United States General Accounting Office

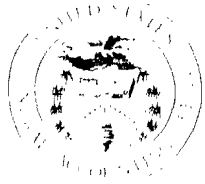
GAO

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



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GAO

United States
General Accounting Office
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National Security and
International Affairs Division

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December 14, 1990

The Honorable Barbara A. Mikulski
Chair, Subcommittee on VA, HUD and
Independent Agencies
Committee on Appropriations
United States Senate

Dear Madam Chair:

As requested, we reviewed the condition of facilities at the National Aeronautics and Space Administration (NASA). Because the condition of some NASA facilities had deteriorated, we evaluated the reasons for such condition. We also reviewed the accuracy of NASA's accounting and budgeting for its maintenance activities.

We are sending copies of this report to the Administrator of NASA and appropriate congressional committees. Copies will also be made available to others on request.

Please contact me on (202) 275-5140 if you or your staff have any questions concerning this report. The major contributors to the report are listed in appendix III.

Sincerely yours,

Mark E. Gebicke

Mark E. Gebicke
Director, NASA Issues

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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Abbreviations

GAO	General Accounting Office
JPL	Jet Propulsion Laboratory
NASA	National Aeronautics and Space Administration

Introduction

The National Aeronautics and Space Administration (NASA) is responsible for conducting research and development, space science, and space flight programs through a nationwide network of administrative and technical facilities. Maintaining the condition and continued availability of these facilities is vital to the accomplishment of NASA's mission. While NASA's headquarters is responsible for overseeing both programs and facilities, historically the centers' directors have managed and controlled their own activities, including facility maintenance and repair, within broad NASA directives and budgetary guidelines and constraints.

Network of Facilities

NASA operates and maintains an extensive inventory of research and office facilities at nine centers, six auxiliary installations, and three deep space communication sites. NASA estimates the total replacement value of these facilities to be about $15 billion. The centers and other sites contain 2,700 buildings, 3,200 other structures, and encompass 36 million square feet of space. Included in the centers' buildings, structures, and integrated equipment are numerous complex and often unique research facilities such as wind tunnels, vacuum chambers, space flight preparation buildings, space launch complexes, high pressure storage tanks, and transmission lines for volatile gases. Many of the 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. Also, many of these facilities are 30 to 50 years old. While all facilities need to be maintained, the need becomes more apparent as they age. Appendix I contains a list of NASA's primary centers and other activities, the average age of their facilities, and the estimated replacement value.

Organizational Structure and Responsibilities

Institutional Associate Administrators in three headquarters program offices are responsible for the overall planning and direction of operations and resources at NASA's centers. These offices primarily exercise their oversight through the budget process. Following are the centers associated with each program office:

- Office of Aeronautics and Exploration Technology
  - Ames Research Center
  - Langley Research Center
  - Lewis Research Center

- Office of Space Science and Applications
  - Goddard Space Flight Center
  - Jet Propulsion Laboratory (JPL)
- Office of Space Flight
  - Johnson Space Center
  - Kennedy Space Center
  - Marshall Space Flight Center
  - Stennis Space Center

NASA's budget summary does not specifically identify the funds to be allocated to facility maintenance. NASA's budgeting process for facility maintenance involves three appropriations: (1) Research and Program Management, (2) Research and Development, and (3) Space Flight Control and Data Communications.

The funds budgeted for maintenance are identifiable only in the centers' summaries of the Research and Program Management appropriation. This appropriation, which is formulated by function, provides funds for a portion of each center's maintenance activities through a line item for facilities' maintenance and related services.

According to NASA's budget estimates, the Research and Development and the Space Flight Control and Data Communications appropriations primarily fund NASA's technical programs. NASA budget estimates include no line items for maintenance in these two funds, but portions are set aside to pay for services—such as maintenance—that benefit all technical programs.

A fourth appropriation, the Construction of Facilities appropriation, is used to fund repair projects for facilities that have already seriously deteriorated. Construction of Facilities' projects, including those for repairs, compete for funding with all such projects NASA-wide.

NASA distributes appropriated funds among the centers. The centers' directors are responsible for executing the agency's technical and administrative programs within budgetary guidelines, and they generally allocate budgeted resources among various center functions as they deem appropriate.

Objectives, Scope, and Methodology

We reviewed NASA's facility maintenance operations at the request of the Chair, Subcommittee on VA, HUD and Independent Agencies, Senate Committee on Appropriations. Our objectives were to evaluate the condition of NASA facilities and, because the facilities had deteriorated, the reasons for such condition. GAO also reviewed the accuracy of NASA's budgeting and accounting for its maintenance activities.

We focused our review on the maintenance of real property, using NASA's definition of "facility maintenance." NASA generally defines facility maintenance as the periodic work required to preserve facilities (buildings, structures, utility systems, and grounds) in such a condition that they may be used for their designated purposes. This work includes preventive maintenance (maintenance cycles of 1 year or less), programmed maintenance (maintenance cycles longer than 1 year), and minor repairs due to breakdowns.

We performed our work at NASA headquarters in Washington, D.C., and at eight of the nine NASA centers. They included the

- Ames Research Center, Moffett Field, California;
- Langley Research Center, Hampton, Virginia;
- Lewis Research Center, Cleveland, Ohio;
- Goddard Space Flight Center, Greenbelt, Maryland;
- JPL, Pasadena, California;
- Johnson Space Center, Houston, Texas;
- Kennedy Space Center, Florida; and
- Marshall Space Flight Center, Huntsville, Alabama.

To evaluate the condition of NASA's facilities, we visited these eight NASA centers and observed the present condition of their facilities and reviewed maintenance documentation of prior facility problems. We coordinated our visits with NASA's maintenance support contractor, SPC Engineering Services, Inc., Arlington, Virginia, and reviewed the results of its evaluation on facility conditions. We also interviewed NASA center officials responsible for overseeing and managing facility maintenance.

To evaluate the reasons for the observed condition of facilities, we (1) compared the centers' actual and estimated costs for facility maintenance during fiscal years 1985-89 to their total funding to determine the level of resources devoted to this function; (2) examined the centers' maintenance management systems to determine whether they provided data to plan, direct, and review maintenance activities; and (3) interviewed NASA headquarters and center officials responsible for budgeting

and accounting for center functions. We analyzed maintenance funding levels from three appropriations—Research and Program Management, Space Flight Control and Data Communications, and Research and Development—to identify the funding variances.

To evaluate maintenance costs, we reviewed fiscal year 1985-89 maintenance expenditures for the eight centers we visited. Because NASA's accounting records do not identify all facility maintenance costs, we asked each of the centers to estimate for this 5-year period the additional maintenance costs that were not included in these records. We requested that the centers include in these estimates the costs for labor, materials, and parts. We asked the centers to exclude the costs for several items such as facility operations, purchased utilities, custodial services, and major rehabilitations and upgrades that are not related to maintenance, but are often handled by the same organizations that perform maintenance. We also excluded funds for the Wind Tunnel Revitalization Program because the proportion of funds devoted to maintenance-related repairs was not clearly identifiable. This is a $300 million special program to repair, rehabilitate, and modernize NASA's aging wind tunnels.

To assess the adequacy of NASA's institutional controls over maintenance activities, we reviewed the National Research Council's[1] Building Research Board recommendations concerning facility maintenance in federal agencies; reviewed a Department of Defense study of real property maintenance activities; and compared these standards and study findings to conditions existing at the NASA centers we visited. In addition, we discussed oversight of facility maintenance with knowledgeable center officials and representatives of the institutional program offices at NASA headquarters.

