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Spaceflight Safety
on the North Coast of America

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Spaceflight Safety on the North Coast of America

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Abstract

Spaceflight Safety (SFS) engineers at NASA Lewis Research Center (LeRC) are responsible for evaluating the microgravity fluids and combustion experiments, payloads and facilities developed at NASA LeRC which are manifested for spaceflight on the Space Shuttle, the Russian space station Mir, and/or the International Space Station (ISS). An ongoing activity at NASA LeRC is the comprehensive training of its SFS engineers through the creation and use of safety tools and processes. Teams of SFS engineers worked on the development of an Internet website (containing a spaceflight safety knowledge database and electronic templates of safety products) and the establishment of a technical peer review process (known as the Safety Assurance for Lewis Spaceflight Activities (SALSA) review).

Introduction

Spaceflight safety (SFS) is a discipline which involves ensuring the safe design and operation of spaceflight hardware. In the United States, this work is particularly essential for manned spaceflight programs, and is centered around NASA activities associated with the Space Shuttle.

NASA Lewis Research Center (LeRC), in Cleveland, Ohio, is responsible for the management of spaceflight investigations, experiments, payloads and facilities (hereafter referred to simply as "experiments") associated with microgravity fluids and combustion phenomena. Each experiment is required to undergo an extensive safety review process before it is certified safe for flight. The particular review process depends on whether the experiment is new hardware, reflight hardware (i.e., uses hardware that has previously been flown), or series hardware (i.e., the hardware is new, but it is built to specifications which have been used for hardware which has previously flown). In addition, safety requirements and processes differ for the various carriers (e.g., Space Shuttle, Russian space station Mir, International Space Station (ISS)). Thus, the assigned SFS engineer must be familiar with a range of related requirements and processes.

Not only is the SFS engineer responsible for understanding various missions and carriers, he/she must also understand the various subsystems and operations associated with each experiment. This requires a broad background in systems engineering as well as design engineering. With a complete understanding of the system, the SFS engineer can then apply the appropriate safety requirements.

Due to the complexity of the various systems and the multitude of carriers, NASA LeRC has made efforts to take advantage of technological advances in information management systems to facilitate the interpretation and application of safety requirements. This effort has included the development of a website (containing a corporate knowledge repository and electronic templates) and the establishment of an independent peer review process.

Spaceflight Safety (SFS) Tools

Each space experiment undergoes a rigorous and comprehensive safety evaluation before it can be certified for flight. Information acquired by performing a safety analysis is documented in a safety compliance data package (SCDP). In addition to carrier-specific technical safety requirements, each experiment is also required to meet mission-specific safety integration requirements provided by the respective NASA Center responsible for payload integration (e.g., Johnson Space Center (JSC), Marshall Space Flight Center (MSFC), Goddard Space Flight Center (GSFC)). Each Integration Center has developed a set of safety integration requirements documents that are intended to represent tailored versions of technical safety requirements, supplemented with safety integration requirements. As a result, NASA LeRC has attempted to establish a standardized method of safety reporting for NASA LeRC experiments.

A website has been developed by the SFS engineers at NASA LeRC to serve as a repository of spaceflight safety information and to capture the collective experience gathered from various projects. The website, as an on-line reference of applicable safety data, can be used by both SFS engineers and experiment developers. As a medium to relay information, the website helps to ensure that the most recent version of safety data is available to the user in one easily-accessible location. It can also eliminate the need to send out reams of paper each time there is a revision to controlled information. As shown in the Appendix, the website contains the SFS Handbook, the SCDP instruction guide and templates, and hazard report templates.

The website address is **http://www.osma.lerc.nasa.gov/sfs/**.

The Spaceflight Safety Handbook serves as a collection of spaceflight safety requirements and knowledge of various experiment subsystems. Each chapter of the Handbook focuses on a specific subsystem (e.g., structures, electrical, etc.) for a typical space experiment and provides detailed information concerning applicable requirements, lessons learned, and typical hazards, causes and controls, which can then be used in developing hazard reports. Designated teams of SFS engineers, representing a mix of experience and expertise, were responsible for the development of each chapter. The chapters were then converted into a consistent format for website display on the Internet.

