International Space Station (ISS) Lean Payload Integration Process Overview

NASA ISS Research Academy and Pre-Application Meeting
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Boeing
International Space Station – Payload Integration
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Goal

- Achieve a six month Payload Integration Template (*Payload Development Template unchanged*)
- Why Six Months?
  - Provides a responsive template, knowing that National Lab payload developers
    - May have limited funding
    - Desire more responsive timetables
  - Drives out multiple iterations of integration products
    - Reduces the burden to the Payload Developer (PD) (making space more attractive)
    - Maximizes efficiencies for the integrator

Guidelines

- Payload Safety Review Process remains untouched
- Agreements with Crew Office remain untouched
- Maintain overall ISS Safety and Payload Interface Integrity

Results

- Characterized Payload Operations, Expedite the Processing of Experiments for Space Station (EXPRESS) and Microgravity Sciences Glovebox (MSG) payload types to be integrated in a “lean” fashion
- Gate process was defined to minimize integration team activities prior to L-6 months; however, some early integration activities are unavoidable at this time
- Implemented significant process improvement for engineering verification via Ship and Shoot (S&S) Testing
# Lean EXPRESS Payload Characteristics

## Complexity vs Payload Characteristic

<table>
<thead>
<tr>
<th></th>
<th>E1 (EXPRESS - Lean SW)</th>
<th>E2 (EXPRESS Reflight/ Series)</th>
<th>E3 (Small - Deployed at EXPRESS)</th>
</tr>
</thead>
</table>
| **Pressurized Hardware** | • EXPRESS Subrack; Single Locker Equivalent  
• Soft-stowed with no services required at the launch site or during ascent/descent  
• Interface Verification data captured via Ship and Shoot Testing  
• Resource requirements fall within established envelopes  
  - 150 Watts average power/thermal  
  - Air and/or water cooled  
  - Ethernet Data Only  
  - No Gas or Vacuum Interfaces | • EXPRESS Subrack; Single Locker Equivalent  
• Previously Flown  
• Soft-stowed with no services required at the launch site or during ascent/descent  
• Use SSP-52000-PVP-ERP/IA 2.3.6 Certification Maintenance for Reflight/Series Hardware  
Or  
• Interface Verification data captured via Ship and Shoot Testing | • Deployed/powered at EXPRESS  
• Envelope – Extension from Rack Front Plane  
  - < 10 inches for maximum placement opportunities  
  - < 17 inches for more limited placement opportunities  
• Soft-stowed with no services required at the launch site or during ascent/descent |
| **Software** | • Complies with pre-defined Lean C&DH Dataset | • Re-flight of previous EXPRESS software interface; C&DH Dataset Previously Flown – No changes to dataset | • None |
| **Flight Operations** | Operations “Simple Payload”  
• No crew displays or unique skills, uses standard procedures  
• Crew involvement limited to setup, take down, and sample exchange  
• Crew training is minimal (via On Board Training, “Self-study CBT”, and/or a short Placeholder Training Opportunity)  
• Fits within pre-established mission planning envelope  
• Standard Command Services limited to one site |
Lean MSG Payload Characteristics

<table>
<thead>
<tr>
<th>Complexity vs Payload Characteristic</th>
<th>M1 (Simple)</th>
<th>M2 (Simple/Tele-science)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pressurized Hardware</strong></td>
<td></td>
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</tr>
<tr>
<td>• Less than 1 MLE in Size</td>
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<td>• Less than 2 MLEs in Size</td>
</tr>
<tr>
<td>• No ISS System requirements (i.e. power, thermal, or data)</td>
<td></td>
<td>• Soft-stowed with no services required at the launch site or during ascent/descent. (ship and shoot)</td>
</tr>
<tr>
<td>• Soft-stowed with no services required at the launch site or during ascent/descent. (ship and shoot)</td>
<td></td>
<td>• EMI testing has been completed</td>
</tr>
<tr>
<td>• Toxicity level 0, no unique hazards, Safety Review(s) out of board</td>
<td></td>
<td>• Requires less than 500 watts of power and cooling</td>
</tr>
<tr>
<td>• Verification limited to certificates of compliance</td>
<td></td>
<td>• Toxicity level 0 with only one level of containment or less required</td>
</tr>
<tr>
<td>• No EMI testing required</td>
<td></td>
<td>• Integrated Safety review conducted out of board.</td>
</tr>
<tr>
<td>• Operated from the ground.</td>
<td></td>
<td>• Simplified verification testing</td>
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<tr>
<td><strong>Software</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• No requirements for command or telemetry</td>
<td></td>
<td>• All data transfer and commanding done via the MSG Laptop Computer Server (MLCS)</td>
</tr>
<tr>
<td>• Data/video downlink limited to normal MSG facility health/status data and video</td>
<td></td>
<td>• Uses MLCS Displays Only</td>
</tr>
<tr>
<td>• No crew displays and no payload software</td>
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<tr>
<td><strong>Flight Operations</strong></td>
<td></td>
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<tr>
<td>Operations “Simple Payload”</td>
<td></td>
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<td>• Fits within pre-established mission planning envelope</td>
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<td>• Standard Command Services limited to one site</td>
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</table>

