on the final systems design and implementation. The Service was thus able to go out to contract with the assurance that the resulting system would meet at least minimum expectations such as the percent of names which could be matched or the numbers of possible matches (misses) if certain attributes were missing.

d. U.S. Post Office Mail Directory System

In 1969, the CCST was called upon by the then U.S. Post Office Department to assist in monitoring a "turn key" contract with the Burroughs Corporation for the design and implementation of a mail directory system. The problem was one of readdressing an estimated 13,000 letters a day for servicemen in the war zones of Viet Nam who, through transfer, hospitalization, or other causes, were no longer at the anticipated address. The Burroughs concept was to couple existing mail-handling equipment, teletypewriters, self-adhesive labels, and a computer into an "Automatic Mail Directory System," AMDS. The CCST role was one of identifying, isolating, and defining problems and possible solutions in order to expedite system implementation. This covered a range of activities from assisting with the predelivery systems test to designing a work shelf for the teletype stands.

e. Development Work in Computer Display Techniques for the Navy

In the period from 1966 to 1968, the CCST conducted an exploratory program in advanced computer-driven display techniques for the Naval Electronic Systems Command. The primary objective of this project was to assist in the preparation of procurement specifications for advanced displays to be installed at the Navy War College in Newport, Rhode Island. Problems addressed included those of interfacing displays to computers and of the man-machine interface by which control actions could be entered from a number of control areas.

f. The Army TACFIRE System

In the spring of 1967, NBS was asked to assist the Army Automatic Data Field Systems Command in the selection of a contractor for development of the TACFIRE computer system. This system is based upon the use of mobile computers with special displays and remote terminal devices for the support of field artillery calculations and other data processing functions. A team of NBS computer specialists was assembled which attended design reviews, participated in a protracted proposal evaluation, and has continued to attend contractor progress reviews. NBS assistance has been directed almost exclusively to software. Qualification testing of various software items, such as the Compiler, Operating System, Maintenance Routines, and Programming Aids is now getting underway. The Engineering Test/System Test phase will be initiated following these tests.

g. Teleprocessing for the Public Health Service

In 1969, a research project was completed for the U.S. Public Health Service. This was a study of the intercommunication of medical information among hospitals and medical facilities. The purpose was to determine the type and quantity of information to be transmitted, its sources and destination, and the ways in which it would be used. This information would serve as the basis for the development of interfacing techniques, including terminal devices, codes, and procedures to permit the desired information transfer to be achieved effectively, with the requisite accuracy, timeliness, and security. The study was conducted jointly with the National Center for Health Services Research and Development and was envisioned as the first phase of an expanded effort. However, emphasis within the sponsoring agency moved in other directions at the conclusion of this project.

h. Image Processing for the CIA

During 1967-1968, a project in Image Manipulation was established at NBS for the CIA. This involved the investigation of techniques whereby halftone images might be processed digitally for use in studies of subjective recognition procedures. Photographs were to be manipulated in various ways to determine the effect on an observer's ability to perceive them. Algorithms were to be developed by which the images might be enlarged or diminished, relocated, blended with the background by a process

analogous to photographic "dodging," and subjected to variations in texture. This project was a joint effort involving several researchers at NBS and outside organizations including the University of Maryland, Auerbach, and EBS. The NBS contribution included a set of routines for blending an image with its background in varying degrees through the use of appropriately modified "noise" patterns.

i. Optical Character Reading Devices for the Post Office

From 1969 to 1970, a project was conducted for the Post Office Department in the optical character reader (OCR) readability of printed mail addresses. The CCST assisted in preparing a specification for machine-addressed letter mail in order to assure readability on OCR-equipped letter sorting machines being installed by the Post Office. A quantity of these machines was in use on an experimental basis at the time that the project was initiated. It was necessary to study the performance of these machines, determine the parameters affecting OCR readability, and establish suitable limits for these parameters. Recommendations were needed of measurements that were capable of being performed with readily available commercial equipment. The use of OCR in this application contrasted greatly with the conventional use of OCR where the most rigid controls are placed on all aspects of the preparation of input documents. For the Post Office application, there is practically no control of the preparation of incoming material,

so the OCR readers must be capable of operating over very wide limits. This is offset to some extent by the fact that reading errors do not have the critical effect that they might have in conventional OCR applications. Fortunately, the characteristics of printed addresses are such that the equipment rarely mis-sorts any mail; it usually rejects anything which cannot be sorted accurately. Use of the automatic equipment is economic even with relatively low "accept" rates, because it is so much faster than hand sorting. A draft specification for the Post Office was developed by NBS as a result of several experimental runs using an extensive collection of mail samples.

j. Aircraft Identification Procedures for the FAA

The FAA is continually confronted with the demand for more precise control of aircraft flying in the National Air Space. One of the most difficult tasks that has plagued air traffic control since its beginning is that of aircraft identity. A system has been planned that employs techniques developed during World War II for identifying "bogies," namely IFF. In essence, each aircraft flying an airway on either IFR or VFR will be equipped with a transponder which when triggered by the ground control radar will transmit to the control center an assigned identifier code. This code will enter the computer driven CRT displays now used quite extensively by air traffic controllers.

Presently, there are 4096 distinct codes available to FAA, and there are more than 21,000 flights per 24 hours in the U.S. Therefore, one can readily observe that a scheme for optimum code assignment is needed. FAA asked the Center to simulate the airways and develop several code assignment plans for identifying aircraft. The NBS 1108 computer was employed for this simulation using a simulation program called "Simscript." A report has been completed on this phase of the program, and a second phase will begin in FY 72 which will address the problems expected during the transition from a relatively simple semi-automatic system to the fully automatic 4096 code identification system.

k. Microimage Work for the National Library of Medicine

In 1966, the National Library of Medicine requested assistance from CCST to improve their microfilming operation in order to capture for archival purposes the contents of old medical texts and documents, some of which date back to the 1700 era. This program is still active and has been expanded to include the generation of better procedures for the everyday operation of the Interlibrary Loan Service. During the past year, the CCST established the requirements for an automated microfilm document image retrieval system with computer controlled capabilities. During the contractor development of this device, the Center monitored the technical activities and will play an important role for the NLM in the installation and acceptance phase.