The safety data package instruction guide details the programmatic requirements which encompass all NASA centers. This guide describes the format to use when creating a SCDP. In addition to containing information about SCDP development, a template was developed that includes ordered headings, titles, tables, forms, etc. Using this template, one can immediately begin an SCDP without spending an inordinate amount of time generating a new format for each SCDP. The template facilitates the creation of SCDPs which are similar in style and content, thus leading to the generation of more consistent and complete SCDPs.

The hazard report templates capture information on hazards common to many spaceflight experiments. Each of the NASA centers responsible for payload integration has attempted to generalize these hazards by providing standard hazard reports for certain types of hazards. These standardized hazard reports provide information on applicable safety requirements, hazard causes, and verification methods. Recently, the development of JSC Form 1230 has combined many of these hazard report templates into a single matrix format for application to fairly simple experiments. NASA LeRC has augmented the matrix with additional standard hazard reports templates of topics not covered by the matrix. The SFS engineer can then relate these hazards to her/his experiment to enhance consistency and completeness of their safety packages. In addition, each template is supplemented with experience-based information acquired in the development of previous safety packages.

Safety Assurance for Lewis Spaceflight Activities (SALSA)

Prior to the submittal of the final safety package to the formal review process, the SFS engineer coordinates with experiment Project personnel on the submittal of their safety package for a SALSA review, which provides an independent technical peer review of each safety package. This not only tends to enhance consistency among packages prepared by different SFS members, but also helps to train SFS engineers in fields outside of their area of expertise and experience. For new SFS engineers, this means learning about idiosyncrasies associated with the interpretation of sometimes ambiguous requirements. For more experienced SFS engineers, the SALSA review provides exposure to comments provided by other team members with greater experience in a particular technical area. The end result is a more consistent, complete and accurate safety package.

The SALSA panel consists of all of the SFS team members (both Civil Servants and Support Service Contractors), Safety Assurance Office (SAO) Management, and the Project Assurance Manager (who oversees the technical efforts of all relevant Safety, Reliability & Quality Assurance (SR&QA) disciplines). This brings to bear the collective experience of the members of the SFS team and allows for effective utilization of their combined talents. The review is chaired by the Chief of the SAO, or his designee. Comments offered during the course of the review, although non-binding, are used by the Chair in determining whether or not to concur on the final safety package.

A typical SALSA review consists of a brief overview of the experiment design and operation, followed by a more detailed discussion of the hazards and controls associated with the experiment. Occasionally the line of questioning seems unduly harsh, but in retrospect, following the completion of the formal reviews, it is generally acknowledged that the SALSA review helped the NASA LeRC team to prepare and refine their presentation and to address areas of potential oversight. Since the resultant package is better, the chances of success at subsequent formal reviews is increased. In addition, the thoroughness of each review provides the project with assurances that the resulting package represents the collective experience of the SFS team, rather than the input of individual SFS engineers. The review also serves to enhance the credibility of the SFS team in working with the experiment's Project Office. This is particularly important in the current environment in which we (the SFS team) provide a service to the customer (the Project Office). In addition, Project personnel are able to witness first-hand, in an informal setting, the process by which the later reviews are likely to be conducted.

Summary and Recommendations

The use of standardized tools and processes has produced a number of benefits to SFS engineers and their customers:

- Safety packages are more complete, consistent and accurate;
- Experiment Project teams are better prepared for formal safety reviews;
- SFS Engineers are trained by virtue of being actively involved in the review of other packages;
- The experiment Project is provided with a heightened level of confidence in the product provided by the SFS team;
- Quick and easy access to relevant information is provided from locations with Internet access; and,
- The collective experience and expertise of the SFS team is utilized.

Although good progress has been made in developing and using these safety products and processes, effective implementation still lies ahead. In anticipation of these tools and processes achieving a more wide-spread use, the next steps include the following:

- Include information on ground safety (for Shuttle missions, this involves operations at NASA Kennedy Space Center to prepare experiment hardware for flight on the Shuttle);
- Include information on additional subsystems, such as ionizing radiation sources and pyrotechnic devices;

- Include new requirements associated with flight operations on the Russian space station Mir and/or the International Space Station (ISS);
- Develop and establish a process in which safety packages are created on a website server and made available to reviewers, thus avoiding the time and effort required to photocopy and distribute safety packages to reviewers.

