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# CONDITION OF FEDERAL LABORATORIES

## HEARING

BEFORE THE

## JOINT ECONOMIC COMMITTEE CONGRESS OF THE UNITED STATES

ONE HUNDRED THIRD CONGRESS

FIRST SESSION

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## JOINT ECONOMIC COMMITTEE

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## WITNESSES AND STATEMENTS FOR THE RECORD

### Thursday, September 23, 1993



### SUBMISSIONS FOR THE RECORD

# CONDITION OF FEDERAL LABORATORIES

**THURSDAY, SEPTEMBER 23, 1993**

CONGRESS OF THE UNITED STATES,
JOINT ECONOMIC COMMITTEE,
*Washington, DC.*

The Committee met, pursuant to notice, at 10:05 a.m., in room SD–628, Dirksen Senate Office Building, Honorable Paul S. Sarbanes (Chairman of the Committee) presiding.

Present: Senator Sarbanes.

Also present: William Buechner, Richard Clinch, Lawrence Hunter, Ed Hutchings, professional staff members.

## OPENING STATEMENT OF SENATOR SARBANES, CHAIRMAN

SENATOR SARBANES. The Committee will come to order.

I would inform the witnesses that the Senate is in session and we may be interrupted with votes from time to time, in which case we will simply have to recess the Committee for purposes of voting and then resume as promptly as we can.

This morning, the Joint Economic Committee is meeting to examine the deteriorating physical condition of federal scientific laboratories across the country. The hearing will focus and, in a sense, take its impetus from a new General Accounting Office report being released today, entitled, "Federal Research: Aging Federal Laboratories Need Repairs and Upgrades."

The federal labs conduct much of the research and development that helps keep the United States at the cutting edge of science and technology. They account for one quarter of the Federal Government's budget for research and development and one tenth of all research and development done in this country. And a higher percentage has, in a sense, been basic research and development.

In Maryland, to take an example dear and close to my heart, we have some of the nation's finest and most important research labs; for example, the National Institutes of Health in Bethesda, the Beltsville Agricultural Research Center, and the National Institute of Standards and Technology. But all of them require significant upgrading.

According to this morning's GAO report, a number of the federal labs are in a distressing state of disrepair.

For example, at Wright Laboratories at the Wright-Paterson Air Force Base in Ohio, where the Defense Department conducts important defense research, the only way scientists could protect equipment from a 10-year leaking roof was to build a second building inside the first with its own roof and sides to enclose the equipment and protect it from the rain. That is illustrated in the pictures from the Wright Lab in Dayton, Ohio.

In another example, at the Beltsville Agricultural Research Center, which is the oldest and largest research lab in the Department of Agriculture, much of the lab space was built before World War II. To keep drafts and humidity from ruining delicate experiments, researchers have had to cover windows with plastic sheeting and even cardboard.

In a lab in the basement of one building, the scientific equipment has been put on stilts to keep it from being ruined by periodic floods. In another building, rain from a leaking roof damaged expensive computer equipment.

At the National Institutes of Health, which is widely recognized as the world's leading medical research facility, the main clinical research laboratory is so outmoded that the Army Corps of Engineers says it needs to be completely replaced. The ventilation system is so overloaded that there is "a potential safety risk that air between laboratories and public spaces in the Clinical Center might be cross-contaminated, according to the GAO report. The age of the building—it is almost 40 years old—and its deteriorating condition have often put the NIH years behind in installing new equipment needed for advanced research.

Last year, John Lyons, Director of the National Institute of Standards and Technology, wrote a letter to the *Washington Post* about conditions in his agency, and I quote:

> Lab facilities for the National Institute of Standards and Technology in Gaithersburg, Maryland, and in Boulder, Colorado, which were built 24 to 40 years ago, are relatively new compared to most federal labs. Yet, despite rigorous maintenance, the more than $2 billion worth of facilities at these sites is deteriorating at an accelerating rate.
>
> NIST scientists must drape their laser experiments in plastic sheeting to protect them from tiny black particles delivered by corroded air circulation systems. Others regularly conduct their experiments at 2:00 and 3:00 a.m. because their laboratory's temperature and humidity controls are inadequate to deal with normal daytime fluctuations. Inadequate building environmental controls have also hampered NIST's ability to make precision engineering measurements.

I am very concerned that the poor physical condition of the federal laboratories is jeopardizing their important scientific missions, and thus weakening the ability of the United States to compete in the world economy.

This morning's GAO report reveals a widespread pattern of underinvestment in the maintenance and repair of government research facilities. GAO found a backlog of about $4 billion. This underinvestment has resulted in poor laboratory conditions that fail to meet scientific standards, that reduce productivity and ruin experiments, and that in some cases violate worker health and safety standards.

While some progress has been made in improving lab conditions, as with the National Institute of Standards and Technology and the Beltsville Agricultural Research Center modernization plans, the report we are releasing today makes clear that more work is needed.

I want to conclude this opening statement by a final quote from Dr. Lyons's letter:

> Laboratory facilities are the infrastructure, the road and bridges of science and technology. Funding for science without funding for facilities is a losing game. In an age in which science and technology are major contributors to economic growth and national security, it is time to find a way to fund upgrading of scientific facilities on a pay-as-you-go basis before the walls come tumbling down.

We are pleased to welcome this morning as our opening witness, Mr. Jim Wells, Associate Director of Energy and Science Issues for the Resources, Community and Economic Development Division of the General Accounting Office, who will present the findings of the GAO report.

He will be followed by Dr. Darwin Murrell, Director of the Beltsville Agricultural Research Center; Mr. Steven Ficca, Associate Director for Research Services at the National Institutes of Health; and General Billie J. McGarvey, Director of Facilities for NASA, who will comment on the laboratory conditions and their impact on research and development programs at each of their agencies.

We will then conclude with a statement from Dr. Joseph Martino, a senior research scientist from the University of Dayton in Ohio.

Gentlemen, we will hear from each of you, and at the conclusion of that, we will have some questions for the members of the panel.

Mr. Wells, why don't you lead off. We would be happy to hear from you.

**STATEMENT OF JIM WELLS, ASSOCIATE DIRECTOR OF ENERGY AND SCIENCE ISSUES, RESOURCES, COMMUNITY AND ECONOMIC DEVELOPMENT DIVISION, GENERAL ACCOUNTING OFFICE**

MR. WELLS. Thank you, Mr. Chairman.

We're pleased to be here today to discuss the findings of the report which you are releasing today to the public. We have a number of copies that are available.

In light of the fact that you excellently summarized the results of the GAO finding, I'll be glad to summarize and hit the highlights and ask that my statement be permitted to be submitted in the record in its entirety.

SENATOR SARBANES. Your full statement will be included in the record.

MR. WELLS. Thank you very much. Mr. Chairman, you genuinely expressed concern about the federal research agencies, that they may be underinvesting in maintaining, repairing and upgrading their laboratory facilities. You wanted information on the condition of the laboratories, the effect of inadequate facilities on the agencies' scientific productivity and their research capabilities. And you also wanted information on the funding needed to repair or upgrade these facilities.

We collected information on eight federal agencies that have responsibility for over 220 government-owned laboratories that spent $18 billion last year in R&D funding.

These agencies were the Department of Commerce, Defense, Energy, EPA, NASA, Agricultural Research Service, NIH, and the Geological Survey. Together these agencies spent about 73 percent of the total $24 billion R&D dollars that were spent in 1992.

The federal laboratory complex and its many facilities has grown rapidly between 1943 and 1972 as their agencies expanded their R&D missions. By the early 1990s, these facilities have aged. Fifty-four percent of the space was more than 30 years old, with 31 percent of the laboratory space more than 40 years old.

We brought a series of pictures with us this morning to highlight some of the conditions that we saw at the five federal laboratories that we visited.

As you can see from the photographs, federal laboratories are experiencing many common problems associated with aging facilities—leaking roofs, gutters, drafty window frames, inefficient ventilation systems that do not bring sufficient air into the laboratories, and overcrowded and limited work space.

In particular, DOE and EPA and NASA have cited deteriorating laboratory facilities as material management weaknesses in their financial integrity reports.

Many older federal laboratories are indeed obsolete. They were not designed to meet today's health and safety standards and advanced R&D needs. Many laboratory buildings do not have, for instance, sprinkler or alarm systems. Similarly, computers and other electronic equipment have increased the demand for electric power, with labs experiencing as many as 20 to 30 power outages per year; while sensitive scientific instruments have increased the importance of controlling the temperature, the humidity, and the air quality, which many of these laboratories are unable to do.

We found that laboratories have generally avoided a prolonged shutdown of R&D projects by successfully engineering around emergencies.

If I may, in terms of Yankee ingenuity that we saw, Mr. Chairman, you referred to the example at Wright Lab Air Force Laboratory where a leaking roof required some ingenuity in terms of building the second building around equipment—complete with gutters—so that would give you some indications of the quantity of rainwater that was actually entering the laboratory.

There's no doubt that the aging facilities have reduced scientific productivity. Typical problems include reporting ventilation systems that do not meet industry standards for circulating air, which have caused even respiratory problems among the scientific researchers, and/or contaminated laboratory samples that have to be redone and experiments redone, as well as electrical power outages.

As a point of reference, the National Research Council's Building Research Board has found that maintenance and repair underfunding is widespread, and it's a persistent problem across the Nation.

The Board believes that an appropriate budget allocation for routine maintenance and repair will typically run in the range of 2 to 4 percent of the aggregate current replacement value for the buildings.

Today, funding constraints, however, have limited some agencies' ability to repair and upgrade their laboratory facilities.

In FY 1992, only ARS and NASA were able to meet the minimum guideline of 2 percent for maintenance and repair. Most agencies reported to us that they're spending about 1 percent or less.

The eight agencies, as you referred to in your opening statement, also reported a total backlog of around $4 billion in needed repairs at their particular laboratories.

While some money is in fact being made available through the appropriation process, in response to budget constraints, the end of the Cold War, and a concern for efficiency, several federal agencies should get credit for having considered alternatives to realign or consolidate their laboratory facilities.

For example, DOD is in fact reducing the combined number of laboratories. Similarly, USDA is studying whether to consolidate some of ARS's 111 laboratories. DOE, for instance, is also considering how to realign its nuclear weapons laboratories, and NASA is doing a good job at beginning to develop a national facility plan.

Mr. Chairman, in terms of a conclusion, if I could just quickly summarize by saying that most of the eight agencies' laboratory facilities that we examined, quite frankly, are over 30 years old. They're requiring increasing maintenance and funding needs. In FY 1992, six of these eight agencies did not spend minimum guidelines for trying to fund routine maintenance and repair. And many agencies currently have billions of dollars in the backlog of needed repairs.

There is evidence that inadequate facilities are in fact limiting research capabilities. Substantial funding would be needed to provide the proposed new laboratory facilities.

We give credit in the fact that in recent years, DOD, DOE, NASA and USDA have initiated task forces to re-examine their R&D missions and/or to improve effectiveness and efficiency at their laboratory facilities.

Such task-force efforts are providing the basis for determining whether to realign or to consolidate laboratories and whether to increase funding for those laboratory facilities considered essential for fulfilling agencies' R&D missions.

We believe that the Federal Government must in fact begin to make strategic management decisions. We think it's good that the agencies are reassessing their R&D missions and that this type of effort is critical before spending large sums of money, perhaps, on old and often outdated structures.

Mr. Chairman, this concludes my summary statement. I'd be happy to respond at the end of the panel discussion to any questions you may have.

[The prepared statement of Mr. Wells, along with the GAO report, starts on pp. 26 and 30, respectively, of Submissions for the Record:]

SENATOR SARBANES. Thank you very much, Mr. Wells. We very much appreciate this fine report by the GAO on this problem. It's a very important contribution to considering this significant issue.

Dr. Murrell, we'd be happy to hear from you, sir.

### STATEMENT OF K. DARWIN MURRELL, DIRECTOR, BELTSVILLE AGRICULTURAL RESEARCH CENTER, AGRICULTURAL RESEARCH SERVICE, USDA

DR. MURRELL. Thank you, Mr. Chairman.

I think that both you and Mr. Wells have made really the most important points. So I would like to just highlight my testimony, particularly those aspects that I think underscore and support the major points that you've made.

I am privileged to be the director of one of the premier research centers in the U.S. Department of Agriculture.

The Beltsville Agricultural Research Center has a long and distinguished history of agricultural research and development and is regarded as the largest agricultural research center in the world.

Currently, the Center has a staff of 350 permanent scientists and about 100 postdoctoral fellows and visiting scientists from all over the world, and about 1,200 support personnel.

We also host 18 other federal and state agencies which occupy some of our offices and laboratories and utilize the research plots on our 7,000 acres.

Although BARC is successful in its mission of research on the Nation's most difficult agricultural and nutrition problems, it is an increasingly difficult struggle to maintain an infrastructure adequate to the challenge.

The majority of BARC's research facilities were built in the 1930s and 1940s. Since then, investments in upgrading our facilities have been constrained by budgetary limitations. This has resulted in deterioration and obsolescence in many of these facilities, which in turn hampers our ability to provide the quality of research expected of us and to fulfill our national mission.

We are just able to meet that minimum 2 percent investment in repair and maintenance each year. But, in spite of that, we have about a $32 million backlog in R&M projects.

I'd like to illustrate the magnitude of the problem with several examples that I believe will give you an indication of the intimate relationship between research facility conditions and scientific progress.

Over the past 30 years, 54 barns or nonlaboratory buildings have been converted to makeshift laboratories because of the press of urgent research assignments. These poorly designed buildings are a severe financial burden. The costs associated with retrofitting ventilation systems are extremely high, and in some cases, we must consider carefully whether we can justify the resources needed to retrofit certain of those buildings for some types of research.

In another example, our Beltsville Human Nutrition Center suffered a catastrophe recently when back-up generators failed during one of our frequent power outages, causing freezer failures. The freezers contained the blood, urine and stool samples from a major human nutrition study, most of which were lost.

The original cost to conduct that study was $240,000, and we're not sure at this point if we have the resources to repeat that trial.

We also have a particular concern at BARC regarding our animal housing. To many of our current facilities do not give us the flexibility to change research direction without costly physical facility changes.

BARC is a world leader in transgenic animal research and is making important advances in the control of parasitic diseases and in animal reproduction and nutrition. However, these programs are dependent upon animal-care facilities that are optimal for animal well-being and health. To maintain that level of animal care, considerable modernization and repair and maintenance of our 50-year-old buildings is required.

Over the past four years, in our germplasm evaluation and mapping research, thousands of cow embryos have been lost because of electrical outages. Each power outage lasting over an hour destroys two weeks of work.

The interim solution has been to purchase numerous back-up generators. Upgrading these electrical systems is among our highest priorities for modernization.

One of the unique capabilities at BARC is an abattoir which allows us to carry out on the campus a variety of projects on reducing the fat content of meat, on meat quality, and on meat safety. However, the deterioration of this building is raising concern about whether we risk the loss of our federal license to operate the facility without major upgrades.

I hope these few examples have clearly illustrated our serious facility problems. I'm sure you've observed a common theme throughout these examples, that of our inadequate electrical distribution systems.

As I mentioned, the utility systems at BARC have long been among our top priorities for modernization. The support of the Department and the Congress has allowed us to make significant progress in upgrading our electrical, steam and water treatment facilities.

Before closing, I would like to comment on our long-term modernization plans at BARC.

The studies that we've carried out strongly recommend that the optimum modernization for BARC should include a mix of rehabilitating existing buildings and building some new replacement buildings.

Those buildings that we would retain are those with solid superstructures. This plan would allow us to demolish many of the deteriorated buildings and to consolidate our research and support personnel into about one third of the number of current buildings.

As an example, our Climate Stress Laboratory, which is devoted to working on the effects of global climate change on plants, is currently housed in nine buildings, which makes inter- and intra-unit collaboration extremely difficult.

I want to again thank the Committee for allowing me an opportunity to express my concern over the plight of one of our Nation's great research treasures. The mission of BARC and the commitment of its people to tackle the most important national agricultural and nutritional problems remains strong. However, our serious facility deficiencies impede our progress.

Mr. Chairman, while I have focused primarily on BARC, it is important to note that the problems are illustrative of facilities throughout the Agricultural Research Service. The agency has projected facility needs to the turn of the century to be over three-quarters of a billion dollars.

I know that the leaders of the other federal research facilities who are also appearing before this Committee share my hope that the help we need to continue our service to this Nation can be found, and that this assistance will be recognized as one of our most important and wise investments for the future.

Mr. Chairman, this concludes my prepared statement. I again will be pleased to respond to any questions.

[The prepared statement of Dr. Murrell, along with an attachment, starts on p.78 of Submissions for the Record:]

SENATOR SARBANES. Thank you very much, Dr. Murrell.

Congressman Ramstad, who has not been able to be with us, has an opening statement and I'll have that included in the record at the beginning of the hearing immediately following my own opening statement.

[The written opening statement of Representative Ramstad starts on p.85 of Submissions for the Record:]

We will now turn to Steven Ficca, Associate Director for Research Services at NIH.

We would be happy to hear from you, sir.

**STATEMENT OF STEPHEN A. FICCA, ASSOCIATE DIRECTOR OF RESEARCH SERVICES, NATIONAL INSTITUTES OF HEALTH**

MR. FICCA. Thank you very much, Mr. Chairman.

Before I give my brief statement, I'd like to introduce some supporting witnesses I have with me today. One is Dr. Lance Liotta, who is Deputy Director for Intramural Research at the National Institutes of Health—NIH. And Mr. Jorge Urrutia, who is Director of Engineering Services for the National Institutes of Health.

Mr. Chairman, I greatly appreciate the opportunity to appear before you to discuss the infrastructure of our federal laboratories. Today, testimony today will focus on the current condition of the research facilities at the NIH and the impact that these conditions have had on the institutes' research mission.

As a result of investment in NIH research, concepts that were not understood and technologies that did not exist as recently as ten years ago are saving lives today. For example, the NIH has played a major role in reducing mortality from heart disease and stroke, in developing new drug treatments that have given children with cancer a better than 50 percent chance of living a normal life, and in the discovery of vaccines to protect against infectious diseases that once killed or maimed millions.

Unfortunately, there are many diseases yet to be conquered. As we speak here today, researchers at NIH are working on better ways to prevent and treat cancer, blindness, arthritis, diabetes, AIDS, and Alzheimer's Disease, to name a few.

As NIH continues to confront disease and disability, we also face unprecedented stress on its physical infrastructure. As the next century approaches, we must pause to consider the profound ramifications of past decisions and pressures that have impacted on the repairs and maintenance of our buildings and facilities.

Dynamic changes in biomedical research and clinical care have led to an ambitious program of new construction and renovation on the NIH campus since the mid-1970s. Despite these efforts, much remains to be done to improve the condition of NIH's intramural research facilities.

More than half of the research buildings on the NIH campus are from 30 to 50 years old. These buildings are deficient in meeting current standards of safety, air conditioning, ventilation, and electrical service. Much of the central utility plant and its distribution systems which support all NIH buildings exceed or are approaching limits on their rated useful lives.

These systems are inefficient, obsolete, unreliable, and have insufficient capacity to meet existing, much less projected, research demands.

The impact of these conditions on NIH research capability is important. For example, we are unable to provide continuing CAT scanning capability due to an inadequate power suppiy. Newly initiated studies on restenosis following angioplasty and another study concerning genetic basis of hypertrophic cardiomyopathy have been curtailed due to infrastructure constraints.

Many of the concerns about campus-wide infrastructure are reflected in the conditions found in the NIH Clinical Center complex, the keystone of the intramural research program at NIH.

The Clinical Center complex is the world's largest hospital devoted exclusively to clinical research. As a national resource, it contains almost half of the country's federally-supported dedicated clinical research beds. Each year, there are about 9000 in-patients from all over the world, and in addition, 145,000 out-patient visitors who participate in clinical trials at the Clinical Center.

The Clinical Center's design places laboratory research side-by-side with patient-care activities. Because of this, the NIH continues to be a world leader in biotechnology transfer; that is, the ability to rapidly take an idea from the laboratory directly to clinical trials.

For example, NIH scientists were the first worldwide to use gene therapy to treat human disease. The first little girl who received the therapy just celebrated her third year of healthy life.

Additionally, the successful use of taxol to treat ovarian and breast cancer, gene therapy protocols for drug-resistant breast cancer, and new treatments for approaches to Alzheimer's Disease have all emanated from research in NIH's intramural program.

Having been built in 1950, the original Clinical Center is over 40 years. Medical research has advanced astronomically. To begin to address changing medical research needs, modernization improvement programs have been undertaken to attempt to repair and upgrade the hospital's infrastructure. These include: the essential maintenance and safety program, undertaken as a measure to improve conditions and address the most critical safety issues in the Clinical Center complex; construction of the ambulatory-care research facility; and construction of the A-wing of the Clinical Center to address the national epidemic of AIDS.

The Clinical Center, however, was not designed to accommodate future expansion. Additions have been based on available space rather than on functional efficiencies, and, as a result, serious functional inefficiencies have occurred.

Additionally, the major utility infrastructure systems within the original building that provide critical electrical power, lighting, air conditioning, ventilation and plumbing are outmoded and do not have the flexibility or capacity to meet current research demands.

For example, because deficiencies in the building's air-handling system pose potential risks to researchers and patients, NIH has had to impose a moratorium on adding fume hoods in individual laboratories, impeding important research activities. And the laboratory located next to one of the surgery units was intended to be used for an expedited program on drug-resistant tuberculosis, but due to incorrect airflow, it cannot be used for this or any other infectious disease research.

In 1987, NIH initiated studies to examine the extent and severity of deficiencies in the Clinical Center's infrastructure systems. These studies indicated that the deficiencies were indeed severe and widespread. Upgrading of the Clinical Center's infrastructure, in terms of essential safety and health needs, has been included in the budget presentations and an upgrade was included in the 1991 Presidential budget submission.

In response to the proposed upgrade, the House Committee on Appropriations requested that the Secretary of Health and Human Services conduct a review of these needs in cooperation with other federal agencies.

The U.S. Army Corps of Engineers agreed to assess NIH's facilities revitalization program. In their 1991 report, the Army Corps of Engineers review committee substantiated the severity of the infrastructure deficiencies and concluded that total replacement of the Clinical Center complex was the optimal technical solution.

This approach is one approach that is under review and future steps to resolve facility problems at the Clinical Center will depend on the outcome of an ongoing review of the intramural research program by the new Director of NIH, as well as the Assistant Secretary for Health and the Secretary of the Department of Health and Human Services.

The NIH is considering integration of all corrective and new construction programs into a comprehensive facilities revitalization program so that ongoing research in clinical care, as well as anticipated growth, can be supported in accordance with modern standards. Future consideration of this proposed plan awaits confirmation of the new director of NIH, and appropriate ancillary studies to examine all available options.

In conclusion, Mr. Chairman, I believe that the future success of NIH's intramural efforts to improve the health of the American people rests in the hands of many: diligent scientists and doctors; engineers and electricians; and ultimately, those of us who allocate resources provided by you and your colleagues.

This concludes my prepared statement. I would be pleased to respond to any questions.

[The prepared statement of Mr. Ficca, together with attachment, starts on p.86 of Submissions for the Record:]

SENATOR SARBANES. Thank you very much, sir, for a helpful statement.

Gentlemen, I'm going to suspend for a few minutes because there is a roll-call vote taking place. I will go and vote and come back as promptly as I can. On my return we will hear the remaining two panelists and then go to questions.

The hearing will stand in recess.

[Recess.]

SENATOR SARBANES. General, we'd be happy to hear from you.

## STATEMENT OF BILLIE J. McGARVEY, GENERAL, DIRECTOR OF FACILITIES ENGINEERING DIVISION, NASA

GEN. MCGARVEY. Thank you, Mr. Chairman.

The previous testimonies regarding the prevalent problems and concerns and deficiencies in the research labs also exist in NASA. I won't take the time to go through those and reiterate them. I would simply like to summarize my statement for you very briefly, and up front, simply say to you that we all suffer the same types of deficiencies in our research labs.

I am extremely pleased to be here to discuss the current facility conditions of NASA's laboratories, which support the accomplishment of wide-ranging and cutting-edge research and technology development in both aeronautics and space.

NASA's inventory facilities are the springboard for our scientific and engineering achievements. Many of our facilities provide the basic capabilities for conducting research, development, and operation of space transportation systems, payloads and launches, and aeronautics and space science endeavors that provide the opportunities for commercial development in the private sector.

Proper maintenance and repair of these facilities, as well as the revitalization of the older facilities, certainly are fundamental to ensuring that NASA's installations are optimally available for the agency and others to accomplish their missions.

As a brief overview of the NASA facilities base, Mr. Chairman, we have nine major centers and nine component installations that comprise 2,700 buildings and 3,200 other test and development structures.

Of this total facility base, there are about 1,025 of these that represent the research laboratories that are being addressed in this audit and survey. Our current replacement value for the total inventory is approximately $14.7 billion. Of this total, $6.7 billion is the replacement value for the labs that we have under discussion.

Leading up to this present audit, NASA conducted a number of in-house assessments and surveys of our own in 1989 and 1990, and we had a similar GAO evaluation that was accomplished in 1990 after the in-house assessments.

Based on these, the actions that we have taken on these previous assessments and audits are that we have revised our maintenance policy for the agency. We have published a comprehensive and detailed handbook, which all of our folks at the centers use as the maintenance bible and maintenance guide. We have instituted formal wall-to-wall condition surveys of all of our facilities.

We have instituted a revision to our cost-accounting systems in the comptroller's office to better account for the total expenditures that are actually being expended for maintenance activities.

We have instituted a continuous tracking of these expenditures. And we do conduct an annual workshop agency-wide for all of our maintenance folks who are involved in the day-to-day maintenance. The latest innovation that we have underway is a benchmarking exercise with both industry and other federal agencies that have similar activities.

We recently completed benchmarking visits with the 3-M Company in St. Paul, Minnesota, and with the duPont people in Wilmington, Delaware. These have turned out to be very productive and enlightening to both us and industry, to find that, in many cases, we are dealing with the same sorts of problems of trying to maintain a responsive infrastructure.

In the pure maintenance and repair area, we have, in my view, made considerable progress since the 1990 timeframe.

In 1989, we were investing approximately 1.7 percent of the current replacement value for our facilities in maintenance and repair. This has increased in 1992. The actual expenditures were 2.2 percent. Our 1994 projections, which are in the current FY 1994 budget before the Congress, will increase to 2.5 to 2.6 percent in 1994.

In the current budget in FY 1993, we have $313 million invested for maintenance and repair. This will rise to about $340 million in 1994.

We suffer the same problems that the other agencies and organizations do. We have a backlog of maintenance and repair that is needed. Agency-wide, for the total physical plant, it amounts to about $1.6 billion. This was based on comprehensive individual assessments of each facility in the inventory.

We did the assessments with both in-house teams and with contract support from contractors to help do the physical inventory.

Of that total of $1.6 billion backlog, approximately $718 million of it is in the research laboratories that are under discussion in this audit.

Examples of problems and challenges that we face, as I said earlier, are very similar to the other agencies. And it is driven primarily by the age of the majority of our facilities and equipment. It is also driven by constrained budgets and being able to identify sufficient funds in the total budget to carry out the required amount of maintenance.

Heating, ventilating and air conditioning systems deficiencies are among the most prominent. Electrical power distribution failures are things that we have to deal with constantly. Chiller capacities for large chiller plants and supporting the laboratories, constant upgrade and maintenance of the chillers, high-pressure air and gas systems, such as helium and nitrogen systems that are used for cleaning purposes in many of our labs and development activities; these are typical examples of the deficiencies and problems that we have in those areas.

In regards to the impact on the research and development activities, the primary impact has been delays in testing and in conducting complete experiments. When there is a breakdown in heavy rotating machinery or in the electrical distribution systems, it is lengthy sometimes to make those repairs. And when the equipment is as old as a lot of it is, it is hard to find replacement parts, and you are forced to manufacture your own parts in many instances.

This has created some schedule slips, and it has caused a lot of unscheduled downtimes. But I'm happy to say that we have not had a cancellation of any research program or any research project that was directly attributable to these kinds of deficiencies.

In the revitalization category of restoring and upgrading facilities, we have undertaken some major upgrades in restoration activities in the last few years. From FY 1990 to FY 1994, for this complement of research labs, we have invested $182 million in upgrades.

The largest program in addition to that which was initiated in FY 1988, and is running through its last increment, is a $300 million Wind Tunnel Revitalization program for all of our major wind tunnels, which encompasses about 21 tunnels at the three basic research centers.

