NSSDC/WDC-A-R&S 94-06

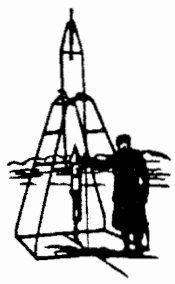
National Space Science Data Center

NSSDC

National Space Science Data Center

1993 ANNUAL REPORT

Goddard Space Flight Center
Greenbelt, Maryland 20771



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ANNUAL STATISTICS AND HIGHLIGHTS REPORT

Joseph H. King
National Space Science Data Center
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PREFACE

This document reports the principal activities and achievements of the National Space Science Data Center (NSSDC) during 1993. Highlighted are the data brought into NSSDC, the data brought online/nearline for user electronic access, the electronic and off-line dissemination of data, the information systems activities (NASA Master Directory, etc.), and the standards and technologies activities.

Especially noteworthy 1993 NSSDC achievements over and above the data and information inflow and outflow rates included initial exploitation of World Wide Web and Mosaic technologies to allow information finding, revamping of NODIS to support a more comprehensible interface to a wider range of NSSDC services, exploitation of 4-mm and 8-mm tapes for receiving and disseminating data in an operational way, providing ANON/FTP access to the first public COBE data, development of a heliospheric CD-ROM with virtually all available near-Earth and deep-space solar wind magnetic field and plasma data, shepherding the new FITS specification through the NOST standards process, support for enthusiastic adoption of SFDU and CDF standards by the ISTP community, and approval of an updated MOU between NSSDC and the Planetary Data System.

NSSDC aspires to archive and disseminate data and information relevant to NASA missions and to the NASA research endeavor in ways most cost beneficial for its user communities. NSSDC welcomes its role as a partner with NASA projects and discipline data systems in the management of the national assets that space data represents. NSSDC solicits comments on and critiques of its services and of this annual report. Please direct such comments and critiques to the NSSDC director.

Joseph H. King
Director, National Space Science Data Center

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1

DATA MANAGEMENT AND DISSEMINATION AT NSSDC

1.0 Data Management and Dissemination at NSSDC

This section is separated into parts addressing the building and management of the archive and the dissemination of data from the archive.

1.1 Building and Managing the Data Archive at NSSDC

During 1993 NSSDC brought many data into its archive, made many newly arriving data and some previously archived data electronically accessible, and migrated some archived data from old to new media. These three activities are separately addressed in the following subsections.

1.1.1 The Data Archive at NSSDC

During 1993 NSSDC added data from 38 distinct NASA missions in the fields of astrophysics, space plasma and solar physics, planetary science, and Earth science. Highlights include the first publicly available COBE radio microwave data, YOHKOH solar X-ray data, Atmospheric Explorer Telemetry data newly organized at the University of Texas/ Dallas, a very large volume of low level Magellan data tapes, and still-proprietary GEOTAIL data. Tables 1-4 show the digital archive at NSSDC grouped by major discipline as of the end of 1993 as well as the data influx during 1993. (See pages 5, 6, 7 and 8.)

Table 5 shows the data received at NSSDC in 1993 in another representation relative to Tables 1-4. (See page 9.) The "Other" column adds information about analog data ingest to NSSDC. These analog data range from Galileo and Magellan images to ISEE 1 plasma spectrograms on 35-mm slides. The overall analog data holdings at NSSDC at the end of 1993 are characterized by discipline in Table 6. (See page 10.)

Total counts of data volumes at NSSDC at the end of 1993 are given in Table 7. (See page 11.) Note that these total counts include both primary and backup copies of data whereas the counts of the previous tables relate to primary copies only.

Yet another discipline-oriented characterization of the NSSDC data archive is Table 8, which shows the total numbers of spaceflight experiments with data at NSSDC. (See page 12.) It is noteworthy that NSSDC held data from 1,135 such experiments, mostly but not totally from NASA missions. More than half of these are space/solar physics, a discipline area in which NASA flew many multi-instrumented spacecraft in its early years.

1.1.2 Bringing Data to Electronic Accessibility

To facilitate data availability to an increasingly networked customer community, NSSDC continued its migration of data to electronic accessibility. NSSDC presently holds a modest amount of data on magnetic disk (on line) and a large and growing amount on its optical disk jukeboxes (near line). NSSDC presently offers three electronic interfaces to various subsets of its archive.

The NSSDC On-Line Data and Information System (NODIS) account offers data set specific interfaces to one very high-interest, modest volume data set, namely, the 1963-1991 hourly solar wind data of OMNI, and to various other information options further discussed in Appendix 4.1. (See page 31.)

Selected additional data sets are held permanently on line for File Transfer Protocol (FTP) access via an ANONYMOUS account. These include COBE data and hourly solar wind data from several heliospheric missions constituting the "COHO" data base.

Finally, the NSSDC Data Archive and Distribution Service (NDADS), makes many more data available than NODIS or FTP-access to the permanently on-line data. NDADS is a pair of jukeboxes holding 12" Write-Once, Read-Many (WORM) optical disks. NDADS has a total capacity of 1.2 TB; actualholdings grew from 270 GB to 395 GB in 1993. Table 9 shows annual amounts of data ingested to NDADS during 1989-1993, separated for astrophysics and space physics missions. (See page 12.)

Table 10 characterizes NSSDC's primary electronically accessible data holdings at the end of 1993 and also shows the amounts of data ingested to NDADS during 1993, by mission. (See page 13.)

1.1.3 Data Restoration at NSSDC

As a key element in its assurance of future accessibility of data in its archives, NSSDC continued its program of migrating data from old 7-track and 9-track tapes to new media pairs (9-track tape and 3480 tape cartridges). Table 11 shows the number of tapes input to the program over its six-year life and the number handled in 1993, by discipline. (See page 13.) Over the past six years a total of 4,405 output media pairs was generated from the 28,450 tapes input. The center is very pleased that in working with data tape holdings ten to 30 years old it has been able to migrate over 98% of all the data addressed. In pursuing this program NSSDC has been guided by community prioritizations of data sets.

1.2 Disseminating Data from NSSDC

NSSDC disseminates many data, both electronically and via off-line mailings of data volumes. This section is separated into subsections addressing these two distinct modes. In most cases of electronic dissemination, there is no NSSDC staff involvement. In the subsections below the NSSDC is able to characterize better its off-line users since more information about off-line requesters is captured into an information base. Such information is impractical to capture where users are accessing data electronically, so the amount of E-access activity to on-line and near-line files is taken as the measure of their value.

1.2.1 Electronic Data Access

During 1993 NSSDC continued to witness continuous growth in the electronic dissemination of data. The numbers of accesses to the various NODIS data files during 1993 are given in Appendix 4.1. (See page 37.) Likewise, the numbers of FTP accesses to data held permanently on magnetic disk are given in Appendix 4.2. (See page 38.) Finally, the numbers of accesses and, separately, the numbers of files downloaded by NDADS users are given in Table 12, by mission. (See page 14.) For comparison the equivalent numbers for 1992 are also shown in Table 13. (See page 14.) Note that, summed over the NODIS and NDADS access paths, the number of electronic accesses to NSSDC data increased from 28,941 to 44,182 between 1992 and 1993. Most of this gain was due to the increased accessibility of high interest data on NDADS. NSSDC is very pleased with this increase.

1.2.2 Off-Line Data Access

During 1993 NSSDC satisfied 4,985 distinct requests for off-line data. Table 14 lists the most frequently requested data sets in order of their request numbers. (See pages 15 and 16.) Note the multidisciplinary character of the data sets high on this list. The planetary data and many other top ranked data sets were largely sent out on CD-ROMs. Table 15 shows the numbers of data requests satisfied by NSSDC in 1993 and over its lifetime. (See page 16.) Planetary requests dominate owing to the popularity of lunar and planetary images. There is a remarkable balance across the other NSSDC-supported disciplines over the years.

Table 16 shows the numbers of media types mailed by NSSDC in 1993. (See page 17.) Note that at 600+ MB/CD-ROM nearly 10 TB of data were disseminated on CD-ROM. The numbers of various media type disseminated at NSSDC are shown in Table 17. (See page 17.) Table 18 shows monthly off-line shipping activity levels. (See page 18.) The numbers are dominated by newsletter mailings, but it is noteworthy that ten to 20 actual data shipments leave NSSDC daily. During 1993 approximately 42% of NSSDC requests for off-line data were received by letter or FAX, 36% were received by telephone or other oral communication, and 22% were received electronically.

Table 19 characterizes the NSSDC off-line data request community. (See page 19.) In addition to continuing its support for the NASA and other U.S. and international research communities, NSSDC is supporting access by the "general public" to NASA data. To a significant extent this represents getting CD-ROMs into the U.S. educational community.

PRIMARY DIGITAL DATA VOLUMES AT NSSDC AS OF DECEMBER 31, 1993

DISCIPLINE MISSION	TOTAL VOLUME COUNTS			VOLUMES RECEIVED IN 1993		
	9-Track Tapes	Other Media	Media Type	9-Track Tapes	Other Media	Media Type
SPACE PHYSICS						
AE-C	62	34	8 mm		34	8 mm
AE-D	4	9	8 mm		9	8 mm
AE-E	68	33	8 mm		33	8 mm
DE 1	9	13	OD		2	OD
DE 2	31	28	OD	10	2	OD
		6	8 mm		6	8 mm
		1	Floppy			
		2	V Tape			
GEOTAIL		235	WO-CD		235	WO-CD
Hawkeye		15	4 mm		15	4 mm
IMP-J	2,926			791		
ISEE 1	780	20	OD	31	10	OD
		10	8 mm		10	8 mm
ISEE 2	298	11	OD	130	10	OD
ISEE 3	197	11	8 mm	6	11	8 mm
San Marco D/L	56			55		
Skylab	1,723	8	Floppy		7	Floppy
SMM	52	1	Floppy		19	8 mm
		5	OD		2	Floppy
YOHKOH		1	Floppy			
		54	8 mm		54	8 mm
Other	13,973	1	Floppy			
TOTALS	20,179	77	OD	968	24	OD
		12	Floppy		9	Floppy
		2	V Tape		176	8 mm
		157	8 mm		15	4 mm
		15	4 mm		235	WO-CD
		235	WO-CD			

Table 1. Space physics data volumes held at NSSDC at the end of 1993 and received during 1993, by mission. Counts of backup copies are not included. In virtually all cases "OD" refers to Write-Once, Read-Many (WORM) optical disks. Space physics includes solar physics. Counts of volumes received at NSSDC during 1993 do not include volumes created at NSSDC.

PRIMARY DIGITAL DATA VOLUMES AT NSSDC AS OF DECEMBER 31, 1993

DISCIPLINE MISSION	TOTAL VOLUME COUNTS			VOLUMES RECEIVED IN 1993		
	9-Track Tapes	Other Media	Media Type	9-Track Tapes	Other Media	Media Type
ASTROPHYSICS						
ASTRO-C	2				1	Network
COBE		1	8 mm		1	8 mm
HEAO 1	450			264		
HEAO 2	23	15	CD			
		11	OD		3	OD
		1	4 mm		1	4 mm
HEAO 3	669				1	Network
HST					4	Network
IRAS	283	5	CD	5		
		45	8 mm		5	8 mm
					25	Network
IUE	1,790	26	4mm	129	26	4 mm
OAO 3	51	1			1	Network
OSO 7	148	1	4 mm	14	1	4 mm
ROSAT		7	OD		7	OD
		4	CD		4	CD
Other	4,937	26	4 mm			
TOTALS	8,353	24	CD	412	10	OD
		18	OD		4	CD
		54	4 mm		28	4 mm
		46	8 mm		6	8 mm
					37	Network

Table 2. Astrophysics data volumes held at NSSDC at the end of 1993 and received during 1993 by mission. Counts of backup copies are not included. In virtually all cases "OD" refers to Write-Once, Read-Many (WORM) optical disks. Counts of volumes received at NSSDC during 1993 do not include volumes created at NSSDC. (Network refers to numbers of data sets received electronically.)

