Payload Developers and Principal Investigators Payload Planning, Integration and Operations Primer

International Space Station Program

ISS National Laboratory Office

June 2010

BASELINE

National Aeronautics and Space Administration
International Space Station Program
Johnson Space Center
Houston, Texas

INTERNATIONAL SPACE STATION PROGRAM

PAYLOAD DEVELOPERS AND PRINCIPAL INVESTIGATORS PAYLOAD PLANNING, INTEGRATION AND OPERATIONS PRIMER

CONCURRENCE

JUNE 2010

REVISION A

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1 Introduction

1.1 Objective

The objective of this Payload Planning, Integration and Operations Primer is to give Payload Developers (PDs) and Principal Investigators (PIs) that are new to the payload integration world an overview of the process and to outline the roles and responsibilities of several organizations with whom the new PDs and PIs will interface during the payload planning, integration and operations process. This primer highlights the many products to which both PDs and PIs will either provide inputs to or develop for their own use, as well as identify services that are available from several NASA ISS Payloads Office organizations that PDs and PIs will use as part of the payload overall integration process.

1.2 Layout

This primer starts from the beginning of the payload process and proceeds step by step (albeit at a very high level) from a proposed payload to a "manifest payload" and from there to integration all the way to launch and payload return. In the lingo of the payload world, one will say from pre-increment planning, real time (execution), to post-increment. The main focus of this document is on the products that PDs/PIs need to develop, provide inputs to and the services that that are available to them to successfully accomplish their payload activities from pre-increment planning to post-increment reporting.

Every effort was made to eliminate as much as possible the daily lingo used in the complex world of payload integration in this document in order to make it as readable as possible to the new-comers to this world. Throughout this document there are many web links that reveal themselves only while reading this document from a display device. They are embedded in this document for those who might wish to have more detailed information on a topic of interest. These web links take the reader to the reference documents that were used to summarize the material for that particular topic. All material (words, sentences, etc) in this document that is shown in a blue color has a web link embedded underneath; simply scroll the mouse over it and follow the instruction to be redirected to that link.

There is also a very important appendix in this document. Appendix A describes a streamlined payload integration process called "Lean Integration Process." The objective of this Lean Integration Process is to make it easier for PDs to fly their payloads faster to ISS using a streamlined version of the standard Payload Integration Process. However, to use the Lean Integration Process certain criteria must be met. All PDs and PIs are urged to carefully read Appendix A.

Finally, on the last page of this document, there is a list of Points of Contact with email addresses that are provided as additional resources for PDs and PIs who might want to seek some additional help or clarification on some of the topics covered in this document.

2 Background

The objective of this section is to discuss at a high level the overall ISS Payload Integration Process. Currently two payload integration templates are available to the payload developer community: (1) The Standard Template and (2) The Lean Template. The standard Payload Integration Template is defined (in this document) as one that involves the integration of a complex payload which requires a high degree of integration with both the ISS vehicle and ground operations. The standard template is a flight/increment driven template in that a payload is assigned a flight on an increment and the Payload Developer (PD) works the associated milestones to meet that flight/increment's template. The Lean Payload Integration Template, on the other hand, is PD's payload readiness driven in that the PD starts the ISS Payload Integration Process whenever the PD's payload is ready and all the associated integration technical data are completed for a flight assignment six months prior to any available flight.

2.1 Payload Integration Templates Definitions

An increment is defined as a specific time period on the ISS which combines different operations. The duration of an increment is the time period from the undocking of a Russian Soyuz vehicle to the undocking of the next Soyuz. Currently, an increment lasts about six months. An increment is comprised of at least one stage. A stage is a designated period defined by the ISS Program that begins and ends with a major activity on the ISS and is used for requirements documentation and planning purposes. It is usually referred to as the period of on-orbit configuration of the ISS after each flight which adds capability to the ISS vehicle.

