NASA National Aeronautics and Space Administration

FY 1989 SAFETY PROGRAM STATUS REPORT

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

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SAFETY PROGRAM OVERVIEW

NASA's safety efforts continued to expand in FY 1989. The centralized safety program played an integral part in a number of major accomplishments. Independent safety assurance was provided for 5 Space Shuttle launches, 1 Expendable Launch Vehicle, and 94 payloads.

The Space Shuttle Program continued its vigorous risk reduction effort to enhance the safety of the workforce and of flight vehicles. A Mission Safety Evaluation (MSE) was prepared for each Space Shuttle launch. The MSE report contains a certified independent assessment and status of the significant risks, including closure rationale, for each mission. A quantitative risk assessment of the Shuttle Data Book was completed.

Major progress was made in the evolutionary process of changing the NASA culture with respect to risk assessment/risk management. The objective is to provide the capability for risk assessment-based technology throughout NASA, making it an integral part of the everyday work of engineers and managers, as well as safety and reliability personnel. The benefits derived through risk prioritization are enhanced decision-making capability on hazard disposition, and on trade-offs between safety, reliability, performance, cost, and schedule throughout all phases of program or facility design, development and operation. Risk assessment/risk management workshops were developed for all NASA Centers, with initial delivery planned for Ames Research Center (ARC) and Langley Research Center (LaRC). Initial introduction to risk assessment concepts is provided through regular presentations at the Advanced Project Management Course. An independent assessment was made of Space Shuttle accident scenario probabilities for Galileo, as well as a review of uncertainties inherent in the overall study of nuclear risk from Galileo. A probabilistic risk assessment of the LaRC 8 Foot High Temperature Wind Tunnel was initiated in FY 1989 at the request of LaRC. The Center has provided extensive engineering and management support. This is the first large scale risk assessment project performed with Headquarters Safety Division funding. The analysis will be completed in the fall of 1990. Reviews of an Air Force range safety study for Space Shuttle launches were also conducted. NASA is working cooperatively with the Air Force and its contractors to reach agreement on data and modeling techniques. Future work will focus on the implications of the study for NASA operations.

Safety awareness at all facilities was a major objective and supported in all facets of NASA's operations including ground operations and facility safety. NASA's biennial Pressure Systems Seminar was held in FY 1989 at the Ames Research Center. The Seminar was well attended with over 120 participants, including representatives from all NASA installations, the Department of Defense, Department of Energy, and a number of contractors. The Seminar is held to discuss the status of the agencywide Pressure System Recertification (RECERT) Program and to provide the pressure system community with a forum for the exchange of information on pressure system related issues. A meeting of the NASA Safe Lifting Working Group was held at the Jet Propulsion Laboratory. Attendees presented briefings on their installations' safe lifting program and the implementation status of the revised NASA Safety Standard for Lifting Devices and Equipment (NSS/GO-1740.9A). All had the opportunity to voice concerns and to make recommendations to improve the Standard.

The Annual Safety Directors Meeting was held on June 13 and 14 in Washington, D.C. Discussion items included the space debris safety policy, documentation, safety information systems, dual processing in the Vehicle Assembly Building, the Galileo mission, status of the Centers' safety programs, Center manpower and budget issues, lost time goals, and the Senior Safety Steering Committee Charter. Nineteen Headquarters action items were generated, of which 6 remained open at the end of FY 1989.

New management issuances, policies, handbooks, standards, and other documents were developed, validated, or revised. Revision of NASA Basic Safety Manual, NHB1700.1 (VI-A), was initiated in FY 1989 with a draft expected to be ready for field installation staffing in 1990. This document represents a revitalized NASA baseline safety document that will posture the program into the 21st Century.

An upgraded version of the Mishap Reporting and Corrective Action System (MR/CAS) software was distributed to all Center safety offices. The software now contains an enhanced query capability to aid safety managers with trend analysis and development of preventive measures. A Corrective Actions Tracking Module was added to the system to provide more efficient tracking of actions developed from mishap investigations. Another new feature is the Preliminary Report option. Centers may enter preliminary information about a potential mishap for immediate circulation electronically or in hard copy, much like the Telephonic Report Form 1627A. After an initial investigation, the event may be upgraded to a mishap or dropped from the system.

Two training videotapes were developed to acquaint safety managers and new safety employees with the capabilities of the MR/CAS software and to familiarize those responsible for reporting mishaps with the standard NASA Mishap Report Form 1627.

Development of a prototype Lessons Learned Information System (LLIS) began in FY 1989. While the initial objective of this effort is to capture engineering lessons learned from earlier NASA programs that apply to the Space Station Freedom Program, the system will eventually be expanded to include those lessons from the operational safety environment.

NASA continued striving to reduce occupational injury and illness claims during FY 1989. Lost Time Injury/Illness Frequency Rates are one of the major parameters used to measure the health of an occupational safety program. Setting lost time rate goals for the Centers proved to be productive in the past; however, a method for assigning the goals was never clearly defined. A new formula for setting lost time frequency rate goals was developed in FY 1989 and will be implemented on an informal, trial basis during FY 1990.

The Headquarters Safety Division continues to assist the field installations' safety programs by participating in facility reviews and conducting safety surveys. Five wind tunnel facility reviews were conducted in FY 1989. Safety surveys are now being conducted as part of the Headquarters SRM&QA Survey Program. The safety programs at three Centers were surveyed in FY 1989.

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

Charles W. Mertz
Director, Safety Division

FY 1989
NASA SAFETY STATISTICS

Fatalities	0		
		OSHA Recordable	NASA Work-Related
Total Injuries/Illnesses		292	119
Lost Time Injuries/Illnesses		120	95
Lost Wages	$93,831		
Chargeback Billing	$5,187,448		
Material Losses	$13,609,000		
Total Losses	$18,890,279		

NASA OCCUPATIONAL INJURY/ILLNESS RECORD

Injuries and illness are divided into two classes, lost time cases and no-lost time cases. 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.

NASA Headquarters Safety Division tracks those clearly work-related injury/illness cases for which preventive action or corrective action plans may be developed to prevent recurrence. OSHA recordable injuries and illnesses include all compensable injury/illness claim cases. This information is provided by the NASA Headquarters Occupational Safety and Health Division to the Department of Labor.

Headquarters tracks injury/illness frequency rates; i.e., the number of injuries/illnesses per 200,000 hours worked. OSHA is now calculating rates according to the number of injury/illness cases per 100 employees. Several charts in this report reflect these formulas.

Table 1 shows the FY 1989 work-related injury/illness statistics for all NASA field installations. The overall work-related lost time rate of 0.44 is an increase from the FY 1988 value of 0.37.

TABLE 1. NASA INJURY/ILLNESS DATA BY INSTALLATION - ANNUAL REPORT FY 1989

			Lost Time Cases			Incidents w/ Injury Cases		Lost Time Rate vs. Goal '89	
	Average No. of Employees	Hours Worked In K	No. Days	No. Cases	Freq. Rate	No. Cases	Freq. Rate	YTD Rate	Goal
ARC/DFRF	2,329	4,674	48	20	0.86	4	0.17	0.86	0.40
GSFC/WFF	3,643	6,575	74	10	0.30	14	0.43	0.30	0.30
HQDB	1,789	3,445	115	7	0.41	3	0.13	0.41	0.40
JSC/WSTF	3,794	6,190	73	8	0.26	12	0.39	0.26	0.30
KSC	2,427	4,878	169	14	0.57	20	0.82	0.57	0.30
LARC	3,001	5,370	134	12	0.45	21	0.78	0.41	0.30
LERC	2,730	5,078	88	14	0.55	35	1.38	0.55	0.50
MSFC	3,553	6,452	106	10	0.31	10	0.31	0.31	0.30
SSC	189	383	0	0	0.00	0	0.00	0.00	0.00
NASA	23,455	43,045	807	95	0.44	119	0.53	0.44	0.40
1988	22,547	43,908	1,269	82	0.37	36	0.16	0.37	0.40

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.

Figure 1 illustrates the relative position of the NASA OSHA recordable lost time injury/illness rate compared to other Federal agencies having more than 15,000 employees in FY 1988 and FY 1989. Within the Federal Government, NASA has ranked second since FY 1984.

Figure 2 plots the NASA OSHA recordable 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 for the private sector are for FY 1988.

Figure 3 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 1988.

Figure 4 shows how the FY 1989 NASA work-related lost time injury/illness frequency rates at the NASA field installations compared to the overall NASA rate of 0.44 and NASA's overall goal of 0.40.

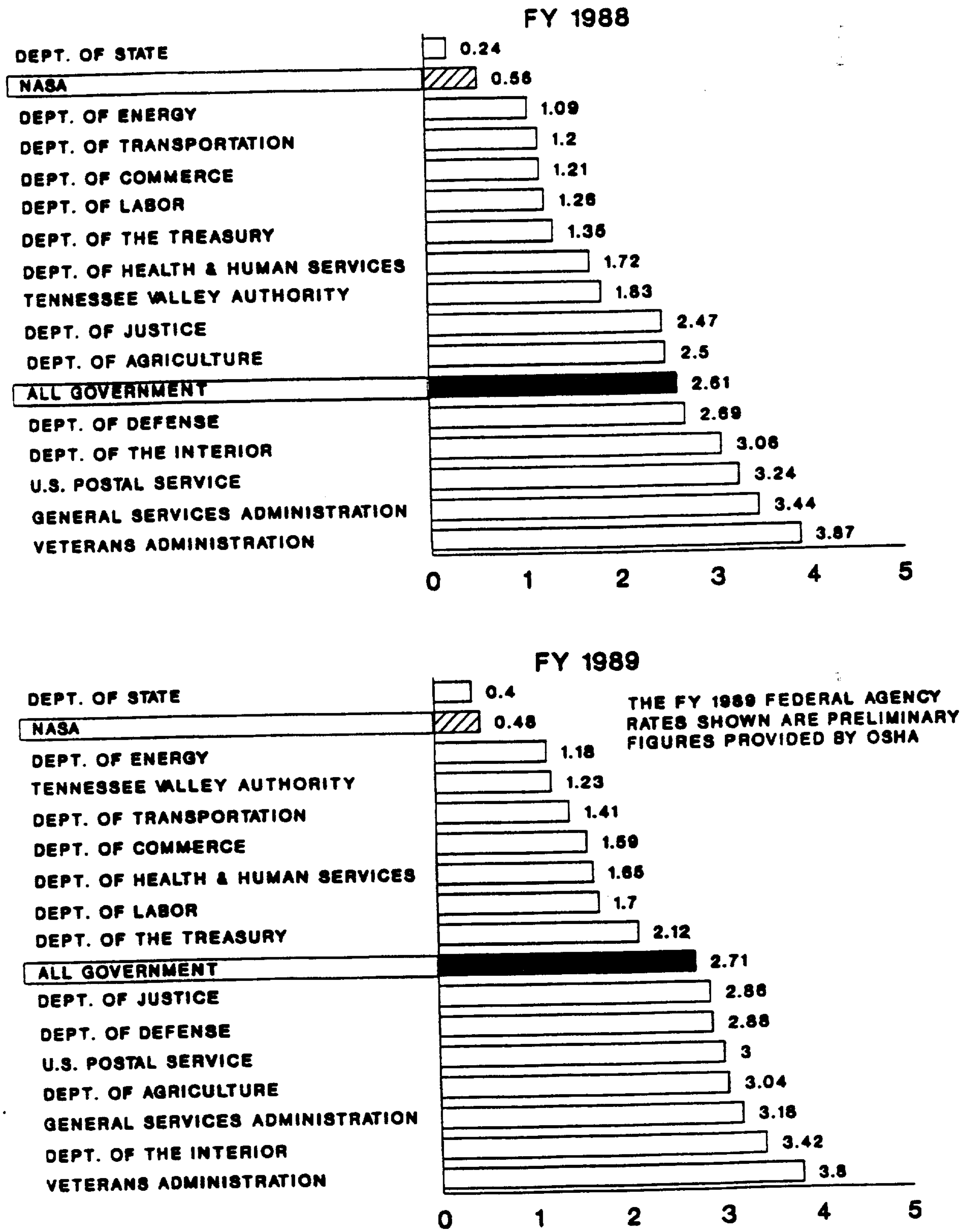
Figure 5 plots the NASA work-related lost time frequency rate, no-lost time rate, and the total rate. FY 1988 was the first year that the number of work-related lost time cases exceeded the number of no-lost time cases. This trend continued in FY 1989.