MLE – Middeck Locker Equivalent, EMI – Electromagnetic Interference, CBT – Computer Based Training
Lean Payload Integration Gate Activities

Gate 1

Establish Program Agreements

YES

Potential Candidate for Lean Integration?
PIM Assigned

NASA Aware of Payload

Gate 2

Assign Additional Open Work to PD

NO

Complies With Lean Payload Criteria?

YES CONTINUE

Gate 3

Is Integration Package Complete?*

Make Flight/Location Request

YES

PIM submits CEF with Lean Integration and Manifest data input to convert “Placeholder” reservation to a specific payload

CEF Review And Approval

Payload Manifested

Gate 4

Finalize Ops Product Development

Update/Complete Integration Processes

Conduct Required Testing

Contact NASA Regarding Opportunity

Complete:
- Phase 0/I/II Payload Safety Review Process
- Operations Nomenclature Request
- Preliminary HFIT/IPLAT Ops Assessment Review
- Ops Training Strategy Team
- Ground Data Services Input (if r’qd)

Payload Overview Data

Complete:
- Phase III Payload Safety Data Package
- Lean Integration Data Package Input

Controlled Data

Packaging

Operations

Packing

Location

• Support Required Testing
  • CoFR

Hardware available for Ship and Shoot Testing

Payload Development

PIM – Payload Integration Manager, HFIT – Human Factors Integration Team, IPLAT – ISS Payload Label Approval Team, CEF – Change Evaluation Form, CoFR – Certification of Flight Readiness

* PIM will conduct Gate Review technical assessments with Host Facility Lead, Payload Engineering Integration, Payload Software Integration, Operations, Payload Safety Review Panel, and Crew Office Representatives
# Lean Integration Data Package Input

<table>
<thead>
<tr>
<th>Data Item</th>
<th>Description</th>
<th>Use</th>
<th>User</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lean Integration Data Input</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>• Payload Technical Data Input, tailored per Host Facility streamlining</td>
<td>Captures streamlined engineering integration data</td>
<td>Development of Payload ICD, Integrated Engineering Analysis, and Tailoring of Generic Ship and Shoot Test Plan</td>
<td>PEI and SSITF Test Engineering</td>
</tr>
<tr>
<td></td>
<td>• Lean Integration Data Sheet (LIDS) for EXPRESS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Interface Requirements Sheet (IRS) for MSG</td>
<td></td>
<td></td>
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<tr>
<td><strong>Payload Hardware</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>• On-Orbit Drawings</td>
<td>Drawings associated with payload on-orbit operational configuration</td>
<td>Topology Assessment and Stage Configuration Drawing Development</td>
<td>PEI</td>
</tr>
<tr>
<td>• MR Loader Manifest and Payload Tactical Plan (PTP) Table Updates</td>
<td>Both sets of data are needed to manifest the payload on a specific flight</td>
<td>Change Evaluation Form (CEF)</td>
<td>MI</td>
</tr>
<tr>
<td>• Test Results</td>
<td>Results of any of the following tests performed prior to Ship and Shoot Testing at MSFC (Off Gas, Vibration, Acoustics, EMI/EMC)</td>
<td>Requirements Verification</td>
<td>PEI</td>
</tr>
<tr>
<td><strong>Payload Operations</strong></td>
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</tr>
<tr>
<td>• Training Material</td>
<td>Written and/or video training material established for ground-based self-study—based on Training Strategy Team review</td>
<td>Ground based crew training via “Self-Study DBT”</td>
<td>Ops Lead</td>
</tr>
<tr>
<td>• Preliminary User Requirements Collection (URC) Input</td>
<td>Preliminary definition of Payload operations activities, durations, sequences, and associated resource requirements</td>
<td>Development of Mission Planning Activity Models</td>
<td>Ops Lead</td>
</tr>
<tr>
<td>• Preliminary Crew and Ground Ops Procedures</td>
<td>Crew Procedures (Note – POIF is the Crew Procedure developer for EXPRESS and MSG payloads.)</td>
<td>Verification by Ops team during Ship and Shoot Processing</td>
<td>Ops Lead</td>
</tr>
<tr>
<td><strong>Payload Safety</strong></td>
<td></td>
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</tr>
<tr>
<td>• Phase III Safety Data Package</td>
<td>Description of the experiment hardware, an operational scenario, a hazard assessment with identified hazards (and hazard controls) documented within hazard reports, and a status of hazard verification.</td>
<td>Hazard Report review and approval. Hazard Reports are stand-alone documents that the Operational Console would use to make real-time decisions on-orbit.</td>
<td>PSRP and Ops Lead</td>
</tr>
<tr>
<td>• Ground Safety Checklist</td>
<td>Standard checklist provided to ground processing and launch processing facilities</td>
<td>Identification of information for ground processing locations and Tailoring of Generic Ship and Shoot Test Plan</td>
<td>PSRP and SSITF Test Engineering</td>
</tr>
</tbody>
</table>