We conducted our review between October 1989 and July 1990 in accordance with generally accepted government auditing standards. NASA provided written comments on a draft of this report. These comments are presented and evaluated in appendix II. NASA's specific comments and suggestions were incorporated into the report where appropriate.

[1]The National Research Council was established by the National Academy of Sciences. The Academy, by authority of the charter granted to it by the Congress in 1863, has a mandate to advise the federal government on scientific and technical matters.

NASA Facilities Are Deteriorating

Over the years, NASA has not adequately maintained its centers' facilities. Many need significant repairs because of deterioration. While facility conditions varied among centers, we observed general deterioration caused by deferred maintenance at each of the eight centers we visited. In addition, NASA has experienced some serious incidents resulting from its practice of deferring maintenance.

In an assessment of facility conditions, a NASA contractor, SPC Engineering Services Inc., generally confirmed our observations and rated the centers' facilities marginal overall. The contractor reported that most centers' facilities had serious deficiencies, many of which concerned deteriorating building components that would not pose an immediate hazard to the users.

Although NASA's practice of deferring maintenance may not immediately affect mission accomplishment, inadequate maintenance leads to increased breakdowns, premature failure of building components, and a general shortening of the time that facilities remain useful. According to the Chief of NASA's Facility Maintenance Management Branch, the correction of deficiencies usually costs far more than a preventive maintenance program would have cost.

NASA headquarter's lack of comprehensive guidance regarding the operation of centers' maintenance management systems has contributed to their facility maintenance problems. Some centers' maintenance management systems did not provide adequate information to plan, budget, schedule, and report on maintenance activities.

Until 1987, NASA had given little emphasis to centers' facility maintenance. Since that time, however, NASA has made organizational changes aimed at focusing on regular facility maintenance and has informed the Office of Management and Budget and Congress of its growing maintenance problems.

Center Facility Conditions Vary

Centers' facilities were deteriorating due to age, weather, and insufficient or deferred maintenance. The extent of visible deterioration, however, varied considerably among the centers. At some centers, we observed serious problems. For example, at Marshall Space Flight Center, the roof of a laboratory building leaked so badly that electricians working with 440-volt electrical equipment had to be moved out of a portion of the building because of a severe shock hazard.

Other less serious problems at each center, included rusted and unreliable heating, ventilating, and air-conditioning systems; leaking steam lines, water valves, and pumps; peeling or missing paint; leaking roofs; and eroded pavement. If left uncorrected, even the less serious problems will lead to breakdowns that will require major repairs. NASA has experienced such problems at several centers. For example, a fire in a mission control building at Marshall Space Flight Center was caused by loose electrical connections. In another case, a cooling tower at Lewis Research Center partially collapsed from the weight of ice that accumulated due to malfunctioning water valves, according to center officials.

Figures 2.1 through 2.4 illustrate deteriorated facility conditions we observed during this review. The figures show a variety of problems, including corrosion and deteriorated roofs and structural components at several centers.

Figure 2.1: High Voltage Distribution Transformer With Corrosion and Oil Leaks at Ames Research Center

Source: Ames Research Center, Moffett Field, California.

Figure 2.2: Wall Damaged by Leaking Water in the Stairwell to a Basement at Goddard Space Flight Center

Source: Goddard Space Flight Center, Greenbelt, Maryland.

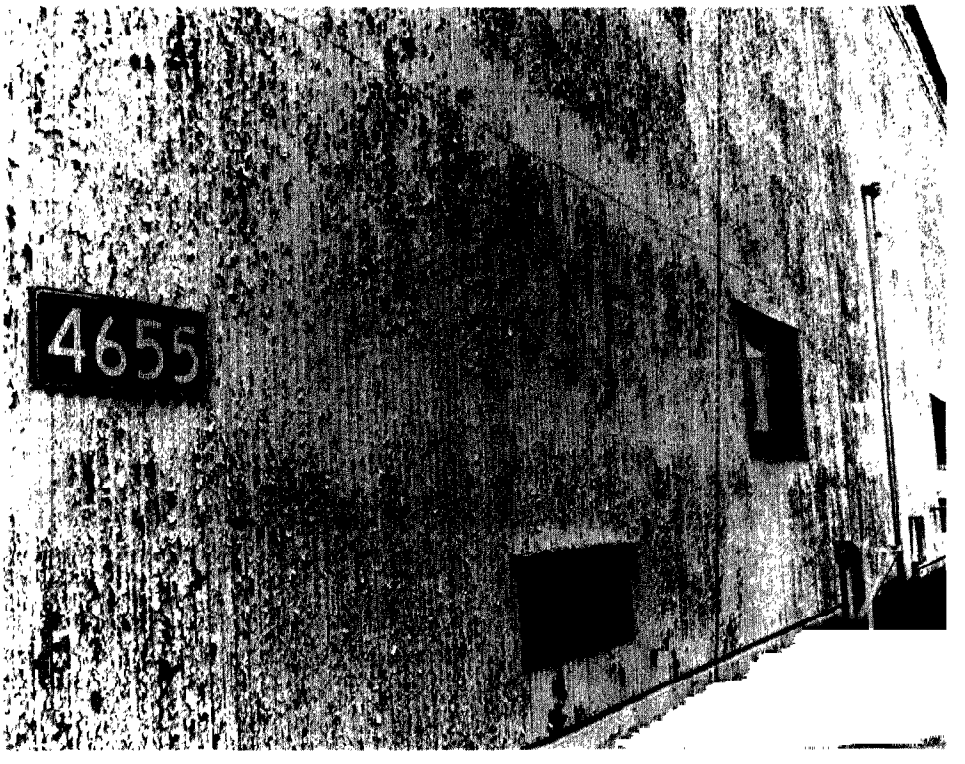
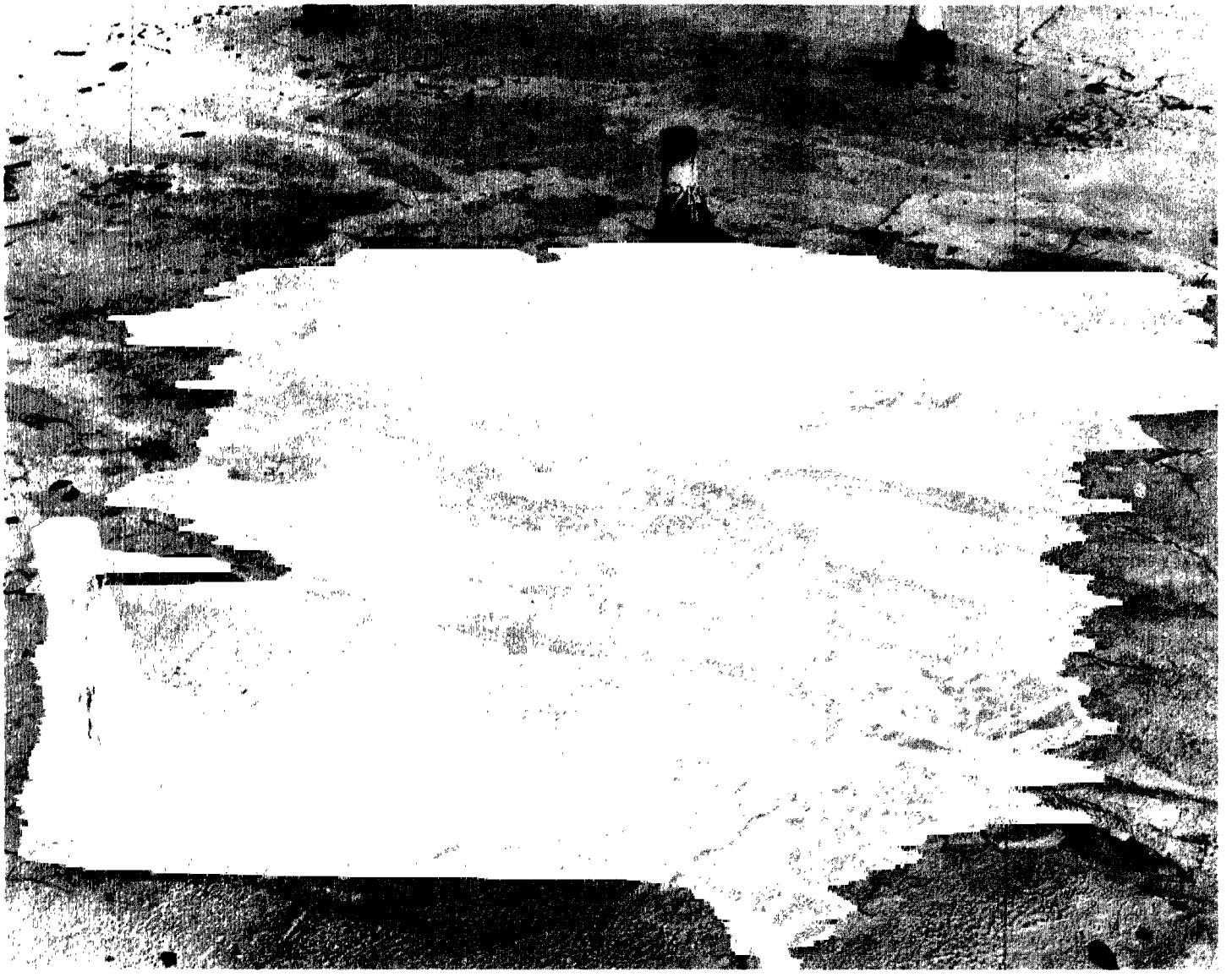