Table 2 shows the work-related lost time rates for contractor employees by installation. The overall contractor rate of 1.07 reflects a slight increase from the FY 1988 value of 1.03.

Figure 6 compares the FY 1989 work-related lost time frequency rates of NASA Federal employees at each installation with the previous year's rate and an average rate for the previous 3 years (FY 1986 - FY 1988).

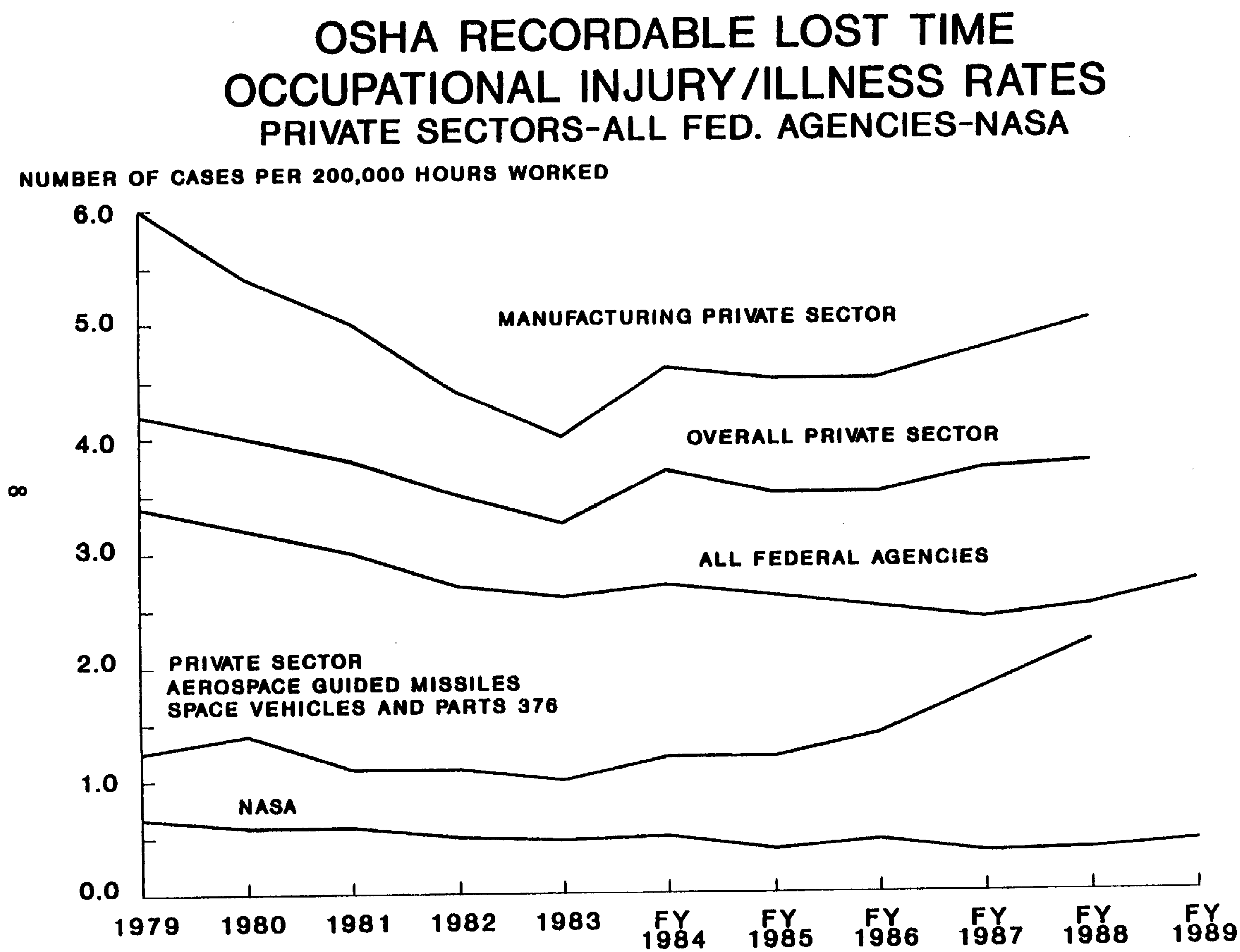
Figure 7 compares the FY 1989 work-related lost time frequency rates of NASA contractor employees at each installation with the previous year's rate and an average rate for the previous 3 years (FY 1986 - FY 1988).

OSHA RECORDABLE LOST TIME INJURY/ILLNESS RATES IN SELECTED FEDERAL AGENCIES *



* HAVING MORE THAN 15,000 EMPLOYEES

Figure 1



OSHA RECORDABLE LOST TIME
OCCUPATIONAL INJURY/ILLNESS RATES
PRIVATE SECTORS-ALL FED. AGENCIES-NASA
NUMBER OF CASES PER 200,000 HOURS WORKED
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
1979
1980
1981
1982
1983
FY 1984
FY 1985
FY 1986
FY 1987
FY 1988
FY 1989