1. Computer Selection and Evaluation Services

The Center is often called upon to assist agencies in the selection and evaluation of computer and associated systems. A listing of such services provided follows:

1. Reviewed in detail for the National Center for Health Statistics a Request for Proposals and made recommendations for improving the RFP and the selection process. - 1966
2. Assisted the Patent Office in determining the suitability and procuring of a computer being released from another Government activity for Patent Office needs prior to releasing an RFP. - 1967
3. Assisted the Peace Corps in the selection of a computer. This involved helping the agency develop criteria and procedures for selection. Helped in the analysis of proposals and benchmark results leading to the selection of an RCA 70/25. - 1967
4. Assisted the National Labor Relations Board in a feasibility study to determine the costs and advantages of procuring a computer to replace a punch card system. - 1967
5. Assisted the Labor Department in a general Department systems planning and review study. Assisted in the selection of a computer. - 1967

6. Assisted the Bonneville Power Administration by reviewing their specifications and evaluation procedures in terms of their objectives and made recommendations for improving the RFP and the selection process. - 1967

7. Wrote an RFP for the Patent Office and assisted in the proposal evaluation and selection for a computer with remote terminals to improve the document location and status operation associated with patent processing.- 1971

m. Prevention of Intentional Destruction of Magnetically Recorded Information

Senior management in the Government, industry, and commercial firms have expressed deep concern over recent attempts, with occasional successes, to disrup computer operations. One sensitive problem area is the maintenance and storage of computer magnetic tape. Many misleading and erroneous statements for example have been made about the ease with which one can damage magnetically recorded data on a reel of tape using hand held magnets. As a result of the varying opinions on this subject, OMB asked the Center to investigate the vulnerability of computer tape files when exposed to magnetic fields.

Using the precise measurement system for calibrating the secondary reference tapes, a series of controlled experiments was performed which exposed pre-recorded tapes to many sources of magnetism all the way from small paper hanging magnets to a large magnetic crane in a local scrap metal yard. The findings along with rule-of-thumb guidelines for tape protection have

been forwarded to OMB and in the near future this information will be transmitted to ADP managers.

It has long been established that a very important element in the NBS program structure is the provision of advisory services to other agencies. When the CCST participates in solving real problems of the real world, its perspective is broadened and it obtains a better feeling for the direction in which limited R&D RTS funds should be spent. The impact of the ADP Standards Program is just beginning to be felt by the Government users, and in the future much of our effort will be needed to advise agencies on how to implement standards on old and new computer hardware and software systems. Likewise, an increasing awareness of the role of teleprocessing will result in an increased call for assistance from the CCST. New devices, continuing software developments, and complex computer architecture will make it extremely necessary for the CCST to maintain a high competence in the fields of software management and computer utilization.

In summary, the Center's responsibility to provide other agencies with advisory and technological services will continue to be of utmost importance and requests for services will occur more frequently as computer technology advances and more applications are identified.

6. Software

Crucially important to the effective utilization of computers, the furtherance of which is laid upon the NBS by PL 89-306 (Brooks Bill), is effective, reliable software to control the operation of the computers and to provide the service which the Government seeks from computer installations. Much CCST work falls under the stricture of the BOB guidance letter of December 1966, "to initiate efforts to solve large-scale and difficult problems sufficiently unique to special needs of Government that outside interests are not likely to undertake vigorous and timely action."

The CCST since its establishment -- as well as the antecedent organizations since the early days of computers -- has worked to assure the availability of computer programs appropriate to the fundamental operation of computers and to the solution of a wide range of mission-derived problems. Much of this work has been accomplished by writing specific computer programs; progressively more of the service has been provided by evaluating and validating existing computer programs and by disseminating directories of available programs.

Synergistic augmentation occurs between CCST activity in software research and development and the technical and advisory services it provides to other agencies. The expressed needs of other agencies highlight those technical areas most urgently requiring work; the hands-on experience of the CCST staff puts

it in a position to provide effective assistance to the other agencies. Often as a result of advisory services given to other agencies CCST is called upon to undertake a specific development task.

The value of the services provided to other agencies and of the supporting research can sometimes be measured in dollars or man-years; more often the measure is in increased effectiveness--being able to do things better than before or even to do what was previously impossible.

The following discussions show the wide applicability throughout Government of many technologies. Indeed, CCST has helped virtually every Federal Department and many of the independent agencies. The missions of the agencies, conversely, often draw on several technical areas in which we are active. Thus, the Defense Communications Agency has required both intensive systems analysis and the processing of two-dimensional information, and the U.S. Patent Office has called on us for systems analysis, science information processing, and application systems design.

a. Data Management Packages

Government Agencies call upon the CCST to assist them in choosing computer program packages appropriate to carrying out their respective missions. Since 1966, we have evaluated data management packages or developed specifications for at least eight Agencies.

AID asked the CCST in 1966 to determine which of the then-available software packages to use for mechanized handling of its Technical Assistance Program intelligence data. A similar request from the Assistant Secretary of Commerce for Science and Technology in 1967 concerned mechanized handling of Government-sponsored computer science project descriptions. A total of 17 software systems was examined in these two studies. The computer science project information is now accessible on the DDC system; AID implemented its first automated information system by using the Formatted File System.

Nine commercially available data management systems were evaluated in 1969 against the requirements of the Public Health Service to make the health records of Federal employees adequately accessible under the constraints of the hardware available to the PHS. The PHS now has a pilot system operational at two of its facilities.

The Urban Information System Interagency Committee (USAC) is trying to assure the transferability from city to city of the techniques developed under its sponsorship. A 1970 study by CCST revealed that none of 160 data management systems fulfills the transferability and applicability criteria. This study convinced USAC and HUD that extensive additional work is required to achieve the pervasive improvements that they seek. CCST, in cooperation with the Technical Analysis Division, is currently assisting USAC in identifying, aggregating,

and analyzing major differences among the various participating municipalities.

The Department of State came to CCST in 1970 for help in making its files of documents, which accrue at the rate of 500,000 per year, effectively accessible to about 400 key users. Of eleven currently operational systems the RECON system of NASA was chosen and is expected to suffice for the next five years. Thirty additional agencies and offices have requested copies of our report on this work for their guidance.

The formulation of systems specifications permitted the Analytical Chemistry Division (NBS) in 1970 to arrange for output reports of graphic art quality from their activation analysis bibliographic data base. In addition, a computer program is presently being produced which will give access to this file via more complex and specific questions than can be accommodated by present, laborious manual methods. A feasibility study in 1971 for the Water Quality Office (Environmental Protection Agency) resulted in an RFP on the basis of which the EPA could solicit bids for a system providing real-time access to information.

b. Application Systems Design

During the period 1966 - 1971, CCST has provided operational computer programs for information processing to some seven organizations.

Following up on an advisory study for the Division of Radiological Health (PHS) covering the entire radiological health survey reporting system, the CCST converted the Pasteurized Milk Network File to the Formatted File System, enabling the production of reports conveying analyzed data within two weeks instead of six months and by two persons instead of eight.

In response to a request from the Property Review Board (Executive Office of the President) the CCST provided in 1971 systems analysis, computer programming, and computer processing to fit the GSA real property inventory into the Quick Query file system. When special reports were previously required months of effort were needed for manual compilation or for special programming effort. Now special compilations are available within 12 hours.

Similar assistance was provided in 1966 and 1967 to the Department of the Treasury in establishing and making operational a central computerized system for recording and reporting the status of all loans or grants to foreign entities made or guaranteed by the U.S. Government. The system facilitated meeting the reporting requirements of the Foreign Assistance Act; it gave the Treasury better and more timely access to the data required both in its international cooperative role and in the financial analysis required domestically.