In our FY 1994 budget, we have allocated $233 million of the total budget for revitalization, restoration and modernization of facilities. This translates to about 1.5 percent of the current replacement value, which we would prefer, of course, to see that increase to a higher rate. And if you convert that, or translate it, to an annual renewal cycle as to how long it would take to renew your infrastructure base, it would only bring you to a 65-year renewal cycle. Our objective and goal is currently about 35 years for a reasonable renewal cycle.

Regarding future outlooks, there are major challenges facing us in severely constrained budgets in FY 1995 and in the out-years as we currently understand them. It will be a real challenge for us to maintain the present momentum in trying to increase these investments.

I'm pleased to say that we have been able to exceed the lower end of the scale, the 2 percent to 4 percent of CRV for maintenance and repair for these activities.

Through utilizing the most efficient maintenance methods and procedures that we can come up with and concentrating heavily on preventive maintenance and predictive maintenance, we hope to continue these improvements.

That concludes my summary, Mr. Chairman. I would be pleased to answer any question that you or the other members may have.

[The prepared statement of Gen. McGarvey starts on p.91 of Submissions for the Record:]

SENATOR SARBANES. Well, thank you very much, General McGarvey.

Dr. Martino, my Republican colleagues on the panel wish to have you here as a witness, and we are pleased to have you.

**STATEMENT OF JOSEPH MARTINO, SENIOR RESEARCH SCIENTIST, UNIVERSITY OF DAYTON RESEARCH INSTITUTE**

DR. MARTINO. Thank you, Mr. Chairman. I appreciate the chance to be here. I have a prepared statement which I will leave and request be entered into the record.

SENATOR SARBANES. The full statements of all the witnesses will be included in the record and I appreciate the fact that each of the witnesses has been summarizing the main points of their testimony.

DR. MARTINO. I will present a summary. I should preface my remarks that I am a research scientist at the University of Dayton Research Institute. My statements do not necessarily represent the views of my employer.

My background includes service in government laboratories and in a university research institute, as well as scholarly research on the management of research and development.

I am currently the principal investigator on a contract between the university and the State of Ohio to find ways to commercialize the Mound Facility, a Department of Energy facility located near Dayton.

The General Accounting Office has documented the poor condition of many federal laboratories. This is being presented as a need to repair and upgrade these laboratories.

I wish to follow up on the GAO suggestion that instead the missions be reconsidered, and, where appropriate, these laboratories be closed rather than upgraded.

My remarks today will cover four main points:

First, one risk associated with federal labs is that they will become mediocre through pork barrel funding; the second risk is that they will become an unwarranted subsidy to specific industries; third, if a federal lab is to serve the needs of industry effectively, it must be privatized; and fourth, this is not the first time that we have faced the issue of what to do with no longer needed federal labs.

I will illustrate each of these points with examples.

The Department of Agriculture is probably the prize example of mediocre science in the Federal Government. Its R&D funding is distributed according to a political formula, rather than according to the economic importance and the scientific merit of the research.

Since 1972, there have been over half a dozen major reviews of the Department of Agriculture labs. Every one of these reviews had harsh criticisms of the department's research. The 1972 National Academy of Science's report said:

> Much of agricultural research is outmoded, pedestrian and inefficient.

One of the reviewers taking part in the 1987 study said:

> It was one of the most depressing things I ever saw. We saw hundreds of millions wasted on people who hadn't published in 20 years.

Why has the Agricultural Research Service remained in such a dismal state? Because the funding is driven by pork barrel politics rather than science. It has been said that the only time you can close a research station is when a congressman dies or is defeated. Providing researchers with lifetime job security, but depriving them of the opportunity for meaningful work is a perfect recipe for driving out the competent people while retaining the time-serving hacks.

This experience with the Department of Agriculture is significant for the future of the federal labs. Keeping them open for the sake of keeping them open is to condemn them to the mediocrity of the Agricultural Research Service.

Regarding subsidies to industry, the current Office of Aeronautics and Space Technology of the National Aeronautics and Space Administration, and its predecessor, the National Advisory Committee for Aeronautics, were established as a subsidy to the aviation industry. This subsidy is still national policy. Its stated goals are to "develop the technology for a fuel-efficient, affordable subsonic aircraft, to develop "the technology for sustained supersonic cruise capability," and to develop the technology for "a transatmospheric vehicle."

For nearly four decades, U.S. aircraft manufacturers have been the preeminent suppliers to the world's airline. To what extent was the current NASA and earlier NACA responsible for that situation?

Miller and Sawyers identified six innovations which made possible what they called the economic airplane, and therefore the start of the airline industry. Only one of these six was due to the NACA, the forerunner of the present NASA. The others were all developed by industry, in some cases with partial military funding.

An interdepartmental study identified 13 innovations, introduced between 1925 and 1940, that were important to aviation. Only three of these came from NACA. All the rest came from industry.

Total U.S. R&D spending on aeronautical research from 1925 to 1975 far exceeded that of NASA and its predecessors. Military and industry spending were roughly equal and amounted to about 95 percent of the total. NASA spending came to about 5 percent of the total aeronautical R&D.

This research indeed paid off. From 1925 through 1975, productivity in the airline industry grew 25 times. The payback in the airline industry alone was about 30 times greater than would have been obtained by investing the same money in high-grade industrial bonds.

However, since most important aeronautical innovations came from outside NASA and its predecessors, since NASA and its predecessors' funding amounted to only about 5 percent of the total, and since the payback from that aeronautical R&D far exceeded the amount spent, it is clear that the subsidy to the airline industry was unneeded. The airline industry alone achieved cost savings which have justified the aviation industry in funding that research itself.

This experience is relevant to the federal labs. If they do good work, the benefits to industry will be sufficient that the industries could afford to fund the research themselves. Changing the mission of the federal labs to support specific industries is an unwarranted subsidy, even if the labs avoid falling into mediocrity.

Regarding privatizing, the Department of Energy's Mound Facility in Miamisburg, Ohio is scheduled to be closed. The State of Ohio has contracted with my university to identify those Mound capabilities which have commercial potential.

Our findings in the effort to commercialize Mound capabilities are relevant to any proposals to convert the federal labs to commercial R&D.

One finding is that the regulatory environment at Mound is incompatible with a commercial venture. Mound has in the past performed so-called work for others. Obtaining approval for this work often takes 12 to 24 months. If Mound were to remain a DOE facility, it would be impossible for it to respond to the demands of commercial markets. For Mound to operate effectively in commercial markets, it must be privatized.

Another finding is that the DOE-mandated overhead structure makes it impossible for Mound to compete for business because it raises costs unnecessarily. Yet another finding is that the DOE bureaucracy prevents Mound from quickly improving its internal processes.

For instance, Mound installed a sophisticated and costly x-ray inspection device. Nearly two years after installation, the Department of Energy has still not approved it for operation. Industrial firms have identical devices in operation within 45 days. No private firm could afford to have such an expensive item sit idle while awaiting approval to operate it.

To summarize our findings regarding Mound, its closing makes privatizing both necessary and possible. If the DOE workload were to be reduced and commercial work sought as a supplement, it would be completely impossible for Mound to compete.

The same will hold true for any attempts to open the federal labs to commercial work. The bureaucracy, the regulations and the overhead will inevitably make the labs noncompetitive.

Prior historical experience. Once before, we faced the issue of what to do with no longer needed federal labs. During World War II, many laboratories were established to carry out R&D for the war effort. One of these was the radiation laboratory at Massachusetts Institute of Technology. This laboratory was highly successful in developing radar equipment and control systems for anti-aircraft guns. The RadLab carried these to the preproduction stage before turning them over to industry.

At the end of the war, the radiation laboratory was simply disbanded. Most of its people returned to industry and to academia. This resulted in the massive transfer of its technology to industry, to academia, and to a new generation of students, one of whom I am, by the way.

This is not surprising. Numerous studies have confirmed that one of the most effective ways to transfer new technology to potential users is to transfer the people who developed it.

The implication of this experience for the federal labs, especially those which are no longer needed for military purposes, is that they should simply be closed. The experience of history is that no longer needed labs should not be kept open and converted to commercial work. The best way to commercialize their capabilities is to transfer their people to industry and academia.

Summarizing my comments, keeping the federal labs open will require a significant investment in buildings and equipment. This gives us the opportunity to rethink their status. Those missions still required should be consolidated. Those labs no longer needed for their original missions should simply be closed. They should not be given a totally new mission.

At best, that would lead to an unwarranted subsidy for industries which can afford the research themselves. More likely, it would lead to expensive mediocrity.

We cannot afford to waste precious R&D dollars on subsidies to industry or on second-rate laboratories.

That completes my prepared statement. I would be pleased to respond to questions.

[The prepared statement of Dr. Martino starts on p.96 of Submissions for the Record:]

SENATOR SARBANES. Thank you very much. I have one question. I just want to be clear exactly what your position is. In your written statement, you say, "I am here to suggest an alternative, that instead of being repaired, they simply be closed down," with respect to the laboratories.

DR. MARTINO. Yes, sir.

SENATOR SARBANES. But in your oral statement, you inserted the phrase, "where appropriate."

DR. MARTINO. I wish I had said that in the written statement. Some laboratories obviously are appropriate.

SENATOR SARBANES. Is it your position that all of these labs ought to be closed, that there's no rationale for sustaining any of these labs under the current system? Is that your position?

DR. MARTINO. No, that is not my position.

SENATOR SARBANES. Okay.

DR. MARTINO. But many of them should be closed. Some few should probably remain open.

SENATOR SARBANES. I wanted to be clear about that. And on the criticism of the Agriculture Research Service, were you applying this to BARC itself or to the field stations, primarily?

DR. MARTINO. Most of the criticism there appears to be directed at the field stations. I am repeating comments made by two different studies by the National Academy of Sciences and by the General Accounting Office, as well as some minor studies.

SENATOR SARBANES. Do you extend that to the Beltville Agricultural Research Center?

DR. MARTINO. I have no personal knowledge about Beltsville. I cannot comment.

SENATOR SARBANES. Now, it is your view that NASA should close out all its R&D?

DR. MARTINO. All its aeronautical R&D, which is an unwarranted subsidy to industry. Five percent of the United States' aeronautical R&D is funded by NASA, 95 percent by everybody else.

They can hardly claim to be responsible for all of the development. Moreover, the savings from that R&D are such that industry could afford it, since it already affords half of what's going on.

SENATOR SARBANES. Now, we did not get NIH within your sights, I don't think, here at the table. I was wondering what your view is of NIH. I just want to lay this out so that we can give these other gentlemen a chance to respond.

DR. MARTINO. Certainly. In my book, *Science Funding*, which was published last year, I report some results regarding the extramural activities at NIH. But I have not made a study of the intramural activities and do not feel competent to comment on them.

SENATOR SARBANES. All right. I wanted to ask those who are in charge of the labs and who are here today, how these poor laboratory conditions impact on, one, your ability to attract and hold top-flight scientific personnel; and second, what it really does to the ability to function, to carry out important research projects. To what extent is it really intruding or hampering your ability to carry out your activities?

Why don't we start with you, Dr. Murrell, and we will just take the three of you. Then, Mr. Wells, you may have some general observation about that. I will turn to you.

DR. MURRELL. Yes. We have experienced at Beltsville an impact on recruitment by our facilities problems. Much of the modern research in agricultural research is very molecular now. It demands some very sophisticated laboratories and sophisticated equipment.

The problem, as I mentioned in my testimony, is that many of our laboratories are converted buildings. They have a configuration that is difficult to change. We don't have enough of the high-volume air turnover that's necessary. We don't enough containment facilities for some of the molecular biology work.

That's our goal. That's what we're working towards. I think that we're in less than a fully competitive position in trying to recruit the best scientists in the country to come to Beltsville.

However, we have had some successes because I think we have been able to encourage these candidates towards that goal, and we have the support for it.

With regard to holding onto our scientists, we've been quite fortunate in that regard. The turnover in the scientists at Beltsville is about 1 percent. That's extremely low.

I think it's because they recognize the potential at Beltsville to achieve what they're interested in. I think they appreciate the support they do get, even though they recognize that we have these facilities limitations.

So I would say that we're in a fortunate position. I hope we can stay in that position. But we are holding onto our best scientists.

With regard to impact, again, as I mentioned in my testimony, our biggest problem is that we have something like 800 buildings at Beltsville. Now, not all of those are laboratories. Many of those are animal facilities. But we need to get rid of about half to two thirds of the buildings that we have, because we have scientists who are scattered all over the 7,000-acre campus, who have a great deal of difficulty in interacting with those with whom they need to interact.

Research has moved away from being very disciplinary-oriented; for example, entomologists who only need to work with entomologists.

Our problems today in agriculture are issues such as sustainability. That requires tackling these problems on a broad front with multidisciplinary teams. We need to have economists. We need soil scientists. We need microbiologists and plant geneticists. All of these must work together in multidisciplinary teams to tackle these problems.

Our difficulty at Beltsville, while we have the land, we have scientists scattered all over the campus in a way that makes it difficult for that interaction to occur.

So that's one of our biggest constraints, this poor distribution of scientists. And that's one of the major goals of the modernization, to be able to consolidate those scientists into fewer buildings so that those collaborations can take place.

SENATOR SARBANES. I am going to have to go vote. Let me quickly put this question to you. It is asserted by Dr. Martino that the Department of Agriculture research is a prime example of mediocre or poor science.

I had the impression that Beltsville was at the cutting edge of developments in the agricultural sector, not only in this country, but worldwide.

DR. MURRELL. Yes, I'd like to respond to that. For instance, at Beltsville, I was just taking a count recently. In the last five months, we've had five scientists who have won national and international awards.

The Nobel Prize in agricultural research is the Von Humbolt Award. I think there have only been seven or eight of those now. Out of those, three of those have been ARS scientists, one of them from Beltsville.

Given the size of the Agricultural Research Service, I think that's a remarkable record.

Another measure, I think, of the quality of Beltsville is the large investment by private industry and by other federal and state agencies in our research. Our successes in competitive grants at Beltwville—we're allowed to compete for some competitive grant programs—is above the national average. We doubled our competitive grants this past year.

We have something like 27 cooperative research and development agreements at Beltsville with private industry. The first one ever signed between the Federal Government and a private company was at Beltsville with Embrex. We have an outstanding record in that area.

We have 129 trust agreements with private industry and other agencies. These are putting money into our program to do that research for them. Trust funds differ in that there's no license issued, but the funds are for research that needs to be done.

These interests are not going to invest in any research organization that is not going to deliver. I think that those are probably some of the best examples I can give to refute the notion that the research is mediocre.

SENATOR SARBANES. Yes. Thank you, sir.

I'm going to suspend. I will be right back, and then pursue it with the other two witnesses.

[Recess.]

SENATOR SARBANES. Gentlemen, I apologize for the interruption, but it is obviously beyond my control. In fact, it is my intention to finish up shortly. You have been here all morning, and we appreciate that very much.

I am hoping we will get in a fair number of questions before the next interruption, or before I have to terminate. I think we are starting across the panel.

MR. FICCA. Thank you very much, Mr. Chairman. You asked about the impact of facilities on recruitment and retention of our scientists and some examples of how the facilities' problems may be hampering research.

I think we have certainly had some exodus of some of our really key and outstanding scientists lately for various reasons. Not all of them, of course, are attributable to the facilities.

But I'd like to take a page from a popular film which says, "Build it and they will come," and give some examples.

We recently had the good fortune to construct a new building on campus—the Silvio Conte Building—which is geared toward the neurosciences and now genetics research. And because of the availability of that resource, we were able to attract one of the outstanding scientists in the country, Dr. Francis Collins, one of the co-discoverers of the cystic fibrosis gene. And because we were able to attract that outstanding scientist, in turn, we've been able to recruit some other very extraordinarily good and creative young researchers in this new field and in this developing area of biotechnology.

There's no question that the facilities have a significant impact on the ability to retain and recruit quality scientists. The new young scientists who are the future leaders, it's very difficult to recruit them and that is a tremendous advantage, and in fact is critical to sustaining our research excellence.

I think the other area of recruitment, though, is not just scientists, but the area of patients. I think the problems that I have discussed with regard to the Clinical Center complex and the ability of NIH to continue to carry out clinical research, which has been so critical to the field of biotechnology and to the scientific and biomedical research enterprise, there's no question that that is threatened, and it is a severe problem that we're going to have to address in the future.

I already mentioned in my opening statement some of the problems, on an operating basis, that we've had with regard to facilities and infrastructure problems and deficiencies with regard to the moratorium on fume hoods. This has limited the kinds of research, particularly in the areas of infectious disease that we can undertake. Also, our ability to rapidly mobilize resources and scientists to address an emerging epidemic, such as drug-resistant tuberculosis, has been hampered because of lack of facilities and because of the improper air systems to handle that.

At this time, though, I think it would be important to appreciate and to emphasize for the record what is being threatened: The quality and productivity of intramural research.

If it would be permitted by the Chairman, I would like Dr. Liotta to give just a brief statement along those lines.

SENATOR SARBANES. Okay.

MR. FICCA. Dr. Liotta?

DR. LIOTTA. Quality in the intramural program at the National Institutes of Health can be measured in four ways.

The first is fundamental discoveries that we have made that impact on disease. For example, we broke the genetic code and took that all the way to the first gene therapy. We were the first to institute genetic therapy for ADA deficiency and now cystic fibrosis. This will revolutionize medicine.

Another example is we elucidated the causative agent of AIDS, and developed the AIDS blood test which saved the blood supply. The first treatment for AIDS—AZT—was launched in our Clinical Center for both adults and children.

We have a number of other pioneering approaches to cancer, to vaccines, to Alzheimer's Disease, and I can submit for the record a list of 200 fundamental discoveries that have profound clinical importance from our intramural program over the last five years.

The second way to measure quality is the standard measures of publication rate and citation rate. A 1992 study done by the Institute for Scientific Information showed that we were at the top of the list for citations and productivity in that measure.

The third way to measure quality is the speed at which we can take a discovery from the laboratory to help the patient. Here, we have the largest number of INDs filed with the FDA for new treatments than any other institution.

And the fourth measure is outside review. In 1989 and 1988, the Institute of Medicine conducted a study of the intramural program at the NIH and concluded that it should not be privatized and concluded that it was stellar in the quality of its science and should be sustained and enhanced.

Thank you, Mr. Chairman.

SENATOR SARBANES. What was the date of that study?

MR. FICCA. It was 1988.

SENATOR SARBANES. Okay. Thank you very much.

MR. FICCA. We can provide a copy.

SENATOR SARBANES. We can get it. General McGarvey?

GEN. MCGARVEY. Sir, we don't have, to my knowledge, any concrete evidence in NASA that the condition of the facilities has been detrimental to retaining our research scientists and engineers.

We do have difficulty in attracting the fresh-outs, the newly graduates entering at the basic level due to the competition from outside. Most of it is salary, as opposed to the work environment in the workplace.

As I say, to my personal knowledge, I don't believe that it has had an adverse impact. If it does, we don't have any evidence of it at this point.

SENATOR SARBANES. As I understand it, you have a highly developed, as it were, master plan to look at the problem of the deteriorating facilities and try to get them back up to standard.

GEN. MCGARVEY. That is correct. In all of our nine major centers, all except one have up-to-date master plans for the facilities and the needed upgrades. As I mentioned earlier, in the past year we have done almost a wall-to-wall inventory at seven of those nine major centers and the other two are in the stage of being completed. These assess the components that make up the facilities; whether it is the electrical systems; whether it is the hydraulic pumps; whether it is the HVAC, the heating, ventilating and air conditioning systems. All of these are detailed for each and every building. The master plan then is based on trying to fit these needs into the available funding and do them on an orderly, structured and upgraded basis.

SENATOR SARBANES. So you are in a position, whatever funding you get, you have pretty well prioritized how that money will be used. Is that correct?

GEN. McGARVEY. That is correct.

SENATOR SARBANES. Now, is NIH in a comparable position?

MR. FICCA. We're in the process of developing a 20-year master plan now. We have a preliminary draft, and we expect the final draft to be completed in December.

In addition, there have been numerous facilities assessments, which help us prioritize the maintenance and repair programs. Those are continuing ongoing. The detailed assessment of the Clinical Center, which represents about half the laboratory and clinical space on campus, has been completed. The facilities assessments of the remaining buildings are underway.

So we have a continuing program of facilities assessment ongoing, as well as the completion of the master plan this fall.

SENATOR SARBANES. Your dominant problem is the Clinical Center, is it not?

MR. FICCA. Yes, it is.

SENATOR SARBANES. How about at Beltsville?

DR. MURRELL. In the late 1980s, we conducted a facilities modernization study by an outside contractor, who more or less provided us with a blueprint for modernization. That is the plan that we are following. I mentioned that in my testimony.

As of yesterday, we finalized contract negotiations for a master plan which will be initiated on October 1. The facility plan will then fit into that umbrella of the master plan.

I would like to say——

SENATOR SARBANES. Suppose, by some happenstance, all of a sudden, you got an extra amount of money, do you know now exactly what you would do with that money in terms of committed money for addressing maintenance and repair problems, or upgrading the facilities?

I understand from NASA that they know exactly where they would put it. They have worked it all out. At least, that is my understanding.

GEN. McGARVEY. That's correct, sir.

SENATOR SARBANES. NIH, I guess your basic view is that we need enough money to do the Clinical Center. That is first and foremost, and it dominates everything else. Would that be correct?

MR. FICCA. Well, it does. I would say that we've got several assessments. In fact, there's about five or six different studies that I could list that have documented the problems in the Clinical Center. I think that we're certainly ready to approach that problem, as well as continuing assessments in most of our other laboratory buildings.

But, as I said, the remaining buildings, the facilities assessments are ongoing right now.

SENATOR SARBANES. At Beltsville, you have this plan. You have it sequenced, do you not?

DR. MURRELL. Yes. We know exactly what projects we would undertake in any given year through the year 2000, either infrastructure or building.

SENATOR SARBANES. Mr. Wells, do you have any observations about this process and so forth?

MR. WELLS. In terms of the master planning, we agree that we saw a fairly detailed master plan. NASA was somewhat outfront in terms of doing their master plan earlier. At each of the agencies represented here at the table, we were encouraged to see the emphasis that has been placed in the most recent years to improve their maintenance and repair scheduling.

So we think they certainly made some major strides and steps in the right direction in order to know where to put the funding.

SENATOR SARBANES. So, in effect, I take it you would view it very important to have a rational plan or arrangement for how you're going to do this.

MR. WELLS. Most definitely.

SENATOR SARBANES. So that the funds don't come hit or miss, and then they're used hit or miss, so to speak.

So, even if they don't yet have the funds, they really ought to be geared up to receive them, if in fact they come. Would that be correct?

MR. WELLS. That's correct.

SENATOR SARBANES. And is there a great variance in the agencies you surveyed as to how far along they are on that curve?

MR. WELLS. Well, I would have to say that NASA was outfront, because they probably started a little earlier, as early as maybe five or six years ago. They also had the benefit of an earlier GAO report that was somewhat critical, and they've taken major strides in doing some recommendations.

But, yes, we saw evidence that ARS and NIH are beginning to move out and do the kind of master planning that we think is needed.

SENATOR SARBANES. I am concerned by these reports that a lot of the work ends up being useless because the conditions vitiate the experiments and so forth. How much of that did you encounter?

MR. WELLS. Going back to one of your earlier questions. As our auditors approached and visited the facilities and talked to the scientists in the laboratories, quite frankly, they were impressed with the spirit, enthusiasm and professionalism that these scientists were bringing to the table through these various measures to work under these condition in order to ensure that they were getting quality research.

SENATOR SARBANES. Are there organizational or administrative factors that have led to these infrastructure problems at the labs, in your view?

MR. WELLS. As you know, when agencies go through their budget process, you have facility managers, people that are in charge of doing maintenance and repair requests, and then you have the scientists that are sitting there trying to do effective, efficient and important scientific work.

So there is always a struggle in terms of diverting R&D money into the maintenance field.

We have seen, as we look back in history, versus where they are today, that the views and the importance of maintenance and repair is significantly improving in terms of their maintenance allocations.

SENATOR SARBANES. I'd like to ask the people from the labs, how quickly advances in technology, in effect, date the lab?

DR. MURRELL. How quickly the research is moving affects the laboratory?

SENATOR SARBANES. Makes the lab outdated. In other words, you come along and you do a state-of-the-art lab, and so on, and then the nature of the conditions you require for the experiment seems to constantly be escalating. So then you say, we built this brand-new lab, state-of-the-art, X-number of years ago and now it doesn't work any more. Or, if you have a rigorous repair and maintenance program, can you stay abreast of things? That is a very general question, but I am interested.

DR. MURRELL. I think it's a very good question.

SENATOR SARBANES. Suppose you have everything at Beltsville right up where you want it. And then you look to the future and someone says, you are going to have to, in effect, redo this whole thing. Or could someone say, look, if we really pay attention to this place and do a reasonable amount of maintenance and repair, we can have a more extended life for these facilities.

DR. MURRELL. Yes, I think that's really the case. In the past, I don't think anyone appreciated how fast research was going to move in new directions with new technologies.

Second, I don't think it was appreciated that the conditions under which research is going to have to be carried out, from a safety standpoint, was also going to change.

We didn't have the concerns 20 years ago of containment in transgenic plant and animal research. And recombinant DNA work requires much different standards of good laboratory practice than we generally had 20 years ago.

The newest laboratory at Beltsville was completed in 1970. We call it the bioscience building. It's about 70,000 or 80,000 square feet. Today, it's almost obsolete for any kind of research. By the way, that building won an award for the architect who designed that building as a laboratory building. But today, we are probably going to have to move all the scientists and the staffs out of there, gut it out and rebuild it, because the ventilation and H-VAC systems are not adequate for the kinds of research that they have to take on today.

Now, the lesson we've learned from that is that we need to design these buildings in a modular, or a more generic, way that gives us the flexibility to make those changes.

That building, when it was designed under the concepts 20 years ago, wa built so specific and so specialized that there was no flexibility at all in th building. But I think we've learned our lesson. That's a factor that we buil into all of our designs now, to have flexibility. It's extremely critical. We car not predict 20 years from now what we're going to be doing in those building:

MR. FICCA. Dr. Murrell makes an excellent point. When the cornerstor for the NIH Clinical Center was laid, the state-of-the-art was the iron lun That building was not built for expansion. It was not built to accommoda the kinds of high-technology that is needed today.

I already mentioned several examples of that in my statement.

The life-cycle cost to maintain the older buildings is extremely high. We know that when we have to go in and address a problem in the Clinical Center, it costs us $128 to do an alteration or renovation, $128 per square foot. And we know that at many other facilities, like at the Salk Institute, for example, they can accomplish the same thing for $50 a square foot.

The issue of designing buildings to meet future needs—that is, designing in the flexibility and adaptability to meet changing research requirements and technological advances—is critical. It reduces the maintenance costs. It reduces the operating costs. It allows the alterations and renovations to meet those needs to be done more economically. And it continues the state-of-the-art for a much longer period of time so that we can address the problems we talked about in terms of retaining and recruiting top scientists, as well as meeting the public health priorities.

SENATOR SARBANES. Of course, in terms of the amount of money we are talking about, as a percentage of the overall money that is invested in your facilities, it is a very small percent. Is that not the case?

MR. FICCA. I can address that.

SENATOR SARBANES. I mean, there is an awful lot of money that has been invested, like in the NIH campus. The amount we are talking about in order to take that campus from where it is to a higher and much more acceptable level, as a percent of the total amount of money that's been put in, is not a very large percentage figure, is it?

MR. FICCA. No. There are several ways of looking at that, in terms of how to address infrastructure.

There's an amount of funds that we have to expend to renovate or repair the institution to bring it up to its original intended use. Then there's the preventive maintenance program, which would keep a facility at that level of its intended use. Then there's the third expenditure, which has to do with those renovations and construction that are required to meet technological advances and to accommodate new advances in biomedical research.

So when you look at that, and we think if we just start with what it takes to maintain at the current use, I think that the percentages that the National Academy of Sciences has identified, the 2 to 4 percent of the replacement value of the facilities, would adequately cover that.

At the NIH, because of the large proportion of our facilities that are laboratory and clinically related, that percentage is probably closer to 3 or 3.1 percent than it is to 2 percent.

And then, I'd say that to meet the future demands; in other words, to reach a new plateau, probably if we look at the total amount that's been invested for the NIH in terms of its operating costs and in terms of carrying out its research programs, we're probably talking about 1 to 2 percent of that investment.

SENATOR SARBANES. General McGarvey?

GEN. MCGARVEY. Yes. I would echo the same concerns, that it is extremely difficult to predict what the future requirements may be, based on the technology breakthroughs.