Figure 2

TOTAL OSHA RECORDABLE OCCUPATIONAL INJURY/ILLNESS RATES
PRIVATE SECTORS-ALL FED. AGENCIES-NASA

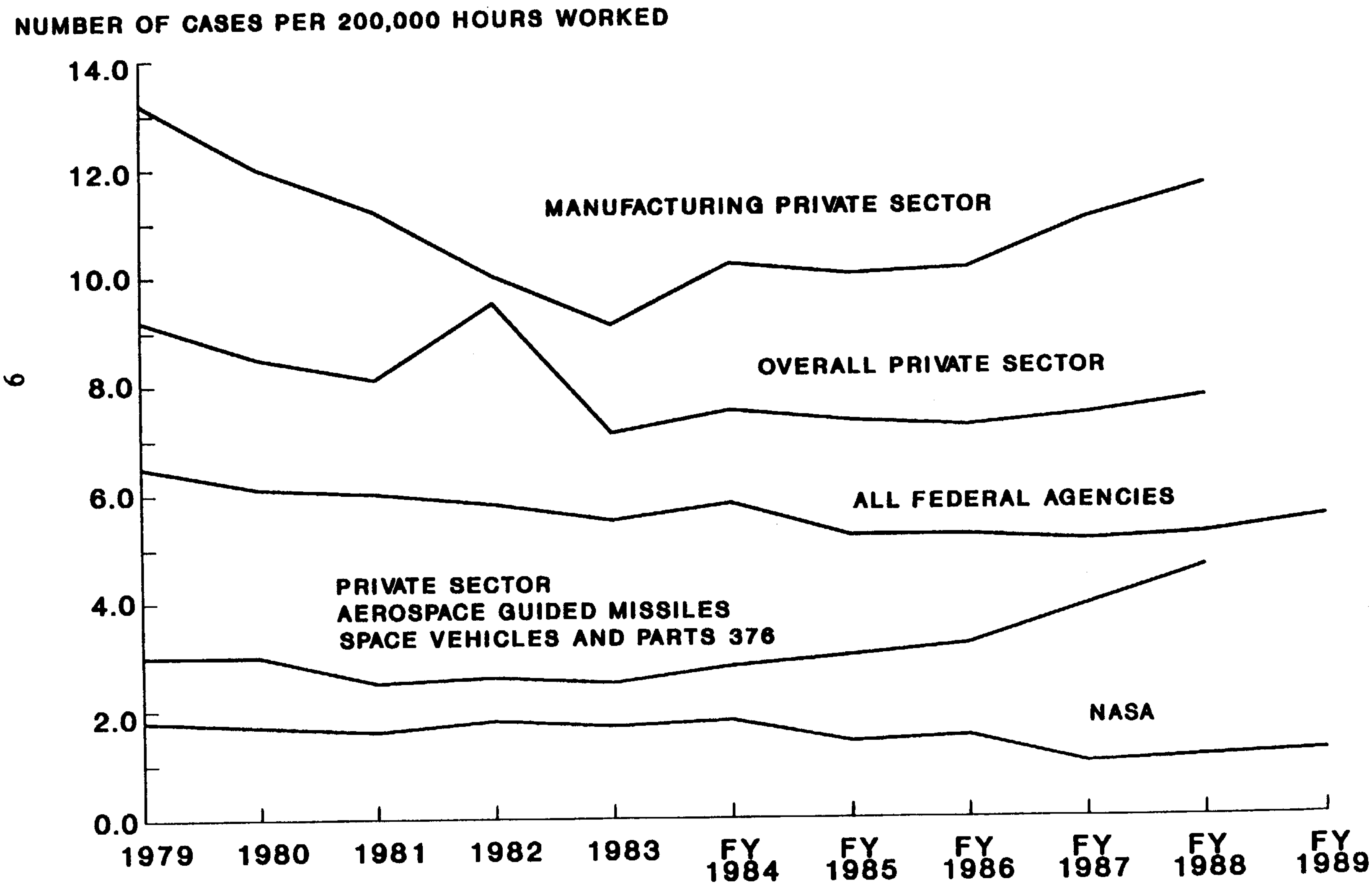


Figure 3

NASA LOST TIME RATES BY CENTER FY 1989

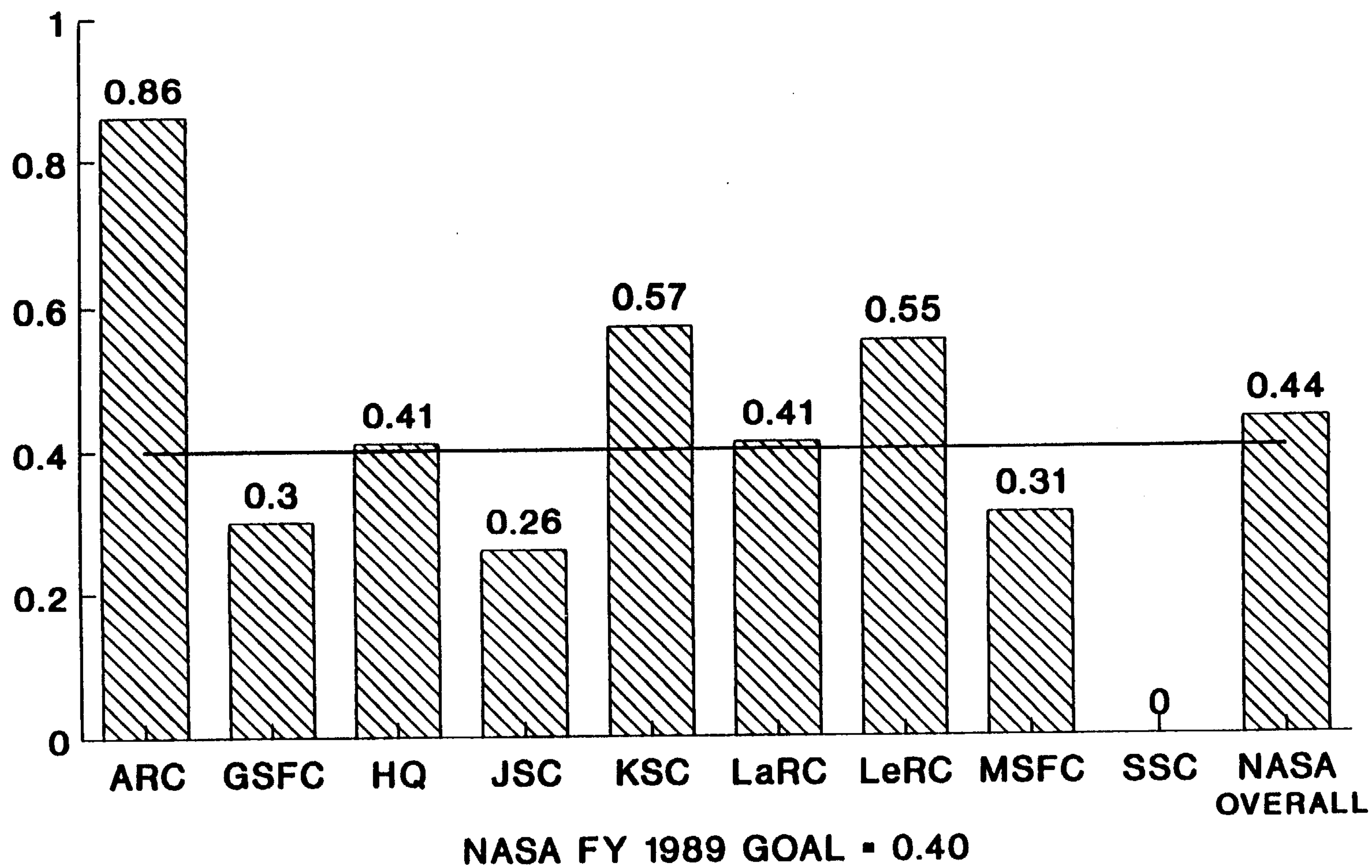


Figure 4

NASA INJURY/ILLNESS* RATES **
1979-1989

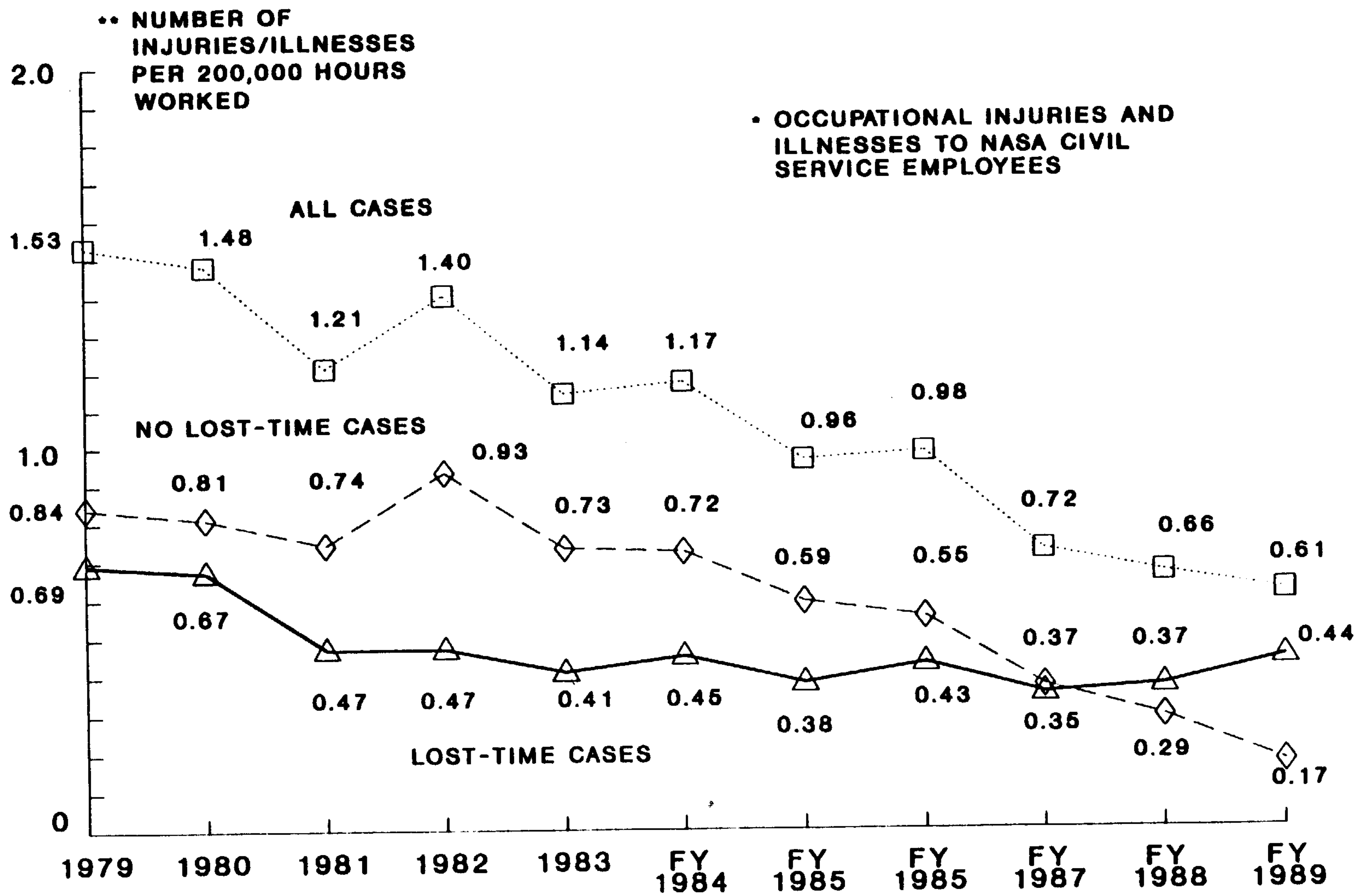


Figure 5

TABLE 2. CONTRACTOR INJURY/ILLNESS DATA BY INSTALLATION - ANNUAL REPORT FY 1989

		Lost Time Cases			Incidents w/ Injury Cases		Lost Time Rate vs. Goal '89	
	Hours Worked In K	No. Days	No. Cases	Freq. Rate	No. Cases	Freq. Rate	YTD Rate	Goal
ARC/DFRF	4,313	61	23	1.07	12	0.56	1.07	1.50
GSFC/WFF	17,278	171	47	0.54	18	0.21	0.54	0.45
HQDB	1,628	0	0	0.00	2	0.25	0.00	0.80
JPL	12,461	531	71	1.14	274	4.40	1.14	1.30
JSC/WSTF	9,871	1,959	86	1.74	147	2.98	1.74	0.90
KSC	27,716	2,351	205	1.48	180	1.30	1.48	0.70
LARC	3,900	99	21	1.08	35	1.80	1.08	1.50
LERC	2,324	224	30	2.58	42	3.62	2.58	1.50
MSFC	12,237	379	19	0.31	146	2.39	0.31	1.00
SSC	2,788	19	4	0.29	0	0.00	0.29	0.80
TOTAL	94,515	5,794	506	1.07	856	1.81	1.07	0.85
1988	79,912	5,202	412	1.03	*	*	1.03	0.85

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.

* No data available for this time period.

