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NASA National Aeronautics and Space Administration

FY 1991 SAFETY PROGRAM STATUS REPORT

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NASA Safety Division
Office of Safety and Mission Quality
Washington, D.C. 20546

NASA National Aeronautics and Space Administration

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SAFETY PROGRAM OVERVIEW

In FY 1991, the NASA Safety Division continued efforts to enhance the quality and productivity of its safety oversight function. Recent initiatives set forth in areas such as training, risk management, safety assurance, operational safety, and safety information systems have matured into viable programs contributing to the safety and success of activities throughout the Agency.

Efforts continued to develop a centralized intra-agency safety training program with establishment of the NASA Safety Training Center at the Johnson Space Center (JSC). The objective is to provide quality training for NASA employees and contractors on a broad range of safety-related topics. Courses developed by the Training Center will be presented at various NASA locations to minimize travel and reach the greatest number of people at the least cost. In FY 1991, as part of the ongoing efforts to enhance the total quality of NASA's safety workforce, the Safety Training Center initiated development of a Certified Safety Professional review course. This course provides a comprehensive review of the skills and knowledge that well-rounded safety professionals must possess to qualify for professional certification. FY 1992 will see the course presented to NASA and contractor employees at all installations via the NASA Video Teleconference System.

The Safety Division developed a Managers Safety Training course. The purpose of the course is to familiarize NASA managers with their responsibilities in complying with OSHA and NASA safety requirements. The course was piloted at the Lewis Research Center (LeRC), Goddard Space Flight Center (GSFC), Kennedy Space Center (KSC), Stennis Space Center (SSC), Wallops Flight Facility (WFF), and JSC. The course materials are now available for tailoring and presentation by the Installations' safety and health staffs. Safety has been integrated into the NASA Program/Project Managers course sponsored by the Headquarters Training Division. One course module, covering a wide range of safety topics, is presented by the Director of the NASA Safety Division. Another module is dedicated to risk management. A NASA Explosive Safety Orientation course was developed and piloted at JSC and KSC. The Safety Division also sponsored the development of a NASA Management Oversight and Risk Tree Analysis Accident Investigation course introduced in FY 1991 at JSC.

Independent safety assurance was provided for 8 Space Shuttle launches, 3 Expendable Launch Vehicles, and 64 payloads. Safety assurance efforts include a Mission Safety Evaluation (MSE) for each Space Shuttle launch. The MSE report contains a certified independent assessment and status of significant mission risks, including acceptance rationale.

A NASA Safety Steering Committee Meeting was held on January 23 through 25, 1991, in Albuquerque, New Mexico. Representatives from all NASA Centers were in attendance to discuss overall NASA safety efforts and to gain insight into the total safety program. Some of the major topics were "Safety 2000" (the Safety Division's strategic plan), revision of the NASA Basic Safety Manual, safety training, survey trends, and safety program organizational changes.

NASA continued its initiatives to control trends, major causes or sources of fatalities, and lost time disabilities, and to lower overall compensation costs. The Safety Division sets annual lost time injury/illness frequency rate goals for each Center. The goals are based on a number of parameters including previous performance as compared to the Center's own past record and to the overall Agency rate, improvement desired, and projected worker hours. This effort is part of an overall safety motivation program that strives to continually reduce injuries in the workplace.

The Safety Division has established an excellent working relationship with OSHA via periodic meetings with OSHA's Office of Federal Agency Programs. Topics covered during these meetings include the extent of safety training available from the OSHA Training Institute, collateral duty safety training, early notification of pending new OSHA safety and health requirements, participation in Federal Safety Councils, proposed Memorandum of Understanding between OSHA and NASA establishing protocols for abatement of cited deficiencies, and proposed establishment of a safety and health professional exchange program.

A major accomplishment in FY 1991 was completion of the NASA Alternate Standard for Suspended Load Crane Operations. This extensive effort required coordination between NASA Headquarters, the Kennedy Space Center, and OSHA national, regional and area offices. The standard was approved by the Department of Labor's Assistant Secretary for Occupational Safety and Health.

NASA participated in the National Highway Traffic Safety Administration Drunk and Drugged Driver Awareness Campaign and the "70% Plus Federal Employees Safety Belt Use" program under Executive Order 12566. NASA excelled with eight of nine Installations achieving a minimum of 70% seat belt utilization ahead of the President's goal of January 1992.

During FY 1991, NASA Safety developed, validated, or revised various new management issuances policies, handbooks, standards, and other documents. A major effort to revise the NASA Basic Safety Manual continued. A final draft was distributed to the NASA field installations for review and comment. A revised NASA Safety Standard for Lifting Devices and Equipment was completed. A Management Instruction defining the NASA Safety Program for Pressure Vessels and Pressurized Systems was completed and published. An Aviation Program Management Instruction, which includes extensive safety requirements, was completed and published. A Management Instruction defining the NASA Emergency Preparedness Program was published. A NASA Safety Standard for Underwater Facility and Non-Open Water Operations was completed and published. A Self Audit Safety Checklist for 29 CFR 1960 Requirements was published. Several documents were drafted/revised and distributed to the field installations for review and comment, including: (1) draft Hydrogen/Oxygen Safety Handbook, (2) draft Explosive Safety Handbook, (3) draft NASA Safety and Health Program Management Instruction, (4) draft NASA Emergency Preparedness Plan, (5) revised NASA Fire Protection Manual, and (6) a form for Employee Reports of Alleged Hazards.

The Headquarters Hazardous Substances Internal Coordinating Committee continued to provide a forum for interdisciplinary discussion among all Headquarters staff concerned with the health, safety, storage, and transportation of hazardous materials, and the environmental exposure of the NASA workforce. The committee was active in screening and assessing the impact of new and proposed regulatory requirements and the need for related training. Committee meetings have included speakers from OSHA's Office of Federal Agency Programs.

NASA Safety sponsored a Fire Protection Meeting in Boston on May 23 in conjunction with the National Fire Protection Association's Annual Meeting.

There were significant efforts to improve and expand NASA's safety information systems in FY 1991. An upgrade to the NASA Mishap Reporting/Corrective Action System (MR/CAS) was approved and funded. The new multiuser system will be implemented at the beginning of FY 1992. Development of a prototype Lessons Learned Information System was initiated. This automated database will be a valuable tool for use by safety personnel, program managers, and engineers throughout NASA. The Safety Division is also developing an Automated NASA Safety Training Catalog. A demonstration prototype was completed in FY 1991. This automated database will provide NASA and contractor personnel instant access to information on safety related courses available throughout the Agency.

The Safety Division continued to participate in the Headquarters SRM&QA Survey Program. All NASA field installations are being surveyed on a 2-year cycle. As part of this effort, the safety programs at Ames Research Center/Dryden Flight Research Facility (ARC/DFRF), Langley Research Center (LaRC), and LeRC were reviewed in FY 1991. The Centers are required to take corrective action on all discrepancies found during the surveys. Lessons learned as a result of the surveys are distributed throughout the Agency so that all may benefit. The Safety Division conducted a special survey of the Headquarters facility to help management assess the posture of the safety program and to make recommendations for program enhancements.

NASA will continue to strive for maximum safety awareness and excellence in all activities. The field installations and the Safety Division will continue to work together to maintain an emphasis on safety.

Leven B. Gray
Acting Director, Safety Division

FY 1991 NASA SAFETY STATISTICS

Fatalities	1
NASA Safety Reportable Injuries/Illnesses	
No-Lost Time	259
Lost Time	94
Total Cases	353
Costs	
Lost Wages	$141,223
Chargeback Billing	$6,012,193
Material Losses	$6,127,578
Total Losses	$12,280,994

Information on injuries/illnesses and material losses was obtained from the NASA Mishap Reporting/Corrective Action System (MR/CAS). Lost wages and chargeback billing figures are from the Office of Workers' Compensation Programs (OWCP).

NASA OCCUPATIONAL INJURY/ILLNESS RECORD

Injuries and illness are divided into lost time cases and no-lost time cases. As defined by OSHA, a recordable (i.e., compensable) lost time case is a work related incident that results in either a nonfatal, traumatic injury that causes loss of time from work or disability beyond the day or shift when the injury occurred, or a nonfatal illness/disease that causes loss of time from work or disability at any time. A no-lost time case is a nonfatal injury (traumatic) or illness/disease (nontraumatic) requiring medical treatment beyond first aid but does not result in lost time. NASA Safety organizations adhere to the OSHA reporting guidelines with some exceptions. For example, NASA Safety does not consider restricted duty or time taken for medical treatment to be lost time. Also, instances of injuries sustained during recreational activities or in parking lots during non-work-related activities are not included in the MR/CAS.

Table 1 shows the FY 1991 NASA Safety reportable injury/illness statistics for Federal employees at NASA Centers and for contractor employees at the Jet Propulsion Laboratory (JPL). (JPL is government owned and contractor operated for the purpose of research and development.) The NASA Safety Division calculates injury/illness frequency rates based on the actual hours worked by each employee. The overall lost time frequency rate of 0.42 for NASA Federal employees is an 11% increase from the FY 1990 rate of 0.38. The lost time frequency rate of 0.87 for JPL contractor employees is a 20% decrease from the FY 1990 rate of 1.09.