2.1.1 Standard Payload Integration Template

If a standard integration template is used, the overall payload integration process can be broken down into four phases: (1) Strategic; (2) Tactical; (3) Operations (Real-time); and (4) Post-Operations (Post-flight). The Strategic Phase defines the payload requirements, the design and build hardware, safety reviews, the payload increment and flight assignment. The Tactical Phase defines the crew procedure development, the crew training, the requirements verification and the pre-ship reviews. The Operations Phase defines the integration of the hardware into the spacecraft, the launch, the on-orbit operations and the return of the payload from the ISS. The Post-Operations phase defines the vehicle deintegration requirements, the return of payload samples/hardware from the landing site to the Payload Developer (PD), the Lessons Learned, the Crew debrief and the required end of mission or increment reports.

The standard template timeframe for the payload integration process is defined in terms of "Increment minus date" (I-XX), "Launch minus date" (L-XX) and "Return plus date" (R+XX). An "Increment minus a date" indicates how many months, weeks or days an activity must occur before that increment begins. For example, I-6 Months indicates that six (6) months before that increment begins item X is due to the ISS Program from the Payload Developer. Currently, an increment begins with the arrival or departure of a Soyuz vehicle. A "Launch minus a date" indicates how many months, weeks or days an activity must occur before that launch. Note that there might be multiple launches within an increment, therefore an "increment minus date" is different from a "launch minus date". A crew's "return plus a date" indicates when that activity begins after the end of that increment. The day the ISS crew returns to earth the clock is set to R+0 and it moves forward from that point on.

Some of the payload integration activities associated with the standard template occur sequentially, but the majority of them follows parallel paths. For example, the standard template normally begins with an agreement between the ISS Program and the PD. Such agreement is referred to as the Program Integration Agreement (PIA), which is discussed in the Mission Integration section below. After such agreement is in place, a Payload Integration Manager (PIM) is assigned to help the PD navigates the ISS Payload Integration Process. From this point on, teams from several NASA organizations begin developing the different integration products needed with inputs from the PD. A generic payload integration flow will look something like (not necessarily in that specific order): (1) Program agreement; (2) PIM assignment; and (3) Payload Strategic work performance. Then, the Tactical Phase begins with: (4) Research Planning/Payload manifest; (5) Hardware Interface Development; (6) Software Development; (7) Human Factors; (8) Payload Safety Review; (9) Operations Integration; (10) Testing; (11) Hardware Delivery; (12) Bench Review; (13) Certification of Flight Readiness (CoFR); (14) Payload launch site support and Launch; (15) On-orbit Real-Time Operations; (16) Landing and Hardware Return; and (17) Post Flight Activities. Each of these activities is discussed at a high level below. It needs to be pointed out that this primer is not organized in this sequential task-oriented manner, instead the information is presented in an organizational manner. This means that each section is discussed from the point of view of the organization or team that is responsible for a number of products that need to be developed which require the PD's inputs. This approach gives the PD a better understand of the products a specific team or organization is responsible for in the integration web and why that team is requesting different types of inputs from the PD. Accordingly, this primer is organized based on the tasks associated with the following teams or organizations within the ISS Payloads

Office: Research Planning, Mission Integration, Payload Engineering and Integration, Software Integration, Payload Operations Integration, Payload Safety, Export Control, Testing Integration, Launch and Landing Support, and Real-time Operations. Because of this approach, the material discusses in this primer does not flow in a step by step payload integration process.

2.1.2 Lean Payload Integration Template

The Lean Payload Integration template differs from the standard one in that it does not follow the strategic and tactical timelines, but rather follows a gate process. This template is applicable to well characterized payloads with fairly simple crew operations. It relies on the PD's payload readiness at any moment in time to take advantage of any upcoming flight, as close as 6 months prior to a flight's scheduled launch date. In order to accommodate a payload within such a short timeframe, the payload needs to meet certain criteria which are defined in Appendix A of this document. In addition to the criteria that must be met, a fair amount of early integration work needs to have been done for a payload to be classified as a Lean payload.

Figure 1 shows the difference between the Standard and the Lean templates. The blue segment represents a generic Standard Integration Process, while the brown represents the Lean Integration one. For the Lean Integration Process, Gates 1-4 phase is the equivalent of the Strategic and Tactical Phases of the Standard Template. Gates 1-3 phase shows the additional (or early) work required for a payload to be classified as a Lean payload in addition to the Strategic Phase payload development work cycle. Gate 4 shows the work required to get the payload integration work done 6 months before the assigned launch date using a Ship and Shoot process. For a more detailed description of the Lean Integration Process, please refer to Appendix A of this primer.

