National Aeronautics and Space Administration

FY 1985 Safety Program Data Report

NASA Safety Division
Office of the Chief Engineer
Washington, D.C. 20546

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SAFETY PROGRAM OVERVIEW

FY 1985

NASA's continuing efforts to control major causes of lost time disabilities and fatalities have resulted in the lowest lost time and overall frequency rates in the last 11 years. In addition, NASA has once again succeeded in reducing illness/injury claims to the Office of Workers' Compensation (OWCP) by far more than the 3% per year goal established by President Reagan in 1983.

The NASA Administrator, Associate Administrators, Chief Engineer, and Center Directors have taken active roles in reducing accidents and injuries. Agency goals for FY 1985 were distributed to the centers, and performance was monitored and reported quarterly to effect a continued overall improvement in agency safety performance.

Efforts to reduce the number of accidents will continue with emphasis placed on implementing corrective action based on lessons learned from previous mishaps.

Robert H. Thompson

Robert H. Thompson
Director, Safety Division

SAFETY ACCOMPLISHMENTS AND INITIATIVES

During FY 1985, new management issuances, policies, handbooks, standards, and other documents were developed at several NASA installations. The National Space Technology Laboratories Safety Manual was revised to comply with NASA Headquarters directives and other regulatory requirements. At the Johnson Space Center (JSC) the safety manual was revised in its entirety, and a decision was made to use the more stringent Air Force safety standards for aircraft operations at Ellington Field. Implementation of the mandatory seat belt policy adopted by Redstone Arsenal was accomplished at the Marshall Space Flight Center (MSFC). In August, Headquarters issued a new handbook, Fire Protection, to provide requirements and guidelines for effective implementation of a comprehensive fire protection program at all NASA centers as well as at Headquarters. The Ames Research Center (ARC) published the Flight Test Program Policy and the Facility Operating Manual for the hazardous waste storage and operations facility.

Additional resources for occupational safety programs were allocated during FY 1985. Many of the centers as well as Headquarters acquired mini-computers and additional personnel to establish effective safety data bases. KSC continued to lead the agency in its use of automated mishap reporting and in the development of an agency-wide automated Mishap Reporting and Corrective Action System (MR/CAS). As the lead center in this effort, KSC is designing the software to be used agency-wide and will provide technical assistance and training to the other field installations at the time of agency-wide implementation.

Two Construction of Facilities projects were awarded to MSFC for repairs or replacement of several high pressure gas storage and transmission systems. Several new films, sound-on-slide programs, and videotapes were purchased and added to the training materials maintained in the Johnson Space Center and Langley Research Center (LaRC) Learning Center/Safety Awareness Training Libraries. At the Lewis Research Center (LeRC) feasibility studies to establish a central chemical storage and distribution center are being conducted. Funds were also allocated for a chemical spill contingency plan.

Due to increasing requirements and work loads, several new positions were allocated to safety efforts. At LaRC funds were allocated to augment the System Safety Engineering Staff by the addition of two civil service engineers and two contractor safety engineers. At LeRC $70,000 was allocated to hire a contract Fire Prevention Engineer. In addition, a Safety Specialist and a Safety Technician were added to the Safety Operations Branch. At Headquarters the Flight Safety Manager's position, vacant for six months, was filled with a military detailee from the Army Safety Center.

Training aimed at assuring safety awareness and hazard recognition was conducted at most NASA installations. NASA Headquarters continued to place emphasis on safety visibility and awareness at a Space Tracking Network Program Review in March, a NASA Safety Directors Workshop in May, and a Pressure Systems Recertification Seminar in September. In addition, Headquarters sponsored several courses which included two accident investigation courses, two life safety courses, and two system safety courses. Approximately 80 engineers, Facility Safety Heads, and Facility Coordinators (collateral safety personnel), and full-time safety personnel attended the Hazardous Chemical Safety Course. Over 800 LeRC employees were trained in confined space entry procedures.

Centers that publish their own newsletters made effective use of this medium to feature safety-related articles. At JSC a new publication, The JSC Safety and Health Newsletter, was created to inform safety representatives and managers about current safety policies and issues. At LeRC safety awareness was achieved through the monthly publication and dissemination of the Health and Safe-T-Gram. NSTL published a newsletter, Safety-N-Health News, to enhance safety awareness among employees.

The effectiveness of safety programs is assessed continually at each NASA installation. Headquarters Safety, Reliability, and Quality Assurance surveys were conducted at the Jet Propulsion Laboratory, the Goddard Space Flight Center/ Wallops Flight Facility, and the Langley Research Center. The ARC prepared a "Life Science Safety Inspection and Chemical Inventory Report" based on a detailed survey and inventory of all Life Sciences laboratories. An in-depth survey of the safety effort at the JSC White Sands Test Facility was conducted by a team of safety professionals and management representatives.

The LeRC annual facilities inspection report for FY 1984, prepared by the Safety Operations Branch, had noted that 31% of all hazards were attributable to walking/working surfaces. In FY 1985, an assessment was made to determine the effectiveness of the special efforts that had been made to reduce this hazard. Statistics revealed that lost-time accidents attributable to walking/working surfaces declined by 40% during FY 1985.

Employee participation, involvement, and consultation in safety-related activities increased considerably during FY 1985. Participation was encouraged through open meetings, training sessions, inspections, membership on safety committees or panels, attendance at awareness programs and seminars, and by review and comments on standards and policies. The Headquarters staff participated in the JANNAF Environmental Health and Safety Symposium, the International System Safety Conference, the Joint Services Safety Conference, and the annual Federal Safety and Health Conference during which one staff member presided over the Federal Safety Council Officers Workshop.

At LeRC a safety specialist from the Safety Operations Branch serves as a consultant in each technical division of the organization. This specialist provides risk assessments and advises Division Management on solving safety problems, thereby heightening safety awareness among senior managers.

All NASA installations made significant efforts to identify, assess, and resolve safety problems. At KSC, following a mishap involving injury to a contractor employee and damage to an orbiter payload bay door, a center-wide review of lifting devices was initiated. Crane operator training courses were reviewed, and recommended changes were implemented. Many activities were conducted at LeRC to resolve safety problems. These included revising the Safety Notification and Abatement Program (SNAP), designing a Potential Hazards Reporting System, and procuring new safety materials.

ARC points to its development of plans for a hazardous material transfer facility, and the correction of several hundred deficiencies in fire alarm and reporting systems as examples of many accomplishments at the Dryden and

Moffett facilities. At LaRC modifications were made to the Aircraft Landing Dynamics Facility, the Transonic Dynamics Tunnel, the 20-inch Supersonic Wind Tunnel, and the 8-foot High Temperature Tunnel.

Appropriate action was taken by NASA Headquarters senior management to resolve safety problems as they arose. Conforming to known precedents supported by top level management resulted in lowering the injury/illness rate for the fiscal year.

NASA installations appropriately recognized and rewarded outstanding achievers in safety-related functions during FY 1985. AT KSC a safety slogan contest netted several hundred entries from which 11 winners were selected. At LeRC 15 employees received awards from the Center Director for their contributions to the safety program. At ARC a Facility Safety Head (FSH) Award program was initiated. A certificate and monetary reward were presented quarterly and annually at the Executive Safety Board Meeting to the FSH who had made the most significant contribution to the safety program. All personnel who signed a "Buckle Up" pledge to wear their car seat belts for the year received the highly sought-after Ames coffee cup. NSTL regularly issued letters of appreciation to contractor or sub-contractor managers when outstanding accident reduction rates were achieved. At JSC three directorates were presented with engraved bronze plaques in recognition of their impressive contributions to the JSC Safety Program.

NASA maintains accountability and performance standards for managers, supervisors, and employees. Supervisors and managers are held accountable for the safety of employees. At KSC disciplinary actions are taken against employees who violate safety policies and procedures. NSTL contractor employees are issued quarterly performance evaluations by NASA.

NASA encourages the use of preventive approaches and practices aimed at designing out hazards and reducing risks. The Life Safety Code Evaluation System, developed for NASA by the National Bureau of Standards, is being used at several centers on a trial basis. Plans and specifications for new or modified facilities are reviewed by Safety Offices. The program to modify ARC facilities to meet National Fire Prevention Association Life and Safety Codes is continuing on schedule. At both GSFC and JSC engineering drawings are routed to the Safety Division for safety and fire protection review prior to approval of final design. At NSTL the Safety Office reviews all construction, contract specifications, and engineering drawings for potential safety problems. The Safety Offices at KSC and at GSFC developed a standard safety briefing checklist for use at construction pre-work meetings that Safety Office personnel were unable to attend.

NASA is continuing its efforts to reduce overall compensation costs and to control major causes of lost-time disabilities and fatalities. Several "Safety Lessons Learned" in the form of summaries and videotapes were distributed to all installations. Although many were aimed at preventing equipment failure and property damage, a videotape produced at KSC heightened agency awareness to oxygen deficient atmosphere hazards by revisiting the 1981 mishap which involved the deaths of two contractor employees and injuries sustained by three contractor employees during nitrogen purging of the Shuttle orbiter aft compartment.

In FY 1986, NASA will continue to strive for increased safety as one means of enhancing quality and improving productivity.

NASA OCCUPATIONAL INJURY/ILLNESS RECORD

FY 1985 STATISTICS

Fatalities	0
No lost time injuries	121
Lost time injuries	78
Lost wages	$145,242
Chargeback billing	$5,212,255

LOST TIME AND NO LOST TIME CASES

Injuries and illness are divided into two classes, lost time and no lost time. A lost time case is defined by OSHA as 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) that does not meet the definition of a lost time case.

The number of lost time injuries/illnesses per 200,000 hours worked is a gross rate which gives an indication of how many lost time incidents were reported in relation to the number of hours worked.

OSHA is now reporting incidence rates as the number of lost time injuries and illnesses per 100 employees.

Table 1 shows injury/illness statistics for all centers for FY 1985. The overall lost time rate for NASA decreased to 0.38 in FY 1985.

TABLE 1. NASA INJURY/ILLNESS DATA BY INSTALLATION -- FY 1985

			TOTAL INJURY/ ILLNESS DATA			LOST-TIME INJURY/ILLNESS DATA					LOST-TIME RATE OBJECTIVES FOR 1985	
	NO. OF EMPLOYEES	HOURS WORKED IN K	NO. CASES	FREQ. RATE 1984	FREQ. RATE 1985	NO. CASES	NO. DAYS	FREQ. RATE 1984	FREQ. RATE 1985	SEVERITY RATE	CUM. RATE	TARGET RATE
ARC/DFRF	2,237	3,997	10	0.47	0.50	6	68	0.28	0.30	3.40	0.30	0.30
GSFC/WFF	3,608	7,015	28	1.00	0.80	8	87	0.57	0.23	2.48	0.23	0.45
HQ	1,547	2,802	25	1.30	1.78	7	115	0.34	0.50	8.21	0.50	0.30
JSC	3,622	6,201	40	1.00	0.23	7	66	0.30	0.23	2.13	0.23	0.30
KSC	2,189	4,718	22	0.42	0.93	14	107	0.25	0.59	4.53	0.59	0.30
LaRC	2,990	5,391	13	1.80	0.48	6	69	0.15	0.22	2.56	0.22	0.30
LeRC	2,670	4,890	41	2.85	0.99	20	211	1.61	0.82	8.65	0.82	0.60
MSFC	3,269	6,061	19	0.62	0.63	10	97	0.13	0.33	3.20	0.33	0.30
NSTL	532	277	1	0	0.71	0	0	0	0	0	0	0.30
TOTAL	22,664	41,352	199	--	0.96	78	820	--	0.38	3.97	0.38	
LAST YR	22,454	41,124	240	1.15	--	93	1,066	0.45	--	5.18	0.45	

1. Total injury/illness frequency rate = number of cases per 200,000 hours worked.

2. Lost time injury/illness frequency rate = number of lost workday cases per 200,000 hours worked.

3. Injury/illness severity rate = number of lost workdays per 200,000 hours worked.

Figure 1 illustrates the relative position of the NASA occupational injury/illness incidence rate compared to other Federal agencies having more than 15,000 employees in FY 1984 and FY 1985. Within the Federal Government NASA ranked second in both years. These statistics are based on the number of lost time cases per 100 employees.

Figure 2 plots the NASA lost time injury/illness rates for the last 11 years against those 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 are for FY 1984.

Figure 3 compares the lost time frequency rates at the NASA field installations to the overall NASA lost time frequency rate. These statistics are based on the number of lost time cases per 200,000 hours worked.

Figure 4 compares the lost time severity rates at the NASA field installations to the overall NASA lost time severity rate. Since compensation for lost wages rather than for medical costs constitutes the bulk of injury-related costs to NASA, this Figure is worthy of special note. NASA's severity rate decreased to 3.97 days lost per 200,000 hours worked in FY 1985 from 5.18 days in FY 1984.

Figure 5 compares the number of NASA employees to the number of lost time cases over the past 11 years.