But in that arena, we have gone to both extremes. We have wind tunnels; for example, a full-scale wind tunnel at Langely Research Center which is the oldest research center in NASA. The tunnel is 63-year-old. It is still performing today, and it has had some upgrades and some modifications over the years. But today, it still does basic research for landing and take-off configurations for modern aircraft, and we make use of that existing investment and have continued to do that over the years.

If we go to the other end of the spectrum, out to Ames Research Center in Mountain View, California, we have the National Aeronautical Simulation facility, which is a simulation facility to check out designs and configurations by simulation on high-speed supercomputers. We have some of the latest CRAY supercomputers in the country in that facility.

It is devoted purely to computational fluid dynamics, which is a basic tool in aeronautics and aerodynamics development. It has been in existence now for about six or seven years and it is the front-end of trying to predict how to deal with simulation so that you do not have to put every model back into the wind tunnel and run actual tests in the tunnels themselves.

So I would agree with the previous statement about complex and sophisticated facilities in the medical world. It is similar to that in the scientific and engineering side of the house.

Our internal goal that we set in NASA was to put 3.5 percent of the CRV into routine maintenance and repair to keep our facilities responsive.

Obviously, we have not been able to do that yet because of funding constraints. But you do need to go to the high end of the spectrum for the highly technical facilities.

SENATOR SARBANES. Gentlemen, thank you very much. This has been a very helpful panel.

We appreciate the obvious work that went into the prepared statements, and they will be included, as I said, in full in the record.

We may submit some questions to some of you and we would like your responses for the written record. I want to again thank the GAO for this very helpful report.

[Questions and answers subsequently supplied for the record start on p.101 of Submissions for the Record:]

[Responses to the arguments from the Republican witness subsequently supplied for the record start on p.106 of the Submissions for the Record:]

[Additional material subsequently supplied for the record start on p.108 of Submissions for the Record:]

The Committee stands adjourned.

[Whereupon, at 12:10 p.m., the Committee adjourned, subject to the call of the Chair.]

O

## SUBMSSIONS FOR THE RECORD

### PREPARED STATEMENT OF JIM WELLS

We are pleased to be here today to discuss the findings of our report to this Committee, which we are releasing today, entitled Federal Research: Aging Federal Laboratories Need Repairs and Upgrades (GAO/RCED-93-203). Citing the importance of federal research and development (R&D) to economic growth and national well-being, Mr. Vice Chairman, you expressed concern that federal research agencies may be underinvesting in maintaining, repairing, and upgrading their laboratories. Accordingly, you requested that we assess the (1) condition of federal laboratory facilities, (2) effect of inadequate laboratory facilities on agencies' scientific productivity and research capabilities, and (3) funding needed to repair or upgrade these facilities.

The information in our report is primarily based on data provided by eight federal agencies for 220 government-owned laboratories that spent about $18.1 billion of the estimated $24.9 billion obligated for R&D at federal laboratories in fiscal year 1992. These agencies are the Departments of Commerce, Defense (DOD), and Energy (DOE); the Environmental Protection Agency (EPA); the National Aeronautics and Space Administration (NASA); the Agricultural Research Service (ARS), within the Department of Agriculture (USDA); the National Institutes of Health (NIH), within the Department of Health and Human Services; and the Geological Survey (USGS), within the Department of the Interior. We also interviewed facilities managers for each agency and laboratory management, researchers, and facilities managers at the eight federal laboratories we visited.

In summary, 54 percent of the floor space of the eight federal agencies' laboratories was more than 30 years old. Typical problems among the agencies' laboratories, according to agencies' facilities managers, included leaking roofs and inadequate ventilating systems that do not meet industry standards for circulating air. In addition, many older laboratories are obsolete--they were not designed to meet today's advanced R&D needs and health and safety code requirements.

The federal laboratory facilities managers and researchers we interviewed identified several instances, particularly involving old ventilating systems and power outages, in which aging laboratory facilities substantially reduced scientific productivity. In addition, several agencies cited the need for advanced laboratory facilities that provide greater flexibility to respond to new programs and scientists' research needs.

The eight agencies reported a backlog of more than $3.8 billion in needed repairs for their laboratories, and facilities managers for four agencies said that funding for repairs was only slightly adequate or inadequate. Furthermore, funding to renovate existing laboratory facilities or construct new ones was either only slightly adequate or inadequate at six agencies.

Four of the eight agencies recently initiated task forces to reexamine their R&D mission and/or improve the effectiveness and efficiency of their laboratory facilities. Reassessing agencies' R&D missions is critical before spending large sums of money on old and often outdated structures. Such task force efforts provide a basis for determining whether to realign, consolidate, or close laboratories and to increase funding for laboratory facilities considered essential for fulfilling agencies' R&D missions.

BACKGROUND

Laboratory facilities, along with scientists and research equipment, provide the basis for conducting advanced R&D at federal laboratories. These facilities include laboratory buildings; heating, ventilating, and air conditioning systems; electrical power supply systems; and water and sewerage systems. Laboratory facilities need to be properly maintained and repaired to continue to work well. In addition, aging laboratory facilities may need to be upgraded--either by renovating existing buildings or constructing new ones--to improve researchers' productivity or enable them to conduct state-of-the-art R&D.

In a June 1990 report, the National Research Council's Building Research Board found that underfunding is a widespread and persistent problem that undermines the maintenance and repair of public buildings.[1] In concluding that procedures and allocations of resources must be changed to recognize the full costs of the ownership of these assets, the Board stated that an appropriate budget allocation for routine maintenance and repair for a substantial inventory of facilities will typically be in the range of 2 to 4 percent of the aggregate current replacement value of those facilities.

## AGING FEDERAL LABORATORIES NEED REPAIRS AND UPGRADES

Federal laboratory facilities grew rapidly between 1943 and 1972 as agencies expanded their R&D missions. By the early 1990s, these facilities had aged--31 percent of the eight federal agencies' laboratory space was more than 40 years old, and 54 percent of the space was more than 30 years old. Only 24 percent of the eight agencies' laboratory space was less than 20 years old.

Mr. Vice Chairman, we have brought a series of pictures of the facilities' conditions at five federal laboratories we visited. As you can see from the photographs, federal laboratories are experiencing many common problems associated with aging facilities --leaking roofs and gutters, drafty window frames, and inefficient ventilating systems that do not bring sufficient fresh air into laboratories. In particular, DOE, EPA, and NASA have cited deteriorating laboratory facilities as a material management weakness in their Financial Integrity Act reports. For example, NASA's 1989-91 reports cited inadequate maintenance funding for its laboratories and other facilities as a material weakness. In response to a growing list of needed repairs and renovations, NASA's Associate Administrator for Aeronautics and Space Technology initiated a 5-year program to augment maintenance and instrumentation funding at three laboratories with $15 million of R&D funds in fiscal year 1991. This amount rose to $30 million in fiscal year 1993.

In addition, some federal laboratories are using government facilities not designed for R&D. For example, Commerce's National Oceanic and Atmospheric Administration (NOAA) is using Fort Crockett, an Army post built in the early 1900s in Galveston, Texas, as a sea turtle and shrimp research laboratory. A NOAA facilities manager told us that about $4 million is needed to repair and renovate this laboratory because the buildings (1) have deteriorated in their advanced age and (2) were designed as barracks for soldiers rather than as laboratories for scientists.

In addition, many older federal laboratories are obsolete-- they were not designed to meet today's health and safety standards and advanced R&D needs. Many laboratory buildings do not have sprinkler and alarm systems and adequate fire walls because they were designed to prior, less stringent requirements. Similarly, computers and other electronic equipment have increased the demand for electrical power and air conditioning, while sensitive scientific instruments that make precise measurements have increased the importance of temperature, humidity, air cleanliness, and vibration controls. Furthermore, potential hazards associated with chemistry and biotechnology R&D have increased air ventilation requirements.

## LABORATORY FACILITIES HAVE LIMITED PRODUCTIVITY AND SCIENTIFIC CAPABILITIES

The agency and laboratory officials we interviewed stated that their laboratories generally have avoided a prolonged shutdown of R&D projects by successfully engineering around emergencies. However, they noted that aging laboratory facilities have reduced scientific productivity, citing various instances in which a facility's problems disrupted R&D programs or reduced confidence in the reproducibility of experimental results. These problems have caused researchers to repeat experiments in many instances. Typical problems reported included (1) ventilating systems that do not meet

[1] Building Research Board, Committing to the Costs of Ownership: Maintenance and Repair of Public Buildings (June 1990).

industry standards for circulating air through laboratories--in three laboratory buildings we visited, inadequate ventilating systems have caused respiratory problems among researchers and/or contaminated laboratory samples; (2) electrical power outages and other systems' malfunctions that ruined long-term experiments; and (3) delays and disruptions in making repairs, limiting researchers' access to equipment or laboratory facilities needed to perform R&D. For example, inadequate ventilation in a 20-year-old laboratory building at ARS' laboratory in Beltsville, Maryland, has caused respiratory problems among researchers and specifically led to the relocation of five researchers from the building. In addition, researchers in one laboratory building at EPA's Gulf Breeze, Florida, facility were relocated to temporary space for 9 months because a newly renovated ventilating system had inadequate air-handling capacity, enabling mold and fungus to grow in the duct work.

NIH has proposed to construct a new $1.6 billion clinical center to replace its existing 38-year-old clinical center, which is at the end of its useful life and does not meet current fire safety requirements. NIH officials stated that the proposed center, which would provide advanced research hospital facilities, is essential for fulfilling NIH's mission because clinical research is fundamental to its biomedical research program. The U.S. Army Corps of Engineers, in a November 1991 report that validated NIH's need, recommended the construction of a new center because the existing clinical center's physical constraints greatly hinder NIH's ability to provide a modern, flexible facility for biomedical research and patient care.

## SEVERAL AGENCIES ARE ASSESSING R&D FACILITY FUNDING NEEDS AND MISSIONS

Each of the eight federal agencies has taken actions to better identify its laboratories' needs for maintenance, repairs, and upgrades. For example, ARS (in 1985) and NOAA (in 1991) initiated surveys on the condition of their laboratory facilities to identify maintenance and repair needs at their primary laboratories. Similarly, NIH and EPA are updating their laboratories' master site plans for the first time since about 1972 and 1985, respectively.

Funding to maintain laboratory facilities was moderately adequate, according to facilities managers at most of the eight agencies. However, funding constraints limit some agencies' ability to repair and upgrade their laboratory facilities. In fiscal year 1992, only ARS and NASA met the Building Research Board's minimum guideline that 2 percent of a facility's current replacement value be spent for routine maintenance and repair. The eight agencies also reported a total backlog of more than $3.8 billion in needed repairs at their laboratories; some agency and laboratory facilities managers noted that their backlog is growing. In addition, facilities managers at DOD, DOE, EPA, NASA, NIH, and USGS told us that funding to renovate existing laboratory facilities or construct new ones is either inadequate or only slightly adequate. According to the facilities managers, the process for funding and making a major repair, such as replacing the roof of a large laboratory building, typically takes about 3 to 5 years from proposal to completion, while the process for renovating existing facilities or constructing new ones takes about 7 to 10 years from proposal to completion. During either process, a number of lower-priority laboratory projects will be dropped, and the amount of funding made available may be reduced because of competing priorities.

The Congress is funding some major projects to modernize existing research facilities and construct new ones needed to perform advanced R&D. In particular, in fiscal year 1993, the Congress appropriated $110 million of $540 million requested by Commerce's National Institute of Standards and Technology to renovate seven existing laboratory buildings and construct the equivalent of two new laboratory buildings with advanced systems to control temperature, humidity, air cleanliness, and vibrations. In addition, ARS officials stated that the Congress has made available about $70 million of $205 million that ARS proposed in 1988 to modernize its Beltsville laboratory.

In response to budget constraints and/or changing R&D missions, several federal agencies have considered alternatives to realign or consolidate their laboratory facilities. For example, within DOD, the Army, Navy, Air Force, and the Armed Forces Radiobiology Research Institute are reducing their combined number of laboratories from 76 to 31, according to DOD research managers. Similarly, USDA is studying whether to close or consolidate some of ARS' 111 laboratories, DOE is considering how to realign its nuclear weapons laboratories in response to the end of the Cold War, and NASA is developing a national facility plan for world-class aeronautics and space facilities. House bill 1432 proposes to establish the Federal Laboratory Mission Evaluation and Coordination Committee, which in part would make recommendations on the advisability of establishing a commission to determine whether specific federal laboratories should be realigned, consolidated, or closed. One criterion that the Laboratory Committee would be directed to consider is improving the efficiency and effectiveness of the overall federal laboratory system.

## CONCLUSIONS

Most of the eight federal agencies' laboratory facilities are at least 30 years old, requiring increased maintenance and repair funding. In fiscal year 1992, six of the eight agencies did not spend the Building Research Board's minimum guideline for funding routine maintenance and repair, and many agencies currently have a substantial backlog of needed repairs. In addition, inadequate facilities are limiting research capabilities at some federal laboratories. Substantial funding would be needed to provide the proposed new laboratory facilities.

In recent years, DOD, DOE, NASA, and USDA have initiated task forces to reexamine their R&D mission and/or improve the effectiveness and efficiency of their laboratory facilities. An important consideration in such reviews is to ensure adequate funding to support laboratory facilities, which may involve (1) reducing expenses by realigning, closing, or consolidating laboratories not essential for fulfilling an agency's R&D mission as well as (2) increasing funding to maintain, repair, and upgrade those laboratory facilities considered essential to fulfilling an agency's R&D mission.

Mr. Vice Chairman, this concludes my statement. I would be happy to respond to any questions that you or members of the Committee may have.

76-813 - 94 - 2

United States General Accounting Office

GAO

Report to the Vice Chairman, Joint Economic Committee, U.S. Congress

September 1993

# FEDERAL RESEARCH

## Aging Federal Laboratories Need Repairs and Upgrades

RESTRICTED--Not to be released outside the General Accounting Office unless specifically approved by the Office of Congressional Relations.

GAO/RCED-93-203

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-254151

September 20, 1993

The Honorable Paul S. Sarbanes
Vice Chairman, Joint Economic Committee
Congress of the United States

Dear Mr. Vice Chairman:

Citing the importance of federal research and development (R&D) to economic growth and national well-being, you expressed concern that federal research agencies may be underinvesting in maintaining, repairing, and upgrading their laboratories. Accordingly, you requested that we assess the (1) condition of federal laboratory facilities, (2) effect of inadequate laboratory facilities on agencies' scientific productivity and research capabilities, and (3) funding needed to repair or upgrade these facilities.

As agreed with your office, the information in this report is based primarily on data provided by eight federal agencies for 220 government-owned laboratories that spent about $18.1 billion of the estimated $24.9 billion obligated for R&D at federal laboratories in fiscal year 1992. These agencies are the Departments of Commerce, Defense (DOD), and Energy (DOE); the Environmental Protection Agency (EPA); the National Aeronautics and Space Administration (NASA); the Agricultural Research Service (ARS), within the Department of Agriculture (USDA); the National Institutes of Health (NIH), within the Department of Health and Human Services; and the Geological Survey (USGS), within the Department of the Interior. We also interviewed facilities managers for each agency and laboratory management, researchers, and facilities managers at the eight federal laboratories we visited.

## Results in Brief

Overall, 54 percent of the floor space of the eight federal agencies' laboratories was more than 30 years old. Typical problems among the agencies' laboratories included leaking roofs and inadequate ventilating systems that do not meet industry standards for circulating air through laboratories, according to agencies' facilities managers. In addition, many older laboratories were not designed to meet today's advanced R&D needs and health and safety code requirements. In recent years, DOE, EPA, and NASA have reported deteriorating laboratory facilities and inadequate funding as material management weaknesses under the Federal Managers' Financial Integrity Act (31 U.S.C. 3512).[1]

The federal laboratory facilities managers and researchers we interviewed identified several instances, particularly involving old ventilating systems and power outages, in which aging laboratory facilities substantially reduced scientific productivity. In addition, several agencies cited the need for advanced laboratory facilities that provide greater flexibility to respond to new programs and scientists' research needs. For example, NIH facilities managers stated that the clinical center, completed in 1955 at NIH's main campus in Bethesda, Maryland, limits productivity and scientific capabilities primarily because many of its utility systems are at the end of their useful lives. In particular, demands on its heating, ventilating, and air conditioning systems exceed capacity by 50 percent, and electrical systems are outmoded and inadequate.

Facilities managers at most of the eight agencies stated that funding for laboratory facilities' maintenance was moderately adequate. However, the eight agencies reported a backlog of more than $3.8 billion in needed repairs for their laboratories, and facilities managers for four agencies said that funding for repairs was only slightly adequate or inadequate. Furthermore, funding to renovate existing laboratory facilities or construct new ones was either only slightly adequate or inadequate at six agencies.

In attempting to address these funding issues, the eight federal agencies have improved the management oversight of their laboratory facilities. In addition, four of the eight agencies recently initiated task forces to reexamine their R&D mission and/or improve the effectiveness and efficiency of their laboratory facilities. Reassessing agencies' R&D missions is critical before spending large sums of money. Such task force efforts provide a basis for determining whether to realign, consolidate, or close laboratories and to increase funding for laboratory facilities considered essential for fulfilling agencies' R&D missions.

## Background

Laboratory facilities, along with scientists and research equipment, provide the basis for conducting advanced R&D at federal laboratories. These facilities include laboratory buildings; heating, ventilating, and air conditioning systems; electrical power supply systems; and water and

[1]The act requires each federal agency to report annually on the adequacy of its internal accounting and administrative controls.

sewerage systems. Laboratory facilities need to be properly maintained and repaired to continue to work well. In addition, aging laboratory facilities may need to be upgraded—either by renovating existing buildings or constructing new ones—to improve researchers' productivity or enable them to conduct state-of-the-art R&D. Federal laboratories also spend facilities funds to improve (1) workers' health and safety by, for example, removing asbestos or installing fire sprinklers and alarms; (2) access to buildings for the handicapped; (3) the environment by, for example, replacing chloro-fluoro-hydrocarbon refrigerants in air conditioning systems, refrigerators, and freezers, in compliance with the Clean Air Act Amendment of 1990; and (4) non-research-related facilities such as roads and parking lots.

In a June 1990 report, the National Research Council's Building Research Board found that underfunding is a widespread and persistent problem that undermines the maintenance and repair of public buildings.[2] In concluding that procedures and allocations of resources must be changed to recognize the full costs of ownership of these assets, the Board stated that an appropriate budget allocation for routine maintenance and repair for a substantial inventory of facilities will typically be in the range of 2 to 4 percent of the aggregate current replacement value of those facilities. The Board further stated that where neglect of maintenance has caused a backlog of needed repairs, spending must exceed this minimum level (2 to 4 percent) until the backlog has been eliminated. The General Services Administration and other federal agencies have begun to use the Board's recommendations as a general guideline for assessing maintenance and repair funding for their buildings and other facilities.

## Aging Federal Laboratories Need Repairs and Upgrades

Federal laboratory facilities grew rapidly between 1943 and 1972 as agencies expanded their R&D missions. By the early 1990s, these facilities had aged—31 percent of the eight federal agencies' laboratory space was more than 40 years old, and 54 percent of the space was more than 30 years old. Only 24 percent of the eight agencies' laboratory space was less than 20 years old. In addition, some federal laboratories are using government facilities not designed for R&D. For example, Commerce's National Oceanic and Atmospheric Administration (NOAA) is using Fort Crockett, an Army post built in the early 1900s in Galveston, Texas, as a sea turtle and shrimp research laboratory. A NOAA facilities manager told us that about $4 million is needed to repair and renovate this laboratory

[2]Building Research Board, Committing to the Costs of Ownership: Maintenance and Repair of Public Buildings (June 1990).

because the buildings (1) have deteriorated in their advanced age and (2) were designed as barracks for soldiers rather than as laboratories for scientists.

Federal laboratories are experiencing many common problems associated with aging facilities—leaking roofs and gutters, drafty window frames, and inefficient ventilating systems that do not bring sufficient fresh air into laboratories. In particular, DOE, EPA, and NASA have cited deteriorating laboratory facilities as a material management weakness in their Financial Integrity Act reports. DOE noted that the average age of its nonnuclear laboratory facilities is 32 years and that many are well beyond the end of their useful lives. EPA also pointed out that most of its Office of Research and Development laboratories are well over 30 years old, stating that its science program is vulnerable if its research facilities do not meet the laboratory standards of the businesses it regulates. NASA's 1989-91 reports cited inadequate maintenance funding for its laboratories and other facilities as a material weakness. In response to a growing list of needed repairs and renovations, NASA's Associate Administrator for Aeronautics and Space Technology initiated a 5-year program to augment maintenance and instrumentation funding at three laboratories with $15 million of R&D funds in fiscal year 1991. This amount rose to $30 million in fiscal year 1993.

In addition, older federal laboratories were not designed for today's health and fire safety standards and advanced R&D needs. Many laboratory buildings do not have sprinkler and alarm systems and adequate fire walls because they were designed to prior, less stringent requirements. Similarly, computers and other electronic equipment have increased the demand for electrical power and air conditioning, while sensitive scientific instruments that make precise measurements have increased the importance of temperature, humidity, air cleanliness, and vibration controls. Furthermore, potential hazards associated with chemistry and biotechnology R&D have increased air ventilation requirements.

## Laboratory Facilities Have Limited Productivity and Scientific Capabilities

The agency and laboratory officials we interviewed stated that their laboratories generally have avoided a prolonged shutdown of R&D projects by successfully engineering around emergencies. However, they noted that aging laboratory facilities have reduced scientific productivity, citing various instances in which a facility's problems disrupted R&D programs or reduced confidence in the reproducibility of experimental results. These problems have caused researchers to repeat experiments in many instances. Typical problems reported included (1) ventilating systems that do not meet industry standards for circulating air through laboratories—in three laboratory buildings we visited, inadequate ventilating systems have caused respiratory problems among researchers and/or contaminated laboratory samples; (2) electrical power outages and other systems' malfunctions that ruined long-term experiments; and (3) delays and disruptions in making repairs, limiting researchers' access to equipment or laboratory facilities needed to perform R&D. For example, inadequate ventilation in a 20-year-old laboratory building at ARS' laboratory in Beltsville, Maryland, has caused respiratory problems among researchers and specifically led to the relocation of five researchers from the building. In addition, researchers in one laboratory building at EPA's Gulf Breeze, Florida, facility were relocated to temporary space for 9 months because a newly renovated ventilating system had inadequate air-handling capacity, enabling mold and fungus to grow in the duct work.

NIH has proposed to construct a new $1.6 billion clinical center to replace its existing 38-year-old clinical center, which is at the end of its useful life and does not meet current fire safety requirements. NIH officials stated that the proposed center, which would provide advanced research hospital facilities, is essential for fulfilling NIH's mission because clinical research is fundamental to its biomedical research program. The U.S. Army Corps of Engineers, in a November 1991 report that validated NIH's need, recommended the construction of a new center because the existing clinical center's physical constraints greatly hinder NIH's ability to provide a modern, flexible facility for biomedical research and patient care.

## Several Agencies Are Assessing R&D Facility Funding Needs and Missions

Each of the eight federal agencies has taken actions to better identify its laboratories' needs for maintenance, repairs, and upgrades. For example, ARS (in 1985) and NOAA (in 1991) initiated surveys on the condition of their laboratory facilities to identify maintenance and repair needs at their primary laboratories. Similarly, NIH and EPA are updating their laboratories' master site plans for the first time since about 1972 and 1985, respectively.

Funding to maintain laboratory facilities was moderately adequate, according to facilities managers at most of the eight agencies. However, funding constraints limit some agencies' ability to repair and upgrade their laboratory facilities. In fiscal year 1992, only ARS and NASA met the Building Research Board's minimum guideline that 2 percent of a facility's current replacement value be spent for routine maintenance and repair. The eight agencies also reported a total backlog of more than $3.8 billion in needed repairs at their laboratories; some agency and laboratory facilities managers noted that their backlog is growing. In addition, facilities managers at DOD, DOE, EPA, NASA, NIH, and USGS told us that funding to renovate existing laboratory facilities or construct new ones is either inadequate or only slightly adequate. According to the facilities managers, the process for funding and making a major repair, such as replacing the roof of a large laboratory building, typically takes about 3 to 5 years from proposal to completion, while the process for renovating existing facilities or constructing new ones takes about 7 to 10 years from proposal to completion. During either process, a number of lower-priority laboratory projects will be dropped, and the amount of funding made available may be reduced because of competing priorities.

The Congress is funding some major projects to modernize existing research facilities and construct new ones needed to perform advanced R&D. In particular, in fiscal year 1993, the Congress appropriated $110 million of $540 million requested by Commerce's National Institute of Standards and Technology to renovate seven existing laboratory buildings and construct the equivalent of two new laboratory buildings with advanced systems to control temperature, humidity, air cleanliness, and vibrations. In addition, ARS officials stated that the Congress has made available about $70 million of $205 million that ARS proposed in 1988 to modernize its Beltsville laboratory.

In response to budget constraints, several federal agencies have considered alternatives to realign or consolidate their laboratory facilities. For example, within DOD, the Army, Navy, Air Force, and the Armed Forces Radiobiology Research Institute are reducing their combined number of laboratories from 76 to 31, according to DOD research managers. Similarly, USDA is studying whether to close or consolidate some of ARS' 111 laboratories, DOE is considering how to realign its nuclear weapons laboratories in response to the end of the Cold War, and NASA is developing a national facility plan for world-class aeronautics and space facilities. House bill 1432 proposes to establish the Federal Laboratory Mission Evaluation and Coordination Committee, which in part would make recommendations on the advisability of establishing a commission to determine whether specific federal laboratories should be realigned, consolidated, or closed. One criterion that the Committee would be directed to consider is improving the efficiency and effectiveness of the overall federal laboratory system.

## Conclusions

Most of the eight federal agencies' laboratory facilities are at least 30 years old, requiring increased maintenance and repair funding. In fiscal year 1992, six of the eight agencies did not meet the Building Research Board's minimum guideline for funding routine maintenance and repair, and many agencies have a substantial backlog of needed repairs. In addition, inadequate facilities are limiting research capabilities at some federal laboratories. Substantial funding would be needed to provide the proposed new laboratory facilities.

In recent years, DOD, DOE, NASA, and USDA have initiated task forces to reexamine their R&D mission and/or improve the effectiveness and efficiency of their laboratory facilities. An important consideration in such reviews is to ensure adequate funding to support laboratory facilities, which may involve (1) reducing expenses by realigning, closing, or consolidating laboratories not essential for fulfilling an agency's R&D mission as well as (2) increasing funding to maintain, repair, and upgrade those laboratory facilities considered essential to fulfilling an agency's R&D mission.

## Agency Comments

We discussed the report's contents with officials from ARS, Commerce, DOD, DOE, EPA, NASA, NIH, and USGS, who generally agreed with the thrust of our findings. In addition, agencies provided clarifying information to improve the report's technical accuracy, which we incorporated as appropriate. However, as requested, we did not obtain written comments on a draft of this report.

We conducted our review between October 1992 and August 1993 in accordance with generally accepted government auditing standards. Information in this report is based primarily on data provided by the eight agencies and interviews with laboratory facilities managers, laboratory management, and researchers. As agreed with your office, we did not examine other problems with facilities that affect federal agencies' R&D programs, including staffing ceilings for facilities' personnel, delays and added costs associated with federal procurement requirements, and leased laboratory space. See appendix IV for details of our objectives, scope, and methodology.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will provide copies of this report to the

Director, Office of Management and Budget. We also will make copies available to others upon request.

Please contact me at (202) 512-3841 if you or your staff have any questions. Major contributors to this report are listed in appendix V.

Sincerely yours,

Victor S. Rezendes
Director, Energy and Science Issues

# Contents

## Figures



**Abbreviations**

| | |
|---|---|
| AFRRI | Armed Forces Radiobiology Research Institute |
| ARS | Agricultural Research Service |
| BARC | Beltsville Agricultural Research Center |
| DOD | Department of Defense |
| DOE | Department of Energy |
| EPA | Environmental Protection Agency |
| FIA | Federal Managers' Financial Integrity Act |
| FY | fiscal year |
| GAO | General Accounting Office |
| HVAC | heating, ventilating, and air conditioning |
| NASA | National Aeronautics and Space Administration |
| NIH | National Institutes of Health |
| NIST | National Institute of Standards and Technology |
| NOAA | National Oceanic and Atmospheric Administration |
| OMB | Office of Management and Budget |
| R&D | research and development |
| USDA | U.S. Department of Agriculture |
| USGS | U.S. Geological Survey |

Appendix I

# Aging Federal Laboratories Need Repairs and Upgrades

The number and size of federal laboratory facilities grew rapidly in the 30 years between 1943 and 1972 as agencies expanded their research and development (R&D) missions. By the early 1990s, however, these laboratory facilities had aged; more than half of the space of the eight federal agencies' laboratory space is more than 30 years old. Common laboratory facilities problems that adversely affected scientists' ability to perform R&D included (1) old systems and equipment that are at the end of their useful lives and need to be repaired or replaced before they break down; (2) insufficient electrical power, ventilation, and chilled water capacity; and (3) scientists' inability to adequately control such factors as temperature, humidity, and air cleanliness. In addition, many laboratory buildings do not meet current health and fire safety standards because they were designed to meet prior, less stringent requirements. In recent years, the Environmental Protection Agency (EPA) and the Department of Energy (DOE) have reported deteriorating facilities, and the National Aeronautics and Space Administration (NASA) has reported inadequate maintenance funding as material management weaknesses under the Federal Managers' Financial Integrity Act (FIA).

