Lessons Learned and Technical Standards

A LOGICAL MARRIAGE

by Paul Gill, William W. Vaughan, and Danny Garcia

A comprehensive database of lessons learned that corresponds with relevant technical standards would be a boon to technical personnel and standards developers. The authors discuss the emergence of one such database within NASA, and show how and why the incorporation of lessons learned into technical standards databases can be an indispensable tool for government and industry.

Passed down from parent to child, teacher to pupil, and from senior to junior employees, lessons learned have been the basis for our accomplishments throughout the ages. Government and industry, too, have long recognized the need to systematically document and utilize the knowledge gained from past experiences in order to avoid the repetition of failures and mishaps. The use of lessons learned is a principle component of any organizational culture committed to continuous improvement. They have formed the foundation for discoveries, inventions, improvements, textbooks, *and* technical standards.

Technical standards are a very logical way to communicate these lessons. Using the time-honored tradition of passing on lessons learned while utilizing the newest in information technology, the National Aeronautics and Space Administration (NASA) has launched an intensive effort to link lessons learned with specific technical standards through various Internet databases. This article will discuss the importance of lessons learned to engineers, the difficulty in finding relevant lessons learned while engaged in an engineering project, and the new NASA project that can help alleviate this difficulty. The article will conclude with recommendations for more expanded cross-sectoral uses of lessons learned with reference to technical standards.

LESSONS LEARNED IN THE TECHNICAL SPHERE

In the technical arena, truly useful lessons learned must be *significant* in that they have a real or assumed impact on operations, *valid* in that they are technically correct, and *applicable* in that they address a design process or decision that mitigates or eliminates the risk of failures or reinforces a positive result. They should communicate only lessons, and should not be used as a replacement for other management information functions such as self-assessment, failure investigation, and corrective action systems.

Lessons learned are a powerful method of sharing ideas for improving work processes, facility or component design and operation, quality, safety, and cost effectiveness. Properly implemented, they should improve management decision-making during every phase of project activity.

It is important to document lessons learned in order to convey information on experiences, to control recurrence of a problem, improve safety, enhance risk management, and facilitate improved interoperability. Thus, they are an important and critical resource that can be used by engineers, scientists, and technicians to support, for example, the design of flight and ground support hardware, software, facilities, and procedures. Sometimes best practices are also referred to as lessons learned applied.

Information on lessons learned may be found in a number of different locations, including organizational technical reports, professional engineering journals, and databases specifically focused on lessons learned. But locating a lesson learned applicable to one's specific interest is generally not a very "user friendly" experience—hence the motivation for developing a "marriage" with technical standards.

THE PROBLEM

With the explosion in technical accomplishments during the past century, especially during the last few decades, it has become critical to rapidly communicate the knowledge gained through experience. This is very true for activities associated with producing more advanced products within the "faster, better, cheaper" philosophy. The dependence upon word of mouth and textbooks to communicate lessons learned, while still important, is no longer adequate or realistic. Expecting engineers and scientists to search through the ever-increasing number and contents of lessons learned databases is less than productive. It is difficult and time consuming for most engineers to search for and use such lessons learned databases. However, there is a viable solution to this problem.

A SOLUTION

All NASA programs and projects are based on the application of technical standards, whether produced by government agencies including the Department of Defense, or by non-government standards developing organizations such as ASTM. The development of these and other technical standards have gone through an extensive review process. Given this database of technical standards, along with the existence of a screened lessons learned database, a productive marriage of the two is now possible.

At the time of this printing, the NASA Technical Standards Program Web site has incorporated over 80 national and international lessons learned databases since June 2001, providing engineers and other interested parties a chance to find the relevant experiences of other professionals who have already encountered specific concerns in aerospace engineering.

To view these, go to http://standards.nasa.gov and then click the NASA Access or Public Access links on the menu page. Once registered, click on the Lessons Learned/Best Practices link for direct access to the listing of lessons learned databases related to aerospace engineering.