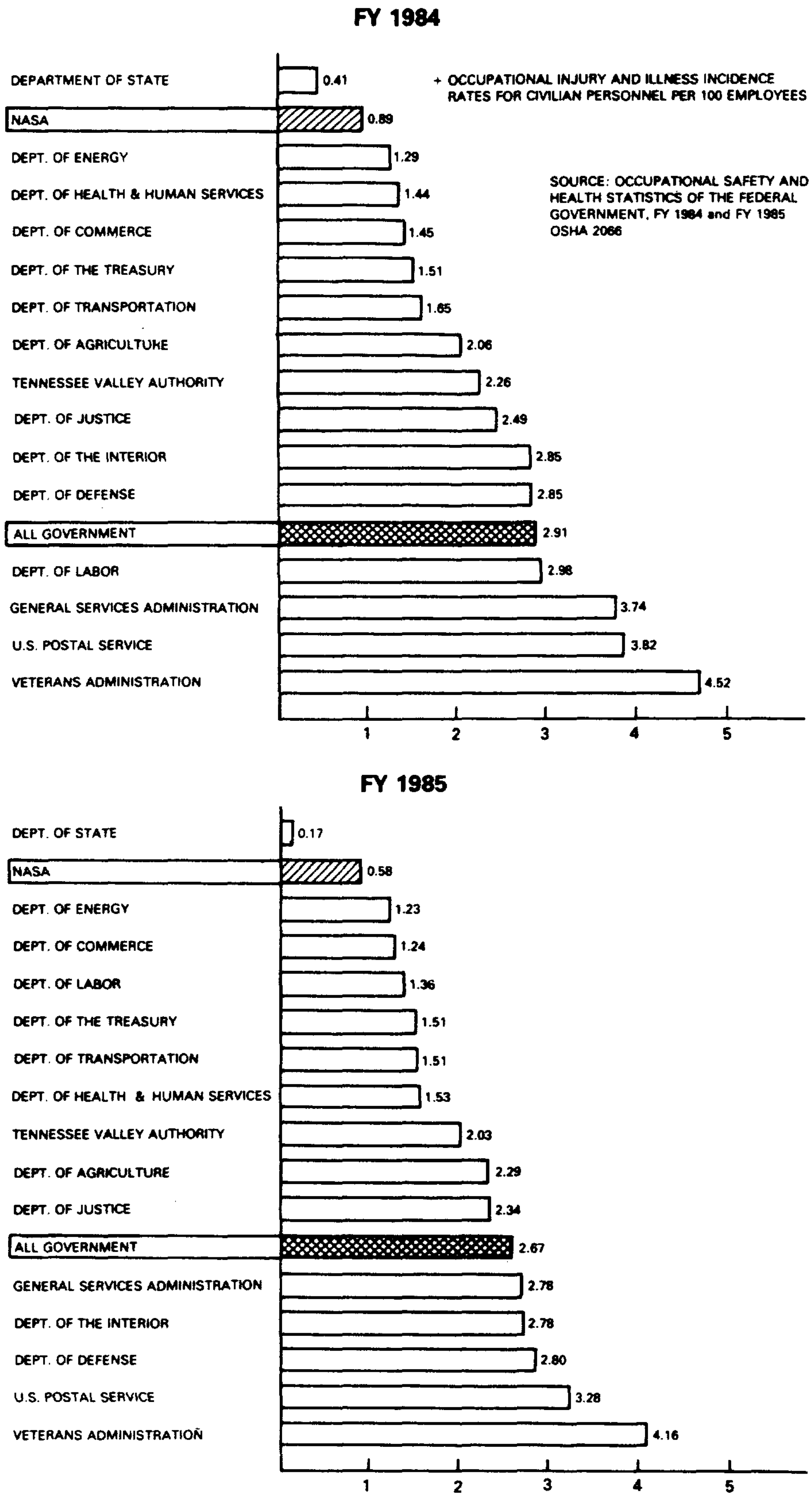
Figure 6 plots the lost time frequency rate, the no lost time rate, and the total reportable rate per 200,000 hours worked. All three rates are the lowest reported in the last 11 years.

Table 2 shows the lost time rates for both NASA civil service and contractor employees by installation. The Marshall Space Flight Center had the lowest combined lost-time rate of the three manned flight centers. The Goddard Space Flight Center had the lowest lost time rate of all field installations, excluding Headquarters. The overall NASA and contractor lost time rate of 0.70 for FY 1985 is the lowest in the three years that combined rates have been calculated.

Figure 7 illustrates NASA's excellent overall illness/injury record as compared to all other Federal agencies, the private sector, private sector manufacturing industry, and the private sector aerospace industry over the last 11 years. The most recent statistics available from the Department of Labor are for FY 1984.

Figure 8 compares the lost time frequency rates of NASA and contractor employees at each center for the last two years.

LOST-TIME INJURY/ILLNESS RATES IN SELECT FEDERAL AGENCIES*

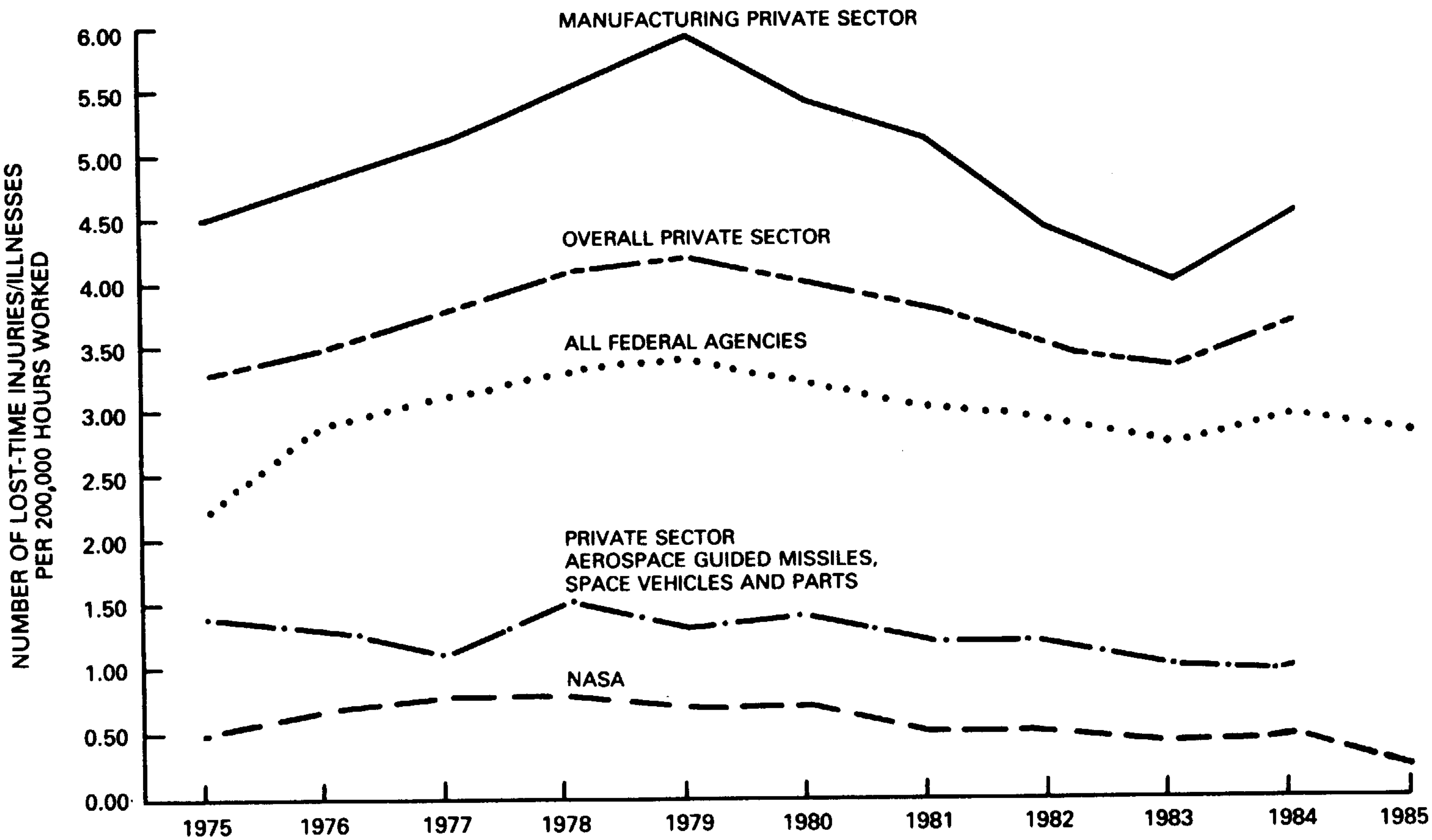


* HAVING MORE THAN 15,000 EMPLOYEES
+ OSHA NO LONGER CALCULATES RATES BASED ON 200,000 HOURS WORKED

Figure 1

LOST-TIME OCCUPATIONAL INJURY/ILLNESS RATES:

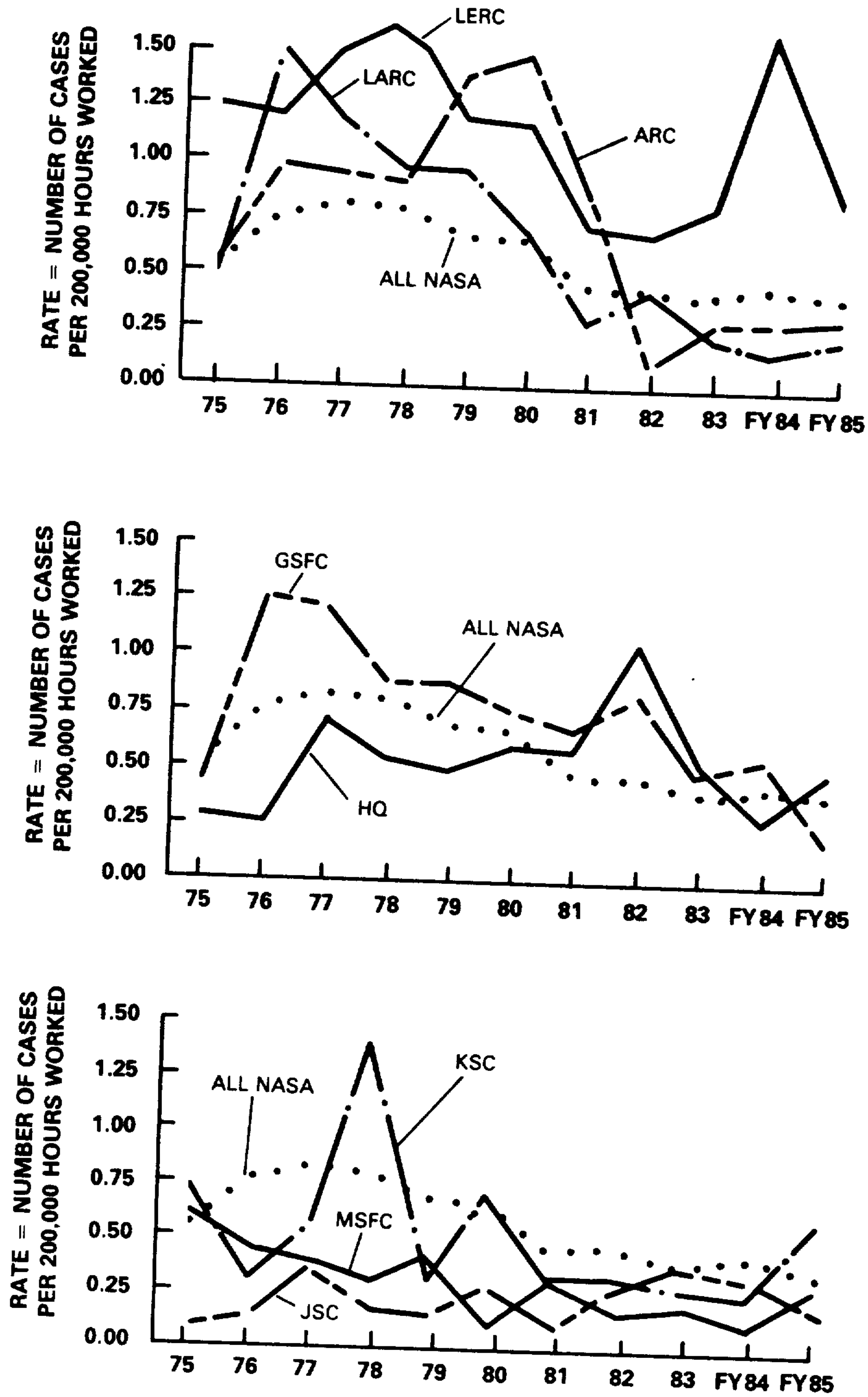
PRIVATE SECTORS-ALL FEDERAL AGENCIES-NASA



NASA HQ DS86-392(1)
2-21-86
Rev. 11-28-86

Figure 2

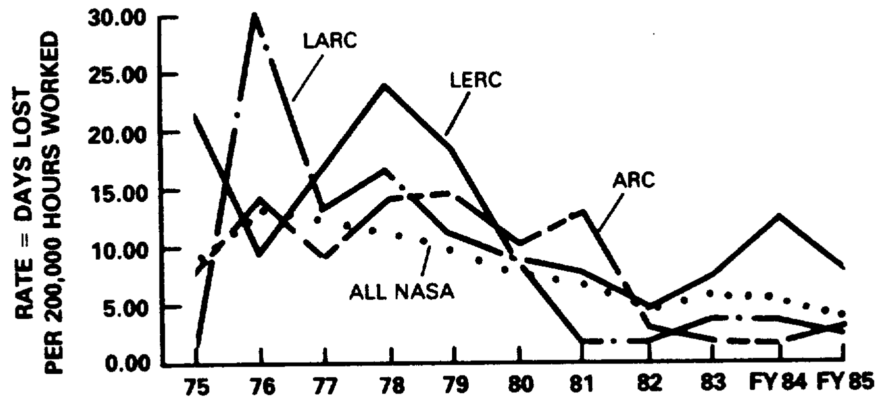
INJURY/ILLNESS FREQUENCY RATES

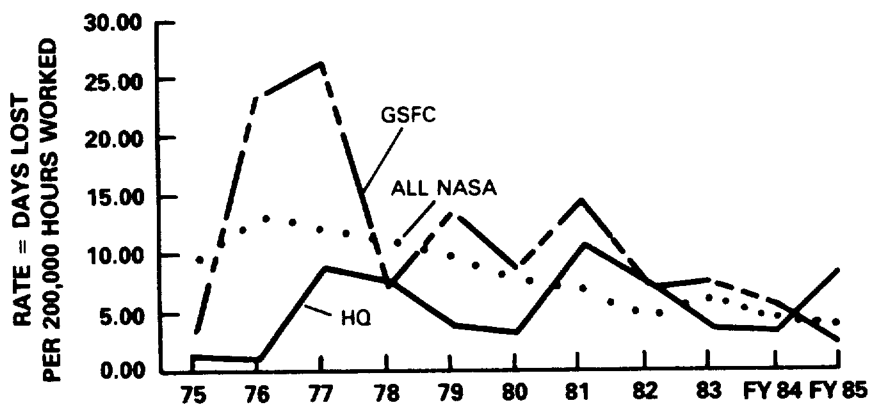


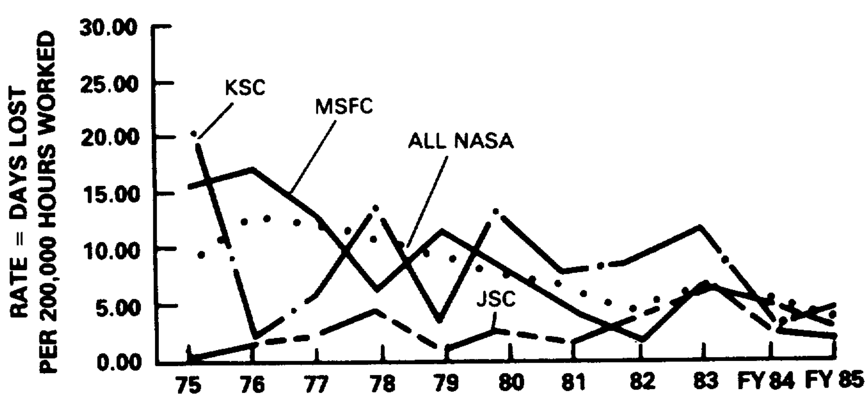
NASA HQ DS86-398 (1)
2-21-86
Rev. 11-28-86