A system currently being programmed by the CCST for the Navy Medical Services Center will provide periodic reports for use directly in such publications as "Statistics of Navy Medicine" during the same month as the last raw data are supplied. This system will replace one man-month of clerical effort with 12 hours of computer use, and perhaps more significantly it will release the equivalent of one full-time statistician.

In 1968 the Agricultural Research Service asked the CCST to design and implement a completely automated accounting system meeting the specific requirements arising out of largely decentralized operation. Between then and 1971, the CCST designed the system, programmed the entire system, and trained Agriculture staff to run it. The ARS thus met, with one and one-half years to spare, the GAO requirement to change to cost accrual accounting. The processing provides more timely reports and has permitted consolidation of three financial administrative divisions into two.

The National Labor Relations Board publishing of its hearings records used to involve as many as five re-typings. An editing and photocomposition routine designed and implemented by CCST not only saves the NLRB $150,000 per year but also reduces the time elapsed from the filing of a claim until the formal publication of a finding by about ten months.

For the U. S. Patent Office, the CCST designed and implemented in 1970 a text processing program to monitor the quality of input data containing multiple type fonts, Greek letters, special symbols, and page arrangements. The input error rate has been reduced by a factor of 10.

A system to produce a whole range of library bibliographic materials in graphic arts quality from a single keyboarding was designed and implemented in 1967 at the request of the Council on Library Resources. Several of the basic concepts were adopted by the Library of Congress and other agencies in developing their automated library systems. More tangibly, the Library of Congress has been able to reduce by 70 the number of GS-4 clerks required for publishing its title, author, and subject index cards. A similar undertaking in 1970 for the Analytical Chemistry Division (NBS) saved the equivalent of one full-time position and reduced by one-third the number of pages published in its bibliographies, at a saving of $18 per page in printing and distribution costs.

CCST personnel recently began designing a photocomposition system for the Office of Solid Waste Management (Environmental Protection Agency) to print the myriad reports prepared by over 100 grantees. Despite going to graphic arts quality, a savings of $750,000 per year is anticipated, exclusive of the savings from handling one-third less paper.

c. Science Information Systems

A research and development project provided the Biotechnology and Resources Branch of the National Institutes of Health with a

prototype pharmacological information storage and retrieval system.

Based on earlier work, the CCST developed during 1968 to 1970 a set of computer programs on its UNIVAC 1108 which permits access within the same system to both chemical structure information and information about the characteristics of chemical substances. The resultant system provides for the first time for chemical substructure search as an integral part of retrieval also seeking descriptive and numeric information. The descriptive and numeric portion is suitable by itself for files having nothing to do with chemistry. The chemical structure portion was recently adapted by CCST to serve a U. S. Patent Office requirement for classifying patents according to the structure of chemical substances mentioned.

The CCST has recently undertaken to define the overall science information requirements of the Bureau of Narcotics and Dangerous Drugs (Department of Justice) and to propose a system for handling drug information. We must pull together the many requirements for information within the Office of Scientific Support and study the applicable systems currently available elsewhere. Readier access to information translates into quicker response to new drugs appearing on the street.

d. Systems Analyses

Since 1965, CCST has been providing technical support and guidance to the Defense Communications Agency in the task of planning, designing, and managing large complex switched networks

with attention to attack susceptibility, reliability, cost, availability, and other indices. For the last six years, CCST has been assisting DCA in developing quantitative measures of network survivability. Computer programs developed by CCST and under contract are being used to identify especially important links. A heuristic program developed by CCST to minimize telephone line rental costs identified changes leading to savings of about $1,600,000 annually, under the TELPAK tariffs then in effect.

During 1970, CCST worked closely with the U.S. Patent Office in devising a plan to realize an operational computer-aided classification procedure for its holdings of about 7,000,000 domestic and foreign patents. The joint task group recommended that only state-of-the-art techniques be relied upon, that emphasis lie on a lexicographic approach to text processing, and that separate attention be given to the problems posed by chemical patents. CCST is conducting linguistic analysis of patent English in support of the lexicographic approach. If more effective organization of the patent collection were to permit reduction by 25% of the time spent for search, then for a corps of 1000 examiners an annual saving of about $2 million would result.

e. Two-Dimensional Information Processing

The Center has responded to requests from the Department of Defense and the National Institutes of Health to address the problems of display of two-dimensional information and analysis of the structure of such information.

Programs produced for the Defense Communications Agency during 1970 and 1971 plot on overlays for Operational Navigation Charts an arbitrary number of geographically designated points marked and labeled in accordance with user requirements and with circles of different diameters drawn about them.

A typical run of 12,400 points uses 70 minutes of computer time and about 200 hours of plotter time in contrast to about one man-year if the points and associated information were to be plotted by hand.

In 1969, CCST undertook a basic research project addressing both analysis of chemical structure diagrams and their display in support of the National Institutes of Health's program to design an adequate pharmacological data management system. The display program accepts as input linear notations which represent chemical structures and plots properly oriented chemical structure diagrams. During 1969 and 1970 CCST applied linguistic techniques to the analysis of chemical structure diagrams. The results of our work were utilized in their own research by NIH staff and were also part of the basis for the design specifications of the Biotechnology Division for its on-line pharmacological information system. Partial publication of the results of the analysis work has evoked interest from chemical industry in the U.S., the United Kingdom and Italy, and from the Jet Propulsion Laboratory.

Upon request originally from the Army and subsequently from the Air Force, CCST staff conducted until 1968 a linguistic analysis of Chinese characters aimed at facilitating the input and output required for processing Chinese text. Based on an explication of Chinese characters a computer program was written which permitted the geometric construction, on a cathode ray tube, of Chinese characters from a dictionary of components. The analysis was instrumental in designing a method to differentiate among several possible readings for poorly printed characters.

Since 1969, CCST has cooperated with the Applied Mathematics Division supporting both hardware and software aspects of an NIH project involving the automatic operation of an optical microscope in scanning medical and biological speciments. Under computer control a mechanized microscope scans around each point specified by the histologist. By use of a sufficiently large remote computer, interactive display and manipulation of scanning images is provided and statistics are derived from the scanning data. With this system, the histologist can isolate data of interest within minutes instead of hours or days and indistinct biological structure in brain tumors can be detected.

f. Real-Time Monitoring

A real-time monitor has been implemented, by adapting the monitor supplied by the manufacturer of the EMR 6135 computer

to the needs of the Analytical Chemistry Division, to acquire data from laboratory instruments, to store them for later analysis, and to provide a control loop for those instruments. The system is designed to allow the experimenters to initiate an experiment at any time and to allow up to about 50 experiments to utilize the computer concurrently. A system of priorities assures that data from the instruments are captured and stored. The first online experiment is currently being debugged.

