PREFERRED RELIABILITY PRACTICES

SPACECRAFT ORBITAL ANOMALY REPORT (SOAR) SYSTEM

Practice:

Implement a positive feedback system for reporting, documenting, collecting, analyzing, and closing orbital anomaly[1] information on spacecraft. An example of such a system is currently managed by Goddard Space Flight Center.

Benefit:

Provides a single uniform, effective, and efficient computer data base for in-orbit reliability studies to identify performance trends for use in design reviews, flight readiness reviews, and in the evaluation of test, reliability, and quality assurance policies.

Programs That Certify Usage

Sampex, COBE instruments and electronic boxes, ISTP instruments, etc.

Center To Contact for More Information:

Goddard Space Flight Center (GSFC)

Implementation Method:

Anomaly Reporting - Immediately after the occurrence of an anomaly, the orbiting spacecraft's control center initiates the procedure shown on the SOAR Flow Diagram, Figure 1, by notifying the cognizant Project Operations Director (POD) or other cognizant NASA/government representative. The originator then enters all known information onto a SOAR reporting form (GSFC Form 4-29), Figure 2 and sends it to the POD. The POD assigns a person to be responsible for determining the cause of the anomaly, corrective actions to be taken, etc. The responsible person conducts an anomaly investigation and analysis with the help, as required, of control center personnel, the system or instrument representative, the system integration contractor, the subsystem fabricator, and the Flight Assurance Manager (FAM) or the SOAR System Manager. The cause of the anomaly is determined, if possible, and corrective action is proposed , agreed to and approved by project and Center management, as appropriate. This information is entered onto the SOAR form by the responsible person. The FAM or SOAR System Manager assures that the agreed-to corrective action indicated on the SOAR

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[1] A departure from normal operation. An abnormality in the mission operations of a spacecraft (in orbit).

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form takes place. When all the SOAR corrective actions have been completed, the FAM or SOAR System Manager is responsible for entering the information onto the SOAR reporting form and closing out the SOAR. The completed SOAR form is distributed to the appropriate project, Flight Assurance, and other interested personnel by the SOAR System Manager. The SOAR System Manager enters information from the SOAR report into the SOAR computer data base and distributes a printout.

Yearly Summary Reports - These reports present a summary of the in-orbit reliability and performance of active spacecraft built under the management of the Goddard Space Flight Center and collectively form a continuous, published record of this performance. These reports provide a variety of statistical summaries including the total number of anomalies, the number of spacecraft over which the anomalies were distributed and a comparison with the anomalies of the previous year. A brief discussion is included of the condition and performance of each active spacecraft. The yearly SOAR reports contain a complete list of all anomalies that occurred during the year, with the subsystem identified that caused each anomaly, the criticality, effect, and a description of the anomaly, and any corrective action that was taken. In addition, graphics show the distribution of anomalies among spacecraft and subsystems and comparisons of levels of criticality, effects, failure categories, and types of anomalies. Anomalies are classified and described in these summaries, lists, graphics, etc. as shown below. These classification categories are defined on the SOAR Form along with instructions for their use.

Subsystems - The spacecraft is divided into the following nine subsystems:

1. Attitude Control & Stabilization	6. Thermal
2. Power	7. Timing, Control & Command
3. Propulsion	8. Instrument (Payload)
4. Structure	9. Other
5. Telemetry & Data Handling	

Mission Effect (Criticality) - The following schedule describes the impact of the anomaly on the mission:

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%

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Anomaly Effect -

1. Spacecraft Failed	6. Subsystem/Instrument Degraded
2. Subsystem/Instrument Failed	7. Indeterminate
3. Component Failed	8. Loss of Redundancy
4. Assembly Failed	9. None
5. Part Failed	

Failure Category -

1. Design Problem	4. Environmental Problem
2. Workmanship Problem	5. Other (w/explanation)
3. Part Problem	6. Unknown

Type of Anomaly-

1. Systematic (would occur if identical equipment were operated under identical circumstances)	3. Wearout (a special case of systematic)
2. Random	4. Indeterminate
	5. Intermittent

An appendix of the yearly SOAR report also presents a table of spacecraft lifetime data. Table 1. is a sample sheet of spacecraft lifetime data from a yearly SOAR report.

Technical Rationale:

The SOAR System provides a positive feedback system for reporting, documenting, collecting, analyzing, and closing orbital anomaly information. The timely recognition and analysis of anomalies can lead to corrective measures that can restore performance and, in some cases, protect the safety of the spacecraft and its payload instruments.