Figure 3

INJURY/ILLNESS SEVERITY RATES







NASA HQ DS86-399 (1)
Rev. 11-28-86

Figure 4

NUMBER OF NASA EMPLOYEES AND NUMBER OF LOST TIME INJURIES VS TIME

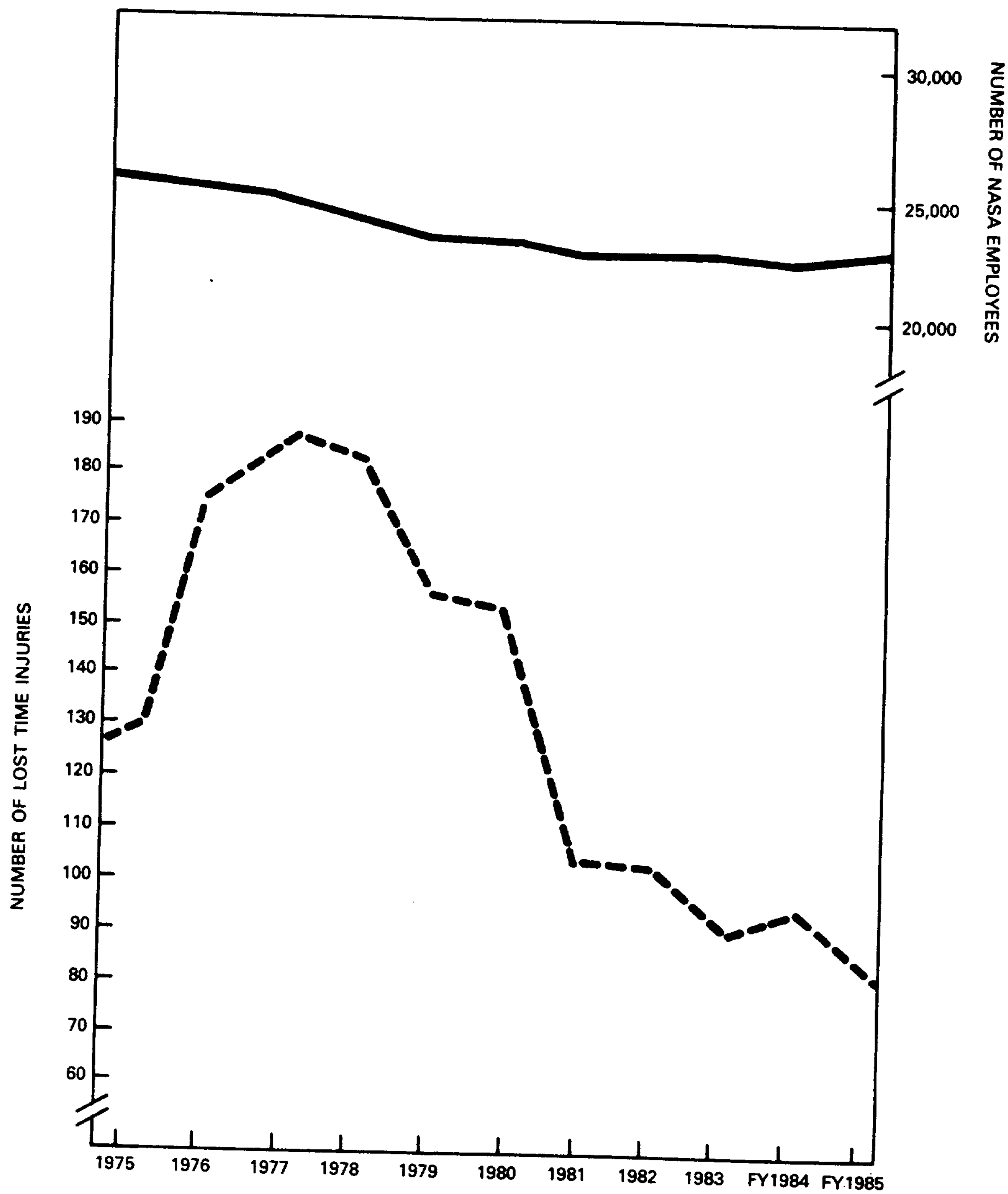
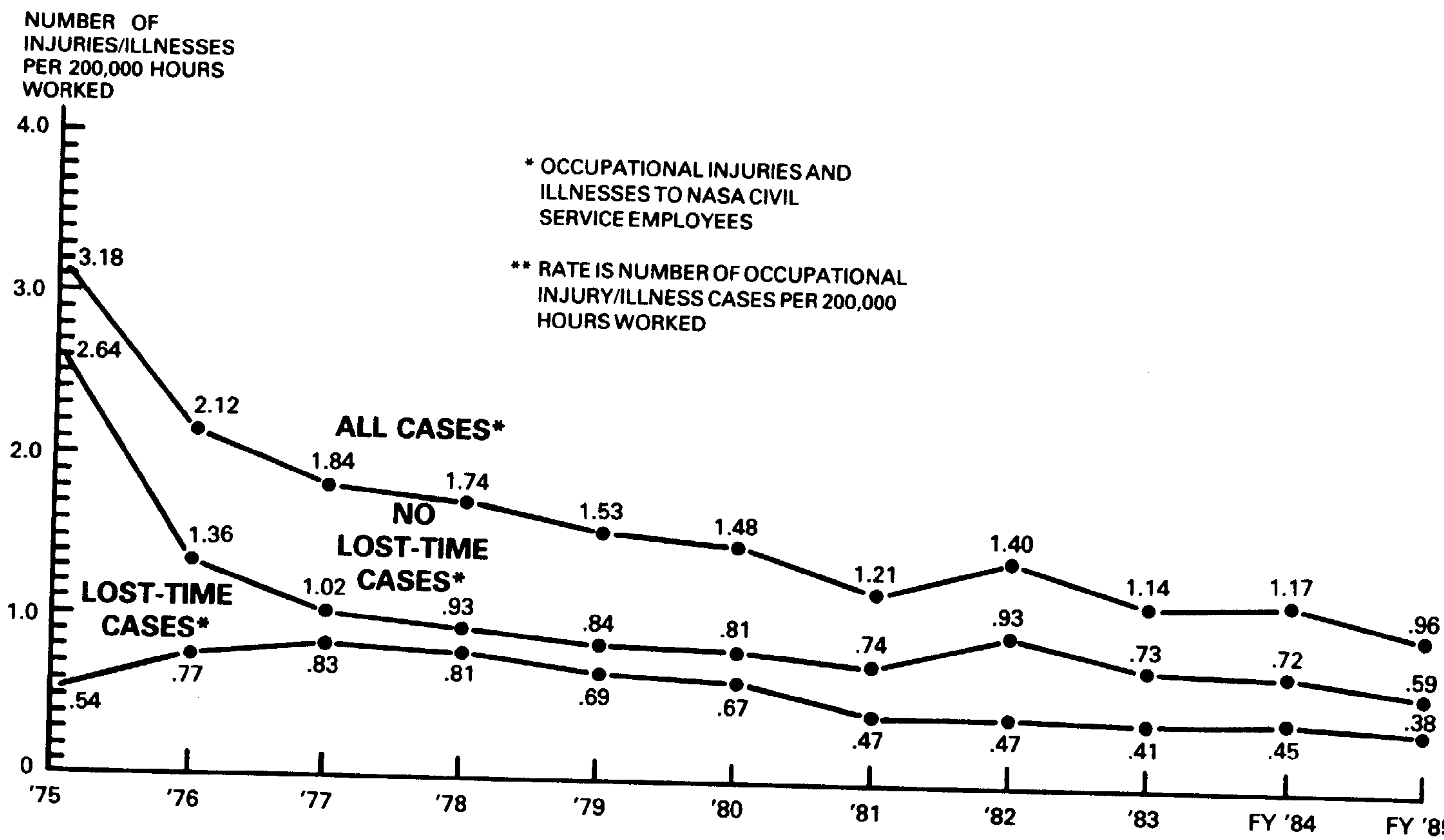


Figure 5

NASA OCCUPATIONAL INJURY/ILLNESS* RATES**
(1975 - 1985)



SOURCE: NASA/OSHA 102F REPORTS

NASA HQ DS83-2764 (1)
Rev. 11-28-86

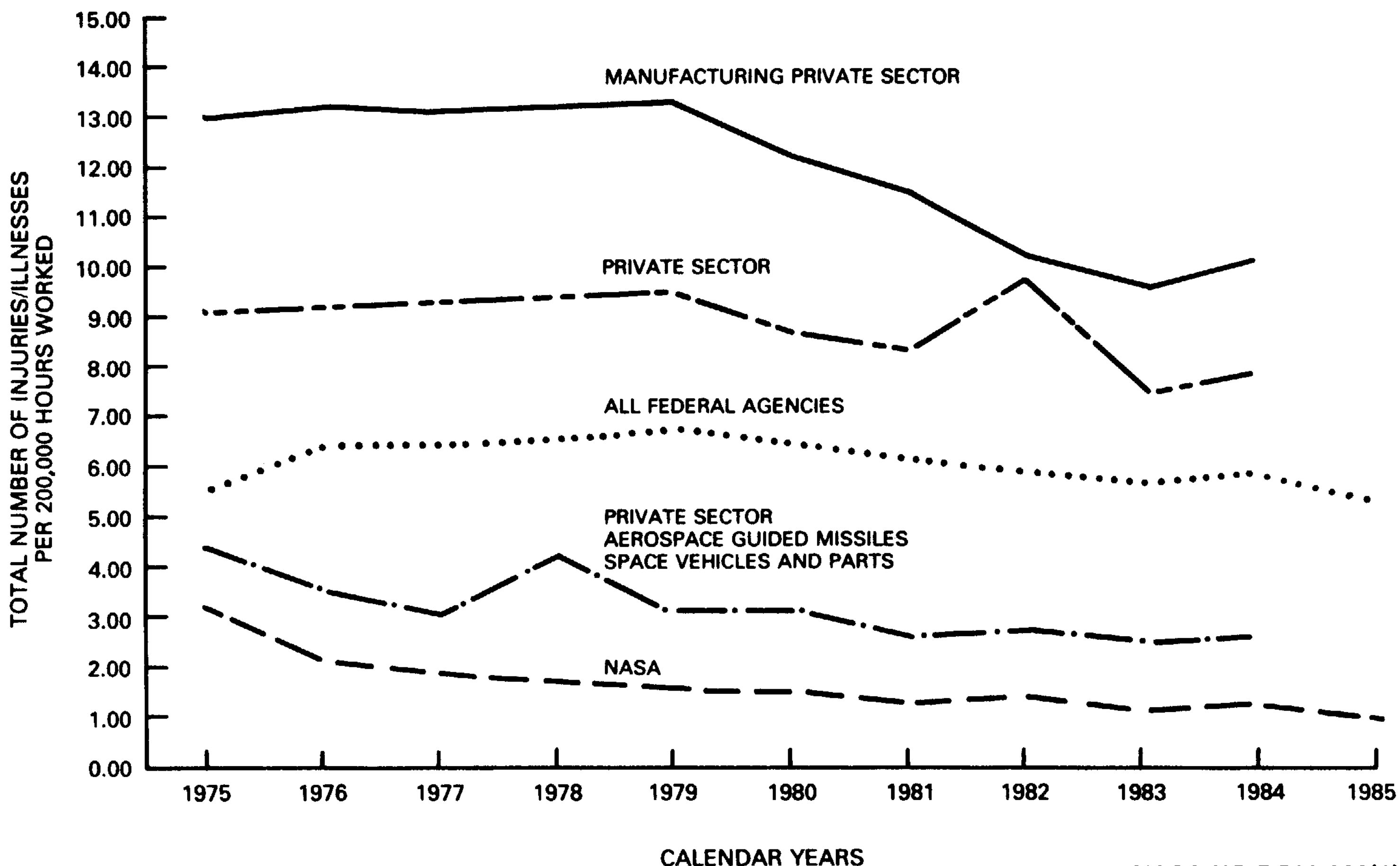
Figure 6

TABLE 2. NASA COMBINED INJURY AND ILLNESS DATA BY INSTALLATION -- FY 1985
CIVIL SERVICE AND CONTRACTOR EMPLOYEES

	HOURS (K) CIV. SERV. EMPLOYEES	NO. L-T CASES	FREQ. RATE	HOURS (K) CONTRACTOR EMPLOYEES	NO. L-T CASES	FREQ. RATE	HOURS (K) COMBINED TOTAL	TOTAL L-T CASES	COMBINED FREQ. RATE
ARC/DFRF	3,997	6	0.30	2,904	26	1.79	6,901	32	0.93
GSFC/WFF	7,015	8	0.23	7,813	28	0.72	14,828	36	0.48
HQ	2,802	7	0.50	774	1	0.26	3,576	8	0.45
JPL	0	-	--	11,061	38	0.69	11,061	38	0.69
JSC	6,201	7	0.23	18,289	91	1.00	24,490	98	0.80
KSC	4,718	14	0.59	24,125	82	0.68	28,843	96	0.67
LaRC	5,391	6	0.22	2,775	25	1.81	8,166	31	0.76
LeRC	4,890	20	0.82	1,843	16	1.74	6,733	36	1.07
MSFC	6,091	10	0.33	2,175	17	1.56	8,266	27	0.65
NSTL	277	0	0	1,474	10	1.35	1,751	10	1.14
TOTAL	41,352	78	0.38	73,233	334	0.91	114,615	403	0.70
LAST YEAR	41,124	93	0.45	56,800	288	1.01	97,924	381	0.78

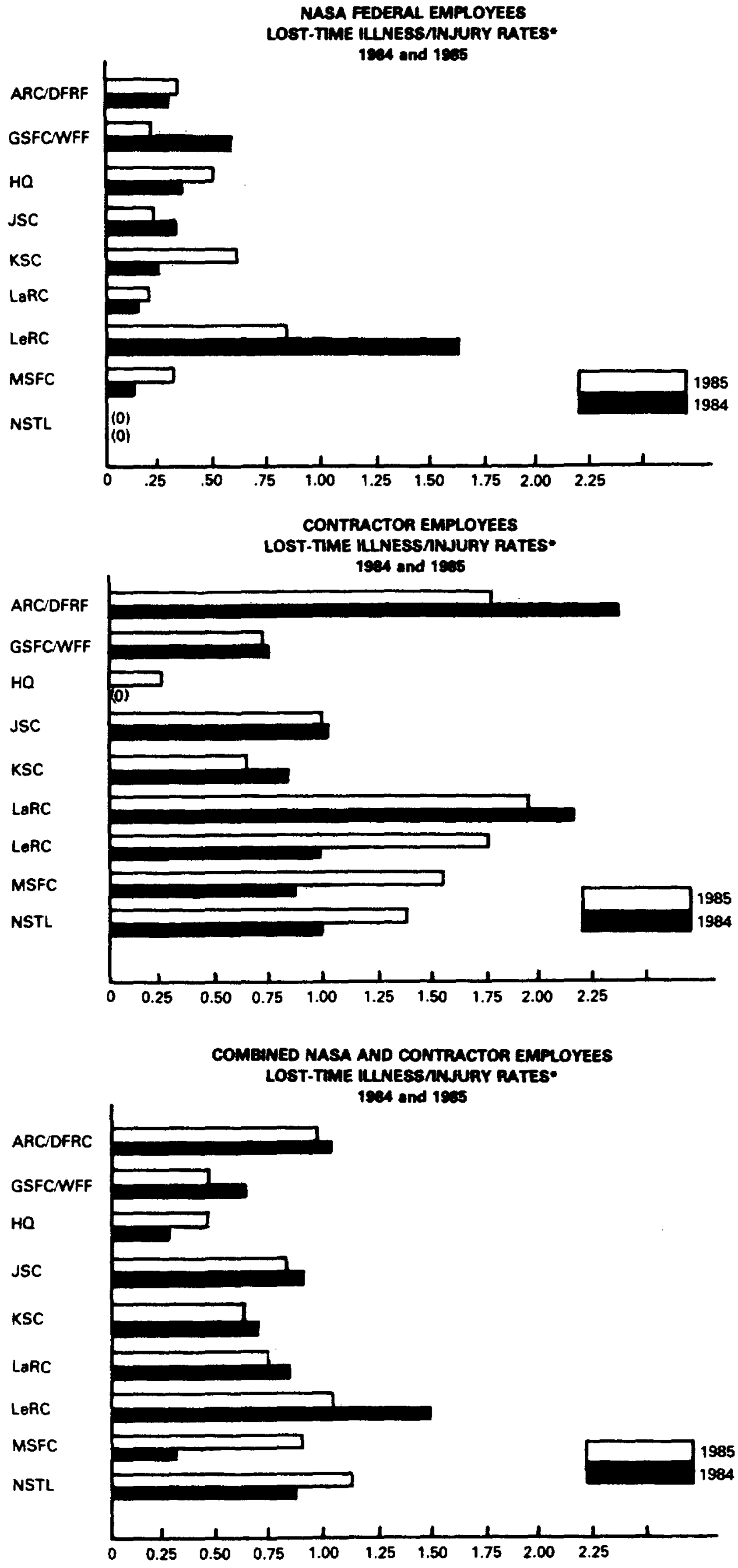
Lost time injury/illness frequency rate = number of lost workday cases per 200,000 hours worked.

