



ISS Payload Interface Requirement Consolidation and Reduction

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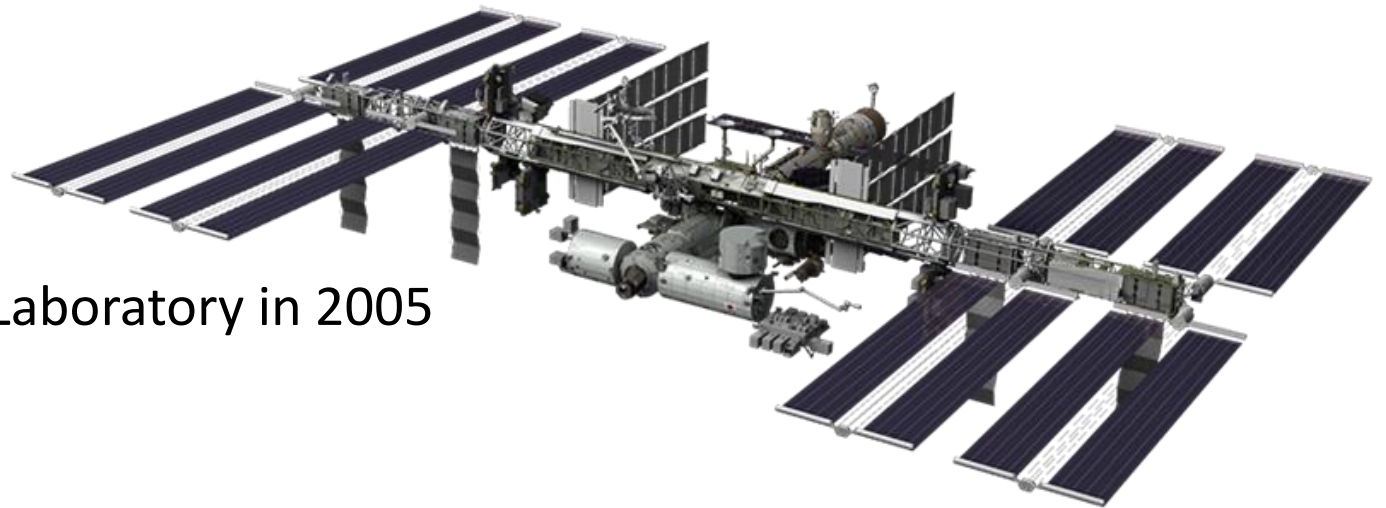
The International Space Station

- International partnership between NASA, Roscosmos, European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA) and Canadian Space Agency (CSA)
- First component launched in 1998
- Continuously occupied since November 2000