The same system could be used by many laboratories which produce quantifiable data for the direct, automatic acquisition of laboratory data in a form for prompt computerized analysis. If such a system conservatively estimated saves the equivalent of one day per week per worker, and if the cost per worker including depreciation of equipment is about $50,000 per year, then a long-term saving (for the same amount of work) of about $10,000 per worker per year is implied.

g. Computer Languages and Programming Aids

Certain problems arising in physics involve complex mathematical derivation which require analytical rather than numerical solution and thus require a symbol manipulation language. During 1967 and 1968, an interpreter for LISP was implemented on the NBS computing facility. Its first practical use was the analytic solution of an important problem in plasma physics involving non-commutative differential operators.

Problems in linguistic analysis of text require a different kind of symbol manipulation. A grammar generator was implemented

as a programming aid, in 1970, using the SNOBOL language on a UNIVAC 1108 operating under the EXEC 8 time-sharing monitor. This work provides a tool to agencies, such as the U.S. Patent Office and the Department of State, which use a linguistic approach to the classification of their document holdings.

None of the higher level languages (such as FORTRAN, COBOL, or LISP) available in 1966 provided detailed access to all parts of a computer storage word as required by programs for chemical structure processing used by the U. S. Patent Office and for image processing being done by the Metallurgy Division of NBS. Similarly, no programming language provides higher-level commands of the type needed for laboratory data gathering. Two distinct language design projects were therefore undertaken. In 1966, NEMO was designed to provide the "bit-picking" and Boolean processing facility of an assembly language but without being tied to a specific computer; it was implemented in 1967 on the UNIVAC 1108 and used in 1967 and 1968 for programming a chemical structure search program for the U. S. Patent Office and NIH. LLLAMA was designed in 1969 as a machine-independent laboratory processing and control language, oriented towards the typical small laboratory computer. Its features have influenced the design of CCST's laboratory automation programs for Analytical Chemistry and NIH.

The problem of file maintenance, file access, and file transferability have been tackled with programming languages designed for the purpose.

DRL, under development at CCST since 1970 as a data storage and retrieval language, contains a set of retrieval commands keyed to access not via the usual route of file position but rather via the nature of the data actually being sought. This language is being implemented as a preprocessor for FORTRAN and is, in principle, transferable to any computer installation with a FORTRAN compiler. The potential impact of better file access can be illustrated by the fact that there exist at least 40 data banks in the Government with information about chemical substances, but no two of these can presently exchange information.

h. Software Inventory

The proliferation of computers in the Federal Government has resulted in ever increasing expenditures for computer software (programs) of all kinds: in 1970, the Government spent over $182 million for programming and related services. The CCST has had under continuous investigation the feasibility of providing a centralized service that will facilitate sharing general purpose computer programs and thus minimize replicative programming activities.

The Center has collected some 60 indexes, directories and catalogs containing descriptions of programs available for shared use in both the public and private sectors. Seven of the more useful ones have been identified and are now being incorporated into a permuted title listing for more efficient and effective

search and retrieval. The primary objective of this effort is to ascertain the existence and availability of programs and to refer potential users to their sources; a corollary objective is to delineate a minimal set of data elements, including a system of classification, for describing a program so that a decision can be made on its applicability to the solution of a given problem with some reasonable probability of satisfaction, and to define a minimal level of supporting documentation. If a reduction of even 5% of the 1970 costs noted above can be reached by more effective program sharing, and it certainly appears reasonable, the estimated savings will be on the order of $9 million.

i. Summary

The construction of computer systems to individual requirements is often very costly and time-consuming. The CCST often serves Government by identifying existing computer programs that may not be ideal but are entirely adequate and by adapting existing programs to accommodate some special requirements. Some government missions are supported by research in areas of special CCST competence. Systems analysis plus related skills and tools, including management studies, heuristic approaches, simulation, operations research techniques, linear programming and linguistic analysis have been used in the last few years to achieve the accomplishments described above. CCST has been

able to save significant amounts of money to help provide for the common defense, to support the useful arts important in our economy, to facilitate one step in ameliorating the plight of our cities, to improve health service and to support health research, to increase the effectiveness of government data bases, and to disseminate useful computer software.

ATTACHMENT 1

1972 ISSUE STUDY

THE ROLE OF NBS IN FEDERAL AUTOMATIC DATA PROCESSING

BY

THE NBS CCST ISSUE STUDY COMMITTEE

A. Statement of Issue

What can be done to make the contribution of the National Bureau of Standards more effective in implementing the Brooks Bill (PL 89-306, 79 Stat 1128)?

B. Significance and Background of Study

Under the Brooks Bill, NBS is authorized to: (1) provide scientific and technological advice to other agencies, and (2) make recommendations to the President relating to the establishment of uniform Federal ADP standards. In addition, the Secretary of Commerce is authorized to undertake such research in the sciences and technologies of automatic data processing computer or related systems as may be required to support these two functions. In addition to implementing the Brooks Bill, the CCST has a number of other responsibilities that derive from the NBS enabling statutes as amended.

NBS has identified several areas in which benefits might accrue from more efficient and effective use of automatic data processing throughout the Government. Many of these areas require cooperation from other agencies for which no mechanism has been established. For NBS to so enlarge its activites under the Brooks Bill, a means to establish such

a mechanism may be needed. The areas themselves must be examined to determine what mechanism is appropriate. More information on Government ADP operations may be needed in order to identify problems and formulate recommendations for changes in current activities and in such areas as training and installation management. This would involve examination of present ADP expenditures and management practices throughout Government and formulating recommendations for program options for consideration both within and beyond the scope of present NBS work. New program options would also have to be examined in the light of NBS legal authority.

C. Specific Objectives of Study

1. Identify problems in Government automatic data processing that affect objectives of the Brooks Bill; and related to these problems identify present practices, alternatives to present practices, resources required in and out of NBS to implement the alternatives, benefits to be derived from the alternatives, and risks or constraints involved in alleviating the problems.
2. Determine whether NBS or other agencies need additional authority or policy guidance, and what fact finding studies, any, are necessary to contribute to the reduction of problems identified in 1 above.

D. Hypotheses

1. Areas of Work - The perspective of NBS might be expanded to cover not only the areas specifically emphasized in the Brooks Bill and

the BOB guidance letter of December 1966, but all aspects of Federal automatic data processing. This could involve expanding or reducing NBS activities in some of the areas in which it is already working and also initiating work in areas in which NBS is not already working.

2. Authorization - Additional legislative authority is assumed not to be necessary since the Brooks Bill may be interpreted as authorizing NBS to work for efficiency and economy in Federal automatic data processing without restricting it to the areas identified in the Bill. However, new BOB guidance may be required to specifically interpret the Brooks Bill to include the required additional areas; and legal questions of authority will be reviewed at the conclusion of the study.

3. Other Agencies - Closer liaison than ever before may be required with other agencies, particularly their ADP installation and ADP management personnel. The study may consider whether BOB would have to advise specifically other agencies regarding their relationships with NBS. This advice could include:

    a) Support of FIPS Task Groups

    b) Unified Government action on voluntary standards

    c) Information reporting to NBS

    d) Acceptance of uniform Federal ADP management practices

    e) Training of Federal ADP personnel

f) Advisory and consulting services and sponsored research

g) Other topics?