Figure 2.3: Peeling Paint and Surface Corrosion on a Building at Marshall Space Flight Center

Source: Marshall Space Flight Center, Huntsville, Alabama.

Figure 2.4: Roofing Splits and Fissures Causing Interior Water Leaks in a Building at Marshall Space Flight Center

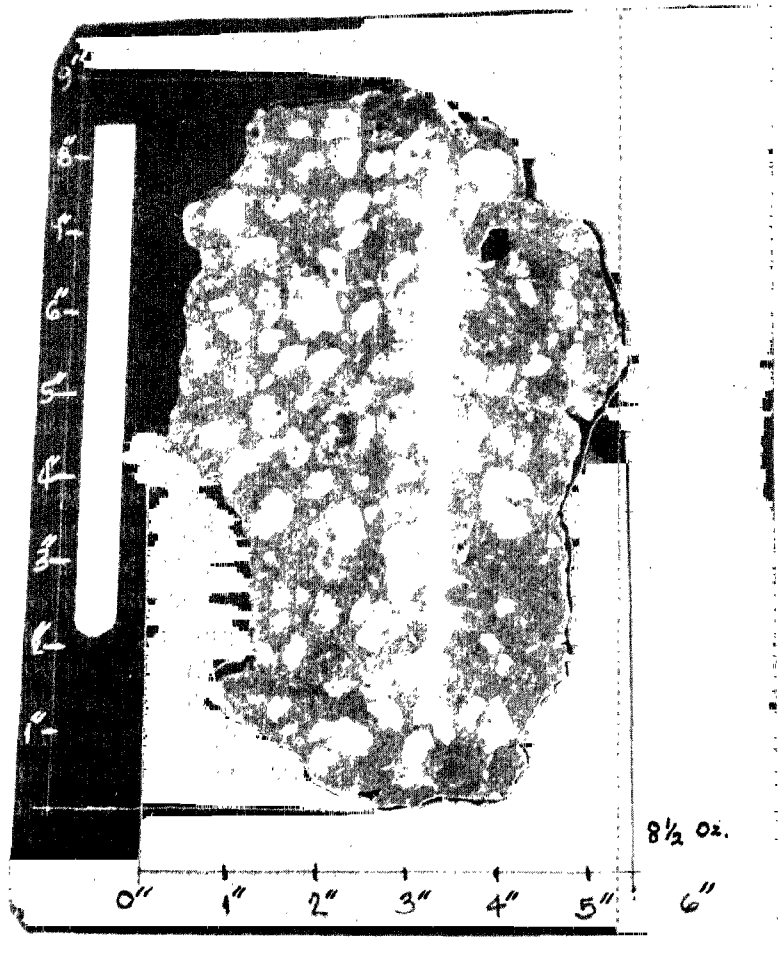


Source: Marshall Space Flight Center, Huntsville, Alabama.

Insufficient or deferred maintenance has already resulted in the need for costly repairs at some NASA centers. For example, at Kennedy Space Center, the roof of the 52-story vehicle assembly building, where the space shuttle is joined to the external fuel tank and solid rocket boosters, has leaked for several years. Delays in repairing the roof have resulted in water penetration of the concrete roof deck. Subsequently,

rust expansion of the roof deck's reinforcing bars caused pieces of concrete to break loose and fall from the underside of the deck. The concrete debris ranges in size from small chips to 8-inch pieces weighing one-half pound or more (see fig. 2.5). To prevent damage to the shuttle or injuries to the workers below, NASA erected nets between the structural steel trusses to catch any falling concrete (see fig. 2.6). NASA's current estimate to repair the leaking vehicle assembly building roof is about $10.7 million, and NASA's fiscal year 1990 Construction of Facilities appropriation includes funds for the repair.

Figure 2.5: Piece of Reinforced Concrete That Fell From the Underside of the Vehicle Assembly Building's Roof Deck at the Kennedy Space Center



Source: Kennedy Space Center, Florida.