- Comparison

Boeing 747: 232 feet long
30936 ft³ press. volume
614 mph

ISS: 356 feet long
32898 ft³ press. volume
17,200 mph

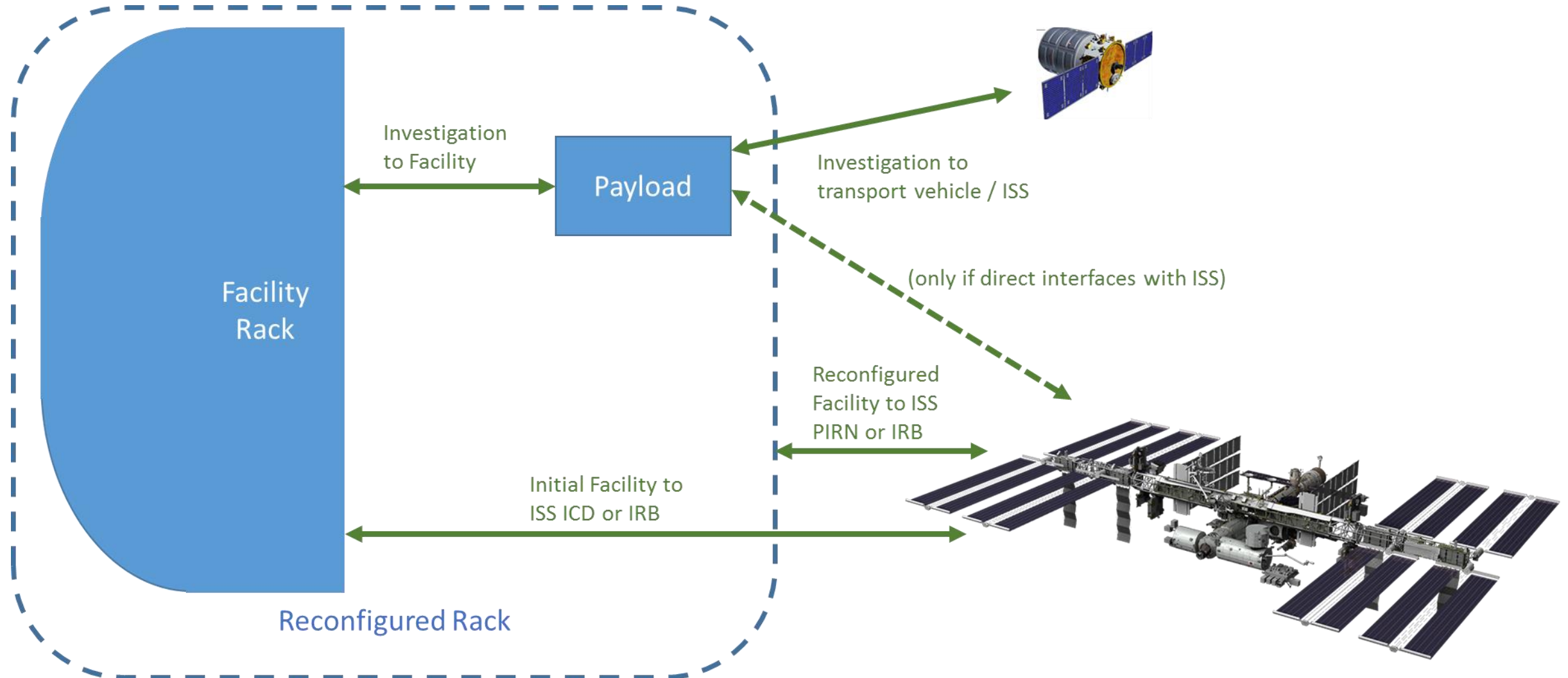


- US segment of ISS declared a National Laboratory in 2005
- ISS assembly completed in 2010

ISS Experiments

- The ISS serves as an orbiting platform for scientific investigation in a microgravity environment
- ISS research includes experiments in physics, biology, medicine, meteorology, astronomy, material science, and other fields
- Experiments are transported to the ISS by multiple spacecraft:
 - Russian Soyuz and Progress
 - American Dragon and Cygnus,
 - Japanese HTV
- ISS experiments are often referred to as “payloads”
- ISS provides power, cooling, data communication, structural attachment, crew interaction and other resources to payloads

ISS Payload Interfaces

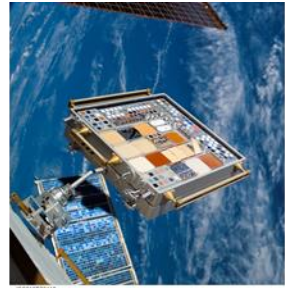


Interface Requirements – Too Many, Too Conservative

- The ISS Program applied interface requirements to investigations on ISS to ensure payloads can be compatible with, and successfully conduct their research in, the space station and transport vehicles
- The requirements enveloped ESA and JAXA interfaces in the Columbus and Kibo modules
 - This ensured NASA experiments would be able to be operated anywhere on the ISS
- These requirements were housed in 11 separate documents containing over two thousand interface requirements that could apply to various types of investigations
- Some of these requirements were too conservative based on their origin
 - passed down from Space Shuttle or earlier programs
 - based on requirements for vehicle systems which could not be allowed to fail
 - in place to minimize crew and operations personnel troubleshooting time
- More conservative requirements appropriate for space vehicles may not be appropriate for ISS experiments and increase the time and cost to put an experiment on ISS

