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General Accounting Office

Opportunities And Constraints For Expanding Use Of Research Facilities At The National Bureau Of Standards

The National Bureau of Standards (NBS) operates a large, expensive, and diverse assortment of facilities to support its mission. Used predominantly by NBS personnel during normal business hours, these research facilities have distinct purposes, different assemblies of equipment, and separate user communities and serve a variety of research programs.

This report shows that decisions to expand use of NBS research facilities must be analyzed on a case-by-case basis and on the basis of the programs each facility serves. While there are opportunities for expanding use of some facilities, there are also some common constraints to increasing the hours of operation and fostering increased non-NBS use of other facilities. Details on current use, comparability with other facilities, and the outlook for expanding use are presented for 14 NBS research facilities, ranging from an intensely used research reactor to an idle plumbing system and drainage research facility.

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RESOURCES, COMMUNITY,
AND ECONOMIC DEVELOPMENT
DIVISION

B-215212

The Honorable Don Fuqua
Chairman, Committee on Science
and Technology
House of Representatives

The Honorable Doug Walgren
Chairman, Subcommittee on Science,
Research and Technology
Committee on Science and Technology
House of Representatives

As requested in your letter of February 21, 1984, we have reviewed utilization and elimination of selected facilities at the National Bureau of Standards (NBS). We determined how NBS is using the facilities, opportunities and constraints to increasing use, and why facilities have been eliminated. As agreed, we also addressed how much the facilities should be used.

Overall, we found that conclusions about utilization of NBS' research facilities must be drawn on a case by case basis and in light of the research programs they support. Some may be able to accommodate expanded use, but there are constraints to increasing the hours of operation or otherwise changing how other NBS research facilities operate. As appendix II shows, NBS has a large and diverse assortment of scientific and engineering research facilities, some of which may be suited to expanded use and some not. Explanations of current use, opportunities for and constraints to increased use, and information comparing use of 14 NBS facilities with similar facilities elsewhere are presented in appendixes III through XVI. A listing of facilities eliminated since 1972 and the reasons for elimination is presented in appendix XVII.

BACKGROUND

The National Bureau of Standards Organic Act of 1901 (15 U.S.C. 271 et seq.) and a number of subsequent laws authorize a variety of NBS functions. The Organic Act specifically authorizes "invention and development of devices to serve special needs of the government" but does not provide clear guidance about how or by whom such devices should be used. Subsequent laws have generally been even less specific regarding equipment or facilities. We are not aware of any criteria within this body of law to guide acquisition or management of research facilities at NBS. Details of original acquisition and current use are presented in the appendixes for the 14 facilities included in our review.

NBS, the oldest national laboratory, was established to play a broad and varied role. Its mission includes providing a scientific basis for accurate measurements and a source of information on basic properties of materials as well as providing a central capability for technical advice and support to other federal agencies. Its activities range from basic research in such fundamental areas as atomic and molecular physics at the Joint Institute for Laboratory Astrophysics[1] to developmental efforts in quality control techniques and standards for automated batch manufacturing factories at the automated manufacturing research facility.[2] Overall, the NBS mission supports both private and public scientific and technological efforts. An extensive and diverse complex of facilities is operated to support the tremendous scope of NBS mission activities.

NBS is located in 40 buildings which include nearly 600,000 square feet of laboratory space and house an equipment inventory of over 48,000 items, valued at more than $146 million. Most of these buildings (26) are located at NBS' headquarters in Gaithersburg, Maryland, constructed in the 1960's at a cost of about $107 million. The remaining 14 are in Boulder, Colorado, where the Joint Institute for Laboratory Astrophysics, co-sponsored by NBS and the University of Colorado, is also located. NBS operates radio stations to broadcast standard time and frequency information from Ft. Collins, Colorado, and Kauai, Hawaii, as well.

Within this large complex of buildings and laboratories, for the purpose of our review, NBS identified 61 major assemblies of equipment--research facilities--in operation and 9 under development, as shown in appendix II. In addition to these research facilities, NBS has numerous other facilities that NBS officials believe to be outside the scope of this review. These include general purpose laboratories and individual items of less specialized equipment; laboratories dedicated to calibration services rather than research; and shops for glass blowing, metalworking, and other commonly required technical support services.

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[1]The Joint Institute for Laboratory Astrophysics is an academic as well as a research organization. It is a collaboration between NBS and the University of Colorado for basic research in atomic and molecular physics, laser and chemical physics, fundamental and precision measurements, geophysical measurement methods, and astrophysics. (See app. III.)

[2]The automated manufacturing research facility is an NBS-developed engineering test bed and demonstration for computer-controlled manufacturing. (See app. VI.)

NBS' research facilities are under the direction of four major organizational units--the National Measurement Laboratory, the National Engineering Laboratory, the Center for Materials Science, and the Institute for Computer Sciences and Technology. These organizational units manage research facilities to support seven major budget activities that have over 20 separate operating programs, as well as perform reimbursable services for other federal agencies and private industry.

Table 1

Overall Funding and Work Years

Fund sources	FY '82[a]	FY '83[a]	FY '84[b]	FY '85[b]
NBS appropriation	$ 106,752	114,576	123,324	120,833
Reimbursements	72,964	76,131	80,332	85,079
Total funding	$ 179,716	190,707	203,656	205,912
Total work years	3,122	3,048	3,147	3,090

[a]Actual obligations in thousands and work years in FY '84 and FY '85 budget justifications.

[b]Estimated obligations in thousands and work years in FY '85 budget justification.

Source: NBS.

Precise figures on how much of these totals was allocated to research facilities or how much it cost to operate individual facilities are generally not available. Some facilities contain loaned or donated equipment, which is paid for by sources other than appropriations and reimbursements. Also, some utility, maintenance, and administrative costs are accumulated in central technical programs and in overhead charges. Finally, most individual facilities are not identifiable in NBS' cost accounting system, which is arranged by organizational units and fund sources.

Generally, purchases of equipment for research facilities are made through NBS' working capital fund. Established in 1950 by an amendment to the Organic Act, this fund receives periodic repayments from NBS' organizational units on the basis of amortization of the acquisition cost of equipment over its useful life. NBS calls these "depreciation charges," and the organizational units pay the charges with funds they receive from appropriations, reimbursements from other agencies, and fees from agencies and corporations for various services they perform.

HOW FACILITIES ARE USED NOW

Most of the NBS research facilities we reviewed are used less than 24-hours-per-day and are used predominantly by NBS personnel. Having been acquired to support NBS programs, these facilities are generally an integral part of NBS-performed research to develop measurement techniques, determine physical and chemical characteristics of materials, and supply information needed to facilitate development of such industrial consensus standards as the size of threads on screws or some combination of these activities. They are justified, paid for, and used as tools of the NBS mission just as ships and boats are tools of the Coast Guard and Navy or desks and typewriters are the tools of administrative agencies.

We found that the following characteristics were common to most of the 14 facilities we reviewed. These commonalities demonstrate the close relationship between the mission goals served by the facilities and who uses them for how much time.

--Acquisition of 10 of the facilities was funded exclusively by NBS appropriations; acquisition of 2--the reactor[3] and the automated manufacturing research facility--was predominantly funded by NBS and contributed to by other federal agencies or private industry; the cost of acquiring the Joint Institute for Laboratory Astrophysics was funded by the University of Colorado. Also, all additions and modifications to the gas flow measurement facility[4] have been funded by the Gas Research Institute since 1980.

--Most of them are available for use during the normal daytime working schedules of NBS researchers, but there is no prohibition against night or weekend use. The reactor routinely operates 24-hours-per-day, and the network protocol test and evaluation facility[5] and others operate around the clock periodically as needed.

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[3]NBS' high flux nuclear reactor is a multi-purpose and multi-user facility to irradiate specimens for such experiments as determining characteristics of materials, establishing radiation standards, and doing nuclear physics experiments. (See app. XIV.)

[4]The gas flow facility is the source of U.S. standards for measuring liquid gases and allows both research and calibrations of instruments for such measurements. (See app. XII.)

[5]The network protocol test and evaluation facility has laboratories in which different configurations of computer equipment can be assembled to study how these machines exchange data; the purpose is to develop industry standards to increase the compatability of such equipment. (See app. XVI.)

--Most facilities are used predominantly by NBS researchers; non-NBS personnel collaborate with NBS researchers to use the facilities as part of NBS' industrial research associate program or as guest workers. In some research programs, many non-NBS personnel use the facilities, but in others, none do. For example, the tri-directional structural test facility[6] has had no guest workers or industrial research associates, the superconductive circuit fabrication facility has had 26 guest workers since completed in 1979,[7] and the automated manufacturing research facility has had 21 industrial research associates and 16 guest workers since 1983, though it is not yet completed.

--Non-NBS users are solicited in special publications and in some cases by active promotion from research program managers--e.g., the Director of the Fire Research Center is actively seeking industrial users of the fire test building[8] to stimulate such research, but the managers of the near-field antenna scanning facility[9] do not actively solicit outside use to avoid diverting activity from NBS research goals in the area. Both facilities are included in a recently published brochure on the availability of NBS research facilities to outside users.

--The physical setup and some intrinsic operating characteristics limit the intensity of use possible and the suitability of some facilities for multiple users or

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[6]Referred to as an earthquake simulator in the request letter, this facility allows engineers to compress, twist, and stretch building equipment specimens while they measure the patterns of stress created. (See app. VII.)

[7]Researchers can make superconducting integrated circuits--used in ultra-high-speed electronic instruments and computers--in this facility. (See app. XIII.)

[8]The building is one of three NBS facilities for measuring heat, smoke, and other characteristics of burning materials and structures. (See app. XI.)

[9]This facility is a demonstration of an NBS-developed technique for measuring antenna performance and provides a reference standard for the accuracy of such measurements. (See app. X.)

24-hour operation--e.g., surface analysis instruments[10] are connected to larger assemblies of equipment and dedicated to single projects for long periods, but the synchrotron ultraviolet radiation facility[11] could support five more separate experiments at once.

CRITERIA FOR HOW FACILITIES SHOULD BE USED

Since we are not aware of any laws, administrative procedures, generally accepted standards, or other sources of clearly specified criteria for the appropriate use of research facilities, we developed two such criteria on the basis of discussions with NBS officials. First, we accepted a reasonable assertion by NBS officials, made during the planning phase of our evaluation, that how critical a facility is to accomplishing NBS' mission is as important as the frequency of use. Some research facilities may be used occasionally but for critical operations. The NBS synchrotron, for example, while not routinely used around the clock, allows NBS to meet its mission to support other agencies' measurement needs--it is the only United States facility capable of calibrating instruments for measuring ultra-violet radiation on the space shuttle. Second, we determined whether comparable non-NBS research facilities were used in the same way.

In commenting on a draft of this report, the Director of NBS reiterated the criteria we used, although he stated that frequency of use is less important than criticality to mission. For the purposes of this report, we have considered both as important criteria. The Director of NBS also pointed out that "increased usage, under certain conditions, by the private sector of unique special-purpose measurement and test facilities . . ." is an NBS goal (see app. XVIII).

Program plans and equipment requirement analysis

We found that all the facilities we reviewed had produced something relevant to NBS' broad mission, and all but one have ongoing work with future objectives. Only the five-story

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[10]Surface analysis instruments measure the outermost atomic layers of a solid as part of multi-discipline surface science experiments. (See app. V.)

[11]This facility is an electron storage ring used to support measurement of radiation and experimental physics. It provides an absolute standard light source for calibrating radiation measurement instruments in the far ultraviolet part of the light spectrum. (See app. IV.)

plumbing facility[12] lacked current or future research activities dependent upon it. The managers of the facility, however, have informal plans for how they could use the facility if they acquire funding in the future.

Our chief difficulty in addressing the question of how much particular facilities should be used was the lack of documented analysis or plans of NBS facilities needs and alternatives considered for meeting the needs. Some of the facilities we reviewed were acquired as part of the original construction of the NBS Gaithersburg complex and not separately planned or justified. Others have been gradually acquired and assembled piece by piece, not justified as a whole. Finally, as previously mentioned, such facilities as the surface analysis facility are really components of larger complexes of equipment which are dedicated to individual long-term projects rather than to multiple-use/multiple-project program areas. Furthermore, these instruments have been extensively modified through the years to keep pace with technological advances as well as to fit the needs of various researchers using them.

An analysis of research program equipment needs would be necessary to develop clear criteria for the facilities and programs touched on in our review. Such an undertaking was far beyond the scope of our review. Lacking such firm criteria, though, we identified past program results and planned objectives requiring use of the facilities. We also reviewed program evaluations and plans for indications that the facilities have research programs dependent upon them. Details are presented in the separate appendixes.

Comparability with other facilities

We found that, where comparisons can be made, NBS operates its research facilities essentially the same hours as other organizations. For example, surface analysis facilities at the Naval Surface Weapons Center and Naval Research Laboratory are principally in operation during normal business hours, just as at NBS. Research reactors generally operate around the clock at NBS as well as at Brookhaven National Laboratory and Oak Ridge National Laboratory. The Department of Defense and NBS both operate

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[12]The five-story plumbing research facility allows study of plumbing fixture and water drainage system performance. (See app. IX.)

environmental chambers[13] primarily during normal business hours but 24-hours-per-day when necessary.

Some NBS facilities are unique and not directly comparable with anything else--because either the equipment or the expertise of the personnel who operate it is not available elsewhere. NBS' synchrotron ultraviolet radiation facility, for example, can perform extraordinarily precise measurements because it has the most nearly perfectly circular storage ring in the United States--it serves as the national standard for the types of measurements it performs. Similarly, the near field antenna scanning facility is the standard for similar facilities, which are based on the NBS-developed technology and were built in consultation with NBS. For this facility and the network protocol test and evaluation facility, the automated manufacturing research facility, and the gas flow measurement facility, the expertise of the NBS reseachers and the neutral (nonproprietary) environment are cited by NBS personnel and the recipients of the research and test results as characteristics unavailable outside.

Another group of facilities lacking directly comparable counterparts are those that have an unusual assembly of equipment. The metals processing laboratory[14] and the superconductive circuit fabrication facility are examples. Both have an uncommon assortment of relatively common equipment which allows researchers to put together samples for experimentation. The whole spectrum of new production processes for rapidly solidified and powdered materials is available in one place at NBS' metals processing laboratory. Similarly, the superconductive circuit fabrication facility allows researchers to put together sample microchips--pieces of the entire production process are in one spot, dedicated to use by researchers.

HOW USE CAN BE INCREASED

As shown in appendix II, we compiled information on NBS managers' views of expanding use at all 61 of the agency's research facilities. Of the research facilities NBS identified as suitable for increased use, some would require modifications and some would not. Our discussions with NBS managers indicate that

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[13]The large environmental chamber allows experiments requiring controlled environmental conditions--e.g. temperature and humidity--to test large specimens or engineered devices, including everything from military tanks to a residential structure. (See app. VIII.)