TOTAL OCCUPATIONAL INJURY/ILLNESS RATES:
PRIVATE SECTORS-ALL FEDERAL AGENCIES-NASA



NASA HQ DS86-393(1)
2-21-86
Rev. 11-28-86

Figure 7



*RATE = NUMBER OF CASES PER 200,000 HOURS WORKED.

Figure 8

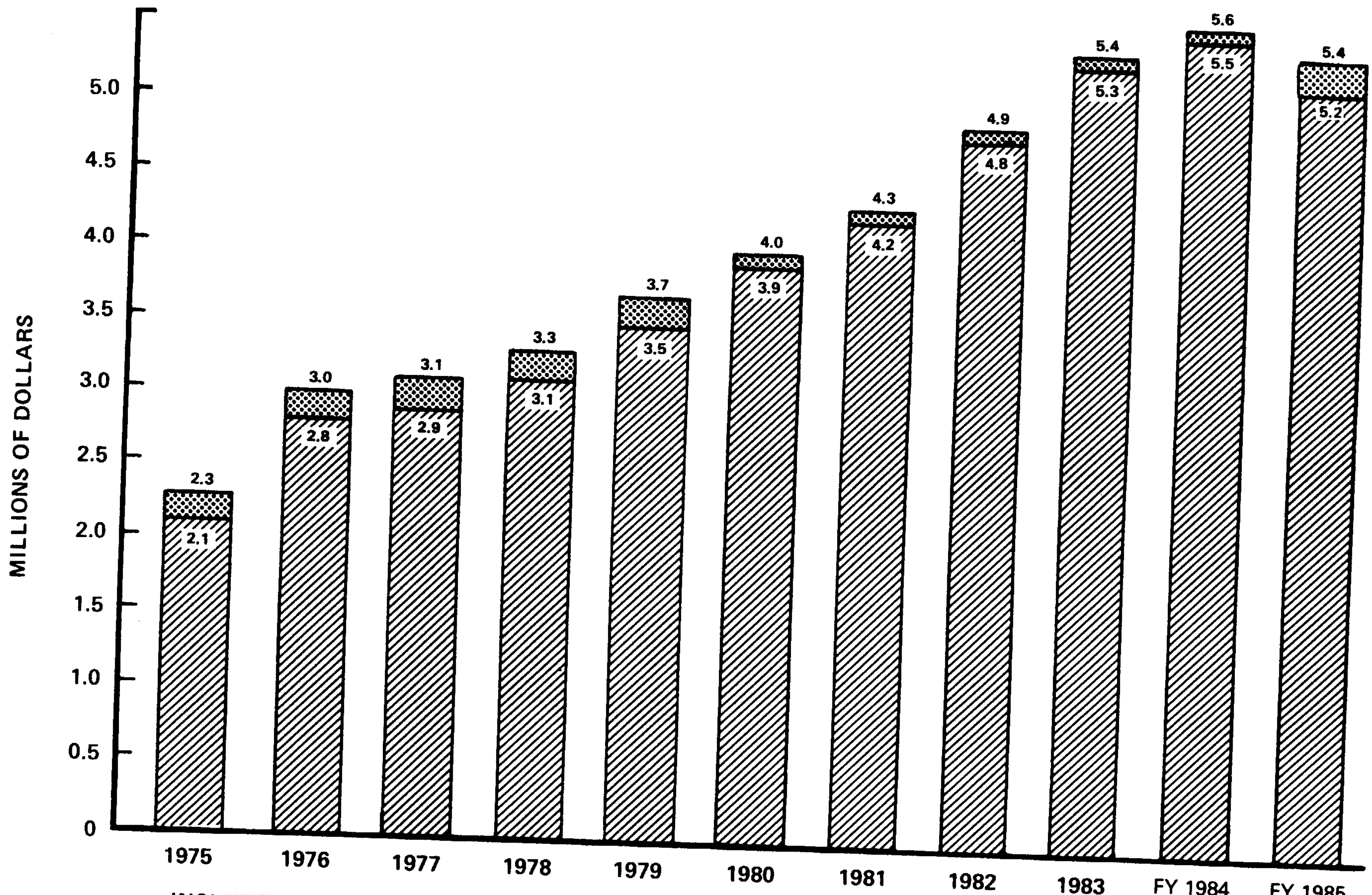
CHARGEBACK BILLING

Chargeback is defined by OSHA as a system under which the U.S. Department of Labor pays compensation and medical costs attributed to injuries which occurred after December 1, 1960 and then bills the agency which employed the individual who received compensation or benefits. In any given year, most of the chargeback billing is a result of illnesses and injuries which occurred in previous years.

Figures 9 and 10 illustrate the relationship between chargeback billing and NASA's total safety-related costs. These include lost wages (continuation of pay) as well as aviation, automobile, fire, and other reportable mishaps. Of the $30.1 million total loss for FY 1985, $5.2 million, or 17.3%, were paid out in chargeback billing costs, a $300,000 decrease from last year.

Figure 11 compares the cost of chargeback billing in the Federal Government to that in NASA for the last 11 years. While chargeback costs increased by nearly ten percent for the Government, these costs decreased by six percent for NASA.

NASA LOSSES DUE TO INJURIES/ ILLNESSES



INCLUDES LOST WAGES AND CHARGE BACK BILLING TO THE FEDERAL EMPLOYEES COMPENSATION FUND, BUT DOES NOT INCLUDE CONTRACTOR LOSSES.

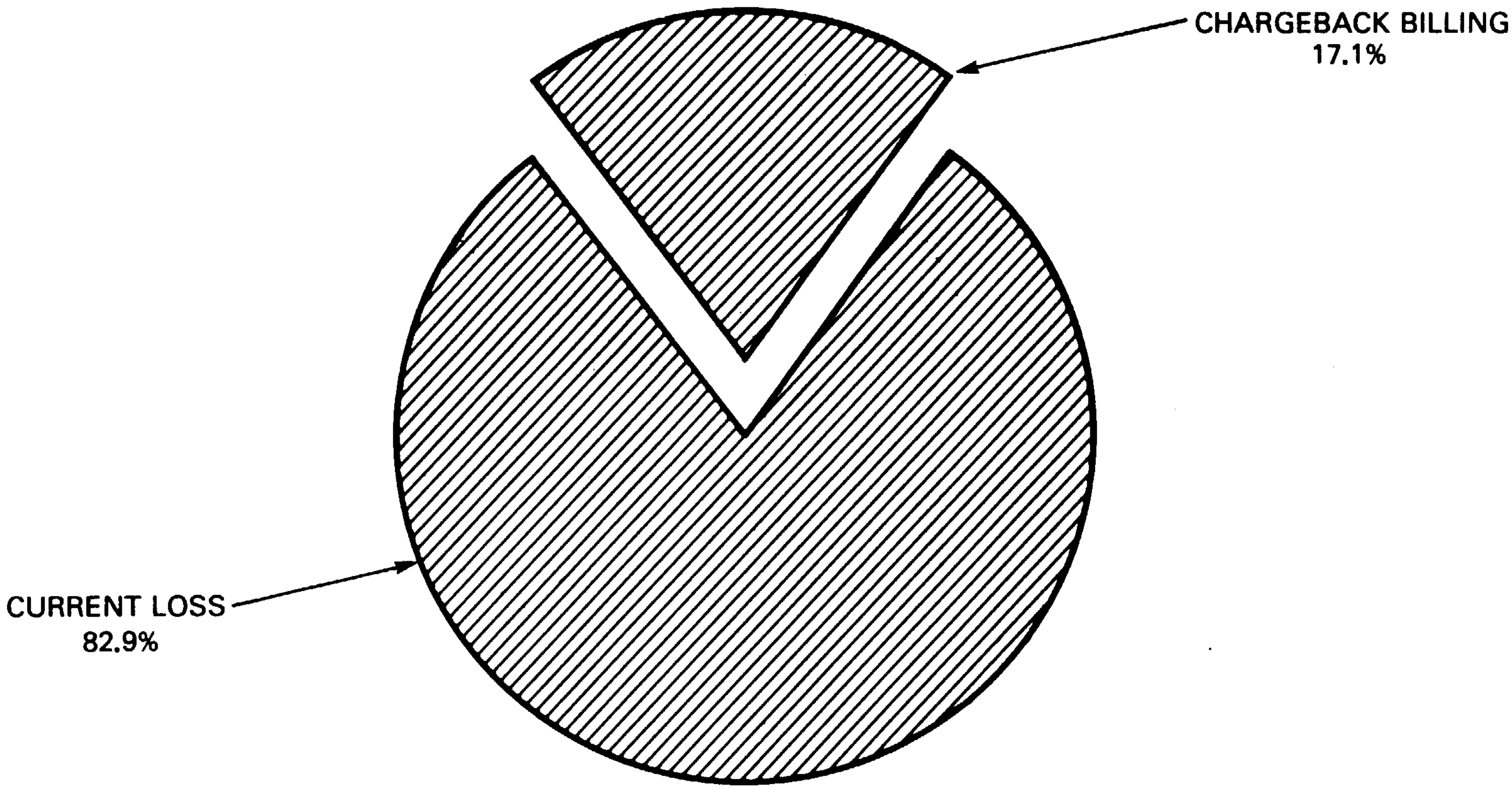
LOST WAGES   CHARGE BACK BILLING

Figure 9
21

NASA HQ DS86-400A (1)
Rev. 11-28-86

COST OF FY 85 NASA MISHAPS/INCIDENTS/INJURIES

TOTAL LOSS = $30,393,796



* EXCLUDES CONTRACTOR DATA

NASA HQ DS86-400(1)
Rev. 11-28-86

TIME HISTORY OF (OWCP) CHARGEBACK BILLINGS
COSTS FOR ALL FEDERAL GOVERNMENT AGENCIES AND NASA

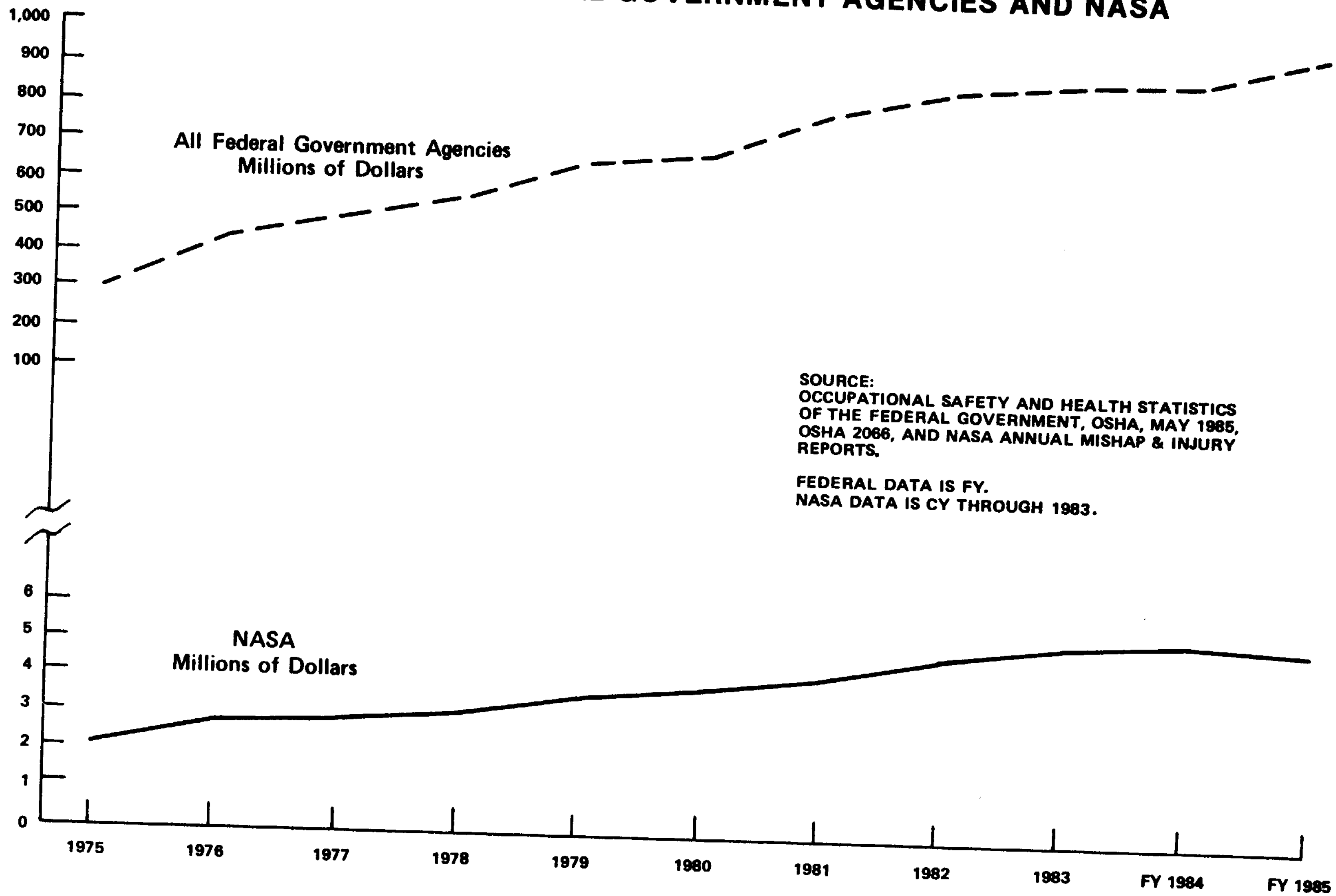


Figure 11

MATERIAL LOSSES

Table 3 lists the FY 1985 statistics for NASA property damage due to mishaps. Mission and test failures are not included.