TABLE 1. NASA SAFETY REPORTABLE INJURIES/ILLNESSES BY INSTALLATION - ANNUAL REPORT FY 1991

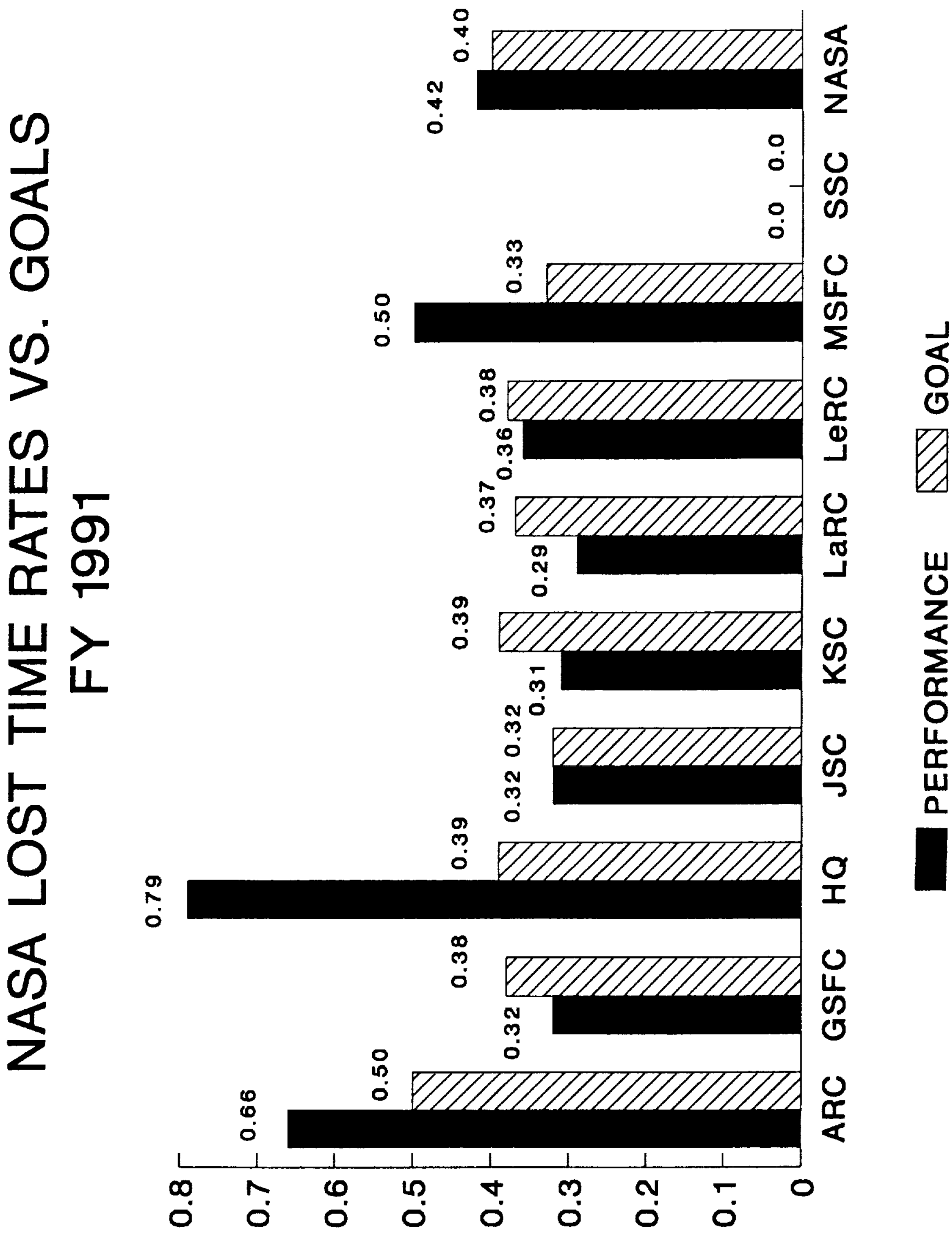
			Lost Time Cases			No Lost Time Incident w/ Injury Cases		Lost Time Rate vs. Goal '91	
	Average No. of Employees	Hours Worked	No. Days	No. Cases	Freq. Rate	No. Cases	Freq. Rate	YTD Rate	Goal
ARC/DFRF	2,454	4,545,349	174	15	0.66	17	0.75	0.66	0.50
GSFC/WFF	3,891	6,818,830	79	11	0.32	4	0.12	0.32	0.38
HQ	2,303	4,062,573	319	16	0.79	8	0.39	0.79	0.39
JSC/WSTF	3,975	6,937,843	60	11	0.32	17	0.49	0.32	0.32
KSC	2,439	4,506,999	94	7	0.31	58	2.57	0.31	0.39
LARC	3,130	5,506,840	100	8	0.29	14	0.51	0.29	0.37
LERC	2,596	5,010,311	115	9	0.36	123	4.91	0.36	0.38
MSFC/MAF	3,750	6,770,317	110	17	0.50	18	0.53	0.50	0.33
SSC	225	468,834	0	0	0	0	0	0	0.00
NASA	24,763	44,627,896	1051	94	0.42	259	1.16	0.42	0.40
1990	24,370	43,952,460	709	83	0.38	233	1.06	0.38	0.40
JPL		13,097,471	285	57	0.87	179	2.73	0.87	0.95
1990		12,707,013	425	69	1.09	263	4.14	1.09	0.95

1. Lost Time frequency rate = Number of lost workday cases per 200,000 hours worked.
2. Incidents w/Injury do not include Lost Time or First Aid cases.
3. Incidents w/Injury frequency rate = Number of injury cases per 200,000 hours worked.
4. The Jet Propulsion Laboratory (JPL) is a government-owned, contractor-operated facility.

Figure 1 shows how the FY 1991 NASA Safety reportable lost time injury/illness frequency rates for Federal employees at NASA Centers compare to the Centers' individual goals set by the Safety Division, the overall NASA goal of 0.40, and the overall FY 1991 NASA rate of 0.42. Although NASA did not meet its overall goal for FY 1991, six of the nine centers did meet their individual goals.

Figure 2 plots the NASA Safety reportable lost time frequency rate, no-lost time rate, and the total rate. Prior to FY 1989, the number of reported no-lost time cases was on the decline, and in FY 1988, actually fell below the number of lost time cases. This trend was reversed in FY 1989, and since that time, the number of no-lost time cases has increased every year. The primary reasons identified for this reversal are the significant increase in activity since 1988 and the establishment of health/first aid clinics at the Centers, resulting in increased reporting and treatment of minor no-lost time injuries/illnesses.

Figure 3 compares the FY 1991 NASA Safety reportable lost time frequency rates of NASA Federal employees at each Center with the previous year's rate and an average rate for the previous 3 years (FY 1988 - FY 1990).



NASA LOST TIME RATES VS. GOALS
FY 1991
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
ARC
GSFC
HQ
JSC
KSC
LaRC
LeRC
MSFC
SSC
NASA
0.66
0.50
0.32
0.38
0.79
0.39
0.32
0.32
0.31
0.39
0.29
0.37
0.36
0.38
0.50
0.33
0.0
0.0
0.42
0.40
PERFORMANCE
GOAL

Figure 1

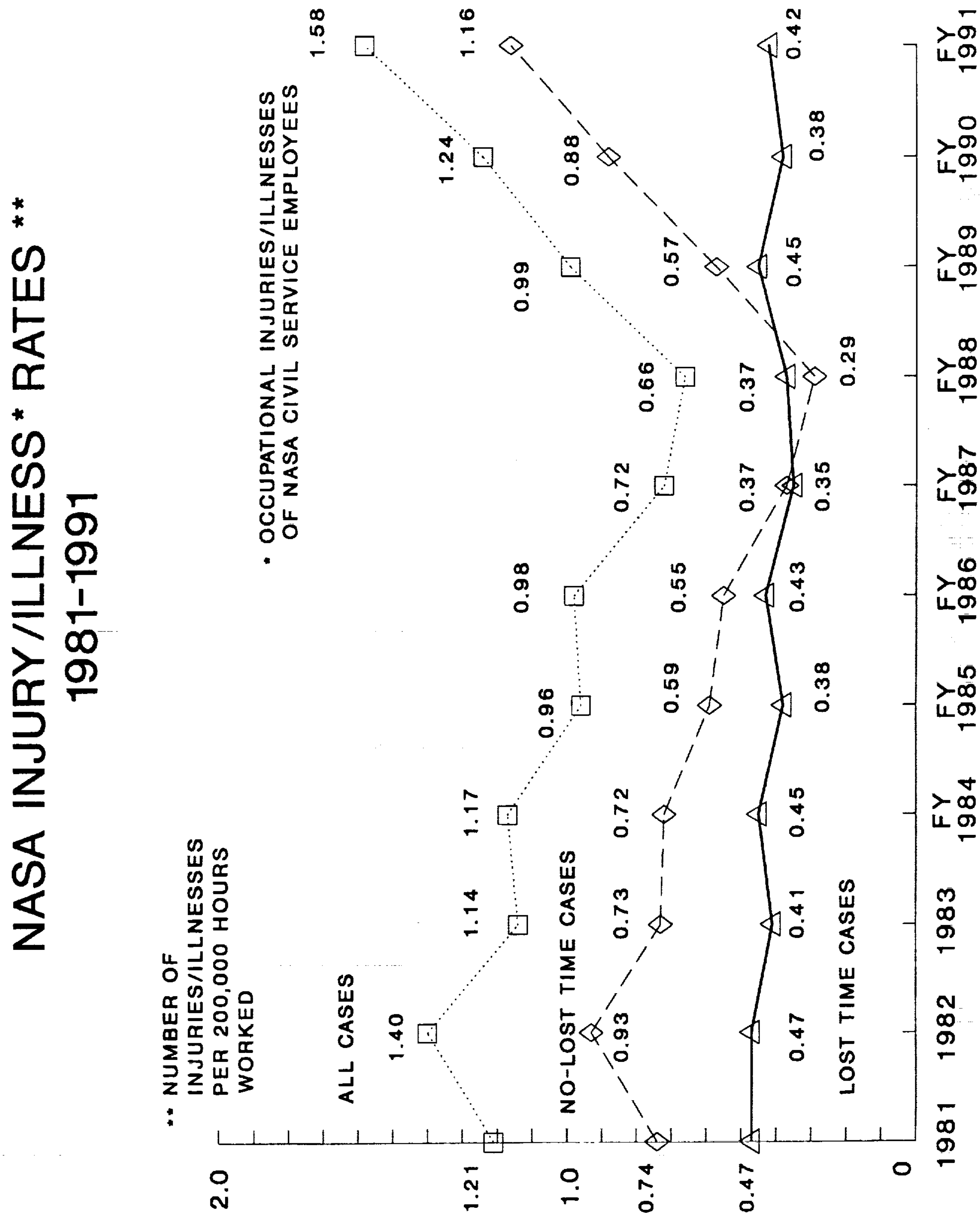
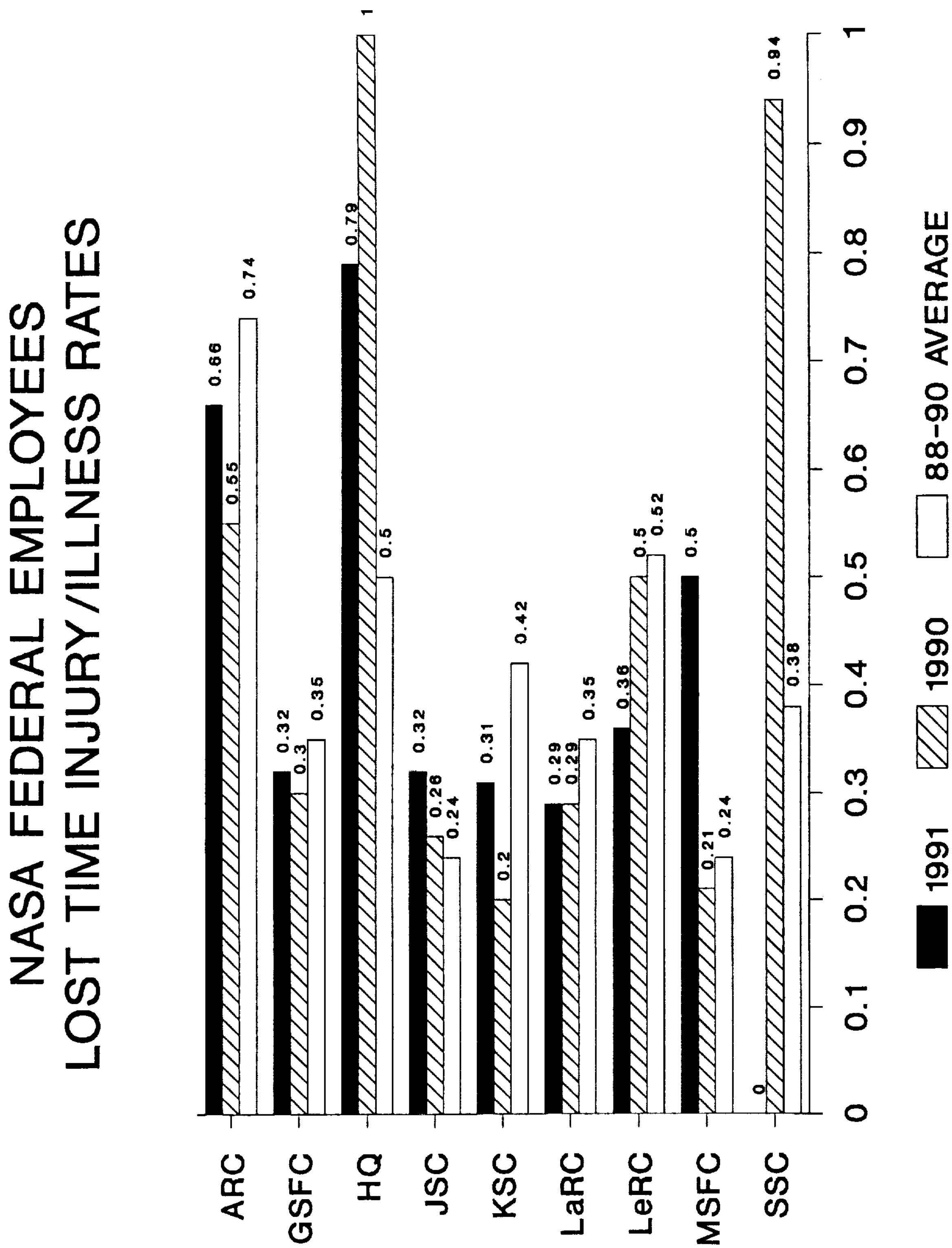