[14]This laboratory allows researchers to make specimens of metals by new rapid solidification processes to experiment with specimens and the processes. (See app. XV.)

such modifications range from simply providing a staff of technicians to making physical alterations and reorienting the facility from internal program support to external user services. Details about how use could be expanded at each of the facilities in our review are presented in appendixes III through XVI.

Just as each facility has different operating characteristics, they each have a different outlook for expanded operating hours or user communities. The reactor, for example, already operates around the clock most of the year and serves a variety of researchers from other institutions as well as NBS. It also has opportunities for expanding both its hours of operation as well as the community of users it serves. Current NBS plans call for modifying the reactor to add a cold neutron source which would enlarge the types of research applications possible. Also, the addition of three more to the operations staff would allow the reactor to operate at full capacity year-round rather than closing down on summer weekends as is currently necessary to allow vacations for operators--such a change has been proposed in the past but not recently.

Two other facilities with an outlook for increased use by both NBS and other researchers are the automated manufacturing research facility and the metals processing laboratory. Both are new facilities of a type not generally available to researchers.

On the other hand, the five-story plumbing facility has been idle for over a year and may remain so indefinitely. Industry associations and other federal agencies have declined to fund research at NBS, and plumbing research is not now considered a priority of the building technology program at the National Engineering Laboratory.

Common constraints

Although we found no apparent pattern to the opportunities to increase facility use, we found some common constraints to expanding the hours of operation or user populations.

--Most of the reviewed facilities have no evidence of demand for access or research results which are not now being met--e.g., the fire test building, large environmental chamber, tri-directional structural test, superconductive circuit fabrication, and synchrotron ultraviolet radiation facilities.

--The expertise of particular scientists and engineers is a major component of some facilities--e.g., the antenna, network protocol, automated manufacturing research, and gas flow facilities. These experts are generally available only during a normal working day, and the equipment

alone may not attract users at night. Also, such experts may find it undesirable to remain at NBS if their jobs become oriented to performing tests, calibrations, and aiding other researchers rather than primarily doing their own research.

--Equipment in some facilities--e.g., the surface analysis instruments, the gas flow facility, and the Joint Institute for Laboratory Astrophysics--is dedicated to individual, long-term experiments and may not be readily disassembled or modified to accommodate multiple users even though the facilities are not used around the clock.

--Increasing use to perform calibrations or tests could potentially compete with commercial facilities or hamper the transfer of NBS-developed technology to the private sector. Such changes may also interfere with continued research--e.g., the antenna facility and surface analysis instruments.

--Expanding use of some facilities by soliciting private research projects from industry may compromise the neutral environment and reputation of some facilities which support development of industrial voluntary consensus standards--e.g., the network protocol and gas flow facilities.

BUDGET AND PERSONNEL CONSTRAINTS

The influence of budget and personnel ceiling decisions on facility use is difficult to pinpoint in most cases. Overall increases and decreases in funds for programs served by the facilities will obviously affect demand in some way. However, given the limitations of the available data, we could not correlate fluctuations in program resources with changes in facility use levels or user populations.

Most of the facilities we reviewed have sustained a relatively consistent level of use since fiscal year 1982. The automated manufacturing research facility and metals processing laboratories have been under development during this period, and utilization is predicted to increase notably. On the other hand, use of the five-story plumbing facility--to support a research area in the building research program not now seen as a funding priority by NBS managers and industry--has decreased to nil.

WHY FACILITIES HAVE BEEN ELIMINATED

NBS officials identified 21 facilities they considered as having been eliminated since 1972. These facilities are no longer in operation; equipment in some has been or is being disposed of, but others are still intact or have been disassembled and recycled

to other NBS facilities. A list of which facilities have been eliminated, what purposes they served, when they were acquired and discontinued, and why is attached as appendix XVII.

As that list reveals, there is a variety of reasons for elimination. The most common reasons are obsolescence and accomplishment of pertinent research objectives. Only 4 of the 21 were eliminated because of reductions or reprogramming within NBS. These four had been in operation for at least 10 years, and more efficient or effective substitutes were available for two--the accoustical thermometer and broadcast station.

Transfer of NBS' research results to private industry or identification of private capability to replace an NBS facility resulted in four facilities' elimination. This reflects how NBS performs its role in developing new methods, instruments, or sets of data for measurements needed by U.S. industry and other federal agencies. Techniques developed by NBS for measuring chlorine and hydrogen in the chlorine flux monitor and hydrogen liquefaction facility, respectively, were assumed by the private sector, and measurement data developed in the nuclear magnetic resonance spectroscopy facility and the soft x-ray spectrometer were transferred to private industry. After these technology transfers, NBS moved on to other measurement research areas.

Technology developed in a fifth facility, the programming languages testing activity, was transferred to the General Services Administration after being developed and refined at NBS. The essential element of this facility, like a number of those now in operation, was the staff rather than the equipment. The equipment was part of the computer science and technology laboratories and is now used for other activities.

ISSUES FOR FURTHER CONSIDERATION

During the course of our review, we identified three issues related to but beyond the scope of our work. While we did not address these issues in depth, we are calling them to the attention of the Director, NBS, for his comments in managing NBS research facilities. These issues deal with (1) what NBS' mission is and its relationship to research organizations in private industry and universities, (2) how decisions for acquiring and eliminating research facilities are made at NBS and whether or not there is a need for clear criteria on utilization of major assemblies of research equipment, and (3) how adequate the existing NBS property management system is.

NBS' research role

The question of how NBS' research role relates to the role of other research organizations underlies the problem of what equipment and facilities the agency needs. There are two aspects of

this question. First, should NBS be performing the research and, second, who should pay for it. The question of whether NBS should be performing and funding all the work it is doing may be more critical to improving overall NBS efficiency than whether individual facilities could be used more. The breadth of NBS' mission and the diversity of its activities complicate understanding what and how facilities should be operated.

We found instances of NBS research facilities for which there may not be a clear need for NBS to do the research. For example, the tri-directional test facility was acquired to support NBS research related to earthquake hazards reduction, but our contacts with advisors to the National Earthquake Hazard Mitigation Program--a multi-agency program coordinated by the Federal Emergency Management Agency--indicated that NBS' research goals are not part of the overall national agenda. This agenda is based on a January 1984 technical evaluation of research needs for improving earthquake-resistant design of buildings by the Earthquake Engineering Research Institute.[15]

In commenting on a draft of this report,[16] NBS said that its role in earthquake research and its need for the tri-directional structural test facility should be clarified. NBS officials pointed out that they have a role in the federal earthquake hazards reduction program, which is included in the draft plan for agencies participating in a federal program being prepared by the Federal Emergency Management Agency. This role includes committee chairmanships and advisory tasks as well as research. Also, they stated that they use the tri-directional facility for projects other than earthquake research, and they believe that the six degrees of freedom their facility has makes it unique.

NBS also thought that this discussion of the tri-directional test facility implied that its program planning, monitoring, and priority-setting system needed to be improved. NBS stated that a number of planning, priority-setting, and review mechanisms at NBS "constitute a thorough process by which NBS activities are planned and reviewed for appropriateness" to the mission and relationship to other institutions. The mechanisms that NBS cited include the Statutory Visiting Committee, the National Academy of Sciences/ National Research Council Boards of Assessment, industrial and federal panels, extensive personnel contacts with outside institutions, and NBS participation on voluntary standards groups. NBS believes these are augmented by congressional review and approval of programs.

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[15]The Earthquake Engineering Research Institute is a nonprofit corporation for the development and dissemination of knowledge on the problems of destructive earthquakes.

[16]Agency comments are enclosed as app. XVIII of this report; changes in facts contained in the appendixes have been incorporated into the appendixes. Also, see p. 18.

Our review of the use of NBS research facilities, however, indicated that there is some unevenness in planning and controlling research activities. Contrasting aspects of NBS' fire and earthquake-related facilities illustrates the point. Research at the fire test building is part of a detailed, coherent national plan in which NBS plays an apparently critical role. Our contacts with other fire research performers and managers of other fire test facilities indicated consensus as to the quality and uniqueness of NBS' facilities.

On the other hand, earthquake-related research at the tri-directional structural test facility is viewed by the building structure engineering and earthquake experts we contacted as unessential to the national earthquake hazards reduction agenda discussed above. These experts disagreed with NBS' opinion that the tri-directional facility's six degrees of freedom constituted a unique and otherwise inaccessible capability. Furthermore, the NBS research role described in a draft plan for the federal earthquake hazards reduction program, coordinated by the Federal Emergency Management Agency, is limited compared with the National Science Foundation's structural engineering and earthquake-related research grant program. Many aspects of NBS' role in supporting development of building codes and construction standards are performed by academic institutions funded for a current total of $13 million by National Science Foundation research grants to colleges and universities across the country.

Even where it is clear that NBS should be performing the research, it is not always clear who should pay for it. This problem was apparent in comparing three facilities--the gas flow measurement, automated manufacturing, and superconductive circuit fabrication facilities. While the natural gas industry pays for all the research in the gas facility, and several industrial firms have loaned or donated automated manufacturing equipment and are actively involved in the facility constructed to address their needs, the computer or electronics industries have not provided funds or equipment to the fabrication facility. Though there may be sound reasons for these different approaches to funding and industry participation, they are not self-evident.

Decisionmaking for research facilities

We also found it troublesome that NBS did not have consistent information justifying or documenting decisions on acquisition, modification, or disposal of major assemblies of equipment. As explained on page 6, we believe an analysis or plan for program objectives, research activities, and related equipment needs would be necessary to allow direction and oversight of how critical equipment is and how much facilities should be used. Such analyses and plans would provide criteria for planning equipment acquisition and disposal as well as review of equipment utilization. Furthermore, the process of developing these documents

would reveal opportunities for clarifying policies on how much equipment each program requires and how it would be kept up-to-date.

Acquisition of the tri-directional structural test facility illustrates our concern regarding this issue. Alternatives to intramural research or to constructing the facility at Gaithersburg were not formally evaluated. The facility was acquired piece-by-piece over a number of years using the working capital fund and represented a substantial investment relative to NBS' small role in a large national research program. (NBS spent over $600,000 on a facility for an effort funded at $475,000 annually as part of a $65 million national program.) The possibility of more economical alternatives--e.g., funding similar research activities at an existing tri-directional structural test facility at the University of Texas or the Marshall Space Flight Center in Huntsville, Alabama--were apparently not considered. NBS has no standard requirement for such an analysis to precede acquisition.

NBS commented on our observation about decisionmaking as part of its comments on the research role issue. These comments and our evaluation are presented on pages 12 and 13.

Limited test of property management controls

Finally, in accordance with generally accepted government auditing standards, we tested internal controls--the property management system--applicable to the activity under review. We found inconsistencies in the way equipment is identified in property records, and errors in the property lists and records of depreciation balances for the working capital fund. These were similar to deficiencies reported in a 1979 GAO report (National Bureau of Standards--Information and Observations on Its Administration, CED-79-29, Mar. 21, 1979), and a 1983 Department of Commerce Inspector General report. On the basis of a 1982 inventory, which required over a year to complete and resulted in the write-off of over $190,000 of equipment (with an original acquisition value of over $3 million) that could not be located, NBS is in the process of revising its property identification methods.

A detailed and thorough review of NBS' property management system was beyond the scope of our review. Thus we are drawing no conclusions on the quality of the system. However, our limited testing discussed below identified potential areas which need management attention.

We selected the 14 most expensive items on NBS' property list at the Joint Institute for Laboratory Astrophysics; all of the items were included in NBS' new barcoding system to identify and track property. We found discrepencies for 5 of the 14 items we

located and examined to verify property list recorded information; we found no discrepancies for nine of the items. These discrepancies and NBS' explanations of their causes are summarized below.

Discrepancies Found in Limited Test of Property Management Records

Item	Discrepancy	NBS explanation
Laser	Recorded serial number incorrect.	Mistake in recordkeeping.
Laser	No identification number tag.	Mistake in tagging and recording acquisition.
Laser	Tagged for identification but not on property list.	Property list originally provided GAO outdated; updated list included item.
Laser	Difficulty in locating because of different equipment descriptions recorded and generic name used by responsible scientists.	Items sometimes recorded by generic names, other times by descriptive names.
Laser	Records showed undepreciated balance of $29,944 as of July 1984 inconsistent with recorded acquisition in 1976 for 4-year depreciable life on $44,644 original value.	Mistake in recordkeeping.
Data Acquisition System	Recorded serial and model numbers incorrect.	Mistake in recordkeeping.

Our initial difficulty in locating listed items to verify recorded information was the difference between recorded and actual locations of equipment. At the Joint Institute for Laboratory Astrophysics, we had to return for a second visit after officials were initially unable to locate the items we selected to examine. They had located all the items on our second visit. NBS' property management chief told us that he believes scientific

and engineering equipment, unlike office equipment, cannot be tracked when it is moved and NBS' requirements in recording the location of its equipment are necessarily special.

In addition to the 14 items at JILA, we also included a plumbing research tower, valued at $81,000, in the inventory in our test. Officials of the Center for Building Technology originally thought the plumbing tower that we attempted to locate was not correctly recorded as their property. Subsequently, they agreed with NBS' comptroller's office that the $81,000 recorded on the property list was for improvements to the five-story plumbing research facility in 1981 and was correctly recorded as belonging to the center.

The chief of NBS' Property Management Office explained the discrepancy as the result of disagreements over whether the 1981 improvements should be accounted for as real property, which is not subject to depreciation charges, or capital equipment, for which depreciation is charged. Officials of the National Engineering Laboratory told us that remaining depreciation charges of approximately $69,000 for the facility--at which research has not been funded since fiscal year 1983--are to be repaid as part of the center's overhead charges for ongoing research activities.

In commenting on a draft of this report, NBS pointed out that since it was able to locate all our sample items, it did not think our criticism of the property management system was warranted. Nevertheless, NBS stated that it is instituting a new method of taking inventory which will improve the timeliness and accuracy of property management activities, and no further evaluation is necessary. NBS interpreted our discussion of this issue in the draft as recommending postponement of implementation of the new system.

Our discussion of property management was not intended as a recommendation to postpone the new system. We have revised our discussion somewhat to eliminate this impression. Also, on the basis of discussions with NBS' chief of property management and deputy comptroller, this final report includes greater detail on the discrepancies we found than were provided in the draft. We continue to believe management attention is needed to correct discrepancies in property records, even in areas where the new inventory system was in effect.

AGENCY COMMENTS AND OUR EVALUATION

At our request, the Department of Commerce and the National Bureau of Standards commented on the draft of this report. These comments are reproduced in appendix XVIII. The Department of Commerce said that it reviewed the NBS comments, found them responsive to matters discussed in the report, and offered no additional comments.

NBS provided comments on the issues we suggested for further consideration and made recommendations for factual changes to enhance the report's technical and factual accuracy. NBS expressed the view that existing planning and evaluation processes for NBS programs are adequate to justify the agency's research role and facility management decisions. NBS also felt that current efforts to improve the property management system are adequate and require no further review. NBS' concerns and our response on these issues are discussed in detail on pages 13 and 16. Technical changes that NBS recommended have been made where appropriate in the appendixes.

