John F. Kennedy Space Center
SPACEPORT ENGINEERING AND TECHNOLOGY

Orbiter Lessons Learned

David Bartine, Ph.D.
NASA

Pedro J. Medelius, Ph.D.
ASRC Aerospace Corporation

Kennedy Space Center

National Aeronautics and
Space Administration

ASRC Aerospace Corporation

Why Projects Succeed

- A close, interactive relationship is developed early in the project between the technology provider and the end user
- The problem and prospective solutions are clearly identified and well defined. This normally required multiple iterations.
- The solution demonstrates that:
  - It works satisfactorily in the relevant environment
  - It presents no danger or interference to existing systems.
- The provider remains involved with the user through installation, acceptance testing, and acclimatization of the new technology.

Steps in Transitioning a Low TRL Design to a Certifiable Product

- Establish a team composed of the product developer, the end user, and the GSE responsible organization.
  - Access experts as required (safety, reliability, etc.)
- Jointly develop a detailed set of requirements.
  - Performance, physical, environmental, safety, reliability, maintainability requirements
- Establish qualification process to certify product.
- Define documentation requirements for qualification process.
- Establish a quality control process to monitor the design, fabrication, testing, and integration of the product into the vehicle or ground system.

Requirements Considerations

- Performance
  - Levied by end-user. Identify specific parameters and tolerances.
- Physical
  - Size, weight, volume, mechanical and electrical interfaces.
- Environmental
  - Determined by mission to be performed: vibration, shock, corrosion, radiation, thermal management, etc.
- Safety and Reliability
  - Established by end-user. Assess materials compatibility early. Intrinsically safe designs for hazardous envoronments.

Flight Certification Processes

What is Flight Certification?

Flight certification is the process by which a system (hardware and/or software) is certified to be safe, functional, and meet all Space Shuttle requirements.

What do I need to do to certify my system?

There are several different ways to certify your system for flight in space. The process used depends on how your system is classified and where it will be installed.

Examples of these processes are:

- Standard Payload Process
- Government Furnished Equipment (GFE) Process
- Orbiter Hardware Process

What is the difference between the processes?

At a top level the processes are very similar. All of the processes are designed to ensure that the system is safe, is able to perform its function reliably, and will survive in the space environment.

At the detail level different processes will require interfacing with different organizations and complying with different (although similar) documentation and requirements.

The differences between the processes are largely due to programmatic differences and differences in the environmental requirements for the locations where the hardware is installed.

Typical Flight Certification Process

- Request Flight Assignment [1]
- Develop Requirements:
  - Developer supplied functional and operational requirements
  - NASA supplied workmanship, safety and environmental requirements [2]
  - Existing Interface Control Document (ICD) for existing systems being interfaced with
- Develop Preliminary Design -> PDR
- Prepare a Payload Integration Plan (PIP) (Payload Process Only)
  - Defines the Shuttle Program and customer responsibilities
  - Defines the technical baseline for implementation
  - Establishes guidelines and constraints for integration and planning
- Develop Interface Control Document (ICD)
  - Developer creates an Interface Definition Document (IDD)
  - Program creates an ICD based on the IDD (Payload Process Only)
- Phase-0 Flight and Ground Safety Reviews
  - Optionally conducted to allow the customer the opportunity to ask questions about the safety process and issues as early as possible in the design process. (Payload Process Only)
- Develop Models
  - Thermal, Structural
- Perform Preliminary Technical Analysis

Typical Flight Certification Process

- Conduct Phase-I Flight and Ground Safety Reviews [4]

  First required safety meeting.

  Purpose: To identify all potential hazards and hazard causes inherent in the preliminary design, to evaluate the means of eliminating, reducing, or controlling the risk, and to establish the preliminary method for safety verification.

  A Payload Safety Data Package and Ground Safety Data Package are developed

  Data packages are submitted to the appropriate Safety Review Panels for approval
- Develop Detailed Design -> CDR
- Conduct Phase-II Flight and Ground Safety Reviews

  The purpose of the phase II safety review is to obtain PRSP/GSRP approval of the updated Safety Data Packages that reflects the Critical Design Review (CDR) level design and operations scenario of the payload.
- Fabricate Qualification Unit
- Initiate Acceptance Data Package (ADP) for qualification units
- Perform Acceptance Testing on Qualification Unit
- Perform Qualification Testing on Qualification Unit
- Prepare Certification Data Package

Typical Flight Certification Process

- Perform Phase-III Flight and Ground Safety Reviews
  - The final Safety Data Packages are prepared and submitted to the appropriate Safety Review panels for approval. The focus of this review is to assess safety verification testing and analysis results.
- Fabricate Flight Unit(s)
- Perform Acceptance Testing on flight units
- Conduct System Acceptance review (SAR)
- Install in Orbiter
- Certification Of Flight Readiness (COFR) Process
- Perform preflight tests (Includes any tests required to mitigate hazards)
- Launch

Flight Certification Lessons Learned

- Materials selection is critical. Certain materials can cause hazards in the space environment that are not apparent in the ground environment. Be sure to address this early.

- Involve the NASA safety community early (conceptual design if possible). Certification problems are often found late in design that could have been easily and less expensively avoided if they were known early.

- Involve ground and flight operations personnel early. These are the people who will be installing and operating your experiments. They understand the vehicle and support systems that will be required to support your experiment. They have seen many pitfalls and can help you avoid them.

- Be aware of the "clash of cultures." Scientist like to build the most scientifically perfect system possible regardless of the time it takes. Flow managers like to ensure that all experiments are integrated in the timeframe necessary to ensure the overall mission launches on time. (i.e. flow milestones do not move easily)

Flight Certification Lessons Learned

- Many references are available to help you understand the process:
  - Payload Web: http://shuttlepayloads.jsc.nasa.gov/flow/overview/overview.htm
  - NSTS 1700.7 "Safety Policy and Requirements for Payloads Using the STS"
  - JSC 28484 "Program Requirements Document for JSC Non-Critical GFE"
  - JSC 17038 "Flight Equipment Non-Critical Hardware Program Requirements Document"
  - SSP 50345 "ISS Non-Integrated Criticality 3 Generic Requirements Document"
  - JSC 26626 "EVA Generic Design Requirements Document"