Dan Goldin, the NASA Administrator, has directed the NASA workforce to work "faster, better, cheaper - without compromising safety." As a result, NASA LeRC has made efforts to take advantage of technological advances in information management to facilitate more efficient support of manned spaceflight activities.

Appendix

Spaceflight Safety

The Spaceflight Safety team of the NASA Lewis Research Center's Safety Assurance Office (SAO) created this webpage to provide spaceflight safety practitioners and payload development personnel with tools to assist them in the development of safety compliance data packages (SCDPs). LeRC corporate knowledge along with requirements contained in various documents were compiled and used in the development of the following Spaceflight Safety Handbook, SCDP Templates, and Hazard Report (HR) Templates.

Safety Assurance for Lewis Spaceflight Activities (SALSA) is the process currently employed by the LeRC SFS team as a technical peer review of completed SCDPs. Information about this process is included on this webpage following the handbook and template sections.

SFS Handbook

The Spaceflight Safety (SFS) Handbook is divided into chapters highlighting the various subsystems which comprise a typical payload. Each chapter contains the following information:

1. a general subsystem description
2. a listing of applicable requirements
3. an identification of common hazards, causes, and controls
4. a miscellaneous section capturing other information, such as lessons learned and undocumented "requirements"

The purpose of this Handbook is to provide a quick reference for the individual evaluating the safety of spaceflight hardware. Currently, only hazards dealing with spaceflight systems are addressed. Future work will address ground systems and alternate carriers.

SCDP Templates

The Flight and Ground SCDP Templates provide a consistent format for the presentation of payload hazards and controls. *Their use is not intended to be in lieu of a hazard analysis.* Each template can be downloaded in Microsoft Word format or in WordPerfect format. Instructions for completing each template can be viewed on-line with a Portable Document Format (PDF) viewer such as Acrobat Reader (*Adobe*) or by referencing NASA Contract Report 198435 - Analysis of Microgravity Space Experiments Space Shuttle Programmatic Safety Requirements.

FLIGHT Safety Compliance Data Package Template

View instructions on line: PDF (632.0 KB)

Template files:

- □ Microsoft Word 6.0 (63.0 KB)
- □ WordPerfect 6.1 (71.4 KB)

Requirements Applicability Matrix (for Flight SCDP only)

The Requirements Applicability Matrix, a necessary part of the Flight SCDP, is only available in WordPerfect version and PDF version format.

- □ WordPerfect 6.1 (414 KB)
- □ PDF (183.0 KB)

GROUND Safety Compliance Data Package Template

View instructions on-line: PDF (595.0 KB)

Template files:

- □ Microsoft Word 6.0 (41.5 KB)
- □ WordPerfect 6.1 (81.2 KB)

HR Templates & Form 1230

JSC Form 1230 has been developed by the Payload Safety Review Panel (PSRP) as a means of streamlining the formal safety review process. This form outlines many of the common hazards in a matrix format and is used in place of certain individual hazard reports in the SCDP. Hazard report templates of common spaceflight hazards not addressed by the Form 1230 are currently being created by the LeRC SFS team.

JSC Form 1230

- □ View form on-line: PDF (293.0KB)
- □ Microsoft Word 6.0 (23.0 KB)

LeRC Hazard Report Templates

These reports are currently under development and will be added as they are completed.

SALSA

Prior to the submittal of the final SCDP to the formal review process, the safety package can be evaluated at a SALSA review, which provides an independent technical peer review of content and format. This not only tends to enhance consistency among packages prepared by different individuals, but also provides each package developer with the opportunity to present their work to a panel acting as a mock PSRP.

The SALSA panel consists of all of the SFS team members (both Civil Servants and Support Service Contractors), SAO Management, and the Project Assurance Manager (who oversees the technical efforts of all relevant safety, reliability and quality assurance disciplines).

A typical SALSA review consists of a brief overview of the experiment design and operation, followed by a more detailed discussion of the hazards and controls associated with the experiment.

For further information about the SALSA process or to set a review time, contact Michael Ciancone, Spaceflight Safety Lead, at 216-433-5387 or via e-mail at [michael.ciancone@lerc.nasa.gov].

If you have questions about PDF or configuring your browser to view these documents, additional information can be obtained from Viewer Help Page.

OS&MA Homepage LeRC Homepage

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You are visitor number 136 *since 2/1/96.*
URL is http://www.osma.lerc.nasa.gov/sfs/sfshome.htm

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