ORBITAL ANOMALIES IN GODDARD SPACECRAFT

FOR

CY 1989

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ASSURANCE REQUIREMENTS OFFICE

OFFICE OF FLIGHT ASSURANCE

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TO: Distribution

FROM: 302/Assurance Requirements Office

SUBJECT: Correction to Reports, *Orbital Anomalies in Goddard Spacecraft for CY1987, 1988, 1989 & 1990*

The purpose of this memorandum is to advise recipients of any of the four subject reports that some of the textual information, in the body of the report and Appendix A, concerning the Landsat-5 Ku Band is in error. The Ku Band subsystem in the spacecraft is functioning satisfactorily (presently using the redundant unit) and it is regularly used to send data from the Thematic Mapper (TM) to the ground via the TDRSS.

William G. Elsen

Summary

This report presents a summary of the in-orbit reliability performance of spacecraft built under the management of the Goddard Space Flight Center that were active during calendar year 1989. It is one of a series of such reports that collectively form a continuous published record of this performance. The major feature of these reports is a log of all anomalies occurring during the report period which provides a description of the anomaly and its time of occurrence. Each anomaly is classified according to criticality, type, subsystem, and other relevant criteria. Although some statistical analysis and comparisons are given, the purpose of the report is primarily documentary, with more extensive statistical treatment to be presented elsewhere.

Introduction

Since the earliest days of the Center, attempts have been made to record the performance of Goddard-managed spacecraft. Although statistical summaries exist, until the last 20 years or so the actual raw data was considered sensitive and was not published. This is unfortunate, since over the years it has been observed that the potential uses for this data are open-ended and cannot be predicted in advance. Hence, any pre-digested data is likely not to be what is needed in many instances.

The first report to contain specific anomaly data was the contractor report Analysis of Spacecraft On-Orbit Anomalies and Lifetimes, PRC R-3579, dated 10 February 1983, which covers roughly the period from 1978 to mid-1982, and includes JPL as well as GSFC spacecraft. This was followed by Orbital Anomalies in Goddard Spacecraft 1982-1983 and yearly reports since, all published by the Office of Flight Assurance. The current report updates the record through 1989.

Spacecraft Activity Schedule

At the beginning of this reporting period, on January 1 1989, there were a total of 20 GSFC spacecraft in full or partial service. This number includes ten meteorological spacecraft operated by NOAA consisting of three of the TIROS/NOAA series and five of the GOES series; Landsat-4, and Landsat-5.

There were two new spacecraft launched during the year and two older spacecraft missions were terminated. In March the TDRS-4(D) spacecraft was successfully launched on STS-29 and in November the COBE spacecraft was launched on a Delta launch vehicle. The AMPTE-CCE mission was terminated in mid-July because of inability to get commands into the spacecraft and the SMM spacecraft re-entered on December 4. The complete list of satellites active during all or part of 1989 is as follows:

NASA		NOAA
AMPTE/CCE		NOAA-9
DE-1	0	NOAA-10
ERBS	N	NOAA-11
IMP-8	G	GOES-2
ICE (ISEE-3)	0	GOES-3
IUE	I	GOES-5
NIMBUS-7	N	GOES-6
SMM	G	GOES-7
TDRS-1		Landsat-4
TDRS-3		Landsat-5
TDRS-4	NEW	
COBE		

Details are shown in the Spacecraft Lifetime Data in Appendix A, which includes virtually all GSFC launches since 1960, excluding minor GAS (Get Away Special) experiments and a number of international missions Goddard participated in but is not considered to have had responsibility.

Overall there were 50 anomalies, distributed over 13 different spacecraft, during the year. The distribution of these anomalies among the spacecraft is presented in Figure 1. (This compares with 25 anomalies distributed over ten spacecraft in the previous year, 1988).

In addition, the distribution of these 50 anomalies amongst the spacecraft subsystems is shown graphically in Figure 2. This figure shows that most of the anomalies occurred in the Attitude Control Subsystem (ACS) and the Instruments.

In the following sections, each mission and its overall performance is discussed in more detail. A complete log of anomalies appears at the end of the report in Table II.

Data Sources

The data reported herein are taken primarily from three sources. For NASA spacecraft, the main source is the Spacecraft Orbital Anomaly Reports (SOAR). For TIROS/NOAA spacecraft the TIROS Orbital Anomaly Reports (TOAR) are used, and the GOES Anomaly Reports (GAR) cover the GOES series. These data bases are maintained by the Assurance Requirements office, in the case of SOAR, and the METSAT Office in the case of TOAR and GAR. The information contained in these reports originates in the corresponding spacecraft operations control centers. Supplementary information is obtained through miscellaneous written reports, attendance of the regular meetings of the Orbiting Satellites Project, and other verbal contacts. Additional backup information on many of these anomalies is available through this office, and are subject to revision. This applies particularly to "open" anomalies.

Spacecraft Performance Summary

The following provides a summary of the condition and performance of the active spacecraft covered by this report:

AMPTE/CCE (Active Magnetospheric Particle Tracer Explorers/charge Composition Explorer)

In early January there was a failure in Command Processor (CP) No. 2 which prevented commanding the spacecraft. The redundant unit, CP No. 1, had failed in April 1988. The ability to command the spacecraft returned in late February and it was possible to configure the spacecraft for the eclipse season, then beginning. At the end of March the spacecraft once again stopped accepting commands. In mid-April telemetry from the spacecraft ceased. The instruments had been turned off. The spacecraft briefly started accepting commands again in early June and in early July. A decision was made to terminate the mission and this was done on July 14th.

COBE (Cosmic Backround Explorer)

This spacecraft, built in-house at Goddard, was launched on a Delta Launch Vehicle into a polar orbit on November 18, 1989. Within 4 days after launch one of the gyros failed and had to be removed from the control loop. This has not hampered attitude control since there are sufficient other gyros for controlling the spacecraft. There were some other minor anomalies that did not detract from the mission. The science data has been excellent and the temperature of the dewar has been running colder than hoped which increases the sensitivity of the measurements.

DE-1 (Dynamic Explorer)

This spacecraft operated throughout the year without any anomalies, achieving eight years in orbit in August. It still endures low power periods and curtailment of operations to prevent over-temperature on the tape recorder. It continued to perform worthwhile science and supported various special programs.

ERBS (Earth Radiation Budget Satellite)

The spacecraft continued to fulfill all its scientific objectives this year and, in general, performed very well. The number of command memory bit changes (bit-flips) this year was fairly low and none caused any operational problems.

On November 1 the Y-gyro in IRU-1 (Inertial Reference Unit) stopped due to bearing wear out. This was the third gyro to fail in the spacecraft and left only the Z-gyro operational in IRU-1. A "No Y-gyro" had been developed for performing yaw turns so IRU-1 was powered down and IRU-2 turned on. For the yaw turn maneuver of 11/15 this "No Y-gyro" procedure was successfully used. Eventually the X or Z gyro will fail; at that time a "Z-only" or "Gyroless" yaw turn procedure, already developed, will be implemented.

Battery aging is beginning to manifest itself as indicated by decreased minimum voltage, increased cell balance, increased temperatures, etc. This will be watched carefully and some operational changes may be required to keep from aggravating the condition.