E. Scope

The study should give specific attention to the following major areas of interest:

1. Standards - Evaluate progress in satisfying the Government's needs for ADP standards. Provide recommendations for increasing the effectiveness of NBS in meeting these needs. Consider the following:

   a) What specifically are the Government's most pressing needs for standards? How do you view current progress in meeting these needs?

   b) How best can these standards be achieved within the desirable time frame? Evaluate present approaches, such as ANSI and FIPS Task Groups, and consider alternative approaches.

   c) In what alternative ways can NBS (CCST) make significant contributions to these objectives?

      - What resources are available and required?
      - How can requirements be met (persuasion, fees for services, additional appropriations, etc.)?

   d) Emphasis in this area is currently placed on hardware, software, and data standards. What consideration should

also be given to the need for the development of standards for applications?

e) Two types of risk are associated with the standardization process. The first is the risk of failing to standardize where compatibility is needed, and the second is the risk of standardizing at the expense of slowing down technological improvement. How do you assess the costs associated with these two types of risk and balance them one against the other?

2. Performance Measurement Techniques - This issue relates to the need for techniques to both validate and evaluate ADP products. It includes the need for techniques to test products for compliance with ADP standards. The techniques should apply to hardware, software, and systems and should be based so far as possible on quantitative measurements.

a) Validation - This refers to verifying that a product or system does, in fact, possess a particular property or perform in a specified manner. Of immediate interest are techniques for measuring the compliance of compilers with COBOL or FORTRAN standards. Also important is the validation of producer's claims as required for the Federal ADP products catalogue recommended in the report of the Charlottesville conference. Who should be responsible for validation?

b) Evaluation - This refers to making a determination as to how well a product or system performs a particular function, usually the carrying out of its intended purpose. In the development of performance standards, there are two aspects of the problem: (1) the development of appropriate yardsticks, and (2) the specification of numerical values on them. Who should carry out these two functions?

3. ADP Management Guidelines - This issue relates to the need for guidelines in various aspects of computer use. It should include means by which management can measure (and evaluate) the overall performance of its computer installations. Possible subjects include systems studies, ADP procurement techniques, selection, operations and evaluation.

4. Coordination and Use of Agency Efforts in Achieving Government Objectives - Work undertaken by agencies on a unilateral basis to to serve their own requirements can often benefit other agencies. Primarily as an aid in performing its own program responsibilities, but also in its role as technical consultant, should NBS consider ways and means for identifying and coordinating such work and exploiting it for Government-wide use. Examples include:

a) COBOL compiler validation techniques developed by Navy and Air Force which could be considered by NBS for adoption as a Government standard, with minimal NBS development effort.

b) I/O interface techniques developed by Livermore which might have application elsewhere.

c) Performance guidelines and practices, such as documentation guidelines, selection and evaluation criteria, "good programming practices," and installation evaluation techniques. These might be adaptable as Government-wide guidelines with only slight modification by NBS.

d) Research, development and applications experiences which have Government-wide utility.

e) Computer programs which might be usable in other agencies.

5. Training - Examine the need for a Government-wide ADP training facility, including: cost of start-up, operating cost, type of training, manner of funding, appropriateness for NBS, Civil Service Commission or Department of Labor?

6. Other Work Programs - Identify contributions to the Brooks Bill objectives of other agency reimbursable work, other direct-funded programs, and services to other NBS programs. How might such work better contribute to Brooks Bill objectives while still accomplishing its primary purpose?

The NBS Issue Study Committee

J. Harrison, Chairman
M. Fox
E. Keren
C. Meadow
R. Moore
T. O'Neill
B. Ramsay

EXECUTIVE OFFICE OF THE PRESIDENT

BUREAU OF THE BUDGET
WASHINGTON, D.C. 20503

ATTACHMENT 2

April 7, 1970

Honorable Larry A. Jobe
Assistant Secretary
for Administration
Department of Commerce
Washington, D. C. 20230

Dear Mr. Jobe:

As was indicated in Director Mayo's letter of March 18 to Secretary Stans, it was anticipated that additional program issues would be identified and requested for intensive analysis. Our respective staffs have identified the following program issues:

1. Automation of Weather Service Activities
2. Hurricane Modification and Control
3. The Role of NBS in Federal ADP Operations
4. User Demand for Patent Office Products and Services
5. Comparative Analysis of International Programs to Stimulate Exports

Further details and specifications of the issues are set forth in the enclosures. These specifications have been developed jointly by our staffs and we understand that agency analysis on these issues is already underway.

As your letter of March 25 indicates, my staff had agreed to extend the deadline from May 1 to June 1 for receiving drafts of the major program issues identified in Director Mayo's letter of March 18. Unfortunately, the timing of the Director's review of the major Commerce program issues has been accelerated from mid-June to late May or early June. Therefore, if it is at all possible we would appreciate receiving the Commerce drafts by May 15. With regard to the program issues identified in this letter, we would appreciate receiving your draft submissions by June 15 and the final products for both the major program issues and the issues identified in this letter by no later than September 15.

We understand that you plan to submit draft Program Memoranda to us by June 1. If it is at all possible we would appreciate draft

submissions by the middle of May, especially for ESSA and DIB. Final submissions should be transmitted by September 15.

As your letter indicates we are also hopeful that the products discussed above will be useful to both agencies in determining funding requirements for 1972.

Sincerely,

John D. Young
Director, Economics, Science,
and Technology Division

Enclosures

1972 Program Issue

The Role of NBS in Federal ADP Operations

A. Statement of Issue

What can be done to make the contribution of the National Bureau of Standards more effective in achieving greater efficiency and economy in Government ADP operations, as envisioned in the Brooks Bill (P.L. 89-306)?

B. Specific Objectives of Study

1. Identify problems in Government Automatic Data Processing operations that affect objectives of the Brooks Bill; and related to these problems, identify present practices, alternatives to present practices, resources required, benefits to be derived from alternative practices and the risks or constraints involved in alleviating the problems.

2. Determine whether NBS or other agencies need additional authority or policy guidance and what fact finding studies, if any, are necessary to contribute to the reduction of problems identified in 1 above.

C. Scope

The study should give specific attention to the following major areas of interest:

1. Standards - Evaluate progress in satisfying the Government's needs for ADP. Provide recommendations for increasing the effectiveness of NBS in meeting these needs. Consider the following:

   a. What, specifically, are the Government's most pressing needs for standards? How do you view current progress in meeting these needs?

   b. How best can these standards be achieved within the desirable time frame? Evaluate present approaches such as ANSI and FIPS Task Groups vs. alternative approaches.

   c. In what alternative ways can NBS (CCST) make significant contributions to these objectives?

      - What resources are available and required?