NASA INJURY/ILLNESS * RATES **
1981-1991
** NUMBER OF INJURIES/ILLNESSES PER 200,000 HOURS WORKED
* OCCUPATIONAL INJURIES/ILLNESSES OF NASA CIVIL SERVICE EMPLOYEES
ALL CASES
NO-LOST TIME CASES
LOST TIME CASES
2.0
1.21
1.0
0.74
0.47
0
1.40
1.14
1.17
0.96
0.98
0.72
0.66
0.99
1.24
1.58
0.93
0.73
0.72
0.59
0.55
0.37
0.37
0.57
0.88
1.16
0.47
0.41
0.45
0.38
0.43
0.35
0.29
0.45
0.38
0.42
1981
1982
1983
FY 1984
FY 1985
FY 1986
FY 1987
FY 1988
FY 1989
FY 1990
FY 1991

Figure 2



NASA FEDERAL EMPLOYEES
LOST TIME INJURY/ILLNESS RATES
ARC
GSFC
HQ
JSC
KSC
LaRC
LeRC
MSFC
SSC
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1991
1990
88-90 AVERAGE
0.66
0.55
0.74
0.32
0.3
0.35
0.79
1
0.5
0.32
0.26
0.24
0.31
0.2
0.42
0.29
0.29
0.35
0.36
0.5
0.52
0.5
0.21
0.24
0
0.94
0.38

Figure 3

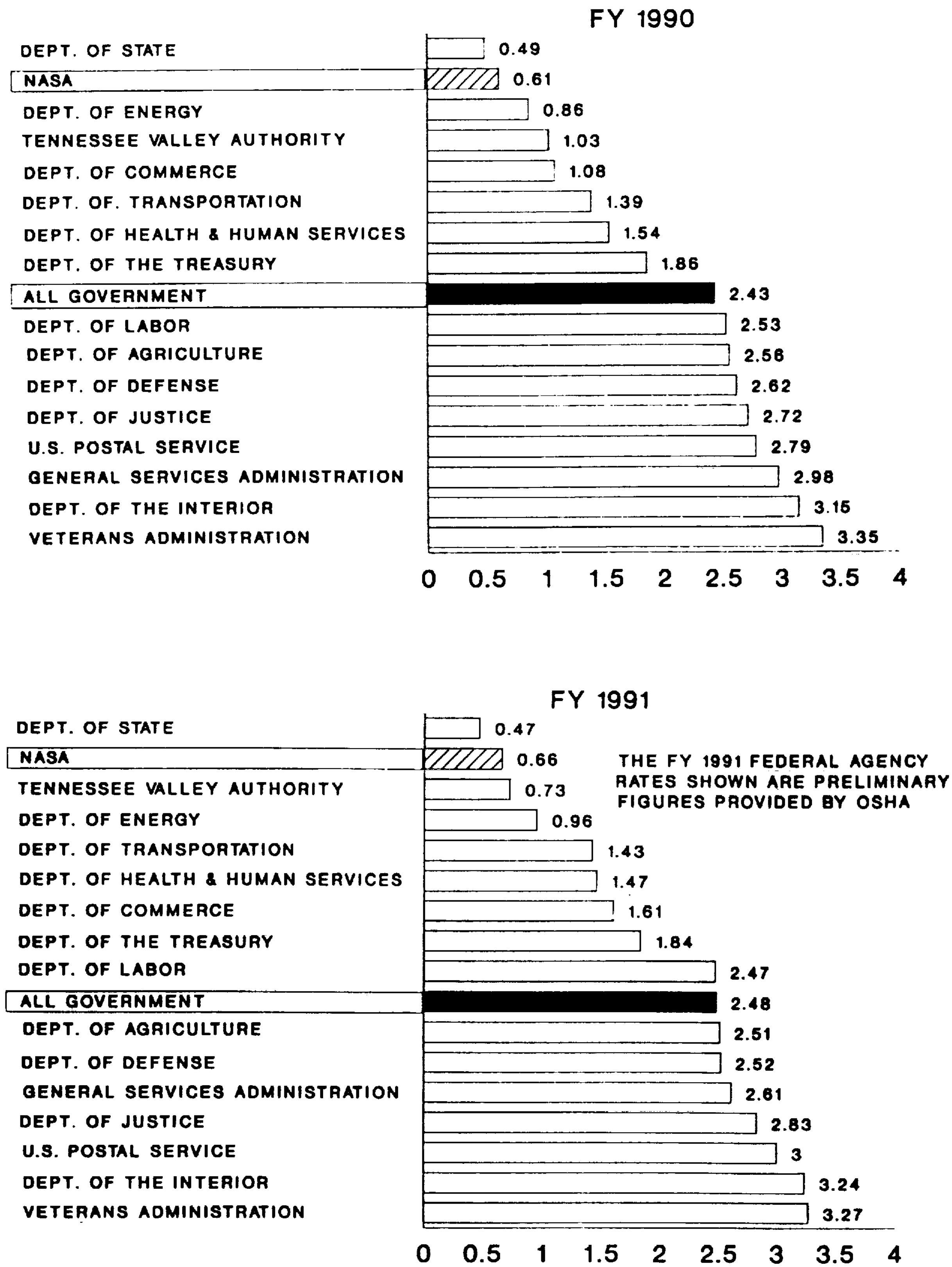
Comparison of NASA's injury/illness performance to that of other government agencies and private industries can be made using the injury/illness incidence rates published by the Department of Labor. Figures 4, 5, and 6 reflect these rates which are based on OWCP data and determined according to the number of injury/illness cases per 100 employees. The incidence rate for NASA is usually slightly higher than the frequency rate calculated by the NASA Safety Division. This is due to inherent differences in the two formulas and variations in the OWCP data. (OWCP tracks the number of claims made on OSHA recordable injuries and illnesses. It is possible for more than one claim to be made as the result of a given injury or illness.)

Figure 4 illustrates the relative position of NASA's lost time injury/illness performance compared to that of other Federal agencies having more than 15,000 employees in FY 1990 and FY 1991. Within this group of Federal agencies, NASA has ranked second since FY 1984.

Figure 5 compares NASA's lost time injury/illness performance for the last 11 years against that of other Federal agencies and select private sector industries. NASA's rates have been consistently lower than those of the Federal Government and the private sector. The most recent statistics available from the Department of Labor for the private sector are for FY 1990.

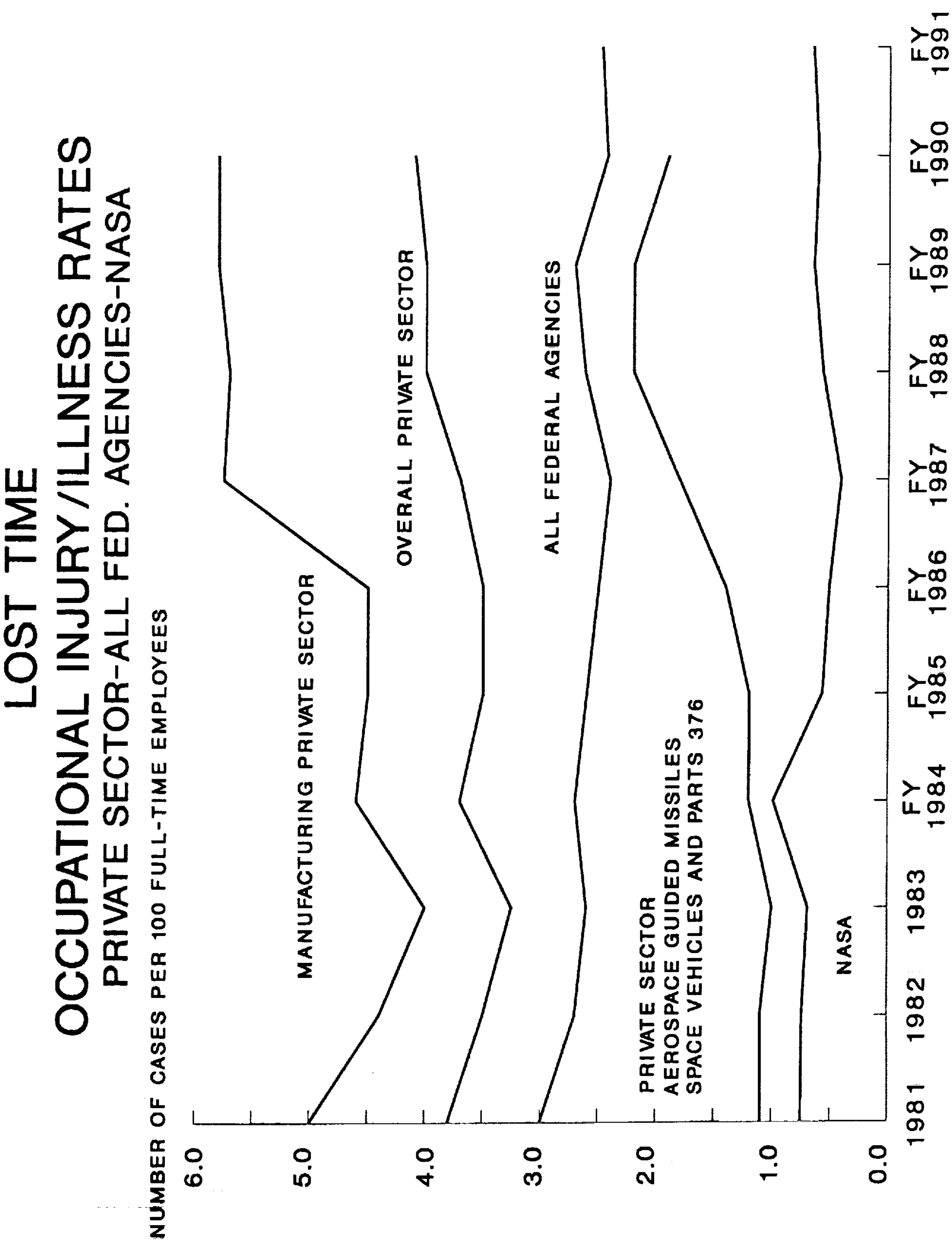
Figure 6 illustrates NASA's excellent overall injury/illness record over the last 11 years as compared to all other Federal agencies, the private sector, private sector manufacturing industry, and the private sector aerospace industry. The most recent statistics available from the Department of Labor for the private sector are for FY 1990.

LOST TIME INJURY/ILLNESS RATES IN SELECTED FEDERAL AGENCIES *



* HAVING MORE THAN 15,000 EMPLOYEES.