PRIMARY DIGITAL DATA VOLUMES AT NSSDC AS OF DECEMBER 31, 1993

DISCIPLINE MISSION	TOTAL VOLUME COUNTS			VOLUMES RECEIVED IN 1993		
	9-Track Tapes	Other Media	Media Type	9-Track Tapes	Other Media	Media Type
PLANETARY SCIENCE						
Magellan	13,243	23	8 mm	13,243	23	8 mm
		169	CD		82	CD
		3	Floppy		3	Floppy
Mariner 9	53			2		
Phobos 2		4	Floppy		4	Floppy
Pioneer 10	362			16		
Pioneer 11	393			20		
Pioneer Venus 1	519	2	4 mm	77	2	4 mm
Viking 1 Orbiter	494	62	CD	1	31	CD
Viking 2 Orbiter	241	47	CD	1	20	CD
Voyager 1	847	7	CD		2	CD
Voyager 2	566	14	CD	4	2	CD
Other	4,172	5	CD			
TOTALS	20,890	304	CD	13,364	137	CD
		2	4 mm		2	4 mm
		23	8 mm		23	8 mm
		7	Floppy		7	Floppy

Table 3. Planetary data volumes held at NSSDC at the end of 1993 and received during 1993, by mission. Pioneer 10 and 11 and Voyager 1 and 2 provided both space physics and planetary data but are fully accounted for under planetary.

PRIMARY DIGITAL DATA VOLUMES AT NSSDC AS OF DECEMBER 31, 1993

DISCIPLINE MISSION	TOTAL VOLUME COUNTS			VOLUMES RECEIVED IN 1993		
	9-Track Tapes	Other Media	Media Type	9-Track Tapes	Other Media	Media Type
EARTH SCIENCE						
ERBS	363	305	OD	9		
Nimbus 7	15,533	7	CD	153		
		1	OD			
		34	Floppy			
		2	V Tape			
Other	37,855	1	V Tape			
		2	CD			
		307	OD			
TOTALS	53,751	9	CD	162		
		613	OD			
		34	Floppy			
		3	V Tape			

Table 4. Earth science data volumes held at NSSDC at the end of 1993 and received during 1993, by mission.

DATA INGEST 1993

SPACECRAFT	TAPES				OPTICAL DISKS		CD-ROMs	OTHER	ANALOG
	9-Track	8 mm	4 mm	3480	Optimem	Sony			
AE-C		34							
AE-D		9							
AE-E		33							
Apollo 15 CSM	1								
ASTRO-C								1†	
DE 1					2			3†	
DE 2	10	6			2				
ERBS	9								
Galileo Orb									413
GEOTAIL								235††	
Hawkeye			15					3†	
HEAO 1	264								
HEAO 2			1			3			
HEAO 3								1†	
HST								4†	
IMP-J	791							1†	1
IRAS	5	5						25†	
ISEE 1	31	10			10				62
ISEE 2	130				10			4†	
ISEE 3	6	11						1†	
Magellan	13,243	23					82	3†	531
Mariner 9				2					
Mars Observer									1
Nimbus 7	135			18					
OAO 3								1†	
OSO 7	14		1						
Phobos 2								4*	
Pioneer 10	16								
Pioneer 11	20								
Pioneer Venus 1	77		2						44
San Marco D/L	55								
Skylab								7* 1†	
SMM		19							
Viking 1, Orbiter				1			31		
Viking 2, Orbiter				1			20		
Voyager 1							2		
Voyager 2	4						2		
YOHKOH		54							

* Floppies † Network (data set count) †† Write-Once CD-ROM

Table 5. Data Volumes Received During 1993 Listed by Discipline

PHOTOGRAPHIC DATA PRODUCTS AT NSSDC BY DISCIPLINE

DISCIPLINE	MICRO-FILM	MICRO-FICHE	FILM (Feet)	FILM (Frames)	REELS	SLIDES	OTHER
Astrophysics	6,020	18,524	100	63,459		89	
Earth Science	1,430		4,200	236,034			1
Planetary Science	3,294	6,345	142,214	390,723	259	5	10
Space Physics	20,187	11,644	4,640	4,314		40,790	28
Communications	183						
Other	162						
TOTAL	31,276	36,513	152,154	694,530	259	40,884	39

Table 6. Photographic Data Products at NSSDC Listed by Discipline

VOLUME OF DATA AT NSSDC BY STORAGE MEDIUM

STORAGE MEDIUM	VOLUME AS OF DECEMBER 31, 1993	INCREASE SINCE DECEMBER 31, 1992
Digital Magnetic Tape:		
1/2 in. x 2,400 ft.	123,243	14,811
4 mm	75	75
8 mm	410	366
3480	2,036	22
CD-ROM (Titles)	371	137
CD-ROM Write-Once	235	235
Optical Disk:		
Optimem	52	24
Sony (managed)	3	3
Floppy Disk	78	14
Video Tape	9	0
Microfilm, 100-ft. Reels	39,125	7
Microfiche	45,542	0
Photographic Film:		
5-in. width, linear ft.	174,578	0
9.5-in. width, linear ft.	268,078	0
70-mm width, linear ft.	590,219	0
35-mm width, linear ft.	707,852	0
16-mm width, linear ft.	353,341	0
70-mm width, each	752	0
4x5 in., each	21,604	203
5x5 in., each	1,181	0
5x7 in., each	874	0
5x12 in., each	4,045	0
8x10 in., each	69,183	305
11x14 in., each	52	0
12x15.5 in., each	8	0
16x20 in., each	95	0
20x24 in., each	8,264	0
2.25x2.25 in., each	36,713	0

Table 7. Total counts of volumes by type in the NSSDC archive as of the end of 1993 and changes relative to the previous year. For round tapes the "increase" represents new tapes submitted less a net dimunition associated with NSSDC's data restoration program. (See section 1.1.3.)

NUMBER OF EXPERIMENTS BY DISCIPLINE/ SUBDISCIPLINE WITH DATA ARCHIVED AT NSSDC THROUGH 1993

DISCIPLINE	EXPERIMENTS WITH DATA	EXPERIMENTS WITH FIRST DATA SET RECEIVED IN 1993
Astrophysics	109	6
Space Physics	624	12
Planetary Sciences	268	5
Earth Sciences	117	0
Life Sciences	4	0
Other	13	0
TOTAL	1,135	23

Table 8. Experiments with Data by Discipline

NEAR-LINE INGEST 1989 - 1993

YEAR	ASTROPHYSICS	SPACE PHYSICS	TOTAL
1989	0.39 GB	0.00 GB	0.39 GB
1990	41.43 GB	5.60 GB	47.03 GB
1991	71.60 GB	4.35 GB	75.95 GB
1992	128.63 GB	25.36 GB	153.99 GB
1993	95.14 GB	22.84 GB	117.98 GB
TOTALS	337.19 GB	58.15 GB	395.34 GB

Table 9. NDADS Ingest Annual Rates by Discipline

DATA ELECTRONICALLY ACCESSIBLE FROM NSSDC AS OF DECEMBER 31, 1993

	TOTAL VOLUME AS OF DECEMBER 31, 1993 (# OF MBYTES)		# OF MBYTES MADE ELECTRONICALLY ACCESSIBLE IN 1993	
Mission	On-Line	Near-Line	On-Line	Near-Line
ADC		4,940		548
COHO	175		43	
Copernicus		5		5
DE		30,220		9,226
GINGA		826		
Hawkeye		13,577		287
HEAO 1		12,580		13,578
HEAO 2		4,361		11,980
HEAO 3		604		
HST		2,600		
IMP 8		6,125		
IRAS		83,040		1,541
ISEE 3		1,430		
ISTP	2,300		2,295	
IUE		189,130		52,627
Nimbus	16			
NRAO		650		282
OGLE		653		653
OMNI	28		9	
ROSAT		29,790		26,687
Skylab		7,350		
STELAR		4,250		572
Vela 5B		3,210		
TOTAL	2,519	395,341	2,347	117,986

Table 10. Electronically-Accessible Data by Mission

NUMBER OF RESTORED TAPES FROM NSSDC BY DISCIPLINE

DISCIPLINE	RESTORED TAPES 1988 - 1993	RESTORED TAPES 1993
Astrophysics	943	199
Space Science (and Solar)	9,855	3,012
Planetary Science (and Lunar)	1,155	616
Earth Science	14,926	869
TOTAL	28,450	4,696

Table 11. Counts of Restored Tapes

NDADS DATA ACCESS CY 1993

DISCIPLINE	NUMBER OF FILES	REQUESTS
Space Physics		
DE	3,305	146
Hawkeye	977	153
IMP 8	4,779	524
ISEE 3	2,996	150
Skylab	279	51
Astrophysics		
ADC	6,680	1,446
Copernicus	1,109	5
HEAO 2	19	9
HST	45	7
IUE	55,612	5,800
IRAS	3,511	448
NRAO	203	32
OGLE	13	11
ROSAT	29,677	3,900
STELAR	798	247
Vela 5B	16,244	391
TOTAL	126,247	13,320

Table 12. Data Disseminated from the NSSDC in 1993 Through NDADS

NDADS DATA ACCESS CY 1992

DISCIPLINE	NUMBER OF FILES	REQUESTS
Space Physics		
DE	3,539	79
IMP 8	2,106	134
ISEE 3	6	5
Skylab	556	81
Astrophysics		
ADC	3,902	668
GINGA	28	22
HEAO 2	29	20
HEAO 3	3	6
HEASARC	80	10
HST	479	10
IUE	100,966	5,799
IRAS	1,305	73
NRAO	87	70
ROSAT	5,609	444
STELAR	461	76
Vela 5B	5,764	228
TOTAL	124,920	7,725

Table 13. NDADS Data Access for 1992 Reflecting Data Collected from November 25 Through December 31, 1992

DATA MOST FREQUENTLY REQUESTED FROM NSSDC CY 1993

RECORD ID	NAME	COMPLETED REQUESTS
77-084A-01	Voyager 1, Imaging	946
77-076A-10	Voyager 2, Imaging	903
75-075A-01	Viking 1, Orbiter Imagings	674
78-098A-09	Nimbus 7, BUV/TOMS-Backscatter UV/Ozone	402
89-033B-01	Magellan, Synthetic Aperture Radar	394
75-083A-01	Viking 2, Orbiter Imaging	363
GA-16	Miscellaneous Astronomy Catalogs	350
89-084B-10	Galileo, Solid-State Imaging (SSI)	166
83-004A-01	IRAS, IR Telescope	82
73-027A-05	Skylab, X-Ray Spectrometer Telescope	64
GA-11	Astronomic Data Catalogs	63
GA-17	Non-Stellar Objects Astronomy Catalogs	47
78-013A-04	HEAO 2, Imaging Proportional Counter	46
91-062A-02	YOHKOH, Soft X-Ray Telescope	40
XD-B3	Planetary Observations, Comets	39
GA-13	Astronomy Catalogs, Spectroscopic Data	38
78-103A-02	HEAO 2, High-Resolution Imager	36
GA-15	Astronomy Catalogs, Combined Data	31
GA-12	Astronomy Catalogs, Photometric Data	26
MN-61	Atmospheric Models	17
MI-91	Ionospheric Models	15
72-096A-05	Apollo 17A, Handheld Camera	14
73-078A-01	IMP-J, Tri-Axis Magnetometer	14
78-103A-02	HEAO 2, Crystal X-Ray Spectrometer	14
78-103A-05	HEAO 2, Solid-State Spectrometer (SSS)	13
67-041A-01	Lunar Orbiter 4, Lunar Photos	12
71-063A-01	Apollo 15A, Handheld Photography	12
73-078A-02	IMP-J, Solar Plasma, Faraday Cup	11
73-078A-10	IMP-J, Plasma, Electrostatic Analyzer	11
78-103A-01	HEAO 2, Monitor Proportional Counter	11
73-085A-01	Mariner 10, Television Photography	9
SL-23	Planetary and Terrestrial Maps	9
67-075A-01	Lunar Orbiter 5, Lunar Photos	8
GA-18	Radio Source Catalogs	8
GR-11	Ground-Based Radio Observations	8
XD-B2	Planetary Observations, Miscellaneous	8
67-008A-01	Lunar Orbiter 3, Lunar Photos	7
69-043A-01	Apollo 10, Photos 70 mm + 36 mm	7

Table 14. Data Sets Sorted by Off-Line Request Activity (continued on the following page)

DATA MOST FREQUENTLY REQUESTED FROM NSSDC CY 1993 (CONTINUED)