Ship and Shoot Processing

Definition
• Evaluate, by testing the payload, all the requirements that are necessary to determine that neither rack performance nor the performance of other payloads in the rack are adversely affected by the operations of that payload.

Benefits
• Provides processing efficiencies to allow for interface verification, crew procedure review, and Human Factors and Label review to be accomplished through a single activity
• Eliminates verification submittals from the Payload Developer (PD) to ISS Payload Engineering Integration (PEI)
  – Reduces PD cost and time
  – Reduces PEI workload for tracking and evaluating data packages
  – Eliminates coordination time between PEI and PD to address data pack questions
• Supports Crew Procedure Validation with hardware
Ship and Shoot Testing Flow

1.1 Lean Payload Arrival
1.2 Receiving Inspection
1.3 Pre-Integration Tests
   1.3a Isolation Test
   1.3b Inrush Test
1.4 Integration With Data Collection Test Setup

Test Readiness Review

1.5 Ship and Shoot (S&S) Data Collection
   • Procedure Review
1.6 Fluid Charging/Sampling
   (EXPRESS Payload, If Required)
   Note 1 – Payload does not return to PD Site following S&S Testing

1.7 Human Factors Integration Team (HFIT) Modifications
   • Human Factors and Label Review

1.8 Pre-Packing (Flight Ready State)
   Payload Hardware Review

1.9 Transfer to Bench Review Location

Note 2 - Bench Review is Inspection of “Flight Ready State Only”, just prior to Flight Bag Packing configuration

Note 3 - Optional Off-Gas, Vibration, Acoustics, and EMI/EMC testing may be conducted at MSFC, at Payload Developer Expense. PD should coordinate with their PIM as early as possible.
Payload Operations Integration Function

<table>
<thead>
<tr>
<th>Gate 2</th>
<th>Gate 3</th>
<th>L-7</th>
<th>Gate 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self Study Crew Training Material, if required</td>
<td>Payload Regulations Input</td>
<td>OCBT Delivery</td>
<td></td>
</tr>
<tr>
<td>Preliminary Crew and Ground Procedures</td>
<td>Payload Regulations</td>
<td></td>
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</tr>
<tr>
<td>User Requirements Collection (URC) Input</td>
<td>Cadre/PD Sims, if required</td>
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<tr>
<td>Ground Data Services (GDS) Input</td>
<td>PTDR, if required</td>
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<tr>
<td>GDS Requirements</td>
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<tr>
<td>Operations Concept</td>
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<tr>
<td>For Training</td>
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<tr>
<td>Strategy Team (TST)</td>
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<tr>
<td>Conduct TST</td>
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<td>Request OpNom</td>
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<td>POIC Database (DB)</td>
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<td>POIC DB</td>
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<tr>
<td>Fit Rules Input</td>
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<tr>
<td>Groundrules &amp; Constraints Transfer List</td>
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<tr>
<td>On Orbit Summary (OOS)</td>
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<tr>
<td>Crew and Ground Procedures</td>
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<tr>
<td>Crew Training Planning Dataset</td>
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<tr>
<td>Lean Payload Input</td>
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<tr>
<td>▲ Payload Integration Team Milestone</td>
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</tbody>
</table>

CBT – Computer Based Training, OCBT – Onboard CBT, PTDR – Payload Training Dry Run