The yearly SOAR reports provide GSFC management, spacecraft projects and designers, as well as flight assurance personnel with both short term and long term in-orbit performance and reliability trends which can indicate areas where design improvements should be made on follow-on spacecraft programs. They also can be used to evaluate the effectiveness of the prelaunch integration and environmental test programs.

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Impact of Nonpractice:

If the practice is not followed, in-orbit anomalies may not be recognized, analyzed, and possibly corrected in a timely manner leading to continued degraded performance and possible damage to the spacecraft. Additionally, deficiencies in designs may not be recognized and corrected in new or follow-on flight missions.

References:

1. Procedure for the Spacecraft Orbital Anomaly Report (SOAR) System GSFC Report No. 303-PROC-013 (Rev C)
2. Individual Yearly Reports --- "Orbital Anomalies In Goddard Spacecraft"

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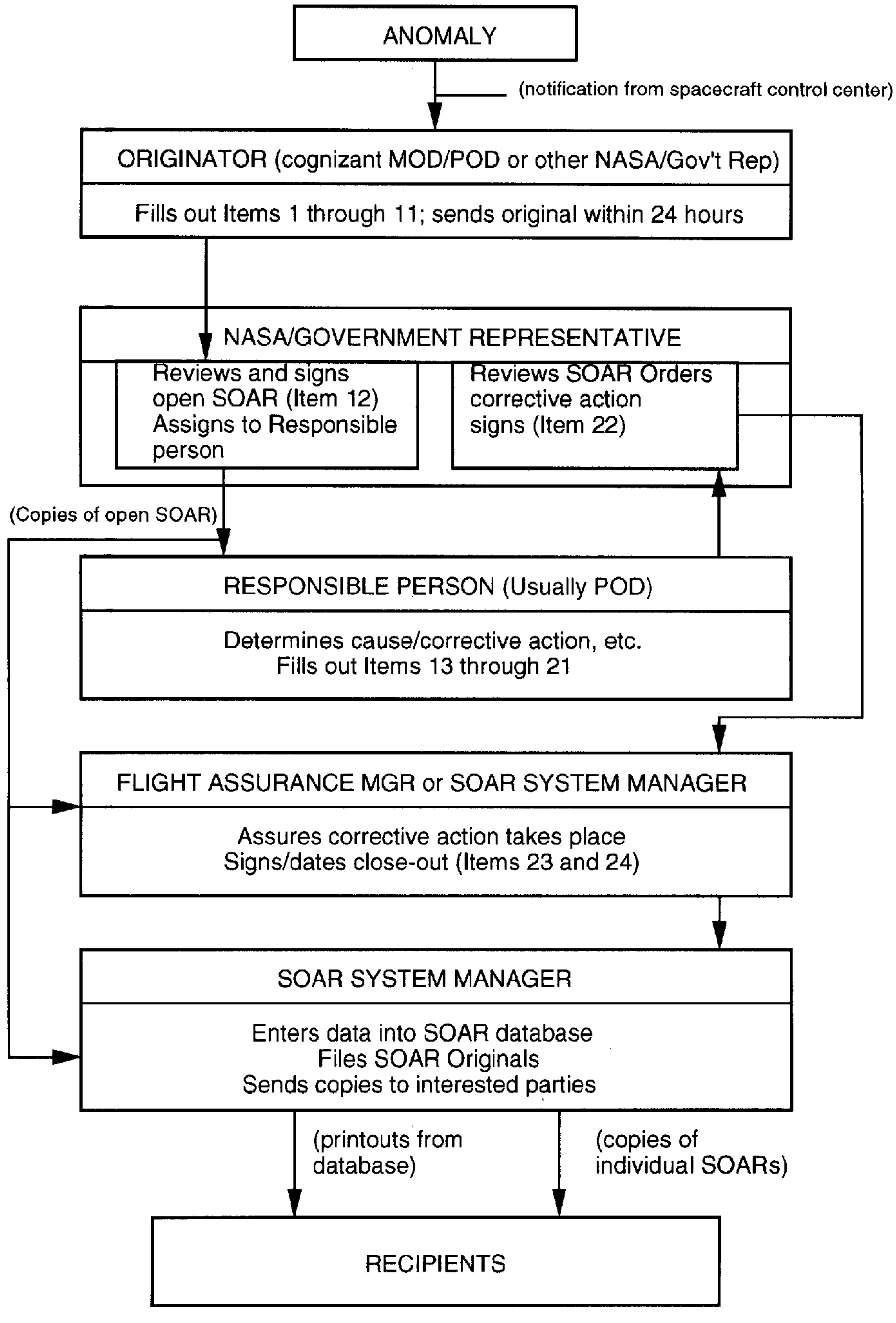