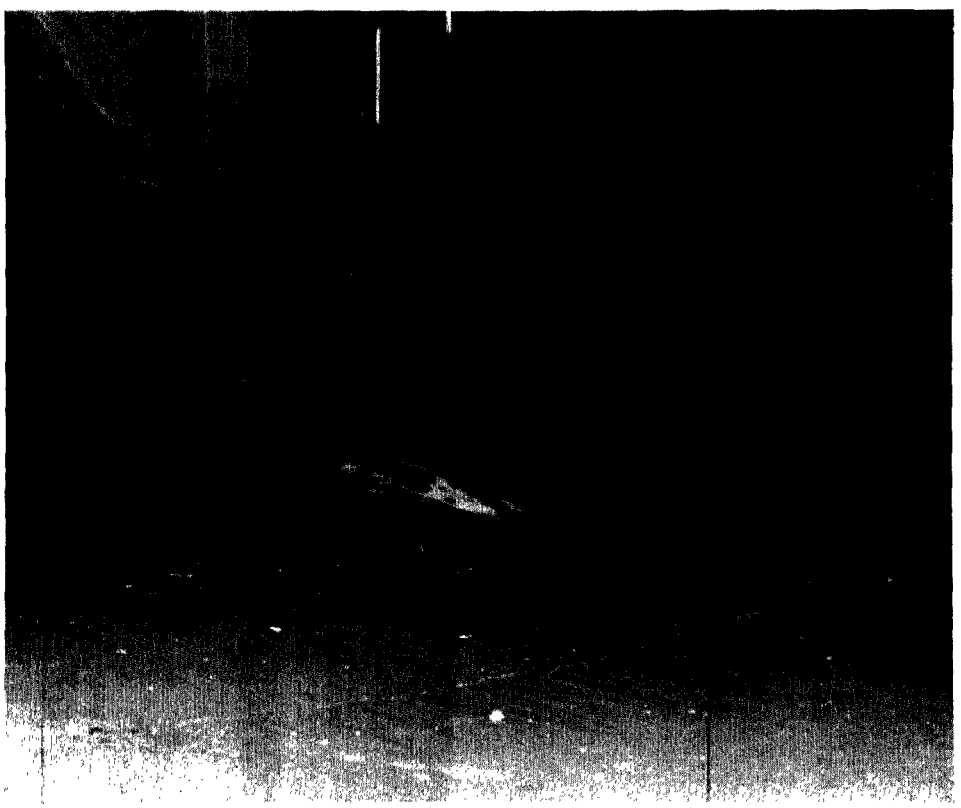


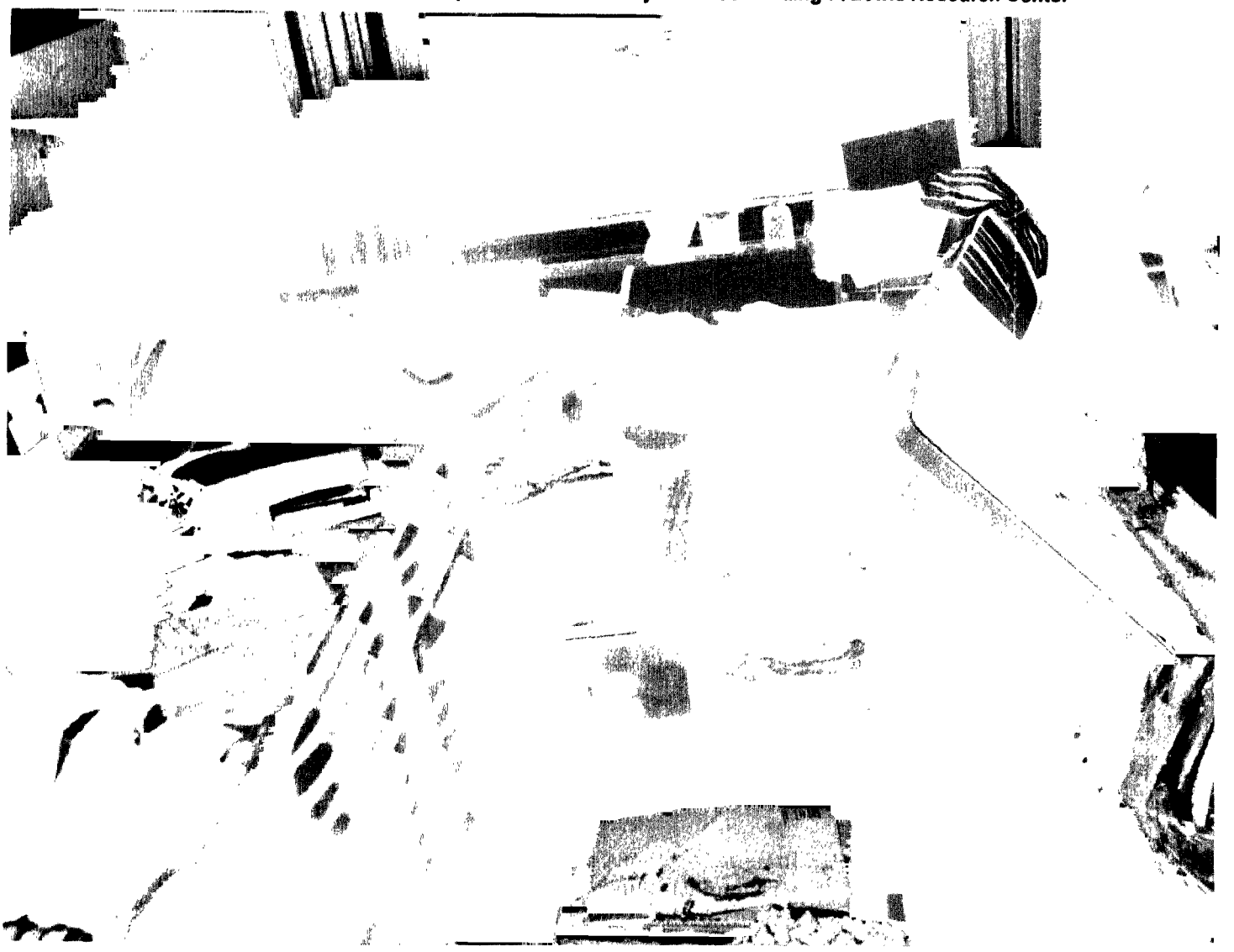
Figure 2.6: Nets Below the Vehicle Assembly Building Roof Showing Water Stains and Concrete Debris at the Kennedy Space Center

Source: Kennedy Space Center, Florida.

At least two of the nine NASA centers have also experienced catastrophic breakdowns of building components due to insufficient or deferred maintenance. On May 26, 1989, at Lewis Research Center, a high-pressure steam shutoff valve ruptured in the basement of the Library Services Building. The valve's failure was partially attributed to badly deteriorated piping supports in a steam line tunnel. Although the tunnel has inspection access holes, the piping supports were not included in a maintenance program. Heavy rains that flooded the tunnel caused steam to condense in the pipes and created a water hammer effect.[1] The vibration of the poorly supported steam pipes caused the valve to rupture. In addition to damage to the valve and piping, high-pressure steam damaged two interior walls, an office, ceiling tiles, painted surfaces, and wall paneling throughout the building. The building was without steam service for 5 months, and the cost of repairs exceeded $1 million. Figure 2.7 shows some of the damage caused by the ruptured steam valve.

[1] A concussion of moving water against the sides of a containing pipe or vessel such as a steam pipe.

Figure 2.7: Damage Caused by a Steam Line Explosion in the Library Services Building at Lewis Research Center



Source: Lewis Research Center, Cleveland, Ohio.

Facilities' Condition Assessed as "Marginal"

In a May 1990 NASA report based on assessments by NASA's maintenance support contractor, JPL, Johnson, and Langley centers were identified as having the fewest facility problems. Lewis, Stennis, and Marshall centers had the most problems and Kennedy, Ames, and Goddard centers were ranked in the middle. Many of the centers' facilities were reported to need immediate repairs. Overall, the conditions of NASA's nine centers

were ranked near or below "marginal."[2] At three of the nine centers, the contractor review teams noted that key mission-critical facilities were better maintained than the support facilities. Each center reviewed, however, showed a full range of conditions. Some components needed significant repairs, while others required no work. The identified maintenance problems included leaking roofs, deteriorating roads, peeling paint and corrosion, leaking pump seals, and groundwater seeping into basement utility rooms. Safety deficiencies, such as corroded pressure relief valves, missing fan guards, and overloaded electrical panels, were also identified.