      - How can requirements be met (persuasion, fees for services, reallocations within CCST, NBS, Commerce; additional appropriations, etc.)?

   d. Emphasis in this area is usually placed on hardware, software, and data standards. Consideration should also be given to the need and role of NBS in the development of standards for applications.

2. Performance Measurement Techniques - This issue relates to the need for techniques to both validate and evaluate ADP products. It includes the need for techniques to test products for compliance with ADP standards. The techniques should apply to hardware, software and systems and should be based so far as possible on quantitative measurements.

   In general the same type of considerations listed under the standards issue are applicable here.

   a. Validation - This refers to verifying that a product or system does, in fact, possess a particular property or perform in a specified manner. Of immediate interest are techniques for measuring the compliance of compilers with COBOL or FORTRAN standards. Also important is the validation of producer's claims as required for the Federal ADP products catalog recommended in the report of the Charlottesville conference.

   b. Evaluation - This refers to making a determination as to how well a product or system performs a particular function, usually the carrying out of its intended purpose. In the development of performance standards, there are two aspects of the problem: first, the development of appropriate yardsticks, and second, the specification of numerical values on them.

3. ADP Management Guidelines - This issue relates to the need for guidelines in various aspects of computer use. It should include means by which management can measure (and evaluate) the overall performance of its computer installations. Possible subjects include systems studies, ADP procurement techniques, selection, operations and evaluation.

4. Coordination and use of agency efforts in achieving Government objectives - Work undertaken by agencies on a unilateral basis to serve their own requirements can often benefit other agencies, including NBS. Primarily as an aid in performing its own program responsibilities, but also in its role as technical consultant, NBS should consider ways and means for identifying and coordinating such work and exploiting it for Government-wide use. Examples include:

   a. COBOL compiler validation techniques developed by Navy and Air Force which could be considered by NBS for adoption as a Government standard, with minimal NBS development effort.

   b. I/O interface techniques developed by Livermore which might have application elsewhere.

   c. Performance guidelines and practices, such as documentation guidelines, selection and evaluation criteria, "good programming practices," and installation evaluation techniques. These might be adaptable as Government-wide guidelines with only slight modification by NBS.

   d. Research and development and applications experiences which have Government-wide stability.

   e. Computer programs which might be usable in other agencies.

5. Training

   Examine the need for a Government-wide ADP training standards or facilities including: cost of start-up, operating cost, type of training, manner of funding, appropriateness for NBS, Civil Service Commission or Department of Labor?

6. Other work programs - Identify and evaluate the progress and impact of all other direct-funded work programs within CCST in terms of (a) their overall contribution toward improved ADP management, and (b) their relative importance vis-a-vis the standards and performance measurement programs.

7. Reimbursable programs - Evaluate the contribution (direct or indirect) to the CCST programs that results from the consultation and development work performed for and funded by other agencies. Are there possibilities for increasing this contribution by a reorientation of this work to more closely parallel the Brooks Bill objectives?

The above items are intended to embrace the total CCST program. The study should give consideration to all of these areas in determining the emphasis and resources that should be allocated to each other in order to achieve a properly balanced program.

D. Assumptions (Hypothesis)

1. Areas of work - The perspective of NBS might be expanded to cover not only the areas specifically emphasized in the Brooks Bill and the BOB guidance letter of December 1966, but all aspects of Federal automatic data processing. This could involve expanding or reducing NBS activities in some of the areas in which it is already working such as ADP standards and ADP validation techniques, and also initiating work in areas in which NBS is not already working such as ADP training, ADP installation management and ADP procurement techniques.

2. Authorization - Additional legislative authority is assumed to be unnecessary since the Brooks Bill may be interpreted as authorizing NBS to work for efficiency and economy in Federal automatic data processing generally without restricting it to the specific areas identified in the bill. However, new BOB guidance may be required to specifically interpret the Brooks Bill to include the required additional areas; and legal questions of authority will be reviewed at the conclusion of the study.

3. Other agencies - Closer liaison than ever before will be required with other agencies, particularly their ADP installation and ADP management personnel. BOB may have to specifically advise agencies regarding their relationships with NBS. This advice could include:

a. Support of FIPS Task Groups

b. Unified Government action on voluntary standards

c. Information reporting to NBS

d. Acceptance of uniform Federal ADP management practices

e. Training of Federal ADP personnel

f. Advisory and consulting services and supported research

1972 ISSUE STUDY

THE ROLE OF NBS IN FEDERAL AUTOMATIC DATA PROCESSING

OUTLINE

Preface

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8. Recommendations and Conclusions

ATTACHMENT 3

MEMORANDUM OF UNDERSTANDING REGARDING TELEPROCESSING ACTIVITIES OF THE NATIONAL BUREAU OF STANDARDS AND THE OFFICE OF TELECOMMUNICATIONS

PURPOSE: To establish a frame of reference within which the teleprocessing programs and activities of the Department of Commerce can be carried out effectively and economically, and to establish working relationships between department organizations which will minimize redundant effort and insure maximum return on resources invested.

NEED FOR ACTION: Teleprocessing represents the most dramatic change in the means of computer utilization which has occurred since 1960. Teleprocessing technology thus offers great potential for achieving cost-effective computer applications to improve efficiency and resource utilization in Government operations. There are many problems which must be solved before the full potential of teleprocessing technology can be realized. Teleprocessing is the intersection of the computer and data communications technologies. Its associated potential as well as its problems lie in the area of convergence of the two related technologies.

Although advances can occur independently within each of the technologies, many important and essential advances can only be achieved through closely coordinated efforts between the

computer and data communications fields. Further, it is evident that many associated problems cannot be solved unilaterally by a single agency or department, by the Federal Government or by industry; they require a concerted and carefully controlled effort involving organizations both in Government and industry. The interaction between Government agencies is especially important in achieving the advantages of specific applications of teleprocessing technology and in providing direction and impetus to any broad effort to exploit teleprocessing technology.

MANDATED RESPONSIBILITIES: No single organization in the Federal Government has a mandated responsibility for teleprocessing as a whole. At best, the principal responsibility is divided between several Executive Branch organizations. Public Law 89-306 (Brooks Bill) divides ADP (which includes teleprocessing as a recently evolved method of providing ADP services) responsibilities between three agencies: the General Services Administration is responsible for coordinating the acquisition and maintenance of ADP equipment; the Department of Commerce is responsible for providing scientific and technological advisory services relating to ADP and related systems, and for necessary research in the sciences and technologies of ADP computer and related systems; and the Office of Management and Budget is responsible for exercising fiscal and policy control.

The Bureau of the Budget letter of December 15, 1966 implemented Department of Commerce responsibilities under P.L. 89-306 and resulted in the establishment of the Center for Computer Sciences and Technology within the National Bureau of Standards. The Center was charged with specific responsibilities in the ADP area, and was authorized to carry out research activities directed primarily toward areas that give promise of satisfying widespread needs within the Federal Government and that offer prospects for significant improvements over existing capabilities. Thus, teleprocessing is clearly a major responsibility of the Center. Executive Order 11556 of September 4, 1970 established the Office of Telecommunications Policy to formulate telecommunications policy. The Order also assigns the Department of Commerce responsibility as a primary source of technical research and analysis to support the Office of Telecommunications Policy.