NASA FEDERAL EMPLOYEES LOST TIME INJURY/ILLNESS RATES

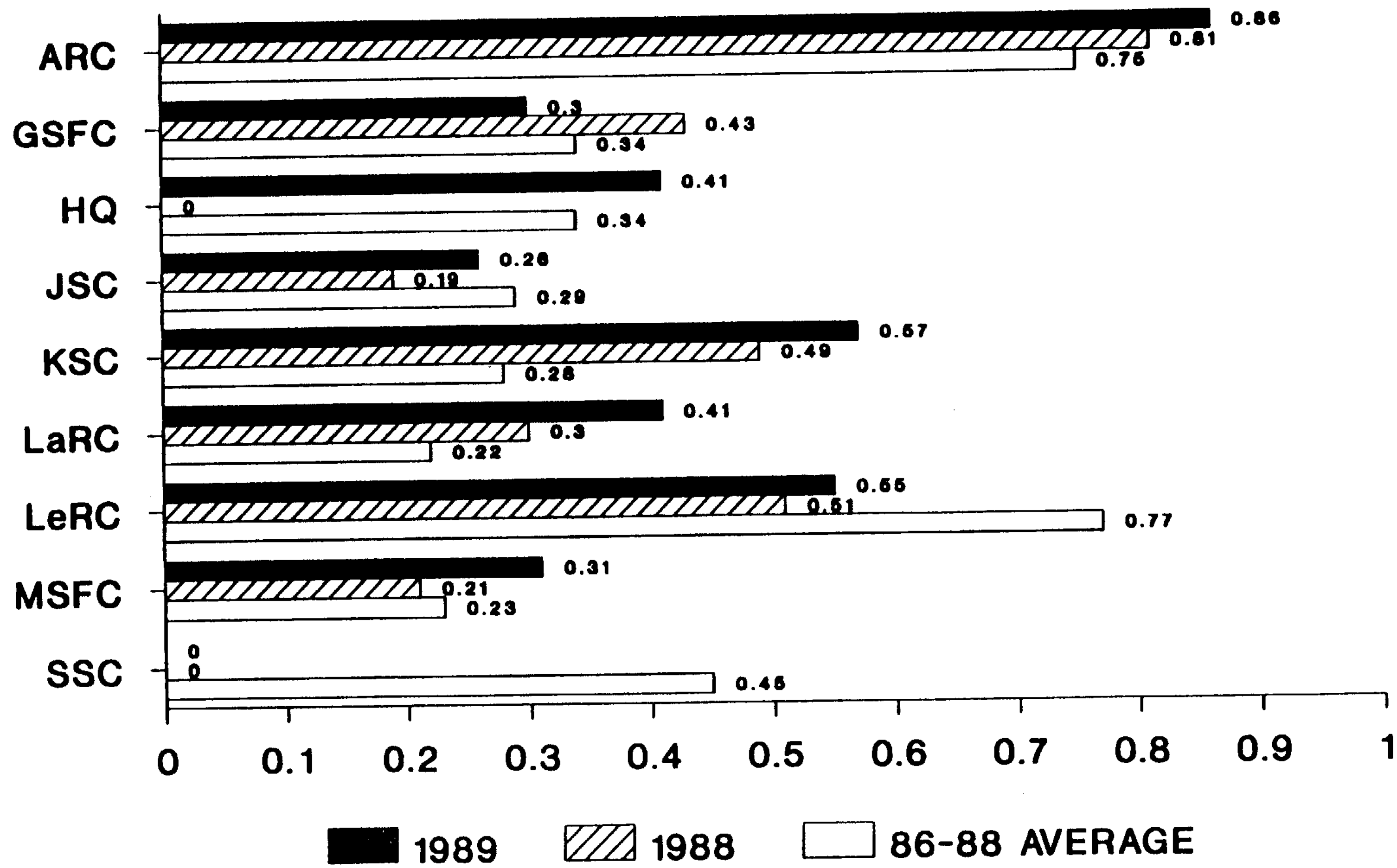


Figure 6

CONTRACTOR EMPLOYEES
LOST TIME INJURY/ILLNESS RATES

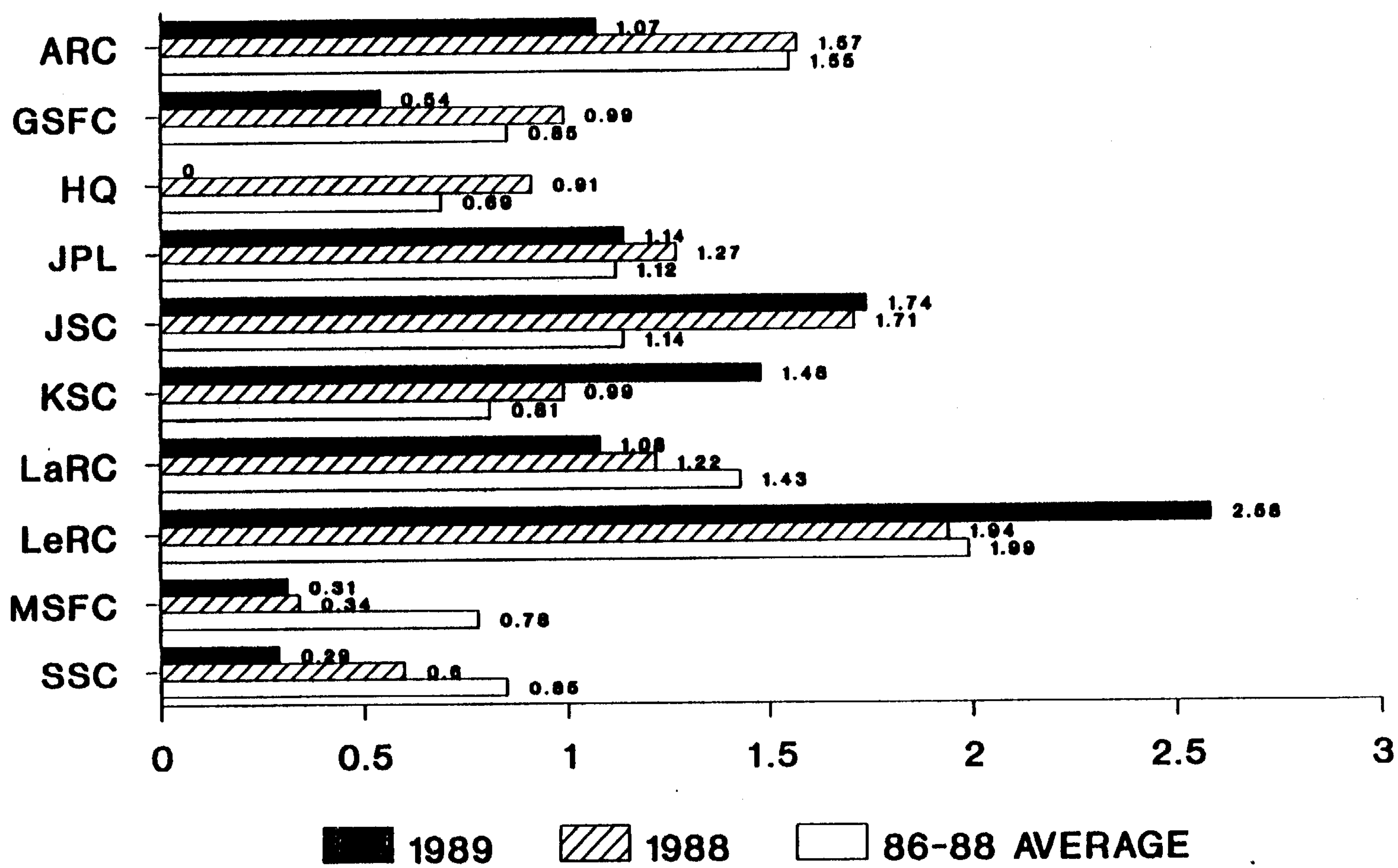


Figure 7

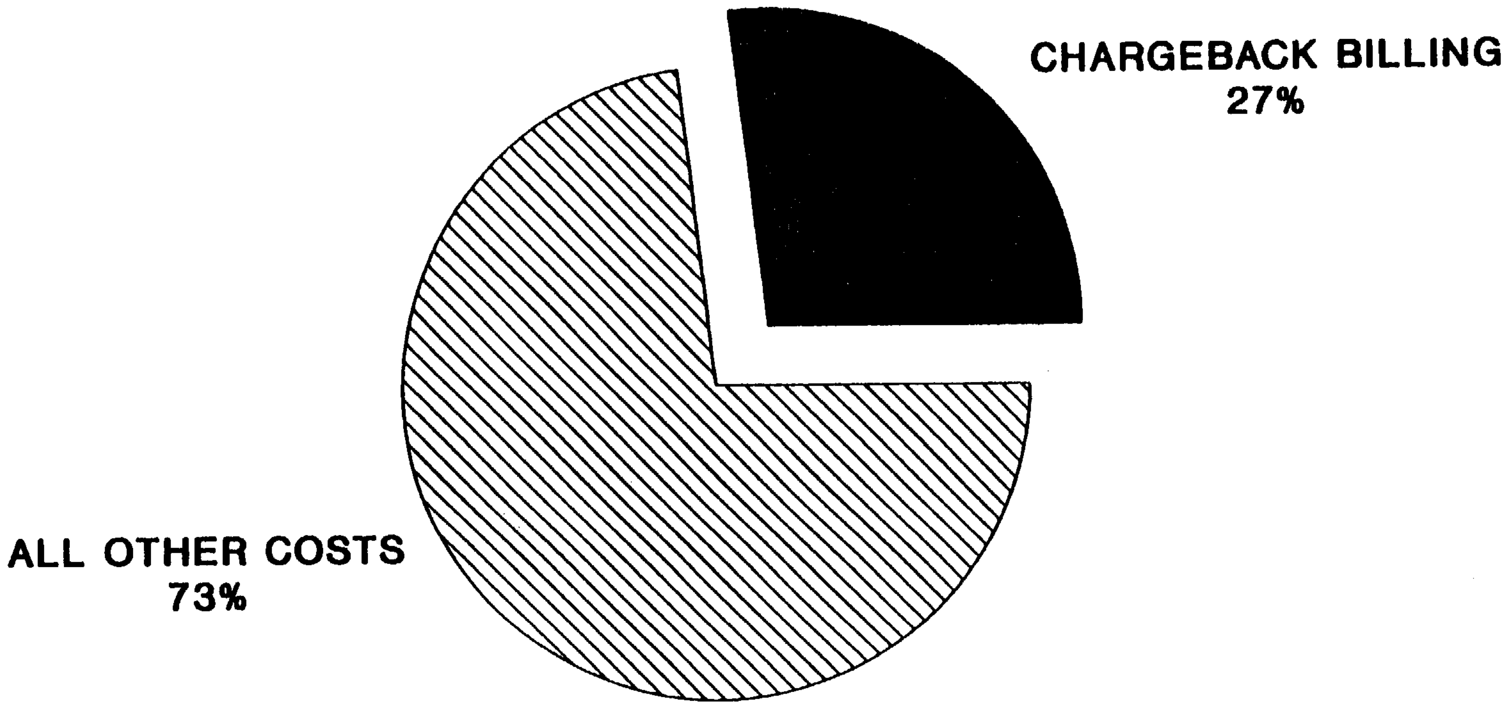
CHARGEBACK BILLING

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 3.2%, or $165,201, of the chargeback billing costs paid in FY 1989 was for injuries that actually occurred during that year.

Figure 8 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 $18.9 million total loss for FY 1989, $5.2 million, or 27%, was paid out in chargeback billing costs.

Figure 9 illustrates the trend of chargeback billing in the Federal Government and in NASA for the last 11 years. While the Federal Government's chargeback billing costs continue to increase, NASA's appear to have stabilized at around $5 million annually.

FY 1989 COST OF NASA MISHAPS/INJURIES
TOTAL LOSS = $18,890,279



DOES NOT INCLUDE
COST OF MISSION FAILURES
AND TEST OPERATIONS LOSSES

Figure 8

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

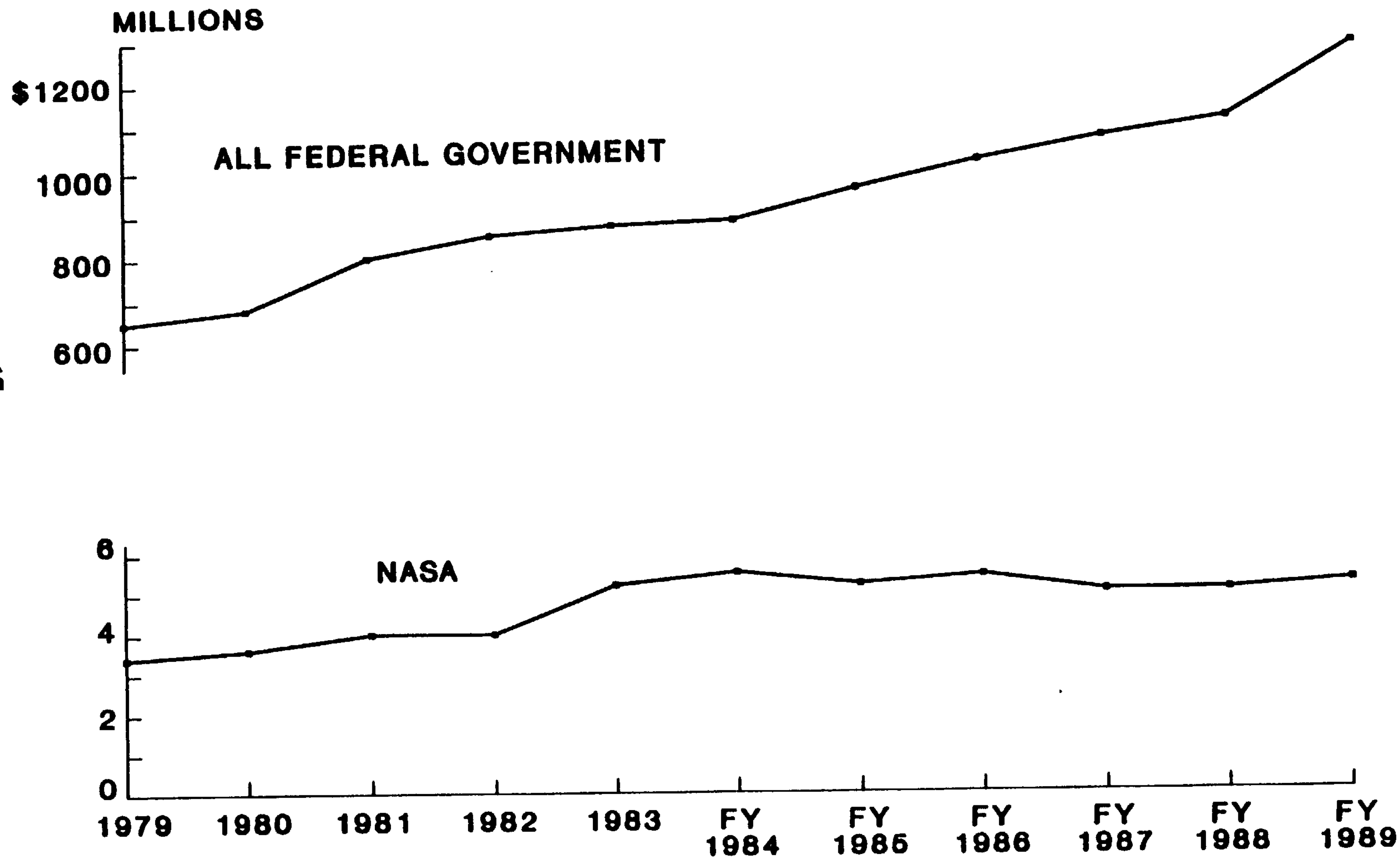


Figure 9

MATERIAL LOSSES

Tables 3A and 3B list the statistics for NASA material losses during FY 1989. Rescheduling and equipment replacement costs from major mission failures are not included in these statistics. Table 3A provides the number of equipment/property damage cases by equipment classification for each installation. Table 3B provides the cost of equipment/property damage cases by equipment classification for each installation.