Material losses are summarized below:

TYPE OF MISHAP	NUMBER	DOLLAR LOSS
Automobile	17	$ 41,699
Aviation	2	18,760,000
Fire	0	0
Other	40	6,234,600
TOTAL	59	$25,036,299

Figure 12 illustrates total costs of material losses due to mishaps over the last 11 years. NASA experienced an increase of $15,733,799 in material losses over FY 1984. The most costly mishaps of FY 1985 are discussed in a later section of this report.

TABLE 3. NASA MISHAP DATA BY INSTALLATION — FY 1985

	AUTO. MISHAP FREQ. RATE		AIRCRAFT MISHAPS		FIRE LOSSES		OTHER MISHAPS		TOTAL MISHAPS	
	GOV	POV	NO.	RATE	NO.	COST($K)	NO.	COST($K)	COST($K)	RATE($K)
ARC/DFRF	1.85	0	2	50.00	0	0	2	210.0	18,972.3	4,743.1
GSFC/WFF	0	0	0	0	0	0	2	199.5	199.5	28.5
HQ	10.00	0	0	0	0	0	0	0	4.8	1.7
JSC	1.67	0	0	0	0	0	0	0	7.7	1.2
KSC	0.60	0	0	0	0	0	31	880.1	893.1	190.0
LaRC	0	0	0	0	0	0	2	1,723.0	1,723.0	287.2
LeRC	0	0	0	0	0	0	2	3,197.5	3,203.9	653.9
MSFC	0.83	1.27	0	0	0	0	0	0	7.5	1.2
NSTL	0	0	0	0	0	0	1	24.5	24.5	87.5
TOTAL	0.73	0.15	2	9.09	0	0	40	6,234.6	25,036.3	604.7
LAST YEAR	1.60	1.22	4	19.33	1	7.5	6	9,249.5	9,302.5	226.3

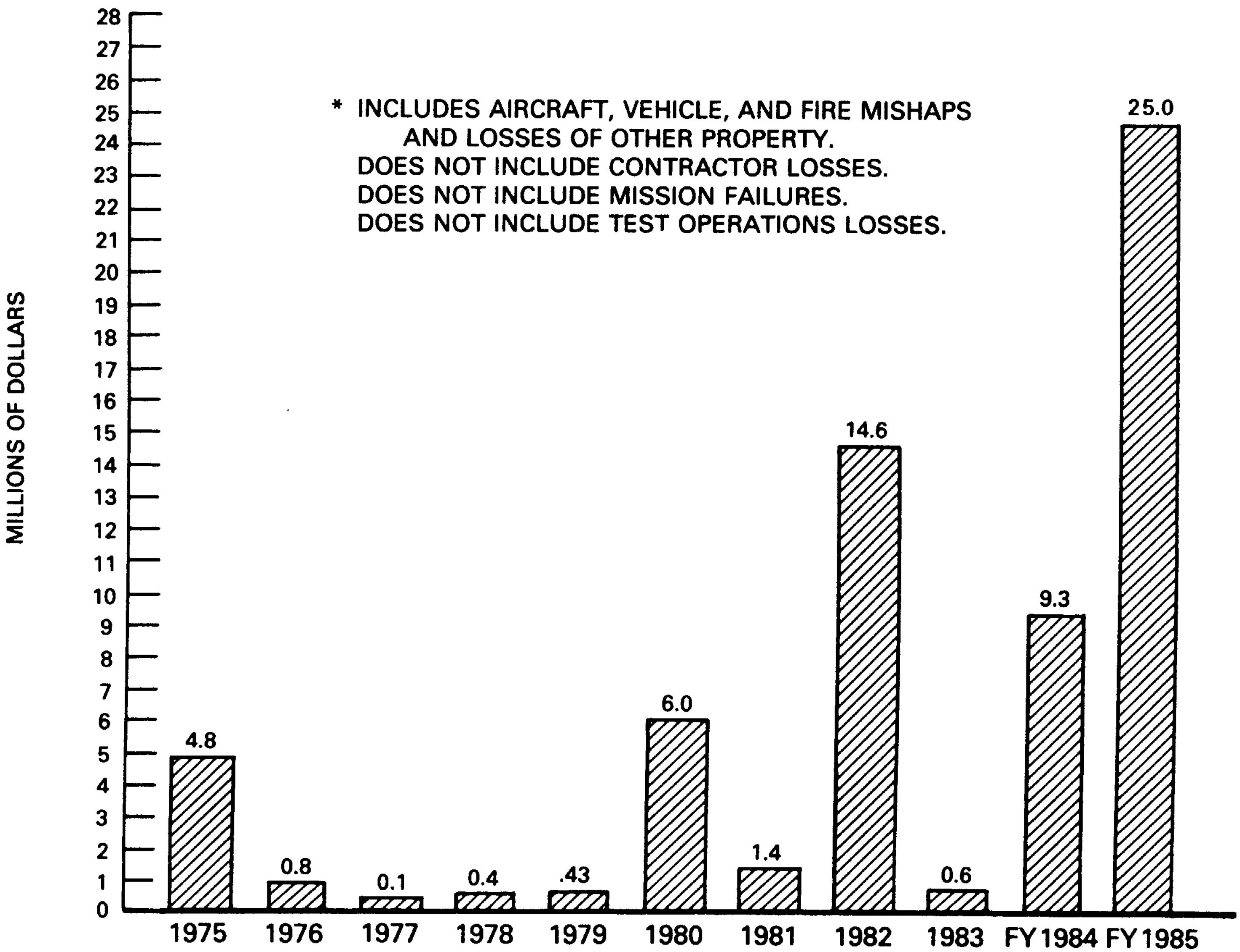
1. Aircraft Mishap Frequency Rate = number of mishaps per 100,000 hours flown.

2. Motor Vehicle Mishap Frequency Rate = number of mishaps per million miles driven.

3. Total Cost of Mishaps includes repairs/replacements of motor vehicles and damage and tort claims (as on obsolete OSHA Form 102FF).

4. Mishap Cost Rate = Total cost of mishaps per million hours worked.

NASA MATERIAL LOSSES DUE TO MISHAPS*



NASA HQ DS86-395(1)
2-21-86

Figure 12

NASA AVIATION SAFETY RECORD

NASA experienced two aircraft mishaps in FY 1985 resulting in a total loss of $18,760,000. One of these mishaps was the destruction by fire of the Convair 990 and all instruments on board. (See narrative of mishap in later section.)

NASA's relatively low number of total annual flight hours (22,493) accounts for a deceptively high mishap frequency rate when held up to the standard 100,000 flight hours.

Figure 13 shows the cost of aircraft losses over the last 11 years.

NASA MOTOR VEHICLE SAFETY RECORD

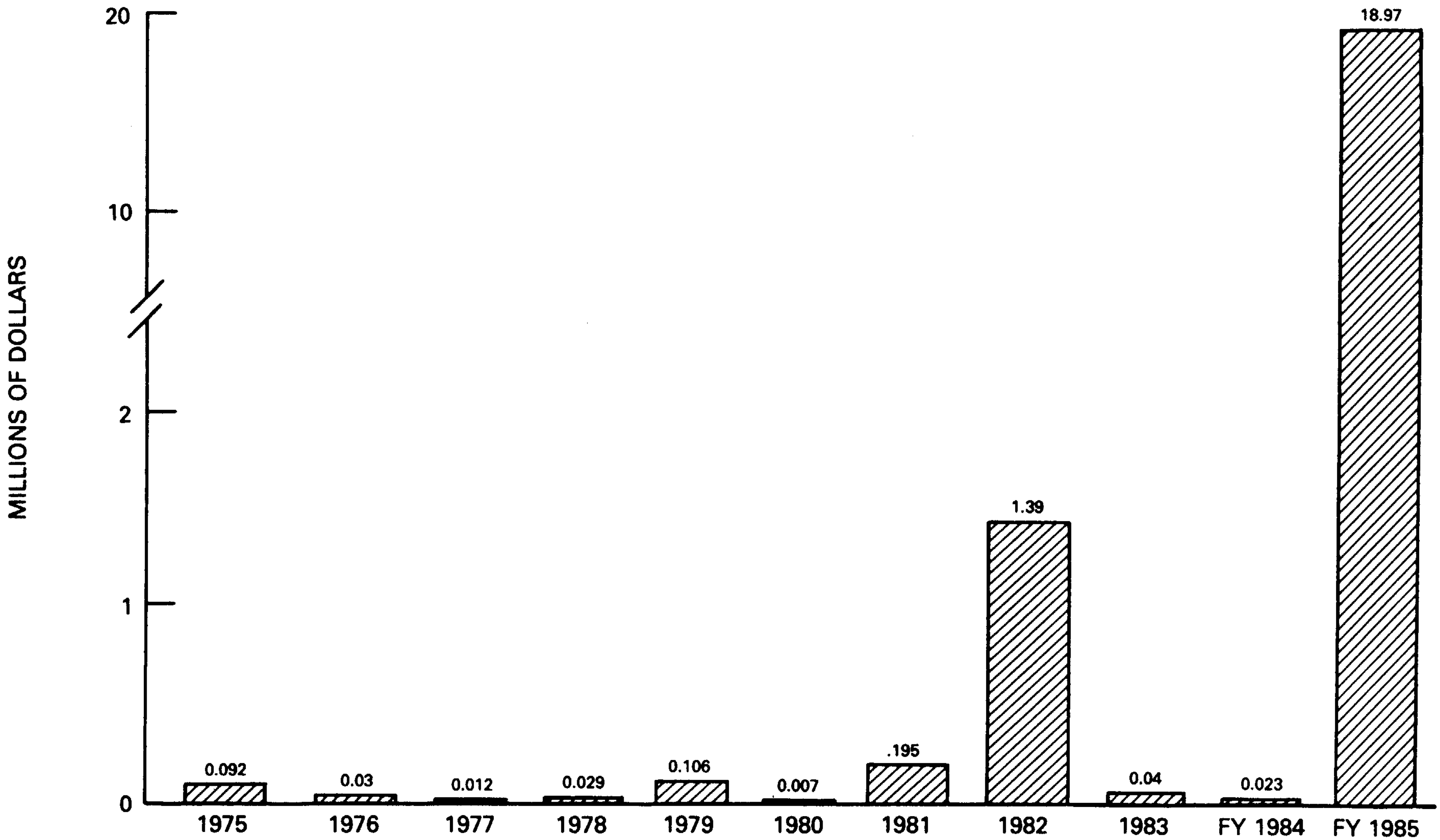
NASA's FY 1985 government automobile accident frequency rate of 0.73 accidents per million miles driven was the lowest recorded in over 11 years. This rate was significantly lower that the goal of 5.0 established by NASA in 1980. The cost of reportable accidents, however, was the highest recorded since 1976.

Figures 14 and 15 show the frequency rates and costs of automobile accidents for the last 11 years.

NASA FIRE EXPERIENCE

As shown in Figures 16 and 17, NASA experienced no fires in FY 1985. A downward trend in fires, begun in 1980, reflects vigorous efforts on the part of center Safety Offices to educate personnel in effective methods of fire prevention.