## Most Federal Laboratory Facilities Are at Least 30 Years Old

As shown in table I.1, federal laboratory space was constructed primarily during the 30-year period between 1943 and 1972. Overall, 31 percent of the floor space of the eight federal agencies' laboratories was more than 40 years old, and 54 percent of the laboratory space was more than 30 years old. Only 24 percent of the federal laboratory space has been constructed since 1972.

**Table I.1: Amount of Laboratory Space Constructed by 10-Year Periods**

Square feet in thousands

| Agency | Year: before 1943 | Year: 1943-52 | Year: 1953-62 | Year: 1963-72 | Year: 1973-82 | Year: 1983-92 | Total |
|---|---|---|---|---|---|---|---|
| USDA | | | | | | | |
| ARS | 3,895 | 453 | 1,485 | 2,872 | 2,291 | 944 | 11,940 |
| Commerce | | | | | | | |
| NIST | 0 | 401 | 23 | 2,480 | 29 | 105 | 3,038 |
| NOAA[a] | | | | | | | |
| DOD | | | | | | | |
| Air Force | 821 | 1,787 | 2,165 | 1,761 | 1,491 | 2,080 | 10,105 |
| Army | 1,678 | 1,398 | 3,080 | 3,049 | 1,943 | 1,294 | 12,442 |
| Navy[b] | 987 | 1,035 | 235 | 675 | 353 | 410 | 3,695 |
| AFRRI | 0 | 0 | 41 | 86 | 37 | 6 | 170 |
| DOE | 1,130 | 19,857 | 16,414 | 7,725 | 7,407 | 7,683 | 60,216 |
| EPA | 1,429 | 86 | 23 | 1,185 | 482 | 165 | 3,370 |
| Health and Human Services | | | | | | | |
| NIH | 600 | 662 | 3,648 | 1,488 | 2,338 | 404 | 9,140 |
| Interior | | | | | | | |
| USGS | 0 | 442 | 34 | 1,046 | 373 | 46 | 1,941 |
| NASA | 1,091 | 3,064 | 3,579 | 6,950 | 1,053 | 1,477 | 17,214 |
| **Total** | **11,631** | **29,185** | **30,727** | **29,317** | **17,797** | **14,614** | **133,271** |
| Percent | 9 | 22 | 23 | 22 | 13 | 11 | 100 |

[a]Information about the age of NOAA's 936,000 square feet of laboratory space was not readily available because some of its laboratories were originally owned by other agencies.

[b]The Navy provided data only for the Naval Research Laboratory.

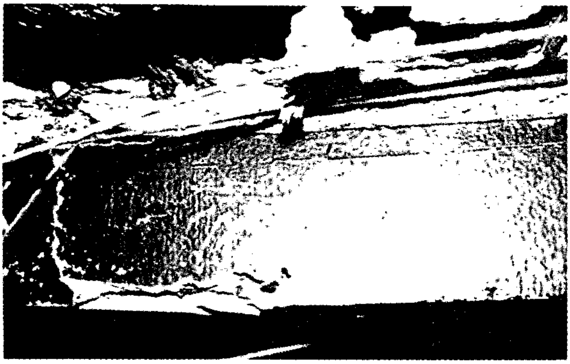
Source: GAO compilation of data from agencies listed in table.

DOE, Department of Defense (DOD), and NASA laboratories accounted for 80 percent of the total floor space. DOE's laboratories, which alone accounted for almost 50 percent of the floor space, are the oldest in the federal laboratory system—35 percent of their floor space is more than 40 years old, and 62 percent of their space is more than 30 years old. Similarly, 29 percent of DOD's laboratory floor space and 24 percent of NASA's laboratory floor space is more than 40 years old.

Many federal laboratory campuses have prominent old buildings that, because their historical significance, cannot be demolished and replaced with modern laboratory facilities and/or office space. For example, the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service and EPA converted old federal facilities into laboratories. The Marine Fisheries' sea turtle and shrimp laboratory in Galveston, Texas, previously was Fort Crockett, an Army post built in the early 1900s. This laboratory needs about $4 million in repairs and renovations, according to a NOAA facilities manager. For example, a facilities condition survey of the laboratory found that the main structural beam and concrete floor slab in two original buildings had deteriorated to the point of failure. (See fig. I.1.) One building, which includes the laboratory director's office, was evacuated during 1992 until temporary repairs were made to support the floor with hydraulic jacks and timbers. Marine Fisheries' laboratories in Tiburon, California; Port Adams, Oregon; and Montlake, Washington, also are using old federal facilities built more than 50 years ago. Similarly, EPA's Environmental Research Laboratory in Gulf Breeze, Florida, originally was a yellow fever quarantine station established by the Public Health Service around 1874. EPA uses the site's original houses mainly for office space and administrative support activities.

**Figure I.1: Cracked Support Beam at NOAA's Galveston Laboratory** (see below)

Building No. 302 originally was a barracks for Fort Crockett.



Cracked structural beam supporting the first floor of building No. 302.

Source: NOAA.

## Federal Laboratories Need Repairs and Upgrades

Many of the eight federal agencies' laboratories had aging buildings, mechanical systems, and utility components that have reached the end of their useful lives and need to be repaired or replaced before they break down. Common problems cited by agency and laboratory facilities managers included leaking roofs; heating, ventilating, and air conditioning (HVAC) systems that cannot provide designed amounts of ventilation needed particularly for biological or chemical R&D; outdated electrical power system components; and water pipes that have corroded or collected excessive deposits through the years. In many cases, the cost of repairing or renovating laboratory facilities is substantially increased because of the presence of asbestos, a known carcinogen used extensively between World War II and the 1970s as a fire retardant and pipe insulation. Special procedures are required to encapsulate or remove asbestos before a repair is made to minimize workers' exposure.

During the past 20 years, many federal laboratories have expanded missions, R&D funding, and staffing. This growth has increased the demand for air ventilation for fume hoods—basic laboratory equipment designed to minimize researchers' exposure to noxious gases during chemical testing by directly exhausting fumes outdoors. Federal scientists also are using sophisticated equipment and advanced computers to perform R&D, thus increasing federal laboratories' demand for electrical power and central air conditioning. Furthermore, older federal laboratories were not designed to provide the temperature, humidity, air cleanliness, and vibration controls that today's sensitive scientific instruments need to make precise measurements.

The following discussions of four federal laboratories illustrate some of the issues associated with aging facilities and the need for modern R&D facilities.

## Beltsville Agricultural Research Center

The Beltsville Agricultural Research Center (BARC), established in 1910 in Beltsville, Maryland, is the Agricultural Research Service's (ARS) largest laboratory. About 77 percent of BARC's laboratory space was built before 1943, making it more than 50 years old. These older buildings were not designed with central air conditioning systems, so BARC laboratories and offices use about 2,000 less-efficient room units. Facilities managers estimated that 90 percent of BARC's laboratory facilities would not meet ARS' standard of 10 to 15 air exchanges per hour, year around. BARC facilities managers and scientists also cited a general need to replace leaking roofs, gutters, and drafty window frames in the older buildings.

BARC's demand for electrical power has grown over the years without a corresponding increase in electrical capacity. As a result, BARC is subject to "brownouts" during the summer, when the demand for air conditioning peaks. Furthermore, backup generator capacity is limited, and on numerous occasions, backup generators failed to start during a power outage. Other common problems related to aging facilities at BARC include old HVAC systems that have outlived their useful lives, poor drinking water quality, leaking roofs, and drafty window frames. (See fig. I.2.)

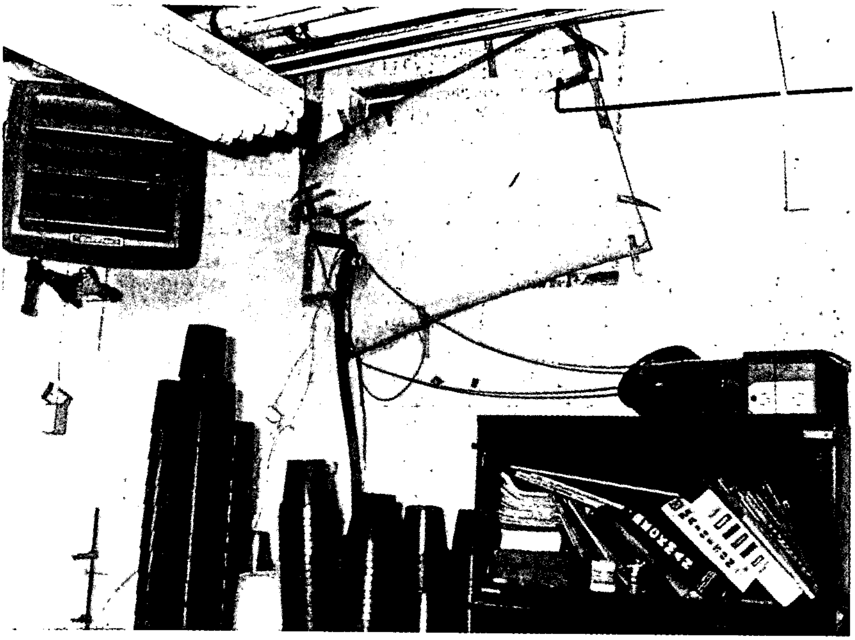
In 1988, ARS proposed a $205 million, 10-year program to modernize BARC's laboratory facilities. The modernization program will renovate many of BARC's original buildings and cluster related research programs in larger laboratory buildings to encourage interactions between researchers. Overall, ARS plans to reduce the number of structures, which include laboratories, former animal quarantine buildings, greenhouses, and animal sheds, from 800 to 165, even though the total square footage would be reduced from 1.75 million to only 1.5 million gross square feet. ARS facilities managers estimate that their new laboratory buildings will have an efficiency of 70 to 80 percent in terms of net-to-gross usable space, as compared with an efficiency of only 30 to 40 percent for older facilities. In response to ARS' proposal, the Congress has made available about $70 million, according to ARS officials.

Figure I.2: Needed Repairs at BARC

Plastic covering window frame in a laboratory to reduce drafts.

Ceiling hole and puddle on floor caused by roof leak and recent storm.

Vacant laboratory scheduled for repair after building's roof is replaced.



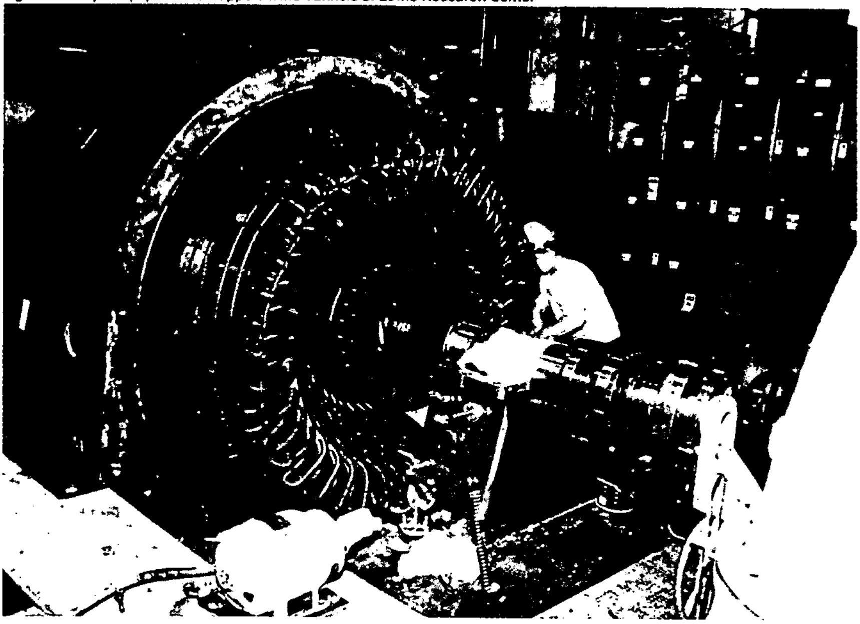
Cardboard covering broken window to keep drafts and dust out of a greenhouse laboratory.

## Lewis Research Center

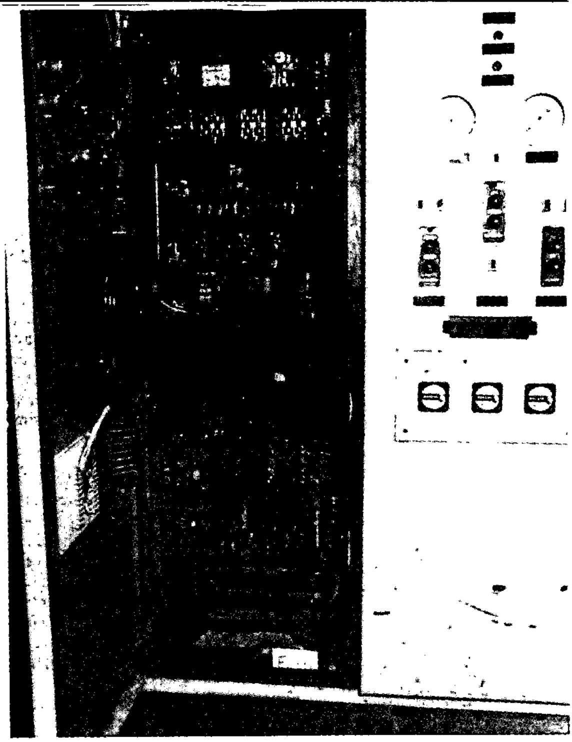
NASA's Lewis Research Center, in Cleveland, Ohio, has several major wind tunnels and other facilities built during the 1940s and 1950s for aircraft engine combustion testing. These facilities rely on large compressors and vacuum pumps (exhausters) in the Lewis Center's central air facility to pull air at high speeds through the test facilities. Because this equipment was installed more than 40 years ago, it has exceeded its expected life.

However, the equipment has been very reliable, and the Lewis Center's facilities managers prefer to rebuild it by, for example, rewinding motors rather than replacing a compressor or exhauster with expensive new equipment that might be less reliable. (See fig. I.3.) The Lewis Center's facilities managers also have established a maintenance and repair program designed to identify and replace components with excessive wear before the equipment fails.

Figure I.3: Major Equipment to Support Wind Tunnels at Lewis Research Center



Worker rewinding the motor of a large compressor.



High-voltage switchgear installed in the 1950s.

Source: Lewis Research Center.

The importance of reliable equipment and preventive maintenance and repair was illustrated when a circuit breaker failed, causing an exhauster to explode in August 1990. According to Lewis facilities managers, the incident shut down the Lewis Center's central air building for 3 months and half of the building for an additional 6 months, closed the Propulsion Systems Laboratory, and limited the use of the Supersonic/Transonic Wind Tunnel.

## National Institutes of Health's Clinical Center

The National Institutes of Health's (NIH) original clinical center, a 12-story research hospital on its main campus in Bethesda, Maryland, was completed 38 years ago. Since then, NIH has upgraded the clinical center through several new additions and renovation projects, resulting in utility infrastructure systems of varying ages and conditions. The major systems that provide fire safety, electrical power, lighting, ventilation, air conditioning, and plumbing are old, outmoded, and/or have insufficient capacity to meet current and future research demands. These systems are at the end of their useful life and, according to NIH facilities managers, have become functionally obsolete, unsafe, and, in some cases, inoperable.[1] For example, neither the clinical center's fire safety or emergency electrical power distribution systems meet current codes and standards.

In 1987, NIH initiated the Clinical Center Complex Infrastructure Modernization and Improvement Program to address known deficiencies in the clinical center's utility infrastructure systems. In response to NIH's initial proposal to upgrade the clinical center and other laboratory facilities, the House Committee on Appropriations, in July 1990, requested that the Secretary of Health and Human Services conduct a review of these needs in cooperation with other federal agencies. The U.S. Army Corps of Engineers agreed to assess NIH's facilities revitalization program regarding the (1) extent of the problems, (2) probable cost of the work, and (3) timetable for accomplishing the work.

In a November 1991 report, the Army Corps of Engineers' review committee stated that it unquestionably substantiated the extent of the overall problems identified in NIH's Facilities Revitalization Program. Specifically, the review committee found that

[1]For more information about building obsolescence, see the Building Research Board's report entitled The Fourth Dimension in Building: Strategies for Minimizing Obsolescence (June 1993).

"The Clinical Center Complex is in serious need of major corrective action to resolve its facilities deficiencies. The Review Committee agrees that the utility systems within the Clinical Center Complex have deteriorated beyond reasonable repair. The systems are no longer reliable, they violate codes and regulations, are difficult and costly to maintain, the capacities of the systems have been exceeded, and they do not provide adequate flexibility for modification or upgrade."

The review committee further stated that the limited space between the clinical center's ceilings and floors constrains the ability to install and service HVAC equipment and duct work, electrical power lines, and other utilities. In comparison with the clinical center's floor-to-floor height of 12 feet, the Department of Veterans Affairs and the Army Corps of Engineers require a minimum 18-foot floor-to-floor height in new and upgraded hospitals. The additional 6 feet provides more space between a ceiling and the floor above for installing and servicing utilities. According to NIH facilities managers, demand on the clinical center's HVAC systems exceeds capacity by 50 percent, resulting in the marginal operation of laboratory fume hoods, degradation of indoor air quality, and cross contamination of air between laboratories.

The Army Corps of Engineers' review committee recommended that NIH construct a new clinical center complex as the best long-term technical solution among four alternatives evaluated for addressing the clinical center's problems. The Corps of Engineers estimated that construction of a new clinical center would cost $1.43 billion and take 14-1/2 years to complete. NIH adopted the review committee's recommendation; its Buildings and Facilities Plan issued in August 1992 included a new clinical center complex estimated to cost $1.6 billion and take 11-1/2 years to complete.[2]

## National Institute of Standards and Technology

The National Institute of Standards and Technology (NIST) has laboratory campuses at Boulder, Colorado, and Gaithersburg, Maryland. In a March 1992 report, NIST proposed the implementation of two separate 10-year plans to upgrade its laboratory facilities to a condition necessary to fulfill its mission.

NIST's first plan addresses the technical obsolescence of environmental systems controls and the reliability of power supplies that limit its ability to provide the exacting measurements of a national reference laboratory.

[2] This cost estimate includes funds for relocating personnel necessary to clear a site for the new clinical center and demolishing the existing clinical center.

NIST's laboratory buildings were state-of-the-art structures when they were constructed at Boulder in the mid-1950s and at Gaithersburg in the early 1960s. However, the combination of (1) advancing age, which requires substantial maintenance and repair to retain originally designed capabilities, and (2) rapidly advancing technology has made these facilities inadequate for many types of advanced research essential to its mission. NIST cited the need for improved temperature, humidity, air cleanliness, and vibration controls for its advanced research that employs such sensitive instruments as optical, electron, and tunneling microscopes.

NIST proposed a $540 million, 10-year effort to upgrade its laboratory facilities. NIST plans to renovate seven existing laboratory buildings and construct the equivalent of two new laboratory buildings with advanced systems to control temperature, humidity, air cleanliness, and vibrations. NIST also plans to improve the reliability of electrical power supplies and, at Boulder, construct a central plant to provide steam and chilled water. The Congress appropriated $110 million in fiscal year 1993 for design and initial construction activities.[3]

NIST's second plan addresses improvements to remedy major safety and systems capacity problems. In particular, NIST would improve fire safety and electrical power systems at both its Gaithersburg and Boulder campuses. In addition, NIST plans to repair the structural deterioration of building foundations and expand the chilled water plant at the Gaithersburg campus. The NIST safety and systems capacity plan is estimated to cost about $98 million, including $4 million that the Congress has already appropriated.

## Three Agencies Have Reported Facilities as a Material Management Weakness

EPA, in its FIA reports for 1989-92, cited as a material management weakness deteriorating laboratory buildings and facilities among its Office of Research and Development's research laboratories and field stations. According to EPA, these laboratory facilities are in various states of disrepair, resulting not only in health, safety, and environmental compliance violations but also in significant delays in EPA's research requirements. EPA stated that its science program is vulnerable if its research facilities do not meet the laboratory standards for the regulated community. To address this material weakness, EPA initiated a master planning process in fiscal year 1991 to identify and prioritize projects for funding through its building and facilities appropriation. The Congress

[3]The appropriation included funding not to exceed $5 million for design and $105 million for construction of new research facilities.

also raised the threshold allowing EPA to make repairs and minor improvements using R&D program funds from $25,000 to $75,000.

In its 1992 FIA report, DOE also cited deteriorating facilities as a material management weakness, noting that the average age of its 25,000 nonnuclear-related buildings, utilities, and other structures is 32 years. DOE stated that a departmentwide program is needed to plan for, acquire, maintain, modernize, replace, and/or dispose of its facilities' infrastructure. For example, DOE plans to develop an infrastructure replacement program to systematically replace facilities needed for its mission and dispose of unneeded or unjustified facilities that have exceeded their useful lives. In addition, DOE program offices have begun to collect maintenance and repair data from operations and maintenance contractors for their laboratories in response to a capital assets management process initiated in March 1992.

NASA, in its FIA reports for 1989-91, cited inadequate maintenance funding for its laboratories and other facilities as a material management weakness. Our December 1990 report also stated that many NASA facilities had not been adequately maintained and were in degraded condition.[4] We noted, however, that NASA's Facilities Maintenance Management Branch, formed in 1987, was working with NASA's laboratories and other facilities to define total maintenance needs and assess facilities' conditions. Since 1990 NASA has increased maintenance and repair funding, enabling it to meet the Building Research Board's minimum guideline that 2 percent of a facility's current replacement value be used for maintenance and repairs. As a result, NASA stopped identifying facilities maintenance as a management weakness in 1992. In addition, in response to a growing list of needed repairs and renovations identified during NASA's wind tunnel revitalization program, the Associate Administrator for Aeronautics and Space Technology initiated a 5-year program to augment maintenance and instrumentation funding at three laboratories with $15 million of R&D funds in fiscal year 1991 that rose to $30 million in fiscal year 1993.

[4] NASA Maintenance: Stronger Commitment Needed to Curb Facility Deterioration (GAO/NSIAD-91-34, Dec. 14, 1990).

Appendix II

# Laboratory Facilities Have Limited Agencies' Productivity and Scientific Capabilities

The federal laboratory facilities managers and researchers we interviewed stated that aging federal laboratories have reduced scientific productivity primarily because many HVAC and other systems can no longer meet their designed capacities; are more apt to break down; and, in some cases, have posed health hazards to researchers. In addition, laboratories' expanding missions and researchers' needs for performing advanced R&D have increased capacity and reliability requirements for such utilities as electrical power, ventilation, and air conditioning. The facilities managers and researchers cited various instances in which a facility's problems disrupted R&D programs or reduced confidence in the reproducibility of experimental results, causing researchers, in many instances, to repeat experiments. However, they stated that their laboratories generally have avoided a prolonged shutdown of R&D programs by successfully engineering around emergencies. Furthermore, some agencies cited the need for advanced laboratory facilities to improve (1) health and safety conditions, particularly for biochemical research; (2) temperature, humidity, air cleanliness, and vibration controls; and/or (3) flexibility to respond to new research programs and scientists' needs.

## Scientific Productivity Is Reduced

Federal facilities managers and researchers stated that aging laboratory facilities have reduced scientific productivity and cited many instances in which productivity was substantially reduced because of (1) inadequate ventilating systems that have caused respiratory problems among researchers or contaminated laboratory samples with microorganisms or particles; (2) delays and disruptions in making facilities repairs that limited researchers' access to equipment or facilities needed to perform R&D; (3) researchers' inability to control experimental conditions that reduced confidence in the reliability of the research results; (4) power outages and other systems malfunctions that disrupted experiments; and (5) inadequate ventilating capacity, which limited researchers' access to fume hoods.

Agency and laboratory facilities managers and researchers provided the following examples of reduced scientific productivity at federal laboratories because of facilities limitations.

- BARC's bioscience building (building 011A) is experiencing ventilation problems that have caused respiratory problems among researchers and specifically have led to the closing of two laboratories within the building and the relocation of five researchers since December 1991. The building, completed in 1972, has 78,000 gross square feet of laboratory and office space. A recent engineering analysis of the building found several fundamental and interrelated problems, including the following: (1) the air conditioning system recirculates air through the corridors; (2) the building's air system tends to distribute rather than contain fumes and/or smoke; (3) the building's outside air intakes are too close to its exhaust stacks, hence exhausted air may be recirculated into the laboratory; and (4) area exhaust capacity in the building's laboratories and the venting of fumes from stored chemicals are inadequate or nonexistent. The design of the bioscience building's HVAC system does not conform with ARS' requirement that its laboratories have at least eight air exchanges per hour with no recirculation of the air. This requirement is derived from the American Society of Heating, Refrigerating, and Air Conditioning Engineers standards for laboratories.[1] In response to the health problems, BARC has given higher priority to renovating the bioscience building's HVAC system within its modernization program by requesting design funding for fiscal year 1995 to be followed by a renovation funding request in fiscal year 1996.

- At EPA's Gulf Breeze facility, the Marine Environment Assessment Laboratory's newly renovated ventilating system had inadequate air-handling capacity, enabling mold and fungus to grow in the duct work. Some researchers experienced severe allergic reactions to the microorganisms, and research samples were contaminated by spores entering the laboratory through the ventilating system. Researchers were relocated to temporary space for 9 months while the ventilating system was upgraded. However, a research manager estimated that researchers in his branch lost 6 months to 1 year on their research projects because of the disruption and the minimal facilities available in the temporary space.
- At BARC, several researchers told us that drafty window frames have caused laboratory rooms to be too cold, too hot, and/or too humid. In some cases, researchers' inability to control temperature and humidity caused inaccurate research results or equipment failure. For example, researchers' inability to control humidity affected an experiment designed to measure the food intake of rats because the food absorbed excessive moisture, leading to inaccurate data.
- Electrical power outages have interrupted, and sometimes even ruined, scientific experiments. BARC researchers cited several examples of the effect of power failures and inadequate emergency backup equipment, including outages that (1) destroyed controlled experiments investigating animals' feeding patterns and (2) lasted sufficiently long enough in one

[1]These standards recommend that the ventilation system for chemical and biological laboratories discharge all exhaust air to the outdoors without recirculating it. The standards also provide a table for determining the minimum number of air changes per hour, depending on the specific research performed.

case to raise the temperature in an ultra-low temperature freezer to the point where 62 cell lines were lost, wiping out one researcher's work conducted over a 2-year period. Similarly, the work of over 200 NIH scientists was virtually halted for 1 week when an old circuit breaker malfunctioned. NIST experiences approximately 20 to 30 power outages each year that, although typically lasting less than a second, have caused computer systems to shut down, resulting in the loss of irretrievable data for long-term experiments, and damaged lasers and other sensitive electronic equipment.

In addition, research animals and plants were lost in some instances because of HVAC malfunctions. For example, a thermostat malfunction in an NIH laboratory caused temperatures to rise above 90 degrees Fahrenheit, resulting in the death of 421 laboratory rats. Similarly, an HVAC failure at an Army laboratory resulted in the death of over 1,000 laboratory animals, while a boiler failure in a BARC greenhouse ruined a major plant disease experiment.

- NIH has imposed a moratorium on adding fume hoods in the clinical center's laboratories because the demands on the ventilating systems have exceeded the available capacity. According to NIH officials, the capacity of the building's ventilation systems is deficient by 50 percent, posing a potential safety risk that air between laboratories and public spaces in the clinical center might be cross-contaminated. Although the clinical center's ventilating systems originally were designed to support 180 fume hoods, more than 226 fume hoods currently are in use. NIH officials told us that as a result fume hoods currently are operating at only 25 to 40 percent of their designed capacity because of the demands on and age of the ventilating systems. Currently, NIH scientists cannot add a fume hood in a clinical center laboratory without correspondingly reducing use elsewhere. To expand their research programs, scientists would either have to perform research in another building where fume hoods are available or wait until a fume hood became available.