RECORD ID	NAME	COMPLETED REQUESTS
69-099A-01	Apollo 12, Photos 70, 16 + 35 mm	7
72-031A-01	Apollo 16A, Handheld Photography	7
PG-18	Magnetic Field Retrieval Programs	7
SM-41	OMNITAPE	7
78-041A-01	HCMM, Radiometer (HCMR)	5
78-098A-07	Nimbus 7, ERB-Earth Radiation Budget	5
GA-14	Astronomy Catalogs Cross Identification	5
71-051A-04	Mariner 9, Television Photography	4
75-075C-06	Viking 1, Lander Imaging	4
75-083C-06	Viking 2, Lander Imaging	4
77-102B-04	ISEE 2, Fluxgate Magnetometer	4
84-108B-01	ERBS, Earth Radiation Budget EXP/ERBE	4
90-049A-02	ROSAT, Position Sensitive Proportional Counter	4

Table 14. (Continued)

NUMBER OF REQUESTS FOR SATELLITE DATA FROM NSSDC BY DISCIPLINE

DISCIPLINE	DATA SET REQUESTS 1968 - 1993	OFF-LINE DATA SET REQUESTS 1993
Astrophysics	6,236	949
Earth Science	6,895	605
Planetary Science	30,367	8,703
Space Physics	6,989	153
Ephemeris	57	7
Other	15	0
TOTAL	50,559	10,417

Table 15. Off-Line Request Counts by Discipline

NSSDC REQUESTS OUTPUT BY MEDIUM CY 1993

MEDIUM	REQUESTS COMPLETED	QUANTITY	AVERAGE QUANTITY PER REQUEST	OUTPUT UNIT
Sent Via Network	140	71	0.507	Each Disk
Floppy Disks	798	912	1.143	Each Disc
CD-ROM	1,320	11,405	8.640	Each Disc
Optical Disks	1	12	12.000	Each Disc
Books/Bound Volumes	2,547	3,181	1.249	Each Binder
Computer Tapes	178	689	3.871	2,400-Foot Tape
8-mm Tapes	31	66	2.129	Each Tape
Negatives (Feet)	1	2	2.000	Each Strip
Hard Copy	394	5,823	14.779	Each Page
Microfilm	8	48	6.000	100-Foot Reel
Microfilm Copies	2	2	1.000	100-Foot Reel
Computer Printout	157	6,895	43.917	Each Page
Slides	12	124	10.333	Each Slide
Transparencies	14	157	11.214	Each Sheet
Photographic Prints	108	1,008	9.333	Each Sheet
Negatives	30	203	6.767	Each Sheet
Other	22	1	0.045	Various

Table 16. Media Types Mailed in 1993

NSSDC DATA DISSEMINATION STATISTICS AS OF DECEMBER 31, 1993

OFF-LINE STATISTICS	1989	1990	1991	1992	1993
Number of Requests for Tapes	673	769	668	483	209
Number of Tapes Mailed	2,775	3,156	2,878	3,358	755
Number of Requests for CD-ROMs	0	331	600	2,277	1,320
Number of CD-ROMs Mailed	0	1,073	3,747	18,373	11,405
Number of Film Requests	294	335	432	261	175
Number of Film Volumes Mailed	41,028	14,381	20,529	8,448	1,544
ON-LINE STATISTICS					
Number of NODIS Sessions	6,294	10,029	15,769	24,921	30,861
Number of NDADS Sessions	0	0	378	7,725	13,320

Table 17. Data Disseminated Through NSSDC in 1993

SHIPPING ACTIVITY CY 1993

MONTH	DOCUMENT SHIPMENTS	DATA SHIPMENTS	TOTAL
January	4	158	162
February	2,967	182	3,149
March	1,819	266	2,805
April	1,453	248	1,701
May	1,588	141	1,729
June	1,883	175	2,058
July	259	182	441
August	268	152	420
September	1,878	126	2,004
October	272	169	441
November	262	137	399
December	1,765	134	1,899
TOTALS	14,418	2,070	16,488

HISTORICAL SUMMARY OF SHIPPING ACTIVITY AT NSSDC (CALENDAR YEAR)

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993
Shipments	34,740	22,609	27,230	24,137	24,471	22,641	23,085	64,642*	16,488†

* Increase because of addition of STEP newsletter distribution.

† No longer supporting STEP newsletter distribution.

Table 18. Shipping Activity

NSSDC USER COMMUNITY CY 1993*

AFFILIATION CATEGORY	TOTAL REQUESTS	PERCENT OF TOTAL
Non-U.S., Excluding Socialist Countries	1,305	31.94
U.S. Universities/Colleges	720	17.62
U.S. Private Industry	432	10.57
No Affiliation (General Public)	1,068	26.14
NASA/GSFC	199	4.87
Other Government Agencies	209	5.12
Miscellaneous	34	0.83
NASA Centers, Excluding GSFC	91	2.23
Former Socialist Countries	28	0.69
Total	4,086	100.00

* Off-line requests only.

Table 19. NSSDC Off-Line User Community

2

INFORMATION MANAGEMENT AT NSSDC

2.0 Information Management

NSSDC manages a great deal of information about data, their source spacecraft and instruments, and about other entities identified below. NSSDC's goals are (1) to support data finding and access in an increasingly distributed NASA and international data environment; (2) to support the retrieval and use of NSSDC-held data; and (3) to provide a comprehensive information base on past, present, and future NASA and other missions and their investigations for both the scientific and NASA program management communities.

Meeting the first of these goals has led to the NASA Master Directory, which is further discussed below. Meeting the second has led to various inventory files at NSSDC related to both its off-line and on-line/near-line data holdings discussed in the previous section. These files are critical to smooth NSSDC operation but will not be described here. Meeting the third goal led NSSDC years ago to create several files discussed below.

2.1 The NASA Master Directory

The NASA Master Directory (NMD) describes at a very high level NASA-research-relevant NASA and non-NASA data publicly accessible worldwide.

Through 1993 it was identical to the multi-agency Global Change Master Directory (GCMD), which has formed the basis for the International Directory Network.

The NMD identifies virtually all NSSDC-held data, virtually all the data held at the various NASA discipline-specific data systems (Planetary Data System, Astrophysics Data System, etc.), and a great deal of data held elsewhere both within and beyond the NASA environment.

The basic NMD information unit is packaged in the Directory Interchange Format and is usually called a DIF. DIFs may describe data considered one data set by the data holding site or may describe a great many such data sets through "aggregation." Because of the practice of aggregation, DIF counts are an imperfect measure, although the most readily available measure, of the status of NMD population.

A more detailed discussion of the Master Directory and of the companion Catalog Interoperability activity is given in section 4.3.

2.2 Relational System for Information Retrieval and Storage (RSIRS)

RSIRS has its heritage in NSSDC's long-term information base that in a pre-relational Data Base Management System (DBMS) environment consisted of a number of hierarchical information files. These files are now the "partitions" of the RSIRS data base and consist of the following:

The Automated Internal Management (AIM) File tracks spacecraft, their on-board experiments, and resulting data sets, primarily those archived at NSSDC. Table 20 shows the numbers of these entities tracked in the AIM file. (See page 24.)

The NSSDC Supplementary Data (NSD) File tracks non-spacecraft data, multi-source spacecraft or other data, models and programs, Astronomical Data Center (ADC) source catalogs, and other NSSDC-held data sets that do not fit the AIM spacecraft/experiment/data set hierarchy. Table 21 shows the number of data sets identified in NSDF by discipline. (See page 24.)

The Technical Reference File (TRF) tracks published and some unpublished papers uniquely associated to spaceflight experiments through their unique NSSDC IDs. (See Table 22 on page 25.)

Table 23 shows the Interactive Request Activity and Name Directory (IRAND) statistics. (See page 25.) The IRAND file tracks people and their multiple addresses, which distribution lists they are on, and their individual requests. (Note that IRAND underlies NODIS/PIMS, discussed in Appendix 4.1, page 37.)

The Interactive Data Archive (IDA) File tracks NSSDC's inventory of digital data volumes. The Rocket file tracks scientific rocket launches. Table 24 shows the IDA's statistics as of December 31, 1993. (See page 25.)

AIM PARTITION STATISTICS AS OF DECEMBER 31, 1993

SUBPARTITION	NUMBER OF RECORDS AS OF 12/31/93	NUMBER ADDED IN 1993
Spacecraft	4,873	122
Experiment	5,395	259
Data Set	5,025	123
TOTAL	15,293	504

Number of Spacecraft with Experiments Known: 944.
Number of Experiments with Data Sets at NSSDC: 1,272.

Table 20. AIM Spacecraft, Experiment, and Data Set Records Inserted in 1992

NSD PARTITION STATISTICS BY DISCIPLINE AS OF DECEMBER 31, 1993

DISCIPLINE	NUMBER OF DATA SETS
Astrophysics	1,029
Space Physics	419
Earth Science	64
Planetary Science	25
Other	18
TOTAL	1,555

Table 21. NSSDC Supplementary Data (NSD) Data Sets by Discipline

TRF PARTITION STATISTICS AS OF DECEMBER 31, 1993

Total Number of Records (Science Papers)	35,532
Number of Records Inserted During 1993	1,630

Table 22. Technical Reference File (TRF) Statistics

IRAND PARTITION STATISTICS AS OF DECEMBER 31, 1993

RECORD TYPE	TOTAL RECORDS	1993 ACTIVITY	
		Records Inserted	Records Updated
Personnel	46,468	3,901	7,444
Request	66,093	4,097	—

Table 23. Interactive Request Activity and Name Directory (IRAND) Statistics

IDA AND ROCKET STATISTICS AS OF DECEMBER 31, 1993

PARTITION	TOTAL RECORDS	RECORDS INSERTED
IDA	140,326	19,618
Rocket	15,478	0

Table 24. Interactive Data Archive (IDA) and Rocket Statistics

3

OTHER NSSDC ACTIVITIES

3.1 NASA/Science Office of Standards and Technology (NOST)

The NASA/Science Office of Standards and Technology (NOST) at the NSSDC was established to serve the NASA science communities in evolving cost-effective, interoperable information systems. The goal is to facilitate the use of new technologies and in particular those technologies based upon or evolving into standards. A standard is understood to be a specification widely available within the community for which implementations, based upon the standard, are desired or prevalent.

Standards in general serve as building blocks for the cost-effective development, operation, and evolution of systems. Basing technologies upon standards provides systems with a range of valuable services such as 1) improved interoperability; 2) improved reliability; 3) reduced design, implementation, and maintenance costs; 4) reduced user training costs; and 5) reduced evolvability costs.

Three broad classes of standards-based technologies can provide significant benefits to the NASA science communities. These are 1) information representation technologies (i.e., data standards), 2) media technologies, and 3) software technologies. Information representation technologies based upon standards support open, distributed access and understanding of data. They are essential in the rapidly evolving electronic communication environment and clearly a domain with large potential payoffs for standards that provide significant improvements in automated digital information interchange. Media technologies based upon standards facilitate multiple vendor support and a larger market, thus reducing media cost and promoting a longer lifetime for vendor support. Software technologies, such as reuse methodologies, reduce the considerable costs associated with software development and maintenance. Basing them on standards increases the potential