Figure 10 illustrates the total costs of material losses over the last 11 years.

Figure 11 provides a percentage breakdown of equipment/property costs for FY 1989. Facility, flight hardware, and aircraft losses were the major contributors.

Figure 12 compares FY 1989 equipment/property cost with FY 1988 results. Significant increases in facility, flight hardware, and aircraft losses resulted in a 315% increase in the total cost of material losses between FY 1988 and FY 1989.

TABLE 3A. EQUIPMENT/PROPERTY DAMAGE BY INSTALLATION - ANNUAL REPORT FY 1989
NUMBER OF CASES BY EQUIPMENT CLASSIFICATION

	Flight Hardware	Ground Support Equip.	Facility	Pressure Vessel	Motor Vehicle	Aircraft	Other	Total Cases
ARC/DFRF	0	0	3	0	0	3	4	10
GSFC/WFF	2	0	0	0	3	0	4	9
HQDB	0	0	0	0	0	0	1	1
JPL	1	0	0	0	2	0	0	3
JSC/WSTF	1	3	5	0	9	1	2	21
KSC	17	11	9	0	36	0	6	79
LARC	0	0	3	1	0	1	5	10
LERC	1	0	2	0	1	0	13	17
MSFC	16	0	7	0	6	0	16	45
SSC	0	0	0	1	0	0	0	1
TOTAL	38	14	29	2	57	5	51	196
1988	14	11	10	3	42	1	77	158

1. The category Motor Vehicle includes GSA leased vehicles, POV rental cars, and Government owned vehicles.

TABLE 3B. EQUIPMENT/PROPERTY COSTS BY INSTALLATION - ANNUAL REPORT FY 1989
COST OF CASES ($K) BY EQUIPMENT CLASSIFICATION

	Flight Hardware	Ground Support Equip.	Facility	Pressure Vessel	Motor Vehicle	Aircraft	Other	Total Costs
ARC/DFRF	0	0	5	0	0	5,011	10	5,025
GSFC/WFF	1,008	0	0	0	3	0	7	1,017
HQDB	0	0	0	0	0	0	1	1
JPL	556	0	0	0	3	0	0	559
JSC/WSTF	700	66	441	0	7	138	1	1,353
KSC	305	156	14	0	38	0	39	553
LARC	0	0	3,258	3	0	38	78	3,377
LERC	100	0	275	0	0	0	70	445
MSFC	600	0	44	0	9	0	615	1,269
SSC	0	0	0	10	0	0	0	10
TOTAL	3,269	222	4,037	13	62	5,186	821	13,609
1988	844	171	91	1	55	9	2,110	3,281

1. Motor Vehicle cost includes GSA leased vehicles, POV rental cars, and Government owned vehicles.
2. Cost of Mission Failures is not included in mishap costs.

NASA MATERIAL LOSSES DUE TO MISHAPS (IN MILLIONS OF DOLLARS) 1979-1989

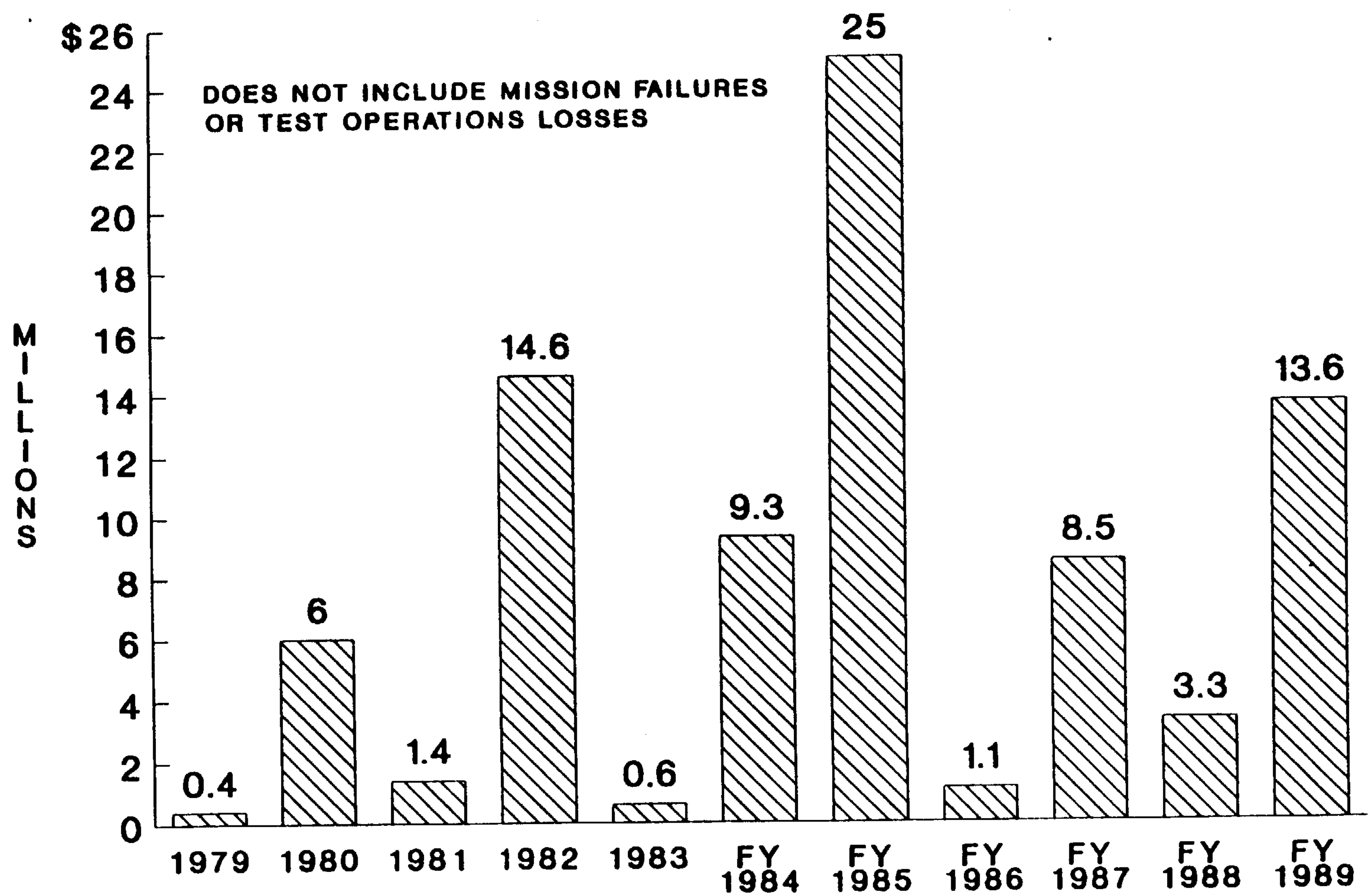


Figure 10

FY 1989 EQUIPMENT/PROPERTY COSTS
NASA TOTAL $13,609,000

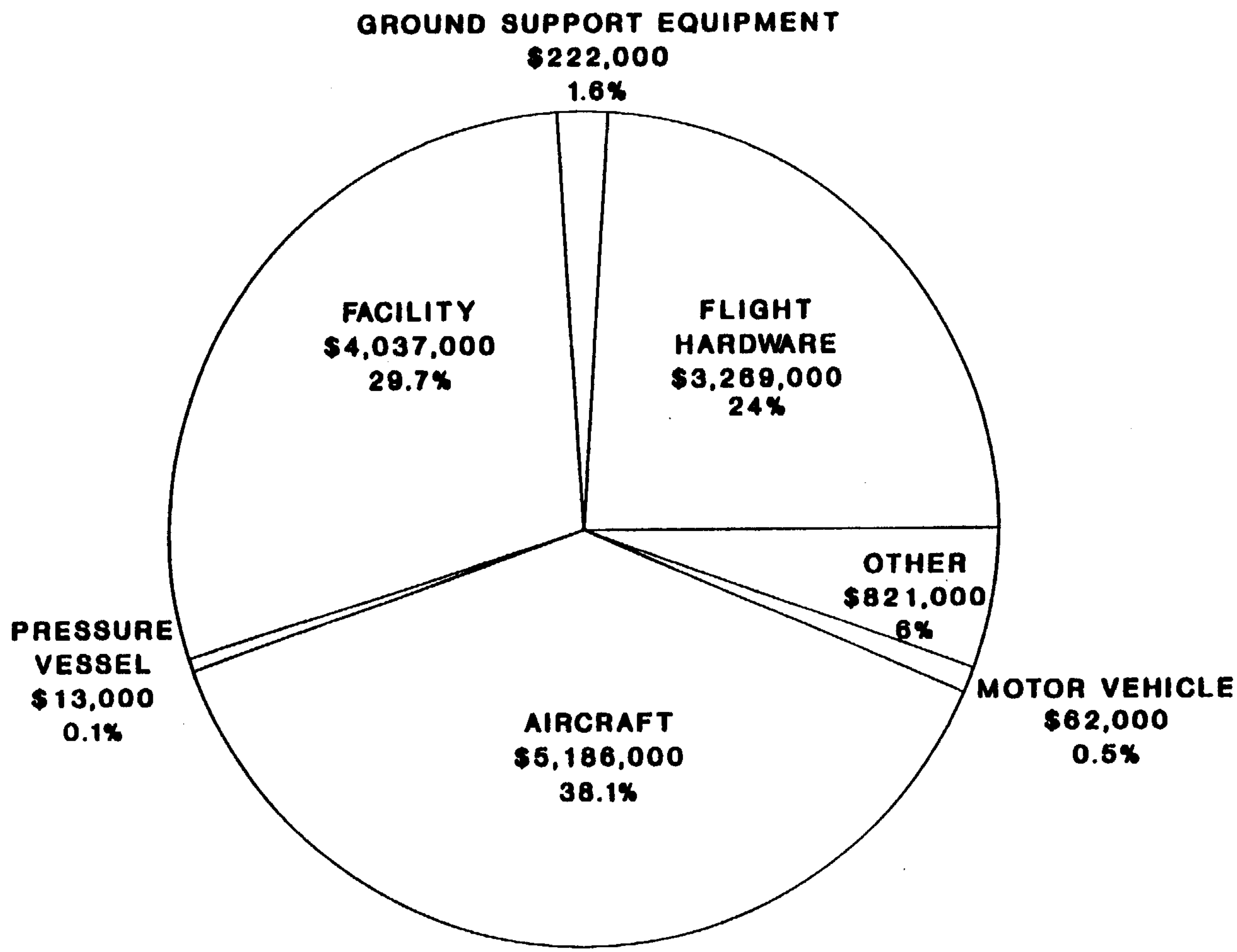


Figure 11

EQUIPMENT/PROPERTY COSTS (IN MILLIONS OF DOLLARS)

