SPACECRAFT LESSONS LEARNED REPORTING SYSTEM

Practice:

Develop a Spacecraft Lessons Learned File (LLF)-- a quick, but formal record of significant occurrences during design, implementation, and operation of spacecraft and support equipment. Provide fast and convenient traceability for knowledge capture of significant events to guide future spacecraft managers and engineers in recognizing and avoiding critical design problems. Maintain the system as a living problem avoidance database for all flight project activities.

Benefits:

The Spacecraft LLF is a quick reference document that preserves the NASA knowledge base, providing engineers and scientists with brief summaries of meaningful events that offer valuable lessons. Within the LLF, lessons of interest can be accessed through a keywords search, with more detailed information accessible from the referenced problem/failure report or alert documentation. The LLF serves as a repository of valuable information, including lessons which were learned at great expense, which would otherwise be lost following personnel turnover.

The JPL LLF activity is performed in coordination with the NASA headquarters LLF program.

Programs Certifying Usage:

Viking, Mariner series, Voyager, Galileo, Mars Observer, Magellan, Sea Satellite (Seasat), Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS), Shuttle Imaging Radar-B (SIR-B), Drop Dynamics Module, Active Magnetospheric Particle Tracer Experiment (AMPTE).

Center to Contact for Information:

Jet Propulsion Laboratory (JPL)

Implementation Method:

Figure 1 depicts the procedure for screening flight experience for valuable lessons. The source material for the LLF is obtained from the organization's existing problem/failure reporting or internal alert system. These systems contain reports which identify an incident’s impact or potential impact on the subject mission and reference additional reference material such as failure investigations. Incidents with either (1) significant impact on a mission or (2) less impact, but with potential for mission failure, typically offer "lessons learned" for future spaceflight project activities.

Candidate lessons must also be applicable to current or future flight projects or related activities if they are to be documented in the LLF. Experience directly related to technology which is unlikely to remain in continued use, or has limited applicability to other projects, is rejected.