Figure 4



LOST TIME
OCCUPATIONAL INJURY/ILLNESS RATES
PRIVATE SECTOR-ALL FED. AGENCIES-NASA
NUMBER OF CASES PER 100 FULL-TIME EMPLOYEES
6.0
5.0
4.0
3.0
2.0
1.0
0.0
MANUFACTURING PRIVATE SECTOR
OVERALL PRIVATE SECTOR
ALL FEDERAL AGENCIES
PRIVATE SECTOR
AEROSPACE GUIDED MISSILES
SPACE VEHICLES AND PARTS 376
NASA
1981
1982
1983
FY 1984
FY 1985
FY 1986
FY 1987
FY 1988
FY 1989
FY 1990
FY 1991

Figure 5

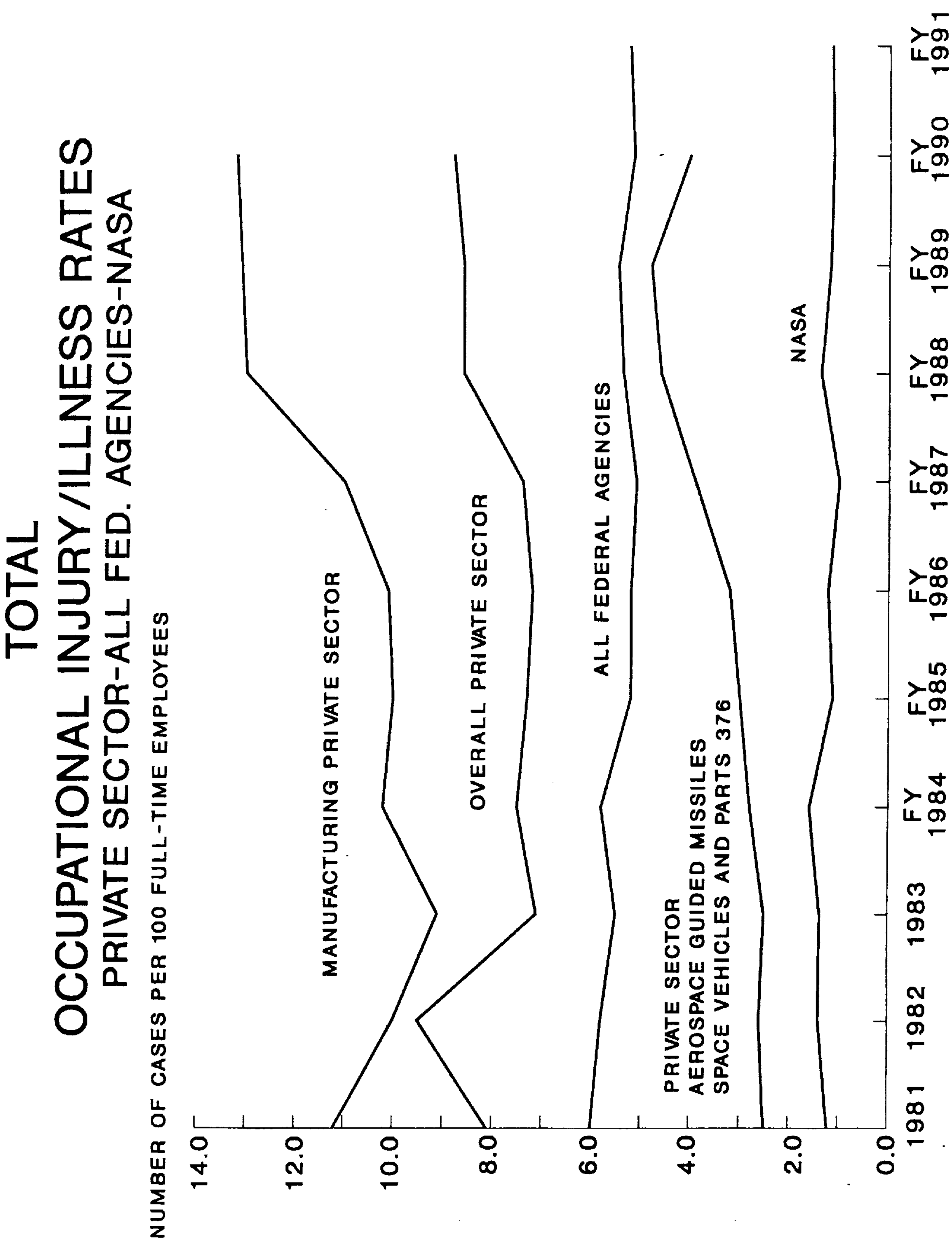

TOTAL
OCCUPATIONAL INJURY/ILLNESS RATES
PRIVATE SECTOR-ALL FED. AGENCIES-NASA
NUMBER OF CASES PER 100 FULL-TIME EMPLOYEES
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
MANUFACTURING PRIVATE SECTOR
OVERALL PRIVATE SECTOR
ALL FEDERAL AGENCIES
PRIVATE SECTOR
AEROSPACE GUIDED MISSILES
SPACE VEHICLES AND PARTS 376
NASA
1981
1982
1983
FY 1984
FY 1985
FY 1986
FY 1987
FY 1988
FY 1989
FY 1990
FY 1991

Figure 6

CHARGEBACK BILLING

Chargeback is defined by OSHA as a system under which the U.S. Department of Labor pays compensation and medical costs attributed to injuries that occurred after December 1, 1960, and then bills the agency that employed the individual who received compensation or benefits. In any given year, most of the chargeback billing is a result of illnesses and injuries that occurred in previous years. Only 2.6%, or $153,762, of the chargeback billing costs paid in FY 1991 were for injuries that actually occurred during that year.

Figure 7 illustrates the relationship between chargeback billing and all other mishap and injury-related costs. These costs include lost wages (continuation of pay) as well as damage to or loss of NASA property in excess of $499. Of the $12.3 million total loss for FY 1991, $6.0 million, or 49%, was paid out in chargeback billing costs.

Figure 8 illustrates the trend of chargeback billing in the Federal Government and in NASA for the last 11 years. The Federal Government's chargeback billing costs have continued to increase each year. NASA's stabilized at around $5 million annually through 1989 but increased to $6.0 million in FY 1990 and remained there in FY 1991.

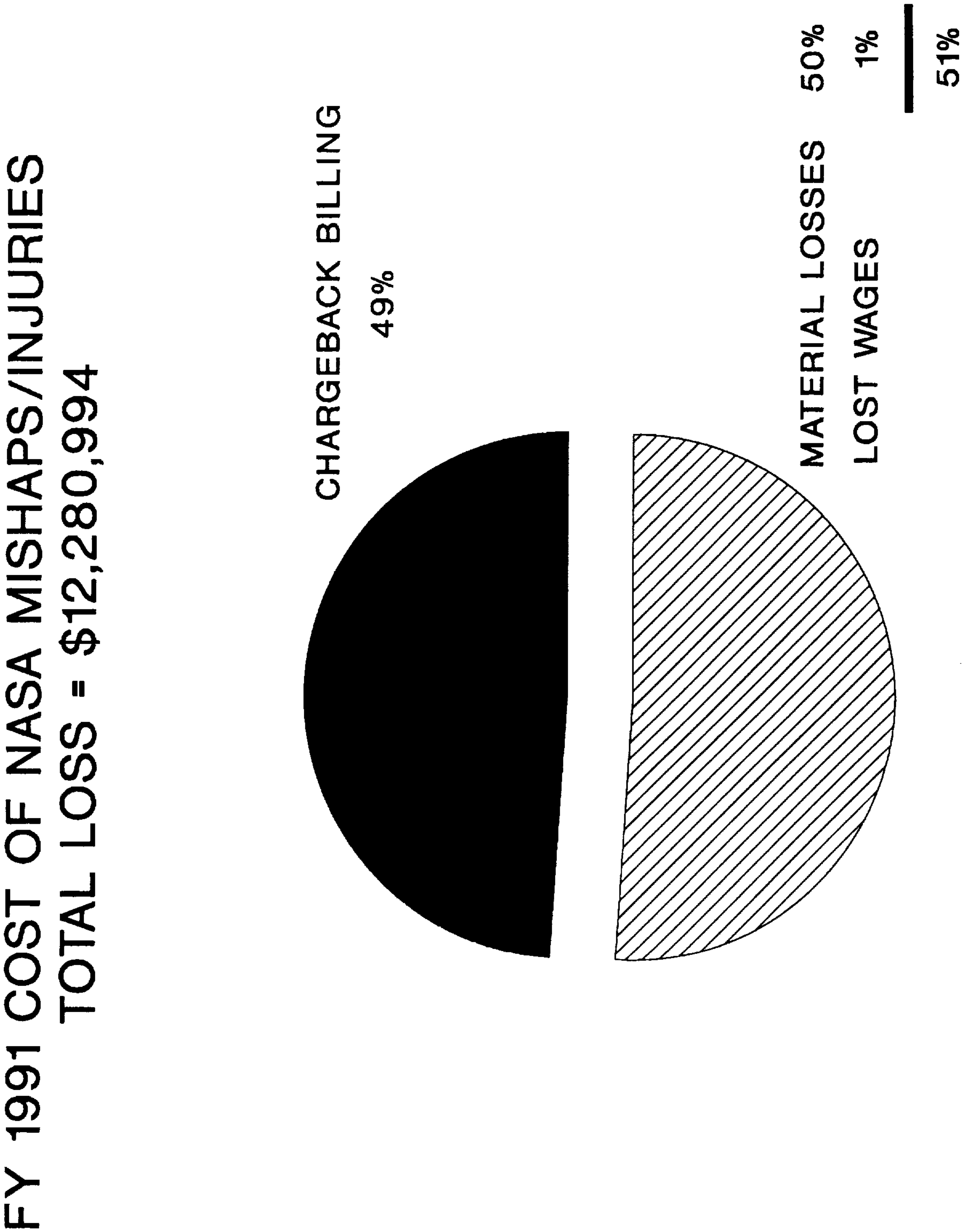

FY 1991 COST OF NASA MISHAPS/INJURIES
TOTAL LOSS = $12,280,994
CHARGEBACK BILLING
49%
MATERIAL LOSSES 50%
LOST WAGES 1%
51%

Figure 7

HISTORY OF CHARGEBACK BILLING COSTS FOR ALL FEDERAL AGENCIES AND NASA (IN MILLIONS OF DOLLARS)