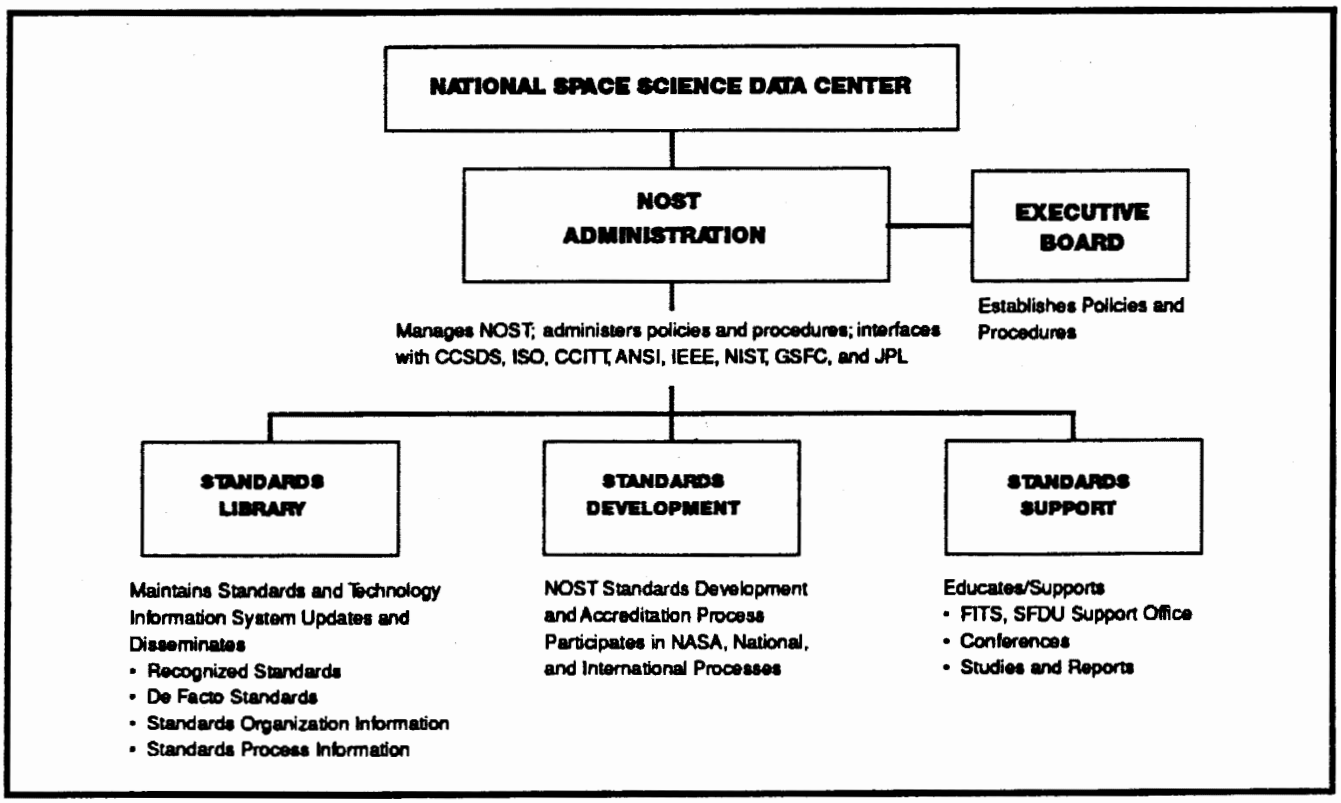

Figure 1. NASA/Science Office of Standards and Technology

audience and improves the chance that effective reuse will take place.

To date, NOST has chosen to apply its resource primarily toward facilitating the development and use of technologies and standards in the information representation and access domain. The biggest impacts can be made in this area because extracting information from digital data is often very time consuming, and it has elements that are specific to the NASA-supported sciences. By contrast, media- and software-related technologies are much more broadly based and will be primarily driven by broad commercial interests. NOST efforts in supporting information representation technologies are described in section 3.1.1, which addresses activities related to Panel 2 of the Consultative Committee for Space Data Systems (CCSDS), and 3.1.2, which addresses activities related to the Flexible Image Transport System (FITS). Finally, section 3.1.3 addresses activities supporting the dissemination of standards and new technology information to the NASA science communities.

3.1.1 Consultative Committee for Space Data Systems (CCSDS)

NOST participates in the international CCSDS Panel 2, which is developing technologies based on standards called CCSDS Recommendations in support of information interchange among the international space agencies. NOST also supports users of these technologies by providing a support office and by providing a data description registration and dissemination service (called a Control Authority Office) in accordance with CCSDS Recommendations. The related activities, services, and accomplishments are described in the remainder of this section.

The CCSDS is a consensus, voluntary organization formed and maintained by representatives of its member agencies. Member agencies include NASA, European Space Agency (ESA), Centre National d' Etudes Spatiales (CNES), British National Space Centre (BNSC), Deutsche Forschungsanstalt für Luft- und Raumfahrt (DLR), Instituto Nacional de Pesquisa Espaciais (INPE), National Aeronautics and Space Development Agency (NASDA), Canadian Space Agency (CSA), and Central Research Institute of Machine Building TsNIIMash Russian Federation (TsNIIMash). Many other agencies also participate as observers, which gives them full rights except for voting.

NOST leads NASA's participation in CCSDS Panel 2. This panel is addressing the problems of information interchange among the agencies and therefore also within the agencies because these problems do not stop at agency boundaries. The recommended technologies support greater automation in understanding the information obtained from or derived from spaced-based sensors, regardless of the scientific discipline involved. To the extent practical, they are based on or add support to already widely used standards.

Panel 2 has evolved a concept known as Standard Formatted Data Units (SFDUs), which can be readily extended by users and also by future Panel 2 Recommendations. The three primary functions are 1) standards for the identification, linking, and packaging of data and metadata (i.e., descriptions of data); 2) computer-interpretable languages for expressing metadata; and 3) establishment of metadata registration and dissemination services to provide recognized, accessible, and permanent archives.

The Recommendation highlights for 1993 were in the area of metadata registration and dissemination. The Recommendation CCSDS 630.0-B-1 was approved by all the agencies and specifies the requirements for establishment and operation of an interagency-coordinated set of Control Authority Offices. These offices assign unique identifiers to submitted metadata objects and return these identifiers to the submitters so that the identifiers can be used to link data objects to their metadata objects. In addition, the draft Recommendation known as Control Authority Data Structures was distributed for formal agency review. It provides a standard package for the submission and dissemination of these metadata objects to facilitate automation of the process.

NOST assists implementers of the Recommendations through its SFDU Support Office, and it has

established the NSSDC Control Authority Office Information System to provide for on-line registration and retrieval of metadata objects. It has provided support to several projects in 1993, including the Upper Atmospheric Research Satelite (UARS), International Solar-Terrestrial Physics/Global Geospace Science (ISTP/GGS), Solar and Heliospheric Observatory (ISTP/SOHO), International Sun-Earth Explorer (ISEE 1), and Dynamics Explorer (DE-A). This year it has also assigned 55 registration identifiers for metadata objects, primarily to GGS.

3.1.2 Flexible Image Transport System (FITS)

The Flexible Image Transport System (FITS) is the standard format for astronomical data transport, endorsed and supervised by the International Astronomical Union (IAU). NOST participates in the evolution of FITS by commenting on proposed new FITS extensions and conventions and by involvement in the work of the overseeing IAU FITS Working Group. NOST supports users of this technology by providing a FITS Support Office; by supporting the development of a formal FITS specification document using the NOST standards accreditation process; and by serving as a source of FITS information, documents, and advice. The related activities, services, and accomplishments are described in the remainder of this section.

The FITS Support Office provides general user support with special attention to NASA projects, develops and distributes FITS documents and software, and coordinates its activities with other scientific and standards bodies. In 1993 support primarily in reviews of proposed designs for FITS files was provided to several projects, including International Ultraviolet Explorer (IUE), Cosmic Background Explorer (COBE), Wisconsin Ultraviolet Photopolarimetry Experiment (WUPPE), and the High Energy Atmospheres Science Archive Research Center (HEASARC) in general as well as the specific Compton Gamma Ray Observatory (GRO) projects Burst And Transient Spectrometer Experiment (BATSE), Oriented Scintillation Spectrometer Experiment (OSSE), and Energetic Gamma-Ray Experiment Telescope (EGRET). The FITS office also produces and maintains the FITS user's guide, a conversational introduction to FITS that provides not only the rules but discusses recommended practices, new developments, and network resources. It was extensively updated in 1993 and made available in electronic form for the first time. Electronic retrievals average about 25 per month as compared to three to five requests for printed copy. An improved version of the FITS Product Conformance Tester software was released. This software, for use by data designers and producers, helps ensure that FITS products conform to the standards and therefore will be readily interpretable by recipient systems.

The NOST FITS Technical Panel produced an internationally reviewed "Definition of the Flexible Image Transport System (FITS)," NOST 100-1.0. It was approved by the NOST Executive Board and has been submitted to the IAU as an official specification of FITS. This provides NASA's astrophysical projects for the first time with a clear specification of the standard.

Astronomers make heavy use of electronic media for their work. The NOST developed a data base of FITS information available by anonymous ftp of general information about FITS; documentation, including the *Definition of FITS* and the FITS user's guide; software, including the FPCT and utility software; and files that can test the ability of a user's software to handle errors. Over 750 accesses were recorded in 1993. In addition, the FITS office is active in a number of electronic FITS discussion groups.

3.1.3 Standards and Technology Information System

The Standards and Technology Information System (STIS) is a centralized electronic library that lets users know about available standards and new technologies. This referenced material may have originated from a variety of sources such as books, technical or popular press articles, government or industry reports, and reports created by the NOST staff or NOST technical contributors. NOST encourages individuals within the community who have an interest in a particular standard or new

technology area to register as NOST technical contributors. By doing so they agree to provide reports as new information comes to them for incorporation into the STIS under their authorship. Hard copies of the documents are maintained in the standards library, managed by a librarian who responds to standards and new technology requests and prepares information for ingest to the STIS.

The STIS information displayed for these documents includes standards identifiers (e.g., ISO 9660), title, source, publication and copyright data, the names of any identified authors or editors, and the organization responsible for the document. The staff also classifies the documents with topic and content codes, assigns a number of keywords to aid the user in searching for the document and often prepares an abstract or comments on the document. If copyright provisions can be accommodated, the full text of many of the shorter documents is provided. Future implementations of the STIS are planned to include the display of information needed to order copies of documents directly from the source. At all times the NOST may be contacted for ordering information.

The STIS is also able to display information on a number of organizations that are active in the standards development field, including information on the areas in which these organizations are working. Contact points within those organizations are provided for users who need further information.

All the information in the STIS is presented through a series of user-friendly menus. Most users find they can use the system without any help or training. Comments and requests to NOST/STIS may be directly entered by users at virtually any point in a session.

The STIS may be accessed through the NSSDC On-Line Data and Information System (NODIS), which is described elsewhere in this report.

In 1993 approximately 245 documents were abstracted and entered to the STIS. On average per month, 186 user sessions accessing 132 items occurred, up slightly from 1992 in which 182 sessions accessing 125 items per month occurred. In addition, the librarian responded to over 90 general requests for standards and related information.

3.2 Common Data Format (CDF)

The Common Data Format (CDF) is a portable scientific data management package designed and developed at NSSDC. The term "CDF" is used synonymously with respect to the data format/files and the software package that produces and exploits them.

The development of CDF arose out of NSSDC's recognition that a class of data models was matched to the structure of scientific data as well as to the question of how such data may be utilized. The software package, known as the CDF Library, allows programmers to access and manage flat and multidimensional data in a fashion consistent with the geometry of their scientific orientation. Traditional methods of handling scientific data such as flat sequential files are generally inefficient in storage, access, or ease-of-use for large complex data sets particularly for applications like visualization. Modern, commercial relational data management systems do not offer an effective solution because they are more oriented toward business applications and do not accommodate multidimensional or hierarchical structures often found in scientific data sets. In addition, relational systems do not provide adequate performance for the size, complexity, and type of access dictated by current and future data sets and their potential usage.

The CDF Library was designed to provide the essential framework from which generic applications (e.g., visualization, statistical analysis, browsers, etc.) can be easily created. The library allows developers of CDF-based applications to easily create applications that permit users to slice data across multidimensional subspaces, access entire structures of data, perform subsampling of data, and access one element independently regardless of its relationship to any other element.

The hallmark of the CDF concept is its data set independence. This independence is achieved by means of an internal format containing its own

CDF USER COMMUNITY

GROUP	NUMBER OF USERS
ISTP-Related Users	Greater than 200
ESA-Related Users	Greater than 300
Others (Government, Universities, Commercial/Private, and Independent Users)	Approximately 100

Table 26. Common Data Format User Community

data dictionary (metadata) as well as the data themselves. In other words CDF describes its own format. This self-describing property makes it possible for the CDF to be used for data from a wide variety of disciplines. The CDF files contain two types of data, the actual data values (i.e., Reals, Integers, Chars, etc.) themselves and the user-provided metadata. Both the metadata and the actual data are accessible by means of standard software routines known as the CDF Interface, which provide the programmer with an abstract view of the contents of the data within a CDF file.

The CDF software package is used by hundreds from government agencies, universities, private, and commercial organizations as well as independent researchers on both national and international levels. The CDF is the foundation upon which NASA's ISTP Project Central Data Handling Facilities (CDHF) has based their software for storing and distributing key parameter data. In addition, the ESA Cluster project is utilizing CDF for storing and distributing data among those in the ESA and the space physics Inter-Agency Consultative Group (IACG) user community. Table 26 illustrates the primary user groups and an estimate of the number of users that are supported in each. (See above.)

The CDF is supported by the Jet Propulsion Laboratory (JPL) Linkwinds visualization software and Research Systems Incorporated (RSI) Interactive Data Language (IDL) analysis package. IDL is a commercial package, is heavily utilized throughout the science community, and has recognized CDF as an instrumental part of that community.