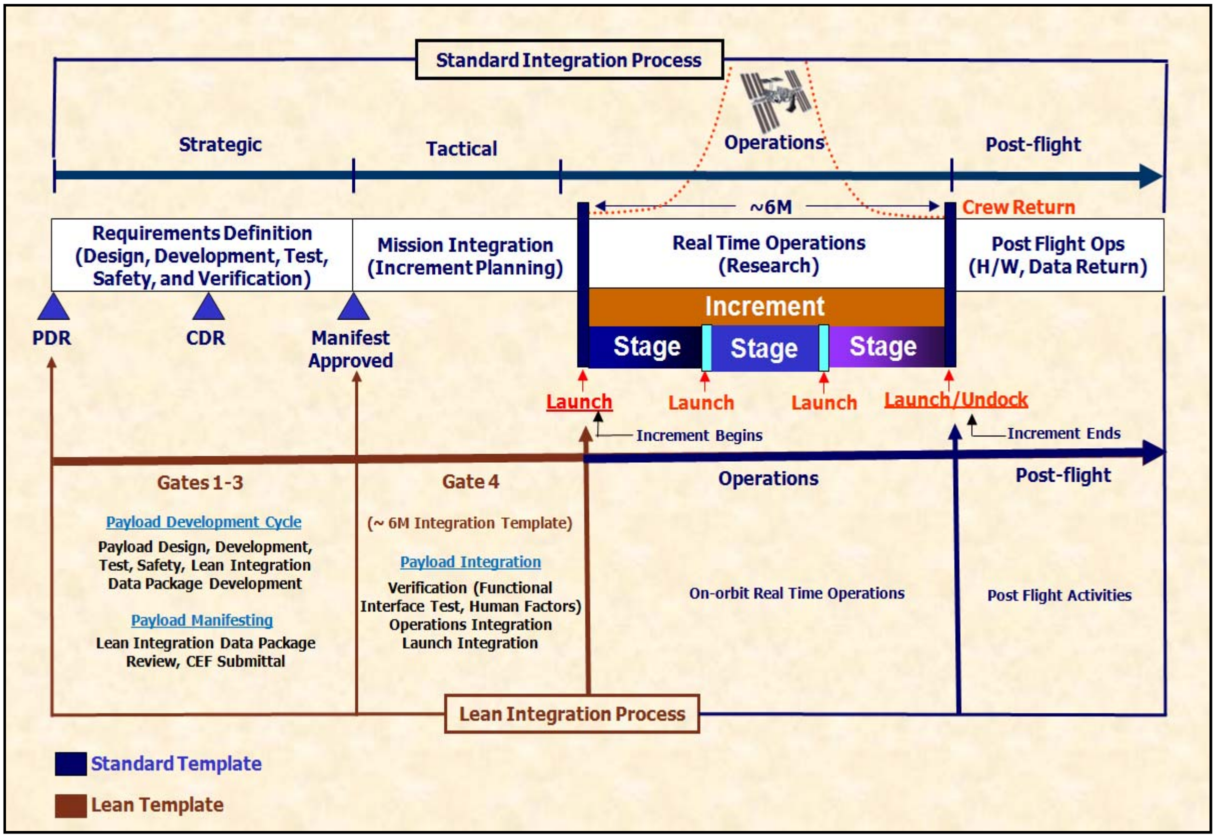


Figure 1 Standard Payload Integration vs. Lean Payload Integration Template

3 Overall Research and Planning Cycle

3.1 Multilateral Research Planning Working Group (MRPWG) Roles and Responsibilities

The MRPWG is the organization that manages the integration of multidisciplinary and international research resource requirements and objectives for the purpose of optimizing the overall research return from the International Space Station (ISS). The MRPWG performs its functions by obtaining, consolidating and integrating research resource requirements and objectives among NASA, other agencies and the International Partners/Participants (IP/P) starting from the increment timeframe through the completion of all research post-flight activities. This working group is a sub-team of the Multilateral Payloads Control Board (MPCB). The research planning cycle is carried out on an increment basis, even though multiple increments are usually in the planning stage simultaneously by the MRPWG.