GOES (Geostationary Operational Environmental Satellite)

GOES-5: This spacecraft was operated as the EAST SPACECRAFT all of 1989. Located at 65 Deg. W, it provided WEFAX, DCS and transponder for GOES-7 mode AAA VAS. The CTU (Central Telemetry Unit) experienced ten SEU's this year, six of which were associated with solar flares. A major solar flare on 10/19 degraded the solar array by about 0.5 amps. Attempted East-West station-keeping maneuvers in November and December did not produce the expected orbit change. Based on this under-performance and anomalous pressure and temperature telemetry, it has been concluded that the hydrazine fuel in GOES-5 has been depleted. It is expected that the spacecraft will slowly begin to drift westward. (VISSR/VAS is inoperable and SEM (Space Environmental monitor) is semi-operational due to degraded and failed channels.)

GOES-6: This spacecraft served as the West operational spacecraft during all of this year positioned at 135 deg West Longitude. It provided WEFAX, DCS and SEM support. On January 21 the final encoder lamp failed, thus ending VAS operations and leaving GOES-7 as the only GOES spacecraft providing imaging data. The telemetry subsystem continued to show degradation throughout 1989 and in late August the RTU-3 (Remote Telemetry Unit) failed completely. Redundant RTU-4 was selected restoring valid telemetry. The October solar flare, mentioned above, also caused a degradation of the solar array on this spacecraft. The amount of hydrazine fuel remaining is very low and North-South maneuvers have been suspended to save fuel for East-West maneuvers.

GOES-7: After the failure of the GOES-6 VAS in January, GOES-7 was designated PRIME spacecraft and repositioned to 108 Deg. W in mid February. This Winter/Spring station was maintained until June to provide better coverage of Pacific winter storms. To provide better coverage during the Atlantic hurricane season, GOES-7 was moved to 98 Deg. W in mid July and maintained there until November, when it was returned to 108 Deg. W for the Winter. This spacecraft provided AAA VAS and SEM all year.

The new LED's in the VAS encoder have performed flawlessly without any erroneous scan lines occurring. These LED's have replaced the incandescent lamps used in earlier GOES.

Solar flare activity late in the year caused a 7% degradation of solar array power capability. This shouldn't cause any problem assuming normal degradation in future years.

ICE (International Cometary Explorer)(formerly ISEE-3)

This 11-year old spacecraft continued to operate successfully throughout this year without any reported anomalies. It continued to provide some good science in its highly eccentric orbit. In May it observed some CME (Coronal Mass Ejection) events on the sun. Taking of data from the spacecraft decreased late in the year due to high priority of other spacecraft on the DSN (Deep Space Network). (Several instruments are partially degraded and the battery failed in December 1981; spacecraft solar arrays always in full sun so battery not needed.)

IUE (International Ultraviolet Explorer)

In general this spacecraft, almost 12 years in orbit, continued to produce excellent science throughout the year. Starting in June it was noted that the drift rate on Gyro-5 was increasing and it continued to increase through the rest of the year. The manufacturer says it is getting old. Since the IUE has only two operational gyros left, work on a “1-gyro system" continued through the year. In addition, work has been ongoing on a "No-gyro system".

Landsat-4

There were no reported anomalies (no SOAR'S) in 1989. The Multispectral Scanner (MSS) continues to supply data and the Thematic Mapper (TM) continues to produce pictures. This is accomplished by curtailing power usage by other parts of the spacecraft when the TM is operating. This is necessary because of the degradation of the power subsystem.

[One SOAR, for an anomaly that occurred in 1988, was not received until 1990, and therefore not included in the 1988 annual report. This anomaly is being listed in the anomaly table of this report, enclosed in brackets and marked with an asterisk.]

Landsat-5

Like Landsat-4 there were no anomalies reported on this spacecraft for 1989. Since the Ku-Band system is out of commission, the only way TM data can be transmitted to the ground is via X-Band to a ground station. There are a number of foreign ground stations that are receiving TM imagery. The TM is operating satisfactorily and the MSS continues to operate satisfactorily.

[A SOAR, for an anomaly that occurred late in 1987, was not received until 1990, and therefore not included in the 1987 anomaly report. This anomaly is being listed in the anomaly table of this report, enclosed in brackets and marked with an asterisk.]

Nimbus-7

In October this spacecraft celebrated 11 years in orbit.

Instruments which continue to operate are: the SAM II (Stratospheric Aerosol Measurement II), the SBUV/TOMS (Solar Backscatter Ultraviolet/Total Ozone Mapping Spectrometer), and the ERB (Earth Radiation Budget).

There were only minor anomalies reported in 1989. Three of them involved the ERB Instrument. One of these ERB anomalies involved temporary loss of the entire instrument. In September there was a failure in the analog multiplexer/digital converter which suspended operation. However four or five days later it started working normally again and has been ok ever since.

NOAA-9

This spacecraft was in a standby status for all of 1989. However it is still providing some low rate science data from the ERBE and the SBUV. The spacecraft has almost continuous power problems requiring extensive power control management.

The AVHRR imagery had it ups and downs throughout the year and in December it began operating like a "young" instrument again.

High solar activity in mid-March caused unusual momentum wheel activity and the roll/yaw coil switched to its backup. However proper attitude control was maintained throughout the event.

In May the number of real time contacts with the spacecraft was reduced to three per day due to the standby status of NOAA-9.

A minor anomaly was written in late March for a telemetry count shift from SATCU. This has happened before on both NOAA-9 and NOAA-11.

The AVHRR and the other instruments, with the exception of the ERBE-Scanner and SARP are functioning well and are operational.

NOAA- 1 0

Early in the year the AVHRR instrument experienced some jitter and noise on channel 3 but it settled down again for awhile. It acted up again in September with "sync" problems but settled down again in a few days.

The mid-March high solar activity affected NOAA-10 in about the same way it affected NOAA-9.

On May 22 the ERBE-Scanner instrument failed due to an electronics failure in a ROM. This failure is similar to the failure of the ERBE-S on NOAA-9 in January 1987.

In the latter quarter of the year the power system performance indicated that some more solar array shunts probably failed. The array has to be offset 70 to 80 degrees to reduce current.

In October there was a minor failure in Digital Tape Recorder 1A which slightly reduces its capacity.

As of September 17 NOAA-10 had been in orbit three years.

NOAA-11

This spacecraft, launched in September of 1988, is the operational afternoon ascending spacecraft. It has experienced a number of minor failures and anomalies during the year. In January one of the DRUs (Data Recovery Unit) failed which reduces the capacity of the DCS (Data Collection System) to process platform transmissions.

From January through September there were at least five occasions when the attitude control mode switched to YGC (Yaw Gyro Compassing) for no apparent reason. It was always possible to return to nominal mode and has been more of an annoyance than anything else. (This has happened on NOAA-10 also).

The March 13 solar activity affected this spacecraft in the same way as NOAA-9 and NOAA-10. Attitude control was maintained satisfactorily.

At least three times during the year the MSU (Microwave Sounding Unit) has experienced noisy telemetry in the housekeeping data; science data has not been affected.

On September 19 the Y-gyro (roll axis) in the IMU (Inertial Measurement Unit) failed, probably due to a failed spin motor. Nominal attitude control was not lost and is now being controlled by yaw, pitch, and skew gyros.

In late November tape recorders, DTR 5A & B could not be played back. This seems to be a permanent failure of these recorders. DTR 1B is now being utilized for operational data recording.

SMM (Solar Maximum Mission)

No anomalies were reported this year but the SMM re-entered the atmosphere on December 4. The mission was actually terminated on November 24 shortly after the solar arrays were jettisoned (the last of the end-of-life tests).

In March and again in October the spacecraft observed some of the largest solar flares ever recorded by SMM. The March 6th flare was a X-15 level flare and a X-13 flare was seen in mid-October.