Here are some examples of lessons learned databases incorporated into the NASA Technical Standards Program Web site:

- NASA/Headquarters—Lessons Learned Information System;
- NASA/Glenn Research Center—Frequently Asked Questions on Failures;
- NASA/Kennedy Space Center—Cryogenic Transfer System Mechanical Design;
- NASA/Goddard Space Flight Center—Systems Engineering Office Lessons Learned;
- Satellite Mission Operations Best Practices; and
- NASA/Langley Research Center—Lessons for Software Systems.

THE APPROACH

On the surface, this marriage appears easily achievable but this is not the case. It requires the talents of dedicated and experienced engineers who must also possess the gifts of persistence and meticulous attention to detail. The material involved must be read and interpreted and then correlated. The lessons learned database must then be integrated with the technical standards database. Both databases continue to grow at a prolific rate. Once related, the lessons learned must be reviewed and associated with the applicable technical standards.

A NASA "pilot" effort to test this approach has been successful. Consideration is being given to expand the effort beyond the NASA Preferred Technical Standards database, which includes selected ASTM and other technical standards. To the degree practical, this should be done in collaboration with the standards developing organizations involved.

The result will be an invaluable database whereby any technical standard required for a program or project design, development, or operations process will also have identified with it any relevant lessons learned. This marriage will without doubt significantly encourage the development of "faster, better, cheaper" products. Also, technical standards with associated lessons learned may be candidates for revision or may spur the development of a new technical standard.

EXAMPLES

To illustrate the results of the pilot effort regarding the integration of information on lessons learned with technical standards, two examples are presented as they appear within the NASA Technical Standards Program Web site. These examples are taken from the agency-wide Full-Text Technical Standards System within the NASA Access site on the main menu page. (Due to licensing agreements on the access to non-government technical standards products, the NASA Access site is only available to those within the nasa.gov domain.)

Figure 1 (next page) provides an illustration of the Standards Document Summary page for MIL-STD-1686 C, Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices), a NASA Preferred Technical Standard. The information provided for a user on this NASA Preferred Technical Standard includes two lessons learned links, plus a brief description of each, that are available on the NASA Lessons Learned Information System (LLIS) database. The nasa.gov domain user of this standard can then easily locate the two listed lessons learned through hyperlinks and decide whether the contents might be applicable to their use of this MIL-STD. The full-text content of this MIL-STD is readily available from both the NASA Access and Public Access sites.

Figure 2 (page 27) provides a similar illustration of the Standards Document Summary page for ASTM B 117, Practice for Operating Salt Spray (Fog) Apparatus. This ASTM technical standard is one that has been endorsed by the agency as a NASA Preferred Technical Standard and it is so identified on both the NASA Access and Public Access sites. However, its full-text content is readily available only from the NASA Access site due to licensing restrictions noted above. There is one lesson learned entry noted from the NASA LLIS database.

VALUE

Both government and industry conscientiously investigate, document, and track all of their successes and failures. Yet, most of that work is meaningless if an industry or government agency fails to incorporate these experiences into ongoing and future programs and projects and their operations. They need a viable mechanism to identify and incorporate lessons learned into

Summary page			
MIL-STD-1686	Revision: C	Status: Active	NASA Status: Preferred
DoDISS info	No. of NASA Accesses since 06/2001: 4	SDO: MIL	Year Reaffirmed:
TITLE: ELECTROSTATIC DISCHARGE CONTROL PROGRAM FOR PROTECTION OF ELECTRICAL AND ELECTRONIC PARTS, ASSEMBLIES AND EQUIPMENT (EXCLUDING ELECTRICALLY INITIATED EXPLOSIVE DEVICES) (SUPERCEDING MIL-STD 1686B)			
Base	Date: 10/25/1995	19 Pages	View Doc View TOC

Document Scope

[Base - 10/25/1995]
The purpose of this standard is to establish comprehensive requirements for an ESD control program to minimize the effects of ESD on parts, assemblies, and equipment.
An effective ESD control program will increase reliability and decrease both
maintenance actions and lifetime costs. This standard shall be tailored for various types of acquisitions.