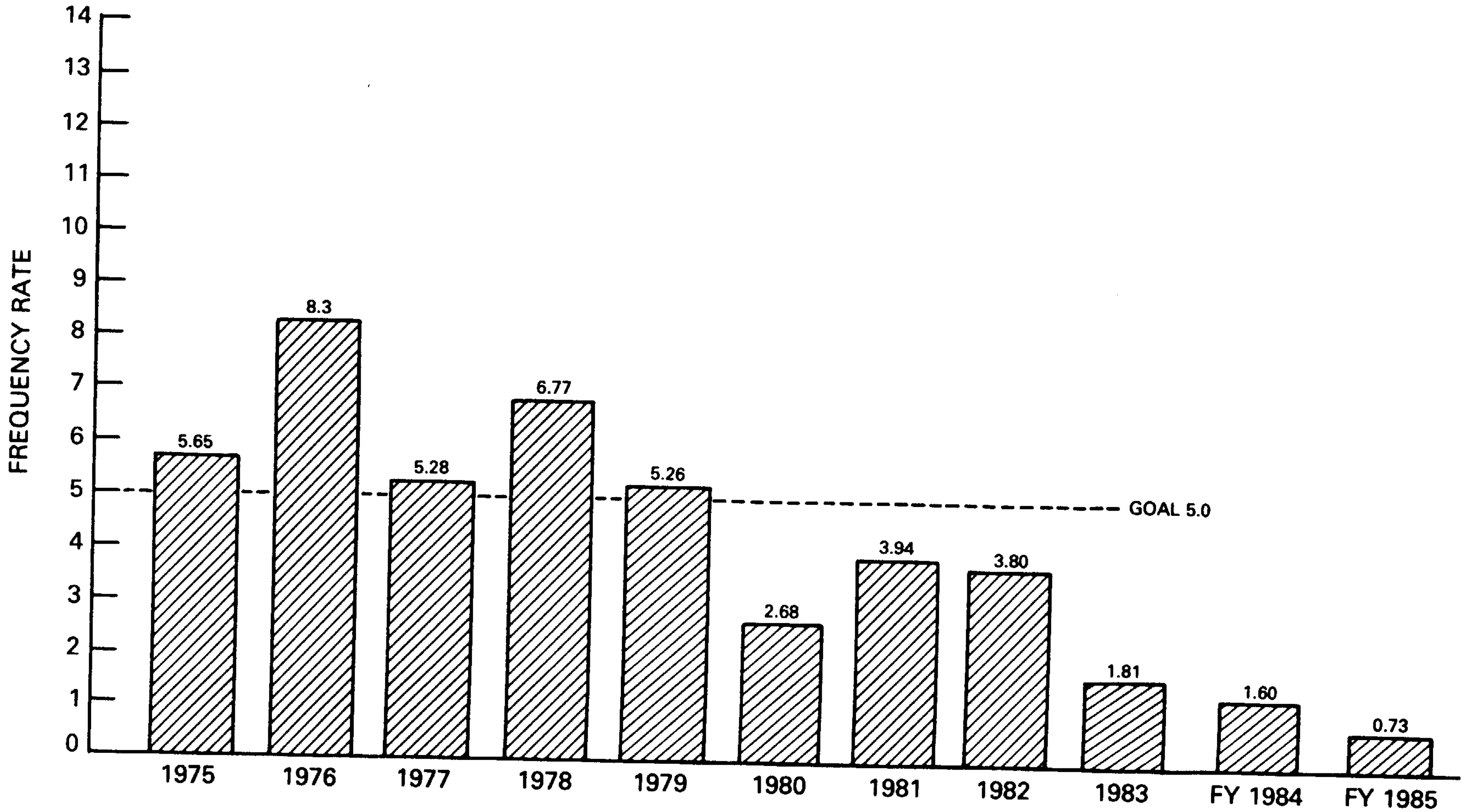
NASA AIRCRAFT LOSSES



NASA HQDS83-2430 (1)
Rev. 11-28-86

Figure 13

NASA GOVERNMENT MOTOR VEHICLE ACCIDENTS

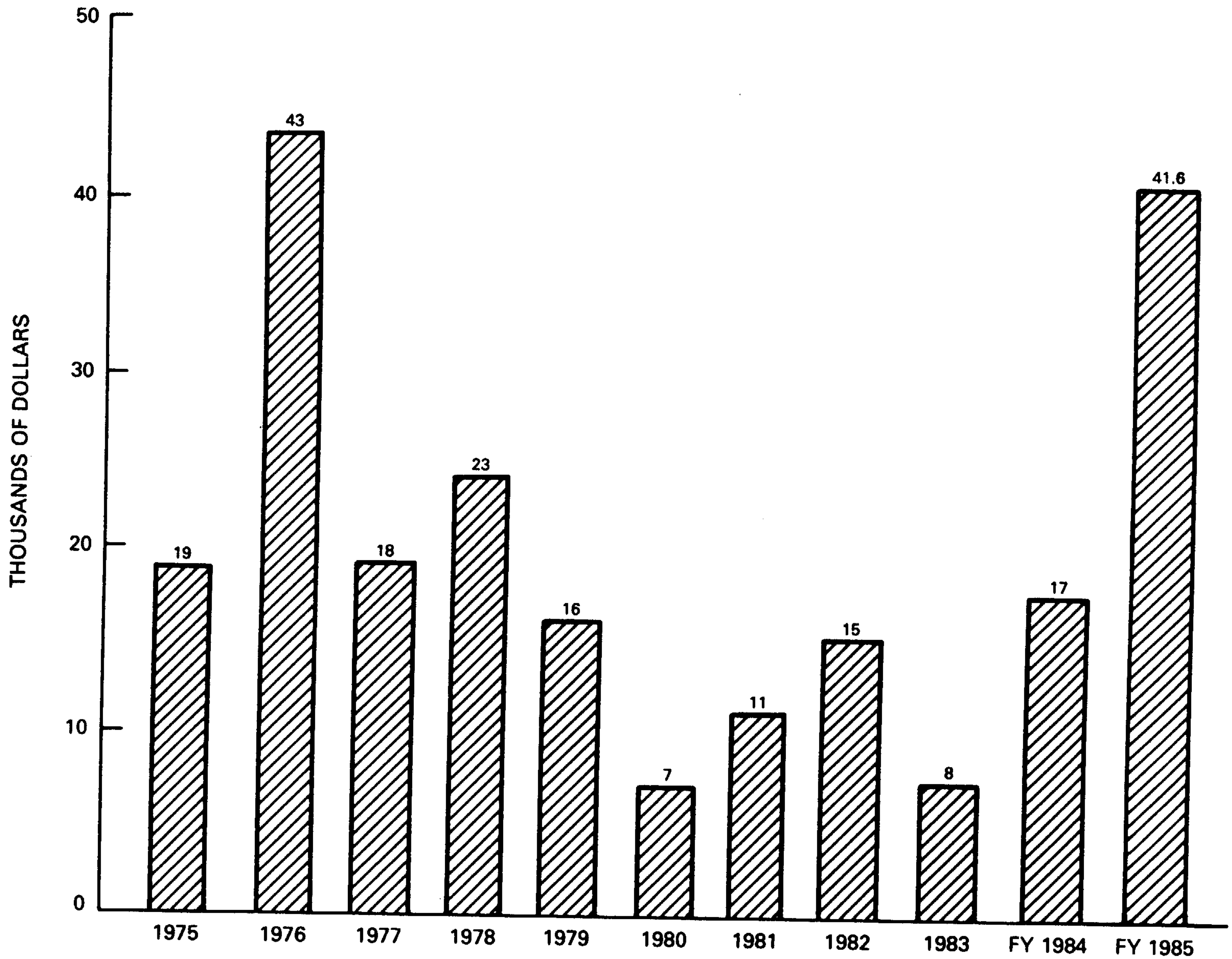


FREQUENCY RATE IS THE NUMBER OF MOTOR VEHICLE ACCIDENTS
PER MILLION MILES DRIVEN.

NASA HQ DS83-2429 (1)
Rev. 11-28-86

Figure 14

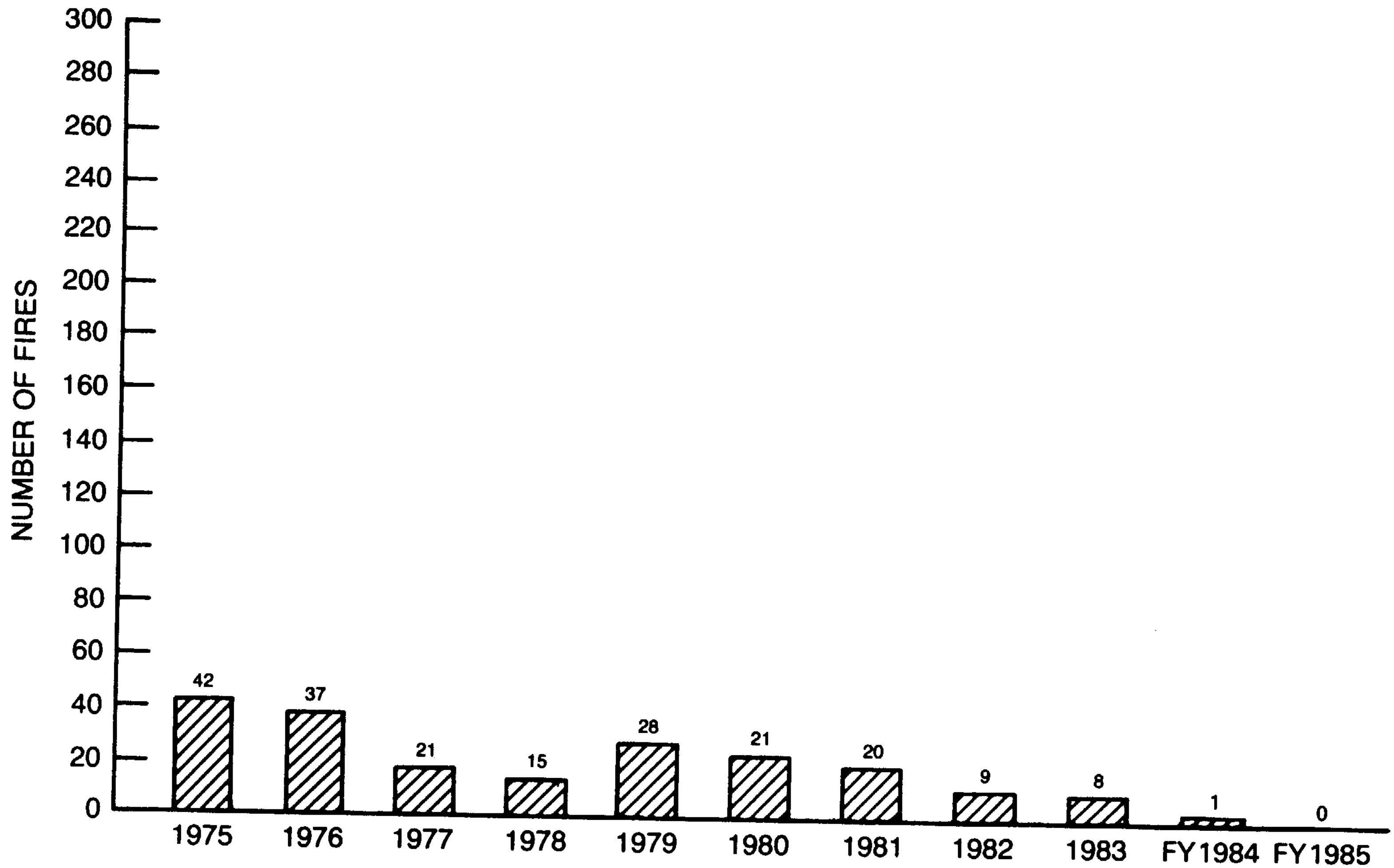
NASA AUTOMOTIVE LOSSES



NASA HQ DS86-389 (1)
Rev. 11-28-86

Figure 15

NUMBER OF NASA FIRE MISHAPS

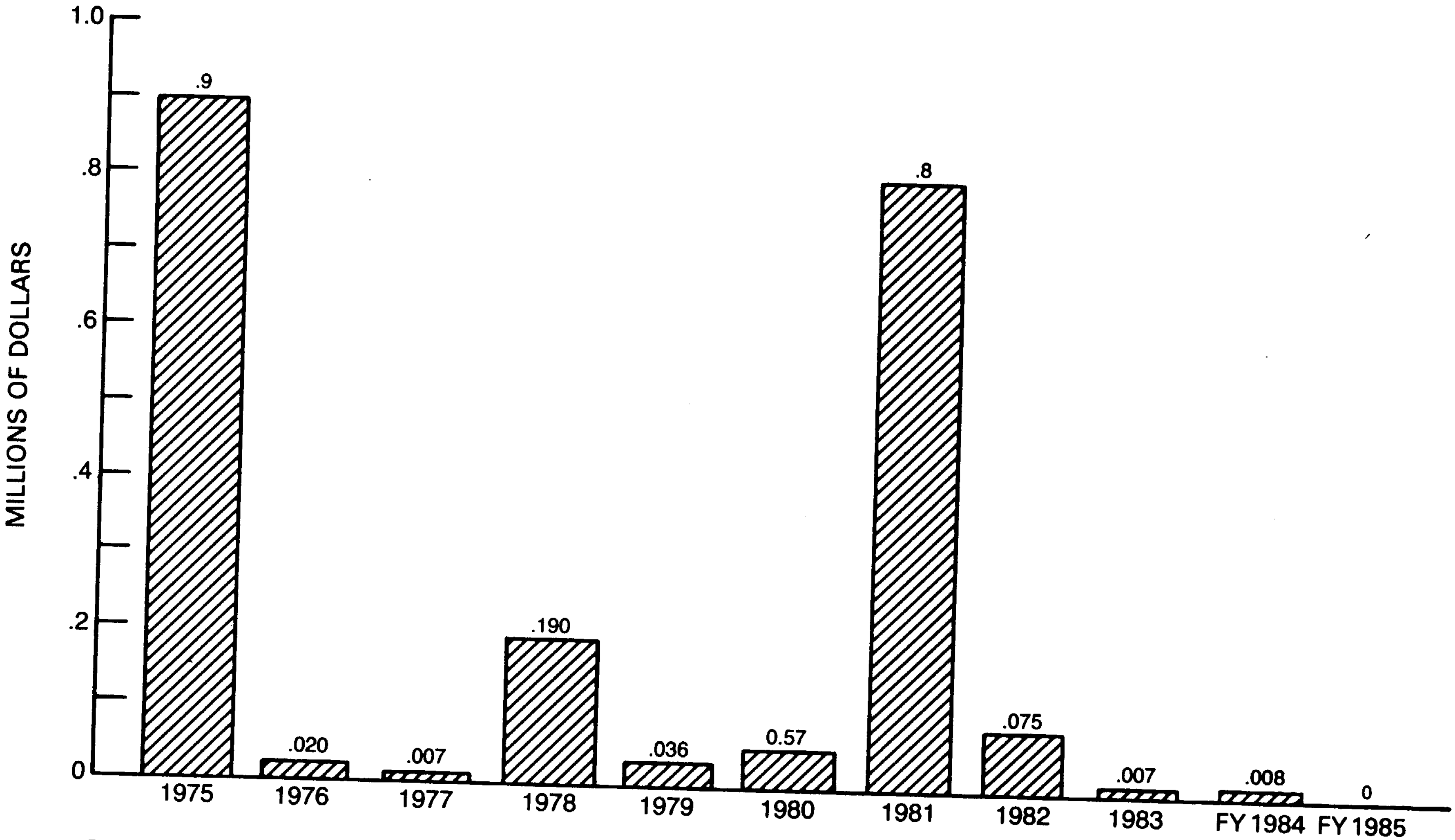


DOES NOT INCLUDE TEST OPERATIONS
DOES NOT INCLUDE MISSION FAILURE

NASA HQ DS86-397(1)
Rev. 11-28-86

Figure 16

NASA FIRE LOSSES



DOES NOT INCLUDE MISSION LOSSES OR TEST OPERATIONS LOSSES.

NASA HQ DS86-396(1)
Rev. 11-28-86

Figure 17

NASA MISHAP DEFINITIONS

TYPE A MISHAP: A mishap causing death, damage to equipment or property equal to or exceeding $500,000, destruction of an aircraft, or destruction of space hardware. NASA Type A mishaps are investigated by a board appointed by the appropriate program or institutional Associate Administrator.

TYPE B MISHAP: A mishap resulting in permanent disability to one or more persons, hospitalization of five or more persons, or damage to equipment or property costing from $250,000 to less than $500,000. NASA Type B mishaps are investigated by a board appointed by the director of the field installation.

TYPE C MISHAP: A mishap resulting in damage to equipment or property costing from $25,000 to less than $250,000, or causing occupational injury or illness which results in a lost workday (or workdays) or restricted duty. NASA Type C mishaps are analyzed locally by committees or individuals unless circumstances dictate a more formal investigation.

MISSION FAILURE: Any event of such a serious nature that it prevents accomplishment of the majority of the primary mission objectives. Mission failures are usually investigated by a formal board.

TEST FAILURE: An unexpected event which jeopardizes a test, prevents accomplishment of major test objectives, causes premature test termination, or destroys test hardware, test stands, or monitoring equipment. Test failures generally result in monetary losses of $25,000 or more, have significant impact on a particular program, or have political or public visibility. A program may call for the use of low cost models and other test items which are specifically designed to meet certain test conditions where damage is likely to occur. When these are damaged or destroyed, circumstances will determine if a test has in fact occurred or if the damage was a likely result of the test. Test failures are investigated or analyzed as determined by program personnel. (When a part or assembly fails without causing a significant monetary loss or program delay, a test failure, according to this definition, has not occurred.)

INCIDENT: An unplanned occurrence which results in injuries to personnel of less severity than those in a Type C mishap or which results in property loss or damage in excess of $500 but less that $25,000. A close call that could generate wide-spread interest may be included in this category.