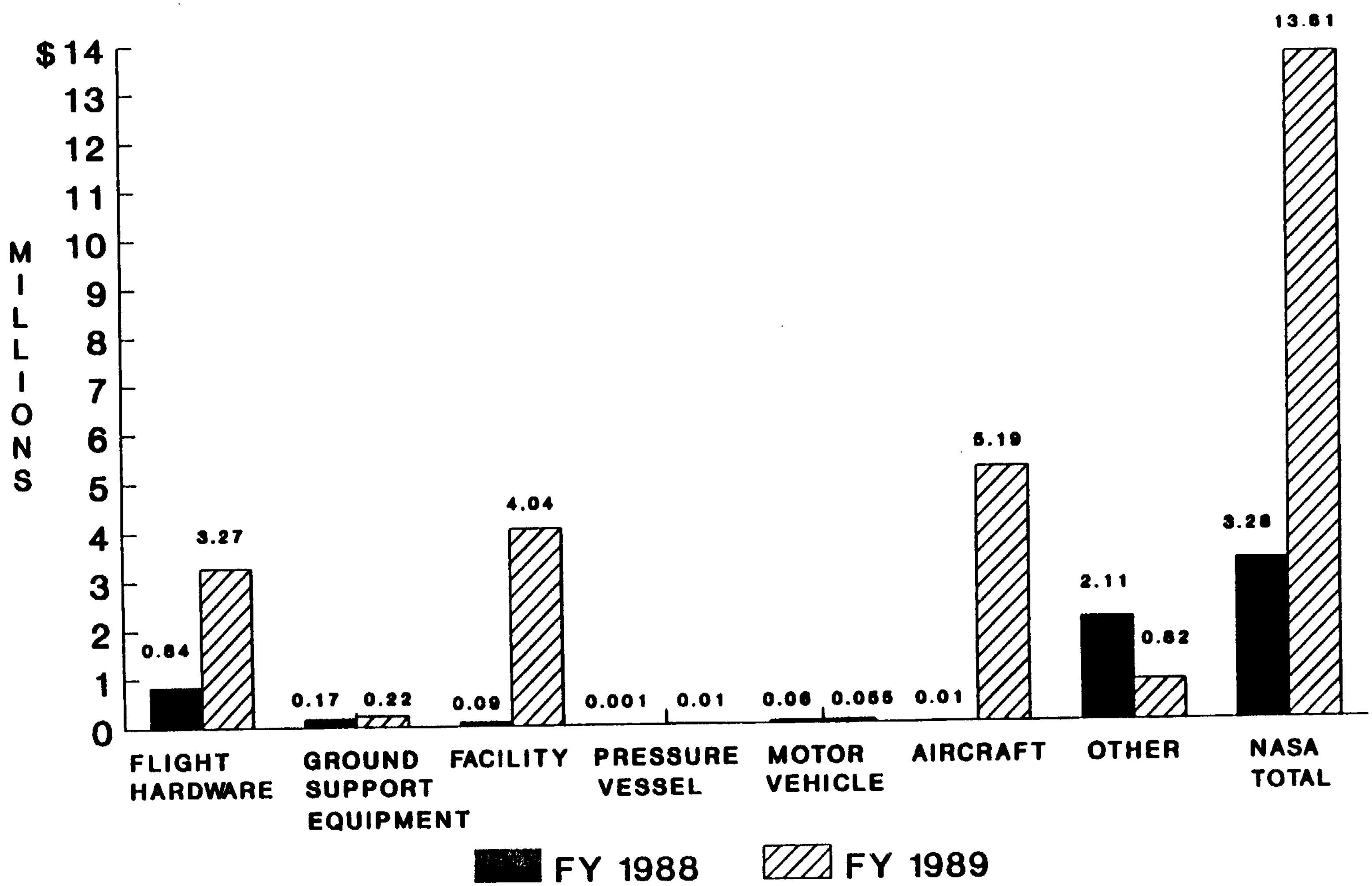


Figure 12

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 1989 were categorized according to the following updated definitions:

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 is also 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 mishaps and test failures that meet these criteria are also included.

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

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 $500 but less than $25,000. Events which have small property loss, less than $500, should be reported as incidents if they have significantly greater potential or high visibility.

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 property/equipment damage, 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 4 and 5 show the mishaps that were reported by the NASA field installations as having significance beyond the minor dollar losses or injury incident categories. These mishaps provide "lessons learned" for all NASA accident prevention programs.

Figure 13 presents an 11-year overview of NASA Type A, Type B, and Type C mishaps. Type B and C personal injuries are reflected in Tables 1 and 2. The dollar limits for each category have escalated over the years due to inflation and policy changes.

Figure 14 presents an 11-year history of NASA's total losses from chargeback billing costs, lost wages, and material losses due to mishaps.

Tables 6A and 6B provide a safety performance summary for FY 1989. Table 6A shows the incident with injury rates for NASA and contractor employees at each installation and compares FY 1989 lost time injury/illness rates with each installations goal and previous performance. Table 6B shows the number and type of mishaps and the cost of material losses for FY 1988 and FY 1989.

TABLE 4. FATALITIES - ANNUAL REPORT FY 1989

Category	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
NASA EMPLOYEES	1	0	4	1	0	0	0	3	0	0	0
CONTRACTOR EMPLOYEES	0	0	5	1	0	1	1	6	1	1	1
OTHER PERSONS	0	0	0	0	0	0	0	3	0	0	0
TOTAL	1	0	9	2	0	1	1	12	1	1	1

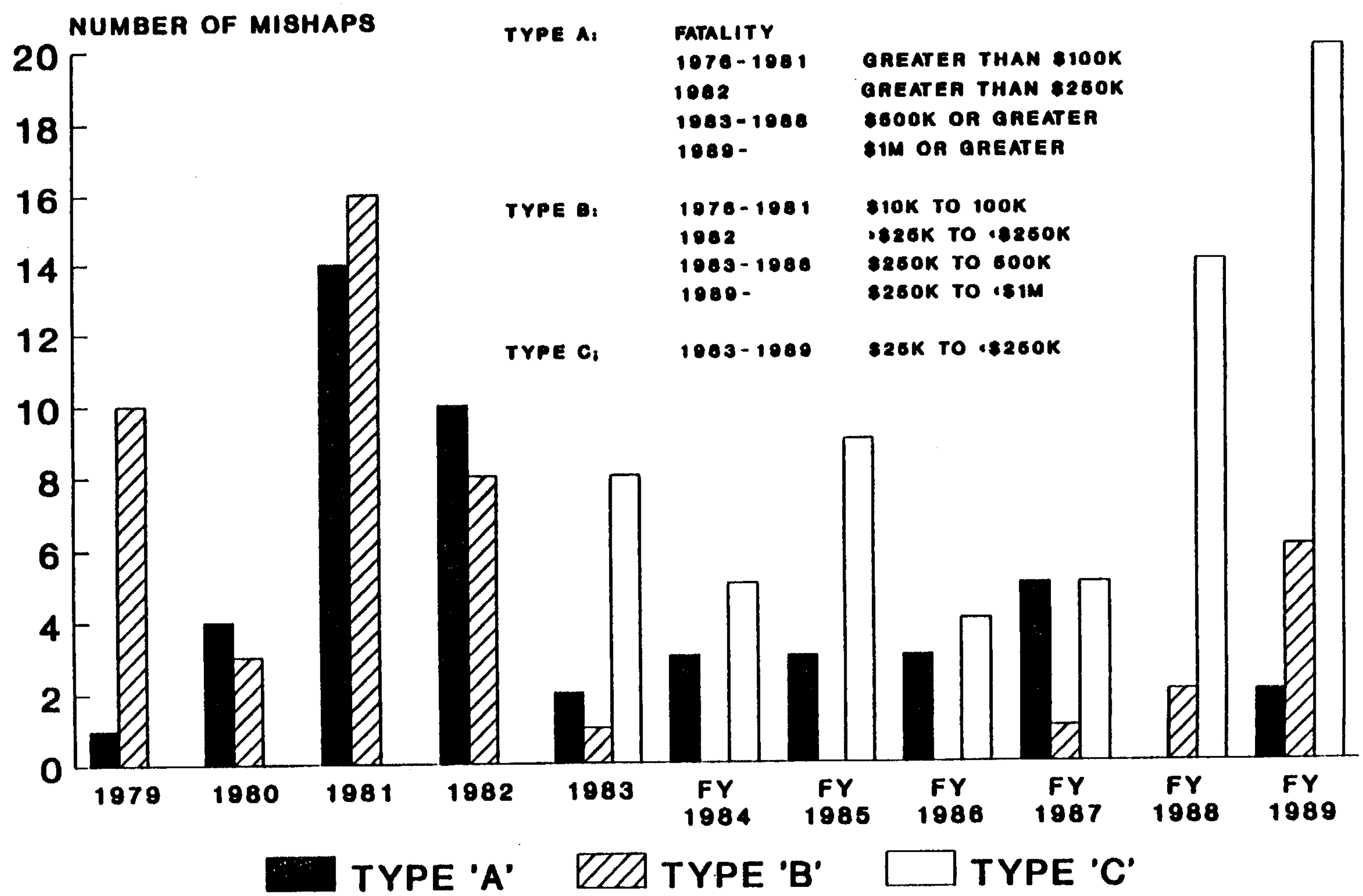
TABLE 5. NASA TYPE A/B/C MISHAPS BY FIELD INSTALLATION - ANNUAL REPORT FY 1989

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
ARC/D	0/ 6	0/ 0	2/ 3	2/ 3	1/ 0/ 2	1/ 0/ 5	1/ 0/ 1	0/ 0/ 0	0/ 0/ 1	0/ 0/ 1	1/ 0/ 0
GSFC/W	0/ 1	1/ 1	0/ 3	1/ 0	1/ 0/ 1	0/ 0/ 0	0/ 0/ 1	1/ 0/ 0	0/ 0/ 1	0/ 0/ 0	0/ 1/ 0
HQDB	0/ 0	0/ 0	0/ 0	0/ 0	0/ 0/ 0	0/ 0/ 0	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/ 1/ 0
JSC/WS	0/ 2	1/ 0	2/ 0	0/ 1	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	1/ 0/ 0	0/ 2/ 0	0/ 0/ 0	0/ 2/ 4
KSC	0/ 0	0/ 1	5/ 3	1/ 2	0/ 1/ 0	0/ 0/ 0	0/ 1/ 6	1/ 1/ 6	1/ 0/ 0	0/ 2/ 3	0/ 0/ 2
LARC	0/ 0	0/ 0	3/ 4	1/ 0	0/ 0/ 0	0/ 0/ 0	1/ 0/ 0	0/ 0/ 2	0/ 0/ 0	0/ 0/ 2	1/ 0/ 3
LERC	1/ 1	0/ 0	0/ 2	0/ 0	0/ 0/ 2	0/ 0/ 0	1/ 0/ 1	0/ 0/ 0	1/ 0/ 0	0/ 0/ 0	0/ 1/ 3
MSFC	0/ 0	2/ 1	1/ 0	4/ 2	0/ 1/ 2	2/ 0/ 0	0/ 0/ 0	0/ 0/ 0	2/ 0/ 7	0/ 1/ 7	0/ 1/ 8
SSC	0/ 0	0/ 0	1/ 1	1/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 0	0/ 0/ 1	0/ 0/ 0
TOTAL	1/10	4/ 3	14/16	10/ 8	2/ 2/ 7	3/ 0/ 5	3/ 1/ 9	3/ 1/ 8	4/ 2/ 9	0/ 3/14	2/ 6/20

1. Lost time mishaps are not shown on this table. See Table 1.
2. Type "C" was first defined in 1983 and partially replaced the previously defined Type "B" mishap.

* No data for installation and time period.