OBJECTIVES, SCOPE, AND METHODOLOGY

Our overall objective was to determine if use of NBS research facilities could be increased and to provide detailed data answering the following questions specified in the request letter (included as app. I of this report):

--How much are NBS research facilities used and by whom?

--Can these facilities sustain around-the-clock use?

--Has curtailment of NBS budget and staff resources reduced research facility use in recent years and has use by non-NBS researchers compensated for such reductions?

--Are outside users solicited?

--What are the constraints to increasing use of NBS research facilities?

--Which facilities could be more effectively used with minor expansion or upgrading?

--What facilities have been phased out since 1972 and why were they eliminated?

To the degree feasible within the time limits required to meet the committee's requested reporting date, we also addressed how much each of the selected facilities should be used.

In answering these questions, the committee requested that we examine approximately 20 percent of NBS' research facilities. Therefore, we selected 14 facilities from an NBS-prepared list of 61 research facilities in operation and 9 under development, as presented in appendix II. These 14 facilities we reviewed represent, in our judgment, a cross section of research facilities in size, suitability for increased use, and organizational responsibility. Eight of these facilities were specified in your request

letter, one was specified in discussions with your office, and we selected five more to provide the desired cross-section. The diversity of user populations, operating characteristics, and program objectives served prevents projecting the results of our analysis to all NBS research facilities.

In addition, we gathered information on all 21 facilities that NBS identified as having been eliminated since 1972. Discussions with officials responsible for managing these facilities when they were in operation were the best sources of information we could find. Where available, we also reviewed documents describing or evaluating these facilities.

NBS does not routinely collect data on use of all research facilities. Therefore, we relied on the managers of the selected facilities to compile data on and explain how and by whom each facility has been used in fiscal years 1982 and 1983. These managers also estimated use for fiscal years 1984 and 1985. We found three facilities in our sample--the reactor, the synchrotron, and the gas flow measurement facility--where managers maintain records of how equipment is used. As much as possible we reviewed data from relevant management systems.

We also discussed with NBS managers how use could be increased for each facility and reviewed relevant analyses, evaluation reports, and proposals for alterations to facilities to expand or change use, when such documents were available. In addition, to confirm NBS officials' views on demand for increased research from or access to these facilities, we contacted non-NBS researchers and recipients of NBS' research services. We also contacted managers of facilities comparable with the NBS facilities for comparison of operating characteristics when possible. Details of our non-NBS contacts to confirm NBS views on demand and to compare NBS operating characteristics are included in the individual appendixes.

Lack of a quantifiable relationship between budgetary data and research facility use data prevented our correlating fluctuations in the two. Funding and personnel allocations cannot generally be identified for individual research facilities because these resources are allocated to programs and organizational units. Most programs and organizational units have multiple research facilities, and some facilities serve multiple organizational units and programs.

Our review of research facility utilization required extensive cooperation from many NBS personnel to develop data and identify pertinent information not routinely collected. We would like to recognize the courtesy and helpfulness of researchers and

managers in the facilities as well as administrative and clerical personnel.

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We are sending copies of this report to the Secretary of Commerce and the Director of the National Bureau of Standards.

J. Dexter Peach
Director

Contents

ABBREVIATIONS

AMRF	Automated Manufacturing Research Facility
DARPA	Defense Advanced Research Projects Agency
ESCA	Electron Spectroscopy for Chemical Analysis
GAO	General Accounting Office
JILA	Joint Institute for Laboratory Astrophysics
MIT	Massachusetts Institute of Technology
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards

APPENDIX I

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE AND TECHNOLOGY

SUITE 2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, D.C. 20515
(202) 225-6371

February 21, 1984

Hon. Charles A. Bowsher
Comptroller General of the United States
U.S. General Accounting Office
441 G Street NW
Washington, DC 20548

Dear Mr. Bowsher:

In 1980 the Congress deleted the continuing authorization for the National Bureau of Standards and initiated a process of annual authorizations for this agency. Since that time our Subcommittee on Science, Research and Technology has become thoroughly familiar with the many diverse and important programs which are conducted at the Bureau, both at its main laboratories in Gaithersburg, Maryland and at its field facilities in Boulder, Colorado.

Within the last year we have become aware of an emerging problem which we believe merits our careful consideration. We are writing you today to ask the assistance of the GAO in obtaining factual information and a careful analysis of this problem.

Our concern is with the issue of research facility utilization. Since the NBS staff moved from the District of Columbia to its present campus in Gaithersburg in 1966, a significant and diverse group of high quality research facilities have gradually been acquired and have been continously upgraded and modernized. We have been encouraged by the many fine results which these facilities have yielded, and by the services they have provided to both the NBS and to industry and other government agencies. It appears, however, at this time, that many of these superb facilities may be seriously underutilized.

We would like to ask that the GAO conduct a survey of the utilization of the major research facilities of the Bureau of Standards. We would be interested in the answers to such questions as: What is the current utilization of each facility by Bureau staff, by the staff of other government agencies, and by researchers from industry and the universities? To what extent is each facility able to sustain around-the-clock use, and to what extent is it used in that manner? In which instances has the curtailment of the Bureau's own staff and resources in recent years resulted in reduced research facility utilization? To what extent have such reductions been compensated for by others use? Has the Bureau actively sought to solicit outside users of these facilities in recent years? Are there other constraints which inhibit full utilization? Which of the facilities could, by comparatively minor expansion or upgrading, be more effectively utilized?

APPENDIX I

We would note that this list of questions is not meant to be exhaustive. We would expect that GAO's experts, after becoming familiar with the general issue of research facility utilization and the specific problems found at the National Bureau of Standards, will adjust these questions and frame others as may be needed to present us with a report which will enable the Subcommittee to make sound judgments about this important question.

In order to obtain a sufficiently broad base of data for this study, we ask that, of the approximately 100 large and medium sized research facilities at the NBS, your study include at least 20. We further ask that your study include the following specific research facilities which are of particular interest to the Subcommittee: The Fire Research Facility, the Automated Manufacturing Test Facility, the High Flux Nuclear Reactor, the Near Field Antenna Scanning Facility, the Large Environmental Chamber, the Three Dimensional Earthquake Simulator, the Network Protocol Testing and Evaluation Facility, and the Synchrotron Ultraviolet Radiation Facility. Please include in your report, as well, a list of the research facilities which have been phased out of use since 1972, and the reason for their elimination.

We have advised the Bureau's Director, Dr. Ernest Ambler, of our concern in this area and asked him to cooperate with you and your staff in the conduct of this study. In order to be most useful to us, the final report should reach us no later than November 30, 1984 so that its results and conclusions can be considered as part of our hearings on the FY 1986 budget request. Should you have specific questions about our request, please contact Dr. John Holmfeld of the Committee staff at (202) 225-1062.

Sincerely,

DON FUQUA
Chairman

DOUG WALGREN, Chairman
Subcommittee on Science
Research and Technology

F/W:Heg

NBS RESEARCH FACILITIES

Responsible Organization Facility Name	Suitability For Additional Use[a]			
National Measurement Laboratory	A	B	C	D
Far Infrared Spectroscope	X			
Microcalorimeter	X			
Photoionization Mass Spectroscope	X			
Rotating Platinum-Lined Adiabatic Bomb Calorimeter	X			
Toxic Chemical Handling Lab (Modification Underway-RIMS, EI Ionization Spectrometer)	X			
Synchrotron Ultraviolet Radiation Facility[b]		X		
Surface Analysis[b]		X		
High Resolution Infrared Spectrometer		X		
Microwave Spectroscopy Facility		X		
Electron Van de Graaff (4 MeV)		X		
Linear Electron Accelerator (140 MeV)		X		
Positive-ion Van de Graaff Accelerator (3 MeV)		X		
Cobalt-60 Irradiation Facility		X		
Inorganic Mass Spectrometer		X		
Compositional Microanalysis Lab		X		
High Pressure Photoionization Mass Spectrometer			X	
NBS Gas Thermometer			X	
Low Pressure Mercury Monometer			X	
WWV, WWVH, WWVB Radio Stations			X	
Picosecond Spectroscope			X	
Molecular Beam Field Emission Microscope			X	
Low Temperature Facility			X	
High Temperature Controlled Atmosphere			X	
Joint Institute for Laboratory Astrophysics[b]			X	
Kinetic MS/MS				X
CW Racetrack Microtron				X

(continued)

APPENDIX II

Responsible Organization Facility Name	Suitability For Additional Use[a]			
	A	B	C	D
National Engineering Laboratory				
High Voltage Measurement Facility	X			
TEM Cells	X			
Universal Testing Machine (Modification Underway-Lateral Force Buttress)	X			
Reverberation and Anechoic Chambers	X			
Passive Solar Test Building	X			
Solar Equipment Evaluation Facility	X			
Outdoor Extrapolation Range for Antenna Measurements	X			
Smoke Detector Test Laboratory	X			
Smoke Movement Study Facility	X			
Two-story Structural Steel Test Facility	X			
Quiet Flow Tunnel	X			
Near-field Antenna Scanning Facility[b]	X			
Large Environmental Chamber[b]	X			
Five-story Plumbing Research Facility[b]	X			
Superconductive Circuit Fabrication Facility[b]		X		
Fire Test Building[b]		X		
Tri-directional Structural Testing Facility (Earthquake Simulator)[b]		X		
Gas Flow Measurement Facility[b]			X	
Large Guarded Hot-plate Facility			X	
Water Flow Calibration Facility			X	
Industrial Furnace			X	
Electro-optical Voltage Field Mapping System			X	
Automated Manufacturing Research Facility[b]				X
Calibrated Hot Box				X
Ground Screen Antenna Range				X
EMI Anechoic Chamber				X
Solid-liquid Flow Loop Facility				X

(continued)

Responsible Organization / Facility Name	Suitability For Additional Use[a]			
	A	B	C	D
Center for Materials Science				
Thin Film Facility	X			
Inorganic Glasses Facility	X			
Rotating X-Ray Anode Diffraction Facility	X			
Three-circle X-Ray Diffractometers	X			
High Flux Nuclear Reactor[b]		X		
Metals Processing Lab[b]		X		
Mossbauer Spectroscopy of Metals Facility		X		
Alloy Phase Diagram Center			X	
200 Megahertz NMA Facility			X	
High Temperature Vaporization Lab			X	
High Pressure Optical Fluorescence Device			X	
Transmission Electron Microscope			X	
Scanning Electron Microscope			X	
NBS-NRL Beam Line at National Synchrotron Light Source, Brookhaven				X
TOF Neutron Spectrometer				X
Institute for Computer Sciences and Technology				
Network Protocol Test and Evaluation Facility[b]			X	
Computer Storage Media Lab			X	

[a]In the judgment of NBS facility managers.

[b]Included in review; detailed information in subsequent appendixes.

A - Suited to additional use as is.
B - Suited to additional use with modification.
C - Not suited to additional use.
D - Under development and not fully operational.

JOINT INSTITUTE FOR LABORATORY ASTROPHYSICS

QUANTUM PHYSICS DIVISION

CENTER FOR BASIC STANDARDS

NATIONAL MEASUREMENT LABORATORY

An agreement between NBS and the University of Colorado established the Joint Institute for Laboratory Astrophysics (JILA) in 1962. JILA is located on the main University of Colorado campus in Boulder, Colorado. As a center for advanced basic research and training, it performs work in atomic and molecular physics, laser and chemical physics, fundamental and precision measurements, geophysical measurement methods, and astrophysics. This institute is recognized as a national center for atomic physics and is open during normal business hours, but scientists and students have access beyond these hours.

JILA consists of a 10-story building, a laboratory wing with a large, isolated underground research bay, and an auditorium. Funding for construction of the facility was provided by the National Science Foundation and the state of Colorado.

LIMITED NBS ROLE

JILA's work supports its own Quantum Physics Division, four other NBS divisions within the Center for Basic Standards, and two other NBS centers. The institute's mission is to establish a reliable foundation for scientific and technological measurements and data. Two examples of JILA's work in scientific measurements are (1) in atomic physics to assist in developing the atomic clock principle used today to measure time, and (2) a stabilized laser, which JILA scientists invented. Based on NBS' research with this laser, the International Committee on Weights and Measures adopted a new unit of length.

NBS and the University of Colorado share utilities and maintenance costs of about $350,000 per year. Equipment was acquired over time, and over 70 percent of all the capital equipment is purchased with funds from a National Science Foundation grant and other federal agency funds. Most of the NBS funds are used for salaries, overhead, and the visiting scientists program. As indicated in the following table, total funding comes from a variety of sources.

Table 2

JILA Funding Sources

Source	Fiscal year 1984 (NBS estimate)
NBS direct appropriation	$2,318,000
State of Colorado	690,000
National Science Foundation	1,122,000
Other federal agencies	2,352,267
Private industry and foreign sources	214,733
Foreign student fellowships	30,000
Total	$6,727,000

NBS funds less acquisition of expensive equipment than the University does. The current equipment property list has 1,975 items totaling $4,251,983; NBS owns 1,189 of these items, valued at about $1.8 million and only four items cost over $30,000. The University of Colorado owns the most expensive items in the inventory--786 items valued at a total of $2.3 million.

Variety of users

Users of JILA, in addition to the NBS and University scientists, are primarily post-doctoral fellows, graduate students, and visiting scientists. JILA has about 172 users per year, coming primarily from academia, as shown below.

Table 3

Typical Users Per Year

	Number
NBS scientists	15
University scientists	10
Visiting scientists (from universities worldwide)	15
Post-doctorals	41
Graduate students	56
NBS scientist (Gaithersburg Rotation Program)	1
Clerical staff (3 NBS and 14 University)	17
Technicians (3 NBS and 14 University)	17
Total	172[a]

[a]Not adjusted for turnover of 40 to 50 students and post-doctoral fellows per year.

Visiting scientists come from other universities throughout the world to collaborate with the JILA scientists on projects, and the graduate students act as technicians. In addition, JILA has 17 full-time technicians. Every year JILA receives over 150 applications from worldwide senior scientists and post-doctoral fellows to participate as visitors. According to JILA managers, the institute can accommodate only about 15 visitors and about 40 post-doctoral fellows per year. The visitor's program advertises in scientific journals, and all scientists are welcome to apply; very few industry scientists, however, do. JILA officials believe that this is because university scientists can obtain sabbaticals for a year of absence more readily than can industry scientists.

JILA has maintained about 172 users per year and has not received budget or personnel cuts. However, the latest National Research Council evaluation panel (October 1981) is concerned that possible future reductions in the National Science Foundation grant or other federal agency reimbursements could adversely affect the institute. JILA officials hope that such cuts will not occur and individual scientists continue to seek funds from other federal agencies to sustain the current level of activity.