CLOSE CALL: An unplanned occurrence in which there is no injury, property damage, or interruption of work, but which has the potential for any of these.

COSTS: Direct costs of repair, retest, delays, replacement, or recovery of

NASA property including manhours, material, and contract costs but excluding indirect costs of cleanup, investigation, injury, and normal operational delay.

NASA MISHAP: Any unplanned event or anomaly that may be classified as a Type A, B, or C mishap, incident, or mission or test failure that involves NASA personnel, equipment, or facilities.

NASA CONTRACTOR MISHAP: Any unplanned event or anomaly that may be classified as a Type A, B, or C mishap, incident, or mission or test failure that involves NASA contractor personnel or equipment in support of operations at NASA. These are normally investigated by the contractor and reviewed by NASA, or depending upon the circumstances, investigated separately by NASA when directed by a NASA official with board appointment authority.

The significant mishaps shown in Tables 4 and 5 are those reported by the NASA field installations and contractors as having significance beyond the minor dollar losses or injury incident categories. These mishaps provide "lessons learned" for all NASA accident prevention programs.

Figure 18 presents an 11-year overview of NASA Type A, Type B, and Type C mishaps. These categories are defined in terms of monetary losses. The limits for each category have escalated over the years largely due to inflation.

Figure 19 illustrates the relationship among chargeback billing costs, lost wages, and total NASA monetary losses due to mishaps over the last 11 years.

Table 6 compares the number of major mishaps experienced by the individual field installations, the lost time rate of civil service and contractor employees, and total monetary losses for the fiscal year against the centers' goals and the previous year's totals. In addition, the status of the first phase of the pressure vessel recertification effort, begun in 1981, is also reported on this Table. NASA's goal is to complete initial inspection and analysis of all pressure vessels by the end of FY 1987.

TABLE 4. FATAL ACCIDENTS

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
NASA EMPLOYEES	0	0	2	0	1	0	4	1	0	0	0
CONTRACTOR EMPLOYEES	1	1	3	1	0	0	5	1	0	1	2
PUBLIC EMPLOYEES	2	0	1	0	0	0	0	0	0	0	0
MILITARY EMPLOYEES	0	0	0	0	0	0	0	0	0	0	0
TOTALS	3	1	6	1	1	0	9	2	0	1	2

TABLE 5. TYPE A/B/C MISHAPS BY INSTALLATION

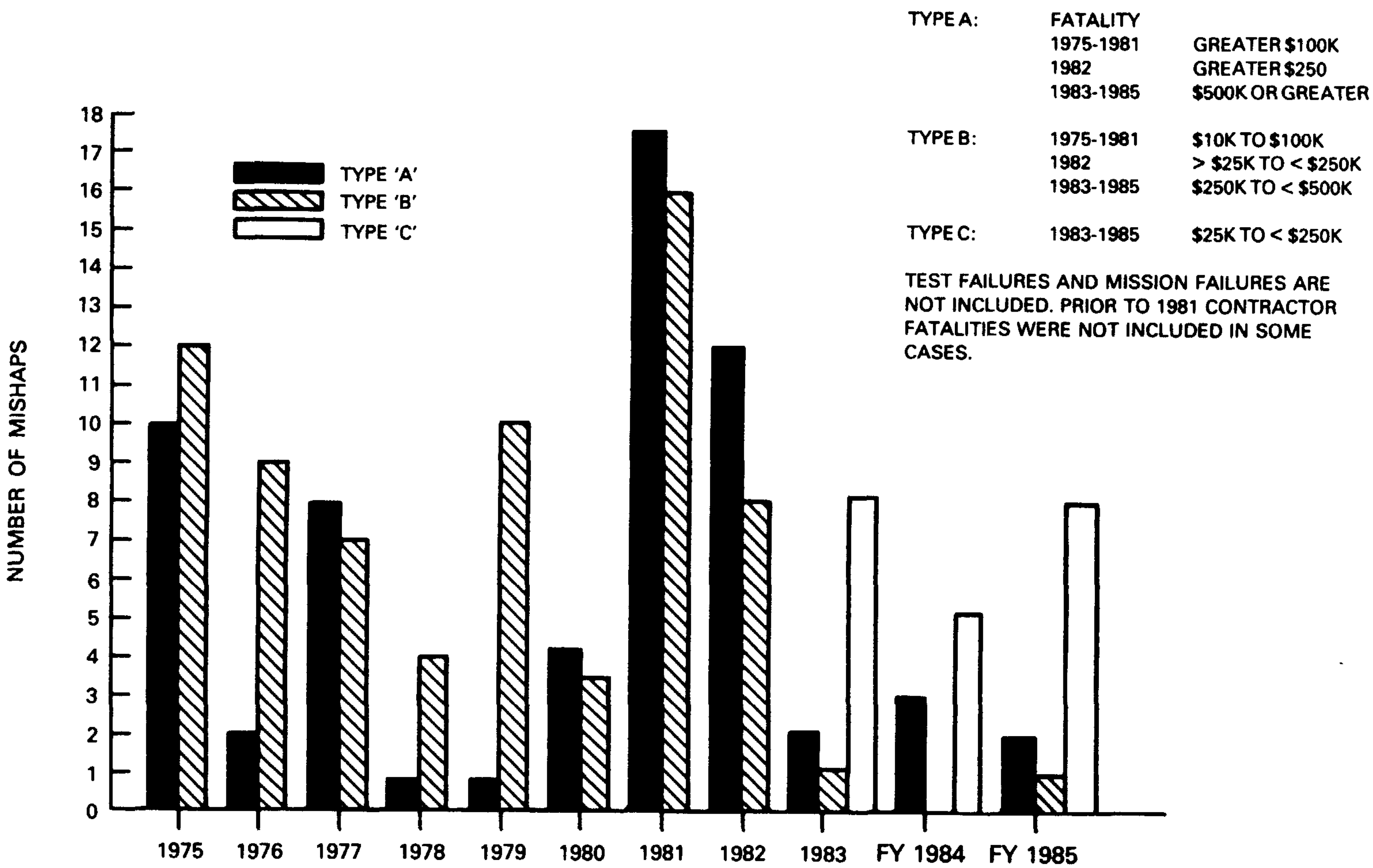
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
ARC/DFRF	0/1	1/1	0/0	1/3	0/6	0/0	2/3	2/3	1/0/2	1/0/5	1/1/0
GSFC/WFF	0/2	0/2	1/4	0/0	0/1	1/1	0/3	1/0	1/0/1	0/0/0	0/0/1
HQ	2/1	0/0	0/1	0/0	0/0	0/0	0/0	0/0	0/0/0	0/0/0	0/0/0
JSC	0/1	0/0	2/1	0/1	0/2	1/0	2/0	0/1	0/0/0	0/0/0	0/0/0
KSC	4/1	0/0	2/1	0/0	0/0	0/1	5/3	1/2	0/0/1	0/0/0	0/0/6
LaRC	0/2	1/1	0/0	0/1	0/0	0/0	3/4	1/0	0/0/0	0/0/0	1/0/0
LeRC	0/1	0/1	0/0	0/0	1/1	0/0	0/2	0/0	0/0/2	0/0/0	1/0/1
MSFC	1/1	0/0	1/0	0/0	0/0	2/1	1/0	4/2	0/1/2	2/0/0	0/0/0
NSTL	0/1	0/1	1/0	0/0	0/0	0/0	1/1	1/0	0/0/0	0/0/0	0/0/0
TOTALS	7/11	2/6	7/7	1/5	1/10	4/3	14/14	10/8	2/1/8	3/0/5	3/1/8

1. Type "C" was first defined in 1983 and replaced the previously defined Type "B" mishap.

2. Types "B" and "C" individual injuries are not shown in this table. See Table 1.

3. Mission and test failures are not included in these statistics.

NASA TYPE 'A', 'B', AND 'C' MISHAPS



NASA HQ DS86-403 (1)
Rev. 11-28-86

Figure 18

TOTAL COSTS TO NASA DUE TO MISHAPS*

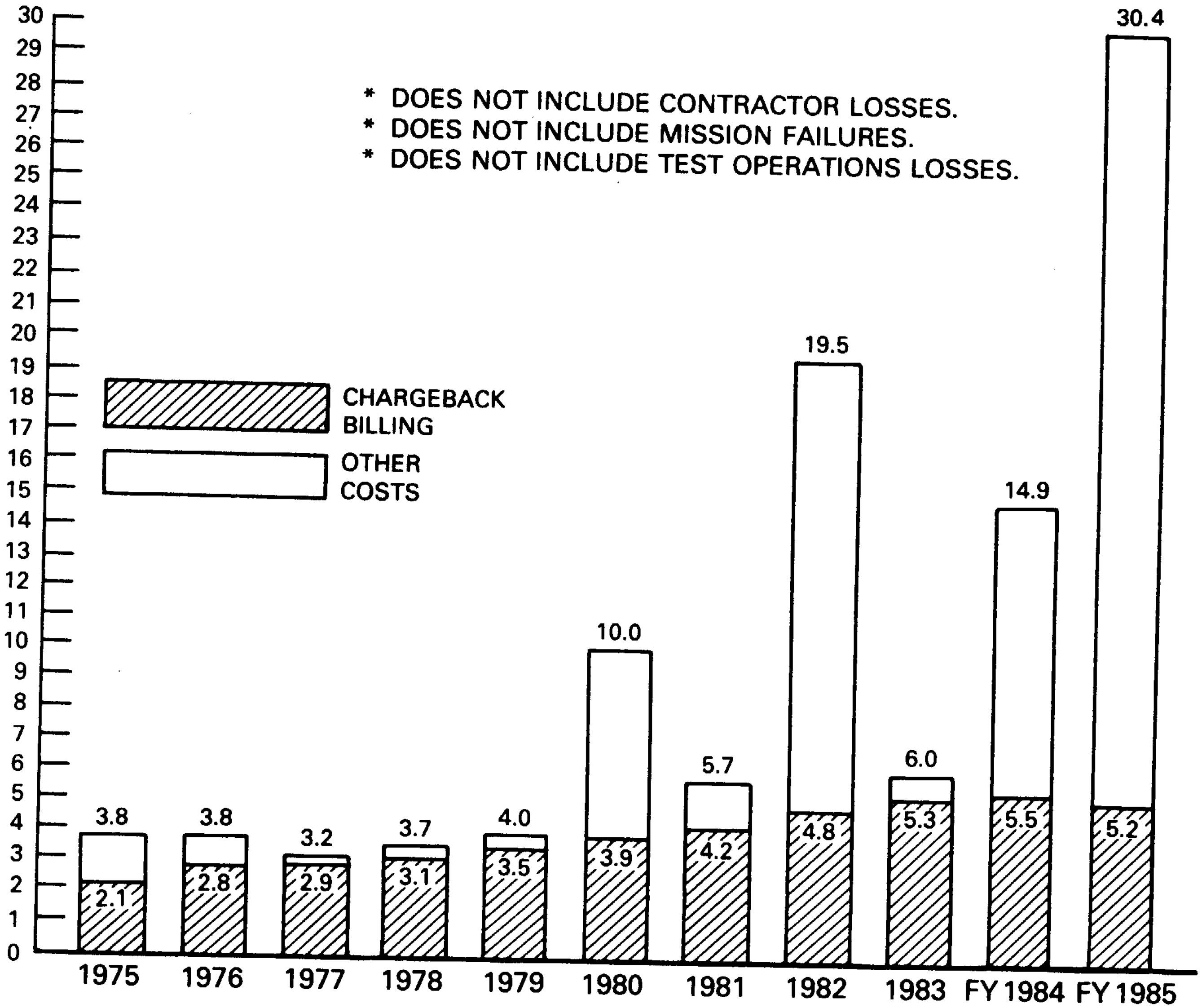


Figure 19
37

NASA HQ D586-394(1)
Rev. 11-28-86

TABLE 6. GOAL STATUS FOR FY 1985

	TYPE A & B MISHAPS			TYPE C MISHAPS			NASA EMPLOYEE L-T RATE			CONTRACTOR EMPLOYEE L-T RATE			MONETARY LOSSES ($K)			PRESSURE VESSEL RECERTIFICATION (% complete)		
	1984	GOAL 1985	STATUS	1984	GOAL 1985	STATUS	1984	GOAL 1985	STATUS	1984	GOAL 1985	STATUS	1984	GOAL 1985	STATUS	1984	GOAL 1985	STATUS
ARC/DFRF	1	1	2	5	1	0	0.28	0.30	0.30	2.34	1.90	1.79	563.4	500	18,972.3	33	55	37
GSFC/WFF	0	0	0	0	0	1	0.60	0.45	0.23	0.58	0.50	0.72	4.8	100	199.5	WFF 75 NSFB	85	30 10
HQ-CODE N	0	0	0	0	0	0	0.34	0.30	0.50	0	0.30	0.26	0.9	0	4.8	--	--	--
JSC	0	0	0	0	1	0	0.30	0.30	0.23	1.08	0.90	1.00	9.7	250	7.7	DwPd30	55	30
KSC	0	0	0	0	1	6	0.25	0.30	0.59	0.81	0.80	0.68	5.7	500	893.1	20	50	5
LaRC	0	0	1	0	0	0	0.15	0.30	0.22	2.18	1.90	1.81	21.6	250	1,723.0	35	55	42
LeRC	0	0	1	0	0	1	1.61	0.60	0.82	0.97	1.00	1.74	14.1	100	3,203.9	54	70	68
MSFC	4	1	0	1	1	0	0.13	0.30	0.33	0.85	0.90	1.56	8,618.6	500	7.5	65	80	90
NSTL	0	0	0	0	0	0	0	0.30	0.00	0.99	1.00	1.35	63.7	100	24.5	100	completed	
NASA	6	2	4	6	4	8	0.45	0.30	0.38	1.01	1.00	1.01	9,302.5	2,550	25,036.3			

1. Mishap goals are for Types B and C.

2. Monetary losses should include those operational losses NASA must pay for independent of NASA or Contractor operations. Mission and test failures are not included, but monetary losses of facilities and equipment associated with such losses, excluding mission or test hardware, should be included.

MAJOR MISHAPS IN FY 1985

HURRICANE DAMAGE TO WALLOPS FLIGHT FACILITY

Damage was sustained by several buildings at the Wallops Flight Facility as a result of Hurricane Gloria. Repairs to roofs and transformers and replacement of electrical cable, doors, fencing, etc. totalled $189,500.

EXHAUST GAS COOLER MISHAP
LEWIS RESEARCH CENTER

At approximately 4:00 p.m. on February 14, 1985, a failure occurred in the basement of the Engine Research Building (ERB) underneath the Hot Section Facility (HSF - Bldg. 38) at the Lewis Research Center. An exhaust gas cooler in the line between ERB and the Central Air Equipment Building (CAEB - Bldg. 64) collapsed under normal operating conditions. Although no longer a functioning cooler, the unit served as an integral part of the exhaust system piping. Examination of the area revealed that the cooler had been destroyed; there was minor damage to a nearby building wall; skylights in the HSF shop area above imploded, and a considerable amount of debris had been drawn into the piping. Some of the debris had been carried as far as the CAEB. There were no injuries to pesonnel or damage to any other equipment. Cost of the damage was assessed at $97,500.