NASA's Facilities Maintenance Management Branch highlighted the following problems identified by NASA's contractor as being among the most significant:

- At Wallops Flight Facility—associated with Goddard Space Flight Center—30-year-old electrical equipment had corroded. If the circuit breakers in this equipment fail to shut off electricity in response to an electrical short, fires or other problems could result and cause the deaths of personnel and/or affect mission performance. According to the NASA report, equipment in this or similar condition can be found at many NASA locations.
- Heating, ventilating, and air-conditioning equipment supporting a critical facility at Kennedy Space Center had rusted so badly that flaps of metal were hanging from the underside.
- Uncontrolled water leaks at Marshall Space Flight Center had caused roof sheathing and joists to rot.
- Gas valves in a pressure-reducing station at Ames Research Center were severely corroded and cluttered with extensive debris.

In its report, NASA concluded that, although conditions varied, its centers' facilities had deficiencies that would require increased maintenance efforts to make their condition acceptable.

[2]According to NASA and the contractor, "marginal" means that there are many deficiencies requiring maintenance and repair.

Centers' Maintenance Management Systems Need Improvement

NASA headquarters has not provided comprehensive guidance to standardize the operation of the centers' maintenance management systems. Consequently, there is no standard maintenance system within NASA, and each center has developed its own approach to plan, budget, schedule, and report on maintenance requirements. The centers' maintenance management systems vary in degrees of effectiveness. Johnson Space Center, JPL, and Langley Research Center include in their systems most of the information needed to plan, budget, schedule, and report on maintenance requirements. These centers have maintenance inventories covering all major systems and provide for preventive and corrective maintenance and service requests. NASA's condition assessment identified these centers as being better maintained than other centers.

On the other hand, Lewis Research Center and Marshall Space Flight Center do not provide all the information needed for a comprehensive maintenance management system and have had more facility maintenance problems. For example, Lewis Research Center's preventive maintenance program does not include the low voltage electrical system, steam lines, or domestic water supply. Instead, these items are repaired when they breakdown. Marshall Space Flight Center does not routinely include exterior painting and roof repairs in its maintenance program. NASA's condition assessment identified these centers as being among the more poorly maintained centers.

Recent Efforts Focus on Facility Maintenance

In 1987 NASA began emphasizing facility maintenance agencywide. At that time, NASA made maintenance a part of the agency's goal to improve its institutional structure. Recognizing this growing problem, NASA assigned functional responsibility for facility maintenance to the Assistant Associate Administrator for Facilities Engineering (formerly known as Facilities Management), and created the Facilities Maintenance Management Branch to advocate improved facility maintenance at the centers. The branch has worked to assess centers' conditions, improve centers' maintenance management, and report on the overall status of NASA's facility maintenance efforts.

In addition, NASA has worked to determine its total maintenance funding needs. Before the recent NASA condition assessment, little effort had been made to determine NASA-wide maintenance needs or to establish funding levels based on need. Between September and November 1989, NASA headquarters requested that centers estimate their total maintenance funding needs for fiscal year 1992. This was NASA's first attempt to estimate total maintenance funding needs on a common basis, and

NASA believes the estimates may therefore contain errors. Nevertheless, this process resulted in significant increases in some centers' estimated funding requirements compared to the amounts they requested in fiscal year 1991. The magnitude of these increases indicates that centers have not requested sufficient maintenance funds in the past. Table 2.1 shows the increased facility maintenance funding needed for the NASA centers.

Table 2.1: Maintenance Funding Estimates

Dollars in millions

Center	Estimated 1991 funding	Estimated 1992 funding needs	Increase over 1991 estimate	Percent increase
Ames	$32.7	$64.7	$32.0	98
Langley	27.2	29.2	2.0	7
Lewis	25.6	41.8	16.2	63
Goddard	15.6	18.5	2.9	19
JPL[a]				
Johnson	16.0	39.6	23.6	148
Kennedy	43.0	48.2	5.2	12
Marshall	13.8	25.6	11.8	86
Stennis	7.2	17.2	10.0	139

[a]JPL is a federally funded research and development center operated under contract by the California Institute of Technology which does not report budget estimates in the same detail as other NASA centers.

In addition to its in-house efforts, NASA has reported its facility maintenance problems to the administration and Congress. In a September 1989 presentation to the Office of Management and Budget, NASA headquarters officials and several center directors stated that maintenance requirements had been underfunded and that the agency had significant problems in this area. In NASA's December 1989 Financial Integrity Act report, the Administrator said that serious institutional problems in areas such as facility maintenance were increasing and had the potential to become material weaknesses. During hearings on May 4, 1990, before the Subcommittee on VA, HUD and Independent Agencies, Senate Committee on Appropriations, the Administrator said that the maintenance, repair, rehabilitation, and modernization of facilities were among NASA's highest priorities.

Conclusions

Over the years, NASA has given little priority to facility maintenance. As a result, the centers' facilities have deteriorated. NASA's problems mainly reflect deterioration of building components, but some could pose safety

hazards or threaten missions. At least two centers have already experienced serious incidents that resulted in costly repairs. In addition, lack of guidance from NASA headquarters regarding facility maintenance and incomplete maintenance management systems at the centers have contributed to facility maintenance problems. If facility deterioration goes uncorrected, breakdowns and costly repairs can be expected to continue.

Recommendation

We recommend 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.

Maintenance Funding Levels Have Not Been Commensurate With Generally Accepted Practices

According to NASA headquarters officials, center directors have been given authority within budgetary guidelines and constraints to determine how funds for their centers' operations are spent. Because perspectives on the priority of continued maintenance differ among the directors, funding levels for this activity vary substantially. Because NASA's accounting records do not identify all facility maintenance costs, we asked each of the centers to estimate the missing costs for fiscal years 1985-89 to facilitate our analysis of actual expenditures. In all cases, maintenance funding is generally less than what experts consider necessary to sustain an adequate program. For example, the National Research Council and other industry experts recommend that between 2 and 4 percent of facilities' replacement value be allocated annually for maintenance. With one exception, NASA centers have spent only 0.9 to 1.5 percent of their facilities' estimated replacement value. NASA cannot ward off continued facility deterioration and costly repairs with this level of funding.

Wide Disparity in Centers' Maintenance Expenditures Between 1985 and 1989

Historically, NASA centers have addressed the importance of facility maintenance to varying degrees. The overall maintenance funding levels for the centers generally corresponded to NASA's condition assessment. This assessment showed that centers allocating more resources to maintenance were generally in better condition.

Our analysis of the funding that centers within the same program office allocate to maintenance shows that some centers have made a stronger commitment to this function than others. For example, among the Office of Aeronautics and Exploration Technology centers, from 1985 through 1989, Langley Research Center allocated a much greater percentage of its available resources each year to facility maintenance (5.7 percent, or about $21.1 million) than the other centers, and NASA considers it to have one of the best maintenance programs. Langley has had no serious incidents due to poor maintenance and, in the recent condition assessment, was ranked as one of the best maintained, even though it is the second oldest NASA center. Langley's higher level of funding and its better overall condition have been attributed to the center's strong commitment to facility maintenance. During that same time, Ames Research Center allocated slightly more of its resources (3.9 percent, or about $16.4 million, per year) to maintenance than Lewis Research Center (2.8 percent, or about $18.3 million, per year). Although both centers were not as well maintained as Langley Research Center, our observations and NASA's condition assessment indicated that there were fewer

maintenance problems at Ames Research Center than at Lewis Research Center.

Similarly, within the Office of Space Science and Applications, from 1985 through 1989, JPL allocated nearly twice as much of its funding each year to maintenance (0.9 percent, or about $8.2 million) as did Goddard Space Flight Center (0.5 percent, or about $8.2 million), and had fewer facility maintenance problems. Although both centers spent the same amount, the much higher replacement value of Goddard's facilities ($536.9 million) compared to JPL's facilities ($416 million) indicates the need for a larger maintenance funding allowance. NASA's assessment and our own observations indicate that the condition of Goddard Space Flight Center's facilities was generally average, while JPL's facilities were in the best condition compared to all other centers.