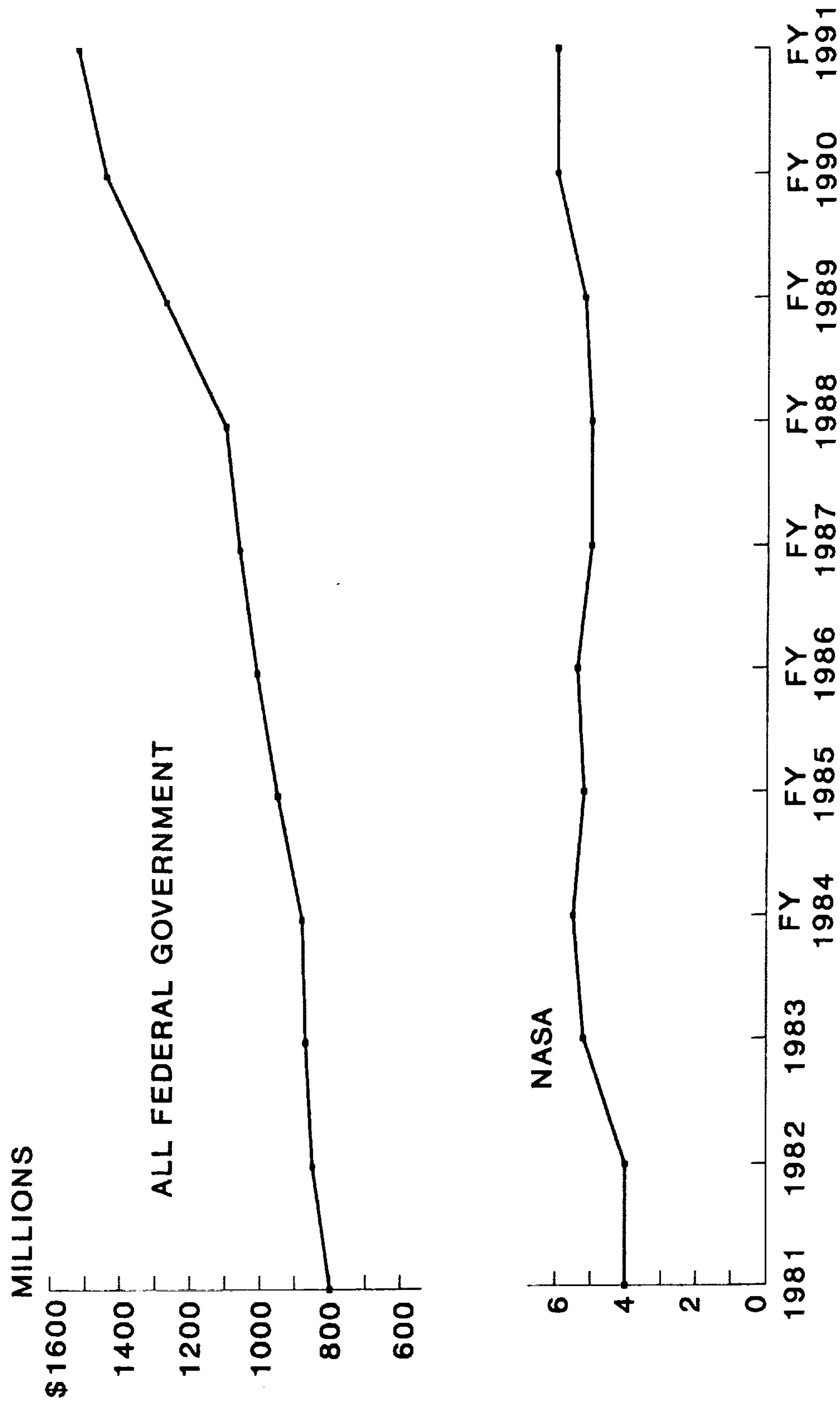


Figure 8

MATERIAL LOSSES

Tables 2A and 2B list the statistics for NASA material losses during FY 1991. Indirect costs associated with cleanup, investigation, injuries, or shutdown of operations are not included in these statistics. Table 2A provides the number of equipment/property damage cases by equipment classification for each installation. Table 2B provides the cost of equipment/property damage cases by equipment classification for each installation.

Figure 9 illustrates the total costs of material losses over the last 11 years.

Figure 10 provides a percentage breakdown of equipment/property costs for FY 1991. Facility and flight hardware losses were the major contributors.

Figure 11 compares FY 1991 equipment/property costs with FY 1990 results. Significant decreases in flight hardware, facility, and ground support equipment losses resulted in a 32% decrease in the total cost of material losses between FY 1990 and FY 1991.

TABLE 2A. EQUIPMENT/PROPERTY DAMAGE BY INSTALLATION - ANNUAL REPORT FY 1991
NUMBER OF CASES BY EQUIPMENT CLASSIFICATION

	Flight Hardware	Ground Support Equip.	Facility	Pressure Vessel	Motor Vehicle	Aircraft	Other	Total Cases
ARC/DFRF	0	2	2	0	0	0	4	8
GSFC/WFF	0	0	1	1	1	0	1	4
HQ	0	0	0	0	0	0	0	0
JPL	0	1	4	0	1	0	2	8
JSC/WSTF	0	0	2	1	3	3	5	14
KSC	7	4	2	0	18	0	2	33
LARC	1	0	3	0	0	1	0	4
LERC	0	0	4	0	1	0	5	10
MSFC	10	3	4	0	6	0	7	30
SSC	0	0	0	1	0	0	0	1
TOTAL	17	10	22	3	30	4	26	112
1990	38	9	30	1	15	2	30	125

TABLE 2B. EQUIPMENT/PROPERTY COSTS BY INSTALLATION - ANNUAL REPORT FY 1991
COST OF CASES BY EQUIPMENT CLASSIFICATION

	Flight Hardware	Ground Support Equip.	Facility	Pressure Vessel	Motor Vehicle	Aircraft	Other	Total Costs
ARC/DFRF	0	56,250	1,200,000	0	0	0	334,574	1,590,824
GSFC/WFF	0	0	2,000	4,000	9,000	0	9,598	24,598
HQ	0	0	0	0	0	0	0	0
JPL	0	2,500	157,000	0	5,000	0	7,000	171,500
JSC/WSTF	0	0	350,797	24,000	4,051	261,173	9,696	649,717
KSC	2,637,080	35,664	42,517	0	55,574	0	3,108	2,773,943
LARC	0	0	72,425	0	0	23,941	0	96,366
LERC	0	0	14,721	0	1,541	0	68,609	84,871
MSFC	381,598	6,400	39,667	0	8,960	0	212,114	648,739
SSC	0	0	0	87,020	0	0	0	87,020
TOTAL	3,018,678	100,814	1,879,127	115,020	84,126	285,114	644,699	6,127,578
1990	4,090,918	514,238	3,414,536	0	34,773	39,945	932,980	9,027,390

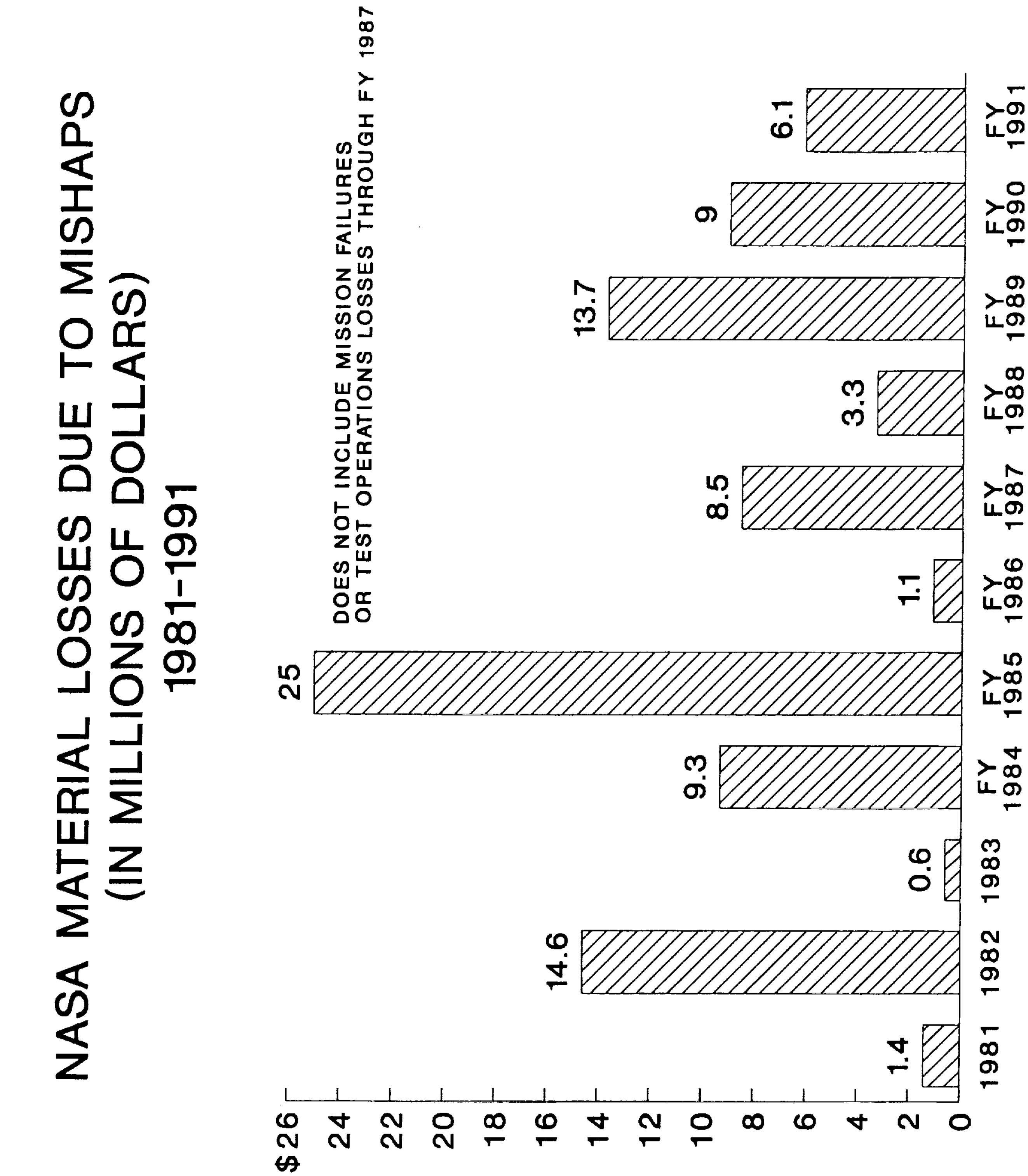

NASA MATERIAL LOSSES DUE TO MISHAPS
(IN MILLIONS OF DOLLARS)
1981-1991
DOES NOT INCLUDE MISSION FAILURES
OR TEST OPERATIONS LOSSES THROUGH FY 1987
MILLIONS
$26
24
22
20
18
16
14
12
10
8
6
4
2
0
1.4
14.6
0.6
9.3
25
1.1
8.5
3.3
13.7
9
6.1
1981
1982
1983
FY 1984
FY 1985
FY 1986
FY 1987
FY 1988
FY 1989
FY 1990
FY 1991