CURRENT USE

We developed data on 13 of the most expensive pieces of equipment to determine usage. Most of these are lasers and computers. The lasers are custom-assembled to accommodate particular experiments. Usage logs for two of the lasers indicate that they were used daily, from 30 minutes to 14 hours per day, between January 1, 1984, and August 27, 1984. Another piece of equipment, which cost $39,710, has been used little in the last 3 years because it requires modernization. Another piece of equipment, originally costing $42,914, was used for about 10 years, but JILA scientists now consider it obsolete and it is idle. One of the two computers we reviewed ran continuously and the other was available for use 8-hours-per-day or more, depending on work load.

Status of equipment plans and evaluations

JILA does not currently have a 5-year research plan, but intends to develop one in the near future. Each senior scientist does, however, have short-term plans for work on non-NBS funded projects. These plans call for equipment to be replaced or upgraded as needed whenever funds become available--mostly from reimbursements.

A National Research Council panel that evaluated JILA in 1980 and 1981 did not evaluate facility or equipment use, but it did cite the need for more modern lasers and computers. In addition, the October 1981 evaluation panel stated its concern that over 70 percent of the capital equipment annual budget comes from the National Science Foundation grant and other federal agency support. This same panel recommended that since NBS depends on JILA for much of its most important basic research, it should begin to provide a significantly larger share of the total capital investment.

COMPARABLE FACILITIES

Though it has laboratories and research equipment, JILA is both a research and educational institute, not a user research facility open to the public. We could find no comparable facilities, so we could not make comparisons.

CONSTRAINTS TO INCREASED USE

Because of JILA's uniqueness as a research and training institute, usage is difficult to assess. JILA is a collaboration of people who perform basic research; equipment is considered a tool of its work. Although some of the equipment periodically runs 24-hours-per-day, the entire institute is not open 24-hours-per-day. This equipment is dedicated to individual experiments; it is custom-assembled to support an academic as well as basic research mission. Equipment assemblies and laboratories are not designed to support multiple users and cannot be easily reconfigured to do so.

SYNCHROTRON ULTRAVIOLET RADIATION FACILITY

RADIATION PHYSICS DIVISION

CENTER FOR RADIATION RESEARCH

NATIONAL MEASUREMENT LABORATORY

The NBS synchrotron ultraviolet radiation facility is an electron storage ring used in radiometry (the measurement of radiation) and experimental physics. It supports the national measurement system in the use of far ultraviolet radiation in energy, atmospheric, and space programs. The facility has 11 beams through which radiation is directed at measurement instruments and data-accumulation equipment. Each beam line can accommodate five experiments at any one time. Generally, the facility operates during normal business hours.

CURRENT USE

The NBS synchrotron facility evolved over a long period of time. The original machine was a betatron built in the 1950's by the General Electric Company for the Oak Ridge National Laboratory. Later, General Electric converted the machine to a synchrotron, and Oak Ridge donated it to NBS. The synchrotron was converted into its present storage ring configuration in the mid-1970's. The upgrade to a storage ring was intended to achieve project objectives more efficiently and accurately by increasing the brightness of the source, the electron current, and machine energy. Conversion to a storage ring cost about $750,000, and subsequent alterations have cost approximately $1.85 million.

NBS, as well as other federal agencies, national laboratories, and universities, collaborate on various research projects using the synchrotron. For example, the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), and the Department of Energy use one particular beam for calibrating spectrographic systems. In a joint project, NBS, the Argonne National Laboratory, and a United Kingdom laboratory use a synchrotron monochromator to study molecular photoionization important to understanding upper atmospheric chemistry. Another beam, which can accommodate up to four work stations, is being used by NBS surface science personnel, universities, and Goddard Space Flight Center scientists. Overall, the facility generally has been used by at least nine guest workers and, according to NBS comments on the draft of this report, occasional industrial researchers in the past.

Synchrotron use is managed informally. For example, a Radiation Physics Division group leader makes most day-to-day decisions regarding synchrotron use, demand for which rarely

exceeds availability. With the exception of a beam used for calibrations, there is no backlog. Proposal review committees are formed when backlogs occur, but the committees disband when demand abates. The director of the National Measurement Laboratory makes facility utilization decisions when proposals are received to use beam lines as dedicated facilities for long-term projects.

NBS funds about 85 percent of the research done on the synchrotron. The remainder is funded by reimbursements from other agencies--e.g., NASA, the Department of Energy, and the Naval Research Laboratory.

Synchrotron use is recorded in daily logs showing who uses the facility and when the facility is operating. In fiscal years 1982 and 1983, the synchrotron was used 70 percent of the total hours available for use. The deputy director for the Center for Radiation Research at NBS believes that this is comparable to or better than the amount of use of other synchrotrons in the United States. Use reports from other synchrotrons confirms his opinion.

COMPARABLE FACILITIES

There are five synchrotron storage rings in the United States--one each at the University of Wisconsin, Stanford University, Cornell University, and two at the Brookhaven National Laboratory. However, NBS' synchrotron is a unique source for radiometry because it is the only storage ring in the world with a circular electron orbit. The circular electron orbit gives it the capability of operating as an absolute standard light source and gives NBS the only facility in the United States to perform radiometric calibrations in the far ultraviolet region of the light spectrum--an activity critical to certain measurements made in space. NASA uses NBS' synchrotron to calibrate space shuttle instruments.

OPPORTUNITIES FOR INCREASED USE

Facility managers have submitted plans to the NBS director to upgrade the synchrotron into a national-user facility. The plan states that, for about $3.77 million ($3 million in capital investment and a $770,000 budgetary addition), staff-perceived limitations in the areas of personnel and facilities can be corrected. According to the staff, operations are hampered by lack of such facilities as a central computer, desk space, a clean room, and a room for assembling equipment. Also, there is now only one engineer and one technician who operate the facility full-time, necessitating the use of research scientists for operations.

The proposed upgrade plan gives three objectives. The first is to increase the productivity and availability of the synchrotron by expanding the building to double its space and enlarging the operations staff to increase operating time. The second and third objectives are to increase the storage ring's maximum electron energy and to upgrade service and facility support for users by expanding user support areas and adding support personnel. NBS officials told us that the NBS director will support the upgrade of the synchrotron if evidence of demand increases.

At present, managers of the facility have no letters requesting access or other concrete evidence of a demand not now met, but they believe such demand exists. They base this belief on recent studies by the Department of Energy and the National Academy of Sciences. According to NBS officials, both of these studies resulted in reports recommending construction of new machines similar to the one at NBS and "user-friendly" operation of existing synchrotron facilities. These officials also cite "strong, positive response of potential users" to presentation of the NBS upgrade proposal at several conferences in the fall of 1984 (see app. XVIII). They believe that they do not receive requests for non-NBS use because the limitations of the facility are known. They say that they do not publicize the NBS synchrotron because it cannot accommodate more users than it now has.

APPENDIX V

SURFACE ANALYSIS

SURFACE SCIENCE DIVISION

CENTER FOR CHEMICAL PHYSICS

NATIONAL MEASUREMENT LABORATORY

The NBS surface analysis facility identified in the 1976 NBS Special Publication 413 is not an independent laboratory but a part of a larger complex of equipment in the Surface Science Division. The goal of the Surface Science Division is to improve the quality of existing surface characterization measurements and to extend the present measurement capability. Surface analysis--the measurement of the outermost atomic layers of a solid--is an essential method of performing surface science that is interdependent with other methods. Currently, the Surface Science Division has two spectrometers that are used for surface analysis experiments and are available during normal business hours.

CURRENT USE

In the early to mid-1970's, NBS purchased two surface analysis instruments--the Auger and the electron spectroscopy for chemical analysis spectrometers (ESCA)--for approximately $165,000. Subsequent upgrades of both instruments have cost a total of about $265,000. These instruments were advertised by NBS as a surface analysis facility available for outside use in 1976.

The Surface Science Division staff of 19 scientists are the predominant users of the surface analysis instruments, accounting for about 90 percent of actual use. Outside users have access to the instruments when NBS is not using them, but because the instruments are integrated into larger assemblies of equipment, such use is allowed only if it will not disrupt ongoing work.

Approximately 75 percent of the division's activities involve use of at least one of the surface analysis spectrometers. Examples of the projects that utilize the spectrometers are studies in catalytic surface chemistry; the development and production of standard reference materials; and the study of surface chemical physics in crystals, alloys, and films. Most of the division's work directly supports NBS programs rather than other agency programs.

COMPARABLE FACILITIES

NBS surface analysis instruments are not unique. The Navy has two surface analysis facilities in the Washington, D.C., area--one at the Naval Research Laboratory and the other at the

Naval Surface Weapons Center. There are a number of Auger instruments at the Naval Research Laboratory to support at least 15 experiments requiring surface analysis work. This equipment is apparently used in essentially the same way as the NBS equipment--during normal business hours. Also, similar instruments are available in private companies such as the XEROX and International Business Machines Corporations as well as such universities as Columbia and Cornell. The NBS Surface Science Division encourages companies requesting surface analysis services to use these commercial laboratories and does not solicit users.

OPPORTUNITIES FOR INCREASED USE

The division chief told us that in 1981, the division chief submitted plans for a surface analysis laboratory at NBS at an estimated cost of $869,000. The plan called for the purchase of Auger and ESCA spectrometers, as well as other equipment, to bring a unique and state-of-the-art capability to NBS. The Department of Commerce rejected the request, and there are no current plans to expand existing equipment into an independent laboratory.

Commenting on rejection of the plan, the Surface Science Division chief said he recognized advantages to performing work in multiple research areas rather than at a central facility as proposed. Surface analysis measurements are conducted in a number of different NBS research areas in addition to the Surface Science Division--e.g., the Inorganic Materials and Metallurgy Divisions (in the Center for Materials Science) and the Chemical Process Metrology Division (in the Center for Chemical Engineering). He believes it may not be cost-effective to do all surface analysis work at a central facility because of cycling times for each experiment. Furthermore, because surface analysis is just one part of a larger experiment, a demand may not exist for surface analysis equipment alone.

The Surface Science Division is somewhat personnel limited. Since 1981, the division has lost six scientists through resignations, reassignments, and reductions-in-force. A National Research Council evaluation report noted that these losses have significantly reduced expertise in surface chemistry. The division chief explained that he cannot correlate these personnel losses to how often particular pieces of equipment are used. Lacking precise data on use of the surface analysis instruments, we could not make such a correlation either.

AUTOMATED MANUFACTURING RESEARCH FACILITY

CENTER FOR MANUFACTURING ENGINEERING

NATIONAL ENGINEERING LABORATORY

The Automated Manufacturing Research Facility (AMRF) is to be developed at the NBS Center for Manufacturing Engineering. It provides an engineering test bed and demonstration, entirely computer controlled by an advanced control system pioneered at NBS--a research prototype of the factory of the future. When it becomes fully operational in 1986, NBS officials believe the AMRF will incorporate the most advanced and flexible automated manufacturing techniques in the world. It is open for research during normal business hours to support two programs of the Center for Manufacturing Engineering--mechanical engineering metrology and automated manufacturing interface standards.

Through fiscal year 1984, a total of $31,514,000 had been spent developing the AMRF. Of this amount, NBS funded $22.558 million; other government agencies contributed $8.421 million (including $300,000 of loaned equipment); and equipment valued at $535,000 was loaned by the private sector. The facility houses approximately 15 major pieces of equipment--e.g., data acquisition computers and robots.

CURRENT USE

NBS was given congressional authorization (Public Law 96-461) in October 1980 to build the AMRF to allow study of issues involving the batch shop manufacturing environment. The role of NBS in automated manufacturing is twofold: (1) to provide the basis for measurement assurance, a means by which the dimensional attributes of manufactured products can be traced to national standards, and (2) to assist in development of voluntary standards needed to successfully automate industry.

The facility supports the automation research of NBS staff and researchers from other government agencies, industrial firms, and academia. It has a full-time operations staff of approximately 60 NBS scientists and engineers and 20 technicians, as well as 22 industrial research associates and 16 guest workers.

Managers of the AMRF solicit outside users of the facility through the NBS Office of Industrial Liaison, which prepares cooperative agreements between NBS and the research party. Under this program, a research project of mutual interest is defined by NBS and an industrial firm. An employee of the firm is sent to work at NBS for a period of 6 months to a year. The person's salary is paid by the firm, and NBS provides general laboratory space and equipment at no cost to the user.

Funding for the facility is also supplemented by three other agencies that have projects of their own. The Navy's Computer Integrated Manufacturing Program is a major supporter of the program, providing more than $3 million per year. The Air Force Intelligent Task Automation Project and the Department of the Army are also contributors. Facility managers estimate that approximately 60 percent of the operation costs of the facility are funded by other agencies.

To maintain a high level of outside interest in the work of the AMRF the Center for Manufacturing Engineering conducts one-day industry briefings. NBS officials have scheduled briefings once every 2 months in the past year. Also, the public was invited to the first AMRF test runs during November 1983 and June 1984, and over 1,000 visitors came.

Although the AMRF is still being developed, its research objectives are well documented in Center long-range plans. A technical implementation plan for the AMRF is also documented. These plans entail research efforts to be undertaken through 1986 and beyond.

COMPARABLE FACILITIES

The AMRF is unique for 2 reasons--it is the only multi-workstation facility with a computerized control system and is set up especially to support research on interface standards and quality control in an automated environment. Although automated research facilities are planned at the Universities of Florida and Wisconsin, they will address different research objectives and perform different applications. NBS officials told us that these facilities will be complementary rather than competitive with the AMRF.

OPPORTUNITIES FOR INCREASED USE

The facility currently has many users though it is still not fully operational, and NBS officials expect use to increase as it undergoes further development. However, even when it is complete in late fiscal year 1986, NBS does not intend to routinely run it 24-hours-a-day. They do not believe that researchers will want to use it at night, but they do believe that use will continue to grow until the facility is completed in 1986 and beyond.

TRI-DIRECTIONAL TEST FACILITY

STRUCTURES DIVISION

CENTER FOR BUILDING TECHNOLOGY

NATIONAL ENGINEERING LABORATORY

The tri-directional test facility (referred to in the request letter as an earthquake simulator) allows engineers 6 degrees of freedom to conduct general purpose tests of structural components subjected to multi-directional forces such as those experienced during an earthquake. Specimens can be compressed, stretched, and twisted in the facility, which is available for use daily during normal business hours. It contains equipment valued at over $500,000.

CURRENT USE

The NBS Center for Building Technology constructed the facility to support NBS participation in the National Earthquake Hazard Reduction Program, established by the Earthquake Hazard Reduction Act of 1977 (Public Law 95-124). Design, construction, and equipment procurement took place over a 2-year period and cost $689,000. Equipment was financed as an investment of the NBS working capital fund--the center will reimburse the fund for these costs through depreciation charges, to be paid over the estimated useful life of the equipment. The designer of a similar facility at the University of Texas was consulted during development, but such alternatives to building a new NBS facility, as modifying the University facility or using a large structural testing facility (with 6 degrees of freedom) at Marshall Space Flight Center in Huntsville, Alabama, were informally considered. Officials of the National Engineering Laboratory say that they rejected such alternatives as inadequate to their needs. Construction was completed in 1983, and there is no current long-range plan against which use of the facility can be compared.