Careful examination of the failed cooler and the exposed floor beams revealed that the stitch welds attaching the floor plate to the external I-beam were heavily rusted. It was also discovered that the floor plate had been welded to the floor beams by an intermittent pattern of nominal 1.5-inch welds 6 inches apart on both edges of the upper flange of the floor beam. It has been postulated that the failure of the welds had been progressing over the 40 years the cooler had been in service. The repeated evacuation and repressurization of the cooler combined with the poor quality of the original welds eventually resulted in weld fatigue, crack propagation, and the failure of the unit. The deterioration of the welds, however, was not evident during a 1983 inspection of the cooler because the proximity of the cooler to the floor prevented inspection of the bottom surfaces of the unit where the failure initiated.

Among the lessons learned was that detailed design drawings do not always depict the actual method of construction. Examination of the failed cooler at LeRC revealed numerous departures from the specified design.

COLLAPSE OF COOLING TOWER #5
LEWIS RESEARCH CENTER

At approximately 5:00 p.m. on February 21, 1985, the southwest corner of Cooling Tower #5 (Bldg. 93) at the Lewis Research Center collapsed. The damage was extensive, making further use of the tower impossible and rendering the cooling tower water system inoperational. The collapse was caused by an unusual accretion of ice in the central portion of the tower. The dead load of the ice overloaded the structural members and caused the collapse. Damage was assessed at $3.1M.

The Mishap Investigation Board found that the water system in Cooling Tower #5 had been operated during January and February 1985 in a manner that permitted water to flow up the riser pipe and into the distribution system of the tower. The air temperature had been consistently below freezing during January and February 1985, and there had been sufficient air flow in the southwest corner of the tower to cause water flowing into the distribution system to collect and freeze. While the air temperature had remained below freezing, the ice that formed had enough structural integrity to reinforce the columns of the structure and permitted the redwood to carry the increased dead load. The Cleveland area had experienced a warming trend for four days preceding the failure, and the ice lost enough of its structural integrity so that the column loading exceeded the critical load. The columns failed, bringing down the center section of the tower. The southwest corner of the tower collapsed probably because of the dynamic loading which resulted from the failure of the center section and the increased ice loading in the southwest corner.

In light of its findings, the Board recommended that written standard operating procedures for all the Cooling Tower Water Systems be developed. These should include permitted deviations from the norm. Any deviations from the SOP should require approval which should include a risk assessment analysis of operational and/or hardware changes. Also, adequate training, inspection, and maintenance procedures should be documented. Control procedures should be established to ensure that all personnel involved are aware of and understand the documented procedures. More thorough inspection of cooling tower structures including normally inaccessible areas should be planned so that critical members and joints can be examined throughout the structure. Finally, inspection by qualified experts of all cooling towers before the advent of the summer cooling season and resumption of normal operation should be provided for.

ORBITER PAYLOAD BAY ACCESS PLATFORM MISHAP
KENNEDY SPACE CENTER

On Friday, March 8, 1985, at approximately 8:00 a.m., the southeast Payload Bay Access Platform (9-1) in High Bay 2 of the Orbiter Processing Facility (OPF) at the Kennedy Space Center abruptly fell from its stowed position. A Lockheed Space Operations Company (LSOC) technician who was working on a lower platform suffered a broken leg and bruised shoulder when platform 9-1 struck him as it descended. The platform came to rest on the left forward payload bay door of the orbiter Discovery, penetrating the insulation blankets in three places and punching two holes in the closed door. Damage was estimated at $200,000, and rollover of Discovery from the OPF to the Vehicle Assembly Building (VAB) was delayed 15 days.

Four days prior to the mishap, an LSOC technician had reported a broken upper limit switch which had caused the telescoping structure to make contact with the supporting structure. The entire up-down portion of this system was subsequenly tagged with DO NOT OPERATE tags. Unfortunately, these were placed beside two older but identical operational warning tags and therefore, were not noticed by the LSOC technicians who operated the platform without incident on March 6. When the bridge assembly was moved on the morning of March 8, the resulting jolt was enough to break the already weakened master link in the wire rope assembly.

In addition to determining the immediate cause of the mishap, the Investigation Board found that improper procedures had been used for hoisting operations and that inadequate procedures had been used by LSOC for tagging and locking out malfunctioning equipment. As a result of the investigation, the Board recommended a revision of operating procedures and operator training to ensure that upper limit switches not be used as operational stops; a revision of tagout/lockout procedures to prevent the unauthorized use of equipment which has been designated unsafe; a revision of the platform preventive maintenance procedures to meet all KSC and OSHA standards. An additional recommendation was the modification of the design of the Payload Bay Access Platform to include the addition of an operational stop and load sensing device in the wire rope system and a redesign of the telescoping tubes to facilitate the required inspection of critical linkages.

MISHAP AT UNDERGROUND AIR STORAGE FACILITY
AMES RESEARCH CENTER

At approximately 7:30 p.m. on March 11, 1985, the Underground Air Storage Facility (UASF) at the Ames Research Center ruptured with the resultant loss of the entire volume of air stored in the facility. No injuries were sustained as a result of the cratering of earth around Cluster #1 and the hurling of mud for a radius of approximately 150 feet. The estimated cost of replacing the UASF was $1.5M.

The Investigating Board determined that the primary cause of the major leak in Casing #6 of Cluster #1 was a general degradation of the casing through anodic corrosion as the result of an insufficient "active" cathodic protection system.

Design and construction of the UASF was done under considerable time constraints due to the immediate need for large quantities of high pressure air. Although everyone associated with the project appeared to be fully aware of the need for an "active" cathodic protection system to ensure long-term integrity of the facility, their immediate concern was to have an operational facility which would later be protected by an active cathodic system. Consequently, design details which would have improved the effectiveness of the eventual cathodic protection system appear not to have been considered in detail.

The Board recommended that the UASF be abandoned and another high pressure air facility be constructed if needed.

CONTAMINATION OF HOPKINS UNIVERSITY TELESCOPE (HUT) EXPERIMENT KENNEDY SPACE CENTER

On May 1, 1985, the Hopkins University Telescope experiment was being aligned in the Operations and Checkout Building at the Kennedy Space Center when after approximately two hours of use without incident, the light bulb shattered. Fragments of the bulb fell into the experiment, contaminating it. There were no injuries to personnel, and the cost of restoring the HUT experiment to its original condition was $248,000.

The requirement to use an external light source for calibrating the HUT was not a planned activity at KSC. It resulted from the fact that the alignment data being taken at KSC did not correlate with the measurements taken at the Goddard Space Flight Center and the Marshall Space Flight Center. A protected light source had not been supplied with the experiment, and an unprotected unit was borrowed for use in the HUT alignment. The test team was apparently not aware of the potential hazards associated with using an unprotected light source in this application.

Several recommendations resulted from the investigation. Protected light sources should be used when there is a potential for damage to payloads or other critical equipment from the shattering of light bulbs. All personnel should be aware of the potential hazards of using unprotected light sources. Lead engineers should be required to approve any planned or unplanned use of external light sources.

CRITICAL MISHAP AT MIXING FACILITY M-24
MORTON THIOKOL, INC., BRIGHAM CITY, UTAH

At 5:14 p.m. on June 3, 1985, while Space Shuttle Solid Rocket Motor composite propellant was being mixed in Building M-24 at Morton Thiokol, Inc., Wasatch Division, lightning struck the building, causing a malfunction of the mixing bowl programmable controller. The bowl lowered at an angle while the mixing blades were still turning, allowing the high speed orbital blade to strike the side of the bowl. The resulting subsurface ignition of the propellant caused an explosion and fire. The Mix Facility was totally demolished, and damage to several adjacent buildings was also sustained. Total cost of the damage was $3.4 million with $45,000 of the cost being borne by NASA. There were no serious injuries. At the time of the mishap, shutdown of mixing operations during electrical storms was not mandatory.

The Investigation Board determined that the electrical current of the lightning strike was properly shunted to the ground by the M-24 lightning grounding system. The intense magnetic field surrounding the lightning bolt, however, will induce a voltage transient into any wires it encounters, such as antennae and feedlines, power lines, or communications lines. It has been concluded that this phenomenon caused the malfunction of the programmable controller.

When the facility was upgraded with a programmable controller, new possibilities of failure were introduced which were not entirely understood at the time. Among the Board's 22 recommendations was the development of a complete failure modes and effects analysis, not only on the mixing facilities, but on all other hazardous operations using similar control systems. The Board also urged MTI to mandate the shutting down of grinding, mixing, and casting operations when an electrical storm approaches to within three miles.

HIGH-SPEED WIND TUNNEL MISHAP
LANGLEY RESEARCH CENTER

While an aircraft model was being tested in the 7 X 10-Foot Wind Tunnel at the Langley Research Center (LaRC) on July 11, 1985, a major mishap occurred which resulted in the complete destruction of all 18 Sitka spruce fan blades, rendering the facility inoperative. The high-speed tunnel, a closed-circuit/single return atmospheric wind tunnel, had been operated since 1945 to support a wide range of subsonic aerodynamic tests and studies. The failed blade set had been in use since 1975. In addition to blade loss, the most significant damage was a bent main drive shaft. The estimated loss was $1.7 million. The EA-6B model being tested was undamaged.

A 14-member board representing NASA Headquarters, Ames Research Center, Lewis Research Center, and Langley Research Center was appointed to conduct the mishap investigation. The board concluded that blade loss was initiated by shear out of a blade at the root/hub region. The shear out was most likely due to wood fatigue. In addition, the flexibility of the drive shaft coupled with the small operating clearance between the blade tips and tunnel shell contributed to the rapid destruction of the blades and subsequent mechanical damage. Additional contributing factors were the apparent inadequate design consideration of high stress concentrations at the blade pin hole boundaries, fatigue, unsteady aerodynamic loading, the thermal environment in the fan cavity, inadequate inspection techniques, and unknown criticality of detected flaws.

Recommendations of the board included a redesign of the root/hub transition region to lower operating stresses, improved inspection methods and procedures which include periodic removal of blades, updating of blade specifications, permanent drive vibration sensors and trips, temperature measurement and monitoring in the fan cavity, increased blade/shell clearance, installation of frangible blade tips, and in-process quality control during blade fabrication. In addition, a more thorough nondestructive examination should be performed on selected components during tunnel repair.

LOSS OF CONVAIR 990

On July 17, 1985, NASA #712, a Convair 990 turbojet aircraft, was destroyed by fire while on the ground at March Air Force Base, California. The pilot aborted the takeoff when the tires on the right main landing gear blew during the takeoff roll. Fragments of either the blown tires or the wheel/brake assemblies struck and punctured the fuel cell on the underside of the right wing causing a fuel leak. While the aircraft was still rolling, the leaking fuel ignited, and the ensuing flames totally consumed the aircraft. Passengers and crew evacuated safely.

The CV-990 had departed its home base at Moffett Field, Mountainview, California to support a scientific flight. The aircraft was scheduled for a 6-hour instrument flight rules flight to observe a man-made barium comet trail. The aircraft flight crew consisted of two pilots, a flight engineer, and a navigator. Fifteen scientists and technicians were on board to operate the experimental equipment. In addition to the aircraft, all scientific instruments on board were destroyed, and the portland cement concrete surface on the departure end of runway 32 where the CV-990 stopped was extensively damaged. Losses have been assessed at $18.75M.

The NASA Aircraft Accident Investigation Board determined that the probable cause of the accident was the nearly simultaneous failure of the two front tires on the right main landing gear at a critical time during the takeoff roll. The Board developed an extensive list of recommendations directed at the Federal Aviation Administration, the Department of Defense, NASA Headquarters, and NASA Aircraft Operations Managers.

COLLAPSE OF TELESCOPING TUBE AT LAUNCH COMPLEX 39 PAD B KENNEDY SPACE CENTER

On September 18, 1985, at the Kennedy Space Center three sections of a telescoping tube assembly at Launch Complex 39, Pad B Rotating Service Structure (RSS) fell from a height of 200 feet. The falling tubes struck, dislodged, and severely damaged the RSS Orbital Maneuvering System (OMS) pod cover. Additional damage of a minor nature was sustained by other portions of the RSS, namely, communications boxes, platforms, cables, and sensors. There were no injuries to personnel. The total damage loss was $90,000.

The immediate cause of the mishap was a failure of the load bearing surfaces provided by bolt-on keepers on tube C. The load bearing surfaces failed between the bolt-on keepers on the fixed tube at their interface with the welded stops on tube A. The most probable cause of this failure was the malfunction of the primary lifting surfaces between tubes C and D. As opposed to a structural failure, this mode of failure was assessed as a "slide-by" or "escape" between mating surfaces. The 1/4" fillet welds at the bearing surfaces of the lift plate on tube D caused a wedging action against the tube C keepers which, after a number of operations, bowed the wall area and decreased the bearing surface.

This mishap was characterized as the failure of a mechanism whose design required unreasonable precision. A critical system such as this tube and platform assembly should have been categorized as Ground Support Equipment (GSE), not part of the RSS. The design did not realistically account for the actual tolerances eventually encountered during structural fabrication and assembly. The use of 1/4" fillet welds for the stops did not leave adequate flat mating surfaces for the keepers. The design lacked an interference analysis to assess performance and ensure that adequate clearances and tolerances existed between the moving surfaces.

TEST AND MISSION FAILURES

Although mission and test failures are not included in NASA's report of property damage due to mishaps, the following summary is provided to communicate lessons learned.

TEST FAILURE OF SPACE SHUTTLE MAIN ENGINE #2308

On March 27, 1985, major damage to a Space Shuttle main engine and minor damage to the facility were sustained when a planned 300-second test on engine #2308 at the Santa Susana, California, A-3 test stand was prematurely terminated at 101.5 seconds. At approximately 89.5 seconds into the test, a small leak developed in a hydrogen line in the main combustion chamber forward manifold outlet. This leak progressed rapidly to a full rupture. The rapid fuel loss resulted in cavitation of the high pressure fuel pump with attendant vibration redline exceedance and cut-off. The significant fuel loss following the rupture resulted in oxidizer rich conditions in the engine which sustained severe internal damage in the ensuing fire. The low pressure pump was left hanging in the stand, and the remainder of the engine fell into the fire bucket.

The Investigation Board determined that the most probable cause of the failure was long-term fatigue and subsequent crack growth. The main combustion chamber (MCC) of engine #2308 had had a significant high and low cycle exposure. As a result, a use limit of 8500 equivalent full power level seconds has been established for the MCC. In addition, a review of critical weld x-rays was recommended.