Figure 9

FY 1991 EQUIPMENT/PROPERTY COSTS
NASA TOTAL $6,127,578

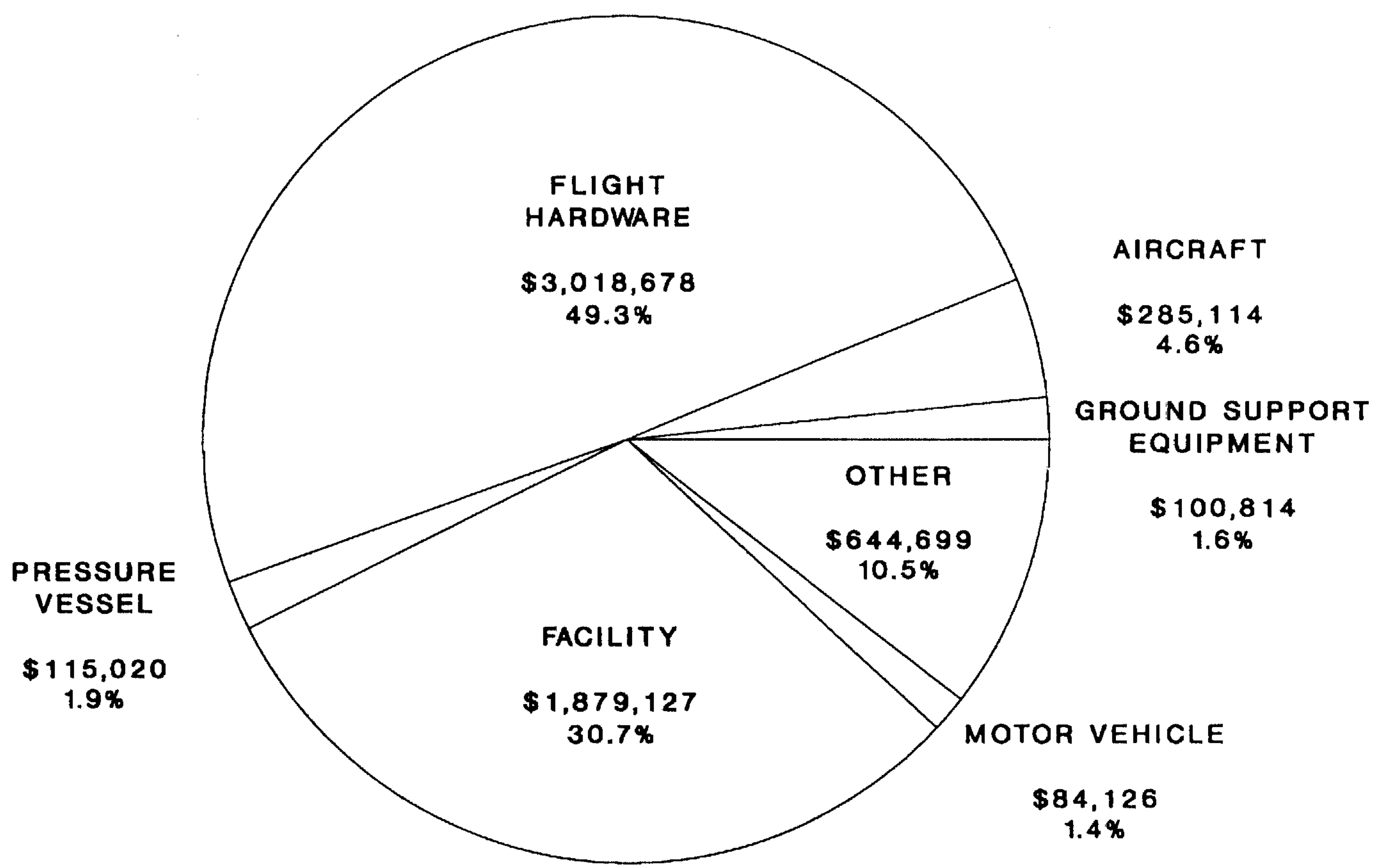


Figure 10

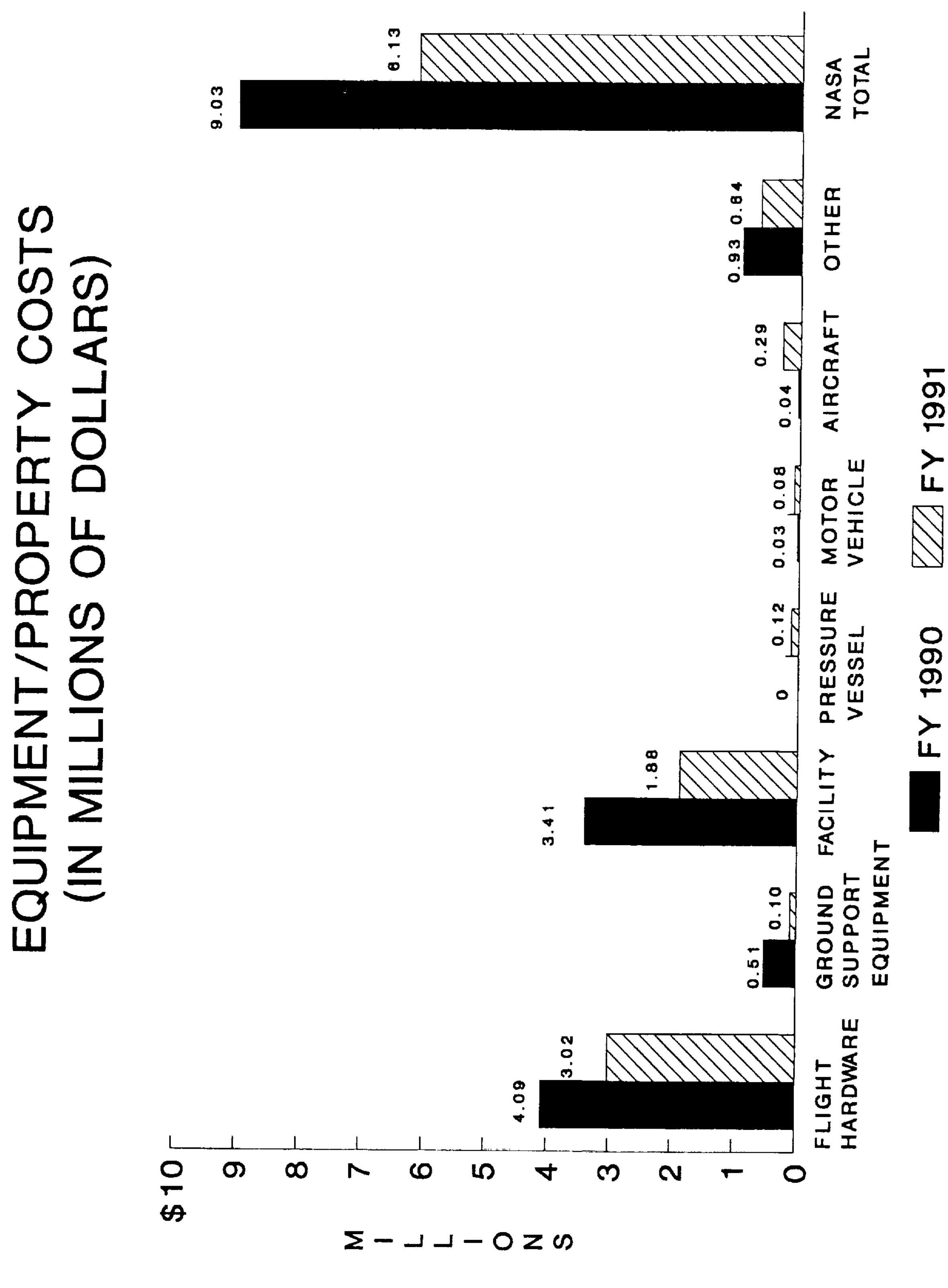

EQUIPMENT/PROPERTY COSTS
(IN MILLIONS OF DOLLARS)
$10
9
8
7
6
5
4
3
2
1
0
MILLIONS
4.09
3.02
0.51
0.10
3.41
1.88
0
0.12
0.03
0.08
0.04
0.29
0.93
0.84
9.03
6.13
FLIGHT HARDWARE
GROUND SUPPORT EQUIPMENT
FACILITY
PRESSURE VESSEL
MOTOR VEHICLE
AIRCRAFT
OTHER
NASA TOTAL
FY 1990
FY 1991

Figure 11

NASA MISHAP DEFINITIONS

The revised NASA Management Instruction for Mishap Reporting and Investigation (NMI 8621.1E), dated September 6, 1988, contains updated NASA mishap definitions. All mishaps reported in FY 1991 were categorized according to these definitions as follows:

1. **NASA MISHAP:** Any unplanned occurrence, event, or anomaly that meets one of the definitions below. Injury to a member of the public while on NASA facilities also is defined as a NASA mishap.

   a. **TYPE A MISHAP:** A mishap causing death and/or damage to equipment or property equal to or greater than $1,000,000. Mishaps resulting in damage to aircraft or space hardware, i.e., flight and ground support hardware, meeting this criterion are included. This definition also applies to a test failure if the damage was unexpected or unanticipated or if the failure is likely to have significant program impact or visibility.

   b. **TYPE B MISHAP:** A mishap resulting in permanent disability to one or more persons, or hospitalization (for other that observation) of five or more persons, and/or damage to equipment or property equal to or greater than $250,000 but less than $1,000,000. Mishaps resulting in damage to aircraft or space hardware which meet this criterion are included, as are test failures where the damage was unexpected or unanticipated.

   c. **TYPE C MISHAP:** A mishap resulting in damage to equipment or property equal to or greater than $25,000 but less than $250,000, and/or causing occupational injury or illness that results in a lost workday case. Mishaps resulting in damage to aircraft or space hardware which meet this criterion are included, as are test failures where the damage was unexpected or unanticipated.

   d. **MISSION FAILURE:** Any mishap (event) of such a serious nature that it prevents accomplishment of a majority of the primary mission objectives. A mishap of whatever intrinsic severity that, in the judgment of the Program Associate Administrator, in coordination with the Associate Administrator for Safety and Mission Quality, prevents the achievement of primary mission objectives as described in the Mission Operations Report or equivalent document.

   e. **INCIDENT:** A mishap consisting of less than Type C severity of injury to personnel (more than first aid severity) and/or property damage equal to or greater than $1,000 but less than $25,000.

2. **NASA CONTRACTOR MISHAP:** Any mishaps as defined in paragraphs 1a through 1e that involve only NASA contractor personnel, equipment, or facilities in support of NASA operations.

3. **IMMEDIATELY REPORTABLE MISHAPS:** All mishaps that require immediate telephonic notification to local and Headquarters safety officials. Included in this category are those mishaps defined in paragraphs 1a through 1d and 2 with the exception of Type C injury/illness cases and incidents.

4. **CLOSE CALL:** An occurrence in which there is no injury, no significant equipment/property damage (less than $1,000), and no significant interruption of productive work, but which possesses a high potential for any of the mishaps as defined in paragraphs 1a through 1e.

5. **OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) RECORDABLE MISHAP:** An occupational death, injury, or illness that must be recorded subject to OSHA requirements in 29 CFR Part 1960 and Part 1910.

6. **COSTS:** Direct costs of repair, retest, program delays, replacement, or recovery of NASA materials including hours, material, and contract costs, but excluding indirect costs of cleanup, investigation (either by NASA, contractor, or consultant), injury, and by normal operational shutdown. Materials or equipment replaced by another organization at no cost to NASA will be calculated at "book" value. This includes those mishaps covered by insurance.

MISHAP STATISTICS

Tables 3 and 4 show the mishaps that were reported by the NASA field installations as having significance beyond the minor dollar losses or no-lost time injury category. These mishaps provide lessons learned for all NASA accident prevention programs.

Figure 12 presents an 11-year overview of all NASA Type A and B mishaps and Type C property damage mishaps. Type B and C personal injuries are reflected in Table 1. The dollar limits for each category have escalated over the years due to inflation and policy changes.

Figure 13 presents an 11-year history of NASA's total losses from chargeback billing costs, lost wages, and material losses due to mishaps.

Tables 5A and 5B provide a safety performance summary for FY 1991. Table 5A shows the incidents with injury rates for NASA employees at each Center and compares FY 1991 lost time injury/illness rates with each Center's goal and previous performance. Table 5B shows the number and type of mishaps and the cost of material losses for FY 1990 and FY 1991.

TABLE 3. FATALITIES - ANNUAL REPORT FY 1991

	1987	1988	1989	1990	1991
	N/ C/ O	N/ C/ O	N/ C/ O	N/ C/ O	N/ C/ O
ARC/DFRF	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	1/ 0/ 0
GSFC/WFF	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0
HQ	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0
JPL	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0
JSC/WSTF	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 1
KSC	0/ 0/ 0	0/ 1/ 0	0/ 1/ 0	0/ 0/ 1	0/ 0/ 0
LARC	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0
LERC	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0
MSFC/MAF	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0
SSC	0/ 0/ 0	0/ 1/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0
TOTAL	0/ 0/ 0	0/ 0/ 0	0/ 1/ 0	0/ 0/ 1	1/ 0/ 1

1. N/ C/ O = NASA / Contractor / Other.

TABLE 4. NASA MAJOR MISHAPS BY INSTALLATION - ANNUAL REPORT FY 1991

	1987	1988	1989	1990	1991
	A/ B/ C	A/ B/ C	A/ B/ C	A/ B/ C	A/ B/ C
ARC/DFRF	0/ 0/ 16	0/ 0/ 21	1/ 0/ 19	1/ 1/ 14	1/ 2/ 16
GSFC/WFF	0/ 0/ 16	0/ 0/ 13	0/ 0/ 8	0/ 0/ 11	0/ 0/ 11
HQ	0/ 0/ 1	0/ 0/ 0	0/ 0/ 8	0/ 0/ 18	0/ 0/ 16
JPL	0/ 0/ 0	0/ 0/ 0	0/ 1/ 0	0/ 0/ 1	0/ 0/ 1
JSC/WSTF	0/ 2/ 8	0/ 0/ 7	0/ 2/ 12	0/ 0/ 12	0/ 1/ 13
KSC	1/ 0/ 6	0/ 2/ 14	0/ 1/ 18	1/ 0/ 12	1/ 0/ 9
LARC	0/ 0/ 5	0/ 0/ 10	1/ 0/ 16	0/ 0/ 8	0/ 0/ 9
LERC	0/ 0/ 20	0/ 0/ 12	0/ 1/ 17	0/ 0/ 13	0/ 0/ 10
MSFC/MAF	2/ 0/ 12	0/ 1/ 14	0/ 1/ 18	0/ 0/ 10	0/ 0/ 23
SSC	0/ 0/ 3	0/ 0/ 2	0/ 0/ 0	0/ 0/ 2	0/ 0/ 1
TOTAL	3/ 2/ 87	0/ 3/ 93	2/ 6/116	2/ 1/101	2/ 3/109

1. Includes NASA fatalities, permanent disabilities, hospitalization of 5 or more persons, lost time mishaps and Type A, B, & C property damage according to NMI 8621.1E.