4

APPENDICES

4.1 NSSDC On-Line Data and Information Service (NODIS)

A major part of the mission of the NSSDC is disseminating information relevant to NASA data and filling requests for the data from the general community. Several years ago this was done mainly through telephoned and mailed requests, requiring days to months to complete. Some time ago, the NSSDC On-Line Data and Information Service (NODIS) revolutionized these methods. Now, many of the data and information requests are filled automatically within minutes through NODIS's openly available, network-accessible, general usage interface leading to interconnected information systems. Requests for off-line data have also been more efficiently handled through the automation of requests. Through NODIS users can access worldwide space and Earth science data information, consult a 40,000-name data base, immediately receive data from selected projects, browse bulletin boards and newsletters, get references on standards, etc. NODIS is a key to NSSDC's suite of information systems.

Data available via NODIS as 1993 ended include Nimbus 7 Total Ozone Mapping Spectrometer (TOMS) Gridded Total Ozone Mapping Spectrometer data, the Interplanetary Medium Data (OMNI) set of hourly solar wind parameters, the Geophysical Models, and the Astronomical Data Center (ADC). The information services include the NASA Master Directory (MD); the Personnel Information Management System (PIMS), an interface to a personnel data base containing over 40,000 users of NSSDC services; the NSSDC Data Request Service (REQ); the Solar-Terrestrial Energy Program (STEP) Bulletin Board Service, the Standards and

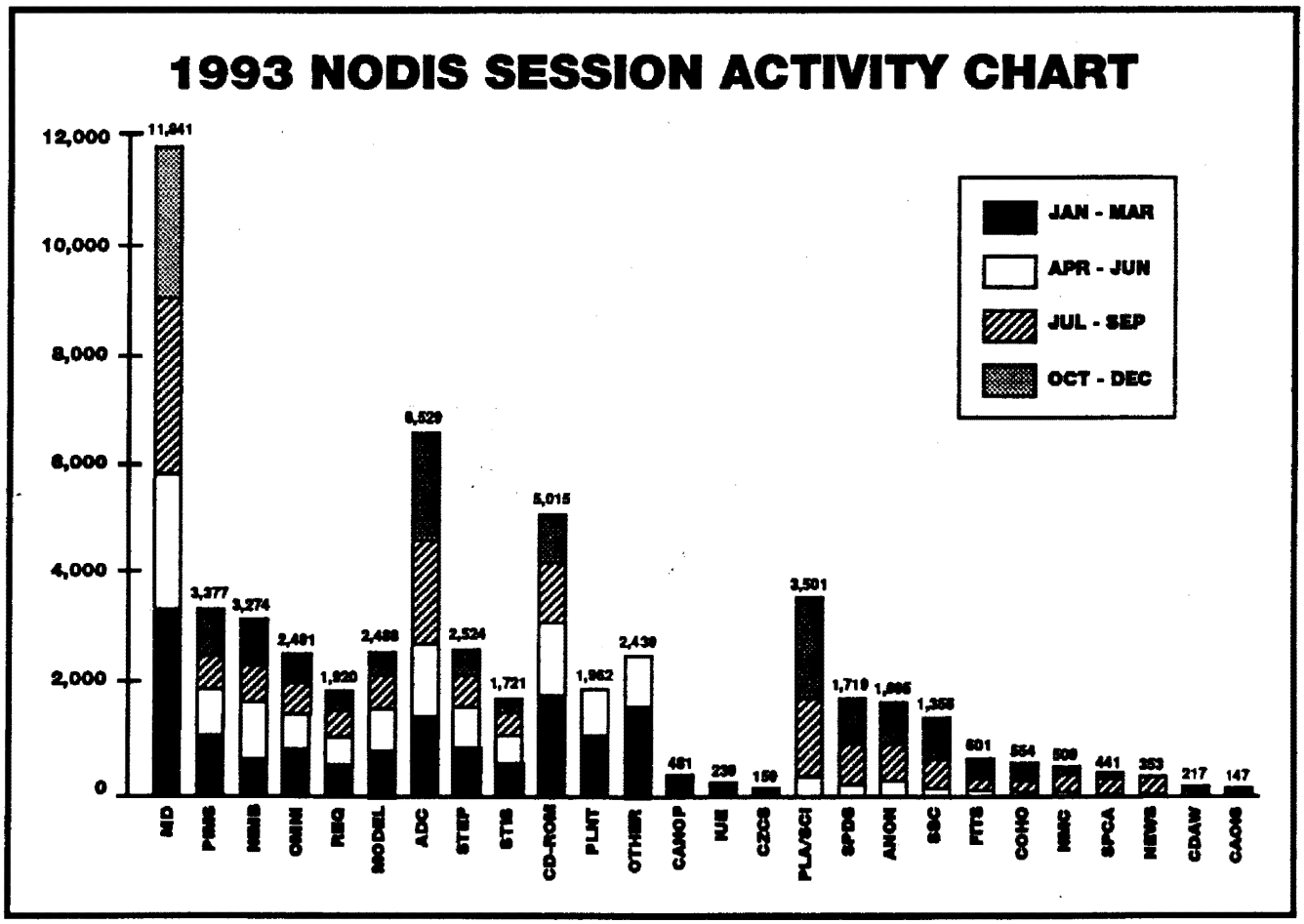

Figure 2. Annual Session Totals for Individual NODIS Services

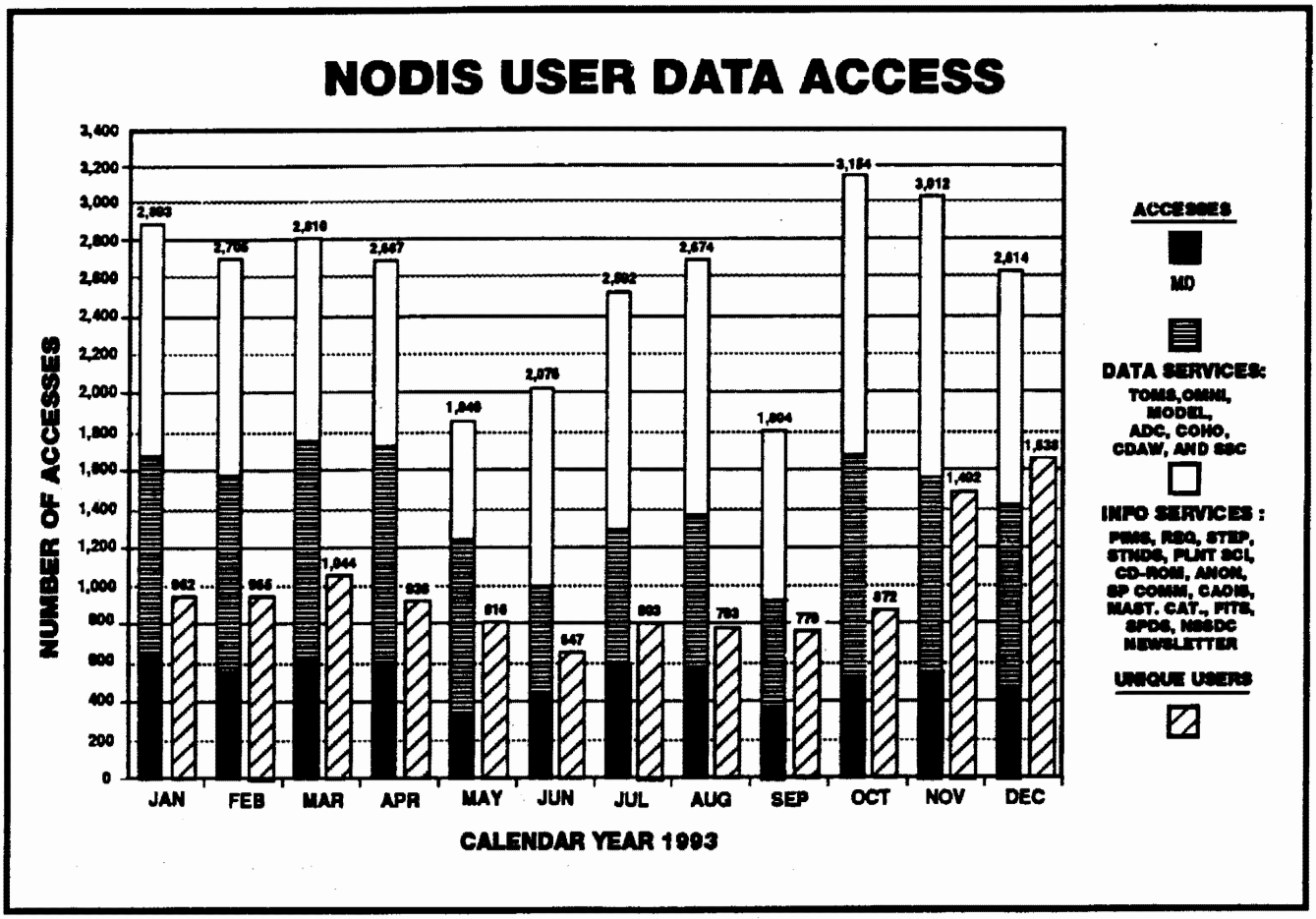

Figure 3. NODIS Options Accesses/Users for 1993

Technology Information System (STIS); the NASA CD-ROM service; and other on-line services. Figure 3 above shows 1993 monthly access rates to groups of these services.

4.2 Anonymous/FTP Access to NSSDC Data and Services

NSSDC maintains some of its most often requested data and information in directories accessible over DECnet and Internet through the Anonymous user account. Flight projects, disciplinary and multi-disciplinary services maintain directories on Anonymous for distribution of project-related data and information accessed utilizing transfer protocols to read and retrieve files.

Permanent data base directories on Anonymous include ACTIVE Data Base Satellite Ephemeris Data; providing on-line Orbital element files for active scientific spacecraft; Artificial Sky Map (ASM), documents and data; Common Data Format (CDF) documentation and software; CD-ROM containing images from NSSDC's existing CD-ROM collection; Cosmic Background Explorer (COBE) data products and related documentation; Coordinated Heliospheric Observations (COHO) data and information from instruments on Pioneer 10 and 11, Voyager 1 and 2, Helios 1 and 2, Pioneer Venus Orbiter and other spacecraft; Flexible Image Transport (FITS) documentation and software, Models Distribution and Staging Directory including holdings from the International Reference Ionosphere (IRS), COSPAR International Reference Atmosphere (CIRA), and many other solar-terrestrial models, Standard Formatted Data Unit (SFDU) information and software; Space Physics Data System (SPDS), data set listings, and other files.