The tri-directional test facility is used to support the building research program in areas other than earthquakes. Since the facility became operational, it has been used for one completed project--unrelated to earthquake hazards reduction--for another government agency on a reimbursable basis. Part of the facility--the data processing capability--was also used in another structural evaluation. To date, only one earthquake-related project that is dependent on the use of the facility has been initiated and is being funded by NBS. Two more projects are planned. A total of 2 NBS personnel have actually used the facility since it was completed. Guest researchers from a university are planned to use it in 1985.

Only NBS scientists and technicians actually operate the facility; there are no guest workers or industrial research associates involved in the facility's research activities. NBS has not received any written requests to use the facility, and we found no evidence other than brochures that use of the facility has been actively solicited. As a matter of fact, a recent technical evaluation by the Earthquake Engineering Institute identified national research laboratories for improving earthquake-resistant design of buildings, but did not include the NBS tri-directional test facility. Our contacts with the authors of this evaluation indicated that they were not aware that NBS had a facility. Furthermore, the program advisors told us that NBS has been assigned a limited role in the National Earthquake Hazards Mitigation Program's 5-year plan because their contribution has been minimal and their research objectives have no real effect on the overall research agenda. (NBS is appropriated $475,000 for earthquake research as part of the total national program, which is estimated at $67 million for fiscal year 1985.)

Although NBS maintains no records of use, facility managers estimated that the test facility has been used an average of 80-days-per-year. Their estimate includes time for installing and setting up instruments to test specimens, collect and analyze data, and remove the test specimen from the facility.

A 1983 report of the National Research Council program evaluation panel recommended equipment improvements at the facility. The panel also noted that long procurement lead times indicated that the NBS should foresee the equipment needs of the Structures Division, and recommended that the Division develop an orderly program for equipment acquisition. Prioritized lists of equipment needs were prepared for fiscal years 1984 and 1985. At the time of our review, a longer range plan had not been developed against which current use could be compared.

COMPARABLE FACILITIES

Facilities comparable with NBS' exist and may have offered alternatives to constructing a new facility at NBS. The University of Texas, for example, has a similar facility. NBS officials did not sponsor structural testing at the University facility, they said, because they believed it could not carry out the needed tests, and they saw no reason to enter into any co-operative agreements or contracts with universities. The researcher who manages the University of Texas' structural test facility--and who was contracted by NBS to review the NBS facility design--indicated that, with modification, he believes the University facility could perform the work done at NBS. The Deputy Director of the Mechanics, Structures, and Engineering Division at the National Science Foundation told us that the University of Texas is one of many

institutions that receive a total of $13 million in grants this year to do research and support building standards and codes--work similar to NBS'.

Another tri-directional structural test facility at Marshall Space Flight Center in Huntsville, Alabama, has six degrees of freedom, like NBS' facility. The director of the Systems Dynamics Laboratory at this NASA research facility told us that (1) NBS' structural test facility, with six degrees of freedom, is not unusual; (2) the NASA structural test facility, which was built in the 1960's, has greater flexibility and controllability than NBS'; (3) the NASA lab also has another, larger structural test facility available to any engineers or researchers requiring very large scale tests; (4) since NASA promotes use of its research facilities, NBS needs could probably be accommodated; and (5) he had never previously heard of NBS' facility.

In responding to a draft of this report, NBS disagreed that any other structural test facility could meet their needs. NBS views its facility's capability as unique and essential to building research and test needs in areas other than the reduction of earthquake hazards.

NBS officials also commented that their role in the National Earthquake Hazards Mitigation Program, coordinated by the Federal Emergency Management Agency, includes more than research. NBS chairs an interagency committee and a joint panel with Japan. The agency also provides technical support to the private sector.

CONSTRAINTS TO INCREASED USE

NBS officials do not believe that routine around-the-clock operation is necessary or that there is sufficient demand to justify extended hours of operation. They said they occasionally use the facility around-the-clock during certain types of testing, but they do not believe that the facility could be more effectively utilized by minor expansion or upgrading.

The Office of Management and Budget proposed eliminating appropriated funding for NBS' building research program for fiscal years 1984 and 1985. Operation of this facility as well as all of the other facilities that support the program would be affected to an unknown degree.

LARGE ENVIRONMENTAL CHAMBER

BUILDING EQUIPMENT AND BUILDING

PHYSICS DIVISIONS

CENTER FOR BUILDING TECHNOLOGY

NATIONAL ENGINEERING LABORATORY

The large environmental chamber is used to simulate environmental conditions in which building, building equipment, and building materials exist. The facility is available for use daily during normal business hours, and when necessary it is used 24-hours-per-day.

CURRENT USE

The large environmental chamber, which supports the Center for Building Technology's building research program, allows development of thermal performance modeling techniques that are required for predicting human comfort and energy efficiency in buildings. It is the largest of seven environmental chambers located at NBS. The chamber was built with a special facilities construction appropriation that covered the relocation of NBS to Gaithersburg in the mid-1960's. However, it was not specifically mentioned in the authorizations for construction. NBS officials told us that there were no written justifications or plans indicating the need and projected use of the facility, and NBS funded the original acquisition cost of approximately $1 million. Subsequent alterations to the chamber--addition of a solar simulator--have totalled $20,000 and were funded by the Department of Energy.

NBS personnel typically perform all operations within the facility, which does not have a full-time operations staff. The average project using the chamber requires two scientists and three technicians. Five of the 6 projects conducted in the facility since fiscal year 1981 have been for other government agencies, principally the Department of Defense and the Department of Energy. The majority of projects conducted during this time were unrelated to NBS' building research program objectives, but NBS personnel operated the facility. Although no facility use data are maintained, facility managers told us that it was in use a total of 82 days from fiscal years 1982 through 1984.

Managers of the Center for Building Technology decide how the facility will be used informally. They told us that there are no written plans indicating long-term research goals or potential equipment needs for the facility. As projects are planned, the chamber is considered for use. A project for the Department of Energy, planned for fiscal year 1985, will use the chamber.

Only one experiment can be conducted in the chamber at a time. Facility managers stated that they have not received any written requests to use the facility and the facility has never hosted any university or guest workers. Also, no industrial research associates had used the facility during the period covered by our review, but 3 research associates used it in the 1970's. We found no evidence of active solicitation efforts to increase the facility's use.

COMPARABLE FACILITIES

The large environmental chamber is the only civilian facility of its kind we could find. Measuring 50x40x30 feet, the chamber can automatically control humidity and temperatures from -50 degrees Fahrenheit to +150 degrees Fahrenheit. The Department of Defense has similar facilities dedicated to military use at White Sands Missile Range, New Mexico, and Fort Walton Beach, Florida. The managers of these environmental chambers told us that they use their facilities much like NBS does--periodically, and for as long as particular activities require, but not around-the-clock, every day.

CONSTRAINTS TO INCREASED USE

Idle periods are experienced between projects, but NBS officials do not attribute these idle periods to budget or personnel cuts that have occurred in recent years. They believe, however, that elimination of the building research program, as proposed in fiscal years 1984 and 1985, would obviously have affected utilization of the facility, but they do not know to what extent. They also believe that they are now meeting all existing demand for the large environmental chamber.

FIVE-STORY PLUMBING RESEARCH LABORATORY

BUILDING EQUIPMENT DIVISION

CENTER FOR BUILDING TECHNOLOGY

NATIONAL ENGINEERING LABORATORY

The five-story plumbing research laboratory was used to study the performance of plumbing fixtures and water supply drainage systems. Before fiscal year 1984, the facility was available for operation during normal business hours; however, it was not used continuously. Recently, it has been idle for over a year. The facility houses two major pieces of equipment--a five-story plumbing tower and a computer data acquisition system and sensors.

CURRENT USE

NBS funded the original acquisition cost, which managers of the Center for Building Research estimate at between $1.8 million and $2.1 million. Center managers also estimate that approximately $650,000 to $750,000 more (a combination of NBS and other agency funds) has been invested to upgrade the facility's instrumentation and data acquisition equipment.

NBS constructed the five-story plumbing laboratory in response to the Plumbing Manufacturers Institute's and other trade associations' desire for a resource that could develop testing methods, descriptions of standards and system design guidelines, and support standards and codes regarding plumbing. It was constructed in the 1960's using the working capital fund to support the Center for Building Technology's building research program, but it has not been used since fiscal year 1983. The facility supported some progress toward fiscal years 1982 and 1983 plumbing research task objectives, but some of the tasks were left unfinished when NBS shifted funding from plumbing research to areas they considered more important. Center officials plan to continue exploring possible cooperative plumbing research projects with industry that would require the use of the plumbing tower in the future; there are no plans to dispose of the facility. A request for funding to support work in the plumbing laboratory is pending with the Pipe Fitting Association.

The facility also supported research funded by other agencies and associations--e.g., U.S. Department of Housing and Urban Development, Environmental Protection Agency, Veterans Administration, and the National Association of Homebuilders--but the number of these research projects steadily declined after fiscal year 1981. From 1981 through 1983, NBS funded the only project using the facility, and the building research program has been the only

NBS program to use the facility. No guest workers have participated in plumbing research and no industrial research associates have used the facility. NBS has received no written requests to use the facility. The facility's managers told us that the Plumbing Manufacturer's Institute has declined an NBS request to fund research at the facility. NBS does not actively solicit users of the facility. Finally, due to lack of demand for plumbing research by other government agencies and the plumbing industry, the center's management team did not include plumbing as a research priority for funding in fiscal years 1984 and 1985.

COMPARABLE FACILITIES

Other plumbing facilities are located throughout the country. One such facility, at the Stevens Institute of Technology, located in Hoboken, New Jersey, is a 10-story configuration and can simulate conditions in tall buildings. Available for use daily during normal business hours, it is used primarily to evaluate plumbing products rather than to support research. However, the manager of this facility told us it could conduct experiments similar to those conducted at NBS if modifications were made.

CONSTRAINTS TO INCREASED USE

Given the apparent lack of demand for and the low importance NBS assigns to plumbing research, it seems unlikely this facility will be used in the near future. Unless facility managers are successful in soliciting funding from a trade association or private company, increased use is improbable.

APPENDIX X

NEAR-FIELD ANTENNA SCANNING FACILITY

ELECTROMAGNETIC FIELDS DIVISION

CENTER FOR ELECTRONICS AND ELECTRICAL ENGINEERING

NATIONAL ENGINEERING LABORATORY

The near-field antenna scanning facility, located at the NBS laboratories in Boulder, Colorado, uses a technique developed by NBS to research measurements of how antennas send and receive electromagnetic waves. The facility also calibrates antennas and probes for private industry and outside agencies. Other work performed at the facility includes maintaining a standard for calibrating antennas. The facility is open primarily during normal business hours, but occasionally a test will run from 12 to 18 hours, and personnel will stay over to complete the work.

Over $400,000 worth of equipment is contained in the facility. Of the 59 items in the facility's inventory, 10 items cost $10,000 or more and 2 items--microwave synthesizers--cost over $30,000 each.

CURRENT USE

The facility has evolved over the years. NBS became involved with indoor near-field testing techniques in about 1960 and assembled a small near-field facility in the mid-1960's. This small facility was replaced in 1972 when NBS adopted an automated computer controlled system. In 1972, equipment costing approximately $146,000 was acquired. Since that time, an additional $230,000 in equipment has been added.

NBS employees are the primary operators of the facility. In fiscal year 1984, these employees consisted of seven engineers/scientists, four technicians, and one graduate student. Only the technicians were assigned full-time to operations of the facility. One Korean guest worker spent a year at the facility from 1982 to 1983 to learn the technology, but no other non-NBS personnel have directly used it.

In addition to NBS mission-related research, the facility is being used for private industry and other agency-sponsored work. Most projects requiring the facility are funded by reimbursements from other agencies and private industry. During fiscal year 1984, the facility performed calibrations for 5 customers, and aided in theory work for 5 sponsors. An 8-month backlog of calibration work for outside customers existed at the beginning of calendar year 1984. NBS does not solicit outside users because of this existing demand for calibration work.

Managers do not believe the facility has been affected by budget cuts. They do believe, however, that their budgeting challenge is to maintain consistent funding from reimbursements. Historically NBS supplies between 30 and 40 percent of the funding for projects using the facility, and the remaining 60 to 70 percent comes from reimbursements for work performed for other agencies and private companies.

COMPARABLE FACILITIES

Worldwide, 25 near-field scanning facilities are in operation, with 19 located in the United States. NBS' experts were consulted during the design and construction of most of these. We compared two outside facilities with NBS. One was operated by private industry and the other by the federal government. Neither facility operated on a 24-hour schedule, even though the private company indicated they could and both were considered fully used by their managers. Neither performed outside calibration work. Also, no other facility provides a national standard of accuracy as provided by NBS. DOD has begun to require a level of accuracy matching NBS' in procurement contracts for military antennas.

CONSTRAINT TO INCREASED USE

Expansion could allow an increased level of calibration work, which might detract from research done at the facility. Antenna facility managers see their mission as helping research rather than providing user services. They believe that after-hours use by outsiders is not possible because measurement set-ups continue from one day to the next and cannot be disassembled to accommodate after-hours users. If expanded use were required, these managers believe that the staff of the facility--both engineers/scientists and technicians--would have to be increased. On the other hand, facility managers claim that 24-hour operation could also be achieved with an estimated $1 million equipment upgrade to make operations more automatic and efficient.

Facility managers believe that proposed policy changes at NBS to allow proprietary research could affect the antenna scanning facility by bringing in more calibration work. They would prefer to continue concentrating on NBS mission research. At present, data collected on a customer's calibrated antenna are not released to the public, but newly discovered techniques or refinements in antenna metrology coming out of the calibration work are published in technical journals and other open literature. NBS cited the need to balance use of the facility for proprietary research with NBS mission responsibilities in commenting on the draft of this report.

FIRE TEST BUILDING

CENTER FOR FIRE RESEARCH

NATIONAL ENGINEERING LABORATORY

The fire test building, completed in 1974 at a cost of more than $1.5 million, was designed specifically for the large-scale fire experiments and tests conducted by the Center for Fire Research. The facility's smoke abatement equipment permits large fire tests to be conducted safely and without pollution of the environment. It also contains instruments to model and verify models of fire development. It is operated about 250-days-per year during normal business hours. The facility houses five major items of equipment, valued at over $30,000 a piece--the fire endurance furnace, furniture calorimeter, NBS rate of release calorimeter, computer, and gas analyzer.

CURRENT USE

In 1974 the Congress established the Center for Fire Research as part of the Federal Fire Prevention and Control Act of 1974 (Public Law 93-498). The fire test building was built with NBS funds to support the research necessary to gain understanding of fire phenomena and evaluation of fire performance of materials, products, and construction characteristics. NBS researchers conduct full-sized room tests in addition to developing computer programs to model fire. The facility's instrumentation has been upgraded to allow mathematical modeling of fire development to eventually replace the current need for costly large-scale testing.