Application Notes

Applicable Revision	Project ID	NASA Center	Creation Date	Note
—	—	JPL	4/26/2001	Requires that each facility have a document that describes how they implement ESD controls (for example, see MSFC-RQMT-2918).

Lessons-Learned and Best-Practice

LL/BP No.	Title	Date	Relevance to the Standard
685	Electrostatic Discharge (ESD) Control in GSE	2/1/1999	The Lesson provides technical recommendations for the control of ESD in aerospace equipment.
732	Electrostatic Discharge (ESD) Control in Flight Hardware	2/1/1999	The Lesson addresses the generation of triboelectric and electrostatic charges as a common cause of damage and/or degradation to unprotected Electrostatic Discharge Sensitive (ESDS) devices. A carefully devised and implemented ESD control program can provide protection from this damage and/or degradation.

Document History

Document No.	Rev	Date	Title	Status
MIL-STD-1686B	B	12/31/1992	ELECTROSTATIC DISCHARGE CONTROL PROGRAM FOR PROTECTION OF ELECTRICAL AND ELECTRONIC PARTS, ASSEMBLIES, AND EQUIPMENT (EXCLUDING ELECTRICALLY INITIATED EXPLOSIVE DEVICES) (S/S BY MIL-STD-1686C) (SUPERCEDING MIL-STD-1686A)	Superseded
MIL-STD-1686A	A	08/08/1988	ELECTROSTATIC DISCHARGE CONTROL PROGRAM FOR PROTECTION OF ELECTRICAL AND ELECTRONIC PARTS, ASSEMBLIES, AND EQUIPMENT (EXCLUDING ELECTRICALLY INITIATED EXPLOSIVE DEVICES) (METRIC) (S/S BY MIL-STD-1686C)	Superseded

FIGURE 1: EXAMPLE STANDARDS DOCUMENT SUMMARY PAGE FOR MIL-STANDARD 1686

their design, development, and operations efforts, thus reducing mission risk. The cost of achieving the marriage of lessons learned and technical standards will be modest compared to the significant results that will be achieved.

VALUE EXAMPLE

This value example illustrates how the Crane Division of the Naval Surface Warfare Center achieved cost avoidances throughout the military services by applying design improvements acquired through lessons learned and associated common specifications for configuration control across several battery systems and related equipment. The example also illustrates how a rather simple component, such as a battery vent cap, can have an enormous impact on maintenance and repair costs. (See the Defense Standardization Program Case Study, Aircraft Batteries and Components, at www.dsp.dla.mil. Click on Library, then click on Standardization Case Studies.)

The types of batteries in military inventories are as diverse as their uses. Batteries range in size from small button cells (0.03 ampere hours) to launch facility batteries (10,000 ampere hours), and span the entire spectrum of chemistries (e.g., alkaline, lead-acid, lithium, nickel-cadmium, nickel-iron, seawater). All told, there are 3,800 different types of military batteries, some costing more than tens of thousands of dollars each.

In some cases, inadequate components on the batteries also caused unanticipated wear or damage to the systems that used them. Attention focused especially on the vent caps for aircraft batteries. Vent caps are supposed to retain the corrosive electrolyte, allow a controlled release of pressure, and prevent contaminants from entering the cells. Despite the requirements, the design and materials of the vent caps on original equipment manufacturer (OEM) batteries allowed leakage to occur during operation. The CH-46 helicopter and C-130 and C-141 aircraft were using flooded lead-acid or nickel cadmium batteries that spilled electrolyte onto the airframe structure. The leakage not only deteriorated the battery and shortened its service life, but also corroded the battery compartment and other aircraft parts. The failure of the vent caps to perform properly led to more than half of the battery failures and maintenance actions.