Figure 1: **SOAR FLOW DIAGRAM**

SPACECRAFT ORBITAL ANOMALY REPORT (SOAR) SYSTEM

GSFC SPACECRAFT ORBITAL ANOMALY REPORT (SOAR)

Section 1. (To be completed by originator)

1. SOAR No. **B-0142**

1A. PROJECT NO. (OPTIONAL) ____________________

2. SPACECRAFT ____________________ 3. SUB-SYSTEM OR INSTRUMENT ____________________ 4. ANOMALY DATE ____________ GMT ______ JDAY ______

5. COMPONENT ____________________ Name __________ Code __________ ID Number __________ Serial# __________ Manufacturer __________

6. ASSEMBLY ____________________ Name __________ ID Number __________ Serial # __________ Manufacturer __________

7A. REV. NO. __________ 7B. LAT. __________ 7C. LONG. __________ 7D. A/D __________ 7E. S/D __________ 7F. LOCAL TIME __________ 8. DAYS OPERATION (Since Launch) __________

9. ANOMALY DESCRIPTION:
____
____

10. ADDITIONAL COMMENTS:
____
____
____
____

11. ORIGINATOR ____________________ 12. NASA/GOVERNMENT REPRESENTATIVE____________________

SECTION 2. (To be completed by responsible person)

13.CAUSE OF ANOMALY:
____
____
____

14. CORRECTIVE ACTION
____
____
____

15 MISSION EFFECT __________ 16. ANOMALY EFFECT __________ 17. FAILURE CATEGORY __________ 18. TYPE OF ANOMALY __________

19 ACTION TO BE TAKEN ON FOLLOW-ON S/C
____
____
____

20. REFERENCE DOCUMENT(S) ID: ____
____

21. RESPONSIBLE PERSON ____________________ 22. NASA/GOVERNMENT REPRESENTATIVE ____________________

23. FAM OR SOAR SYSTEM MGR. ____________________ 24. CLOSE-OUT: ENTER CLOSURE DATE ____________________

PLEASE PRINT

GSFC 4-29(2/92)

Figure 2. Spacecraft Orbital Anomaly Report (SOAR) Form

SPACECRAFT ORBITAL ANOMALY REPORT (SOAR) SYSTEM

TABLE 1: SAMPLE SHEET OF SPACECRAFT ANOMALY LIFETIME DATA

SPACECRAFT	LAUNCH DATE	DESIGN LIFE (YRS)	USEFUL LIFE (YRS)	ACTIVE LIFE (YRS)	REMARKS
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	9.2	VAS failed 7/30/84. Loss of station-keeping 12/89. Deactivated 7/18/90. Out of station-keeping fuel.
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	9.57	9.57	Mission terminated. (can't command S/C) 2/26/91.
DE-2(B)	8/3/81	1.0	1.54	1.54	Reentered as expected 2/28/91.
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.
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	
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). ERBE-S failed (2/90). IRU-2/X-gyro failed (7/90.
NOAA-9(F)	12/12/84	2.0	3.92	ACTIVE	MSU & ERBE-S failure. Placed in standby 11/8/88.
SPARTAN-1	6/20/85	--	--	--	STS attached payload mission.
SPOC/HITCH-HIKER	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 & DTR5 A & B failed in late 1989.
TDRS-3(C)	9/29/88	*	ACTIVE	ACTIVE	
TDRS-4(D)	3/1/89	*	ACTIVE	ACTIVE	
COBE	11/18/89	0.83	ACTIVE	ACTIVE	Gyro failed.
PEGSAT	4/5/90	0.25	0.75	0.75	PEGASUS. Limited life mission.
HST	4/24/90	15**	ACTIVE	ACTIVE	Spherical aberration in primary mirror.
SSBUV	10/6/90	--	--	--	STS attached payload mission.
BBXRT	12/2/90	--	--	--	STS attached payload mission.

<u>Useful Life</u> refers to the time during which the major mission objectives were met.

<u>Active Life</u> is the total lifetime during which the satellite remained in service.