NBS performs an average of 31 fire research projects per year, which are special requests from other government agencies and the private sector, some funded by NBS and others funded on a reimbursable basis. For instance, during fiscal year 1984, NBS conducted fire tests and evaluations for several government agencies, including the Department of Transportation, Department of Energy, and the Consumer Product Safety Commission, and performed internally developed research efforts in nine fire research program areas.

Generally, no one uses the facility without the technical assistance of and collaboration with NBS personnel. Industrial research associates and guest workers participate in ongoing research and use the facility in collaboration with NBS personnel. For example, a large burn experiment will require three to six scientists, four to eight technicians, and as many as three guest workers and two industrial research associates.

The director of the center is actively exploring the potential of increasing the facility's use by private sector and other federal government agency programs. NBS and the National Fire Protection Association recently sponsored a National Fire Research Strategy Conference to discuss the essential need for continued fire research and update the National Fire Research Plan.

Elimination of direct federal funding of the fire program was proposed in fiscal years 1984 and 1985 on the assumption that NBS is undertaking efforts that are more properly the role of the private sector and state and local governments. NBS does not keep records on funding or the costs associated with using the fire test building from which we could measure the effects of budget and personnel reductions. However, a shift of funding sources is evident--80 percent of fiscal year 1984 funding for the fire test building came from NBS' appropriation, and the remaining 20 percent came from reimbursements, contrasted to 2 years ago, when NBS supplied 40 percent of the funding, and the remaining 60 percent was in the form of reimbursements. Total funding levels and facility use levels have remained the same despite this shift in funding sources.

The fire test building is one of three main facilities dedicated to the NFS fire research program, which has well documented objectives and long-range research plans. Researchers from other institutions agree that some of the objectives involving the fire test building are unique to NBS, particularly mathematical modeling of fires. Summaries of progress on all NBS fire research activities are presented at annual conferences, and a report on the most recent conference includes abstracts of all work in progress.

COMPARABLE FACILITIES

The fire test building apparently is unique and has an array of instrumentation not available elsewhere. Though other commercial facilities--e.g., Factory Mutual Research Corporation, Southwest Research Institute, and several laboratories located in Canada, Japan, United Kingdom, France and Sweden--do conduct full-scale fire tests, these facilities address other kinds of fire problems related to storage warehouses, manufacturers' facilities, and product testing. The facility managers of the 2 commercial fire research facilities agreed with NBS officials that the calorimeters at the NBS fire test building are unique and are not available elsewhere. Moreover, they said the sophistication of NBS' instrumentation and data collection is not available elsewhere because it was custom-made by NBS for its use.

CONSTRAINTS TO INCREASED USE

Possible lack of outside interest and funding uncertainties may constrain increasing use of the fire facilities. Facility managers believe increased use of the facility by private firms and outside agencies would not only ease NBS funding difficulties but, more importantly, enable joint venture programs. The Director of the Center for Fire Research has contacted companies and associations, including the Man Made Fibers Producers Association and the Society of Plastics Industries, to solicit use of NBS' fire research facilities but had received no firm commitments as of the time of our review.

If direct funding for fire research is eliminated as proposed in fiscal years 1984 and 1985, use of the facility would be affected. While it is obvious that NBS use would be reduced, how much this decrease could be offset by non-NBS use is unclear.

APPENDIX XII

GAS FLOW MEASUREMENT FACILITY

CHEMICAL ENGINEERING SCIENCE DIVISION

CENTER FOR CHEMICAL ENGINEERING

NATIONAL ENGINEERING LABORATORY

NBS acquired the gas flow measurement facility to provide a standard of accuracy for calibrating equipment that measures liquified gases and to increase the accuracy of measurements in the gas industry. The facility is considered a world leader in measurement methodology for liquified gases.

It is open for use during normal business hours but is also accessible after hours as needed. Test experiments are run about 120 days per year; on test days the equipment runs 10-hours-per-day. The remaining time is dedicated to setup, disassembly, or modification of experiments. The facility managers estimate that it contains about 100 pieces of equipment, and about 25 major pieces cost more than $25,000--e.g., data accumulation computers and related equipment.

CURRENT USE

The gas flow measurement facility supports the mission of the Chemical Engineering Science Division, which addresses measurement and standards needs of the energy industry by providing data, measurement standards, and methods to accurately measure energy fluids. The division provides data, measurement standards, and methodology for commercial exchange and processing of industrial chemicals, fuels, and feedstocks. The facility, to support those activities, was constructed in 1969 in an existing NBS building at an estimated replacement cost of $500,000. In 1977 it was upgraded to study the flow characteristics of natural gas and the accuracy of gas-metering equipment. Since 1979 NBS has invested an additional $200,000.

The facility operates under a contract with the Gas Research Institute that explains the justification and need for a gas flow measurement facility and states who the users of the facility will be. Current funding for research at the facility comes entirely from the gas industry as shown below.

Table 4

Sources of Funding

Source	Fiscal year 1984 (NBS estimate)
Gas Research Institute	$610,000
Compressed Gas Association	15,000
American Gas Association/Pipeline Research Committee	20,000
Other industry funds	10,000
Total	$655,000

Currently, 85 percent of facility use is for the Gas Research Institute (a private nonprofit funding agency whose budget is reviewed by the Federal Energy Regulatory Commission). The level of effort in the facility has been increasing each year and is expected to continue increasing until 1990.

Typically, six NBS engineers and scientists, one technician, and one foreign guest worker use the facility. Nobody else is allowed access because of the complexity of the operations.

COMPARABLE FACILITIES

The gas flow measurement facility is a unique facility that allows NBS to function as a neutral third-party expert. We could not identify comparable facilities anywhere in the world.

CONSTRAINTS TO INCREASED USE

Its managers say the facility is dedicated to individual projects and cannot be easily reconfigured to allow for 24-hour operation. The division chief believes that (1) outside use of this facility would impede progress of the ongoing measurement program, (2) outside users would increase operating costs, and (3) there is no evidence of demand outside of the current projects and users.

SUPERCONDUCTIVE CIRCUIT FABRICATION FACILITY

CENTER FOR ELECTRONICS AND ELECTRICAL ENGINEERING

NATIONAL ENGINEERING LABORATOTY

The superconductive circuit fabrication facility at the NBS laboratories, Boulder, Colorado, is used to fabricate complex superconducting integrated circuits and ultra-high-speed semiconductor optical detectors. The facility assists in meeting NBS mission requirements by keeping NBS scientists informed about superconducting technology and by providing measurement science support for industrial development and use of ultra-high-speed electronic instrumentation, computers, and other complex systems. The fabrication facility provides a nonproprietary domestic source of expertise and capability to make superconductors for research use. It operates during normal business hours but is also accessable during evenings and weekends. The facility has five major pieces of equipment costing $30,000 or more--e.g., an electron microscope and electron beam lithograph.

CURRENT USE

In 1969 NBS formed a group to develop practical superconducting standards and instruments. To do this work, NBS constructed a small clean room within an existing building. The facility is used to make integrated circuits using Josephson junction superconducting technology. NBS has developed it gradually over a period of years since 1970. Total original acquisition cost for the facility is $73,500, and subsequent modifications have cost approximately $540,000.

Current users of the fabrication facility include 13 NBS scientists, 11 graduate students, and 6 guest workers. NBS obtains outside users through proposals, advertisements for graduate research assistants, word-of-mouth, and an active guest worker program. Industry guest workers do research at the facility as part of their obligations under other federal agency contracts. Since 1978, 28 guest workers have used the fabrication facility. These guest workers came from eight foreign and domestic universities, six foreign and domestic companies, and two other federal agencies. NBS, however, does not conduct proprietary research at the fabrication facility.

No NBS staff members work full time on operations of the facility--the most time spent by any one staff member is 50 percent. In fiscal year 1984, NBS provided 70 percent of the total funding for 10 projects using the facility, and other agencies provided 30 percent for 6 projects.

COMPARABLE FACILITIES

Although 15 other superconductive circuit fabrication facilities exist in this country, the NBS facility is the only one dedicated to research and having a complete set of equipment for fabricating the devices. At similar facilities we contacted in two major computer manufacturing companies, researchers must share some fabrication instruments with nonresearch users. These private facilities are available during the same normal business hours as the NBS facility. NBS does not believe that any comparable facility would meet their research needs.

CONSTRAINTS TO INCREASED USE

The fabrication facility is available for use 24-hours-per-day, but now there is no demand for use other than during normal business hours and occasional weekends and evenings. Approximately six to nine individuals can currently use the facility simultaneously depending on the nature of the work, and NBS has no formal plans for expanding the facility.

To date, there have been no personnel or budget cuts for areas using the facility, and facility managers believe NBS can rely on future funding by the Office of Naval Research and the National Security Agency. Recently, NBS provided funds to support some research efforts in the facility.

NBS has identified the fabrication facility for possible proprietary use in the future; however, to date no proprietary research has been performed at the facility. Two small companies have expressed an interest in manufacturing integrated circuits at the facility and selling them. NBS had not performed any analysis of the ramifications of performing such proprietary activities at the facility at the time of our review because they believe the companies' interest is "casual."

HIGH FLUX NUCLEAR REACTOR

REACTOR RADIATION DIVISION

CENTER FOR MATERIALS SCIENCE

The NBS high flux nuclear research reactor is available for experiments in materials research, nuclear analytical techniques, radiation standards, and nuclear physics. The reactor was orginally built to serve the needs of NBS and other agencies in the Washington, D.C., area, but it has evolved into a center for applying neutron methods of interest to researchers from elsewhere. The reactor is managed by the Reactor Radiation Division and has 25 major assemblies of instruments, which can be operated simultaneously. It has operated 24-hours-a-day for over 260 days a year--at over 70 percent capacity each of the past 2 years. It is idle only for maintenance and to allow reactor operators to take summer vacations.

CURRENT USE

Initial planning for the reactor began in 1955. The original purpose was to fill a gap in (1) developing nuclear standards and measurement techniques to support Atomic Energy Commission research and engineering and (2) using neutron diffraction and activation analysis techniques for materials research. The Congress appropriated design and construction funds in 1961, and routine operations began in 1969. NBS funded most of the total original acquisition cost of $12.5 million for the reactor and related research instruments. However, other research institutions--e.g., the Naval Research Laboratory--also contributed funds. Subsequent alterations have cost approximately $1 million.

Scientists and engineers from over 50 organizations, including NBS, other federal agencies, universities, and private industry, conduct experiments at the reactor. For example, in 1983, nearly 40 Reactor Radiation Division and collaborative research programs used the reactor. This work involved scientists from NBS, industry, and academia--e.g., E.I. DuPont de Nemours and Company, the Bell Laboratories, Cornell University, and the University of Utah. In addition, another 20 experiments for NBS programs outside the Reactor Radiation Division were performed. Furthermore, irradiation service programs with the Food and Drug Administration and the Naval Research Laboratory also utilized the NBS reactor.

Although backlogs of researchers are waiting to use reactor instruments, the Reactor Radiation Division has no formal rules prioritizing reactor use; decisions occur at different levels. For example, activation analysis work is scheduled by 1 of the

15 reactor operators. On the other hand, user committees, consisting of NBS scientists and outside guest workers who collaborate on experiments, schedule the neutron scattering instruments each month. An NBS scientist and a University of Maryland collaborator independently schedule their work on a reactor gamma ray instrument to accommodate their needs.

The primary use of the reactor is to support NBS programs. NBS funds about 80 percent of operating costs; the remainder is funded by reimbursements from other agencies.

COMPARABLE FACILITIES

Several research reactors in the U.S. compare with the one at NBS in a number of ways. For example, Brookhaven and Oak Ridge National Laboratory research reactors generally operate 24-hours-per-day, 7-days-a-week just as NBS' does. Also, Brookhaven, Oak Ridge, and NBS conduct neutron-scattering experiments and activation analysis.

CONSTRAINTS TO INCREASED USE

Historically, NBS has not funded the reactor to support maximum year-round, 24-hour-per-day operation. Reactor managers operate the reactor 5-days-a-week during the summer months to accommodate operator's annual leave (NBS has 15 operators). In the past, requests for budget increases to hire an additional shift of operators were submitted and approved by the Office of Management and Budget, but in recent years the reactor managers did not request the funds because they thought it was futile.

NBS is planning upgrades to increase use of the reactor. For example, NBS has been licensed by the Nuclear Regulatory Commission to operate the reactor at twice its current power beginning in 1984. Also, NBS is proposing to add a cold neutron source and at least 15 experimental instruments. The National Research Council recommended adding this capability at NBS in a July 1984 report. This alteration is scheduled to begin in fiscal year 1986 and be completed in fiscal year 1989 at a total cost of $25 million. When completed, this cold neutron research facility will be open to any U.S. researcher wanting to use it.

METALS PROCESSING LABORATORY

METALLURGY DIVISION

CENTER FOR MATERIALS SCIENCE

The primary goal of the metals processing laboratory is to expand research into advanced processing of metals--primarily rapid solidification processing. Today, the metals processing facility contains seven special instruments for producing rapidly solidified alloy research samples, which are difficult for researchers to otherwise obtain. The facility operates on a normal business day schedule; six of seven instruments are now available for use and the seventh is under development.

CURRENT USE

The metals processing lab is a relatively new NBS facility. NBS used the working capital fund to acquire major metals processing instruments for a total of about $535,000. NBS bought five and constructed one of the instruments, and the Defense Advanced Research Projects Agency (DARPA) donated a seventh.

Scientists from NBS, other federal agencies, universities, private companies, and associations collaborate with metals processing lab staff in a number of ways. For example, DARPA is reimbursing NBS for research to support DARPA's rapid solidification program. NBS has cooperative projects with the Massachusetts Institute of Technology (MIT) whereby students assist NBS scientists in producing rapidly solidified alloy specimens for study at MIT. Also, under a cooperative agreement with NBS, the American Iron and Steel Institute is providing industrial research associates who use the metals processing facility to develop sensors for monitoring and control in steel production.

The Metallurgy Division manages the metals processing lab informally and does not maintain detailed records of the total time each instrument is used. The chief of the division told us that the facility is new and all current users have been accommodated without formal procedures.

Funding for the metals processing facility is mixed. The chief of the Metallurgy Division estimates that 50 percent of the facility's support will come from reimbursements in fiscal year 1985, and the remainder will come from direct funding for NBS research objectives.

The Metallurgy Division has not developed a formal long-range plan for facility use. Although the chief of the Metallurgy Division wants to upgrade facility instruments to make them more versatile, no formal plans to do so have been developed.

COMPARABLE FACILITIES

The NBS metals processing facility appears to be unique in fundamental research of rapid solidification. For example, the individual instruments contained in the NBS facility are available at such industrial laboratories as the Bell Laboratories, but the mixture of the seven instruments in one facility specializing in rapid solidification techniques is not available commercially or at universities. Also, a DARPA official told us that other federal laboratories at the Department of Energy and Department of Defense either have no rapid solidification programs or are not as comprehensive as the one at NBS. Similarly, we found no universities with such complete facilities.