NIH building engineers also told us that preparing space in the clinical center for such new diagnostic and treatment equipment as positron emission tomography scanners and other large and heavy advanced research equipment sometimes has taken years. The time needed to prepare this space has delayed important clinical studies and has severely inhibited researchers' ability to perform various types of advanced research, according to NIH research managers. For example, development of a medical technologies area within the clinical center is nearly impossible because of limited utility capacities. As a result, needed diagnostic scanning equipment has been stored in a warehouse until additional utilities can be added.

## Obsolete Facilities Have Limited Scientific Capabilities at Some Federal Laboratories

Facilities managers at some of the laboratories we visited stated that their scientists' ability to perform advanced R&D has been constrained in certain cases by obsolete laboratory facilities. In addition, NASA is developing a national facilities plan for world-class aeronautics and space facilities.

NIH's research capabilities are limited because it cannot provide adequate laboratory facilities for performing research in some new medical fields, particularly ones that require such biocontainment systems as the use of negative air pressure and specialized rooms. For example, the Chief of the Nuclear Medicine Department stated that (1) protocols are limited because only four rooms in the clinical center have the specialized facilities needed to segregate out radioactive gases given to patients, (2) research projects are canceled 75 percent of the time if they must wait for space to be prepared for needed equipment, and (3) using outside laboratories to perform nuclear research is very difficult because of stringent regulatory requirements and concerns that hazardous radioactive materials might contaminate the outside laboratories.

NIH facilities managers also stated that many of the utility systems in the clinical center and other buildings are functionally obsolete, citing as an example that the Bethesda campus's electrical power supplies are outmoded and inadequate. According to the facilities managers, NIH needs to increase both electrical power capacity and reliability. In addition, NIH needs to provide proper grounding and install uninterrupted power supply systems and equipment to provide "clean" power because modern medical instruments and equipment are sensitive to harmonic distortions.

NIST performs R&D to provide the measurements, calibrations, and quality assurance techniques that underpin U.S. commerce and technological progress and help U.S. industry develop advanced technologies. However, in a March 1992 report, NIST stated that it cannot provide some U.S. manufacturers with such services as state-of-the-art calibrations needed to maintain production-line quality controls on a par with Japanese and European competitors because it lacks high-quality environmental systems controls to allow precision measurements under predictable, stable conditions. In a 1991 study for NIST, Smith, Hinchman & Grylls Associates, Inc., found that 42 percent of the laboratories at Gaithersburg and 59 percent of the laboratories at Boulder failed to meet system performance levels required by current scientific and engineering programs.

As an example of its facilities' shortcomings, NIST cited its need for laboratory space with precise temperature control for an advanced coordinate-measuring machine because the length of metal parts is sensitive to temperature changes—one of NIST's recent calibration tests operates completely under computer control because even the operator's body heat in the room when measurements are taken can degrade the accuracy of final results. NIST has begun to replace the temperature control system, designed 30 years ago with vacuum tube technology, with substantially more reliable temperature control technology that uses semiconductors.

NIST also cited as an example the semiconductor industry's need for standard reference materials to ensure the quality of high-purity solvents and high-purity water used in fabricating the microscopic dimensions of integrated circuits. NIST cannot provide these reference materials; however, Japan's National Institute for Environmental Science already has clean-room facilities with the capabilities required for such ultra-high-purity analyses. This laboratory, as well as national standards laboratories in Switzerland and Canada, have special inorganic chemistry facilities featuring plastic walls, ceilings, floors, and furniture that enable them to outpace NIST's ability to detect low levels of such important metallic elements as iron, nickel, and copper by a factor of 100.

In November 1992, NASA's Administrator initiated a task force to develop a national facility plan for world-class aeronautics and space facilities that meets the needs of U.S. industry and federal agencies. This study, which will assess DOD's and NASA's mission requirements through the year 2023, will (1) determine where U.S. facilities do not meet national aerospace needs, (2) define new facilities required to make U.S. capabilities world-class, (3) define where the consolidation and phase-out of existing facilities are appropriate, and (4) develop a long-term national plan for world-class facility acquisition and shared usage. The task force is expected to issue its final report in the spring of 1994.

# Several Agencies Are Assessing R&D Facilities' Funding Needs and Missions

In recent years, the eight federal agencies have improved management oversight of their laboratory facilities to address the growing need to maintain, repair, and upgrade aging buildings. However, the eight agencies cited a total backlog of at least $3.8 billion in needed repairs for their laboratories, and facilities managers at six of the eight agencies told us that funding to renovate existing laboratory facilities or construct new ones is either inadequate or only slightly adequate.

## Laboratory Facilities Management

The eight federal agencies have strengthened their management of laboratory facilities through several initiatives designed to improve facilities planning and provide a basis for justifying increased funding to maintain, repair, or upgrade their laboratory facilities. For example, both ARS and NOAA have conducted facility condition surveys to identify and prioritize their laboratories' repair and replacement needs, and NIH and EPA are updating their laboratories' master site plans for future development.[1]

As part of its modernization plan initiated in 1985, ARS has completed comprehensive assessments of maintenance and repair needs at about 15 major laboratories and used in-house personnel to assess needs at its other laboratories. ARS' estimate of its backlog of needed repairs grew from about $350 million in 1985 to $700 million in 1993 primarily as a result of these assessments, which provided better information about needed repairs, and cost growth for making repairs.

NOAA became concerned about the deteriorating condition of its laboratories and other facilities about 4 years ago. Because maintenance and repair competed with R&D programs for limited funds, NOAA's laboratories repaired or replaced HVAC equipment, roofs, and other facilities almost entirely on an emergency basis without a plan for repairing and maintaining them in an acceptable condition. As part of its capital improvements program initiated in 1990, NOAA has completed comprehensive assessments at 15 laboratories. In addition, the Congress established a construction account for NOAA in fiscal year 1992. Although most of the $94.5 million appropriated in fiscal year 1993 is designated for Weather Service modernization projects, a line item in the account is designated for facilities maintenance.

NIH is updating its site master plans for the potential future expansion of its facilities to meet the R&D mission needs of its laboratories in Bethesda and Poolesville, Maryland. In particular, the Bethesda plan, which was last

[1]NIH is conducting facility condition assessments as part of its master planning process.

updated more than 20 years ago, is addressing space constraints and local community concerns about traffic and parking. In its 1991 evaluation of NIH's plans to renovate the clinical center complex and several other laboratory buildings, the Army Corps of Engineers recommended that NIH accelerate its master planning process, stating that the absence of a quality, up-to-date plan definitely hinders the ability of the NIH engineering staff to develop sound and reasonable strategies for future facility use and expansion.

EPA is updating its site master plans for each of its laboratories. The Gulf Breeze laboratory, which initially conducted R&D on the effects of pesticides on aquatic organisms, has expanded its mission substantially since EPA acquired the site in 1970. Correspondingly, the laboratory has grown from 14 buildings to 42 buildings, including 3 laboratory buildings, several small houses built when it was a yellow fever quarantine station, and leased trailers. The draft Gulf Breeze master plan proposes to consolidate offices and support services in a few larger buildings. For example, the computer center, currently housed in a trailer, would be moved to a central administration building. Several small buildings and temporary trailers would be eliminated, reducing maintenance and repair expenses.

## Funding for Maintenance and Repair

Facilities managers for most of the eight federal agencies stated that funding for maintaining laboratory facilities was moderately adequate; however, facilities managers for four agencies said that funding for repairing laboratory facilities was only slightly adequate or inadequate. Facilities managers for the Navy, Geological Survey (USGS), and NASA's Offices of Aeronautics and Space Technology and Space Science said that the adequacy of funding for laboratory maintenance and repair was moderate to great. In contrast, NIH, NOAA, Air Force, Army, and NASA's Office of Space Flight managers told us that funding for both laboratory maintenance and repair was inadequate or slightly adequate. EPA and NIST officials stated that laboratory maintenance funding was moderately adequate, but funding for laboratory repairs was inadequate or only slightly adequate. DOE managers said that maintenance funding was moderately adequate, while repair funding was between slightly and moderately adequate. In general, federal laboratories are responsible for maintenance and minor repairs, paying for these expenses with R&D program funds; major repair projects generally are submitted to a central facilities organization within an agency for approval and funding prioritization.

Both NOAA and EPA officials stated that a repair request typically must reach a critical stage before it is funded. In particular, NOAA facilities managers stated that maintenance and repair funding of $2.9 million per year is inadequate to bring the condition of NOAA's laboratory facilities up to an acceptable level within a reasonable period of time, especially with an increasing backlog of maintenance and repair projects that currently exceeds $38 million. EPA facilities managers similarly noted that a recent survey of field offices identified $120 million in needed repairs and improvements for EPA's laboratory facilities, while only $12.1 million was appropriated for such expenses in fiscal year 1993.

## Routine Maintenance and Repair

The National Research Council's Building Research Board, in its report Committing to the Cost of Ownership: Maintenance and Repair of Public Buildings, noted that the underfunding of maintenance and repairs of public buildings is a widespread and persistent problem. The Board recommended that 2 to 4 percent of the current replacement value for a substantial inventory of facilities (excluding land and major associated infrastructure) be allocated each year for routine maintenance and repair. The Board further stated that this funding level (1) should be used as an absolute minimum value in the absence of specific information upon which to base the maintenance and repair budget and (2) excludes funds for operations, alterations, and the reduction of any backlog of repairs. According to the Board's Director, this recommended guideline is intended to encourage government agencies to develop a maintenance and repair program on the basis of the appropriate service life of roofs, HVAC systems, and other building components. Whether a facility is at the high or low end of the 2- to 4-percent range primarily depends on the (1) age of buildings and utility systems; (2) level of use of the buildings, which affects utility systems requirements; (3) type of construction—permanent versus temporary; (4) climate; and (5) structure of the maintenance organization. For example, hospitals and R&D laboratories have a substantially greater level of use of a building's ventilation, electrical power, and other utility systems than office buildings because of the former's greater functional needs and concerns about health and safety, reliability, and adaptability. Accordingly, a greater proportion of hospitals' and R&D laboratories' current replacement value would generally be spent on maintenance and repair than on office buildings.

As shown in table III.1, ARS and NASA spent at least 2 percent of their laboratory facilities' current replacement value on routine maintenance and repair in fiscal year 1992. The other six agencies spent a lower percentage, ranging from 0.29 percent for NIST facilities to 1.82 percent for DOE facilities.

**Table III.1: Routine Maintenance and Repair as a Percentage of the Current Replacement Value of Federal Laboratories**

Dollars in thousands

| Agency | FY 1992 funding for routine maintenance and repair | Current replacement value | Percent |
|---|---|---|---|
| USDA | | | |
| ARS | $ 35,960[a] | $ 1,684,070 | 2.14 |
| Commerce | | | |
| NIST | 4,031 | 1,376,049 | .29 |
| NOAA | 1,179 | [b] | [b] |
| DOD | | | |
| Air Force | 10,067 | 1,648,311 | .61 |
| Army[c] | 14,550 | 1,574,777 | .92 |
| Navy[d] | 9,900 | 607,752 | 1.63 |
| DOE | 528,443 | 28,978,293 | 1.82 |
| EPA[e] | 7,747 | 471,415 | 1.64 |
| Health and Human Services | | | |
| NIH | 32,354 | 1,797,084 | 1.80 |
| Interior | | | |
| USGS | 3,748 | 404,000 | .93 |
| NASA[f] | 111,298 | 4,716,910 | 2.36 |
| **Total** | **$759,277** | **$43,258,661** | **1.76** |

[a]ARS' data include some modernization program funding for renovating facilities.

[b]Data not available.

[c]Data for six Army laboratories were not available.

[d]The Navy provided data only for the Naval Research Laboratory.

[e]Data for R&D laboratories only.

[f]Data for three NASA laboratories were not available.

Source: Federal agencies listed in table.

Facilities managers at ARS, EPA, NASA, NIH, and NOAA told us that the 2- to 4-percent guideline is about right for their laboratory facilities. Some of these managers noted, however, that the 4-percent guideline is more appropriate for their laboratory facilities. In contrast, NIST facilities managers said that this level could be somewhat high for maintenance and repair at NIST during the period when the major renovations in its capital improvement facilities project are taking place. DOD and DOE facilities managers stated that using a percentage of the current replacement value was not appropriate for estimating routine maintenance and repair funding primarily because it does not (1) differentiate between types of facilities—laboratories generally have substantially greater utility infrastructure needs than office space—and (2) account for added maintenance and repair needs associated with older facilities. The DOD and DOE managers noted that data obtained through condition assessments of and actual experience at facilities would be more accurate.

## Backlog of Laboratory Facilities' Repairs

The total backlog of laboratory repairs reported by seven federal agencies ranged from $3.8 billion to $4.5 billion. (See table III.2.) This backlog, which represents about 10 percent of the current replacement value of the laboratory facilities, is about five times greater than the agencies' funding for laboratories' routine maintenance and repairs in fiscal year 1992. DOE, which has the most and the oldest laboratory space among the eight agencies, reported the largest backlog of repairs. However, ARS reported a proportionately greater problem; the agency reported a $700 million backlog, while spending only $36 million for routine maintenance and repair in fiscal year 1992. According to ARS facilities managers, even though funding for routine maintenance and repair is about 2 percent of the current replacement value of ARS' facilities, it is inadequate for addressing ARS' facilities needs because of their age and the extent of the repair backlog.

Table III.2: Repair Backlog by Agency

Dollars in millions

| Agency | Backlog |
|---|---|
| USDA | |
| ARS | $ 700 |
| Commerce | |
| NIST | 94 |
| NOAA | 38 |
| DOD | |
| Air Force | 39 |
| Army | 350 |
| Navy | 33[a] |
| AFRRI | 3 |
| DOE | 1,400 - 2,100 |
| EPA | 120[b] |
| Health and Human Services | |
| NIH | 330 |
| Interior | |
| USGS | 16 |
| NASA | 718 |
| **Total** | **$3,841 - $4,541** |

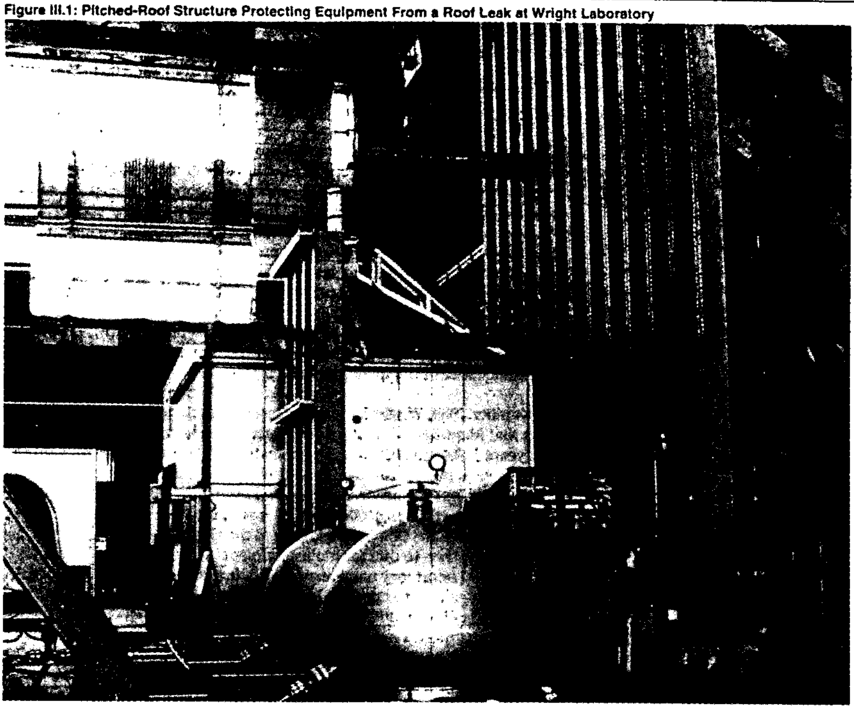
[a]The Navy provided data only for the Naval Research Laboratory.

[b]Does not include implementation of EPA's master plan, which includes repair and new construction needs.

Source: Federal agencies listed in table.

Facilities managers estimated that major repairs costing about $1 million, such as replacing a roof or an HVAC system, typically take from 3 to 5 years to implement from the time when laboratory management initially propose the repair until completion. This time involves waiting for funding to be made available, procuring contractors, and designing and making the repair. In some cases, the delay in making repairs is longer. An example is the replacement of a laboratory building's roof at Wright Laboratory located on the Wright-Patterson Air Force Base in Ohio. The roof replacement, estimated to cost $1.5 million, was delayed for 10 years because of limited funding available for repairs at Wright-Patterson. Facilities personnel installed a small structure with a pitched roof and a gutter around equipment in the laboratory to protect it from rain water leaking through the building's roof. (See center of fig. III.1.)

Figure III.1: Pitched-Roof Structure Protecting Equipment From a Roof Leak at Wright Laboratory



Source: Wright Laboratory.

## Funding for Upgrading Laboratory Facilities

Facilities managers at DOD, DOE, EPA, NASA, NIH, and USGS told us that funding to renovate existing laboratory facilities or construct new ones is either inadequate or only slightly adequate. As shown previously in table I.1, construction of new laboratory space dropped from a high of

30.7 million square feet between 1953 and 1962 to 14.4 million square feet between 1983 and 1992. NIH, for example, built little new laboratory space in the past 10 years in contrast to earlier years. Similarly, EPA facilities managers told us that, in recent years, the Office of Management and Budget (OMB) has not approved any EPA laboratory construction projects; the Congress has, however, appropriated funding for new construction.

The facilities managers noted that the process for obtaining funding and either renovating existing laboratory facilities or constructing new ones is long—typically taking about 7 to 10 years from proposal to completion. While this process includes procuring services and designing and constructing the facility, a substantial portion of total time reflects the budgetary review process. Laboratory projects compete for limited funds among themselves, with other agency construction needs, and with other agencies funded in the same appropriations bill. Projects are reviewed within the agency and by OMB before being submitted to the Congress. During this process, a number of lower-priority laboratory projects will be dropped, and the amount of funding made available for a project may be reduced because of competing priorities.

In November 1989, Wright Laboratory issued a facilities modernization report that identified 28 military construction projects for funding between fiscal years 1992 and 2010 with an estimated total cost of $591 million. However, each project must be submitted to Civil Engineering, which annually develops and prioritizes Wright-Patterson Air Force Base's military construction projects. This list is submitted for review and approval to the Base Commander, then to the Office of the Secretary of the Air Force, and then to OMB for inclusion in DOD's budget. Over the past 10 years, Wright Laboratory has averaged less than one project every 2 years, and the average cost per project has been less than $7 million. Wright Laboratory facilities managers noted that laboratory projects compete at Wright-Patterson Air Force Base with housing and other quality-of-life needs for Air Force families as well as facilities for the Aeronautical Systems Center, which recently was established at Wright-Patterson.

To illustrate the problems in obtaining new laboratory space, Wright Laboratory facilities and research managers cited the construction of a major new addition to its Avionics laboratory, initially proposed around 1980 at a cost of $35 million. Wright Laboratory was advised to break the $35 million project into three construction phases to increase its funding likelihood. Phase 1, approved in fiscal year 1992, began in March 1993; phase 2 is included in DOD's 1994 budget; and phase 3 was pushed back to the fiscal year 1997 budget. Assuming that phase 3 is approved, construction of the Avionics laboratory addition will be completed about 20 years after it was initially proposed.

## Alternative Actions to Address Aging Federal Laboratory Facilities

Federal agencies are confronted with aging laboratory facilities that have a substantial backlog of repairs and, in some cases, limited research capabilities. Several federal agencies are assessing options for improving the effectiveness and efficiency of their laboratories in response to the end of the Cold War and/or funding constraints because of the budget deficit.

### Realigning, Consolidating, And/or Closing Laboratories

In response to budget constraints and/or changing mission needs, several federal agencies have examined options for realigning, consolidating, and/or closing some of their laboratory facilities. Important considerations include (1) any changes to an agency's mission and the R&D capabilities needed to fulfill that mission; (2) the adequacy of funding to maintain, repair, and upgrade these laboratory facilities; and (3) potential budget savings achieved by consolidating laboratories that are not essential for fulfilling the agency's mission and/or closing inefficient older laboratories.

DOD, DOE, and USDA have taken steps to reevaluate their laboratories' missions and R&D capabilities. In response to the end of the Cold War, the Army, Navy, Air Force, and Armed Forces Radiobiology Research Institute (AFRRI) are reducing their combined laboratories from 76 to 31, according to DOD research managers. Similarly, earlier this year, DOE initiated a review of the roles, missions, and core competencies of its principal laboratories, including a review of whether to realign the mission of one of its three nuclear weapons laboratories, which together spend almost half of DOE's R&D funds. In addition, USDA is studying whether to close or consolidate some of ARS' 111 laboratories. Most of these laboratories spend less than $5 million on R&D each year; about half are colocated with university laboratories.

House bill 1432, introduced in March 1993, proposes to establish a Federal Laboratory Mission Evaluation and Coordination Committee, which in part would make recommendations on the advisability of establishing a commission to determine whether specific federal laboratories should be realigned, consolidated, or closed. One criterion that the Committee would be directed to consider is improving the efficiency and effectiveness of the overall federal laboratory system.

## Upgrading Federal R&D Facilities

Several federal agencies have proposed substantial laboratory modernization programs to improve scientific productivity and/or research capabilities. The following are examples of programs that have been proposed and/or funded.

- The Congress has made available about $70 million of $205 million that ARS requested in 1988 to modernize BARC's laboratory facilities by (1) renovating many of BARC's original buildings and (2) clustering related research programs in larger laboratory buildings to encourage interactions between researchers.
- In fiscal year 1993, the Congress appropriated $110 million of NIST's proposed $540 million, 10-year-effort to upgrade laboratory facilities at its Gaithersburg and Boulder campuses. NIST plans to (1) renovate seven existing buildings, (2) construct the equivalent of two advanced technology buildings, (3) improve the reliability of electrical power supplies, and (4) at Boulder, construct a central plant to provide steam and chilled water.
- NIH has proposed construction of a new clinical center complex at an estimated cost of $1.6 billion. The new clinical center would replace the existing 38-year-old clinical center, which does not have the (1) fire protection systems required for a modern research hospital or (2) flexibility, particularly in ventilating and cooling systems, to adequately address NIH's biomedical research programs.
- A task force appointed by NASA's Administrator is expected to issue a national facility plan in the spring of 1994 for world-class aeronautics and space facilities that meet the needs of U.S. industry and federal agencies.

## Providing Spending Flexibility

DOD and DOE officials suggested that their laboratories would be able to respond faster to scientists' needs for important R&D capabilities in certain instances if they were given greater authority to proceed with minor new construction without obtaining specific congressional authorization.

In November 1989, the Deputy Secretary of Defense initiated the Laboratory Demonstration Program to improve the quality, productivity, and efficiency of DOD laboratories. The Deputy Secretary proposed that legislation be drafted to address inadequate funding for R&D projects in the annual military construction bill and the need for new construction in part to modernize aging laboratory facilities and exploit new technologies. Among its recommendations, the Laboratory Demonstration Program has proposed providing laboratories with greater flexibility to upgrade facilities by increasing the threshold for (1) minor construction projects using operations and maintenance funds from $300,000 to $1 million and (2) unspecified minor construction projects using military construction funds from $1.5 million to $3 million without obtaining specific congressional authorization.

DOE has proposed to increase its General Plant Projects threshold for minor construction from $1.2 million to $2.5 million without obtaining specific congressional authorization. DOE officials noted that the $1.2 million threshold has not been increased since it was established in 1983. In contrast, they stated that construction costs have increased to the point where $1.2 million, which would pay for a 20,000-square-foot module in 1983, would pay for only an 8,300-square-foot module using inexpensive building materials in 1993.

Appendix IV

# Objectives, Scope, and Methodology

The Vice Chairman, Joint Economic Committee, U.S. Congress, expressed concern that federal research agencies may be underinvesting in maintaining, repairing, and upgrading their laboratory facilities. Citing the importance of federal R&D to economic growth and national well-being, the Vice Chairman requested that we assess the (1) condition of federal laboratory facilities, (2) effect of inadequate laboratory facilities on agencies' scientific productivity and research capabilities, and (3) funding needed to repair or upgrade these facilities.

As agreed with the Vice Chairman's office, to assess the condition of federal laboratory facilities, we obtained information from the Department of Commerce; DOD; DOE; EPA; NASA; ARS, within the Department of Agriculture; NIH, within the Department of Health and Human Services; and USGS, within the Department of the Interior. These agencies have 220 government-owned laboratory campuses that spent about $18.1 billion of the estimated $24.9 billion obligated for R&D at federal laboratories in fiscal year 1992. (See table IV.1.) In addition, ARS, EPA, NOAA, and NIH lease some of their laboratories from state governments, universities, or private companies.[1]

[1]For example, 9 of EPA's 32 laboratories and field stations and 15 of NOAA's 39 laboratories are leased facilities.

**Table IV.1: Federal Laboratories' R&D Funding**

Dollars in millions

| Federal agency | Number of laboratory campuses | Estimated R&D obligations for agencies' laboratories in FY 1992 |
| --- | --- | --- |
| USDA | | |
| ARS | 111 | $653 |
| Commerce | | |
| NIST | 2 | 295 |
| NOAA | 24 | 272 |
| DOD | | |
| Air Force | 4 | 1,949 |
| Army | 21 | 2,083 |
| Navy[a] | 1 | 583 |
| AFRRI | 1 | 17 |
| DOE | 16 | 6,607 |
| EPA | 23 | 167 |
| Health and Human Services | | |
| NIH | 5 | 1,753 |
| Interior | | |
| USGS | 3 | 246 |
| NASA | 9 | 3,499 |
| **Total** | **220[b]** | **$18,124** |

[a]The Navy provided data for the Naval Research Laboratory, which primarily performs R&D, but did not provide data for its four test and evaluation laboratories.

[b]Total number of laboratories excludes satellite laboratory facilities and laboratories that the federal government leases from other organizations.

Specifically, to assess the nature and extent of deteriorating buildings and inadequate infrastructure, we obtained (1) condition studies, modernization proposals, and other laboratory facilities assessments; (2) data showing the age of laboratory buildings by 10-year periods; (3) information about major problems at facilities that occurred during the past 3 years; and (4) any of the agencies' FIA reports that identified deteriorating facilities as a material management weakness. We also visited eight laboratories, shown in table IV.2, to observe the facilities and obtain the views of laboratory facilities and research managers about the condition of laboratory facilities.

Table IV.2: Federal Laboratories Visited

| Federal agency | Laboratory | Location |
|---|---|---|
| Commerce | NIST | Gaithersburg, Md. |
| | NOAA's Southeast Fisheries Center | Miami, Fla. |
| | NOAA's Atlantic Oceanographic and Meteorological Laboratory | Miami, Fla. |
| DOD/Air Force | Wright Laboratory | Wright-Patterson Air Force Base, Ohio |
| EPA | Environmental Research Laboratory | Gulf Breeze, Fla. |
| Health and Human Services | NIH | Bethesda, Md. |
| NASA | Lewis Research Center | Cleveland, Ohio |
| USDA | ARS | Beltsville, Md. |

To evaluate the effects of inadequate infrastructure on agencies' scientific productivity and research capabilities, we interviewed (1) agencies' facilities managers and (2) laboratory management, scientists, facilities managers, and other personnel at the eight laboratories visited. We also obtained information about the effect of such laboratory facilities problems as electrical outages and inadequate ventilation on scientific research. In addition, we reviewed reports by the Army Corps of Engineers and architect and engineering consultants that evaluated laboratory facilities needs to perform advanced R&D.

To analyze the funding needed to repair or upgrade federal laboratory facilities, we interviewed the Director of the National Research Council's Building Research Board and reviewed the Board's report entitled Committing to the Cost of Ownership: Maintenance and Repair of Public Buildings. We then obtained data from each of the eight agencies to (1) compare agencies' funding for routine maintenance and repair of laboratory facilities with the facilities' current replacement value and (2) estimate the backlog of laboratory repairs. We also obtained the views of agencies' facilities managers about the adequacy of funding for maintaining, repairing, and renovating existing laboratory space or constructing new space. We reviewed laboratory facilities modernization studies and obtained information about any studies by agencies to realign, consolidate, or close their laboratory facilities.