Paradigm Shift

- With ISS assembly completed, more focus turned toward utilization, and the ISS Program management looked for ways to encourage more science on-orbit
- The Program agreed to allow the payload developers to take responsibility for payload mission success, but wanted to ensure the ISS and the crew were not affected
- The Evolved Payload Interface Control (EPIC) team was tasked with streamlining the payload interface requirements to allow payload developers more control over their design and to save costs for the ISS program and its payload developers, while still ensuring the safety of the ISS crew and hardware.



**No Failure
High Cost**
\$\$\$\$



**Accept Failure
Low Cost**
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Goals

1. Requirements that need formal verification are limited to those necessary to protect the ISS and launch vehicle interface and ensure crew, facility, and neighbor payload safety
 2. Mission success requirements will be provided to the developer as design guidelines with no formal verification needed by ISS Program
 3. Eliminate duplication of requirements between organizations (primarily Vehicle, Safety, and Visiting Vehicles)
 4. Requirements that can only be verified by integrated analysis by ISS Program teams will be revised to only ask for data inputs from the PD. The requirement will be closed by the Program team
 5. Reduce pointers to other documents containing relevant payload requirements by pulling the necessary requirements set into the new documents to be applicable only for ISS payloads
 6. Consolidate multiple requirement documents into one document for payloads inside ISS and one document for payloads external to ISS
- There were many other goals to be met for other Program integration processes by streamlining the requirements that are not addressed in this presentation

Requirements, Guidelines and Data Deliverables

- Existing requirements (all “shall”) were reviewed and rewritten as:
 - Requirements
 - Needed to ensure crew safety and to protect ISS, other vehicles or other payloads
 - Denoted by “**shall**”
 - Guidelines
 - Design guidelines to ensure compatibility with an interface (“mission success”)
 - Changed to “*should*”
 - The Program does not collect verification for guidelines
 - Data Deliverables
 - Specifies information that the payload developer must provide to the ISS Program for system integration analyses
 - Deleted
 - Become redundant due to book consolidation, or obsolete
 - Are covered by other ISS processes (like Safety)

Methodology

- A small EPIC core team was established to review the existing requirements
- The core team used a checklist to categorize each existing requirement as either a requirement, guideline, data deliverable or a potential deletion
 - Protects crew, transport vehicle, ISS, facility or other payloads? → Requirement
 - Ensures physical integration and proper function of payload? → Guideline
 - Provides data needed for integration? → Data Deliverable
 - Duplicate or covered by another process? → Delete
- Results of the core team assessment of each requirement section reviewed by requirement stakeholders including technical discipline teams and international partners
- After each review a stakeholder meeting was held to reach agreement line by line
- Any disagreements elevated to an ISS board for disposition