CONSTRAINTS TO INCREASED USE

Increased use of the metals processing lab is limited by the number of people available to operate it. The lab has three full-time staff members, two professionals, and one technician, and they cannot operate all seven pieces of equipment at once. Because the facility cannot accommodate any more users, NBS does not actively solicit outside users. The chief of the division estimates he will need at least three additional staff members to keep all instruments fully utilized during normal business hours.

NETWORK PROTOCOL TEST AND EVALUATION FACILITY

CENTER FOR COMPUTER SYSTEMS ENGINEERING

INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY

The Institute for Computer Sciences and Technology at NBS is the technical organization responsible for developing computer standards for the federal government. These standards are issued as Federal Information Processing standards for implementation by agencies. Network protocol test and evaluation is an activity of this unit and has 3 primary goals--(1) develop networking standards and protocols that can be implemented in commercial computer products, (2) develop testing methods to support the development and implementation of computer network protocols, and (3) assist government and industry users in applying network technologies and assist computer and communication manufacturers in implementing standard protocols.

Currently, the institute has seven laboratories where testing methodologies and implementations of draft standards are developed, including computer network protocols. Such protocols are developed in these labs for federal government computer activities and for use by industry as voluntary industry standards. The institute uses these labs to work with such organizations as the American National Standards Institute, industry, and federal government agencies to develop the protocols and test methods.

CURRENT USE

The NBS Institute's program to develop national and international automated data processing (ADP) standards is based on two authorities: Public Law 89-306 (The Brooks Act) and Executive Order 11717. The Brooks Act assigned the Secretary of Commerce the authority to develop and recommend ADP standards and undertake research in computer science and technology. Executive Order 11717 transfered the responsibility for developing federal data-processing standards from the Office of Management and Budget to NBS and assigned to the Secretary of Commerce the authority to approve federal ADP standards. The total original acquisition cost for laboratories involved in network protocol work is about $1.3 million, and subsequent alterations have cost approximately $800,000.

Research in developing prototype implementations and testing techniques is carried out cooperatively among NBS, other federal agencies, and private industry. More than 30 computer manufacturers, 10 other federal agencies, and 5 research laboratories in other countries are involved in cooperative research in computer networking. For example, the institute's local area networking

laboratory produced performance measurement and correctness techniques for testing certain types of computer information exchange standard specifications. NBS is also part of a cooperative research effort among 16 U.S. corporations on implementing and applying international network standards.

The NBS institute solicits prospective collaborators through announcements in the Federal Register and the Commerce Business Daily. It arranges to work with those companies that agree to work with the institute on specific projects. Then, user needs are informally worked out. Companies that want to cooperate with NBS in reaching its research objectives have priority for using the laboratories.

NBS funds most of the projects using the network protocol laboratories. In fact, in fiscal years 1982 and 1983, NBS funded over 74 percent of the activities in the labs. The remainder of the projects was funded by reimbursements from such federal agencies as the Departments of Defense and Justice. Private companies provide no funding support to NBS for computer standards related work.

COMPARABLE FACILITIES

The institute is apparently unique in aggregating the requirements of both federal and industry computer users. It provides neutral, third-party expertise for researching and testing computer standards. Institute efforts are supported by government and industry computer users. For example, a 1983 National Research Council evaluation report notes,

> "The neutral stance that is natural for the Institute of Computer Sciences and Technology but counterproductive for any specific competitor, combined with the necessary ICST talent . . . makes ICST a natural choice as the initial drafter of intricate starting positions in which the conflicting needs of diverse interests must be balanced . . . ."

The Network Users Association said the NBS institute has become the research and development lab for manufacturers and the federal government. Also, the National Association for State Information Systems wrote that the institute's leadership and representation of the user community is ". . . unique and unsurpassed by any other government or industry organization."

OPPORTUNITIES FOR INCREASED USE

Currently, NBS' network protocol laboratories operate on a normal business schedule providing research in several implementation and test activities. Although the facility has operated

around-the-clock when needed, the director of the institute believes there is no need for routine 24-hours-per-day operation. The urgency of the need for the research results does not warrant the additional costs to acquire and maintain extra staff to accommodate cooperative research 24-hours-per-day.

A satellite communications laboratory is currently being developed at NBS. The objective of this government/industry cooperative research effort is to test international standard protocols over satellite communications. COMSAT Laboratories, a private company, will provide the satellite channel and related communications equipment for the research.

On the other hand, the Office of Management and Budget believes that the majority of NBS' computer technology program should be conducted by the private sector and proposed to reduce it in the fiscal year 1984 budget from $10 million to $3 million and the fiscal year 1985 budget from $10 million to $5 million. Network protocol test and evaluation operations would be affected to an unknown degree by reduction of funding for the institute.

NBS ELIMINATED FACILITIES

RESPONSIBLE ORGANIZATION	PURPOSE OF FACILITY	APPROXIMATE DATE OF ACQUISITION/ELIMINATION	REASON FOR ELIMINATION
National Measurement Laboratory			
Chlorine Flux Monitor	Method/instrument to measure low levels of chlorine in water	1973/1975	Method was turned over to the private sector through patent process.
Multichannel Flame Spectrometer	Analyze trace elements in flour and blood	1969/1976	Obsolete and replaced with updated equipment.
Fluorine Combustion Calorimeter	Method/instrumentation to produce experimental values for measuring heat combustion for rocket and jet engine performance	1959/1984	Objectives met, research efforts changed directions, and other agency funding ended.
Platinum-Lined Adiabatic Solution Calorimeter	Methods to produce and verify standard reference materials and to permit measurements in biothermodynamics	1968/1978	Eliminated as a result of FY 1979 reprogramming when all biochemistry research ended.
Flash Photolysis Resonance Fluorescence Device	Data for atmospheric research on extreme pressure and temperature	1968/1980	Equipment incorporated into more complex facility—"spin off" to more complex research areas.
High Pressure Generator	Data on material properties as a function of temperature and pressure	1960/1984	Objectives met; data published.

APPENDIX XVII

RESPONSIBLE ORGANIZATION	PURPOSE OF FACILITY	APPROXIMATE DATE OF ACQUISITION/ELIMINATION	REASON FOR ELIMINATION
National Measurement Laboratory			
Accoustical Thermometer	Data for international temperature scale and calibration standards for thermometers	1965/1978	As a result of FY 1979 reprogramming--more accurate facility in England.
WWVL-VLF Broadcast Station	Time and Frequency Information	1962/1972	Budget reduction--inefficient energy use; replaced with other NBS radio stations.
National Engineering Laboratory			
Universal Testing Laboratory	Research testing and calibrations for engineering mechanics	Unknown/1976	Measurement technology changed; no demand for use.
Wind Tunnel for Unsteady Flows	Tests and data on fluid dynamics	1971/ near future	Replaced by two other wind tunnels with better operating characteristics.
Consumer Product & Human Factors Testing Laboratory	Data on energy consumption	1977/1980	Initial objectives met, other agency funding ended, discontinued as priority.
Hydrogen Liquefaction Facility	Research data on hydrogen gas for hydrogen bomb	1952/1958	Private facilities became available.
Liquified Natural Gas (LNG) Facility	Experiments/measurement data and calibration of LNG instruments	1968/1972	Has 2-inch pipes and LNG industry uses 32-inch pipes; demand low for LNG research.
Rooftop Antenna Testing Facility	Collect test impedance data of antennas	1972/1978	Replaced by technology advance at time of NBS reorganization in 1978.

APPENDIX XVII

RESPONSIBLE ORGANIZATION	PURPOSE OF FACILITY	APPROXIMATE DATE OF ACQUISITION/ELIMINATION	REASON FOR ELIMINATION
Center for Materials Science			
Far Infrared Spectroscopy Facility	Light wave length measurements	1971/1982	Replaced by technology advance within NBS.
Surface Area Analyses	Data on surface characteristics of materials	1960/1978	FY 1979 reprogramming--change research direction; Department of Treasury continued research.
Low Temperature Adiabatic Calorimeter	Data on thermodynamic properties of glasses	1963/1978	Lack of users for very high precision measurements--research ended.
High Pressure PVT Dilatometer	Measure density of liquids and solids with varying temperature and pressure	1976/1983	Obsolete and replaced with updated equipment.
Nuclear Magnetic Resonance Spectroscopy Facility	Standard reference data and methods for examining metals' properties	1958/1982	Measurement data transferred to private industry.
Soft X-ray Spectrometer	Standard reference data and methods for measuring metals' properties	1960/1981	Measurement data transferred to private industry.
Institute of Computer Science Technology			
Programming Languages Testing Activity	Routines and procedures for testing programming language compilers and processors for quality control	1968/1980	Objectives accomplished and procedures tranferred to the General Services Administration.

APPENDIX XVII

APPENDIX XVIII

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Administration
Washington, D.C. 20230

JAN 24 1985

Mr. J. Dexter Peach
Director, Resources, Community, and
Economic Development Division
United States General
Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

This is in reply to GAO's letter of December 13, 1984 requesting comments on the draft report entitled, Opportunities and Constraints for Expanding Use of Research Facilities at the National Bureau of Standards.

We have reviewed the enclosed comments of the Director of National Bureau of Standards and believe they are responsive to the matters discussed in the report.

Sincerely,

Kay Bulow

Kay Bulow
Assistant Secretary
for Administration

Enclosure

APPENDIX XVIII

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Gaithersburg, Maryland 20899
OFFICE OF THE DIRECTOR

JAN 24 1985

Mr. J. Dexter Peach
Director, Resources, Community, and
Economic Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

Thank you for the opportunity to comment on the draft report entitled, "Opportunities and Constraints for Expanding Use of Research Facilities at the National Bureau of Standards." Increased usage, under certain conditions, by the private sector of unique, special-purpose measurement and test facilities at the National Bureau of Standards (NBS) is one of our aims in support of government policy to improve U.S. competitiveness. We have received the strong support of the Department of Commerce in this regard.

The draft report identifies three "Issues for Further Consideration" for additional attention by the Congress and myself. These issues concern: (1) the NBS mission and its relationship to research organizations in private industry and universities, (2) decisions for acquiring and eliminating research facilities at NBS and whether or not there is a need for utilization criteria for major assemblies of research equipment, and (3) the adequacy of the existing NBS property management system (pp. 11-16[1]).

With regard to the first two issues, the report seems to imply that NBS has no clear process for planning and monitoring our research programs and setting priorities. On the contrary, NBS uses several mechanisms for planning and priority setting, including formal and informal interactions with our clientele and technical advisors. We rely on information and recommendations from the Statutory Visiting Committee, the National Academy of Sciences/National Research Council Boards of Assessment for each programmatic Center, industrial panels (National Conference of Standards Laboratories, Committee on Radiation Measurement), and federal panels (Calibration Coordination Group, Interagency Committee on Standards Policy). The NBS staff has extensive contacts in industry and academia, through professional and technical societies, and through widespread participation in voluntary standards groups. Furthermore, we make use of economic analyses, both of general nature, such as costs to the economy of measurements, as well as specific benefit-cost studies on NBS work and economic assessments of potential impact of proposed NBS work. These mechanisms, together with Congressional review and approval of the programs and funding for NBS research, constitute a thorough process by which NBS activities are planned and reviewed for appropriateness with the NBS mission and in relationship to the needs and activities of the private sector, academia, and other government agencies.

[1] Page numbers which referred to our draft report have been changed to correspond with those in this final report. Except as noted in the attachment, NBS comments have been incorporated as provided.

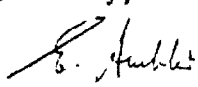
The research facilities are an integral part of the NBS programs. In many cases they are tools with which NBS scientists and engineers conduct their research. Internal and external reviews monitor existing programs and recommend areas in which there are needs for additional NBS activities. Both plans and funding of new and existing programs consider the needs and costs of research facilities as part of the overall review process. Contrary to the statement on page 6, research facilities are established and maintained because of their criticality to supporting the NBS mission; frequency of use is of secondary importance. For many facilities, there is little to be gained by keeping detailed records of usage since it is the research results or the calibrations obtained through use of the facility that are of value.

With regard to the Property Management System, NBS questions the basis for the statement that the limited test "found potential weaknesses in the way equipment is identified and errors in the property lists and records of depreciation balances for the working capital fund." Neither the limited test in which all 15 items were located (the test did not fail to locate the plumbing tower as reported, rather it identified an instance of confusion between equipment and real property for which there is no obligation for repayment to the working capital fund), nor the May 1984 Inspector General test which located all 20 items sampled, seem to warrant such a statement and advice to postpone the GAO-recommended barcoding for yet another evaluation of NBS property management controls.

NBS has been responsive to past criticisms of this system and continues to implement improvements as needed. Earlier criticisms led to the hundred percent inventory in 1982 which resulted in a one-time write off of equipment with an undepreciated balance of $194 thousand (acquisition costs were $3 million out of $125 million total), much of which had been acquired in the early years of NBS' existence. NBS has requested a meeting with GAO to discuss the basis for the statements and recommendations. Unless additional information supporting these GAO recommendations is provided, we cannot concur with the conclusions about the NBS property management system.

I have enclosed with this letter some recommendations for specific changes in the text of the report which would improve the technical and factual accuracy.[2] I hope that the final report will include these changes and address the concerns I have expressed.

Sincerely,



Ernest Ambler
Director

Enclosures

[2]Technical and factual corrections have been incorporated in the appendixes.

SPECIFIC COMMENTS ON DRAFT GAO REPORT ENTITLED, "OPPORTUNITIES AND CONSTRAINTS FOR EXPANDING USE OF RESERACH FACILITIES AT THE NATIONAL BUREAU OF STANDARDS"

LIMITED TEST OF PROPERTY MANAGEMENT CONTROLS

Pages 14-16

NBS questions many of the statements and recommendations of this section of the report. GAO has agreed to meet with NBS staff to discuss issues related to statements regarding the property management system.

The second paragraph on page 16 should be replaced with the following text: "A discrepancy was found in the NBS property management system for a plumbing tower listed as having an acquisition value of over $80,000 and an undepreciated balance of over $69,000 owed to the Working Capital Fund. Responsible officials were attempting to resolve the discrepancies."

SYNCHROTRON ULTRAVIOLET RADIATION FACILITY

Pages 29 and 31

Page 29, paragraph 3, line 9: To improve technical accuracy, replace "upper atmospheric conditions" with "molecular photoionization of importance to understanding upper atmospheric chemistry."

Page 29, paragraph 3, line 15: Because there have been scientists from Westinghouse and IBM as users of the facility, replace "no industrial" with "occasional industrial."