Within the Office of Space Flight, from 1985 through 1989, Kennedy Space Center spent far more of its resources on maintenance each year (3.1 percent, or about $29.3 million) than did the other two Office of Space Flight centers we visited. However, NASA's condition assessment showed that Kennedy Space Center has more facility problems than Johnson Space Center, which allocated fewer resources (0.7 percent, or about $13 million, per year) to maintenance. While Kennedy Space Center spent a greater proportion of its resources on maintenance, it was in worse condition than Johnson Space Center because Kennedy's complex facilities associated with the shuttle program require extensive maintenance, and it has a much lower total funding level than Johnson. Of the Office of Space Flight centers, Marshall Space Flight Center devoted the lowest percentage of its resources to maintenance (0.5 percent, or about $11.3 million, per year), and its condition is considered the worst of all centers.

Research and Development Funds Used to Supplement Maintenance Activity

According to NASA budget estimates, the Research and Program Management appropriation is the only source of funds that specifically identifies maintenance activity. Most centers spent comparable proportions of their Research and Program Management funding for maintenance. In addition to maintenance, this appropriation covers items that represent fixed costs such as civil service salaries and purchased utilities. According to NASA headquarters and center officials, since the use of a majority of the Research and Program Management funding is relatively fixed, during tight budget years the maintenance portion of this appropriation is often reduced.

A portion of the Space Flight Control and Data Communications appropriation is also used by NASA to fund some maintenance activities related to shuttle operations and other space flight programs. Only Kennedy Space Center funds a significant portion of its maintenance from this appropriation.

The Research and Development appropriation offers the greatest flexibility for maintenance funding. Maintenance, however, often directly competes with various research programs. We found a wide disparity in maintenance funding from this appropriation among centers. At the eight centers we visited, variances in allocations from the Research and Development appropriation accounted for most of the differences in centers' total maintenance funding from 1985 through 1989.

Centers Attempt to Cope by Deferring Maintenance

When funding is reduced, centers often attempt to cope with the shortage by deferring maintenance. The deferred maintenance, which often results in a backlog of maintenance activities, not only has an overall cumulative effect on the condition and function of facilities but also significantly increases the original cost of repairs. NASA considers the costs associated with deferred maintenance at the various centers to be significant, even though it has not documented all these costs. In many cases, it has been necessary to allocate large dollar amounts for major repairs, as a result of deferred maintenance. Examples of some of the effects associated with deferred maintenance, provided by center officials, are as follows:

- Estimates of deferred road repairs at Lewis Research Center revealed a 56-percent cost increase, from $289,000 to $450,000, in 2 years.
- Backlogged air-conditioning repairs at Goddard Space Flight Center are estimated to cost $1.5 million to $2 million per year for the next 5 to 10 years. According to the Deputy Chief, Plant Operations and Maintenance Division, if the deferred preventive maintenance had been performed, the yearly costs would only be about one-half that amount.
- The deferral of circuit breaker replacements at Goddard Space Flight Center resulted in a fire and damages 100 times the estimated cost of the initial repair.
- The estimated cost of roof repair at Goddard Space Flight Center increased 50 percent, from $200,000 to $300,000, over a 3-year period.

Experts Recommend Minimum Funding Levels

In June 1990, the National Research Council's Building Research Board reported[1] that inadequate resource allocation is a widespread and persistent problem in the maintenance and repair of public buildings. The Board believes that safeguarding facilities should include a commitment to provide the maintenance needed to prevent deterioration and to ensure the continued use of the facilities. This view corresponds to the federal government standards for internal controls that require federal agencies to ensure all assets entrusted to them are safeguarded. Furthermore, the Board recommended that the appropriate level of maintenance and repair spending should range, on average, from 2 to 4 percent of the facilities' replacement value. The Board stated that in the absence of information about specific needs upon which to base a maintenance and repair budget, this funding level should be used as an absolute minimum. The Board argues that if this level of funding persists, facilities should remain in a "steady state situation"; that is, facilities neither decline nor improve and a backlog of deferred maintenance does not develop.

The replacement value is a significant number because it provides a common denominator and includes such variables as the relative complexity and size of the facilities to be maintained. One method of estimating the amount of maintenance funds required for a collection of facilities is to multiply a percentage factor by the replacement value of the inventory of facilities.

In a September 20, 1989, briefing to the Office of Management and Budget, NASA illustrated that it had allocated inadequate resources relative to replacement value to facility maintenance. During the briefing, NASA stated that its facility maintenance funding as a percentage of replacement value has historically been far less than industry averages as well as some other federal agencies.[2]

In a study completed in March 1989, the Department of Defense also used replacement values to determine adequate maintenance funding levels. In the study, entitled Renewing the Built Environment, Defense reviewed the maintenance funding levels of 16 major private sector corporations and revealed that these corporations spent, on average, 3.5 percent of their facility replacement value on maintenance.

[1]Committing to the Cost of Ownership: Maintenance and Repair of Public Buildings

[2]Federal agencies cited by NASA include the Departments of Defense and Energy.

Centers Need to Allocate Sufficient Resources

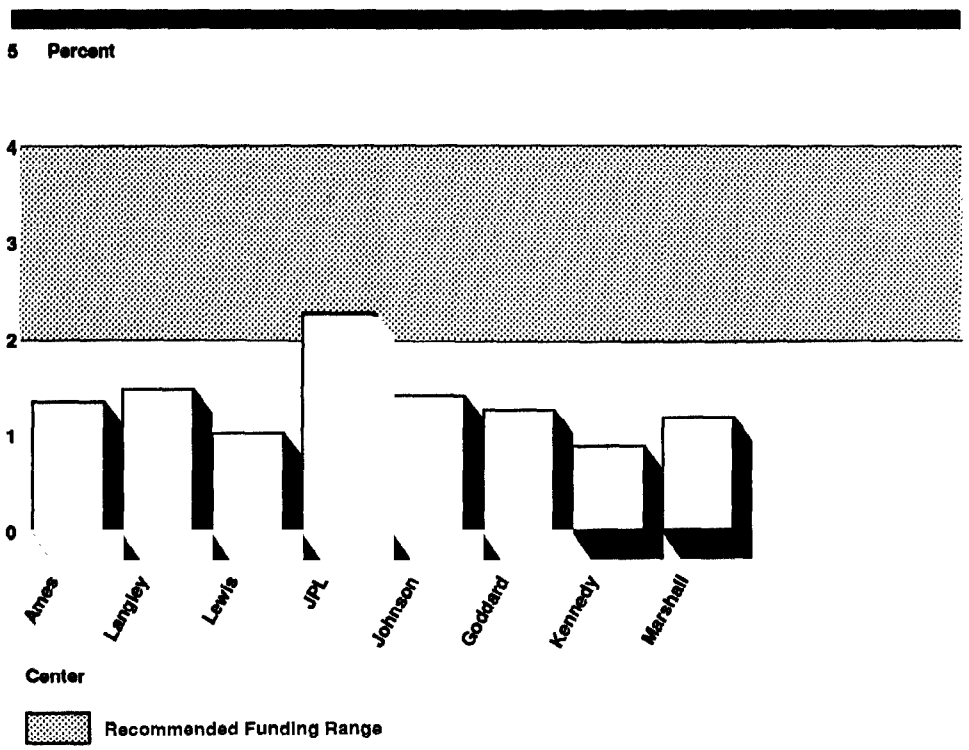
NASA has historically underfunded maintenance because centers' maintenance budgets have been based on the previous year's spending level, plus an additional percentage for inflation. This approach has not resulted in adequate funding to meet NASA's growing maintenance problems, as evidenced by the current marginal condition of NASA center facilities.