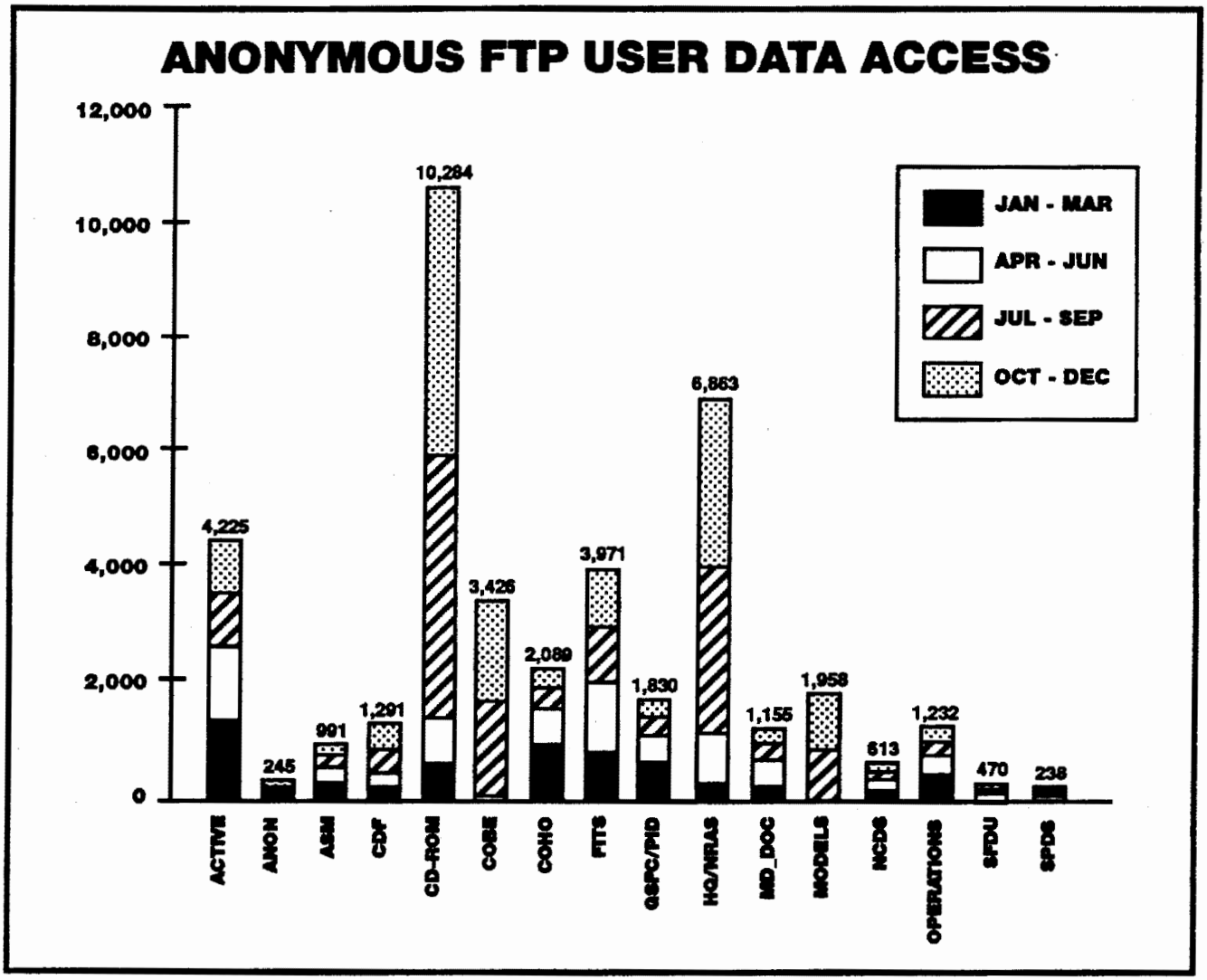

Figure 4. Annual Session Totals for Individual ANONYMOUS Services

4.3 Master Directory/Catalog Interoperability (MD/CI)

The Master Directory at Goddard Space Flight Center was originally established as an aid for NASA-funded researchers to find data. The directory contains brief summary information about data sets sufficient for researchers to determine whether further investigation is warranted. It also provides automated links to other information systems that give more detail on data sets of interest (guides) or on the parts of the data sets (inventories), or an indication of whom to talk to for additional information. The directory serves its purpose well, and other agencies and international organizations have been given copies of the directory software to perform the same function within their groups. These directories have been interconnected via computer network to enable information sharing to the benefit of all. In addition, the directory at Goddard Space Flight Center has been requested to serve as the centralized Global Change Master Directory for describing the global change data holdings of the U.S. federal agencies. (During 1994 steps were taken to separate the NSSDC-managed NASA Master Directory for which responsibility was recently transferred to the Global Change Data Center at Goddard. In addition, World Wide Web access to the Master Directory was being provided.)

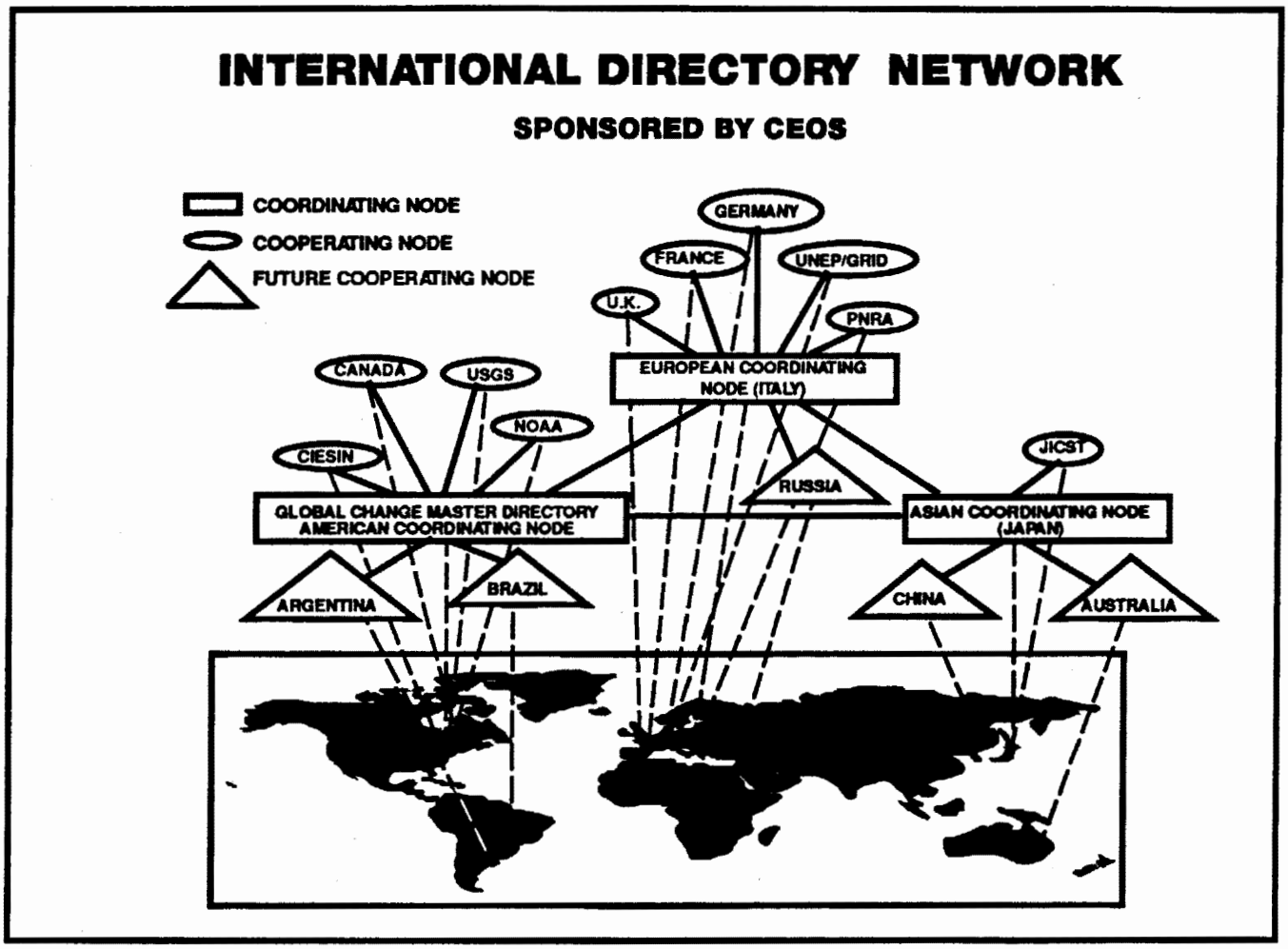

Figure 5. International Directory Network

The directories represent the most widely-used part of the interoperable data information system. This is evident from their ever-increasing usage. The Master Directory at GSFC has been operational for four years, and present usage is approaching 10,000 user sessions per year at the GSFC node. Since the directory is intended to provide quick information to users and lead them to actual data sources, wherever they may be, the users do not need many sessions to obtain results. Thus, several thousand users were accommodated by the Goddard node during last year.

Not just data sets are described in the directory. There is also supplementary information about other data information systems and data archives, organized data collecting campaigns and projects, data sources such as spacecraft or Earth-based observing platforms, and data sensors used to acquire the data. The number of data information systems described in the directory has reached nearly 140. Approximately 70 data information systems may be directly accessed from the directory through an automated network link performed automatically upon request by the user.

For more than eight years a project called Catalog Interoperability or CI has been seeking to enable rapid and efficient identification, location, and access to data of interest to the science community. It started as a NASA effort but now includes representatives from other U.S. federal agencies, international agencies, and academic institutions. The goal of the CI group is to create a worldwide data information network composed of interconnected directory, guide, and inventory systems.

The first steps to establishing this network were to create directories to aid in finding data. The NASA Master Directory was created to serve this purpose for NASA.

A common format for describing data sets on the directory level has been developed by the Catalog Interoperability group, called the Directory Interchange Format (DIF), which is used as the basis of information to be shared among the directories. These DIF files can be passed among the directories to keep their information up to date.

THE INTERCONNECTED DIRECTORY SYSTEM

With the development of the DIF, the sharing of information among directories was made significantly easier. An interconnected International Directory Network (IDN) that would share information via DIF file exchange was formed. Figure 5 shows the present configuration of the directory system. (See page 40.) These are just the directory nodes. Connections to other data information systems (guides, inventories) are not shown. The directory nodes include the three coordinating nodes that are identical copies of each other and have the main responsibility for gathering, reviewing, and distributing data information throughout the network. The coordinating nodes are located at GSFC; at the European Space Agency (ESA) office in Frascati, Italy; and at the Earth Observation Center in Hatoyama, Japan.

Cooperating nodes share in the information distribution by contributing directory information. They may have full or partial directory data bases according to their needs. The present nodes are the Canadian Centre for Remote Sensing (CCRS) node in Ottawa, Canada; the NOAA Earth System Data Directory (NESDD); the USGS Earth Science Data Directory (ESDD); the Deutsches Forschungs Anstalt für Luft- und Raumfahrt (DLR) node in Munich, Federal Republic of Germany; the United Nations Environmental Programme/Global Resources Information Data Base (UNEP/GRID) node in Geneva, Switzerland; the Antarctic data base directory node in Italy (PNRA); the British National Space Center node (U.K.); the French space agency node (CNES); the Japan Information Center for Science and Technology (JICST); and the Consortium for International Earth Science Information Network (CIESIN) distributed nodes. A number of additional nodes are planned for the near future.

MASTER DIRECTORY STATUS

The information content of the directory has made similar progress. As shown in Figure 6, over 2,000 entries are contained in the directory, describing the most useful and usable data sets in

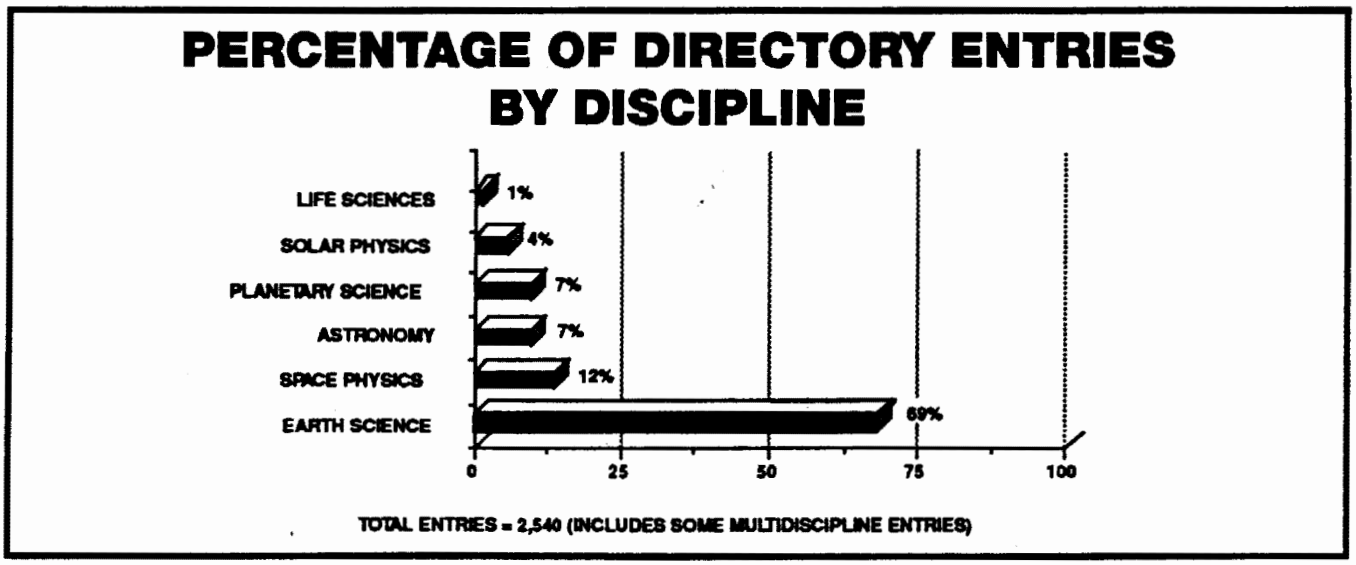

Figure 6. Percentage of Directory Entries by Discipline

the six major discipline categories. (See page 41.) Since more than one data set can be described in a single entry (and sometimes tens to hundreds may be aggregated in this way), there are many more than 2,000 data sets described in the directory. Hundreds of these were added in the past year, and many of the existing entries were reviewed and/or revised. This reflects the emphasis on keeping information current as well as maintaining quality and utility of the entries rather than concentrating only on increasing quantity. The number of entries will increase more rapidly as the new directory nodes of the IDN begin to describe their data holdings and the data in their surrounding community.