In mid-July the "end-of-life tests" were started with the switching of the ACRIM (Active Cavity Radiometer Irradiance Monitor) to Mode 8.

In mid-November fine pointing control was lost due to the increased atmospheric drag on the spacecraft, so coarse pointing control was selected. The instruments that require fine pointing were turned off leaving only the ACRIM, HXRBS (Hard X-ray Burst Spectrometer), and GRE (Gamma Ray Experiment) still on.

As part of the final end-of-life engineering tests, the High-Gain antenna was jettisoned successfully on November 21 and the solar array successfully jettisoned on November 24. (The spacecraft lasted about 5 more hours on battery power alone.) As mentioned above SMM re-entry occurred on December 4. The actual re-entry was unobserved by anyone, as far as we know.

In its lifetime this spacecraft was very successful and accomplished considerable excellent science.

TDRSS (Tracking and Data Relay Satellite System)

TDRS-1: In April this spacecraft had its 6th anniversary in orbit. With the launch of TDRS-4 on March 13, 1989, there were two new spacecraft in orbit so the TDRS-1 was placed in a standby mode early in the year, after the TDRS-4 launch.

Five anomaly reports were written on this spacecraft this year. All of these were fairly minor in nature. One of these was the TWT-4 failure in November after behaving abnormally since late August. Operations switched to TWT-3. Also on the last day in August the SSA-R1 showed degradation probably caused by a failure in the synthesizer. No action was taken at the time since the TDRS-1 is in a standby mode.

TDRS-3: During the year this new spacecraft performed very well as TDRS-WEST, with relatively few problems. Five anomaly reports were received, all of which were of an almost negligible nature. The most noteworthy of these was a non-acquisition event in July of the Multiple Access System which resulted in the loss of six minutes of data from Landsat-4. Corrective action was a modification of procedures.

TDRS-4: On March 13th this year the third TDRS was successfully placed in orbit by STS-29. This became operational as the TDRS-EAST spacecraft.

Immediately after insertion into orbit there were a rash of mostly annoyance-type anomalies reported. These are, for example, C-Band telemetry did not indicate that it had deployed and the SA-2 antenna did not fully deploy initially due to harness interference. Additional commands did finally produce full deployment. All the anomalies are contained in the tabular listing of anomalies later in this report.

Anomaly Data: Classification and Description

In the table of anomalies (Table II), the following information is provided:

1. Index -- This is a chronological enumeration of the anomalies, beginning at launch. Numbers lower than the first number used in this report will be found in earlier reports of the series.

2. Date -- This is the date of the occurrence of the anomaly, and in parentheses the number of days since launch is given, counting launch day as one.

3. Subsystem -- For the purposes of this data base, the spacecraft is divided into nine subsystems. These are:

    1. Attitude Control and Stabilization (ACS)
    2. Power
    3. Propulsion
    4. Structure
    5. Telemetry & Data Handling (TLM & DH)
    6. Thermal
    7. Timing, Control & Command (TC & C)
    8. Instrument (payload)
    9. Other (name to be entered)

4. Criticality -- This describes the impact of the anomaly on the mission, according to the following schedule:

1. Negligible	(0 - 5% loss)
2. Non-negligible but small (Minor)	(5 - 33%)
3. 1/3 - 2/3 Mission Loss (Substantial)	(33 - 66%)
4. 2/3 to Nearly Total Loss (Major)	(66 - 95%)
5. Essentially Total Loss (Catastrophic)	(95 - 100%)

5. Description -- A brief description of the anomaly and its probable cause, if known.

6. Effect/Action -- The effect of the anomaly on the mission and corrective action, either for this mission or future missions, if any and if known.

7. Reference -- The number on the SOAR, TOAR, or GAR (if any) covering this particular incident.

Anomalies are also classified in various ways for the purpose of statistical analysis. SOAR calls for the following classifications:

ITEM	CODE	DESCRIPTION
Anomaly Effect:	1	Spacecraft failure
	2	Subsystem/instrument failure
	3	Component failure
	4	Assembly failure
	5	Part failure
	6	Subsystem/instrument degradation
	7	Indeterminate
	8	Loss of redundancy
	9	None
Failure Category:	1	Design problem
	2	Workmanship problem
	3	Part problem
	4	Environmental problem
	5	Other (w/explanation)
	6	Unknown
Type of Anomaly:	1	Systematic (would occur if identical equipment were operated under identical circumstances)
	2	Random
	3	Wearout (a special case of systematic)
	4	Indeterminate
	5	Intermittent
	6	Normal/Expected Operation

These classifications for the 1989 anomalies are given in Table I.

Using the data in Table I, the 50 "1989 anomalies" can be summarized in various ways. These are presented, following Table I, in various tables and graphs.

TABLE I

CLASSIFICATION OF 1988 ANOMALIES

Spacecraft	A	B	C	D	E	F	
AMPTE/CCE	12	7	5	1	4	4	
COBE	1	4	1	5	3	1	
	2	1	1	4	3	2	
	3	8	2	7	6	4	
	4	8	2	7	4	1	
ERBS	12	1	2	6	4	5	
	13	1	2	5	5	3	
GOES-5	34	3	2	4	5	3	
GOES-6	22	8	4	2	3	3	
	23	5	2	3	6	4	
GOES-7	13	8	1	9	6	4	
LANDSAT-4	[33	5	2	6	5	31	< 1988 Anomaly
LANDSAT-5	9	5	2	7	5	4]	< 1987 "
NIMBUS-7	55	7	2	9	6	4	
	56	8	2	9	5	5	
	57	8	1	9	5	4	
	58	8	1	9	6	5	
NOAA-9	32	5	1	9	1	1	
NOAA-10	16	2	1	9	4	1	
	17	1	1	9	4	1	
	18	8	2	2	3	1	
	19	7	1	9	6	4	
	20	5	1	9	6	2	
NOAA-11	2	8	1	5	3	2	
	3	8	1	9	6	4	
	4	1	1	7	6	5	
	5	8	1	5	3	2	
	6	1	1	7	6	5	
	7	1	2	3	6	4	
	8	5	1	9	1	1	A = Index
	9	5	1	9	5	5	
	10	5	2	3	6	4	B = Subsystem
	11	8	1	9	6	4	
TDRS-1	55	8	1	7	6	5	C = Criticality
	56	8	2	3	5	3	(Mission Effect)
	57	8	2	7	6	4	
	58	8	1	7	6	4	D = Anomaly Effect
	59	1	1	7	5	4	
TDRS-3	8	2	1	9	5	1	E = Failure Category
	9	2	1	9	4	1	
	10	1	1	9	6	4	F = Type of Anomaly
	11	8	2	7	6	4	
	12	1	1	7	6	4	

TABLE I (continued)

Spacecraft	A	B	C	D	E	F
TDRS-4		1	5	1	9	6	4
		2	4	2	9	6	1
		3	1	1	7	6	4
		4	1	1	7	6	4
		5	1	1	9	6	4
		6	1	1	9	6	4
		7	2	1	9	4	1
		8	1	1	9	6	4
		9	3	1	7	1	1

A = Index
B = Subsystem
C = Criticality (Mission Effect)
D = Anomaly Effect
E = Failure Category
F = Type of Anomaly

Criticality	No. of Anomalies
Negligible	33
Minor	15
Substantial (1/3 to 2/3 Mission Loss)	0
Major (2/3 to Nearly Total Loss)	1
Catastrophic (Total Loss)	1

[SEE FIGURE 31

The loss listed as Major, above, was the loss of the VAS on the GOES-6 spacecraft, which marked the end of the "Useful Life" of the spacecraft. The catastrophic anomaly listed (Command Processor failure) was the loss of the ability to communicate/command the AMPTE-CCE Spacecraft, which led to the termination of the mission.