NASA TYPE 'A', 'B', AND 'C' MISHAPS
1979-1989



TEST FAILURES AND MISSION FAILURES ARE NOT INCLUDED

Figure 13

TOTAL COSTS TO NASA DUE TO MISHAPS (IN MILLIONS OF DOLLARS) 1979-1989

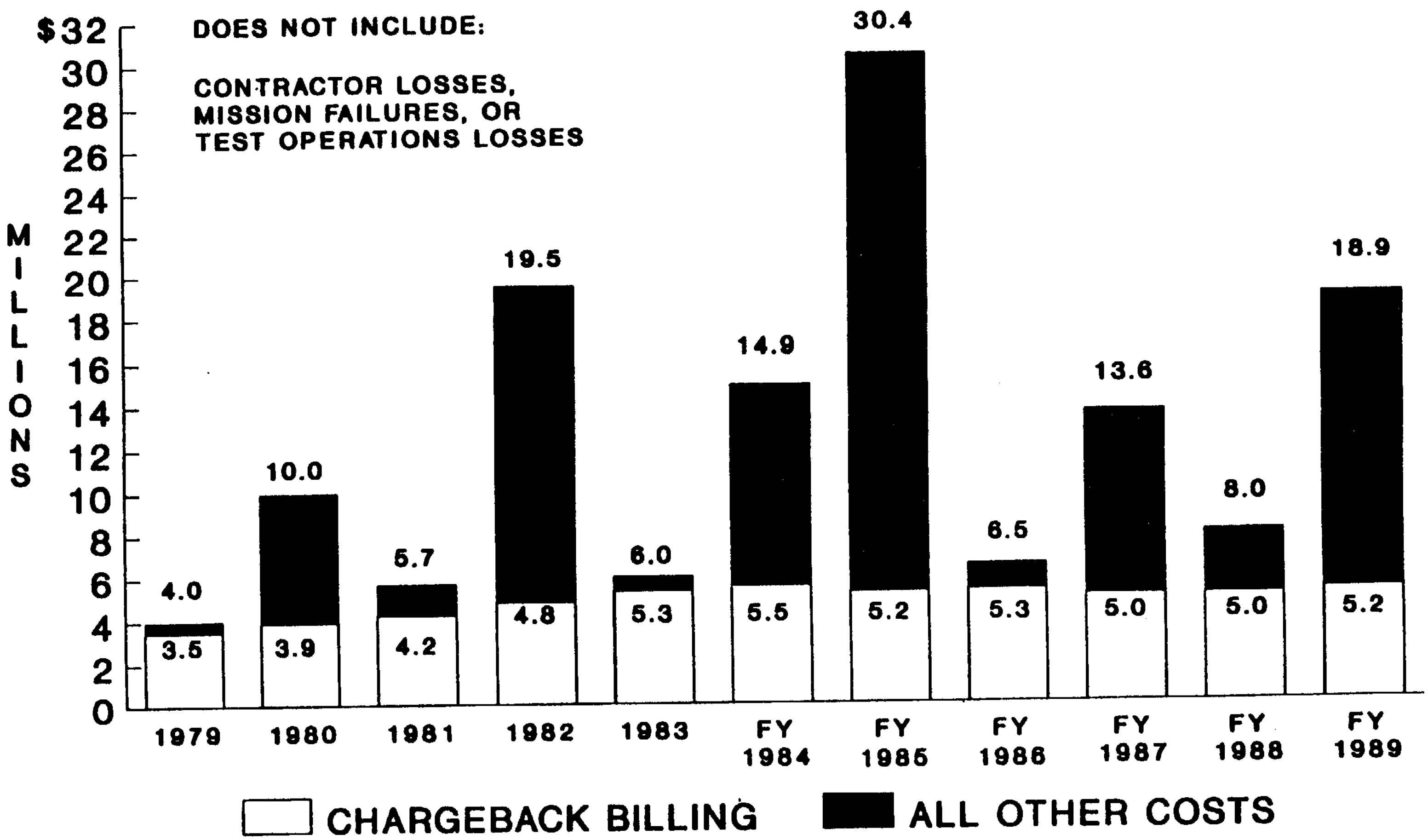


Figure 14

TABLE 6A. PERFORMANCE SUMMARY FOR FY 1989

	NASA INCIDENT W/INJURY RATES		NASA LOST TIME RATES			CONTRACTOR INCIDENT W/INJURY RATES		CONTRACTOR LOST TIME RATES		
	1988	1989	1988	GOAL 1989	1989	1988	1989	1988	GOAL 1989	1989
ARC/DFRF	0.13	0.17	0.77	0.40	0.86	*	0.56	1.15	1.50	1.07
GSFC/WFF	0.17	0.43	0.42	0.30	0.30	*	0.21	0.57	0.45	0.54
HQDB	0.00	0.13	0.00	0.40	0.41	*	0.25	1.32	0.40	0.00
JPL	--	--	--	--	--	*	4.40	1.29	1.30	1.14
JSC/WSTF	0.00	0.39	0.27	0.30	0.26	*	2.98	1.83	0.90	1.74
KSC	0.00	0.82	0.62	0.30	0.57	*	1.30	1.23	0.70	1.48
LARC	0.11	0.78	0.30	0.30	0.41	*	1.80	1.13	1.50	1.08
LERC	0.62	1.38	0.47	0.50	0.55	*	3.62	2.04	1.50	2.58
MSFC	0.14	0.31	0.14	0.30	0.31	*	2.39	0.29	1.00	0.31
SSC	0.00	0.00	0.00	0.00	0.00	*	0.00	0.47	0.80	0.29
NASA	0.16	0.53	0.37	0.40	0.44	*	1.81	1.03	0.85	1.07

* No data available for this time period.

TABLE 6B. PERFORMANCE SUMMARY FOR FY 1989

	TYPE A MISHAPS			TYPE B MISHAPS		TYPE C MISHAPS		MATERIAL LOSSES (K)	
	1988	1989	(FATALITIES) 1989	1988	1989	1988	1989	1988	1989
ARC/DFRF	0	1		0	0	1	0	219	5,025
GSFC/WFF	0	0		0	1	0	0	16	1,017
HQDB	0	0		0	0	0	0	0	1
JPL	0	0		0	1	0	0	0	559
JSC/WSTF	0	0		0	2	0	4	418	1,353
KSC	0	0		2	0	3	2	1,040	553
LARC	0	1		0	0	2	3	194	3,377
LERC	0	0		0	1	0	3	9	445
MSFC	0	0		1	1	7	8	1,288	1,269
SSC	0	0		0	0	1	0	96	10
TOTALS	0	2		3	6	14	20	3,281	13,609

1. Type C Mishaps do not include Lost Time cases. See Table 6A.
2. Costs of Mission Failures are not included in Material Losses.

MAJOR MISHAPS IN FY 1989

F-18 AIRCRAFT CRASH
AMES RESEARCH CENTER
TYPE A

On October 7, 1988, a pre-production U.S. Navy F/A-18A aircraft, on loan to the NASA Ames-Dryden Flight Research Facility, crashed on a routine safety chase mission in support of another NASA F/A-18A conducting high angle-of-attack research and a photo support TF/A-18 aircraft.

During a steep left bank repositioning turn at about 3.8G and 368 knots, the aircraft became unstable when the inboard leading-edge flap failed to an abnormal position of approximately 73 degrees upward deflection. Initially, the pilot was able to return the aircraft to straight and level flight. However, after a short time, the aircraft again became unstable with a large yaw and roll to the right along with a nose down pitch attitude of almost 70 degrees. With altitude decreasing rapidly, the pilot ejected as the aircraft descended through about 10,700 feet Mean Sea Level (8,400 feet above the ground). The unmanned aircraft continued to steepen its pitch and hit the ground in a near-vertical attitude at high speed in desert terrain, approximately 25 miles east of Edwards Air Force Base, near Boron, California. The aircraft was totally destroyed by the high-speed impact and the ensuing explosion and fire.

Evidence indicates that as the pilot achieved seat/man separation from the aircraft, a portion of the left parachute riser struck the left side of his helmet and oxygen mask, resulting in a broken jaw and significant sprain to the left side of his neck. He landed about ½ mile from the impact site and was administered first aid by an emergency unit from Boron, prior to being met by a U.S. Air Force rescue helicopter and transported to the Edwards Air Force Base Hospital.

The Mishap Investigation Board determined that the most probable cause of the leading-edge flap failure began with the stripping of the splines on the torque tube between the hydraulic drive unit and the left angle drive gearbox. This condition was probably preceded by excessive wear caused, in part, by lack of lubrication and poor durability of non-nitrided splines. The Board recommended that those F/A-18A aircraft with early production, standard leading-edge flap drive system components be updated to the current production configuration. Research of aircraft documentation revealed a surprising number of discrepancies between actual aircraft configuration and that which NASA personnel were led to believe existed according to U.S. Navy records supplied with the aircraft. The Board recommended that the U.S. Navy ensure that actual aircraft configuration conforms to that officially documented in the aircraft maintenance records and NASA review aircraft acceptance procedures to verify the configuration and airworthiness of newly acquired aircraft. Recommendations also were made for modifications to the F/A-18 parachutes and aircrew personal equipment to prevent the type of injury experienced by the pilot in this case when he ejected from the aircraft. Final cost of the mishap was $5,000,000.

FATALITY
KENNEDY SPACE CENTER
TYPE A/CONTRACTOR

On July 27, 1989, at approximately 1332 EDT, an electrical technician sustained fatal head injuries when he fell 16.5 feet from a chilled water line in the Utility Annex, Building K6-947. The technician was positioning himself to feed six electrical cables into a conduit leading toward the Motor Control Center. He had accessed the position from which he fell by using an electrically operated manlift and then walking approximately 44 feet along the top of a 16-inch diameter chilled water pipe. As he lowered himself to another 16-inch pipe five feet below, he lost his footing and fell. This fatal mishap was the result of the technician's failure to use appropriate equipment to safely access the proper location to feed the cable into the conduit. This equipment (manlift) was available; however, it needed to be repositioned which the technician elected not to do.

WIND TUNNEL FAN BLADES DAMAGED
LANGLEY RESEARCH CENTER
TYPE A

On January 18, 1989, the National Transonic Facility (NTF) at the Langley Research Center was operating within the established operating envelope when an automatic shutdown of the tunnel drive system occurred due to high vibration levels. Investigation revealed major damage to all 25 fan blades and minor damage to other tunnel internals. The mishap was initiated by fatigue and fracture failure in the stainless steel sheet metal band of the External Thermal Barrier (ETB) retainer on the fan drive shaft. This resulted in a high-energy release of metallic parts from the ETB that impacted and dislodged five upstream nacelle bulkhead fairing plates into the flowstream. The fairing plates and the ETB parts were swept into the fan blades. The Investigation Board found the design of the drive shaft thermal protection system in the area of the fan cavity to be less than adequate. The Board noted deficiencies in equipment design, system engineering, and system integration. The ETB was not treated as a critical assembly or as a critical item of the NTF drive system (i.e., it was not recognized as a potential single point failure which could cause a Type A Mishap). The Board developed a set of recommendations to prevent recurrence of failure mechanisms which caused the NTF mishap. These recommendations address the potential problems associated with the design and management of high technology facilities, specifically the design of rotating machinery components of these facilities, and the need for independent assessment of single point failures and of failure modes and effects analyses. Final cost of the mishap was $3,200,000.

PAYLOAD FREE FALL FROM BALLOON
GODDARD SPACE FLIGHT CENTER
TYPE B

Balloon Flight 1482P, conducted by the National Scientific Balloon Facility (NSFB) for the Goddard Space Flight Center, experienced a premature flight termination and unplanned impact in an area west of Fort Worth, Texas, on June 7, 1989. Evidence indicates that while the balloon was floating over a large band of thunderstorms near Graham, Texas, the entire parachute/flight train/payload system went into a free fall. When the parachute inflated to a point where it could offer some significant drag, the payload separated from the rest of the flight train and free fell. The investigation committee determined that the most probable cause of the mishap was a low-level high-voltage current induced into the termination electronics package by lightning activity present in the area. The experiment did not achieve the minimum success criteria and the mission was declared a failure. There were no personal injuries or significant property damage. Final cost of the destroyed hardware and instrumentation was $900,000.