Department of Commerce Organization Order 30-5A of September 18, 1970 established the Office of Telecommunications to perform communications research to support the Office of Telecommunications Policy, and provide advisory services in telecommunications to Federal agencies and State and local governments. The Office receives research and engineering support from the National Bureau of Standards.

Several Divisions in the Institute for Basic Standards (IBS), in pursuing their statutory responsibilities, develop competence in areas touching upon telecommunications. These competences are generally of a character involving scientific and technical expertise in the complete spectrum of electromagnetic radiation from d.c. through the visible and beyond. It is understood that OT will be able to draw upon these competences by entering into reimbursable contractual arrangements according to standard NBS practices. The Technical Analysis Division is prepared to assist the Office of Telecommunications in carrying out systems analyses related to teleprocessing, in collaboration with CCST or individually as the requirement dictates. The working arrangements between the IBS, IAT and CCST are an internal responsibility of the Director, NBS.

UNDERSTANDING: The National Bureau of Standards through its Center for Computer Sciences and Technology (CCST) and the Office of Telecommunications (OT) both have mandated responsibilities in their respective areas of technology, i.e., computer and telecommunications. The interests and responsibilities of the two groups converge in the teleprocessing area which involves both the computer and data communications technologies. Clearly, NBS (CCST) and OT will discharge their respective mandated responsibilities independently and without

specific reference to each other except where obviously required or desirable. In the computer-data communications area, however, there is a need for coordination of efforts of the CCST and OT.

The CCST will carry out its research and developmental program in teleprocessing, making use of OT's telecommunications capabilities wherever appropriate. The CCST and OT will work together in designing and conducting collaborative efforts involving joint interests and responsibilities in teleprocessing. CCST will respond directly to the Office of Telecommunications Policy and other Government agencies requesting information, guidance and support in the teleprocessing area; the CCST will advise OT of these activities and will refer to OT any requests which impinge directly on OT's responsibilities and activities.

The Office of Telecommunications will carry out its telecommunications research program, drawing on CCST's teleprocessing and computer research capabilities where appropriate. OT will not duplicate the CCST's teleprocessing and computer research and developmental efforts. The OT will respond directly to the Office of Telecommunications Policy and other Government agencies requesting information, guidance and support in the telecommunications area; OT will advise the CCST of any requests which impinge directly on CCST's responsibilities and activities.

The Director, NBS, and the Director, OT, will keep the Assistant Secretary for Science and Technology advised of their

collaborative efforts. Direct points-of-contact between NBS and OT in this regard will be Dr. Ruth M. Davis and Mr. Kandoian.

This memorandum of understanding will be implemented through later memoranda establishing points of contact and working arrangements.

ATTACHMENT 4

Resources Needed for NBS to Assume Additional Responsibilities for the Data Elements and Codes Standard Program

1. Background

The ADP standards program was established by Public Law 89-306 (the Brooks Bill) in 1965 which authorized the Secretary of Commerce to make appropriate recommendations to the President relating to the establishment of uniform Federal automatic data processing standards. Subsequently, the Office of Management and Budget (formerly the Bureau of the Budget) provided guidance to the Secretary of Commerce in fulfilling the assigned responsibilities in a letter of December 15, 1966. NBS responsibilities cited in the letter excluded standards for data elements and codes. In September 1967, OMB Circular No. A-86, Standardization of data elements and codes in data systems, was issued. It assigned specific responsibilities to OMB, Federal departments and establishments, and NBS. The basic differences between the approach taken to data standards and that taken for other ADP standards are: (1) OMB is the program manager rather than NBS; (2) standards are developed either by OMB chartered task groups or principal program agencies rather than by NBS; (3) agencies are encouraged to develop standards for use within their agencies when not in conflict with existing or proposed standards; (4) agencies can approve and publish certain standards within their program or functional area; and (5) NBS is involved only to the extent of registering data standards and providing technical

assistance to agencies or task groups as requested. (NBS does publish certain data standards designated for general use.) OMB in early 1971 drafted a Bulletin that provides further guidance on data standards and places more importance on the registry of data standards by NBS and its use by agencies.

2. Assumptions

In acquiring additional responsibilities for data elements and codes standardization by NBS, it is assumed that a revised OMB Circular would be issued either by amending Circular No. A-71 to include this area thus superseding Circular A-86 or revising Circular A-86 to include all information processing standards including data elements and codes. In either case, it is further assumed that these would be revised to reflect the following statements regarding data elements and codes standardization:

a. That NBS would be the program manager as with other standards.

b. That NBS, with OMB support and direction, would arrange for appropriate departments and establishments to develop and maintain specific Federal general and Federal program standards. The cost for such efforts to be funded by the designated agency and not NBS.

c. That NBS would arrange for liaison with organizations representing industry and State and local governments on data standards of mutual interests. When representation to such

organizations is provided by agencies other than NBS, the cost will be borne by that agency and not NBS.

d. That OMB will retain approval authority over Federal general data standards.

e. That NBS will publish a list of agency points of contact for data standards.

f. That NBS will provide for the preparation of guidelines and criteria to assist agencies, task forces and equivalent groups in developing standards.

g. That NBS will utilize the Federal Information Processing Standards Coordinating and Advisory Committee (FIPSCAC) or its equivalent rather than the Federal Automatic Data Processing Advisory Council as now in Circular No. A-86 to advise NBS on matters regarding data standards.

h. That a general policy statement on the implementation of standards and waivers will be developed and included that pertains to all standards in general and not just data elements and codes.

i. That NBS as the program amanger will assess the effectiveness of the standards program by determining those areas where standards would be most beneficial, establishing standardization priorities, and monitoring the implementation of approved standards.

j. That NBS will continue: (1) to register data standards; (2) publish general standards; and (3) to provide active participation on ANSI and ISO standards committees.

3. Program Plan

Assuming that NBS is assigned additional responsibilities for the standardization of data elements and codes and that the necessary resources are allocated, the following program would be planned and initiated:

a. The development and implementation of an information base reflecting the data requirements and interfaces (interchanges) of Federal-wide programs and associated agency data systems. Before this can be accomplished techniques and guidelines need to be developed and furnished to Federal agencies, since in most cases this information is not currently available at the agency level.

b. The development of techniques to analyze this information base to determine existing or potential interchange difficulties and those areas or subjects most facilitated by the benefits of standards.

c. Based upon the findings in (b), the establishment of standards projects either under the auspices of NBS (with additional funding) or by delegation to other Federal agencies.

d. The continuation of current activities in the development and promulgation of a standards codes register, ANSI and

ISO participation and on-going Federal data elements and codes projects.

e. The development of a training course on data standards to assist agencies in their assigned responsibilities. This course would either be conducted by NBS or the Civil Service Commission, as determined most appropriate.

f. The development of procedures and techniques to assess the effectiveness of the program to include the standardization phases of planning, development, implementation and maintenance.