Anomalv Effect	No. of Anomalies
1. S/C Failure	1
2. Subsys./Ins't Failure	2
3. Component Failure	4
4. Assembly Failure	2
5. Part Failure	4
6. Subsys./Ins't Degradation	1
7. Indeterminate	13
8. Loss of Redundancy	0
9. None	23

[SEE FIGURE 4]

Failure Category	No, of Anomalies
1. Design Problem	3
2. Workmanship Problem	0
3. Part Problem	6
4. Environmental Problem	7
5. Other (w/explan.)	8
6. Unknown	26

(SEE FIGURE 5)

Type of Anomaly	No, of Anomalies
1. Systematic	12
2. Random	4
3. Wearout	4
4. Indeterminate	23
5. Intermittent	7

[SEE FIGURE 6]

Figure - 1 1989 Anomalies - Distribution Among Spacecraft

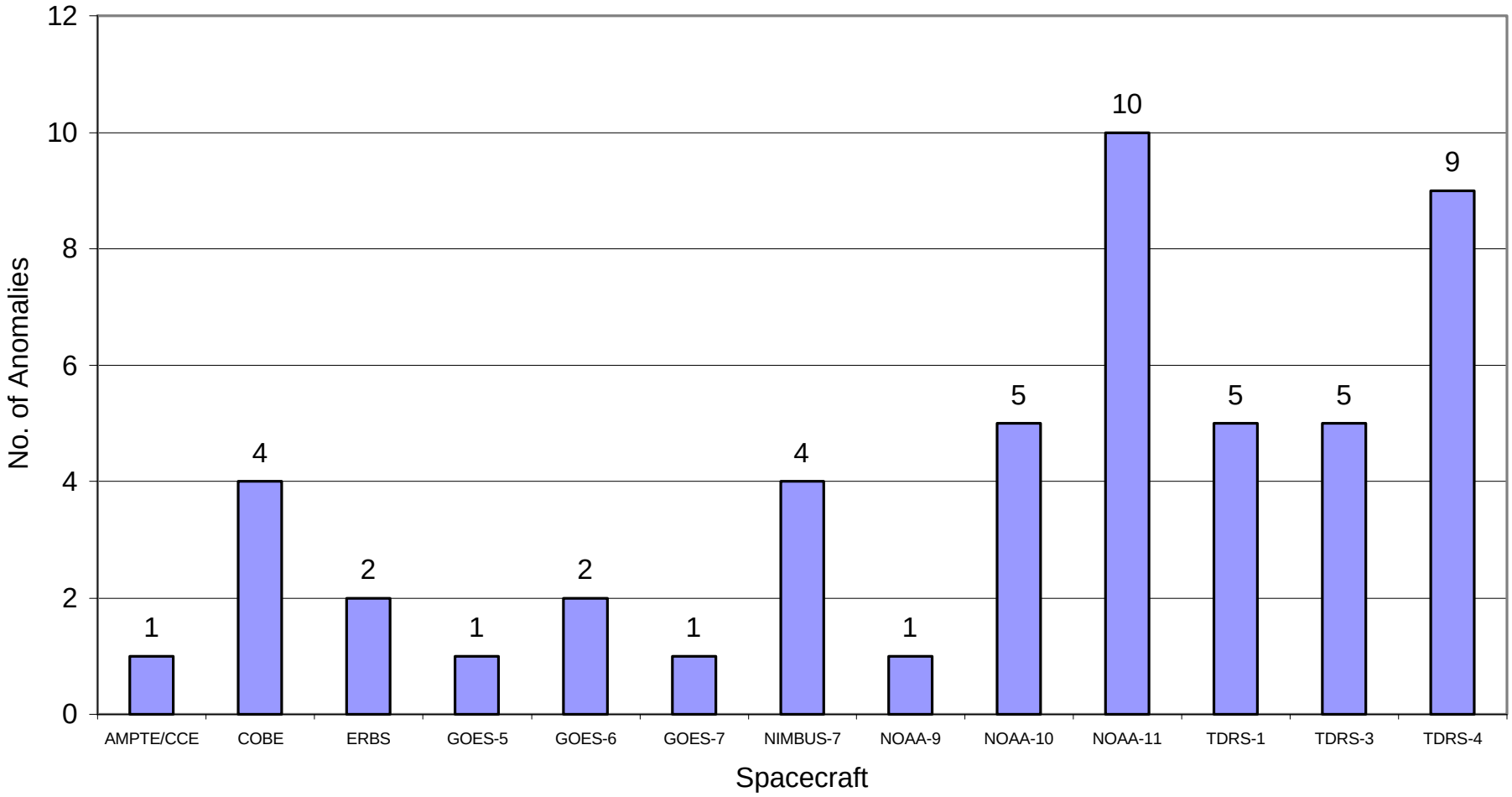
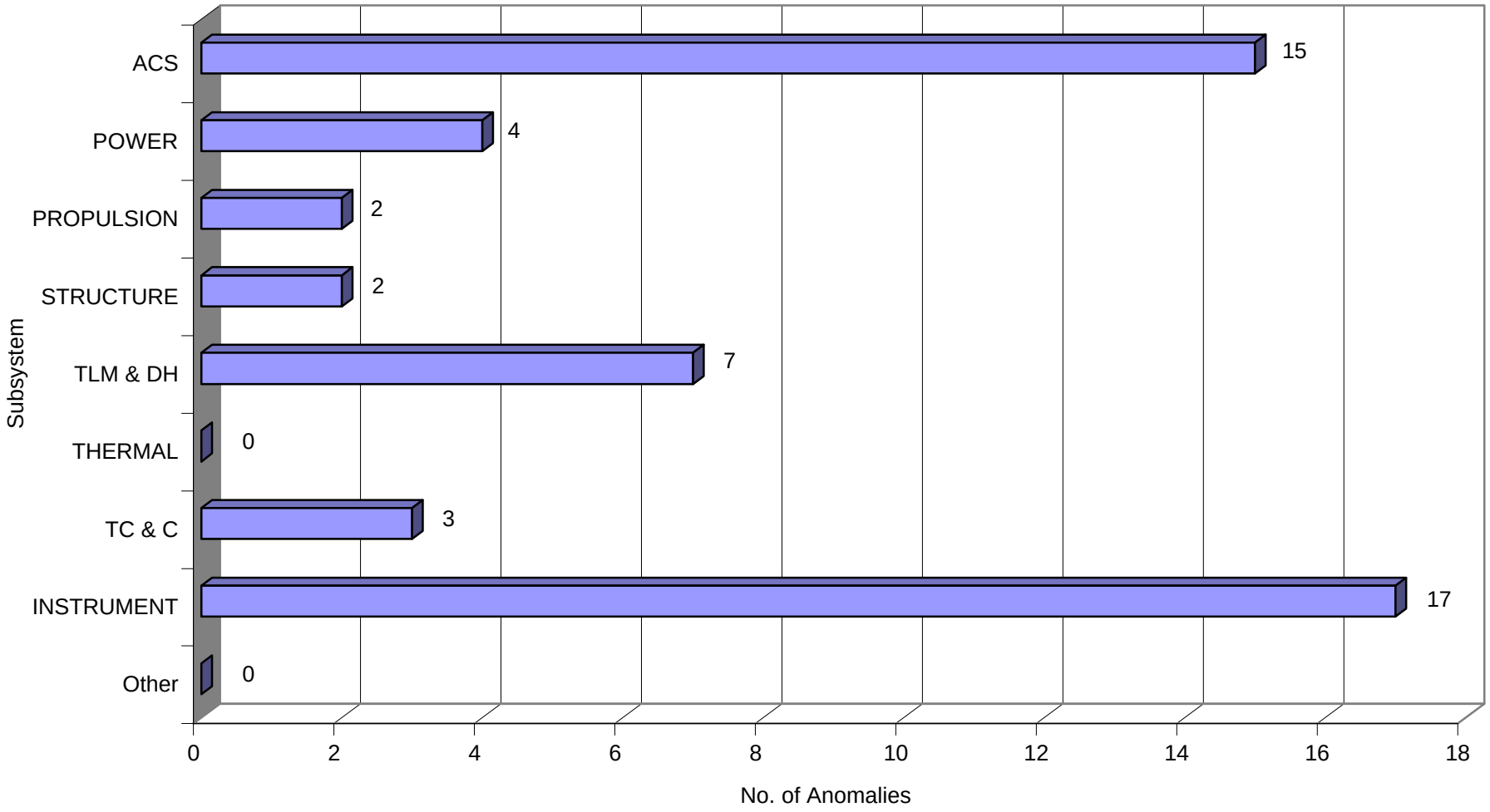