Facilities managers at several agencies cited problems with maintaining, repairing, and upgrading their laboratory facilities that were beyond the scope of our assessment. For example, some managers stated that, in addition to funding limitations, their maintenance and repair programs have been constrained by (1) staffing ceilings for facilities personnel; (2) procurement requirements that lengthen the time or add to the cost associated with hiring contractors to replace major building systems, renovate existing laboratory space, or construct new facilities; and (3) procurement requirements that delay purchases of critical spare parts. In addition, EPA and NOAA officials cited problems with leased laboratory facilities—in many cases, they pay for maintenance, repairs, and renovations because of a lease's terms. Furthermore, EPA officials told us that OMB effectively has made leasing new laboratory space unrealistic by requiring that an agency set aside funding for the duration of a lease, known as "scoring," before the lease is signed.

Appendix V

# Major Contributors to This Report

## Resources, Community, and Economic Development Division, Washington, D.C.

Jim Wells, Associate Director
Robert E. Allen, Jr., Assistant Director
Richard Cheston, Evaluator-in-Charge
John Johnson, Staff Evaluator

# Related GAO Products

Federal Budget: Choosing Public Investment Programs (GAO/AIMD-93-25, July 23, 1993).

Department of Energy: Cleaning Up Inactive Facilities Will Be Difficult (GAO/RCED-93-149, June 25, 1993).

Navy Laboratories: Plans for Consolidation and Progress Toward Implementation (GAO/NSIAD-93-160, June 23, 1993).

Military Bases: Army's Planned Consolidation of Research, Development, Test and Evaluation (GAO/NSIAD-93-150, Apr. 29, 1993).

Transition Series: Investment (GAO/OCG-93-2TR, Dec. 1992).

Federal Buildings: Actions Needed to Prevent Further Deterioration and Obsolescence (GAO/GGD-91-57, May 13, 1991).

NASA Maintenance: Stronger Commitment Needed to Curb Facility Deterioration (GAO/NSIAD-91-34, Dec. 14, 1990).

PREPARED STATEMENT OF K. DARWIN MURRELL

Mr. Chairman, I am pleased to be here today to discuss the issue of Federal Laboratories Infrastructure. I am privileged to be the Director of one of the premier research Centers in the U.S. Department of Agriculture. The Beltsville Agricultural Research Center (BARC) has a long and distinguished history of agricultural research and development and is regarded as the largest agricultural research center in the world. BARC has, from its very beginning nearly 85 years ago, been a leader in national and international agricultural research and technology transfer. For example, the very first Federal Cooperative Research and Development Agreement with industry was with a BARC laboratory. Among the notable introductions of the Center are crops and animals with improved nutritional quality and safety, sustainable farming systems and technologies that protect natural resources and floral and landscape plants that enhance our environment.

Currently, the Center has a staff of 450 scientists and about 1,200 support personnel. We are also host to 18 other Federal and State agencies which occupy some of our offices and laboratories and utilize research plots on our 7,000 acres.

Although BARC is successful in its mission of research on the Nation's most difficult agricultural and nutrition problems, it is an increasingly difficult struggle to maintain an infrastructure adequate to the challenge. The majority of BARC's research facilities were built in the 1930's and 1940's. Since then, investments in upgrading our facilities have been constrained by budgetary limitations. This has resulted in deterioration and obsolescence of many of these facilities, which in turn hampers our ability to provide the quality of research expected of us and to fulfill our national mission. In recognition of this, the Congress has appropriated nearly $78 million dollars over the past eight years to address our infrastructure problems. Inspite of this badly needed help, however, much remains to be done. I'd like to illustrate the magnitude of the problem with several examples that I believe will give you an indication of the intimate relationship between research facility conditions and scientific progress.

Over the past 30 years, 54 barns or non-laboratory buildings have been converted to make-shift laboratories because of the press of urgent research assignments. Many years ago, this was not such a drastic action because the requirements for meeting occupational safety and research equipment specifications were less demanding. Today, however, these poorly designed buildings are a severe financial burden. The costs associated with retrofitting ventilation systems are extremely high and, in some cases, we must consider carefully whether we can justify the resources needed to retrofit some laboratories for certain types of research. This is, needless to say, an important determinant in our ability to encourage cutting-edge research and to recruit outstanding scientists.

Some of these projects, such as roof repairs, are so serious that there is little choice but to divert scarce research dollars from the laboratories to get these repairs made before disasters occur.

Our Beltsville Human Nutrition Center suffered a catastrophe recently when back up generators failed during one of our frequent power outages, causing freezer failure. The freezers contained blood, urine, and stool samples from a major human nutrition study, most of which were lost. The original cost to conduct this study was $240,000. The cost to repeat this human trial may be prohibitive.

The Nutrition Center has also recently experienced a severe problem in pursuing its investigations on the nutritional needs of postmenopausal women. Nearly one-quarter of the volunteers withdrew from the study because the elevator servicing the building was out of commission for three weeks; the women were either incapable or unwilling to climb two flights of stairs to the Human Study Facility. Because the building and elevator are so old, parts and service are hard to obtain and some parts must be machined to order.

Complete building shutdowns are increasingly frequent now at BARC. This past year, because of storm damaged roofs, flooding due to inadequate drains, and deteriorating steam tunnels, a one-story laboratory building was severely affected, making it necessary to close the building for two months for repairs. In another instance, a corroded water pipe broke in a greenhouse, disabling a controlled environment chamber. The laboratory is now seeking funds to replace the growth chamber, and meanwhile the research on plant adaptation to climate change is delayed. Another building, which houses several laboratories, is now being evaluated by occupational health specialists. We may be limited in the types of research we will be able to carry out in that building because of its poor air exchange system.

We have a particular concern at BARC regarding our animal housing. Many of our facilities for housing research animals, although state-of-the-art in the 1930's, are no longer ideal for the type of research we now must pursue. Too many current facilities do not give us the flexibility to change research direction without costly physical facility changes. Necessary upgrades to meet animal care standards are also very costly. These conditions often prevent us from taking advantage of more efficient technologies and automation that would reduce labor costs. BARC is a world leader in transgenic animal research and is making important advances in the control of animal parasitic diseases, animal reproduction and nutrition. However, these programs are dependent upon animal care facilities that are conducive to animal well-being and health. To attain that level of animal care, considerable modernization and repair and maintenance of our 50-year old buildings is required. To accomplish this, some research groups must allocate 25 per cent of each scientist's discretionary funds to repair and upgrading.

One laboratory, the Nonruminant Animal Nutrition Laboratory, has spent, over the last 10 years, $25,000 or more annually to modernize laboratory and animal facilities. This has necessitated postponement of the purchase of some critical, state-of-the-art equipment. In some cases, such as our program on poultry reproductive biology, the cost to update existing facilities to allow certain new research approaches is prohibitive. A substantial part of the Gene Evaluation and Mapping Laboratory's research deals with utilization of cow embryos grown in culture. Over the past four years, thousands of cow embryos have been lost because of electrical outages. Each power outage lasting over an hour (four or five per year) destroys two weeks of work. This represents a loss of over 100 staff hours each time we lose facility power. The interim solution has been to purchase numerous back-up generators. Upgrading these electrical systems is among our highest priorities for modernization.

One of the unique capabilities we have at BARC is an abattoir which allows us to carry out a variety of projects on reducing the fat content of meat, on meat quality and on meat safety. However, the deterioration of this building is raising concern about whether we will risk the loss of our Federal license by operating the facility without major upgrades. Finally, repeated failures in the 30-year old HVAC system in the main building of the U.S. National Arboretum, a component of the Beltsville Area, has jeopardized not only its valuable herbarium, but also seriously interrupted the research program. The HVAC system is so old it is difficult to repair. I worry that we will be forced to remove it before we have replacement funds identified.

I hope these few examples have clearly illustrated our serious facility problems. I'm sure you observed a common theme throughout these examples, our inadequate electrical distribution systems. The number of failures in this system is very high, and because only a few of our laboratories, greenhouses, and barns are equipped with back-up generators, research losses are all too frequent. As I mentioned, the utilities systems at BARC have been among our top priorities for modernization. The support of both the Department and the Congress has allowed us to make significant progress in upgrading our electrical, steam, and water treatment facilities. With continued modernization support, we expect in a few years to have in place an infrastructure plant adequate to properly modernize the rest of our research facilities.

Before closing, I would like to comment on our long-term modernization plans at BARC. Studies that we have carried out strongly recommend that the optimal modernization for BARC should include a mix of rehabilitated existing buildings and some new replacement buildings. Those buildings we would retain are those with solid superstructures. This would allow us to demolish many of the deteriorated buildings and to consolidate our research and support personnel into about one-third of the number of current buildings. For example, our Climate Stress Laboratory is currently housed in nine buildings, making inter-unit collaboration extremely difficult. Consolidation would allow us to achieve much needed program clustering, centralized services and energy savings. One of our most pressing needs is a larger Human Nutrition Research facility, which would allow us to increase the size of human nutrition trials. Larger study groups would enable us to include a wider genetic diversity among the human subjects. The existing facility greatly restricts the size of these nutrition studies, making it difficult to take advantage of the great human genetic diversity found in the Baltimore-Washington Area. With the opening of the Metro Station at Greenbelt, BARC is conveniently located to draw upon this large population for badly needed research on the influence of genetics on nutritional requirements, a serious gap in our national nutritional recommendations.

I want to again thank the Committee for allowing me an opportunity to express my concern over the plight of one of our Nation's great research treasures. The mission of BARC and the commitment of its people to tackle the most important national agricultural and nutritional problems remains strong. However, our serious facility deficiencies impede our progress. Mr. Chairman, while I have focused primarily on BARC, it is important to note that the problems are illustrative of facilities throughout the Agricultural Research Service. The Agency's has projected facility needs to the turn of the century--only a little over 6 years from now--to be over three quarters of a billion dollars. I know that the leaders of the other Federal research facilities that are also appearing before this Committee share my hope that the help we need to continue our service to this Nation and its people will be found and that this assistance will be recognized as one of our most important and wise investments for the future.

Mr. Chairman, this concludes my prepared statement. I will be pleased to respond to questions.

**ATTACHMENT TO DR. MURRELL'S PREPARED STATEMENT**

RESEARCH ACCOMPLISHMENTS FROM
THE BELTSVILLE AGRICULTURAL RESEARCH CENTER

RECENT ACCOMPLISHMENTS

- Discovered a technique using a laser beam to identify and separate X- and Y-Chromosome-bearing sperm of farm animals. Procedure may permit livestock producers to pre-select the sex of animals at conception for more efficient meat or milk production. Potential high economic impact for dairy industry.
- Transferred economically important foreign genes into the genome of swine and sheep to improve growth characteristics, increase disease resistance, and produce biological products in the mammary gland.
- Discovered a new animal parasite, Neospora caninum, that causes widespread illness and abortion in cattle and pets.
- Discovered that clinical mastitis is reduced 75 percent by inserting abraded plastic loops in cows' udders. Reduced infections resulted in increased milk yield averaging almost 4 pounds per cow per day.
- Demonstrated that a new complex carbohydrate from cereals (Oatrim) reduces cholesterol in the blood of humans and aids in weight loss.
- Demonstrated that decreasing fat in the human diet and increasing the proportion of fat from vegetable sources significantly reduces high blood pressure.
- Developed new techniques for measuring carotenoids (yellow and orange pigments) in fruits and vegetables. These techniques will allow scientists to evaluate the importance of food carotenoids in the reduction of cancer risk.
- Developed technology that uses near-infrared light combined with computerized data analysis to instantly measure percent of body fat, water, and protein without harming the subject.
- Developed multiple-volume treatise of detailed taxonomic information on over 15,000 species of North American moths, a group responsible for devastating crop losses.
- Developed computerized databases and information files on beneficial organisms, primarily those of foreign origin, as an aid in biological control of pests.
- Discovered and helped commercialize rapid immunodiagnostic test for trichinosis, the first such test for a food-borne parasite. Now in use both in the United States and in foreign countries.
- Provided research data that formed the basis for the first FDA approval for irradiation of meat to control a pathogen.
- Discovered a new synthetic control for fire ants that increases the ratio of drone ants to workers, slowly causing the ant colony to weaken and die. These pests infest 230 million acres in the South.
- Genetically engineered, in a cooperative effort with private industry, a parasite antigen that stimulates host immunity -- an important first step for a vaccine against coccidiosis, which costs U.S. poultry producers almost $300 million a year.
- Introduced exotic new impatiens germplasm, and used ovule-culture to develop otherwise impossible hybrids to create new kinds of impatiens, a flower-garden bedding plant, that is now more popular than petunia.
- Detected nutrient deficiencies in corn and soybean from an aircraft or satellite using a nitrogen-gas laser. Plant leaves fluoresce in specific wavelengths that indicate their status of specified elements, such as iron, nitrogen, and potassium.
- Released to plant breeders four snap bean germplasm lines resistant to all 28 races of Uromyces phaseoli (fungus that causes bean rust) that occur in the

United States. Snap and dry beans are an important source of protein and energy in the human diet.

- Discovered a chemical attractant that will cause the spined soldier bug--a type of stink bug that eats other insects--to gather in areas where they may help the farmer control pest insects.
- Developed snowmelt-runoff model that can predict the amount and timing of water delivery to the 17 irrigated States in the Western United States.
- Identified the role of macropore flow in soils as a major pathway for the movement of pesticides into groundwater.
- Developed role of satellite remote sensing to monitor soil erosion.
- Developed a disposal unit that uses ozone and microorganisms to destroy pesticide residues in wastewater.
- Developed first naturally occurring beneficial fungus approved by EPA for biocontrol of plant diseases. This fungus controls "damping off", a major killer of seedlings of ornamentals and vegetables.
- Developed improved strain of gypsy moth virus that provides economical foliage protection and gypsy moth population reduction without endangering other animals or plants.
- Developed a diagnostic kit that can detect all members of one of the world's most damaging plant viruses. The broad spectrum specificity of the test makes it a valuable tool for seed-testers, nurseries, farmers and research scientists.
- Developed a computerized database called the Germplasm Resources Information Network (GRIN) which contains all available information on plant germplasm necessary to improve the quality and productivity of crops.
- Developed tissue culture techniques enabling cultivation of disease resistant peach trees.
- Developed first biopesticide-attractant combination for control of the soybean cyst nematode, a major crop pest.
- Issued the USDA Plant Hardiness Nap for Canada and United States to guide gardeners and landscapers in selecting outstanding ornamental plants.
- Introduced cultivars of crab apples that are resistant to powdery mildew, fire blight, apple scab, and cedar-apple rust and that possess superior landscape characteristics of superb flowering, fruiting, fall foliage color, and adaptation to a wide range of sites over North America.
- Discovered that postharvest application of calcium to apples reduces virulence of storage diseases and could substitute for pesticides, leading to improved marketability.
- Developed new and improved analytical procedures for detecting antibiotic residues in meat and milk. Methods are now in use by industry, Food and Drug Administration, and Food Safety and Inspection Service.
- Enhanced quality of low-fat hamburgers by developing criteria for eliminating defects and improving palatability. These criteria have become the basis for purchase specifications for the National School Lunch Program and rations for the Armed Forces.
- Developed a room-sized calorimeter for human studies that permits measurement of 24-hour energy expenditure to help define the interrelationships among diet composition, body composition, and energy expenditure.
- Demonstrated that daily consumption of carrots could increase blood beta-carotene levels nearly 600 percent in humans to lower the risk of life-threatening diseases.
- Developed child rearing cost estimates that are used in many states for determining child support awards and foster care rates.

HISTORICAL ACCOMPLISHMENTS

- Developed genetic concepts that laid the foundation for modern plant and animal breeding and proved the value of statistical methods in evaluating inherited characteristics in populations.
- Pioneered research on plant responses to variations in light quality and daylength which culminated in the chemical isolation of phytochrome, the photoreceptor that regulates many plant growth and development responses to light.
- Developed and introduced many pest-resistant potato varieties, from the famous 'Katahdin' potato of the 1930's to the new superior baking potato bred to grow in the Northeast--'BelRus'.
- Invented and developed the "bug bomb" (precursor of the aerosol can), saving thousands of lives from malaria and other tropical diseases during World War II and its aftermath.
- Developed the Beltsville Small White turkey and improved the efficiency of artificial insemination of commercial turkeys.
- Contributed to the "Green Revolution" (a turning point in agriculture that drastically reduced world hunger) by identifying and supplying disease-resistant wheat to plant-breeding centers around the world.
- Originated high-quality, large-fruited blueberry varieties from the wild that started the new and valuable cultivated blueberry industry.
- Developed detergent chemical methods for determining the nutritional value of feedstuff -- now widely used throughout the world in both human and animal nutrition. 5
- Conducted fundamental research that defined the energy requirements of the lactating dairy cow. These concepts led to a practical feeding system adopted by the National Academy of Science.
- Discovered and synthesized the chemicals that a variety of -major insect pests emit to attract their mates--now being used for mass trapping and to survey insect populations for integrating pest management programs.
- Discovered plant viroids--a new class of disease-causing particles 80 times smaller than viruses. Developed a practical test for the presence of viroids in potatoes.
- Developed the near-infrared reflectance spectroscopic technique for rapid evaluation of major quality constituents in food, feed, and agricultural products.
- Discovered that a group of protozoan parasites (Sarcocystis species), long thought to be harmless cysts in the muscles of cattle, sheep, and swine, actually can cause weight loss, produce abortion in pregnant animals, decrease milk yields, and even cause death.
- Developed a standardized reference diet for use as a research tool in human metabolic studies.
- Developed and continue to increase the World's largest germplasm collection of bacteria (Rhizobium), which enhance grain yields of soybeans by forming nitrogen-fixing symbioses with the roots of the plant, thus reducing the need for nitrogenous fertilizers.
- Pioneered research on lowering body fat in swine through genetic selection.
- Discovered that rice plants, grown only from pollen, can be chemically selected in the laboratory for increased protein and other desirable characteristics. One rice variety produced this way has 42 percent more lysine (an essential amino acid) than normal rice.
- Discovered the selectivity of the herbicide 2,4-D to kill broad leaf plants (dicots) while doing little damage to grasses (monocots). This discovery revolutionized

weed control and fostered the establishment of the agricultural chemical industry.

- Developed coupling of the flame ionization detector with a sensitive electrometer for the measurement of the plant hormone ethylene. This enabled plant scientists to measure low amounts of ethylene, and led to the means of controlling the amount of fruit-ripening ethylene in storage rooms.
- Discovered a class of plant growth regulating substances known as brassinolides. These compounds are steriodal in nature and function with other hormones in accelerating plant development and maturation.

**WRITTEN OPENING STATEMENT OF REPRESENTATIVE RAMSTAD**

Mr. Chairman, thank you for holding this hearing this morning. I also want to thank the witnesses for the testimony on this important issue.

While I understand the General Accounting Office's 9GAO) concern about the condition of federal laboratories, I must say I have some concerns about the GAO's recommendations for additional expenditures to upgrad the eight laboratories reviewed in the study.

The poor condition of these facilities, despite the billions of federal dollars spent on science research each year, concerns me deeply.

That's why I am pleased to have Dr. Joseph Martino here to discuss privatizing federal research. I certainly share the concern of many that federally funded research is often simply a cover for pork barrel spending.

Again, Mr. Chairman, I think you for holding this hearing and I look forward to hearing the testimony of our distinguished witnesses.

**PREPARED STATEMENT OF STEPHEN A. FICCA**

Mr. Chairman and members of the Committee, I greatly appreciate the opportunity to appear before you to discuss the infrastructure of our Federal laboratories. My testimony today will focus on the current condition of the research facilities of the National Institutes of Health, and the impact that these conditions have on the institutes' research missions.

NIH now consists of 21 institutes, centers and divisions with broad mandates in areas as diverse as aging, cancer, heart disease, and acquired immunodeficiency syndrome. Simply stated, the goal of NIH research is to acquire new knowledge to help prevent, detect, diagnose, and treat disease and disability, from the rarest genetic disorder to the common cold.

As a result of investment in NIH research, concepts that were not understood and technologies that did not exist as recently as 10 years ago are saving lives today. Evidence of the scientific excellence and continued productivity of the NIH Intramural Program is found in its extensive publications, new drug applications (NDA's) on file with the Food and Drug Administration (FDA), and its collaborations with industry and academia, and breakthrough research such as the world's first clinical experiment to treat patients with gene therapy. The NIH has played a major role in reducing mortality from heart disease and stroke? in developing new drug treatments that have given children with cancer a better than 50 percent chance of living a normal life; and in the discovery of vaccines to protect against infectious diseases that once killed and maimed millions. Unfortunately, many diseases are yet to be conquered. As we speak here today, researchers at NIH are working on better ways to prevent and treat cancer, blindness, arthritis, diabetes, AIDS, and Alzheimer's Disease, to name a few.

As NIH continues to confront disease and disability, our intramural research program, which represents 11 percent of our budget, faces unprecedented stress on its very foundation. For that portion of our activities, the National Institutes of Health intramural program - a distinctly American contribution to the health of the world - depends heavily on the facilities that house the scientists dedicated to increasing life expectancy and decreasing pain and disability. As the next century approaches, we must pause to consider the profound ramifications of past decisions and pressures that have impacted on the repairs and maintenance to our buildings and facilities. Without increased attention to these often unseen and sometimes mundane infrastructure projects, NIH intramural research activities will be similarly affected.

Evolution of the NIH Campus

In 1930, the Ransdell Act redesignated the Hygienic Laboratory, located in Washington, D.C., as the National Institute of Health.

In 1935, Mr. and Mrs. Luke Wilson made the first of several land gifts that now form the nucleus of the present 320-acre Bethesda reservation.

The original buildings, constructed in the late 1930's to mid-1940's, consisted of a cluster of laboratories surrounding Building #1 (now named the James A. Shannon Building), which served as both the main administration center and the power plant. The most notable addition to campus came in 1953 with the dedication of the Clinical Center - NIH's research hospital. The Clinical Center was re-dedicated in 1981 to the late Senator Warren Grant Magnuson.

The 1950's, though certainly not ancient history for many of us, was a time of seemingly ancient technology and knowledge by current standards. In 1952 there were nearly 600,000 cases of polio in the United States. Dr. Jonas Salk, using the findings of an NIH-supported team of Harvard researchers, developed a vaccine and in 1954, 400,000 children were inoculated against this crippling disease. The 1950's were also a time when a blood transfusion posed a high risk of contracting hepatitis B, and when chemotherapy was only an experimental treatment for cancer patients. In 1950 no one had yet imagined a fax machine, much less a CAT scanner, or the advent of biotechnology that would allow us to even contemplate the miracle of gene therapy.

Dynamic changes in biomedical research and clinical care have led to an ambitious program of new construction and renovation on the NIH campus since the mid-1970's. For example: expansion of the computer center was completed in 1979; A program to upgrade NIH animal facilities was initiated in 1986; and, construction of a state-of-the art laboratory facility to consolidate Child Health and Neurosciences research programs was completed in 1993.

One of the most comprehensive programs undertaken by NIH to address infrastructure deficiencies was initiated in 1981. The Round Robin Program was designed to renovate six of the oldest laboratory buildings on campus. To date, three buildings have been renovated at a cost of approximately $45 million.

In addition, NIH is currently implementing a $200 million Infrastructure Modernization Program to upgrade site utilities that have suffered from years of neglect.

Despite these efforts, much remains to be done to improve the condition of NIH's intramural research facilities.

STATE OF THE CAMPUS

More than half of the research buildings on the NIH campus, however, are from 30 - 50 years old. These buildings are deficient in meeting current standards for safety, air conditioning, ventilation, and electrical service. Much of the central utility plant and its distribution systems which support all NIH buildings exceed or are approaching limits on their rated useful lives. These systems are inefficient, obsolete, unreliable, and have insufficient capacity to meet existing, much less projected, research demands.

The impact that these conditions have on NIH intramural research capabilities are important. For example, the Deputy Executive Officer for Planning and Technology for the Clinical Center says that they are unable to provide continuous CAT scanning capability because of dependence on a shared central chiller for air conditioning - a system that has no back up to provide for emergency loss of power; and according to Dr. Edward Korn, Scientific Director of the National Heart, Lung and Blood Institute, new initiatives in the Cardiology Branch that were designed to study restenosis following angioplasty and the genetic basis of hypertrophic cardiomyopathy have been curtailed due to infrastructure constraints imposed by the condition of the Clinical Center.

Similar infrastructure problems exist throughout campus. For example, in Building 3, one of the original laboratories built on the NIH campus, researchers at the National Heart, Lung and Blood Institute have stated that the condition of the facility makes it not only impossible to consider new initiatives, but makes ongoing research far less productive. For example, the entire building is serviced by a single supply fan and a single exhaust fan, which provide the necessary ventilation required to provide a safe laboratory environment. There is no back-up should these systems fail.

However, we have some very expensive, remarkable research space in the remaining half of the campus buildings that are less than 30 years old. In fact, much of this space has been constructed in the last five years and truly provides a state-of-the-art research environment.

NIH CLINICAL CENTER

Many of the concerns about campus-wide infrastructure are reflected in the conditions found in the Clinical Center -- the keystone of the Intramural Research Program at NIH.

The concentration of scientists and resources within the Clinical Center make it unlike any other place in the world. Here sophisticated scientific advances are applied directly to the treatment of both inpatients and outpatients. The Clinical Center Complex is the world's largest hospital devoted exclusively to clinical research. As a national resource, the

Clinical Center contains almost half of the country's federally supported dedicated clinical research beds.

Each year about 9,000 patients come from all over the world to participate as inpatients in clinical studies. Patients are referred by their physicians and selected for admission to the Clinical Center because they have an illness being studied in one of the research programs. Additionally, there are about 145,000 outpatient visits a year to the Clinical Center's Ambulatory Care Research Facility (ACRF). All patients voluntarily consent to participate in NIH studies and are treated without charge.

The Clinical Center's design places laboratory research side-by- side with patient care activities. This design promotes scientific interaction and facilitates rapid transfer of discoveries to patient treatment applications. No university, medical center, or hospital can match the Clinical Center's intellectual resources, its depth of scientific knowledge, or its concentration of laboratory space and research beds under one roof. The NIH Clinical Center continues to be a world leader in technology transfer; that is the ability to take an idea from the' lab directly to clinical trials. For example, NIH scientists were the first worldwide to use gene therapy to treat human disease. The first little girl who received the therapy just celebrated her third year of healthy life. Additionally, successful use of taxol to treat ovarian and breast cancer, gene therapy protocols for drug resistant breast cancer, and new treatment approaches to Alzheimer's Disease have all emanated from research in NIH's intramural program.

With over 1.3 million square feet, the original Clinical Center opened in 1953 as the world's premier biomedical research facility. Primarily through the addition of the Ambulatory Care Research Facility in 1980, the Clinical Center Complex today contains approximately 3.0 million square feet and houses over 2,000 research laboratories and approximately 6,800 employees.

Designed by the General Services Administration (GSA) in the 1940's, the Clinical Center contained the latest innovations in research design and building technology. It is important to remember, though, the speed with which both building and medical technology has advanced - we were still using the iron lung when the cornerstone to the Clinical Center was laid by President Harry Truman.

Having been built in 1950, the Clinical Center by 1990 was 40 years old and medical research had advanced astronomically. To begin to address changing medical research needs, modernization and improvement programs have been undertaken to repair and upgrade the hospital's infrastructure. These include: the Essential Maintenance and Safety Program, undertaken as an interim measure to improve conditions and address the most critical safety issues in the Clinical Center Complex; construction of the Ambulatory Care Research Facility (ACRF); and, construction of the A-wing of the Clinical Center for AIDS research.

Current Status of Clinical Center Infrastructure

The Clinical Center faces additional challenges. The major utility infrastructure systems within the original building that provide critical electrical power, lighting, air conditioning, ventilation, and plumbing are outmoded and do not have the flexibility or capacity to meet current research demands. These systems are at the end of their useful lives and are potentially unsafe for maintenance staff, employees and patients. For example, fume hood exhaust systems, critical for the safe containment of hazardous materials, cannot satisfy even current user demands. This situation has forced NIH to impose a moratorium on adding fume hoods in individual laboratories in the Clinical Center - a policy that severely impacts both current and future research capabilities. Beginning in 1981, funds were appropriated for the Clinical Center Modernization Program to address the functional and architectural deficiencies within the existing Clinical Center. In FY 1991, the Clinical Center Modernization Program was reoriented to address life, safety and utility renovations, such as fume hood problems. To date, we have invested $70 million toward an overall $143 million effort to correct such problems. Of the $70 million, the majority was spent on correcting functional and architectural deficiencies.