From 1985 through 1989, the eight NASA centers we visited spent, on average, about $125.8 million annually to maintain their facilities. This represents only about 1.5 percent of the eight centers' average annual appropriations, $8.6 billion, during that period. During the same period, we compared facility replacement values[3] at eight centers to their maintenance funding levels. With the exception of JPL (which spent 2.3 percent), the other centers spent less than 1.5 percent of their facilities' estimated replacement value on maintenance. Figure 3.1 shows the average percentage of facility replacement value spent on maintenance at the NASA centers.

As indicated in figure 3.1, with the exception of JPL, every NASA center falls below recommended funding levels. However, if NASA funds maintenance commensurate with the centers' estimated fiscal year 1992 needs, most centers will be spending above or near recommended levels as shown in figure 3.2.

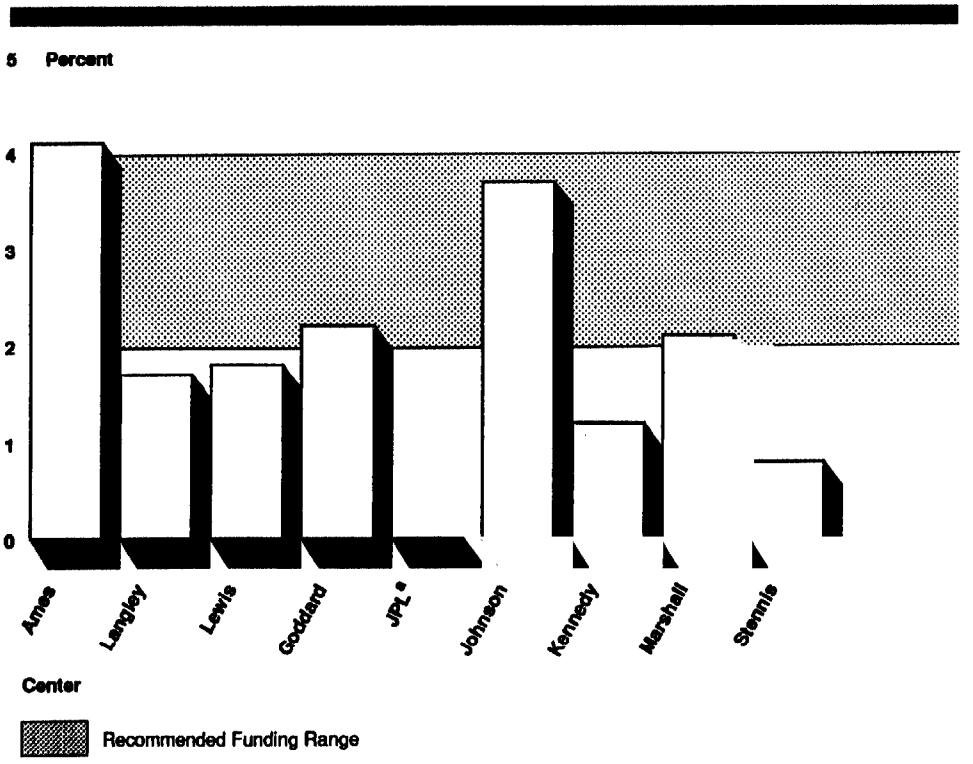
[3]The replacement values used in the comparison were based on each center's official property records for fiscal years 1985-89.

Figure 3.1: Average Yearly Maintenance Spending as Percentages of Average Yearly Replacement Value for Fiscal Years 1985-89



Note: Percentages for centers based on averages for the 5-year period, with the exception of Lewis and Goddard which did not begin calculating replacement values for all facilities until fiscal years 1988 and 1989, respectively.

Figure 3.2: Estimated Fiscal Year 1992 Maintenance Funding Needs as a Percent of Estimated Fiscal Year 1992 Replacement Value



Note: Fiscal year 1992 replacement values were estimated by using a compounded annual growth rate of 4 percent, since the replacement value of NASA centers' facilities appreciated annually at a rate of 4 percent from fiscal year 1985 to 1989.

[a]Funding needs not available.

Conclusions

The differences in the condition of facilities among centers and the deferral of needed maintenance correspond to the differences in maintenance funding levels. Most centers have not funded maintenance based on their overall funding needs and, as a result, fall far below the National Research Council's recommended funding levels. This low funding leaves NASA centers unable to adequately meet their overall maintenance requirements. A strong and highly visible commitment to maintenance is critical to ensure that NASA will not continue to underfund facility maintenance.

Recommendations

We recommend that the NASA Administrator:

- 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.

- Emphasize responsibility for protecting centers' facilities by making facility maintenance a critical element in annual objectives established for directors of centers and heads of headquarters program offices.

Critical Financial Management Information Is Currently Not Available

NASA centers do not have adequate information to properly administer their facility maintenance activities. To fulfill their maintenance responsibilities, center officials need to know their facilities' maintenance expenditures and the total resources required for this function. Such data are not always available because NASA has not previously required centers to report all maintenance costs or develop their total maintenance needs. As a result, the centers' accounting systems currently do not identify all center maintenance expenditures. In addition, most centers' maintenance budgets are not based on the overall condition of centers' facilities.

Centers Are Not Accounting for All Facility Maintenance Expenditures

None of the centers accurately account for their facility maintenance expenditures. The availability of reliable cost data is essential for centers to effectively monitor maintenance program execution, anticipate additional costs, and provide a basis for future program and budget planning. Centers' accounting systems did not accurately identify certain maintenance costs. These unidentified costs included (1) maintenance charged directly to research and development programs; (2) maintenance performed under contracts, such as those for wind tunnel and space shuttle operations; and (3) the salaries of civil service employees involved in managing or performing maintenance. Consequently, center directors do not always have complete and accurate information essential to planning and controlling center maintenance activities.

NASA budget estimates for the Research and Program Management appropriation identify maintenance as a part of the appropriation. Funds for maintenance were generally identified in the accounting records. However, maintenance funded through the Research and Development and Space Flight Control and Data Communications appropriations was not completely identified in NASA's accounting system. Consequently, we asked the centers to estimate the missing costs to determine their total maintenance expenditures for fiscal years 1985-89. For this 5-year period, the centers estimated that they spent over $250 million more on maintenance than was identified in NASA's accounting system. According to NASA headquarters Chief of the Maintenance Management Branch, this was the first time NASA had attempted to identify its total maintenance costs.

Centers had the most difficulty with identifying maintenance expenditures funded through the Research and Development appropriation. Mostly, they could not identify maintenance costs that were charged

directly to research and development programs. In addition, costs for maintenance performed by contractors that operate technical facilities such as wind tunnels and shuttle processing are reported as operations costs in center accounting systems. For example, Ames Research Center estimated that in fiscal year 1989 an additional $8.7 million had not previously been identified as maintenance of its technical facilities. Similarly, at Kennedy Space Center, the contractors responsible for shuttle processing and payload ground operations reported nearly $19 million in fiscal year 1989 as operating expenditures rather than maintenance costs.