Figure - 2 1989 Anomalies - Distribution Among Subsystems



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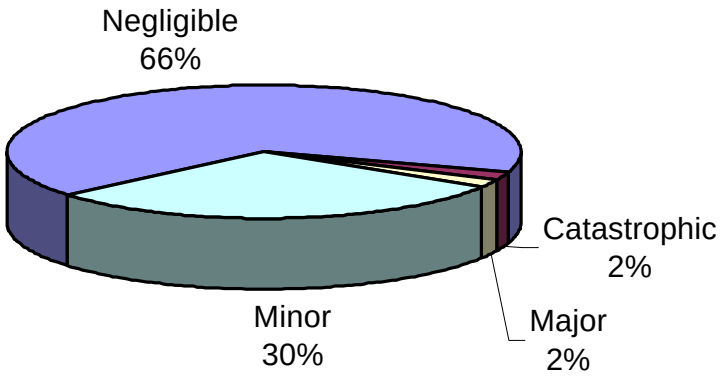
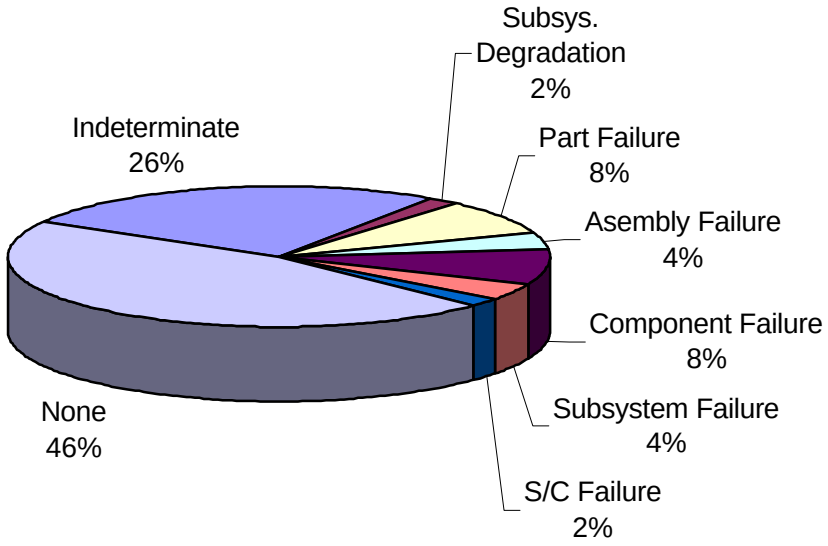


Figure 3 - Criticality



Note: Anomaly Effect refers to the highest level of assembly the anomaly has affected.

Figure 4 - Anomaly Effect

Orbital Anomalies in Goddard Spacecraft
(CY 1989)

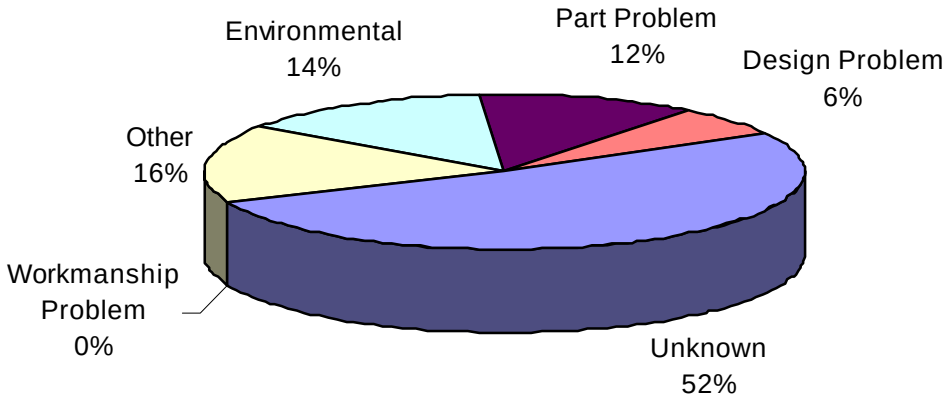


Figure 5 - Failure Category

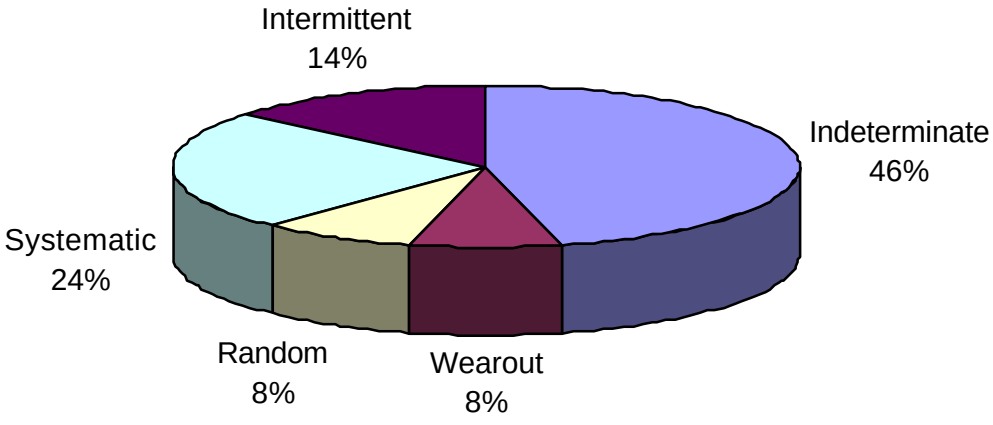


Figure 6 - Type of Anomalies

TABLE II

INDEX	DATE/(DAYS)	SUBSYSTEM	CRITICALITY	DESCRIPTION	EFFECT/ACTION	REF.
				AMPTE/CCE		
12	1/10/89 (1608)	TC&C	5	Cannot communicate with or command spacecraft. Failure in command Processor #2.	Mission over July 14	A00909
				COBE		
1	11/18/89 (1)	Structural	1	Solar array deployment microswitch failed.	Negligible/ none	A01274
2	11/22/89 (2)	ACS	1	Gyro-B failed-probable power supply short.	Gyro removed from control loop.	A01281
3	11/25/89 (3)	INST-FIRAS	2	MTM overscans and end-of-travel hits.	Bad for Mirror/ change S/W	A01283
4	11/30/89 (4)	INST-DMR	2	Differential output of 31 GHz "B" Channel Head drifting toward saturation.	Very little/ None	A01282
				DE-1		
				NO ANOMALIES REPORTED IN 1989.		
				ERBS		
12	4/22/89 (1660)	ACS	2	Sun-sensor 2 degradation due to radiation damage.	Minor/none	A01108
13	11/l/89 (1853)	ACS	2	Y-Gyro in IRU-1 ceased operating due to wear out.	Switched to IRU-2.	A00910