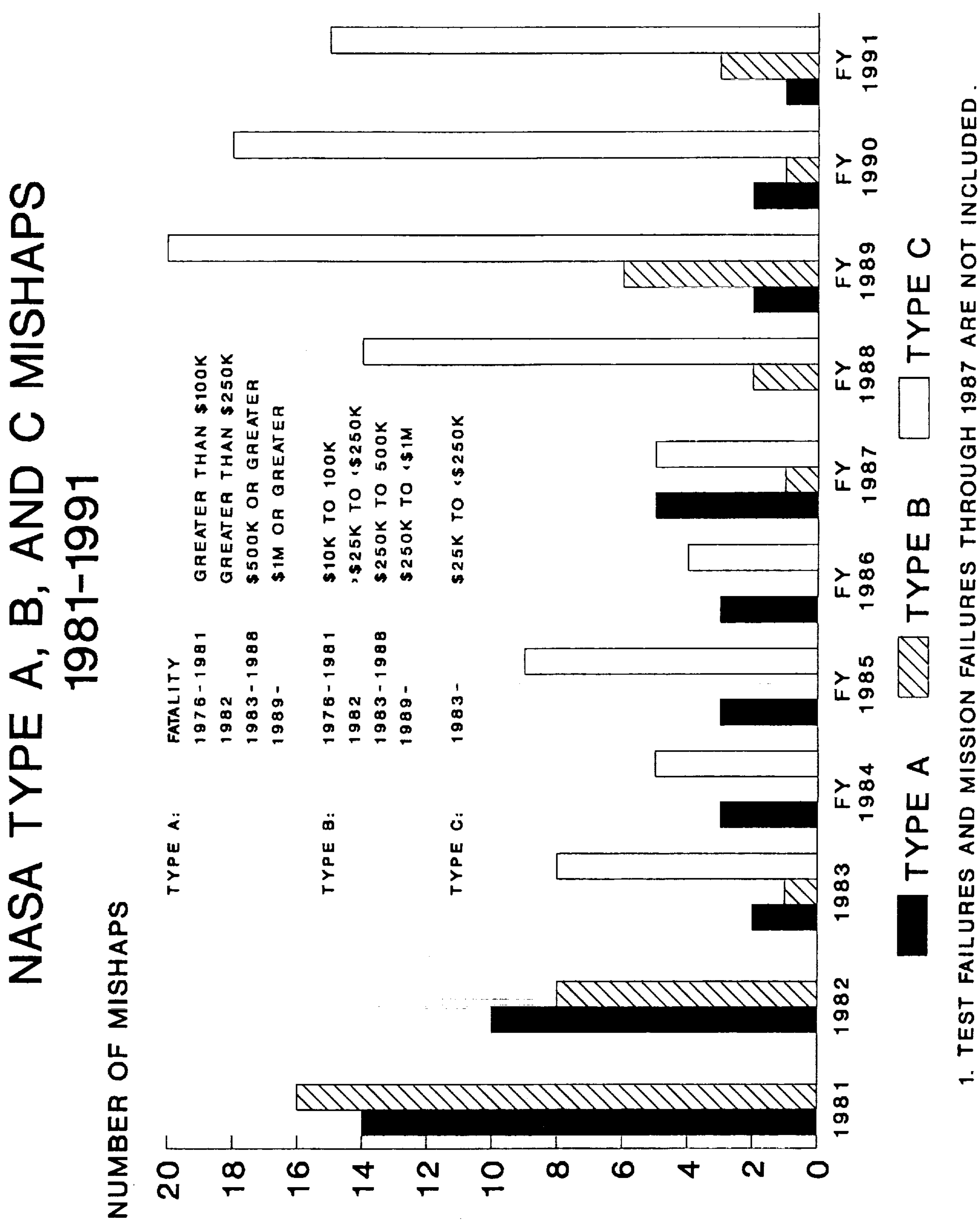

NASA TYPE A, B, AND C MISHAPS
1981-1991
NUMBER OF MISHAPS
0
2
4
6
8
10
12
14
16
18
20
TYPE A: FATALITY
1976-1981 GREATER THAN $100K
1982 GREATER THAN $250K
1983-1988 $500K OR GREATER
1989- $1M OR GREATER
TYPE B: 1976-1981 $10K TO 100K
1982 >$25K TO <$250K
1983-1988 $250K TO 500K
1989- $250K TO <$1M
TYPE C: 1983- $25K TO <$250K
1981
1982
1983
FY 1984
FY 1985
FY 1986
FY 1987
FY 1988
FY 1989
FY 1990
FY 1991
TYPE A
TYPE B
TYPE C
1. TEST FAILURES AND MISSION FAILURES THROUGH 1987 ARE NOT INCLUDED.
2. LOST TIME INJURIES ARE NOT INCLUDED.

Figure 12

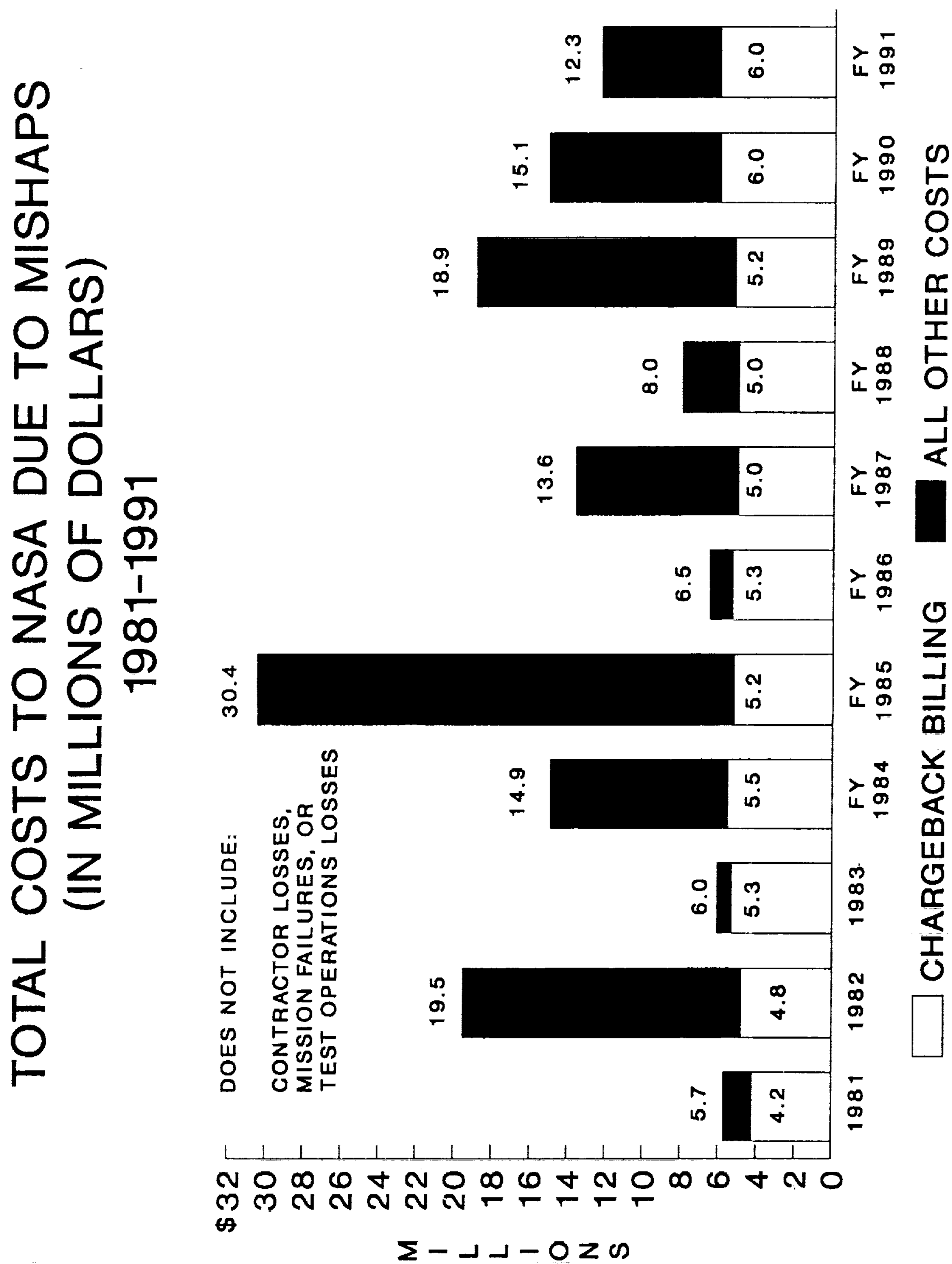

TOTAL COSTS TO NASA DUE TO MISHAPS
(IN MILLIONS OF DOLLARS)
1981-1991
DOES NOT INCLUDE:
CONTRACTOR LOSSES, MISSION FAILURES, OR TEST OPERATIONS LOSSES
MILLIONS
$32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1981
1982
1983
FY 1984
FY 1985
FY 1986
FY 1987
FY 1988
FY 1989
FY 1990
FY 1991
5.7
4.2
19.5
4.8
6.0
5.3
14.9
5.5
30.4
5.2
6.5
5.3
13.6
5.0
8.0
5.0
18.9
5.2
15.1
6.0
12.3
6.0
CHARGEBACK BILLING
ALL OTHER COSTS

Figure 13

TABLE 5A. PERFORMANCE SUMMARY - ANNUAL REPORT FY 1991

	NASA NO-LOST TIME INCIDENT W/INJURY RATES		NASA LOST TIME RATES		
	1990	1991	1990	GOAL 1991	1991
ARC/DFRF	0.09	0.75	0.55	0.50	0.66
GSFC/WFF	0.83	0.12	0.30	0.38	0.32
HQ	0.83	0.39	0.99	0.39	0.79
JSC/WSTF	0.21	0.49	0.26	0.32	0.32
KSC	1.41	2.57	0.20	0.39	0.31
LARC	0.59	0.51	0.29	0.37	0.29
LERC	3.15	4.91	0.50	0.38	0.36
MSFC/MAF	0.51	0.53	0.21	0.33	0.50
SSC	0.00	0.00	0.72	0.00	0.00
NASA	1.06	1.16	0.38	0.40	0.42

TABLE 5B. PERFORMANCE SUMMARY - ANNUAL REPORT FY 91

	TYPE A MISHAPS			TYPE B MISHAPS		TYPE C MISHAPS		MATERIAL LOSSES	
	1990	1991	(FATALITIES) 1991	1990	1991	1990	1991	1990	1991
ARC/DFRF	1	0	0	1	2	14	16	3,080,000	1,590,824
GSFC/WFF	0	0	0	0	0	11	11	277,800	24,598
HQ	0	0	0	0	0	18	16	0	0
JPL	0	0	0	0	0	1	1	201,200	171,500
JSC/WSTF	0	0	0	0	1	12	13	208,052	649,717
KSC	1	1	0	0	0	11	9	4,204,928	2,773,943
LARC	0	0	0	0	0	8	9	47,800	96,366
LERC	0	0	0	0	0	13	10	210,562	84,871
MSFC/MAF	0	0	0	0	0	10	23	785,898	648,739
SSC	0	0	0	0	0	2	1	11,150	87,020
TOTALS	2	1	0	1	3	100	109	9,027,390	6,127,578

MAJOR MISHAPS IN FY 1991

FATALITY
AMES RESEARCH CENTER
TYPE A

On February 1, 1991, a NASA employee from the Ames Dryden Flight Research Facility was killed in a commercial airline accident at the Los Angeles International Airport while traveling on Agency business. She was one of ten passengers on a SkyWest twin-engine Fairchild Metroliner III commuter plane that was preparing for take off when it was struck by a USAir Boeing 737 that was in the process of landing. The National Transportation Safety Board investigated the mishap.