The problem of faulty vent caps was addressed by replacing OEM vent caps with standard government-designed vent caps. These included the following improvements:

- Using O-ring material and vent band materials that are impervious to electrolyte.
- Changing the physical shape of the battery to redirect the electrolyte away from gas vent paths, thereby eliminating the expulsion of electrolyte as cell pressure increased.
- Applying configuration control through common specifications, which eliminate tolerance issues between rival battery manufacturers and allow one vent cap to be used on products from different companies.

In addition, major cost avoidances have resulted from reduced damage to the battery compartment and aircraft structural components. The

CONTINUED AFTER BALLOT

FIGURE 2: STANDARDS DOCUMENT SUMMARY PAGE FOR ASTM B 117

Summary page

ASTM B 117	Revision: 1997	Status: Active	NASA Status: Preferred
DoDISS info	No. of NASA Accesses since 06/2001: 0	SDO: ASTM	Year Reaffirmed:
TITLE: OPERATING SALT SPRAY (FOG) APPARATUS (SUPERSEDING ASTM B 117-1995) *(DoD Adopted)*			
Base	Date: 04/10/1997	8 Pages	View Doc

Document Scope

[Base - 04/10/1997]

1. Scope

1.1 This practice describes the apparatus, procedure, and conditions required to create and maintain the salt spray (fog) test environment. Suitable apparatus which may be used is described in Appendix X1.

1.2 This practice does not prescribe the type of test specimen or exposure periods to be used for a specific product, nor the interpretation to be given to the results.

1.3 The values stated in SI units are to be regarded as standard. The inch-pound units in parentheses are provided for information and may be approximate.

1.4 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Application Notes

Applicable Revision	Project ID	NASA Center	Creation Date	Note

Lessons Learned and Best Practice

LL/BP No.	Title	Date	Relevance to the Standard
764	Controlling Stress Corrosion Cracking in Aerospace Applications	2/1/1999	This Lesson presents considerations that should be evaluated and applied concerning stress corrosion and subsequent crack propogation in mechanical devices, structural devices, and related components used in aerospace applications.

View History

documented cost for the vent cap replacements as $717,000, which resulted in a significant $165,120,000 in cost avoidances through fiscal year 1999 for the DoD.

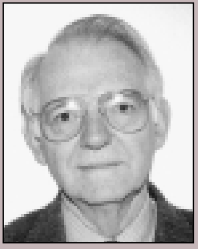
RECOMMENDATIONS

Links should be established as soon as practical between lessons learned and, where possible, the technical standards to which they relate. This can be accomplished by government organizations such as NASA and DoD, industry groups, and standards developing organizations. The results can then be made available and shared with all interested parties. Users of the technical standards would then have immediate links, access to lessons learned and other relevant information as they select and apply technical standards in the normal design, development, and operations process.

The longer-term goal should be to update technical standards and, where appropriate, to reflect lessons learned. Normal practice in the standards community is for technical standards to be reviewed and, where necessary, updated at least once in five years. Links to related lessons learned would provide a basis for additions and updates of technical standards, thus facilitating the marriage process. For government and non-government developed technical standards, the addition of lessons learned can be made directly whenever prudent. To accomplish this goal, and thus reduce mission risk, it is recommended that initiatives by those developing and using technical standards products be established to integrate lessons learned with technical standards.

There are no guarantees that future mishaps like the recent two NASA/JPL Mars Missions will not occur. However, the existence of an integrated lessons learned and technical standards system will certainly contribute toward minimizing such risks. Only one project saved or enhanced will repay the cost of developing an integrated lessons learned and technical standards system many-fold. Without this marriage the lessons learned database, and other similar databases, will continue to find limited and very focused utility relative to the development and operation of future industry and government programs and projects. //

PAUL GILL is manager, Technical Standards Program, National Aeronautics and Space Administration.



WILLIAM W. VAUGHAN is associated with the NASA Technical Standards Program as a consultant and is a professor at the University of Alabama in Huntsville.

DANNY GARCIA is the lead systems engineer for the NASA Technical Standards Program Office.