4. Workload

If the assumptions in paragraphs 2 and 3 are valid, and are accepted, it is estimated that four full time professionals are needed to adequately perform the NBS responsibilities. In addition, one clerical person is needed for administrative support. Assuming an average grade of GS-14 for the four professionals at an annual cost of $53,000 each (including leave, benefits, and overhead), the annual personnel cost would be $220,500. It is estimated that other objects which include travel ($6,000), computer time ($10,000), and other miscellaneous items ($5,000) would amount to $21,000, bringing the annual amount needed to $241,000.

In FY 71, NBS is spending at the rate of approximately $55,000 for data standards. This includes the part-time participation of two professionals, a GS-15 and a GS-14. Accordingly,

an annual increase of $186,500 would be necessary to provide for an adequate effort in this area.

ATTACHMENT 5

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

April 30, 1971

Honorable Elmer B. Staats
Comptroller General of the
United States
General Accounting Office
Washington, D. C. 20548

Dear Mr. Staats:

As you remember, Dr. Ruth Davis, Mr. Cunningham, Dr. Chauncey Starr and Mr. Mahoney of your staff met with you on March 18. The purpose of the meeting was to discuss progress in achieving plug-to-plug compatibility among selected computer components. In addition, work underway at NBS in interface standards development was reported on by Dr. Davis.

During the meeting, you suggested the advisability of the National Academy of Engineering assisting the Center for Computer Sciences and Technology primarily through reviewing their work in interface standards. Dr. Davis was pleased with this suggestion and agreed to pursue it. In later informal conversations she had with Dr. Starr and Dr. Piori, NAE, it was decided that the Computer Sciences and Engineering Board (CSEB) of the NAS-NAE would be the proper group to review the work of the Center and to provide consultant assistance.

At the first subsequent meeting of the Computer Sciences and Engineering Board on April 22, 1971, Dr. Davis briefed the Board and asked its assistance. The Board unanimously agreed and the Chairman, Dr. Oettinger, is currently appointing a Task Force chairman and five-to-seven members to assist Dr. Davis.

We wanted to inform you of our progress in following your suggestion and to indicate that we are still meeting the schedule as Dr. Davis reported it. Our report on Interface Standards will be provided to the CSEB for review by June 1. She and the CSEB Task Force will brief you as soon as possible after that on their combined recommendations. We would appreciate a contact on your staff so that Dr. Davis and Dr. Oettinger may make the necessary formal arrangements for participation by the Computer Sciences and Engineering Board.

Sincerely,

Lewis M. Branscomb
Director

ATTACHMENT 6

NBS-NSF RELATIONSHIPS

In the formative years of the National Science Foundation (NSF), Dr. Astin and Dr. Waterman evolved a policy (undocumented) which led to a de facto practice of only minor involvement in joint activities. Several circumstances contributed to this situation.

a. NSF emphasized expanding and sustaining the capabilities of universities.

b. NBS was concentrating its efforts in basic and applied research conducted in its own laboratories.

The need for closer collaboration between NBS and NSF arises from several recent circumstances:

a. NBS mission objectives relate to strengthening the Nation's science and technology, paying particular attention to fostering the effective application of science and technology for public benefit.

b. By statutory responsibility and by interagency agreements, NBS is deeply involved in applied research directed at almost every area of national need to which the science and engineering of physical measurement is relevant.

c. The 1968 Amendment to the NSF Act authorizes the conduct of applied research on national problems. To this end NSF has budgeted a request for $81 million in FY 1972 in the program Research Applied to National Needs (RANN).

NBS can and should assist NSF both directly and indirectly in the conduct of effective applied programs to meet national needs. NBS and NSF programs and capabilities complement one another in many respects.

NBS has a need for closer links with the academic community because:

a. Many of our responsibilities (fire research, building research, failure analysis, precision measurement...) pose very difficult and often sophisticated problems to which university talent can make important contributions.

b. Many of the disciplines and skills found vital to NBS work are very badly underemphasized and therefore underexploited in universities; we believe an industrial market exists for such skills (optical technologies for dimensional metrology, automotive vehicle safety technology, materials quality control technology...).

c. NBS can help university groups establish effective inputs to the users of applied research, especially in the area of research to support the rational regulation of technology by all levels of Government.

NBS has had many years of experience in university collaboration especially in its most intimate form as exemplified in the Joint Institute for Laboratory Astrophysics at the University of Colorado. To meet an urgent need to sustain the Nation's capabilities in high precision measurement, NBS has initiated an unsolicited grant program for academic younger investigators (Precision Measurement Awards).

NBS can be of assistance to NSF by assisting NSF-funded investigators to couple their work to applications. The availability of a large, diversified capable laboratory staff at NBS with well established cooperative relationships with many other agencies could prove a useful interface between Federal policy and academic research.

Six categories of possible cooperative activities between NSF and NBS are identified.

a. We should consider the development of joint research programs and the exchange of personnel between NBS and selected universities with interests and capabilities in selected areas. Initial support for such a cooperative program would be provided by NSF. NBS would encourage voluntary technical participation by industry or other agency personnel as appropriate.

b. We should propose to develop a joint program in which we provide jointly agreed upon facilities, including the operation of Data Centers, for the use of NSF supported students and faculty.

c. NBS should insure that NSF program RANN managers are familiar with the program opportunities at NBS for research to meet identified high priority national needs.

d. NBS could provide to NSF program review and evaluation services, either on a voluntary or reimbursable basis, or in a cooperative program such as is envisioned under (a) or (c).

e. In general NBS would fund its own investment in long range and basic research. But in special cases where NBS has truly unique opportunity, which will otherwise be lost, NBS could consider solicitation of NSF for sponsorship.

f. NBS might propose to NSF the funding of in-service retraining programs at post-doctoral or other professional levels where there is a mutual interest, especially in specialized applied skills where U.S. capabilities are weak. Special emphasis should be given to this program of retraining professionals. NBS has a number of programs for which there is a shortage of skills, and its facilities can be made available for retraining while NSF could provide support for the trainees.

NBS and NSF senior managements have held preliminary discussions to explore interest in joint efforts. The NSF has been sufficiently receptive, especially on RANN programs, that NBS is preparing a more detailed document to be used in further discussions. The RANN program is particularly interested in program management and several areas, especially fire research and earthquake engineering, for which RANN is requesting funds are areas in which NBS has on-going programs. In fire research, NBS has statutory responsibilities and the NBS programs can form the base for an enlarged national effort.

Congressman John Davis, Chairman of the Subcommittee on Science, Research and Development of the Committee on Science and Astronautics, House of Representatives, invited the Director of NBS to testify on RANN during the authorization hearings for that program. This invitation was issued because of the acknowledged complementarity of NBS and RANN programs. A copy of the testimony was mailed to the members of the Visiting Committee.