FATALITY
JOHNSON SPACE CENTER
TYPE A

On April 5, 1991, Astronaut Captain Manley L. "Sonny" Carter was killed in a commercial airline accident in Georgia while traveling on government business. He was one of 23 people on an Atlantic Southeast Airline Brazilian-made Embraer 120 twin-engine turboprop commuter plane on route from Atlanta to Brunswick. The plane crashed in a wooded area approximately 3 miles from its destination, the Glynco Jetport. There were no survivors. The National Transportation Safety Board investigated the mishap.

Captain Carter was a Navy officer who flew aboard the Space Shuttle Discovery on a Department of Defense mission (STS-33) in November 1989 and was scheduled to fly aboard the International Microgravity Lab-1 mission (STS-42).

FUEL CELL MISHAP
KENNEDY SPACE CENTER
TYPE A

On August 12, 1991, two of the three fuel cells installed on Orbiter Atlantis, OV-104, were damaged when they were inadvertently left connected to the Orbiter's main electrical power busses without water removal capability. The accumulation of water can cause severe damage to the fuel cells.

Atlantis landed at KSC on August 11, 1991 after completing the STS-43 mission. The vehicle was undergoing deservice and safing operations in the Orbiter Processing Facility (OPF) High Bay 2 as part of the turnaround activities for its next mission, STS-44. As the result of an inadequate test procedure, helium was inadvertently ingested into the fuel cell oxygen supply. Ingestion of helium does not harm the fuel cells, but it does degrade performance. In this case, it initiated a sequence of events that resulted in damage to the fuel cells. The decrease in power necessitated the implementation of an emergency power down procedure. This procedure consisted of 6 crew module switch actions and was believed to have electrically isolated the fuel cells from the Orbiter's main busses. However, the procedure did not address the loss of multiple fuel cells with no vehicle ground power, as was the case. There was no power available to drive the fuel cell main bus motor switches to the open (isolate) position. Unknowingly, the fuel cells were left connected to the Orbiter's main electrical power busses. The chemical reaction within the fuel cells continued to generate electrical power and water for 16 hours and 36 minutes before reports of occasional alarms and noises (e.g., fans operating) emanating from the Orbiter led to the realization that the fuel cells were still connected to the Orbiter's main busses. The fuel cells were removed from the busses at approximately 8:34 p.m. EDT August 12, 1991, by use of ground power through the Orbiter ground umbilicals. Final cost of the mishap was $2,575,000.

FIRE
MODULAR BUILDING
AMES RESEARCH CENTER
TYPE B

On December 5, 1990, a fire occurred at approximately 12:45 a.m. at the Ames Research Center in a modular building where research in microwave landing systems was being conducted.

The fire started in one of the building's four heat pump units. Sawdust in an improperly installed duct connector was exposed to the heat pump's furnace electric coils. Once the sawdust was ignited, the fire spread to the wood framing and paper backed insulation in the walls. Most of the fire damage occurred above the suspended ceiling. Heat, water, and smoke damage was sustained throughout the building including the various computers and test equipment. Final cost of the damage to property and equipment was $600,000.

PROPELLER TEST RIG
AMES RESEARCH CENTER
TYPE B

A mishap occurred in the 40 × 80 Foot Wind Tunnel on March 27, 1991, at approximately 6:30 p.m. It was caused by the failure of a bearing set in the collective pitch control system of the Propeller Test Rig (PTR). A three-bladed propeller rotor, 25-feet in diameter, was being tested at the time of the failure.

Failure of the bearing set occurred in several stages, allowing the collective pitch tube to progressively move forward, causing decreased pitch. Rotor torque went from about 10,000 foot-pounds to -2,000 foot-pounds. At that point, the rotor control system locked up as designed to prevent PTR damage. It was recognized there was a problem and the breaker for the model motors was opened. (Opening the breaker had been successful during a previous incident, and it was thought that this was a similar event.) It was unknown that the rotor blades had gone to a lower blade angle. As soon as the breaker was opened, the rotor began to accelerate. Redlines were rapidly indicated and a Wind Tunnel Emergency Stop was initiated. Unfortunately, the failure had progressed too far, and the rotor continued to accelerate until it self-destructed due to overspeed. One blade tore loose and lodged in the top of the test section. The remaining rotor and mast assembly tore loose from the model drive system due to imbalance. The rotor assembly went down the tunnel, coming to rest against a safety fence. Some debris went past the first fence but most was collected against a second. Damage was limited to the model, PTR, tunnel test section, and the first safety fence. The only damage to the tunnel drive was a small gouge in one of the blades.

The primary cause of the mishap was a design deficiency. The collective tube thrust bearing set was undersized. The bearing set was selected over 20 years ago; since then PTR loads have increased threefold. Although the load increase had been recognized, and the design reviewed twice, the bearing capacity was overlooked both times. A contributing factor was that the onset of bearing failure could not be detected. Because the failure went undetected, the emergency procedures taken were not adequate to minimize damage. Cost of the mishap is estimated at $850,000.

FIRE
PRECIOUS METALS FINISHING SHOP
JOHNSON SPACE CENTER
TYPE B

A fire occurred at approximately 2:40 a.m. on April 5, 1991, in the Precious Metals Finishing Shop at the Johnson Space Center. A 1000-watt quartz heater was unintentionally left energized in a bucket of water the previous afternoon. The heater was not designed to shut off automatically if the water dropped below an acceptable level. Once the water evaporated, the heater's protective sheath melted and the polypropylene bucket partially melted and later ignited. A simulation, conducted after the fire, verified the plausibility of spontaneous ignition under these conditions. Fortunately, the fire was contained to a small area within the shop. The cost of damage to facilities and equipment was $350,000.

TYPE C MISHAPS
EQUIPMENT/PROPERTY DAMAGE

Ames Research Center
A NASA aircraft was damaged when it rolled into a tow tug at the Yokota Air Force Base in Japan. The aircraft was parked with one nose gear chocked when the brakes inadvertently released. The aircraft began to roll, ejecting the chock. It came to a stop when it contacted the tow tug. Cost of the mishap was estimated at $55,000.

Jet Propulsion Laboratory
Several buildings were damaged during an earthquake on June 28, 1991. Cost of the damage was estimated to be $155,000.

Johnson Space Flight Center
The right hand engine on NASA aircraft N-946 shut down during a high power checkout. A visual inspection revealed a hole in the engine. Primary cause of the mishap was material failure. Final cost of the mishap was $167,600.

NASA aircraft 956 ground aborted a pilot proficiency flight when the left engine failed immediately following runway lineup power check and selection of afterburner. The failure was due to foreign object damage to the engine compressor. The primary cause of the mishap was equipment failure due to lack of proper maintenance. Final cost of the mishap was $71,684.

Kennedy Space Center
Various power modules in an AC uninterruptible power supply system were burned out when a contractor installed a new electrical buss duct. The cause was a dead short in the new buss duct. A shipping bracket was found bolted to the newly installed buss duct breaker housing. The contractor failed to test the new buss duct prior to energizing it. Final cost of the mishap was $27,517.

Twenty-two fuel cells were damaged when they were accidentally filled with contaminated waste during a manufacturing process at a contractor's facility. The contractor was building a Space Shuttle battery section. The cells were lowered into a tank to be charged with a hydroxide solution. An operator started the vacuum pump without realizing that a drain valve to a hazardous waste solution tank was open. The waste backfilled into the fuel cells. The mishap was attributed to lack of attention by the operator. Final cost of the mishap was $40,000.

Langley Research Center
A 2-dimensional rotorcraft model and the 8-Foot Transonic Pressure Wind Tunnel were damaged when screws used to attach part of the model's supercritical wing flap failed during a test. The primary cause of the mishap was equipment failure due to design deficiency. Final cost of the mishap was $56,500.

Lewis Research Center

A service air compressor motor began smoking and broke out in flames. Operators had just completed running a check on recent repairs to the compressor's aftercooler. The fire started when they attempted to shut down the machine. The primary cause of the mishap was found to be equipment failure due to material failure. Final cost of the mishap was $50,000.

Marshall Space Flight Center

A Transfer Orbit Stage (TOS) rocket engine module (REM) was damaged during a handling operation. An acoustic test had just been completed on the TOS. A mobile lift was being moved into position to remove plastic sheeting when a railing on the lift caught the REM, bending a thermal standoff. The primary cause of the mishap was a procedure deficiency. Contributing factors were poor communications and inadequate task supervision. Cost of the mishap was estimated at $100,000.

A Centaur stage, donated to the Alabama Space and Rocket Center (ASROC) for display, was damaged when it struck an overpass during transport from General Dynamics Corporation, San Diego, California. The primary cause of the mishap was a deviation from proper procedures. The escort driver did not have the fiberglass clearance pole properly secured to avoid wind deflection. Cost of the mishap was estimated at $81,400.

A 300-second shuttle main engine test was cut off when a fire was observed in the fuel tank pressurant line facility interface. Post-test leak checks revealed a class III leak at a "B" nut which was loose. This area passed a leak check prior to the test. Damage from heating was found at 6 engine harnesses and a controller coolant duct bellows. The cause of the mishap was equipment failure due to material failure. Cost of the mishap was estimated at $25,000.

The insulation on a 5-kv power line failed resulting in a fire at an electrical substation. The mishap was caused by equipment failure due to material failure. Final cost of the mishap was $25,767.

Damage to a Shuttle Main Engine High Pressure Fuel Turbopump was discovered after a test run was aborted due to high lift-off seal delta pressure. A post-test borescope inspection revealed debris in the roller bearing compartment. During preparation for the test, a high pressure blowdown and venting was noted. It is believed that this caused a dry-spin of the turbopump resulting in the damage. Final cost of the mishap was $107,464.

The insulation in a solid rocket booster segment was damaged when a main film board being positioned inside the segment contacted the insulation. It was discovered that the air bearing deck used to support the segment had floated during the procedure, causing the segment to shift out of alignment, resulting in the damage to the segments insulation. The insulation was only slightly imprinted, but the segment could not be used in the flight motor test as scheduled. Final cost of the mishap was $220,000.

Stennis Space Center

A liquid nitrogen vessel cracked while it was being filled. The primary cause of the mishap was equipment failure due to lack of proper maintenance. Final cost of the mishap was $87,020.