DIRECTORY ACCESS

The best way to reach an understanding of the nature and utility of the directories is to try them. Table 27 shows the procedures for accessing the directory at NASA/GSFC through several networks or via dial-in line. (See below.)

CATALOG INTEROPERABILITY

As mentioned previously, the directories are only the first step in achieving the goals of catalog interoperability. Once users have determined from the directory where data of interest might reside, they usually need to obtain more information about the data and/or determine whether data exist for a particular criterion, such as time or location. The CI project seeks to make the simple interconnection process (level 1 interoperability) ever more efficient.

Several methods of potential use to increase interoperability are currently being applied in limited situations. Context passing (level 2 interoperability) was demonstrated in 1990 using the Master Directory and several remote systems. A limited form of automated multi-system searching (one form of level 3 interoperability), which does not assume Standard Query Language (SQL) data bases in remote systems, is being developed for Version 0 of the EOS project Data and Information System (EOSDIS). The Astrophysics Data System (ADS) is testing multi-system searching through creating a uniform data base overlay software. Other groups are also testing different methods of multi-system searching. The lessons learned from these various approaches will be applied more generally in the future to improve the overall search process and access to data.

NSI/DECnet

$ SET HOST NSSDCA

USERNAME: **NSSDC**

INTERNET

TELNET NSSDC.GSFC.NASA.GOV

TELNET 128.183.36.23

USERNAME: **NSSDC**

DIAL-IN LINES

Dial 301-286-9000

CONNECT 1200 (or 2400 or 300)
Enter several carriage returns
ENTER NUMBER

MD
CALLING 55201 (or 55202)
CALL COMPLETE
Enter several carriage returns
USERNAME: **NSSDC**

ITALICS INDICATE RESPONSE FROM THE COMPUTER.

Table 27. Directory Access

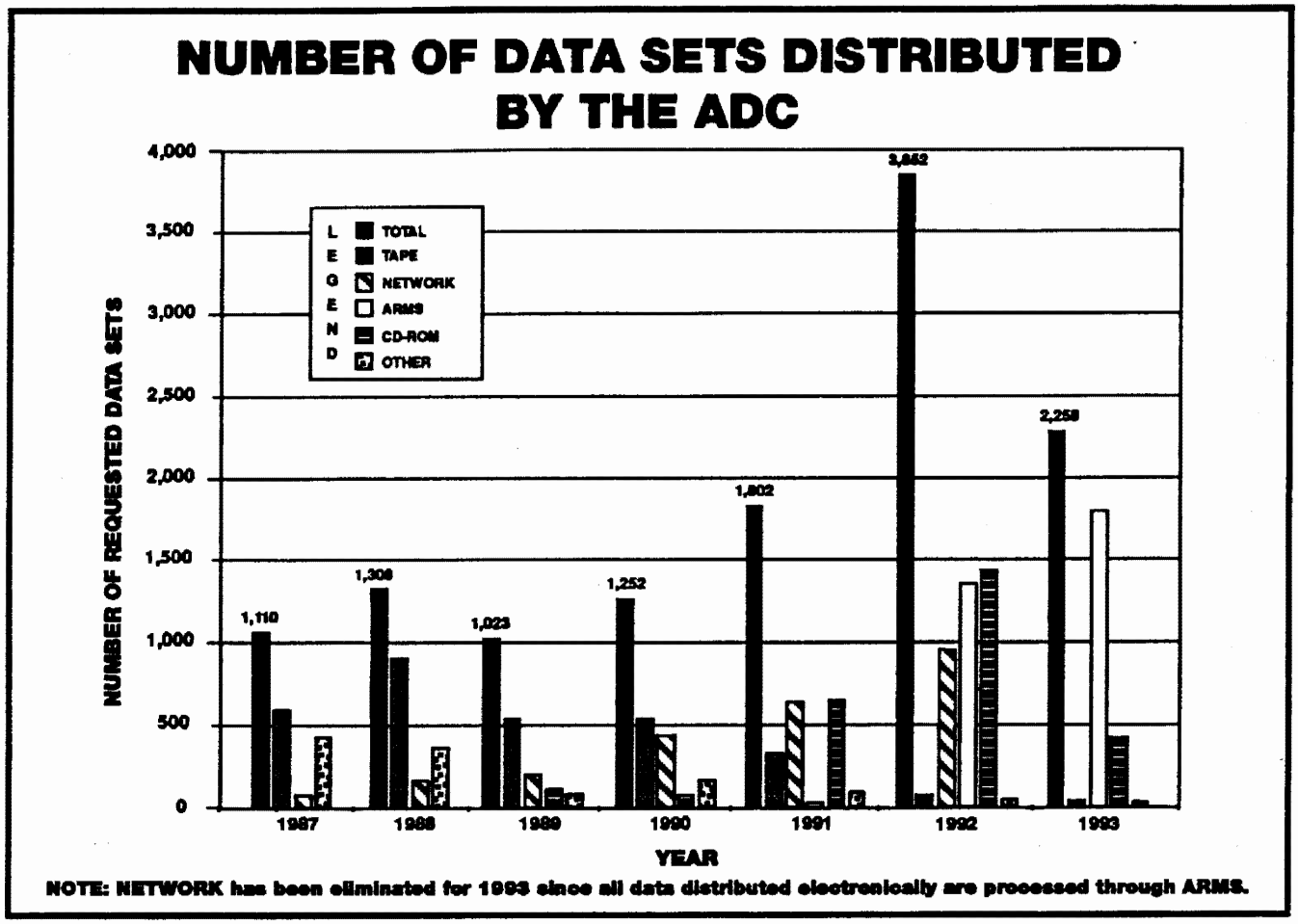

Figure 7. Requests and Number of Data Sets Distributed by the ADC

4.4 Astronomical Data Center (ADC)

The Astronomical Data Center (ADC) is part of the National Space Science Data Center/World Data Center-A for Rockets and Satellites at NASA Goddard Space Flight Center. The ADC acquires, verifies, formats, documents, and distributes catalogs containing astronomical data in computer-readable form. It also develops and maintains software tools to access these data.

During 1993 the ADC ingested 82 new and updated catalogs, including several significant acquisitions such as the *Hipparcos Input Catalogue, Version 2* (Turon et al., 1993), *Tycho Input Catalogue* (Egret et al., 1992), *Improved Collisional Excitation Rates for Interstellar Water* (Green et al., 1993), *An Atlas of Ultraviolet Spectra of Starforming Galaxies* (Kinney et al., 1993), *A Catalog and Atlas of Cataclysmic Variables* (Downes and Shara, 1993), and *The 6C Survey of Radio Sources – I-VI* (Baldwin, Hales et al., 1985-93). The ADC archives currently contain more than 740 catalogs of astrometry, photometry, spectroscopy, radio, and other miscellaneous data for stellar and non-stellar objects. These catalogs were acquired as direct contributions from the international astronomical community, exchanges with the Centre de Données Astronomiques de Strasbourg (CDS), and exchanges with other astronomical data centers worldwide.

To date the ADC has distributed more than 11,000 data sets via computer networks, tape, CD-ROM, microfiche, and microfilm to more than 3,300 individual requesters worldwide. The ADC has

provided data and/or software to various space astronomy projects, such as the InfraRed Astronomical Satellite (IRAS), the International Ultraviolet Explorer (IUE), the Hubble Space Telescope (HST), the Cosmic Background Explorer (COBE), the ASTRO 1 Ultraviolet and X-Ray Astronomy Space Shuttle Mission, and the High Energy Astrophysics Science Archive Research Center (HEASARC).

In 1993 the staff of the ADC prepared a new reference publication for its user community, the *Astronomical Catalog Desk Reference*. The first edition of this book contains lists, indices, and brief descriptions of data sets available from the ADC, information on how to get those data sets, and information on other sources for astronomical catalogs.

The ADC also published the three *Durchmusterung (DM) Catalogs* in ten volumes and a cross index of the *Washington Double Star Catalog*, the *HD*, the *Aitken Double Star Catalog*, and the *Durchmusterungs*. The *Durchmusterungs* had been out of print for many years. They were printed from the electronic version with many corrections included.

During 1993 the ADC began to make its information available via the Internet system known as the World Wide Web (WWW). From WWW users can learn about the ADC, access its on-line information system, and search ADC data set documents by text string.

THE ASTRONOMICAL DATA CENTER CD-ROM, SELECTED ASTRONOMICAL CATALOGS, VOLUME I

This ADC CD-ROM set has been one of the most frequently requested data sets at the NSSDC in 1993. It has been used by the community as a convenient compilation to make catalogs available from on-line data bases for further research. Especially searches across catalogs were made easier because the ADC CD-ROM used consistent headers from catalog to catalog.

The NSSDC/ADC demonstrated a range of interactive data services and distributed hundreds of CD-ROMs at the 181st meeting of the American Astronomical Society (AAS), held in Phoenix, Arizona, on January 4-8, 1993. Those not among the over 2,000 astronomers worldwide who have already requested and received Volume I should know that the Astronomical Data Center CD-ROM, Selected Astronomical Catalogs, Volume I is currently available from the NSSDC/WDC-A-R&S.

The ADC CD-ROM is a two-disk set containing 114 astronomical catalogs, including several significant new releases, such as the *Astrographic Catalog Reference Stars* (Corbin and Urban, 1991), *IRAS Faint Source Catalog, Version 2.0* (IPAC, 1990), and preliminary versions of the *General Catalog of Trigonometric Stellar Parallaxes* (van Altena et al., 1991), the *Catalog of Nearby Stars* (Gliese et al., 1991), and the *Fifth Edition of the Bright Star Catalog* (Hoffleit and Warren, 1991), prepared especially for this CD-ROM release.

The catalogs appearing on the ADC CD-ROM were chosen in consultation with the astronomical data centers in China, France, the Federal Republic of Germany, Japan, and the Commonwealth of Independent States (C.I.S.). The International Astronomical Union (IAU) has lent valuable support in the form of a grant to defray costs of distributing the data to small institutions in developing countries that might otherwise have difficulty in acquiring and using such large volumes of data.

Requests for this CD-ROM set may be placed using the on-line information system described below (select catalog number 6906A) or may be forwarded to the NSSDC Coordinated Request and User Support Office (CRUSO). CRUSO's contact information appears at the end of this section.

THE ADC ON-LINE INFORMATION SYSTEM

The ADC On-Line Information System provides information on all catalogs held at the ADC and allows interactive submission of requests. In 1992 the ADC On-Line Information System was the most frequently used method in the efficient location of astronomical catalogs of interest and in the fulfillment of requests for the data sets selected. The system is maintained under a "captive" account on the NSSDC VAX cluster called the NSSDC On-Line Data and Information Service (NODIS). One may connect to the NODIS account over NSI/DECnet or Internet. To connect through NSI/

GENERAL INQUIRIES DEALING WITH CATALOG REQUESTS Contact:

Requesters WITHIN the United States:

NSSDC Coordinated Request and User Support Office
NASA/Goddard Space Flight Center
Code 633.4
Greenbelt, Maryland 20771, U.S.A.

Requesters OUTSIDE the United States:

World Data Center-A for Rockets and Satellites
NASA/Goddard Space Flight Center
Code 633
Greenbelt, Maryland 20771, U.S.A.