MAGELLAN ELECTRICAL MISHAP
JET PROPULSION LABORATORY
TYPE B

The Magellan spacecraft experienced an electrical fire during an electrical power system checkout in the Spacecraft Assembly and Encapsulation Facility-2 at the Kennedy Space Center on October 17, 1988. The primary cause of the mishap was the inadvertent mismating of at least two pins of a spacecraft harness connector to a battery connector. The mismate created an electrical short circuit within the battery connector resulting in electrical arcs and additional short circuits that, using stored battery energy, damaged the battery, the spacecraft harness connector, and the battery thermal blanket. The Mishap Investigation Board found the use of different connector keying did not prevent mating of differently keyed connector halves. Post-mishap testing confirmed the ability to get electrical contact on up to 10 of 37 pins. It was recommended that an Alert be issued indicating the possibility of inadvertent electrical mating of differently keyed connector halves. Future connector applications should consider the use of "scoop-proof" connectors. Final cost of the mishap was $556,000.

ORBITER FLIGHT COMPUTER MISHAP
JOHNSON SPACE FLIGHT CENTER
TYPE B

On June 23, 1989, during redundant set testing of several orbiter General Purpose Computers, GPC S/N 00513 experienced a "fail to synchronize" with the other computers. Immediate investigation of the computer indicated the unit was very hot and had operated without proper cooling for 11.5 hours. Further investigation found the GPC was improperly installed. An air duct cover (that should have been removed at the time of installation) was still in place over the facility cooling system air duct at the rear of the GPC. The primary cause of the mishap was failure to follow proper installation procedures. The GPC was returned to the manufacturer for analysis. Several thermal sensors inside the unit indicated that the GPC had been overheated beyond design limits. Subsequent analysis and checkout indicated that the GPC is fit to perform as a test, or prototype unit. Final cost of the mishap was $700,000 (the difference in cost between a flight GPC and a test GPC).

HURRICANE CHANTAL
JOHNSON SPACE FLIGHT CENTER
TYPE B

On August 1, 1989, several buildings at the Johnson Space Flight Center suffered wind and water damage as a result of Hurricane Chantal. Cost of the widespread damage to the installation totaled $350,000.

PERMANENT DISABILITY
KENNEDY SPACE CENTER
TYPE B/CONTRACTOR

On March 3, 1989, a contractor employee fell 60 feet from the airlock roof of the Spacecraft Assembly and Encapsulation Facility Number 2 (SAEF-2) at the Kennedy Space Center. The employee and his supervisor were working on an air handler unit on the roof. As they were completing the day's planned task, the employee was instructed by his supervisor to gather up tools and materials. While attempting to throw an extension cord off the roof, the employee slipped and fell. He was found conscious on the pavement inside the Solid Rocket Motor Ring. Subsequently, he was transported by emergency personnel to Jess Parrish Hospital, and later transferred to the Gainesville North Florida Regional Medical Center. The investigation team determined that the sole cause of this mishap was failure of the employee and/or his supervisor to follow the company and OSHA safety standards for working at height.

STEAM VALVE RUPTURE
LEWIS RESEARCH CENTER
TYPE B

On May 26, 1989, at approximately 3:45 a.m., a high pressure steam valve ruptured in the basement of the Library Services Building at Lewis Research Center. The accident resulted from dynamic loading caused by severe "water hammer." Heavy rainfall caused flooding of a steam trench. The steam line, enclosed in cool water, set up a heat exchange process, thus forming excessive condensation. These water slugs generated dynamic loads in the piping system. The cast gray iron steam valve, which was brittle and had very low ductility or impact strength, subsequently fractured. Hot, high pressure steam was released throughout the building causing damage to two interior non-bearing walls, ceilings tiles, and painted and paneled walls. In addition to damage to the valve, an expansion joint, and piping, some asbestos insulation on the steam pipes was damaged; asbestos fibers were dispersed throughout portions of the building by the escaping steam. No employees were in the building at the time and no injuries were sustained. Repair and cleanup costs were estimated at $250,000.

FIRE
HIGH ENERGY PHYSICS LABORATORY, STANFORD UNIVERSITY
MARSHALL SPACE FLIGHT CENTER
TYPE B

A fire occurred on April 29, 1989, in Room 132 of the Hansen High Energy Physics Laboratory located on Via Palou, Stanford University, Stanford, California. This room was being used to fabricate and assemble the gyroscopes for the NASA Gravity Probe-B Project and therefore contained a large quantity of specialty and high precision equipment. The fire apparently started in or near a plastic clean/wet bench that was completely consumed. Sufficient heat was released to damage other nearby equipment and melt plastic components at the upper levels of the room. Smoke damage was extensive in the room and an adjacent room. The probable cause of the fire was a failure in the electrical circuit of a deionized water heater mounted near the right rear corner of the clean/wet bench. The heater's safety cutoff system design was found to be deficient. Indications of a heater control circuitry problem had been noted previously, prompting Stanford to initiate a procedural safeguard requiring users to shut off the water heater each night. This procedure was not followed the evening prior to the fire. Final cost of the mishap was $400,000.

TYPE C MISHAPS
EQUIPMENT/PROPERTY DAMAGE

Johnson Space Flight Center

The pilot of NASA 904 (T-38) performed an unintentional gear-up landing following a functional check flight after minor maintenance. The primary cause of the mishap was pilot error. Final cost of the mishap was $137,000.

The high bay roll-up door in Building B-32 fell while a technician was in the process of closing it. Attempts to stop the door with the stop switch were not successful. As the technician, realizing something was wrong, turned away from the area, he was struck on the right arm by a falling sprocket. The mishap was attributed to equipment failure due to a design deficiency. Final cost of the mishap was $44,015.

The high bay roll-up door in Building B-7 dropped about 6 feet when the door operator shaft broke. The primary cause of the mishap was equipment failure due to a design deficiency. Improper maintenance was a contributing factor. Cost of the mishap was estimated at $44,000.

A break in a chilled water line resulted in water leaking through the ceiling of Room 1069A of Building B-30 causing damage to some communication equipment. The primary cause of the mishap was equipment failure due to material failure. Final cost of the mishap was $51,561.

Kennedy Space Center

High winds buffeted the A77-8425 SRM access platform (scissor lift) stored on the south west corner of the Vehicle Assembly Building parking lot. The sideways movement of the access platform caused welds on the support legs to fracture. The platform fell coming to rest on its underside. There was extensive structural damage to the platform, support structure, scissor arms, and support legs. The primary cause of the mishap was the high winds. Equipment failure due to a design deficiency was a contributing factor. Final cost of the mishap was $129,000.

On September 24, 1989, the Orbiter Processing Facility High Bay No. 2 water deluge system was inadvertently activated during Firex Viking Valve removal and replacement. The orbiter Columbia was in the facility at the time and was sprayed with an extensive amount of water over a period of approximately 10 minutes. Cost of the mishap was estimated at $249,999.

Langley Research Center

A helicopter drive mechanism and blade failed during a test in the 14 x 22-foot wind tunnel. Final cost of the mishap was $56,700.

NASA 515 (Boeing 737) contacted a sea gull on approach to Wallops Flight Center. Damage was sustained to the fan blades of Engine No. 1. Final cost of the mishap was $38,316.

During testing of a 48-inch semi-span advanced turboprop model in the 14 x 22-foot wind tunnel, the model balance bearing failed. The failure resulted in the separation of the hub from the model. Two of the eight blades on the hub broke off and traveled down the tunnel circuit to the first set of turning vanes. The primary cause of the mishap was equipment failure due to material failure. Final cost of the mishap was $33,000.

Lewis Research Center

A flash explosion and fire were experienced during the pressurization of an O_2 trailer from 1600 psi to 2500 psi. The tube trailer was vented, transfer line attached, main transfer valve opened, and flow initiated when the incident occurred. Cost of the mishap was estimated at $40,000.

While employees were disassembling the SCAD solar concentrator module, the module counterweight become dislodged and fell causing damage to an adjacent module. The primary cause of the mishap was equipment failure due to a design deficiency. Cost of the mishap was estimated at $100,000.

A pump failed in Building 301 during the pump down of Vacuum Tank No. 6, spilling mercury-contaminated oil in various areas of the building. Cost of the mishap was estimated at $25,000.

Marshall Space Flight Center

A loose bolt caused the External Tank-60 Barrel Panel No. 3 to "mismatch" when it was loaded into the LH_2 forward barrel assembly trim and weld fixture. A gouge in the panel resulted. The primary cause of the mishap was personnel inexperience. Final cost of the mishap was $30,535.

A trunnion weld separated from the T1650128 slosh baffle assembly internal adapter during proofload testing causing the south side of the adapter to fall approximately 20 feet to the floor. The mishap was attributed to equipment failure due to a design deficiency. Final cost of the mishap was $71,335.

Three Solid Rocket Motor (SRM) railcars loaded with fired segments were being switched in the Union Pacific rail yard at Clearfield, Utah. During the switching operation, the three railcars "sideswiped" two stationary SRM rail cars causing extensive damage to three segment covers. The primary cause of the mishap was a deviation from proper handling procedures due to a lack of attention by personnel. Cost of the mishap was estimated at $83,000.

During the vertical bore mill machining operation on a forward nose ring, a brief power outage occurred during a lightning storm. The vertical bore mill table coasted to a stop after loss of power, but the tool ram dropped several thousandths of an inch before the brake engaged gouging the node ring. The magnetic brake was incorrectly adjusted. The primary cause of the mishap was a deficiency in the milling procedure. Lightning was a contributing factor. Final cost of the mishap was $60,849.

During completion of the wide field planetary camera transportation purge manifold of the Hubble Space Telescope, an engineer bumped into the side of the aft Low Gain Antenna (LGA) tearing the end section of the LGA from the main body of the antenna. The primary cause of the mishap was inadequate procedural requirements. Inadequate task coordination/planning and personnel fatigue were contributing factors. Final cost of the mishap was $100,000.

During microshaft travel tests on the Space Shuttle Main Engine High Pressure Oxidizer Turbopump 4007 conducted at the Stennis Space Center, an excessive load of approximately 20,000 pounds was applied to the rotating assembly shaft in the pump end direction using a hydraulic hand pump. The assembly was designed for a normal load of 2,500 pounds. The primary cause of the mishap was inadequate coordination and planning. Personnel misjudgment of conditions and equipment failure due to design deficiency were contributing factors. Final cost of the mishap was $211,550.

A refurbished Integrated Electronics Assembly (IEA) was damaged during shipping from Allied Bendix to KSC. The IEA, packed in a shipping container, was delivered to the Continental Airlines freight terminal, Newark, New Jersey, and loaded aboard a baggage transporter. The airline employee operating the tow motor for the baggage transporter accelerated and executed a hard turn, causing the IEA to fall from the transporter. The IEA had to be disassembled and recertified. The primary cause of the mishap was a deviation from proper handling procedures. Personnel lack of attention was a contributing factor. Final cost of the mishap was $125,000.

During disassembly of the Space Shuttle Main Engine High Pressure Fuel Turbopump balance assembly, the first stage impeller bearing journal threads were stripped. Pressure exceeding the maximum allowable was applied in the wrong direction. The primary cause of the mishap was a lack of personnel training. Cost of the mishap was estimated at $25,000.