Perhaps the most disruptive and costly impacts stem from seemingly minor repairs and renovations. For instance, the simple knocking down of a partition wall to combine two lab units in the Clinical Center is often a major undertaking. Asbestos is prevalent throughout the building and must be contained, and ultimately eliminated, when any disruption to it occurs. On average, it costs us $128 a square foot to renovate a lab module in the Clinical Center. By contrast, a typical lab renovation at facilities designed according to modern standards, such as the Salk Institute in California, costs only $50 per square foot. Besides the costs associated with asbestos removal, this difference is due to the age and the limited utility capacity of the Clinical Center, and by the extraordinary amount of infrastructure modifications that must be made for even the smallest change or addition. For example, to add a fume hood to a laboratory at the Salk Institute, they would simply bring the hood into the laboratory and connect it to the utility systems that run directly above the unit. By contrast, under the best conditions we must pull down the ceiling for the entire length of the corridor until we find a connector of sufficient capacity to accommodate the new hood, thus disrupting the work of a number of laboratories. Often we must undertake major renovations to create the capacity needed.

Fume hoods are but one example of the general problem that the Clinical Center has with providing for technologies that require local exhaust ventilation. Deficiencies in the building's air systems result is potential exposure of NIH personnel to hazardous fumes, and in the delaying of important research. For example, a laboratory located next to one of our surgery units was to be used for drug resistant TB research, but because of incorrect air flow, can not be used for this or any other infectious disease work.

In 1987 NIH initiated studies to examine the extent and severity of deficiencies in the Clinical Center's infrastructure systems. These studies indicated that the deficiencies were severe and widespread. Upgrading of the Clinical Center in terms of essential safety and health infrastructure needs was included in the FY 1991 Presidential budget submission.

In response to NIH's initial proposal to upgrade the Clinical Center and other laboratory facilities, the House Committee on Appropriations requested that the Secretary of Health and Human Services conduct a review of these needs in cooperation with other Federal agencies. The U.S. Army Corps of Engineers agreed to assess NIH's Facilities Revitalization Program regarding the extent of the problems, and the probable cost and time table for accomplishing the work. In their 1991 report, the Army Corps of Engineers Review Committee substantiated the extent of the overall problems identified in NIH's Facilities Revitalization Program.

Specifically, the review committee found that "the Clinical Center Complex is in serious need of major corrective action to resolve its facilities deficiencies. The Review Committee agrees that the utility systems within the Clinical Center Complex have deteriorated beyond reasonable repair. The systems are no longer reliable; they violate codes and regulations, and are difficult and costly to maintain; the capacity of the systems has been exceeded, and they do not provide adequate flexibility for modification or upgrade." The Review Committee concluded that NIH's proposed solution -- to upgrade the existing Clinical Center -- was not the best solution. Further, the Committee concluded that total replacement of the Clinical Center Complex is the optimal technical solution, although other reasonable alterations would be less costly. The Corps was not asked to address whether the scope and size of the current program is still appropriate. This question must be answered before proceeding.

Future steps to resolve facility problems at the Clinical Center will depend on the outcome of a review of the intramural research program by the new Director of NIH, the Assistant Secretary for Health, and the Secretary, DHHS. This review is in response to a request made in the House Report accompanying the FY 1993 Labor and Health and Human Services appropriation bill (H. Rept. 102- 708).

CONCLUSION

In conclusion, I believe that the future success of NIH's intramural efforts to improve the health of the American people rests in the hands of many: diligent scientists and doctors; engineers and electricians; and ultimately those of us who allocate resources provided by you and your colleagues.

This concludes my prepared statement. I would be pleased to respond to your questions.

**ATTACHMENT TO MR. FICCA'S PREPARED STATEMENT**

BUILDING HISTORY OF THE NIH

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|---|---|
| 1930 | The Ransdell Act redesignated the Hygienic Laboratory, located in Washington, D.C., as the National Institute of Health. |
| 1935 | Mr. and Mrs. Luke Wilson made the first of several land gifts that now form the nucleus of the present 320-acre Bethesda reservation. |
| 1930s - 1940s | The original buildings, constructed in the late 1930's to mid-1940's, consisted of a cluster of laboratories surrounding Building 1 (known as the James A. Shannon Building), which served as both a main administration center and power plant. |
| 1950's | The massive Clinical Center had been added, along with a new power plant, a warehouse, shops and laundry facilities, an extensive animal center, and other support structures. |
| 1960's | Several additional laboratory facilities were constructed for the NIH Institutes as well as for the Food and Drug Administration. In addition to these research buildings, a large office building, the National Library of Medicine, a computer center, and a surgical complex associated with the Clinical Center were added. A refrigeration plan was added in 1967 and expanded in 1971 to satisfy utility demands associated with these new facilities. |
| 1970's | Dynamic changes in research and clinical care have resulted in an ambitious program of new construction and renovation on the NIH campus since the mid-1970's, including:<br>• Expansion of the Computer Center in 1979<br>• The addition of the Lister Hill Center for Biomedical Communications in 1980<br>• Construction of the Ambulatory Care Research Facility (ACRF) as an addition to the Clinical Center in 1981<br>• A program for Clinical Center Modernization, begun in 1979<br>• A program to rehabilitate the oldest of NIH's laboratory buildings, begun in 1981<br>• Construction of a consolidated Child Health and Neurosciences facility, completed in 1993<br>• A program to upgrade NIH animal facilities initiated in 1986<br>• A multi-story addition to the A-wing of the Clinical Center for AIDS research, completed in 1992<br>• Construction of Phase I of the William H. Natcher Building, currently in progress |

PREPARED STATEMENT OF BILLIE J. McGARVEY

Mr. Chairman and Members of the Joint Committee, I am pleased to be here today to have the opportunity to discuss current facility conditions of NASA's laboratories which support the accomplishment of wide-ranging and cutting-edge research and technology development in aeronautics and space.

NASA's inventory of facilities is the springboard for our achievements. Many of our facilities provide the basic capabilities for conducting research, development and operation of space transportation systems, payloads and launches, and aeronautics and space science endeavors that provide the opportunities for commercial developments in the private sector. Proper maintenance and repair of these facilities, as well as the "revitalization" of older facilities, are fundamental to ensuring that NASA's installations are optimally available for the agency and others to accomplish their missions.

**Overview of Facilities Inventory**

The Agency's facilities supporting research, development, and flight activities are located at nine major Centers and nine component installations throughout the United States. NASA's Centers and other activities are made up of over 2,700 buildings and 3,200 other major structures, and encompass 36 million square feet of space. The FY 1993 current replacement value (CRV) of these facilities is $14.7 billion. Approximately 1,025 of these buildings and structures are identified as Research and Development facilities that comprise over 17 million square feet and $6.7 billion in current replacement value at eight major Centers and three component installations. Many of NASA's facilities are 30-50 years old and are in their second to third life-cycle for major component systems.

**Past Studies and Reports**

In 1990, the Building Research Board of the National Research Council, published "*Committing to the Cost of Ownership,*" a report on maintenance and repair activities of government agencies. The report concluded that the country's public buildings and facility systems are national assets" that are being "systematically neglected." The report included findings and recommendations that:

1. Underfunding of maintenance and repair (M&R) is a widespread and persistent problem. M&R budgets should identify explicitly routine M&R requirements and activities to reduce the backlog of deferred deficiencies. Appropriate budgets for routine M&R should typically be 2-4 percent of the CRV of those facilities.
2. Formal facility condition assessment programs should be implemented by agencies responsible for M&R budgets.

At the request of the Subcommittee on VA, HUD and Independent Agencies, Senate Committee on Appropriations, GAO previously evaluated the condition of NASA facilities. After visiting the major NASA centers, their report in December 1990, contained the following observations:

1. Many of NASA's facilities were not adequately maintained and were in degraded condition.
2. Annual surveys to determine maintenance and repair requirements needed to be performed, and far fewer funds than the 2-4 percent of facilities' CRV that generally accepted maintenance guidelines dictate were invested.
3. Procedures for budgeting and accounting for maintenance resources were not always adequate. Maintenance and repair budgets were not always set by actual needs and did not always accurately account for all maintenance and repair expenditures.

**NASA's Actions in Response to Past Studies and Reports**

In response to this and other in-house studies, NASA developed and published a new Agency policy and handbook on facilities maintenance, instituted regular formal condition assessments of the facilities inventory, revised the cost accounting codes, and implemented the tracking of M&R expenditures on a continuing basis and now conducts annual agencywide maintenance workshops.

Our most recent initiative has been the establishment of an Agency "benchmarking" team to apply selected Total Quality Management principles in support of the program. Surveys have been conducted of a cross section of private sector businesses and visits have been recently completed at the corporate headquarters and laboratories of the 3M and Du Pont companies. Future benchmarking is also planned with other government agencies.

**Maintenance and Repair**

NASA's funding of M&R, expressed as a percentage of CRV, has progressively increased from 1.7 percent in FY 1989 to 2.2 percent in FY 1992. The projected expenditure for FY 1994, subject to final passage of the NASA budget, is 2.6 percent of the CRV. Although these figures are for the entire NASA physical plant, the Research and Development facilities are in the same range. The total M&R effort was approximately $313 million in FY 1992.

Maintenance and center funded repairs are funded by the NASA Program Offices from their Research and Development, and Space Flight, Control and Data Communications budgets. The Center level funded portion of the M&R effort was approximately $243 million and the Construction of Facilities (CoF) funded repairs included $70 million.

**Backlog of Maintenance and Repair**

The Office of Space Flight (OSF) performed detailed facilities condition assessments during 1991 and 1992 at NASA's Space Flight Centers-- Kennedy Space Center, Johnson Space Center, Marshall Space Flight Center and Stennis Space Center. An approximate $831 million backlog of maintenance and repair requirements was identified. This estimate represents a comprehensive assessment of all Space Flight facilities using a standard industry- based, multi-disciplined approach.

The Office of Aeronautics performed a similar assessment of NASA's Aeronautics Research Centers at the Langley, Lewis, and Ames Centers. They identified a roughly $500 million backlog of maintenance and repair.

The remaining $300 million of a total estimated backlog of $1.6 billion was empirically calculated from the CRV for the Goddard Space Flight Center and the Jet Propulsion Laboratory. The estimated backlog for the Research and Development facilities only is $7 1 8 niiilion.

**Impacts on Research and Development Activities**

In the majority of cases over the years, the actual impact of the condition of facilities on the Agency's Research and Development activities has been delays or the necessity for conducting activities in an inconvenient and inefficient manner. However, it has normally been the exception that NASA has been unable to perform Research and Development activities as a direct result of the condition of facilities. The following illustrates some individual site experiences and observations regarding maintenance and repairs of major research and test facilities.

Langley Research Center

Langley Research Center (LaRC) is NASA's oldest Center. Many of it's facilities are over 50 years old and some are 75 years old. They contain numerous original components and systems that have become obsolete. Despite the age of LaRC research facilities, their excellent maintenance program has kept many obsolete facility components in operable condition. However, as replacement parts become less available, the equipment becomes more difficult to keep at full operational status. Critical spare parts are not available for many facilities and failure of one-of-a-kind equipment can require a long time to repair or replace.

In 1989, NASA implemented a structured multi-year aeronautical facilities revitalization program within the CoF program to restore and modernize aeronautical

Research and Development facilities at Ames, Lewis, and Langley Research Centers. Roughly $300 million was appropriated for this effort through FY 1993, and LaRC received approximately $59 million. These funds were used to replace worn out and obsolete components and to enhance operating reliability, quality, and productivity of research. This effort included the Hypersonic Facilities Complex, six major wind tunnels, and the high pressure air distribution system at Langley.

To better concentrate available resources on the most productive facilities and enhance the ability to serve industry, LaRC has either closed, or is considering closure of, some of its older facilities. The 7x10 foot High Speed Tunnel (48 yrs. old) was closed in 1993; the 8 foot Transonic Pressure Tunnel (40 yrs. old) and the 30x60 foot Tunnel (63 yrs. old) are under consideration for closure within the next two years.

In summary, LaRC facilities are old and contain many obsolete components that have been maintained in operational condition through an aggressive maintenance program. LaRC does experience periodic breakdowns that impact industry and NASA research, and the risk will continue to grow with time.

Ames Research Center

At the Ames Research Center (ARC), the benefits of the aeronautical facilities revitalization program are coming to fmition. The 12 foot Pressure Wind Tunnel Restoration Project (approximately $102 million) is nearing completion and the facility will be placed in operation in FY 1995. This restoration project will return this unique facility to its original operating pressure level of 6 atmospheres and will provide a two to three fold increase in productivity over the original tunnel. The Unitary Plan Wind Tunnel Modernization Project (63 million dollars) is now entering the initial construction phase. This project will modernize major portions of the original equipment, which has been in continuous operation for 40 years, and will provide a 50 percent increase in productivity over the original tunnel.

Major breakdowns and lengthy repair incidents result in unplanned down-time of key facilities. Down-time of major test and development facilities affects both efficiency and the ability to meet program schedules. Since the operational crews are idle during down-time, there is also a significant loss in efficiency. Down-time can affect program schedules in two ways. If the testing window is constrained and cannot be changed, a reduction in the scope of the testing invariably results. If the schedule can or must slide, then testing time is extended, which incurs additional cost to the clients, both in direct support of the test and in the costs associated with the design team. The down-time causes all other tests on the schedule to slip, or to search for alternate facilities if a slip is intolerable. Down-time also reduces the throughput by reducing the number of tests that can be accomplished during the occupancy year.

Lewis Research Center

The aeronautical facilities revitalization program at the Lewis Research Center (LeRC) consisted of a number of rehabilitation projects to Lewis' aeronautical testing facilities and centralized support systems. Some typical examples are: Rehabilitation and modification of the 10x10 Supersonic Wind Tunnel, Hypersonic Test Facility, 8x6 Supersonic Wind Tunnel/9x15 Low Speed Wind Tunnel, Icing Research Tunnel and refrigeration system, Propulsion Systems Laboratory, and the rehabilitation of the Central Air System and Altitude Exhaust System.

In general, the major factor contributing to the concern over readiness of the research facilities and support systems at the Lewis Research Center is the age of critical systems. Several major systems contain large rotating machinery and electrical equipment that is 40-50 years old. While this equipment is functional, its age requires more maintenance attention and the risk of failure requiring repair is greater. Typically in the high voltage electrical power system, Lewis is operating transformers and other critical gear beyond the normally expected useful service life. Despite the additional maintenance effort expended over the past few years, some maintenance deficiencies have been responsible for several component failures that have adversely impacted research completion dates.

The benefits from the aeronautical facilities revitalization program along with the increased emphasis on facilities maintenance has resulted in a 50 percent increase in productivity today as compared to the conditions prior to revitalization program. The past rehabilitation projects have played a major role in the productivity increase.

Space Flight Centers

NASA's Space Flight Program has three field Centers and one field installation that have significant Research and Development capabilities that were surveyed by the GAO. They are: the Johnson Space Center, Marshall Space Flight Center, Stennis Space Center, and the White Sands Test Facility.

Over two-thirds of the Space Flight laboratories identified in the survey were constructed in the 1963-1972 time period. Another 16 percent of these facilities were constructed during the 1953-1962 time period. As such, these laboratories face many of the facility maintenance and repair problems one would expect from facilities extensively used and of this age. Many obsolete and worn out building systems, are reflective of an infrastructure that is over 30 years old. Within this framework, the condition of Space Flight Research and Development laboratories are considered as fair with facility equipment in a somewhat lesser state. However, the fact that these Research and Development laboratories still perform their missions despite the age of the facilities and supporting systems attest to the maintenance staffs' ability to stretch the systems beyond normally expected life cycles.

These Centers have experienced infrastructure and equipment failures such as thermal cyclic fatigue in large and complex piping systems, corrosion and cyclic fatigue that reduce the reliability of engine exhaust deflectors and require extensive repairs to assure engine test reliability. Large chiller units have failed and threatened vital tests and required the set up of temporary chiller systems. Electrical control systems have failed, many with obsolete parts requiring significant rework and impacting operational capability. Despite these facility and system breakdowns, the performance of Research and Development has continued with the recognition that the performance margins are extremely narrow now and that long-range planning is required to assure that the labs are available for the future.

**Revitalization**

Revitalization is a critical component of NASA's infrastructure investment. It is the renewal effort applied to the existing overall facility inventory that extends the useful service life beyond the original design life. This effort focuses on restoring and modernizing the existing plant, including remediation of environmental damage. This does not include the routine maintenance requirements.

Revitalization can be expressed in either of two ways, as an annual percentage rate or renewal frequency. Both are derived in relation to the CRV of NASA's facilities inventory. The annual percentage rate is determined by dividing the yearly revitalization funding by the CRV, multiplied by 100. The renewal frequency in years is obtained by dividing CRV by yearly revitalization funding.

Within NASA, our revitalization efforts include major restoration and modernization projects, minor repair and rehabilitation/modification projects, and environmental remediation projects. The current FY 1994 budget includes approximately $233 million for revitalization. This investment translates to 1.5 percent of the CRV and an annual renewal cycle of 65 years.

**The Future of Facilities Maintenance and Repair**

The present constrained budget climate poses significant challenges in maintaining recent internal funding augmentations and improvements in the facilities maintenance and repair program. Our efforts will continue to identify increased efficiencies in execution, state-of-theart facilities maintenance practices, and opportunities for consolidating or mothballing appropriate facilities to conserve the available resources so that they may be redirected to the most effective areas.

That concludes my statement, Mr. Chairman. I will be happy to answer any questions that you or the other Members of the Joint Committee may have.

**PREPARED STATEMENT OF JOSEPH P. MARTINO**

Good morning.

I am Dr. Joseph P. Martino. I am a senior research scientist at the University of Dayton Research Institute. The opinions I will present are my own and do not necessarily represent those of my employer.

My background includes service in government laboratories and in a university research institute, as well as scholarly research on the management of research and development (R&D). During my Air Force career, I served two tours of duty in the Avionics Laboratory at Wright-Patterson AFB, Ohio, and one tour of duty in the Office of Research Analyses, then at Holloman AFB, New Mexico. I served two tours of duty at Air Force Office of Scientific Research, in Washington, DC, as a project officer with fund-granting responsibility. My final assignment was as Director of an engineering organization with a staff of over 200 people. Since retiring from the Air Force eighteen years ago, I have held a full-time research appointment at the University of Dayton Research Institute, where I have been supported by grants and contracts from government and industry. I have written numerous articles on the management of R&D, and since 1969 have served on the editorial board of the journal, *Transactions on Engineering Management,* published by the Institute of Electrical & Electronics Engineers. My book, *Science Funding,* was published in 1992 by Transaction Publishers.

Of particular relevance to today's hearings, I am currently the Principal Investigator on a contract between the University and the State of Ohio to find ways to commercialize the Mound Facility, a Department of Energy research and production facility located near Dayton, which is scheduled to be closed. This contract was the result of an unsolicited proposal which I submitted to the state government.

The General Accounting Office has prepared a report which documents the poor condition of many Federal laboratories. This is being presented as a need for repair and upgrading of these laboratories. I am here to suggest an alternative -- that instead of being repaired, they simply be closed down.

My remarks today will cover four main points.

1) One of the serious risks associated with Federal labs is that they will become mediocre and inefficient, as a result of porkbarrel funding.

2) Another of the serious risks associated with Federal labs is that if they do not become mediocre, they will become an unwarranted subsidy to specific industries.

3) If a Federal lab is to serve the needs of industry effectively, it must be privatized.

4) This is not the first time we have faced the issue of what to do with no-longer-needed Federal labs. We can learn from history.

I will illustrate each of these points with examples.

MEDIOCRE LABS

The Department of Agriculture is probably the prize example of mediocre or even poor science in the Federal Government. It was established as a subsidy to farmers, not as support for science. Its R&D funding is distributed to the experiment stations in the various states according to a formula which owes everything to politics and nothing to either the economic importance or the scientific merit of the research being performed. There is no peer review of the quality of the work, and no evaluation of its importance to American taxpayers.

Since 1972, there have been at least half a dozen major reviews of Department of Agriculture in-house research. Three of these were by the National Academy of Sciences, and one was by the General Accounting Office. Every one of these reviews had harsh criticisms of the Department's research. The 1972 NAS report said, "much of agricultural research is outmoded, pedestrian, and inefficient." One of the reviewers taking part in the 1987 study said, "It was one of the most depressing things I ever saw. . . We saw hundreds of millions wasted on people who haven't published in 20 years. It was appalling." Another member of the review committee said, "USDA loses many good people even though the money is easy. They are bound up in paperwork. It is a depressing environment." A former researcher at the Beltsville (Maryland) Agricultural Research Center, now at a university, said that many ARS scientists "leave after a few years or stay forever." The clear implication is that in most cases, it is the good ones who leave after a few years; the ones who stay forever tend to be those who aren't good enough to find employment elsewhere. The good ones who stay a long time are the exception, not the rule.

A year ago, the National Research Council began yet one more study, this one to last three years, of the agricultural experiment stations. A primary reason for the new study is that despite the strong criticisms leveled by previous studies, little has been done to fix the problems.

Why has so little changed? Why, despite over two decades of studies, has the Agricultural Research Service remained in such a dismal state? Largely because its funding is driven by porkbarrel politics rather than science. As someone has remarked, the only time you can close a research station is when a congressman dies or is defeated. Providing researchers with lifetime job security but depriving them of the opportunity for meaningful work is a perfect recipe for driving out the competent people while retaining the time-serving hacks.

This experience with the Department of Agriculture is significant for the future of the Federal labs. Keeping them open for the sake of keeping them open is to condemn them to the mediocrity of the Agricultural Research Service. We don't need another expensive but second-rate scientific establishment in the U.S.

SUBSIDIES TO INDUSTRY

As already noted, the Agricultural Research Service was established as a subsidy to farmers. However, it is not the only R&D agency whose primary mission is to subsidize a specific industry. The Office of Aeronautics & Space Technology (OA&ST) of the National Aeronautics and Space Administration (NASA) is the direct successor of the National Advisory Committee for Aeronautics, which was established to advance aeronautical technology. Today, slightly less than half of OA&ST's operating budget, and nearly two-thirds of its facilities budget, goes for aeronautics.

This subsidy to the air transport industry is not something hidden. It has been stated explicitly as national policy by the Office of Science and Technology Policy. One stated goal of that policy is to develop the technology which would allow a "fuel-efficient, affordable" subsonic aircraft to be flown by U.S. airlines and to capture the foreign airline market. Another stated goal of that policy is to develop the technology for "sustained supersonic cruise capability." A third stated goal is to develop the technology for a "trans-atmospheric" vehicle "to routinely cruise and maneuver into and out of the atmosphere with takeoff and landing from conventional runways."

For nearly four decades, U.S. aircraft manufacturers have been the pre-eminent suppliers to the world's airlines. How did that come about? To what extent was OA&ST and (earlier) NACA responsible for that situation?

Ronald Miller and David Sawers have identified six innovations, dating from 1927 to 1935, which made possible the "economic airplane" and therefore the start of the airline industry. These were the NACA cowl, the all-metal structure, streamlining, the variable-pitch propeller, wing flaps, and engines of high power. Only one of these six, the NACA cowl, was due to NACA. The others were all developed by industry, in some cases with partial military funding.

An interdepartmental study conducted in 1972 identified thirteen innovations, introduced between 1925 and 1940, that were important to aviation generally. These included the radial engine, high-octane fuel, supercharging, the controllable-pitch propeller, retractable landing gear, stressed-skin construction, high-strength aluminum alloys, high-lift flaps, the auto pilot, the NACA Standard Atmosphere, wing de-icing equipment, cabin pressurization, and two-way radio communication. Only three of these came from NACA. All the rest came from industry, with (in some cases) part military funding.

Total U.S. R&D spending on aeronautical research from 1925 to 1975 far e ceeded that of NACA/OA&ST. Military and industry spending were roughly equ and amounted to about 95% of the total. NACA/OA&ST funding came to about 5 of the total.

This research paid off handsomely. From 1925 through 1975, productivity of bot capital and labor in the airline industry grew by about twenty-five times. The paybac from aeronautical R&D, in the airline industry alone, was about thirty times greate than would have been obtained by investing the same money in high-grade industria bonds. All other benefits to society were in addition to this.

Given that most important aeronautical innovations came form outsid NACA/OA&ST, that NACA/OA&ST funding amounted to only about 5% of the total, and that the payback from aeronautical R&D far exceeded the amounts spent, it is clear that this subsidy to the airline industry was totally unwarranted. The issue is not that NACA/OA&ST didn't do good work. It did do good work. The issue is that the airline industry alone achieved cost savings which would have justified the aviation industry in funding that research even if NACA/OA&ST had never existed. Instead of the aviation industry funding the research, however, we found middle-class taxpayers subsidizing the airline flights of the jet set.

This experience with NACA/OA&ST is significant with regard to the future of the Federal labs. Even if they do good work, the benefits to the affected industries will be sufficient that the industries could afford to fund the research themselves. Changing the mission of the Federal labs, to support specific industries, is an unwarranted subsidy even if the labs avoid the problems of mediocrity.

PRIVATIZING

The Department of Energy's Mound Facility, in Miamisburg, Ohio, is a laboratory in everything but name. Because it includes manufacturing capability, DoE refers to it as a "facility" rather than a laboratory. This installation is scheduled to be closed in 1995, and its several missions transferred to other DoE installations. The State of Ohio wishes to retain the high-technology capability of Mound, and has contracted with the University of Dayton to identify those Mound capabilities which have commercial potential, and to identify the commercial markets for these capabilities. A follow-on contract will provide funding for the development of business plans for those capabilities which appear to be commercially viable.

Our findings in the effort to commercialize Mound capabilities have significant implications for any proposals to keep the Federal laboratories open but to convert them to commercial R&D.

One finding is that the regulatory environment in which Mound operates is incompatible with a commercial venture. Mound has in the past performed what DoE calls "work for others," primarily for the Department of Defense but also for other government agencies. Obtaining approval for this work has been time-consuming and inefficient. It has often taken 12 to 24 months for DoE to approve contracts between Mound and the military Services. It is clear that if Mound were to remain a DoE facility, it would be impossible for it to respond to the demands of commercial markets. For Mound to operate effectively in commercial ventures, developing and marketing new products, it is essential that Mound be privatized.

Another finding is that the cost structure imposed by DoE overhead would make it impossible for Mound to compete for business with private firms. Each research or production activity at Mound is burdened by an enormous overhead cost which results directly from DoE regulations. In many cases the people at Mound simply have no idea of what a given activity costs, or how to charge for it if it were offered commercially. One of our tasks under the follow-on contract will be to help identify the real costs of doing business at Mound, and gain a better idea of how competitive Mound could be if the DoE-mandated overhead were removed.

Yet another finding is that the slow-moving DoE bureaucracy would make it impossible for Mound to act quickly to alter its internal structure or processes. As one example, Mound has installed a sophisticated and very costly X-ray inspection device. This is a standard product, bought commercially and used widely in industry. Nearly two years after installation, the DoE has still not approved it for operation. By contrast, industrial firms typically have identical similar devices in operation within 30 to 45 days after installation. No private firm could afford to pay the capital costs of such a piece of equipment and then let it sit idle for two years while the bureaucracy slowly churns through the approve process.

Perhaps the best way to summarize our findings regarding the Mound Facility is that its complete closure by DoE makes it both necessary and possible to privatize some of its capabilities. If instead the DoE workload were to be reduced but not eliminated, and commercial work sought as a supplement to the DoE work, it would be impossible for Mound to compete effectively because of the DoE regulatory environment and the DoE overhead cost structure. The same will hold true for any attempts to open the Federal labs to commercial work. The bureaucracy, the regulations, and the overhead will inevitably make the labs noncompetitive.

PRIOR HISTORICAL EXPERIENCE

This is not the first time the U.S. has faced the issue of what to do with no-longer-needed Federal laboratories. During World War II, many laboratories were established to carry out R&D necessary for the war effort. Some of these, particularly those dealing with atomic weapons, were kept in existence to meet the needs of the Cold War. Many, however, were simply closed at the end of the war.

One of those laboratories closed was the Radiation Laboratory at Massachusetts Institute of Technology. This laboratory was highly successful in developing surface and airborne radar equipment, and control systems for anti-aircraft guns. The RadLab carried these to the pre-production stage before turning them over to industry. The RadLab-developed SCR-584 radar, with its associated gun-control servomechanisms, was a major contributor to the defeat of the V-1 "buzz bomb" threat during the last few months of World War II in Europe.

At the end of the war, the Radiation Laboratory was simply disbanded. Most of its personnel returned to industry or to academia, some of the latter staying at MIT and others going elsewhere. Some of these former RadLab people founded new labs, such as the MIT Instrumentation Laboratory (now the Draper Laboratory), which developed auto pilots, flight control systems, and inertial navigation systems for aircraft, missiles, and spacecraft.

The wartime work of the RadLab was summarized in a series of twenty-some volumes which were widely used as handbooks and textbooks for at least fifteen years after the end of the war. I used several books out of that series as texts when I attended graduate school in the mid-1950s.