Page 31, paragraph 2, line 5: New information became available since the last interview with the GAO audit team. The report of the Seitz committee, and the results of the presentations became available only recently and therefore represent new confirming evidence of the demand for this facility. Thus we recommend a footnote after "exists" to read as follows:

"They believe this demand is borne out by two recent studies that were conducted by a DOE appointed committee cochaired by P. Eisenberger and M. Knotek and a National Academy of Sciences appointed committee cochaired by F. Seitz and D. Eastman. The reports of each of these committees recognized the need for additional research time on such facilities and specifically recommend both the construction of new machines and the operation of existing facilities in a "user friendly" mode to take full

advantage of these facilities. They also believe their demand was indicated by the strong positive response of potential users to the presentation of the NBS synchrotron radiation facility upgrade proposal at the SRC Users Meeting in Stoughton, Wisconsin, the Applications of Accelerators Conference in Denton, Texas, and the Workshop on Synchrotron Radiation Facilities held by the NAS Committee on Atomic and Molecular Sciences -- all held in the fall of 1984.

AUTOMATED MANUFACTURING RESEARCH FACILITY

Pages 34 and 35

Contribution towards developmental costs from industry and other government agencies should reflect equipment loans rather than donations.

The test runs described were held during November 1983 and June 1984.

TRI-DIRECTIONAL TEST FACILITY

Pages 12-14 and 36-38

The role of NBS in the National Earthquake Hazards Reduction Program (NEHRP) and the description and discussion of the tri-directional test facility needs to be clarified. The NBS tri-directional test facility allows engineers six degrees of freedom to stretch, compress, shear, twist, and bend building structural specimens while they measure the resistance properties. The design of the facility is unique and provides the flexibility for research which is not available on other similar facilities.

Alternatives to constructing the tri-directional test facility at NBS were examined. The facility at NBS is unique in that it allows six degrees of freedom in contrast to other testing machines with a much more limited capability. Comparable facilities do not exist. The option of rebuilding an existing, less-controlled, tri-directional structural testing facility at the University of Texas and contracting researchers there was considered, but was determined to be inadequate to meet NBS' program responsibilities. Cooperative agreements or contracts with universities for research on a less controllable tri-directional test facility was not considered appropriate to accomplish the NBS program objectives.

The nature and number of experiments that can be conducted on the tri-directional facility needs clarification. The facility is

multipurpose for both earthquake and nonearthquake research. In addition to its tri-directional configuration, it can be used in one or two directional configurations. The Kansas City Hyatt Regency Walkway Investigation is an example of such a case. The computer controlled data processing capability can be used independently of the tri-directional configuration and is used in a variety of projects. In its tri-directional configuration, one project unrelated to the NEHRP has been completed. Currently, there are three earthquake-related projects, rather than one, that are dependent on this facility. One of these projects commenced in 1983 and involved multiple tests over a prolonged timeframe between 1983 and 1984. The other two projects, which involve experiments on small-scale bridge columns and steel frames, are in the planning stage and will be funded by NBS and other agencies.

External involvement regarding the tri-directional test facility is greater than the report indicates. Three university researchers, one designer, and two trade association representatives have participated in planning the masonry research project conducted on the facility. Many other professionals, university researchers, and industry representatives have participated in planning and conducting the overall program of which this facility is an integral part. Although this facility has not been directly used by guest workers or industrial research associates to date, guest university researchers will use the facility in 1985.

GAO COMMENT: We reviewed non-NBS use of the research facility, as requested, rather than non-NBS participation in project or program planning, as NBS commented. We can, therefore, express no view on the degree of outside influence on project planning or program management. We did note NBS' plans for using guest workers in 1985 on page 36.

APPENDIX XVIII

The NBS' role and contribution to the NEHRP is significant and far greater than the draft report indicates. The 1978 Presidential Plan for the NEHRP specifically describes the NBS role. The tri-directional test facility is one of the NBS facilities that is critical for NBS to fulfill its mandate under this Program. The NBS role and accomplishments to date under this mandate are described in the Report to Congress of FY 1983. This report includes photographs and descriptions of the important research activities being conducted on the tri-directional test facility. The planned use of the tri-directional test facility and other NBS activities are also described in the 1985-1989 5-year plan for the NEHRP. NBS also has chairmanship of two important groups concerned with seismic safety: 1) Committee for Interagency Seismic Safety in Construction for development of seismic safety facilities for Federal use; and 2) U.S.-Japan Panel on Earthquake and Wind Effects for international cooperation in research. In addition, NBS provides technical support for private sector development of seismic design and construction provisions. NBS' research results in the development of performance criteria and measurement technology for seismic safety.

The 1984 Earthquake Engineering Institute's report on research facilities needed for improving earthquake-resistance design of buildings was the result of a 1982 workshop held on this subject, in which NBS participated. At that time, the tri-directional structural test facility was not constructed. We feel that the commissioning of the test facility at NBS was responsive to this workshop's recommendations. The views expressed to the GAO staff by some of the authors of the report were personal opinions and did not reflect the views of the participating agencies. Also, the lack of awareness by some in the research community of the tri-directional structural test facility at NBS, as noted by GAO based upon limited interviews, raises questions relative to communications regarding the National Earthquake Hazards Reduction Program.

GAO COMMENT: We contacted four participants in the workshop NBS refers to in its comments as well as the two authors of the report. These six individuals provided professional opinions as to the uniqueness of NBS' facility and its relationship to similar facilities elsewhere. We also contacted two other individuals familiar with NASA's structural test facilities for professional opinions regarding the comparability of NBS' facility with NASA's. We believe this is a sufficient basis for questioning the uniqueness of NBS' facility and the research it supports.

APPENDIX XVIII

The discussion regarding equipment aquisition in the Structures Division, in which the tri-directional test facility is assigned, should be amended. Prioritized lists of equipment needs for the Structures Division exist for fiscal years 1984 and 1985.

With respect to the funding of the NBS buiding research program it should be noted that while the Administration's FY84 and FY85 budgets proposed elimination of the building research program, the Congress took action to ensure continuation of the program. If funding for this program had been eliminated, alternatives to shutting down the tri-directional facility would have been considered.

LARGE ENVIRONMENTAL CHAMBER

Pages 39 and 40

The purpose of the chamber should be expanded. The chamber simulates environmental conditions in which buildings, building equipment systems, and materials exist. It supports the Center for Building Technology's research program and allows for the development and validation of thermal performance modeling techniques that are required for predicting energy efficiency of buildings and human comfort. Fire safety in buildings is not studied in this chamber.

The description of the chamber's modification should note that the only subsequent alteration to the facility has been the addition of a solar simulator. This modification cost $20,000 and was funded by the Department of Energy.

Since no log is maintained for the operation of the chamber, the facility manager estimated the total days in use from fiscal years 1982 through 1984.

The nature of the projects conducted in the chamber since 1981 should be clarified. The four projects not related to the NBS building research program were conducted by Army personnel who collected data on the performance of military equipment over a wide range of temperatures. NBS personnel provided the

controlled environment according to Army specifications.

The planning process for use of the chamber needs amplification. The managers of the Center for Building Technology decide how the facility will be used as an integral part of their research planning process. As projects are planned, consideration is given to how the chamber can be used to accomplish program objectives. For example, a major experiment for the Department of Energy is planned to take place in the chamber during fiscal year 1985 to determine the effect that modern building lighting systems have on the performance of heating and air conditioning systems.

Although no industrial research associates have used the chamber during the period covered by the review, prior industrial participation had occurred. Two research associates from the Dow Chemical Company participated in a study to evaluate innovative construction techniques in a mobile home from 1975-1977. A research associate from Skidmore, Owings, and Merrill participated in a study during 1979 to evaluate energy conserving schemes for masonry buildings. The availability of the facility for external use and opportunities for guest workers are described in a brochure widely circulated to the outside community.

FIVE-STORY PLUMBING RESEARCH LABORATORY

Pages 41 and 42

The history of this facility should be clarified. This laboratory was constructed in the 1960's in response to the U.S. plumbing industry's request that plumbing research continue after NBS moves to Gaithersburg. NBS was asked to develop testing methods and engineering data that could be used for design and as a basis for standards, and to support the development of standards and codes regarding plumbing.

Although there have been no industrial guest workers that used the plumbing tower, a guest worker from Burnel University participated in the Center for Building Technology's program in plumbing research.

Within the past six months, NBS sent a request to the Plastic Pipe Fitting Association for funds to support work in the plumbing laboratory. This request is pending.

NEAR-FIELD ANTENNA SCANNING FACILITY

Pages 43 and 44

With regard to the cost of the facility's equipment, ten items cost $10,000 or more, rather than $100,000 or more as noted in the report.

The near-field antenna scanning facility is located in the same area as the Outdoor Extrapolation Range for Antenna Measurements, which was excluded from a detailed analysis in this audit. While twelve NBS employees cited in the report are involved in the operation of both of these facilities, only the four technicians are assigned full-time.

With respect to the discussion on proprietary research, NBS managers recognize the need to protect proprietary information in disclosing newly discovered techniques or refinements in antenna metrology resulting from calibration services for the private sector. Use of the facility for proprietary research will have to be balanced to insure that the NBS mission responsibilities for the development of new and improved measurement techniques and the provision of calibration services to the public and private sector are maintained.

FIRE TEST BUILDING

Pages 45-48

The purpose of the tests conducted in this facility and its upgraded instrumentation should be clarified. Full-scale fire tests are conducted for investigating fire phenomena to provide the inputs necessary for the development of computer programs that model fire accurately. The facility's instrumentation has been upgraded to collect fire test data required to understand the fire phenomena and provide data for computer modeling of fire development and to verify models with the objective of eventually reducing or eliminating the current need for costly large-scale testing.

The discussion of funding sources should be revised to indicate that the fire test building was constructed with funds made available from a special supplemental appropriation, not from the original NBS construction appropriation. Further, the percentages that illustrate a shift of funding between FY 1982 and FY 1984 represent funding associated with the fire test building rather than the overall Center for Fire Research program.

GAS FLOW MEASUREMENT FACILITY

Pages 4, 18, 48 and 49

The third paragraph on page 4 should be amended to indicate that the gas flow measurement facility was initially acquired with NBS funds. However, all additions and modifications since 1980 were funded by the Gas Research Institute.

The facilities described on page 18 that maintain records of equipment use should be expanded to include the gas flow measurement facility.

The statements in the Appendix describing the purpose of the Chemical Engineering Science Division, in which the facility is assigned, should be clarified. It provides data, measurement standards and methodology for commercial exchange and processing of industrial chemicals, fuels, and feedstocks.

The facility was constructed in 1969 at an estimated replacement cost of $500,000 and upgraded in 1977 for additional equipment at an approximate cost of $75,000. The purpose of the upgrade was twofold: 1) to study the flow characteristics of natural gas; and 2) to study the accuracy of gas metering equipment.

The Gas Research Institute's relationship to the operation of the facility needs clarification. A variety of industry groups sponsor the facility's operation. The Gas Research Institute is the major sponsor, but does not determine who the facility users will be. In 1984, various industrial groups contributed approximately $655,000 for the operation of the facility.

Additional public access to the facility is limited because of the complexity of the operations and the time required to disassemble, set-up, and configure experiments. Additional outside users would increase operating costs.

SUPERCONDUCTIVE CIRCUIT FABRICATION FACILITY

Pages 50 and 51

The concerns of the 1982 National Research Council's Evaluation Panel and the NBS response to their recommendations as noted in the draft GAO report are not relevant to the superconductive circuit fabrication facility. The Panel's comments did not address the condition nor planning of this facility, but rather the acquisition of new tools and processes that were dedicated to specific tasks that were excluded from the scope of this

particular facility's audit. For the record, such equipment was acquired soon after the Panel's report. The 1983 Panel's recommendation for better planning pertained only to the use of the electron-beam lithography system, not the entire facility. Such planning did occur. Since the Panel's report, numerous projects of high importance to NBS have been carried out using this system. These projects include the fabrication of fast optical detectors, ultra-small Josephson junctions, and superconducting integrated circuits. Studies and procurements have also been initiated in response to the Panel's recommendation for increased cleanhood space.

The funding situation should be updated. At the time of the interview, facility managers believed that future funding from the Office of Naval Research and the National Security Agency may be reduced as a result of overall government budget restrictions. Since the interview, other agency funding plans have become much more positive. In addition, internal NBS funds have been made available to support the research effort on the Josephson series arrary voltage standard.

With regard to comparable facilities, it should be noted that there is no known laboratory or commercial facility anywhere in the world where the superconducting devices required for the NBS research program could be fabricated and made available to NBS upon demand.

The discussion of this facility's proprietary use should be amended to indicate that two small companies expressed only a "casual" interest in the facility. Thus, there has been no need to date for NBS to perform a detailed analysis of such informal requests.

HIGH FLUX NUCLEAR REACTOR

Pages 52 and 53

Page 53 , paragraph 3, lines 4-6: Oak Ridge performs neutron scattering as well as activation analysis and isotope production, contrary to the implication of this sentence in the report.

Page 53 , paragraph 4: NBS has 15 operators, which is enough for five shifts. This is adequate for 24 hours-a-day operation, seven days a week, if no leave is taken, but not enough to accommodate leave. Therefore, the reactor operates only five days a week during the summer, which requires only three shifts (nine operators) so the other operators can take their annual leave.

Page 53 , paragraph 1, lines 1-3: The current cost estimates and time schedule for the proposed cold source, guide hall, and

instruments is $25 million beginning in fiscal year 1986 and to be completed in fiscal year 1989.

In the last sentence replace "any researcher wanting to use it." with "U.S. researchers."

METALS PROCESSING LABORATORY

Pages 54 and 55

Page 54, paragraph 3, line 11: Replace "to the metals" with "which utilize, in part, the metals."

Page 54, paragraph 4, lines 2-3: Replace "records of how much it is used." with "detailed records of the total time each instrument is used."

Page 54, paragraph 4, line 4: Replace "can be" with "have been."

Page 55, paragraph 2, line 2: Replace "for the facility" with "for outside users access to the facility."

Page 55, paragraph 4, lines 2-3: Replace "only three" with "less than four equivalent."

Page 55, paragraph, 4, line 8: Replace "keep up with current work during" with "keep all instruments fully utilized during."

NETWORK PROTOCOL TEST AND EVALUATION FACILITY

Pages 56-58

Page 56, paragraph 1, line 3: Insert the following sentence after "government." "These standards are issued as Federal Information Processing Standards for implementation by agencies."

Page 56, paragraph 2, lines 3-8: Replace current text with the following sentences. "Such protocols developed in these labs are for Federal government computer activities and for use by industry as voluntary industry standards. The Institute uses these labs to work with organizations such as the American National Standards Institute, industry, and Federal government agencies to develop the protocols and test methods."

Page 57, paragraph 1, line 5: Add a period after the word "operation."

Page 58, paragraph 1, lines 6-8: Replace current text with the following sentence. "The urgency of the need for the research results does not warrant the additional costs to acquire and maintain extra staff to accommodate cooperative research 24

hours-per-day."

Page 58, paragraph 3, line 1: Delete "On the other hand," and capitalize "the."

Page 58, paragraph 3, lines 6-9: Since the FY 85 budget is no longer a proposal and the FY 86 budget proposal is not yet available, suggest these lines be replaced with the following sentence. "Operation of the Network Protocol Test and Evaluation Facility would be affected to an unknown degree by reduction of funding for ICST."

(005706)

30555

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