				GOES-5		
34	11/14/89 (3098)	Propulsion	2	3 East-West station-keeping maneuvers failed to achieve orbit change-hydrazine fuel depleted.	Loss of station-keeping	123
				GOES-6		
22	1/21/89 (2095)	INST-VAS	4	Primary Scan Drive Encoder Lamp 1 failed.	VAS failed.	120
23	8/29/89 (2315)	TLM&DH	2	RTU-3 failed. (Romote Telemetry Unit)	Redundant RTU-4 selected.	122
				GOES-7		
13	2/26/89 (731)	INST-VAS	1	VISSR Digital Multiplier-1 bit mode command failed after eclipse	Temporary failure/ None	121
				ICE		
				NO ANOMALIES REPORTED IN 1989.		
				IUE		
				NO ANOMALIES REPORTED IN 1989.		
				LANDSAT-4		
*33	[1/7/88] (2183)	TLM&DH	2	KU-TWTA Prime helix current increased causing trip circuit to activate.	Switched to redundant TWTA.	A01069

				LANDSAT-5		
*9	[10/4/87] (1312)	TLM&DH	2	X-Band Prime Helix current increased causing over-current trip circuit to activate.		A01070
				NIMBUS-7		
55	5/18/89 (3859)	TC&C	2	The command “XPNDR-A XMTR OFF", which is stored in Prime Comstor, failed to execute.	Comstor reloaded and then OK.	A01206
56	9/24/89 (3988)	INST-ERB	2	Failure in anolog multiplexer/digital converter.	ERB use temporarily lost.	A01242
57	10/23/89 (4017)	INST-ERB	1	Indication of "chopper motor on" occurred anomalously.	No impact.	A01243
58	11/28/89 (4053)	INST-ERB	1	Following dual calibration, ref. channel #1 failed to close when commanded.	Electronics cycled to reset logic.	A01244
				NOAA-9		
32	3/30/89 (1569)	TLM&DH	1	SATCU TLM CH5 exhibits a cyclic shift of 8 counts only when VTX2 is enabled. Has been seen since launch and seen on NOAA-11.	No action.	284
				NOAA-10		
16	1/4/89 (840)	Power	1	During a solar calibration the solar array blocked the ERBE-NS solar monitor detector.	Modify procedure in future.	282
17	3/13/89 (908)	ACS	1	Excessive X RWA speed after mag. Momentum unloading, caused roll/ yaw coil to switch to backup. Caused by solar activity.	No action.	283

18	5/22/89 (978)	INST-ERBE-S	2	All Dig. A data went to zero. Data restored by CPU reset command. Scan mode/ command causes shut down. Failure in ROM.	ERBE-S non-operational	287
19	10/1/89 (1110)	TC&C	1	SCU 28 volt switch power indicated on. Command line glitch or solar influence possible cause.	Under investigation	290
20	10/5/89 (1114)	TLM&DH	1	DTR1A shows premature standby condition in GAC record mode. Position counter problem.	Random failure. Available capacity reduced- still sufficient capacity.	291

NOAA-11

2	1/19/89 (117)	INST-DCS	1	The DCS DRU4 stopped processing messages. Random part failure.	Mission or future instruments not affected.	279
3	1/25/89 (124)	INST-AVHRR	1	Resync noted in HRPT telemetry. Sync stable before and after event.	Investigate later.	280
4	1/27/89 (126)	ACS	1	ADACS control mode switched from nominal to YGC for no apparent reason.	Under investigation. Has happened on NOAA-10.	281
5	3/7/89 (164)	INST-MSU	1	Some telemetry points are noisy. Probably IC part failure in common circuit.	Radiometric data and cals not affected.	285
6	4/13/89 (201)	ACS	1	Same as Index 4, above.	Under investigation.	286
7	9/19/89 (360)	ACS	2	Y-gyro spin motor indicated it has failed - Gyro not usable.	Under investigation.	288
8	9/19/89 (360)	TLM&DH	1	Clock update of - 1.25 seconds did not reduce TIP and command clocks accordingly.	Temporary problem. No action required.	289
9	10/11/89 (382)	TLM&DH	1	TIP clock lost additional one-half second following 1.25 sec. ETC correction. S/W problem.	Change ops procedures.	292

10	11/17/89 (388)	DLM&DH	2	DTR5 A/B is terminating playback with early BOT. Playbacks brief or non-existent. Probable permanent failure of this tape recorder.	Remove recorder from use.	293
11	11/26/89 (397)	INST-MSU	1	MSU position encoder telemetry provides false intermittent readings. Science data not affected.	Investigate and recommend for future MSU'S.	294

SMM

NO ANOMALIES REPORTED IN 1989.
(SMM MISSION TERMINATED 11/89)

TDRS-1

55	7/5/89 (2284)	INST-MA (R)	1	Link cals failed. Element 10 has intermittent failure.		A01271 (93)
56	8/28/89 (2338)	INST-Payload	2	K-band TWT-4 Helix current increased exponentially, defocused electron beam and finally TWTA failed on 11/11/89.	Plans to switch to TWT-3.	A01343 (95)
57	8/31/89 (2341)	INST-Payload	2	SSA-R1 degradation problem caused by failure in synthesizer.	None at present. TDRS-1 is in standby.	A01344 (96)
58	9/28/89 (2369)	INST-Payload	1	SA-1 antenna did not find E/W null during null search.	Under investigation.	A01345 (97)
59	11/2/89 (2404)	ACS	1	Command processor electronics had probable SEU causing temporary loss of attitude control.	Under investigation.	A01346 (98)

TDRS-3

8	1/15/89 (108)	Power	1	Battery cell scanner mis-read.	None	A01239 (81)

9	2/25/89 (149)	Power	1	Battery auto-disconnected from bus prematurely (at wrong temperature).	Procedure modified.	A01255 (82)
10	3/6/89 (158)	ACS	1	Momentary anomalous value of telemetry parameter, “ESA Pitch.”	No action.	A01266 (90)
11	7/20/89 (294)	INST-Payload	2	Lost 6 min, of data from Landsat-4 due to non-acquisition by MA.	Modify procedure.	A01348 (94)
12	11/16/89 (413)	ACS	1	ESA pitch glitch - has happened before.	None	A01347 (92)

TDRS-4

1	3/14/89 (2)	TLM&DH	1	C-Boom/2 telemetry did not reflect the fact of its deployment.	None	A01257 (83)
2	3/14/89 (2)	Structural	2	Antenna SA-2 did not fully deploy initially due to harness interference.	Additional commands successful.	A01258 (84)
3	3/14/89 (2)	ACS	1	Glitch in ESA pitch – has happened before.	None	A01259 (85)
4	3/14/89 (2)	ACS	1	DCE-A had defective null indications for east-west movement of SA-2.	Switch to DCE-B	A01260 (86)
5	3/18/89 (6)	ACS	1	CPE anonalously initialized causing attitude divergence.	Commands sent to correct.	A01261 (87)
6	3/22/89 (10)	ACS	1	SA-2 Roll gimbal null not found after roll excursion.	None	A01262 (88)
7	3/21/89 (9)	POWER	1	Anoyance-type battery scanner anomalies.	None	A01263 (89)
8	5/8/89 (56)	ACS	1	Possible SEU causing ESA Roll output alarm.	None	A01268 (91)
9	11/10/89 (242)	Propulsion	1	ISO valve BA telemetry failed to indicate “closed” when closed	Verified – actually closed	A01349 (99)

*Not received until 1990.