Salaries of civil service employees involved in managing and performing maintenance were not accurately accounted for as maintenance costs. For example, Johnson and Kennedy Space Centers did not report any civil service salaries as maintenance costs but estimated that maintenance-related salary costs were $525,000 and $1.8 million, respectively, in fiscal year 1989. Goddard Space Flight Center reported about $1.1 million of its civil service salaries as a maintenance cost in fiscal year 1989. The center estimated, however, that actual salary costs related to maintenance were about $3.9 million that year.

Annual Facility Condition Surveys Can Improve Maintenance Budgeting

In the absence of more specific information, a percentage of facilities' replacement value can be used to estimate appropriate maintenance funding levels. The National Research Council's Building Research Board, however, recommends that formalized condition surveys be used to a greater extent to protect public assets. Before the fiscal year 1990 assessment, NASA had not attempted to consistently determine the condition of its centers' facilities. The condition assessment identified many deficiencies in the centers' facilities, including some safety problems that needed immediate attention. An effective assessment program can provide center directors with the (1) basis for establishing appropriate levels of required funding, (2) management tools for monitoring the effectiveness of maintenance activities, and (3) capability to realize the full benefit from the funds made available.

Conclusions

NASA centers' accounting and budgeting systems do not provide complete and accurate data on facility maintenance costs. In addition, NASA has not conducted regular assessments of the condition of its facilities to provide accurate information about actual conditions. As a result, not all the necessary information is available to oversee and to make sound decisions on the maintenance of facilities. Although a NASA contractor

assessed a sample of each center's facilities in 1990, NASA will not be able to maintain a current data base on facility conditions and repair requirements until centers develop the capability to make their own annual assessments.

Recommendations

We recommend that the NASA Administrator direct the centers to strengthen their procedures for budgeting and accounting for facility maintenance to ensure that maintenance functions are properly controlled. In addition, NASA should direct the centers to conduct annual surveys to determine the centers' respective maintenance and repair requirements.

Average Age and Estimated Replacement Value of NASA's Primary Centers and Activities

Dollars in millions

Location	Average age (years)	Total estimated replacement value
Ames Research Center	35.3	$1,274.7
Dryden Flight Research Facility	27.2	105.6
Goddard Space Flight Center	26.1	536.9
Wallops Flight Facility	37.7	201.4
Jet Propulsion Laboratory	[a]	416.0
Deep Space Communication Sites	[a]	245.3
Johnson Space Center	25.4	1,031.9
White Sands Test Facility	24.3	141.4
Kennedy Space Center	23.6	3,616.9
Langley Research Center	38.1	1,516.8
Lewis Research Center	39.3	1,639.8
Plum Brook Station	33.4	407.9
Marshall Space Flight Center	28.6	1,072.3
Michoud Assembly Facility	34.6	708.5
Slidell Computer Complex	26.6	33.3
Stennis Space Center	24.2	1,908.0
Total replacement value		**$14,856.7**

Note: All figures are based on fiscal year 1989 data.

[a]Not available.

Comments From the National Aeronautics and Space Administration

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

OCT 1 0 1990

Mr. Frank C. Conahan
Assistant Comptroller General
United States General Accounting Office
Washington, DC 20548

Dear Mr. Conahan:

This is the National Aeronautics and Space Administration's (NASA) response to the General Accounting Office (GAO) Draft Report GAO/NSIAD-90-266, entitled "NASA MAINTENANCE: Stronger Commitment Needed to Curb Facility Deterioration," dated October 1990.

The draft report presents a useful assessment of some of the key issues pertaining to NASA facilities maintenance. NASA shares the concerns identified by the GAO and is in the process of implementing programs to address them. GAO acknowledges these programs and recognizes them in the report. NASA finds the recommendations in the report to be constructive and appropriate.

See comment 1.

The report is particularly critical of maintenance funding allocation decisions made by NASA's Center Directors. We would like to point out that the NASA Center Directors have not always been provided with sufficient funding by NASA Headquarters over the years in the facilities maintenance area, and that this has forced them to defer maintenance tasks they would otherwise have undertaken. NASA Headquarters did not always have sufficient funds available to give to the Centers.

See comment 2.

The draft report gives particular emphasis to the "2 to 4 percent of replacement value" advocated by the National Research Council (NRC) as a standard for facilities maintenance. NASA participated in the preparation of the NRC committee report on budgeting for facilities maintenance, and we know that considerable care must be taken in applying it to a particular agency. Firstly, the standard is intended to be used as a guide, rather than the final budgeting or sole measurement tool. Secondly, the NRC's model for "maintenance" is far more inclusive than the NASA budget numbers used for comparison in the draft GAO report. NASA "maintenance" budget numbers shown in the report do not include the costs of NASA civil service employees who plan, manage, and at times perform facilities maintenance, or the funds spent on major repairs to facilities. These two items are included in different appropriations than those from which the NASA "maintenance" funds were tabulated in the draft GAO report. The NRC 2 to 4 percent standard is intended to include maintenance supervision and planning costs and some repair costs. Addition of these expenditures to the tabulated amounts of NASA "maintenance" expenditures would show that NASA is not quite as far from the NRC model's goal as the draft GAO report would indicate. However, this is not to say that NASA does not acknowledge that maintenance activities have been, and are, underfunded. Steps are underway to remedy this deficiency, over time; and the NRC 2 to 4 percent model is one tool we will use in developing budgets for maintenance activities.

See comment 3.

The enclosure provides more specific comments and suggestions that we believe will strengthen the report and reduce possible misinterpretations. We appreciate the efforts of your staff to solicit and consider NASA's views through the process of the review.

Sincerely,

John E. O'Brien
Assistant Deputy Administrator

Enclosure

The following are GAO's comments on NASA's letter dated October 10, 1990.

GAO Comments

1. It is appropriate to share the responsibility for underfunding with the program offices, but availability of funding is not a valid issue. Discretionary money was available for maintenance, and some centers, such as Langley, allocated more funds to maintenance than others that were operating in the same budget environment. In response to this concern, we revised the report to show that NASA headquarter's Institutional Program Offices and Centers share the responsibility for allocating far fewer funds to this function than generally accepted maintenance guidelines dictate.

2. In the report, we acknowledge that the National Research Council's (NRC) Building Research Board's recommendation is a guide. We state that, "In the absence of specific needs based information, the Board stated that this funding level (2 to 4 percent) should be used as an absolute minimum." We note that, while recognizing that a percentage of the facilities' replacement value can be used to estimate appropriate maintenance funding levels, the NRC recommends a much greater use of formalized condition assessments to protect public assets. We also state that an effective assessment program can provide a basis for establishing appropriate levels of required funding.

Concerning maintenance costs, we believe that to the extent available, all appropriate costs were included in the comparisons of centers' maintenance expenditures to the NRC recommended funding level. Because NASA's accounting system did not accurately identify all facility maintenance costs, we asked centers to estimate, where necessary, their total maintenance expenditures. Regarding salaries, each center provided an estimate of the costs for civil service staff that performed, monitored, or managed facility maintenance. Those costs were included in the analyses of centers' maintenance expenditures. In addition, we asked each center to verify the accuracy of their estimates prior to finalizing our analyses. We did not include the costs for major repairs in our analyses. The NRC report stated that the costs for routine maintenance and repairs would typically be in the range of 2 to 4 percent of facilities' replacement value. We did not consider expenses for major repairs, rehabilitations, or facility upgrades to fall within the category of routine maintenance and repairs.

3. We incorporated NASA's specific comments into this report where appropriate.

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