For all requesters:

Internet: REQUEST@NSSDCA.GSFC.NASA.GOV
NSI/DECnet: NSSDCA::REQUEST
Telephone: (301) 286-6695; FAX: (301) 286-1771

GENERAL INQUIRIES ON ASTRONOMICAL CATALOGS, DATA SUBMISSION, AVAILABILITY, AND THE ADC ON-LINE INFORMATION SYSTEM:

Gail L. Schneider
National Space Science Data Center
Hughes STX
Code 633
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771, U.S.A.
Internet: GAIL@NDADSA.GSFC.NASA.GOV
NSI/DECnet: NDADSA::GAIL
Telephone: (301) 286-8310; FAX: (301) 286-1771

QUESTIONS ABOUT SCIENTIFIC CONTENT OF CATALOGS:

N. Paul M. Kuin
National Space Science Data Center
Hughes STX
Code 633
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771, U.S.A.
Internet: KUIN@NSSDCA.GSFC.NASA.GOV
NSI/DECnet: NSSDCA::KUIN
Telephone: (301) 286-0677; FAX: (301) 286-1771

Nancy G. Roman
National Space Science Data Center
Hughes STX
Code 633
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771, U.S.A.
Internet: ROMAN@HYPATIA.GSFC.NASA.GOV
NSI/DECnet: NSSDCA::ROMAN
Telephone: (301) 286-4070; FAX: (301) 286-1771

QUESTIONS ON CD-ROM DEVELOPMENT:

Lee E. Brotzman
National Space Science Data Center
Hughes STX
Code 633
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771, U.S.A.
Internet: BROTZMAN@NDADSA.GSFC.NASA.GOV
NSI/DECnet: NDADSA::BROTZMAN
Telephone: (301) 441-4172; FAX: (301) 441-9486

GENERAL QUESTIONS AND COMMENTS ON ADC SERVICES AND SUPPORT:

N. Paul M. Kuin
National Space Science Data Center
Hughes STX
Code 633
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771, U.S.A.
Internet: KUIN@NSSDCA.GSFC.NASA.GOV
NSI/DECnet: NSSDCA::KUIN
Telephone: (301) 286-0677; FAX: (301) 286-1771

David Leisawitz
Astrophysics Data Facility
Code 631
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771, U.S.A.
Internet: LEISAWITZ@STARS.GSFC.NASA.GOV
NSI/DECnet: STARS::LEISAWITZ
Telephone: (301) 286-0807; FAX: (301) 286-1771

Table 28. ADC Contact and Subscription Information

DECnet, users can execute

```
SET HOST NSSDCA
```

To connect through Internet, users can execute

```
telnet nssdca.gsfc.nasa.gov or
telnet 128.183.36.23
```

Once connected, users should enter "NODIS" in response to the "Username:" prompt; no password is required. NODIS is integrated with the NSSDC Request Activity and Name Directory (RAND). The system will ask for the user's name and check the NSSDC requester data base for a match. If users have never requested data from NSSDC before, they should enter complete information so that any catalog requests registered later will be filled promptly and correctly.

Currently, NODIS has two menu display options, a window-like and textual manual display; the Astronomical Data Center is option 2.1. Once connected to the ADC option, users will notice some

system messages followed by the opening menu of search options. The on-line system assumes that the user is using a VT100-compatible terminal and emits ANSI escape sequences to clear the screen.

The system has three search options – by ADC (CDS) number, by text search of abbreviated titles, and by text search of keywords. Each of these options is designed to create a list of catalogs meeting the given criteria. Catalogs are then selected from the list, and information such as the full title and reference, file format description, comments, and the current distribution status is displayed. Requests can be entered interactively; the system will guide the user through providing the information necessary to fulfill the request.

THE NDADS AUTOMATED RETRIEVAL MAIL SYSTEM (NDADS ARMS)

In December 1991 the ADC-held data were written to optical disk platters with the disks residing in a robotic "jukebox" near-line environment. Requests for data over the network are filled by the Automated Retrieval Mail System (ARMS) on the NSSDC Data Archives and Distribution Service (NDADS). Each request is usually filled within ten minutes after the files have been requested. When the data are ready, requesters are notified by E-mail. ARMS also permits researchers to rapidly retrieve selections from the current ADC NDADS holdings. Requests are submitted via electronic mail, and the data may be retrieved via anonymous FTP or default NSI/DECnet copy. It is also possible to arrange to have the data sent directly to the requester's computer.

For more information on ARMS, users can send an electronic mail message as follows:

Via NSI/DECnet:

```
Send to: NDADSA::ARCHIVES
Subject: SEND INFORMATION
```

Or via Internet:

```
Send to: ARCHIVES@NDADSA.GSFC.NASA.GOV
Subject: SEND INFORMATION
```

No information is required in the body of the mail message in order to receive a reply. Users should note that this is an automated service. Although the mail is monitored, staff do not normally reply to E-mail sent to ARCHIVES.

ADC ELECTRONIC NEWSLETTER

The ADC started to publish the quarterly *ADC Electronic News* in 1992 to inform the astronomical community about new data holdings and services. Issues contain lists of the latest acquisitions, articles about ADC services, and errata for the ADC CD-ROM and other catalogs. More than 900 astronomers worldwide received the *ADC Electronic News* in 1993.

New subscriptions to the *ADC Electronic News* can be made by sending E-mail to

```
LISTSERV@HYPATIA.GSFC.NASA.GOV
```

In the body of the mail message (not the subject line), users should put only the following command:

```
SUBSCRIBE ADCNEWS <Your Name>
```

where <Your Name> is a full name, not a user ID or an E-mail address. The LISTSERV program will get the proper E-mail address for the subscription from the mail header. Once the subscription is accepted, a "welcome" message will explain how to get back issues.

Users can send subscription questions via E-mail to

```
ADC-INFO@HYPATIA.GSFC.NASA.GOV
```

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PUBLICATIONS LIST 1993

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Bonner Durchmusterung Volume 3, NSSDC/WDC-A-R&S 93-04, February 1993.

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Vol. 2, No. 1, January 1993
Vol. 2, No. 2, April 1993
Vol. 2, No. 3, July 1993
Vol. 2, No. 4, October 1993

Gass, J., A. Warnock, L. Brotzman, D. Kovalsky, M. E. Van Steenberg, and F. Giovane, "The Electronic Distribution of Astronomical Literature," OSSA *Information Systems Newsletter*, Issue 27, January 1993.

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Vol. 9, No. 1, Spring 1993
Vol. 9, No. 2, Summer 1993
Vol. 9, No. 3, Fall 1993
Vol. 9, No. 4, Winter 1993

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SPX/471, January 1993
SPX/472, February 1993
SPX/473, March 1993
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SPX/475, May 1993
SPX/476, June 1993

SPX/477, July 1993
SPX/478, August 1993
SPX/479, September 1993
SPX/480, October 1993
SPX/481, November 1993
SPX/482, December 1993

Solar-Terrestrial Energy Program (STEP) newsletter, *STEP International*, published monthly by the NSSDC, 12 issues:

Volume 3, No. 1, January 1993
Volume 3, No. 2, February 1993
Volume 3, No. 3, March 1993
Volume 3, No. 4, April 1993
Volume 3, No. 5, May 1993
Volume 3, No. 6, June 1993
Volume 3, No. 7, July 1993
Volume 3, No. 8, August 1993
Volume 3, No. 9, September 1993
Volume 3, No. 10, October 1993
Volume 3, No. 11, November 1993
Volume 3, No. 12, December 1993

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ACRONYMS AND ABBREVIATIONS LIST

AAS	American Astronomical Society
ACT	Achievement Course Training
ADC	Astronomical Data Center
ADS	Astrophysics Data System
AIAA	American Institute for Aeronautics and Astronautics
AIM	Automated Internal Management File
ANSI	American National Standards Institute
ARMS	Automated Retrieval Mail System
ARPAnet	Advanced Research Projects Agency Network
ASM	Artificial Sky Map
BATSE	Burst And Transient Spectrometer Experiment
BNSC	British National Space Centre
CCRS	Canadian Centre for Remote Sensing
CCSDS	Consultative Committee for Space Data Systems
CDF	Common Data Format
CDHF	Central Data Handling Facilities
CD-ROM	Compact Disc-Read Only Memory
CDS	Centre de Données de Strasbourg
CI	Catalog Interoperability
CIESIN	Consortium for International Earth Science Information Network
CIRA	COSPAR International Reference Atmosphere
C.I.S.	Commonwealth of Independent States
CNES	Centre Nationale d'Etudes Spatiales
COBE	Cosmic Background Explorer
COHO	Coordinated Heliospheric Observations
COSPAR	Committee On Space Research
CRUSO	Coordinated Request and User Support Office
CSA	Canadian Space Agency
CZCS	Coastal Zone Color Scanner
DBMS	Data Base Management System
DE	Dynamics Explorer
DECnet	Digital Equipment Corporation network
DIF	Directory Interchange Format
DLR	Deutsches Forschungs Anstalt füer Luft- und Raumfahrt
EGRET	Energetic Gamma-Ray Experiment Telescope
EOS	Earth Observing System
EOSDIS	EOS (project) Data and Information System
ERB	Nimbus 7 Earth Radiation Budget Instrument
ERBE	Nimbus 7 Earth Radiation Budget Experiment
ERBS	Earth Radiation Budget Satellite
ESA	European Space Agency
ESDD	USGS Earth Science Data Directory
E-SPAN	SPAN in Europe
FITS	Flexible Image Transport System
FRG	Federal Republic of Germany
FTP	Anonymous File Transfer Protocol

GCMD	Global Change Master Directory
GGS	Global Geospace Science
GRO	Gamma Ray Observatory
GSFC	Goddard Space Flight Center
HEAO	High Energy Astrophysics Observatory
HEASARC	High Energy Astrophysics Science Archive Research Center
HST	Hubble Space Telescope
IDA	Interactive Data Archive
IDL	Interactive Data Language
IDN	International Directory Network
IMP	Interplanetary Monitoring Platform
INPE	Instituto Nacional de Pesquisa Espaciais
IRAND	Interactive Request Activity and Name Directory
IRAS	Infrared Astronomical Satellite (The Netherlands-NASA-U.K.)
IRS	International Reference Ionosphere
ISCCP	International Satellite Cloud Climatology Project
ISEE	International Sun-Earth Explorer
ISO	Information Systems Office
ISO	International Standards Organization
ISTP	International Solar-Terrestrial Physics
IUE	International Ultraviolet Explorer (satellite, NASA-U.K.-ESA)
IUWDS	International URSIGRAM and World Days Service
JICST	Japan Information Center for Science and Technology
JPL	Jet Propulsion Laboratory (NASA)
MD	Master Directory (NASA)
NASA	National Aeronautics and Space Administration
NASDA	National Aeronautics and Space Development Agency
NCDS	NASA's Climate Data System
NDADS	NSSDC Data Archive and Distribution System
NESDD	NOAA Earth System Data Directory
NMD	NASA Master Directory
NOAA	National Oceanographic and Atmospheric Administration
NODIS	NSSDC On-Line Data and Information Services
NOST	NASA/Science Office of Standards and Technology
NRAO	National Radio Astronomy Observatory
NSDF	NSSDC Supplemental Data File
NSSDC	National Space Science Data Center (NASA)
OMNI	Interplanetary Medium Data
OSSA	Office of Space Science and Applications
OSSE	Oriented Scintillation Spectrometer Experiment
PIMS	Personnel Information Management System
PNRA	Programme Nazionale di Ricerche Antartide
RAND	Request Activity and Name Directory
REQ	NSSDC Data Request Service

ROSAT	Roentgen Satellite (German X-ray research satellite)
RSI	Research Systems Incorporated
RSIRS	Relational System for Information Retrieval and Storage
SAGE	Stratospheric Aerosol and Gas Experiment
SFDU	Standard Formatted Data Unit
SHARP	Summer High School Apprentice Research Training Program
SIR	Shuttle Imaging Radar
SOHO	Solar and Heliospheric Observatory
SPACEWARN	World Warning Agency for Satellites
SPAN	Space Physics Analysis Network
SPDS	Space Physics Data System
SPOT	Systeme Probatoire d'Observation de la Terre
SQL	Standard Query Language
SSDOO	Space Science Data Operations Office
SSI	Solid State Imaging
STELAR	Study of Electronic Literature for Astronomical Research
STEP	Solar-Terrestrial Energy Program
STIS	Standards and Technology Information System
TOMS	Total Ozone Mapping Spectrometer
TRF	Technical Reference File
TsNIIMash	Central Research Institute of Machine Building (TsNIIMash) Russian Federation
UARS	Upper Atmospheric Research Satellite
U.K.	United Kingdom
UNEP/GRID	United Nations Environmental Programme/Global Resources Information Data Base
USGS	United States Geological Survey
USRSDC	U.S. ROSAT Science Data Center
US-SPAN	SPAN in the U.S.
WDC-A-R&S	World Data Center-A for Rockets and Satellites
WORM	Write-Once, Read-Many
WUPPE	Wisconsin Ultraviolet Photopolarimetry Experiment