In short, disbanding the Radiation Laboratory resulted in the massive transfer of its wartime-developed technology to industry, to academia, and to a new generation of students. This result is not surprising. Numerous studies of technology transfer have confirmed that one of the most effective ways to transfer new technology to potential users is to transfer the people who developed it.

The implication of this experience for the Federal labs, especially those which are no longer needed for military purposes, is that they should simply be closed. If some portion of their activity is still needed for military purposes, they should be downsized or that portion of the mission transferred to labs which are being kept open. The experience of history is that the no-longer-needed labs should *not* be kept open and converted to commercial work. The best way to commercialize their capabilities is to transfer their people to industry and academia.

CONCLUSIONS

The Federal labs have reached a critical point in their history. Keeping them open will require a significant investment in buildings and equipment. Instead of automatically assuming that they should be kept open, we have the opportunity to rethink their status. Some of their missions will still be required for national defense. Those missions should be consolidated, or where transfer of a mission is not possible because of unique local conditions or the existence of specialized equipment which does not yet require replacement, the labs should be downsized to retain only those unique capabilities. Those labs no longer needed for their original missions should simply be closed. They emphatically should not be given a totally new mission, in a misguided attempt to somehow "save" their capabilities. At best that would lead to an unwarranted subsidy for industries which can afford the research themselves. More likely, it would lead to expensive mediocrity. We cannot afford to waste precious R&D dollars on subsidies to industry or on second-rate laboratories.

**QUESTIONS AND ANSWERS**

## Under-Investment in Maintenance and Repair

The Building Research Board of the National Research Council suggested in their 1990 report Committing to the Cost of Ownership that agencies should spend between 2% and 4% of facility replacement value on general maintenance and repair. Only 2 of the 11 agencies surveyed met even the lower bound of this range. However, simply meeting the required level of maintenance and repair spending alone is not sufficient. Meeting the required level will prevent further deterioration, but will not reduce the backlog or improve existing conditions. Furthermore, the suggested range is for all government facilities, such as offices or schools. Laboratories are special-use facilities with higher maintenance and repair requirements. Some estimate that private sector labs spend 5-9% of facility value on maintenance.

1) How inadequate is maintenance and repair spending? How much more money is needed?

**(Answer: Just over $100 million is needed to reach the 2% threshold. A total of $960 million would be required to meet the 4% level.)**

2) Is the required maintenance and repair spending range of 2% to 4% of facility replacement value appropriate for laboratories? is a higher level needed because of the special requirements of laboratory facilities?

**(Answer: in the GAO report, the agencies basically said that 2% was sufficient. This however differs from what private sector labs are thought to spend.)**

## Old Age of Federal Laboratories

More than half of federal laboratories were constructed more than 30 years ago and fully three-quarters are more than 20 years old. Because of their age, many laboratories are nearing the end of their useful lives and have correspondingly higher maintenance and repair requirements. These higher requirements increase the cost of operating the laboratory and increase the amount of research time lost as repairs are made. Furthermore, the older the facility the higher the chance of a major system failure. For instance, a electrical failure at NASA's Lewis Research Center caused some laboratories to be closed for 6 months and limited the use of the facility's wind tunnel.

1) As I understand it, more than three-quarters of federal lab space was constructed more than 20 years ago. what is the average useful life of a laboratory?

**(Answer: The is no generally accepted answer - however, 20 years is frequently quoted.)**

2) To what extent are poor laboratory conditions caused by the old age of the facilities?

**(Answer: The old age of the laboratories is a significant factor.)**

3) How does the old age of the facilities impact maintenance and repair requirements?

**(Answer: The older a facility the higher the cost of maintenance and repair. Age also increases the possibility of major failures.)**

### Technical Obsolescence

Many laboratories were up to date when they were built in the 1950s, 1960s and 1970s. However, advances in scientific technology have made these once state-of-the-art facilities obsolete. Many labs lack the heating, cooling, ventilation and electrical capacity required for modem laboratories. For instance, several of the labs at Beltsville Agricultural Research Center and NIH do not meet the current standard of 10 to 15 air exchanges (complete transfer and replacement of air) per hour. The problem of technical obsolescence has been compounded by the conversion of non-laboratory facilities into labs. At Beltsville they have converted sections of greenhouses and even pig barns into labs. At NIH an alleyway was covered with a roof and converted into a lab. Few of these converted facilities meet scientific standards.

1) Does the existing stock of federal laboratories meet current engineering and scientific standards?

**(Answer: Some do and some don't, it depends on the agency and the lab. Few government laboratories are as well built, maintained or equipped as university or private sector labs.)**

2) To what extent does the old age of federal laboratory facilities reduce their technical capacity?

**(Answer: The old age is the major factor limiting productivity. Technological advances have made many government labs obsolete.)**

### The Backlog of Facilities Needs

The GAO study found a backlog of laboratory maintenance, repair and upgrade needs ranging from $3.8 billion to $4.5 billion. The backlog consists of a wide range of problems, including everything from minor repairs such as replacing leaky windows - to compete renovation to new construction - like the NIH Clinical Center.

Three agencies, the Department of Energy, NASA and the Agricultural Research Service, account for approximately three quarters of the total backlog. The Agricultural Research Service laboratories are in the worst overall shape, with the backlog representing 40 percent of the replacement cost of all facilities.

1) Can you discuss the nature of the $4 billion backlog of facilities maintenance, repair and upgrade needs? What kinds of projects are included in this backlog?

**(Answer: All types of projects are included. They are as small as repainting a lab and as large as replacing NIH's Clinical Center.)**

2) How long would it take for the federal labs to eliminate this backlog?

**(Answer: They can't with existing budgets. More money is needed.)**

### The impact of Poor Laboratory Conditions

### Federal Laboratory Research

It is impossible to quantify the cost of poor laboratory conditions on research activities. Poor laboratory conditions have forced researchers to duplicate experiments and have limited the ability of some labs to attract and keep scientific personnel. In some cases poor conditions have prevented laboratories from doing certain types of research - for instance, due to the lack of suitable lab space, NIH lacked the ability to respond quickly to the need for research on drug resistant tuberculosis. in the worst cases, poor conditions have caused experiments to be ruined or results lost. Clearly, factors that limit the ability of labs to perform the types of research they need or cause experiments to fail come at some cost.

1) How do poor laboratory conditions impact the scientific capabilities of the federal labs? is there a way to assess the costs to the government and the economy?

**(Answer: there is no way to quantify the impact. However, this question will give GAO and the representatives of the labs a chance to discuss the impact of lab conditions on their work and enter examples of problems into the record.)**

## Reinventing Government

Some of the infrastructure problems with federal labs are caused by red tape and bureaucracy. No set policies for maintaining government facilities exist. At the labs, maintenance and repair must directly compete with research programs for scarce funds. As a result, maintenance and repair is frequently underfunded. In some cases, -maintenance and repair budgets are so limited that scientists must pay for repairs with research funds, as at Beltsville Agricultural Research center. At some EPA laboratories maintenance budgets are so -adequate that each program must pay a "toll" (a percentage of their research budget) to the maintenance department. Frequently, funds are not made available until a major system failure occurs. Then entire systems must be repaired or replaced - at a much higher cost than if there had been regular maintenance.

Delays in agency, OMB or Congressional approval of major facility repairs or upgrades has also been a significant problem. For instance, around 1980, the Air Force's Wright Laboratory proposed a $35 million expansion of its avionics laboratory. The lab was advised to divide the project into three construction phases in order to speed the approval process. Phase I was approved in the 1992 budget, Phase II in the 1994 budget but Phase III was pushed back to the 1997 budget. Assuming Phase III is completed, the simple expansion of a laboratory will have taken over 20 years.

In response to these problems, agencies are developing formal facility maintenance, repair and upgrade plans. However, plans are of little use if they are not adequately funded. Congress should insist that all federal facilities have adequate maintenance and repair plans and budgets.

1) What organizational and administrative factors led to the infrastructure problems at the federal labs? what can Congress do to prevent or solve these problems?

**(Answer: Agencies are working to develop procedures for maintenance, repair and upgrades. NIST, NOAA and NASA are assessing agency-wide facilities needs. All agencies have plans. The main problem is funding and approval of major projects. An alternative is a required level of maintenance and repair spending - like the Building Research Board's suggested range of 2% to 4% of replacement value).**

## Beltsville Agricultural Research Center (BARC)

BARC is the oldest and the largest of the Agricultural Research Services labs. More than 77% of BARC's facilities are more than 50 years old. Because of the old age of the facilities and acute underfunding of maintenance over the past several years, BARC has some of the most serious infrastructural problems in the federal laboratory system.

Most of BARC's laboratory space is old and does not meet current scientific standards or program needs. Expanding research needs, combined with a lack of new construction funds, forced the conversion of a variety of non-laboratory facilities into labs. Even the headhouses (potting rooms) of greenhouses and pig barns have been converted into labs. Many of the laboratory facilities are wholly inadequate. In one basement lab, equipment has been placed on stilts to keep it from being damaged from periodic floods. In another, rain from a leaky roof damaged computer equipment. The center consists of over 890 separate structures. Program laboratories are frequently dispersed into several different buildings - causing scientists to shuttle back and forth. Difficulties with the ventilation system in the center's bioscience building have caused respiratory problems with some researchers.

Despite the poor conditions, BARC is a national - even international - leader in some fields. BARC's nutrition center is a leader in nutrition research and has the only Calorimeter - a device to measure human calorie expenditures - in the United States. However, infrastructural problems limit the scientific capabilities of the nutrition center. BARC is seeking funding for a new nutrition center.

BARC is in the midst of a $205 million modernization program. Congress has made $70 million of this available.

1) How do conditions at BARC impact the center's scientific mission?

2) How much money is needed to address the center's facility needs?

**(Answer: $150 to $200 million.)**

3) How do infrastructural problems hinder the Nutrition Center's ability to meet new research requirements?

**(Answer: They would like to get the nutrition center project entered into the record.)**

### The National Institutes of Health (NIH)

On average, NIH laboratories are in better shape than most other agencies. The backlog of facility needs is small and maintenance and repair budgets are considered adequate. However, some problems do exist. The National Heart, Lung and Blood Institute's labs have almost all of the problems experienced at other labs. The most pressing infrastructural need at the NIH is a new clinical center. The existing clinical center is 38 years old. The fire safety, electrical power, lighting, ventilation, air conditioning and plumbing stems all have insufficient capacity to meet current and future needs. in 1991, an Army Corp of Engineers committee endorsed the construction of a new clinical center as the best long term solution.

1) How have laboratory conditions impacted the scientific mission of NIH?

2) What is NIH's most pressing infrastructural need - what studies have been done to assess these needs?

### The National Aeronautics and Space Administration (NASA)

While NASA has a relatively large ($718 million) backlog of maintenance and repair needs, the agency still provides a good example of how to address the problems of poor facilities conditions and underinvestment in maintenance and repair. NASA listed inadequate maintenance of laboratories and facilities as a material weakness in its Financial Integrity Act reports for 1989-1991. A 1990 GAO study found that many NASA facilities had not been adequately maintained and were in degraded condition. However, since 1990, NASA increased maintenance and repair funding to the 2% level suggested by the Building Rematch Board. The agency no longer lists maintenance as a material weakness. In 1992, NASA instituted a facility plan to assess both the needs and conditions of its laboratories.

1) It seems from reading the GAO report that NASA has developed programs to assess and improve laboratory conditions. what makes NASA's maintenance, repair and upgrade procedures successful?

2) What can other agencies learn from NASA's efforts to improve facility conditions?

**(Answer: The purpose of the first two questions is to publicize some of the policy changes needed to correct the infrastructure problems.)**

3) How have laboratory conditions impacted the scientific mission of NASA?

**RESPONSES TO THE ARGUMENTS FROM THE REPUBLICAN WITNESS**

SUMMARY

Dr. Martino makes the basic argument that federal funding distorts science and that the government should "privatize" the funding of science. He is not directly critical of federal labs in his book, his main criticism is of scientific earmarking.

FEDERAL LABS

Dr. Martino does not attack the federal labs in his book. in fact, the only quote in his book mentioning the labs is positive. He says that "the end result [of technology transfer from federal laboratories will be that the taxpayers will receive double benefit from federal in-house R&D: the accomplishment of the mission for which the R&D was performed; and technology transfer to the private economy."

SCIENTIFIC EARMARKING

Dr. Martino's opposition of scientific earmarking is shared by most of the science and technology community because it uses scarce research funds for non-peer reviewed projects at the expense of more meritorious projects. in 1992, Congress earmarked $993 million for R&D and research facilities - less than 2% of total science and technology funding.

ARE THE ARGUMENTS FOR GOVERNMENT R&D FALSE?

In his book, Dr. Martino questions the argument that firms underinvest in R&D. He feels that firms must adequately invest in R&D to remain competitive. This argument ignores the difference between basic research (high risk research on new scientific breakthroughs) and applied research and development (research on improving a technology or creating a product). While firms must invest in applied research and development or fall behind their competitors, they have little incentive to invest in basic research because the results are easily duplicated by their competitors. Also, today's smaller high technology firms do not have the resources to support basic R&D. Finally, the government, which does not need to show an immediate return on an R&D investment, is better able than the private sector to conduct risky basic R&D.

Dr. Martino also argues that the government should not support R&D because: 1) there is no way of determining how much R&D a country needs; and 2) even if the amount could be measured, "government failure" would prevent the public sector from reaching that amount. These arguments amount to saying that since we don't know how much we need - we shouldn't do anything.

DOES GOVERNMENT FUNDING DISTORT SCIENCE?

While it is true that politics do impact the funding of science projects and that earmarks sometimes fund poor quality research, Martino himself points to the many successes of the U.S. science and technology system. The United States leads the world in most fields of science, holds the most Nobel prizes and other scientific awards, is the international center for science education and has the strongest high technology sector. All of this was accomplished with the current system of mixed government-private sector funding of R&D. While there are problems, we still have the best system in the world.

SHOULD THE GOVERNMENT PRIVATIZE ITS SCIENCE ROLE?

Dr. Martino will make the argument that the private sector, philanthropies and the general public should replace government science funding. Because of the magnitude of government spending ($66 billion and 43% of total national spending) it is unlikely that government funding could be fully replaced. Private sector R&D spending would have to nearly double to replace government funding. Furthermore, the private sector now depends on the government for most basic research (the government funds 63% of national basic R&D). As for private citizens and philanthropies, they spend less than $3 billion on R&D and account for less than 2% of total national

R&D. it is unlikely that they could take over for government. Finally, there are national science needs - such as defense and health research - that can not be completely met by the private sector.

1) Given that the federal government currently funds 430/0 of total R&D and spends over $60 billion on R&D - can the private sector replace it as a source of funds?

**(Answer: No, all other sources of R&D funds would have to nearly double. Furthermore, the U.S. currently spends a lower share of GNP on R&D than our major competitors - 2.7% in the U.S. compared to 3.00/0 in Japan and 2.9% in Germany. Reduced government R&D support would enlarge this gap - reducing national competitiveness.)**

**ADDITIONAL MATERIAL SUBMITTED FOR THE RECORD**

# REPORT ON THE ACTIVITIES OF THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

NIST

National Institute of Standards and Technology
Technology Administration
U.S. Department of Commerce
March 1992

## EXECUTIVE SUMMARY

More than $2 billion worth of facilities at the National Institute of Standards and Technology (NIST) are deteriorating at an accelerating pace. Built in Gaithersburg, Md., and Boulder, Colo., between 25 and 40 years ago, the sites feature 45 specialized laboratory buildings used to conduct a wide range of advanced research in areas such as semiconductor electronics, biotechnology, manufacturing engineering, atomic-scale physics, computer science, and advanced materials. (Site maps appear on pages 38 and 39.)

As the only federal laboratory explicitly charged with helping U.S. industry improve its competitiveness, NIST plays a critical role in the nation's long-term economic health. The decaying state of the Institute's facilities already has made it impossible to provide some U.S. manufacturers with essential services, such as state-of-the-art calibrations urgently needed to maintain production line quality controls on a par with Japanese and European competitors.

NIST proposes implementation of two separate 10-year plans to upgrade its facilities to the first-rate condition necessary to carry out its mission. The first plan addresses technical obsolescence of environmental systems controls and reliability of power supplies at NIST's research buildings that limits its ability to provide the exacting measurements required of a national reference laboratory. At a total cost of $540 million, the plan includes construction of new advanced technology laboratory space, as well as major renovation of seven existing buildings located at the two sites. *The full cost of this plan has yet to be approved by the Administration. Design of the new facilities will be flexible in that, if insufficient funds are available, NIST would still be able to achieve a portion of its facilities objectives.*

The second plan addresses urgently needed improvements to remedy major safety and systems capacity problems. These repairs and modernization projects cannot be delayed any longer without endangering employees and NIST visitors or risking failures of major building systems with potentially disastrous results. The 10-year systems and capacity plan was begun in FY 1991 with a $1 million appropriation and a $3 million appropriation in FY

1992. The plan requires steady-state funding of $7 million per year from FY 1993 through FY 2001.

Both an independent architectural and engineering study, done by Smith, Hinchman & Grylls Associates, Inc. (SH&G), and NIST's oversight Visiting Committee on Advanced Technology have confirmed the necessity of major facilities improvements. For the last 2 years, the Visiting Committee has identified upgrades and repairs of NIST's physical plant as its highest budget priority. The architectural and engineering study concluded the "overwhelming majority" of laboratory space at NIST "will fail to meet operational requirements of programs in the current decade." Its recommended plan of action totals $1.2 billion. Following a stringent review to limit required funding to only the highest priority projects, NIST cut the plan to less than half SH&G's proposed amount.

The urgency of proceeding now with implementation of these capital improvements cannot be overstated. Even if full funding is provided beginning in FY 1993, new advanced technology laboratory facilities needed by NIST's most technically demanding programs will be not be ready for occupancy until 1997. (See charts on page 3.)

In an age in which technology utilization and economic growth have become critical determinants of national security and standards of living, the United States simply cannot afford to let its National Institute of Standards and Technology drift into second-rate status.

## INTRODUCTION

Before the National Bureau of Standards was created by the U.S. Congress in 1901, there were more than eight different authoritative "standard" gallons in the United States. Major cities like Brooklyn, N.Y., recognized more than four different legal measures of the "foot." An estimated 50 percent of scales used in the retail sale of butter and other common products were woefully inaccurate.

The drawbacks of not having uniform national standards of weights, measures, and industrial quality at the turn of the century were glaring. Hoses from neighboring firehouse jurisdictions did not fit together. Between 15 and 20 percent of purchased construction material was of unusable quality. Three-quarters of light bulbs purchased by the federal government failed to meet performance requirements. The lack of standardization also meant that nearly all precision measuring instruments made in the United States at the time had to be sent to Europe for calibration.

Today, nearly a century later, U.S. industry benefits from one of the most rigorously maintained systems of national standards in the world. Nevertheless, history could soon repeat itself.

The keeper of the nation's standards—now with a much expanded mission and renamed as the National Institute of Standards and Technology—is once again struggling to keep up with its international counterparts, this time in both Europe and Japan. After decades as a clear world leader in most precision measurement areas, NIST is steadily losing ground in a number of key technologies. The problem is not a lack of scientific talent, but rather a lack of adequate facilities to conduct today's ultraprecise cutting-edge science.

NIST's headquarters site in Gaithersburg, Md., was built more than 25 years ago and includes 29 buildings located on 234 hectares (578 acres). Its Boulder, Colo., field site was built more than 35 years ago and consists of 16 buildings on 83 hectares (205 acres). The current value of the facilities on both sites exceeds $2 billion.

At the time of construction, these buildings were state-of-the-art structures in relatively remote locations that provided ideal environments for first-rate science. Thirty years ago, crude integrated circuits barely had been invented. Lasers were an infant technology. And analytical chemists were generally measuring chemical composition at the part per thousand level, rather than the part per billion level and below common today.

The combination of advancing age and even more rapidly advancing technology has made NIST's current facilities inadequate for many types of advanced research essential to its mission of providing U.S. industry with the best possible national standards and helping it develop and commercialize very demanding new technologies. The principal problem is a lack of high-quality environmental systems controls to allow precision measurements under predictable, stable conditions. Poor air quality, inadequate temperature and humidity control, lack of vibration isolation, and uneven, unreliable power supplies are major problems at both sites.

NIST's buildings also are suffering from serious safety and systems capacity problems. Smoke detection and sprinkler systems are lacking, serious structural deterioration in building foundations must be repaired, exhaust systems for chemical fumes fail to meet modern standards, and power supplies and a centralized chilled water system for cooling lasers and other energy-intensive research equipment need upgrading. The Boulder site lacks a centralized plant for efficient, reliable heating, air conditioning, and equipment cooling. It also has overhead power lines that are put out of service regularly by high winds and underground water pipes so clogged with rust that water pressure at hydrants is currently less than 40 percent of fire code requirements.

In a 1990 report to the Department of Commerce, NIST's Visiting Committee on Advanced Technology described the Institute's two sites this way: "Both laboratories have been well cared for and routine maintenance has been exemplary. However, beneath the Institute's attractive exterior, the deterioration and obsolescence of major structures and plant equipment have become so extensive that a 'business as usual' approach is inadequate."

The committee, which is composed of senior personnel from U.S. corporations and universities, provides oversight of NIST's policies, organization, budget, and research programs. For the past 2 years, the committee has cited the upgrading of NIST facilities its top budget priority.

GAO

United States General Accounting Office

Report to the Chair, Subcommittee on VA, HUD and Independent Agencies, Committee on Appropriations, U.S. Senate

December 1990

# NASA MAINTENANCE

## Stronger Commitment Needed to Curb Facility Deterioration

GAO/NSIAD-91-34

# Executive Summary

## Purpose

The National Aeronautics and Space Administration (NASA) has a $15 billion network of facilities to house and support its research, development, and flight activities. These facilities are located throughout the United States at nine centers, six auxiliary installations, and three deep space network sites. Many of these facilities support development of the spaced-based shuttle payloads and space shuttle launches. They also contribute to the aeronautical and aerospace testing capabilities of NASA, as well as military and private industry users. Proper maintenance is needed to ensure that these facilities are available for NASA and others to accomplish their missions.

At the request of the Subcommittee on VA, HUD and Independent Agencies, Senate Committee on Appropriations, GAO evaluated the condition of NASA facilities and, because the facilities had deteriorated, the reasons for such condition. GAO also reviewed the accuracy of NASA's accounting and budgeting for its maintenance activities.

## Background

NASA's centers and other activities contain 2,700 buildings and 3,200 other major structures, and encompass 36 million square feet of space. Many of NASA's facilities are 30 to 50 years old. All facilities require maintenance, but the effect of neglected or deferred maintenance becomes more apparent as facilities age.

Federal government standards for internal controls require federal agencies to ensure that all assets entrusted to them are safeguarded. The National Research Council's Building Research Board believes that this safeguarding should include a commitment to provide the maintenance needed to prevent deterioration and to ensure the continued use of the facilities. NASA funds its maintenance efforts from portions of three different appropriations: (1) Research and Program Management, (2) Research and Development, and (3) Space Flight Control and Data Communications. NASA headquarters uses the budget process to oversee the centers' programs and facilities, but center directors have been given the authority to allocate budgeted resources among various center functions as they deem appropriate.

## Results in Brief

Many of NASA's facilities have not been adequately maintained and are in degraded condition. Consequently, many need significant repair. In addition, several serious incidents have been caused by the facilities' deterioration, including a fire and a steam line explosion. Deferred or insufficient maintenance increases the likelihood of more such events in the future, as well as increased maintenance costs. Although some mission-critical facilities like the launch pads and the orbiter processing facility used for the space shuttle are generally well maintained, the eight centers GAO visited all have deteriorating facilities, such as leaking roofs, peeling paint, and leaking steam lines.

For the most part, the actual expenditures for maintaining NASA's centers have been left to the discretion of the centers' directors. Historically, NASA's headquarters program offices and centers have not conducted annual surveys to determine maintenance requirements and allocated far fewer funds than the 2 to 4 percent of facilities' replacement value that generally accepted maintenance guidelines dictate.

Procedures for budgeting and accounting for maintenance resources at some centers are inadequate. Centers have not based their maintenance budgets on actual needs and have not accurately accounted for all maintenance expenditures. This inadequacy contributes to NASA's difficulties.

Recognizing the need to improve its management of centers' facilities maintenance, NASA has recently taken steps to focus on the problems.

## Principal Findings

### NASA's Facilities Are Deteriorating

The condition of facilities varies from center to center. NASA's practice of deferring maintenance has resulted in severe deterioration of some facilities. An example of deterioration is concrete falling from the roof of the 52-story building where the shuttle is joined with the external fuel tank and solid rocket boosters. NASA installed netting beneath the roof deck to catch the concrete. NASA has also experienced catastrophic breakdowns of facilities due to insufficient or deferred maintenance. For example, a cooling tower partially collapsed from the weight of ice that accumulated because water valves were not functioning properly. Additional problems include faulty wiring (which caused a fire) in a mission control building, leaking roofs, water seeping into electrical rooms, and a ruptured steam line.

In fiscal year 1990, NASA contracted for an assessment of the condition of its centers' facilities. The assessment rated the facilities "marginal" overall, which corroborated GAO's observations.

## Maintenance Funding Levels Have Not Been Commensurate With Generally Accepted Practices

GAO estimates that from 1985 through 1989, the eight NASA centers visited spent about $125.8 million annually to maintain their facilities. GAO noted a wide disparity in maintenance funding levels among centers of comparable age and mission because funding is largely left to the discretion of center directors, who have different perspectives on the priority of continued maintenance. Often, the centers have chosen to defer maintenance.

In most cases maintenance funding levels are lower than what experts consider adequate. Specifically, the National Research Council's Building Research Board has recommended that agencies allocate for maintenance a minimum of 2 to 4 percent of their facilities' replacement value. Between 1985 and 1989, with the exception of the Jet Propulsion Laboratory (which spent 2.3 percent of their facilities' replacement value on maintenance), centers allocated only 0.9 to 1.5 percent of their facilities' replacement value. According to the Chief of NASA's Facility Maintenance Management Branch, the correction of deficiencies usually costs much more than a preventive maintenance program would have cost.

## Critical Financial Management Information Is Currently Not Available

NASA headquarter's lack of guidance concerning the establishment of comprehensive maintenance management systems has contributed to facility maintenance problems. Without that guidance, some centers have maintenance management systems that do not provide adequate information to plan, budget, schedule, and report on maintenance activities and needs.

To make informed and reliable maintenance decisions NASA center directors need accurate budgeting and accounting data. Historically, NASA centers have not based their maintenance budgets on actual need. Without a clear understanding of their total maintenance requirements, center directors are unable to determine the total resources that should be allocated to facility maintenance. None of the centers accurately accounted for their facility maintenance expenditures. Center accounting systems did not accurately identify maintenance charged directly to research and development programs or performed under facility operation contracts. Because of these information voids, center directors cannot properly oversee maintenance activities.

Moreover, without knowing its overall facility maintenance requirements or the resources being used to meet these requirements, NASA cannot make reliable maintenance budget decisions.

## Efforts to Focus on Facility Maintenance

NASA has recognized that maintenance of centers' facilities is a growing problem. As a result, NASA created the Facilities Maintenance Management Branch, which, during the past 2 years, has worked with the centers to begin to define their total maintenance needs and assess the condition of their facilities. NASA has also highlighted its need for better facility maintenance in its fiscal year 1989 Financial Integrity Act report and in a September 1989 presentation to the Office of Management and Budget.

## Recommendations

In order to ensure NASA center facilities are properly maintained, GAO recommends that the NASA Administrator:

- Establish standards to guide centers in the development of comprehensive maintenance management systems that include all the information needed to identify maintenance needs and plan, budget, schedule, and report maintenance requirements.
- Direct centers to allocate funds to maintenance in accordance with the annual 2 to 4 percent of facility replacement value recommended by the National Research Council, or at a minimum to demonstrate that sufficient funds are allocated to maintain center facilities at least at a "steady state" condition.
- Direct the centers to conduct annual surveys to determine the centers' respective maintenance and repair requirements.
- Emphasize responsibility for protecting centers' facilities by making facility maintenance a critical element in annual objectives established for directors of the centers and heads of headquarters program offices.

GAO also recommends that the Administrator direct the centers to strengthen their procedures for budgeting and accounting for facility maintenance to ensure that maintenance functions are properly controlled.

## Agency Comments

In commenting on a draft of GAO's report, NASA indicated that GAO's recommendations were constructive and appropriate. NASA shared GAO's concerns and explained it was implementing programs to address them. NASA provided some specific comments and suggestions, which were incorporated into the report where appropriate.

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