SPACECRAFT LESSONS LEARNED REPORTING SYSTEM

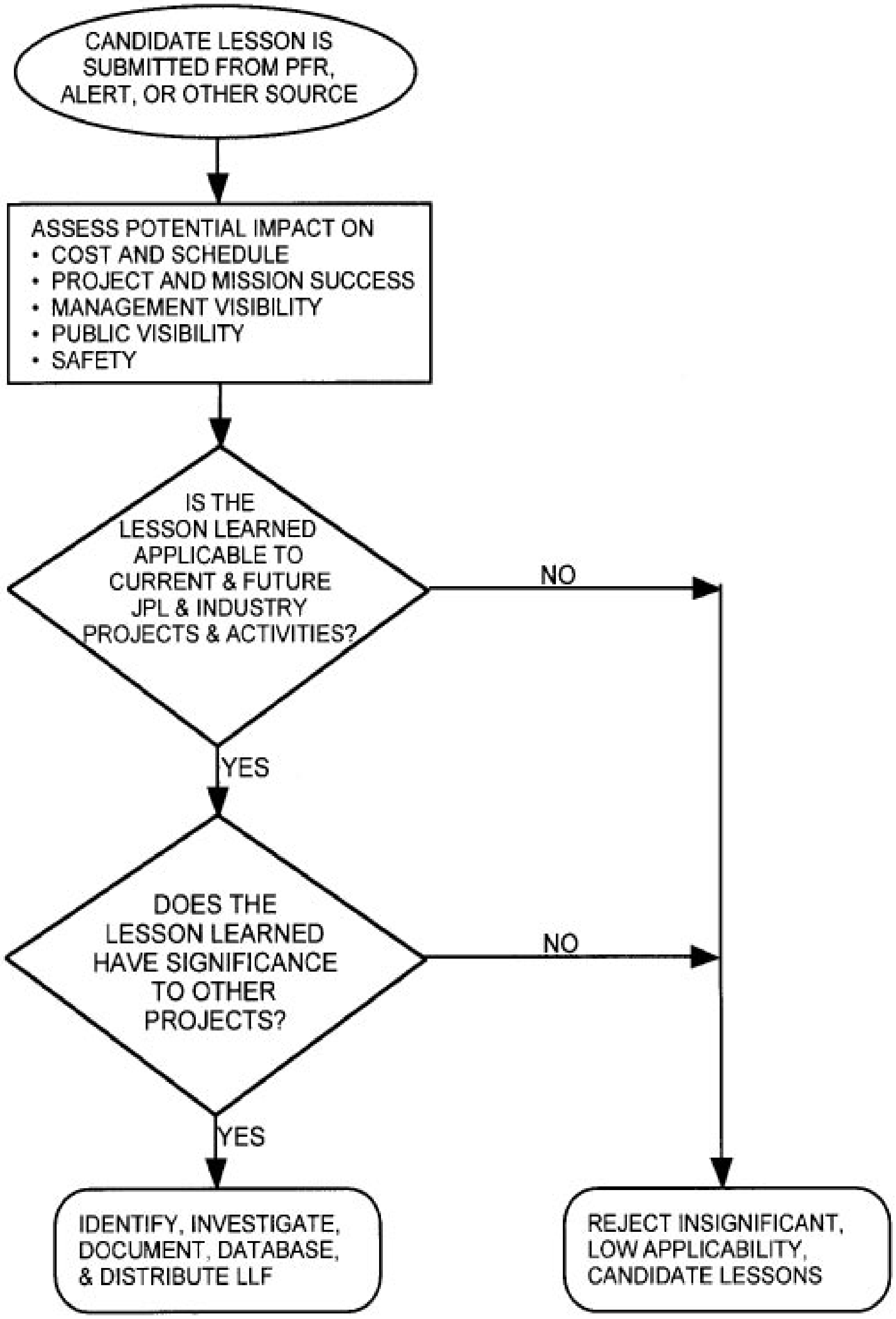

Figure 1: Spacecraft Lessons Learned Reporting System Procedural Flow Diagram

SPACECRAFT LESSONS LEARNED REPORTING SYSTEM

Figure 2 illustrates the content of the documented lesson. Each lesson in the LLF includes recommendations for remedial action, as shown in the “Recommendations” box. When the recommendations are finalized, the lessons learned are documented and distributed to cognizant project engineers and managers. Periodic reviews of prior events ensure continued awareness of advances in technology or methodology. LLF entries which are no longer applicable are purged. Whether of JPL or non-JPL origin, each candidate significant event is screened for technical applicability and referenced by subject in a database. As shown in the (Figure 2) example, inclusion of key words such as “inheritance review” or “inherited design” facilitates search and retrieval of pertinent information on the Mars Observer spacecraft design heritage. For maximum benefit to other projects, the LLF should be concise, distinct, and widely circulated.

Responsibility for supporting and implementing the LLF are shared by key technical and support groups within an organization. At JPL, for example, the LLF is supported by a steering group consisting of representatives from each technical division, the Office of Space Science and Instruments, the Systems Assurance Division, and the Office of Engineering and Mission Assurance. The Office of Engineering and Mission Assurance chairs the group.

Technical Rationale:

Reliability is an integral part of the systems engineering process, and the application of proven reliability measures is key to a cost effective and technically sound space program. The LLF offers a very efficient and effective method of capitalizing on unique spacecraft development experiences to minimize risk to subsequent projects, commensurate with cost and schedules. The LLF provides an “expert system” for archiving flight project experience which might be forgotten or lost as projects conclude and cognizant personnel transition.

Impact of Non-practice:

Without formal, well organized methods of documenting past events and disseminating significant information, future projects may be subject to increased technical risk. Repetitions of past errors and the need to “relearn” past lessons will have cost and schedule impacts, and mission success may be compromised unnecessarily.

Related Practices:

1. *Problem/Failure Report: Independent Review/Approval*, Practice No. PD-AP-1304
2. *Risk Rating of Problem/Failure* Reports, Practice No. PD-AP-1305

References:

1. *Lessons Learned File Reporting System and Procedure*, JPL Publication D-1926 (FPO 600-5), October 18, 1984.

SPACECRAFT LESSONS LEARNED REPORTING SYSTEM

JPL **LESSON LEARNED**	**FILE NO.** 1-106 — **Page 1 of 1** **CATEGORY 1**
SUBJECT (Activity/Area of Event Occurrence) Use of Heritage Designs on the Mars Observer	**INDICES/KEYWORDS** Inherited Designs Inheritance Reviews Mars Observer
EVENT DESCRIPTION (What Happened and Impact)	**YEAR OF EVENT OCCURRENCE:** 1993

As originally envisioned, inherited designs were to be used for many of the Mars Observer spacecraft's engineering subsystems. During its eight-plus year development period, however, the Mars Observer mission underwent a number of significant changes. Many of the spacecraft subsystems were so extensively modified for Mars Observer that their heritage was lost. Other subsystems, whose heritage remained intact but which were designed for an earth-orbital environment, were not requalified to verify that they would function properly on an interplanetary mission of three years duration. Examples include:

- Failure to fully qualify the Traveling Wave Tubes (TWTs) in the transmitter power amplifiers for operation during pyro-shock events.
- The lack of robustness in the design of the bipropellant pressurization system for long duration missions.
- The use of fault-management software, containing processing algorithms derived from the Defense Meteorological Satellite Program (DMSP), that were not fully understood.

References:

1. Mars Observer Loss of Signal: Special Review Board Final Report: JPL Pub. 93-28.

2. JPL Lesson Learned, No. 3-108, Subject: MO Pressure Modulator Infrared Radiometer Cooler Failure During Vibration Test.

3. JPL Lesson Learned, No. 10-102, Subject: Mars Observer Inertial Reference Loss.

LESSONS LEARNED

Reliance on heritage hardware/software in spacecraft design, without a thorough analysis of compatibility with mission requirements and required changes, can result in the use of design and components which are inappropriate for the mission.

RECOMMENDATIONS

1. Perform inheritance reviews to span the differences between the previous use of existing spacecraft designs, hardware, and software, and planned new usage.

2. Inheritance review should include the following assessments:

- Verification that the inherited hardware/software designs are compatible with the spacecraft design, mission environment, qualification requirements and product assurance requirements.
- Verification of the necessity and mission compatibility of design changes and implementation plans.
- Determination of whether additional protoflight testing will be required for the inherited hardware/software.
- Identification of potential risks associated with documented problems of inherited hardware and software.

3. Delta inheritance reviews should be performed when major mission changes occur.

SUBMITTED BY	DATE	SSEF APPROVAL	DATE
M. M. Platt	10/13/94	J.A. Roberts	10/20/94

Figure 2: Example Lesson Learned from Mars Observer