APPENDIX A

SPACECRAFT LIFETIME DATA

NOTE: In the following table, the term "-useful life" refers to the time during which the major mission objectives were met. Active life is the total lifetime during which the satellite remained in service. A blank space means the information was not available. Data is through 1989; see text for update.

SPACECRAFT LIFETIMES

SPACECRAFT	LAUNCH DATE	DESIGN LIFE (YRS)	USEFUL LIFE (YRS)	ACTIVE LIFE (YRS)	REMARKS
TIROS	4/1/60	0.25	.24	.24	TV system useful for 77 days
Explorer VIII (S-30)	11/3/60	0.25	.15	.15	Last transmission 12/28/60
TIROS-II	11/23/60		.63	1.03	TV data useful to 7/12/61
Explorer XI (S-15)	4/27/61		.61	.61	Last transmission 12/7/61
TIROS-III	7/12/61	.25	.40	.63	TV data useful to 12/4/61. Lost tape recorders.
Explorer XII (S-3)	8/15/61	1.0	.31	.31	Transmission ceased abruptly
TIROS-IV	2/8/62	0.25	.36	.44	TV useful to 6/9/62. Lost tape recorders.
OSO-I	3/7/62	0.5	1.40	1.40	Lost tape recorder @ 2 mos. starfish incident degraded power system.
Ariel-I (S-51)	4/26/62	1.0	0.88		Degraded by starfish incident of 7/9/62.
TIROS-V	6/19/62	0.5	0.88	0.88	TV useful to 5/4/63. Camera filaments failed.
TIROS-VI	9/18/62	0.5	1.06	1.06	TV useful to 10/11/63. Filaments and focus out.
Explorer XIV (S-3a)	10/2/62		0.85	1.20	Last transmission 2/17/64
Explorer XV (S-3b)	10/27/62	0.17	0.26	0.55	Despin system failed. Last transmission 5/19/63.
Relay I	12/13/62	2.0	2.53	2.53	
Syncom I	2/14/63	2.0	0	0	Lost power, mission failure.
Explorer XVII (S-6)	4/3/63	0.25	.27	.27	Batteries degraded. No solar array.
TIROS-VII	6/19/63	0.5	4.33	4.96	Deactivated. Camera focus out 12/65.
Syncom II	7/26/63	2.0	N/A	N/A	
IMP-A	11/26/63	1.0	0.82		
TIROS-VIII	12/21/63	0.5	3.53	3.53	Deactivated.
Relay-II	1/21/64	1.0	1.68	3.50	
Ariel-II (S-52)	3/27/64	1.0	0.53		Had spin rate and attitude control problems.
Syncom III	8/19/64	3.0	N/A	N/A	
Explorer XX (S-48)	8/25/64		1.60	1.60	Based on last transmission 3/30/66.
Nimbus-I	8/28/64	0.5	0.07	0.07	Solar array drive failed.
OGO-1(A)	9/4/64	1.0	5.23	5.23	Mission failure. 3-axis stabilization not achieved.
IMP-B	10/3/64	1.0	0.50	1.25	Reentered. Placed in wrong orbit.
Explorer XXVI (S-3c)	12/21/64	1.0	2.10	2.10	Last transmission 1/21/67.
TIROS-IX	1/22/65	0.5	2.73	3.4	Deactivated. Camera contrast out 10/66.

SPACECRAFT LIFETIMES

SPACECRAFT	LAUNCH DATE	DESIGN LIFE (YRS)	USEFUL LIFE (YRS)	ACTIVE LIFE (YRS)	REMARKS
OSO-II	2/3/65	0.5	0.75	0.75	Used up control gas.
IMP-1(C)	5/29/65	1.0	1.92	1.92	Reentered.
TIROS-X	7/2/65	1.0	1.16	2.00	Deactivated.
OGO-2(C)	10/14/65	1.0	3.48		Mission failure: Horizon scanners did not maintain earth lock.
ESSA-I	2/3/66	1.0	2.36	2.36	Deactivated.
ESSA-II	2/28/66	1.0	4.64	4.64	Deactivated.
OAO-I	4/8/66	1.0	0	0	Mission failure: Lost power
Nimbus-II	5/16/66	0.5	2.67	2.67	ACS scanner failed.
AE-B	5/25/66	0.5	0.82		Higher than planned orbit. Two sensors did not work.
OGO-3(B)	6/6/66	1.0	2.04	3.5	Boom oscillation problem.
AIMP-2(D)	7/1/66	0.5	4.92		Failed to achieve lunar orbit.
ESSA-III	10/2/66	1.0	2.02	2.02	Deactivated. Cameras failed
ATS-I	12/6/66	3.0		ACTIVE	Gas expended. Limited service
ESSA-IV	1/26/67	1.0	0.41	1.27	Deactivated. One camera failed, one degraded.
OSO-III	3/8/67	0.5	3.0	3.0	Tape recorder failure at 18 mos. ACS controlled manually.
ESSA-V	4/20/67	1.0	2.83	2.83	Deactivated. IR failed, cameras gradually degraded.
IMP-3(F)	5/24/67	1.0	1.95	1.95	Reentered.
AIMP-4(E)	7/19/67		3.50	3.50	Lunar orbit. Subsequent period of intermittent operation.
OGO-4(D)	7/28/67	1.0	2.24	2.75	Thermal bending of antenna caused stabilization control problem.
OSO-IV	10/18/67	0.5	0.90		Tape recorder failure at 6 mos.
ATS-III	11/5/67	3.0		ACTIVE	Instruments no longer in use
ESSA-VI	11/10/67	1.0	2.09	2.09	Deactivated Cameras degraded
OGO-5(E)	3/4/68	1.0	3.60	3.60	Deactivated. Data glut
RAE-A	7/4/68	1.0	4.50	4.50	Deactivated. Data quality had become marginal.
ESSA-VII	8/16/68	1.0	0.92	1.56	Deactivated. Early camera and tape recorder failures
OAO-II	12/7/68	1.0	4.20	4.20	Prime instrument (WEP) failed.
ESSA-VIII	12/15/68	1.0	4.95	6.75	Deactivated. Camera problems
OSO-V	1/22/69	0.5	3.9	3.9	