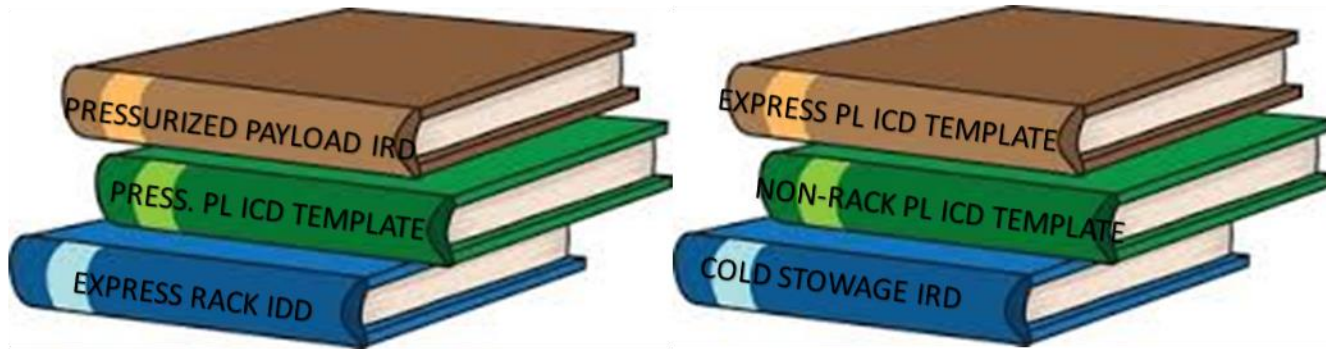
International Partners

- NASA held several meetings with the International Partners (ESA and JAXA) to introduce to changes the Program was bringing to payload integration processes
- The perception of acceptable risk differs culturally with each space agency
 - JAXA is sensitive to experiment failures being perceived by the Japanese public as failures of the Japanese space program in general.
 - JAXA was accepting of the NASA proposed changes for NASA payload requirements because the final result still protected the Kibo module and the crew
 - JAXA is now revising their internal requirements for Japanese experiments, and we look forward to comparing their results with ours
 - ESA was generally welcoming to the changes proposed for payload integration processes
 - ESA will not revise their payload interface requirements, but will instead address the idea of “mission success” and “guidelines” during the development of the individual payload Verification Control Plan

Requirement Document Consolidation

- Reduced payload requirement documents from 11 to 2
- Reduced pointers to other documents from 222 to 67
- Documents maintained in TeamCenter SE and available on NASA database

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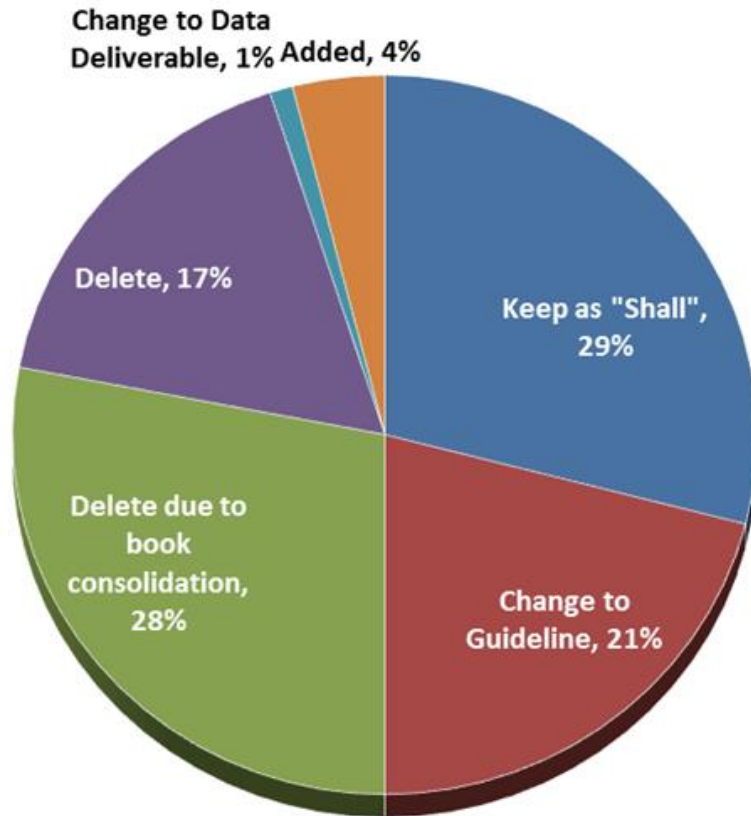


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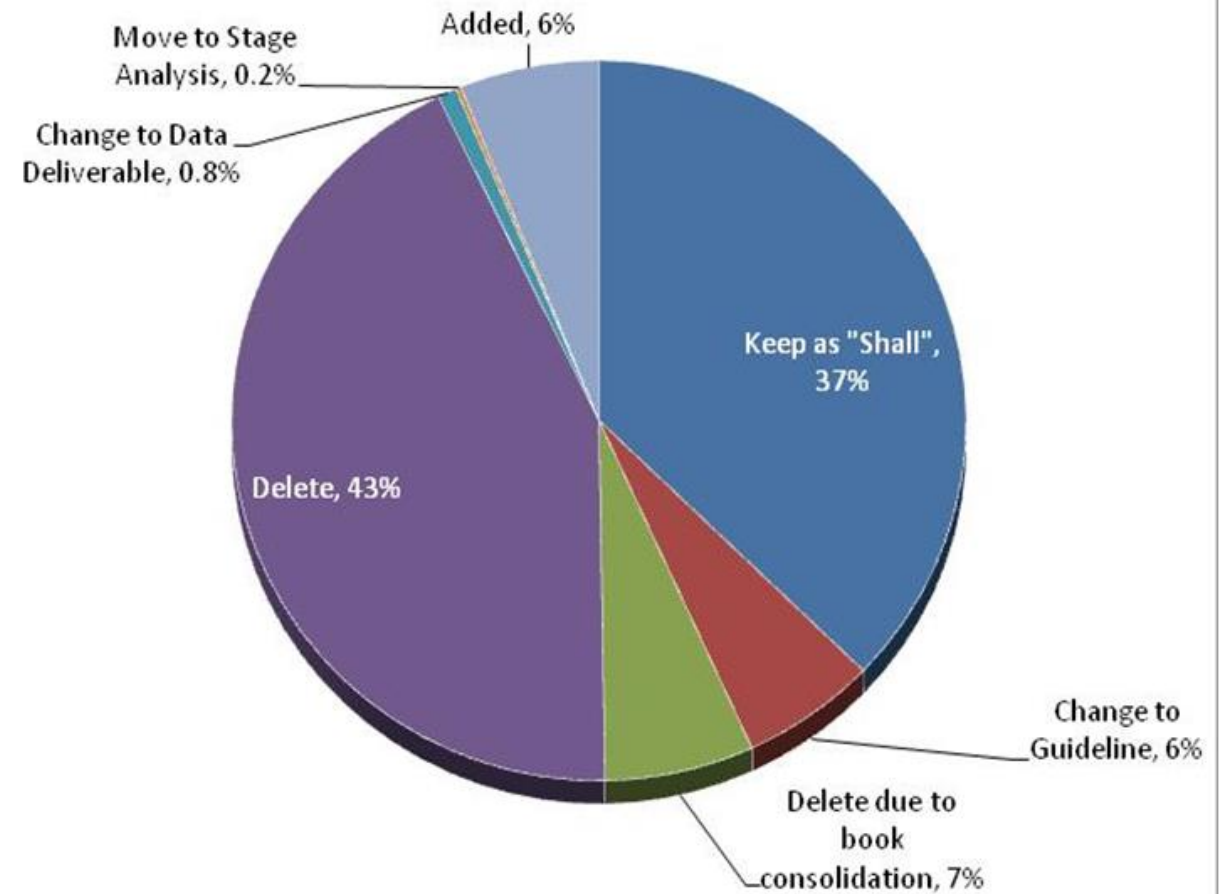


Results

Pressurized Volume Payload Requirements



External Payload Requirements



Summary

- Verification of interface requirements for flight and on-orbit is a significant effort and cost for individual payload developers
- A Program philosophy of acceptance of risk for payload mission success was adopted to allow for greater reduction of requirements
- The Evolved Payload Interface Control (EPIC) team was tasked with applying systems engineering principles to create a streamlined set of payload interface requirements to save costs for the ISS program and its customers (payload developers), while ensuring the safety of the ISS crew and hardware
- This effort resulted in reduced effort for payload developers and the ISS Program.
- Requirements needing formal verification were limited to those necessary to protect the ISS and launch vehicle interface and ensure crew/ISS safety and neighboring payload safety/operations
- The requirements documents were consolidated and the requirements to be verified were reduced by approximately 50%
- This reduction makes the ISS more customer-friendly, reduces the cost for payload developers and encourages more payloads to utilize the ISS