SPACECRAFT LIFETIMES

SPACECRAFT	LAUNCH DATE	DESIGN LIFE (YRS)	USEFUL LIFE (YRS)	ACTIVE LIFE (YRS)	REMARKS
ESSA-IX	2/26/69		4.1	4.1	Deactivated. Standby after 4/71.
Nimbus-3	4/19/69	0.5	2.67		ACS Scanner failed 1/72.
OGO-6 (F)	6/5/69	1.0	2.06	2.25	Deactivated. Data glut
IMP-5(G)	6/21/69		3.51	3.51	Reentered.
OSO-VI	8/9/69	0.5	3.30	3.30	
ATS V	8/12/69	3.0	14.84	14.84	Mission officially unsuccessful: Stabilization not achieved. Deorbited 3/20/84
TIROS-M	1/23/70	1.0	1.40	1.40	Momentum wheel assembly failed.
Nimbus-4	4/8/70	1.0	10.00	10.00	Deactivated.
NOAA-1 (ITOS-A)	12/11/70	1.0	.56	0.75	Deactivated. Momentum wheel assembly problems.
SAS-A	12/12/70	0.5	4.00	4.00	Transmitter failure terminated mission.
IMP-6(I)	3/13/71	1.0	3.56	3.56	Reentered.
OSO-VII	9/29/71	0.5	3.17	3.17	Reentered due to bad orbit
SSS-A	11/15/71	1.0	2.87	2.87	Deactivated. Battery unusable, as expected after 1 year.
Landsat-1 (ERTS-A)	7/23/72	1.0	5.58	5.58	Deactivated: Funding withdrawn
OAO-C	8/21/72	1.0	8.50	8.50	Deactivated: Funding withdrawn
IMP-7(H)	9/22/72	2.0	6.10	6.10	Power system failed.
NOAA-2 (ITOS-D)	10/15/72	1.0	2.25	2.40	Standby after 3/74. Some experiments failed.
SAS-B	11/16/72	0.5	.54	.54	Experiment low voltage power supply failed.
Nimbus-5	12/12/72	1.0	10.30	10.30	Deactivated 3/31/83. Second HDRSS failed 7/27/82.
RAE-B	6/10/73	1.0	3.75	3.75	Deactivated. Mission objectives achieved.
IMP-8(J)	10/25/73	2.0	ACTIVE	ACTIVE	All instruments operating.
NOAA-3 (ITOS-F)	11/6/73	1.0	2.84	2.84	Deactivated. Radiometer, VTPR, VHRR out
AE-C	12/16/73	1.0	5.00	5.00	Reentered.
SMS-1	5/17/74	2.0	1.60	6.70	Standby after 1/76. Deactivated 1/31/81.
ATS-6(F)	5/30/74	5.0	5.17	5.17	Deactivated.
NOAA-4 (ITOS-G)	11/15/74	1.0	4.00	4.00	Deactivated. Radiometer, VHRR's out.
Landsat-2	1/22/75	1.0	8.51	8.51	Yaw flywheel stopped 11/79, recovered 5/80. Permanently turned off July 27, 1983.
SMS-2(B)	2/6/75	2.0	6.50	7.50	Second encoder failed on 8/5/81.

SPACECRAFT LIFETIMES

SPACECRAFT	LAUNCH DATE	DESIGN LIFE (YRS)	USEFUL LIFE (YRS)	ACTIVE LIFE (YRS)	REMARKS
SAS-C	5/7/75	1.0	4.92	4.92	Reentered.
Nimbus-6(F)	6/12/75	1.0	7.18	8.28	Yaw flywheel failed 8/14/82.
OSO-8(I)	6/21/75	1.0	3.40	3.40	Funding withdrawn
AE-D	10/6/75	1.0	0.42	0.42	Shorted diode in power supply electronics.
GOES-1(A)	10/16/75	3.0	9.3	9.4	VISSR failed 2/85
AE-E	11/20/75	1.0	5.56	5.56	Reentered 6/10/81
NOAA-5 (ITOS-H)	7/29/76	1.0	2.96	2.96	Failed 7/79
GOES-2 (B)	6/16/77	3.0	1.55	1.55	VISSR failed 1/79
ISEE-1(A)	10/22/77	2.0	9.93	9.93	S/C re-entered 9/26/87
IUE	1/26/78	3.0	ACTIVE	ACTIVE	Fully operational. Some problems w/ computer "HALTS"
Landsat-3(C)	3/5/78	3.0	5.07	5.51	Problems with MSS instrument
AEM-A (HCMM)	4/26/78	1.0	2.40	2.40	Deactivated. Battery degraded 9/14/80.
GOES-3(C)	6/16/78	3.0	2.21	7.89	VISSR degraded 9/80. Failed 5/6/81. S/C to standby 4/28/86.
ISEE-3(C) [ICE]	8/12/78	2.0	ACTIVE	ACTIVE	Some instrument losses.
TIROS-N	10/13/78	2.0	2.38	2.38	ACS failed 2/27/81.
Nimbus-7(G)	10/24/78	1.0	ACTIVE	ACTIVE	Solar array power and some instruments degraded.
AEM-B (SAGE)	2/18/79	1.0	2.75	2.75	Battery degraded. Failed 11/18/81.
NOAA-6(A)	6/27/79	2.0	7.39	7.75	S/C turned off 3/31/87
Magsat	10/30/79	0.4	.61	.61	Reentered as planned 6/11/80
SMM*	2/14/80	2.0	[0.83] +[5.62]	9.78	Lost fine pointing control 12/12/80, then repaired. Mission terminated 11/24/89: re-entered 12/2/89.
GOES-4(D)	9/9/80	7.0	2.21	6.66	VAS failed 11/25/82.
GOES-5(E)	5/22/81	7.0	3.19	ACTIVE	VAS failed 7/30/84. Loss of Station-keeping 12/89.
NOAA-7(C)	6/23/81	2.0	3.62	4.92	Failed HIRS, degraded SSU, disabled power system.
DE-1(A)	8/3/81	1.0	ACTIVE	ACTIVE	
DE-2(B)	8/3/81	1.0	1.54	1.54	Reentered as expected 2/19/83.
OSS-1	3/22/82	--	--	--	Shuttle attached payload mission.
Landsat-4(D)	7/16/82	3.0	ACTIVE	ACTIVE	Partial solar array loss.
NOAA-8(E)	3/28/83	2.0	1.25	1.25	Failed 7/1/84. Recovered May 1985. Failed again 1/86.

SPACECRAFT LIFETIMES

SPACECRAFT	LAUNCH DATE	DESIGN LIFE (YRS)	USEFUL LIFE (YRS)	ACTIVE LIFE (YRS)	REMARKS
TDRS-1(A)	4/4/83	**	ACTIVE	ACTIVE	Some loss of capability. Orbital spare in early ’89.
GOES-6(F)	4/28/83	7.0	5.73	ACTIVE	VAS failed 1/21/89..
Landsat-5(D')	3/1/84	3.0	ACTIVE	ACTIVE	K-Band failed; can’t send TM data via TDRS-1 (Late ’87)
AMPTE/CCE	8/16/84	1.0	4.92	4.92	Some solar array degradation. Mission terminated 7/14/89.
ERBS	10/5/84	2.0	ACTIVE	ACTIVE	IRU-1/X-gyro failed (8/86), IRU-2/Y-gyro failed (7/88), IRU-1/Y gyro failed (11/89).
NOAA-9(F)	12/12/84	2.0	ACTIVE	3.92	MSU & ERBE-S failure. Placed in standby 11/8/88.
SPARTAN-1	6/20/85	--	--	--	STS attached payload mission
SPOC/HITCHHIKER	1/12/86	--	--	--	STS attached payload mission
NOAA-10(G)	9/17/86	2.0	ACTIVE	ACTIVE	Array shunts degraded. ERBE-S & SARP failed.
GOES-7(H)	2/26/87	7.0	ACTIVE	ACTIVE	
NOAA-11(H)	9/24/88	2.0	ACTIVE	ACTIVE	Y-gyro & DTR 5 A & B failed in late 1989.
TDRS-3(C)	9/29/88	**	ACTIVE	ACTIVE	
TDRS-4(D)	3/13/89	**	ACTIVE	ACTIVE	
COBE	11/18/89	0.83	ACTIVE	ACTIVE	Gyro failed.

* Repaired by crew of shuttle flight 41-C on April 12, 1984.
** Complex warranty provisions call essentially for 10-year service from TDRSS system.