3.2 Overall Research Planning

Integral in the research planning activity for a given ISS increment is the development of an Increment Research Plan (IRP) by the MRPWG. The MRPWG produces the IRP as an input to the Space Station Program (SSP) 540XX-ANX5 document, the Payload Tactical Plan (PTP), which is baselined for each increment. In the course of the development of the IRP, an analysis of the available resources against payload requirements is done. This analysis takes into account the research already on-orbit, as well as new research to be added to the increment. The IRP consists of a payload manifest for the cargo transportation vehicle flights and existing on-orbit resource requirements. The basic steps associated with the development of an IRP are outlined below.

3.2.1 Call for Payload Inputs through Release of Research Plan (RP) Development Data Package

Eighteen months prior to Increment start (I-18m), the MRPWG Chairman issues a call for investigations and payloads desired to be flown and/or performed during the increment whose planning is being developed. The call goes out to the science and payload support communities. A research plan development data package is specified as the required set of information needed from PDs to develop the IRP. The data package consists of:

- The Research Plan Requirements Definition Planning Schedule
- Increment-specific Flight Sequence Schedule
- Payload Candidate List Submittal Template
- Payload 2-Pager Development Format
- Payload Tactical Plan Workbook development webpage address
- Experiment Summary (for NASA investigations only)
- Target Milestone Chart for Experiments with Human Subjects

3.2.2 Data Package Information Gathering Process

The process of data gathering differs among the Payload Developers (PDs) but the data package is essentially the same since it is template driven. The PDs who have flown the same or similar science and / or hardware often extrapolate historical data for their future flight. new PDs or PDs who are flying new science and / or hardware start with blank templates.

1. The "Research Plan Requirements Definition Planning Schedule" is provided by the Multilateral Research Planning Working Group (MRPWG) Chairman to PDs. It contains milestones and dates for when the requested data and information are due to the MRPWG for review. There are no requirements per se in that document other than for the PD team to comply with the schedule.

2. The "Increment-specific Flight Sequence Schedule" is a list of all flights (US and International Partners' vehicles) within the Increment on which science and hardware may be manifested for launch and return.

3. The "Payload Candidate List Submittal Template" is a simple template which has a one-line description for each of the candidate science investigations the sponsoring organization desires to manifest. This is the first required document that is provided to the MRPWG on behalf of the PD by the organization or agency that is sponsoring that payload..

4. The "Payload 2-Pager Development Format" is a template provided by the MRPWG to the PDs. The first page of the template describes the science name and acronym, the research objective, a brief description of planned on-orbit operations and key personnel responsible for the payload (science and engineering management). There is also a small sub-template which describes the hardware, operational window, operational issues and constraints and human subject data (if any). The second page of the template illustrates the flight(s) which support the science, the on-orbit operation scenario and crew time involved with that scenario, and primary payload characteristics such as mass, crew training and baseline data collection (if any). This is the second required document that is provided on behalf of the PD by the sponsoring organization to the MRPWG. It is due approximately four to six weeks after the Payload Candidate List.

5. The "Payload Tactical Plan Workbook" is a multi-page, complex set of spreadsheets which require technical information describing the manifest plan, science, engineering, on-orbit operations, special conditions, constraints and other related issues about the payload. The workbook provides a guide for the submission of the data. There is a website and a point of contact within the Payloads Office Integration Management Team to help support the submission of data. This is the third required document

that is provided on behalf of the PD by the sponsoring organization to the MRPWG. It is due at the same time as the "Payload 2-Pager"- approximately four to six weeks after the Payload Candidate List.

6. The "Experiment Summary" is a template provided by the ISS Program Scientist's Office. It contains high level science and engineering information which will be posted on that office website and made available to the general public as open-source literature information. It is the fourth required document that is provided on behalf of the PD by the sponsoring organization to the MRPWG. It is due at the same time as the "Payload 2-Pager" and "Payload Tactical Plan" -approximately four to six weeks after the Payload Candidate List. This one is required only for payloads that are sponsored by NASA.

7. The "Target Milestone Chart for Experiments with Human test Subjects" is a template and reference material provided by the Human Research Program (HRP) team to collect information needed from the PD team to prepare briefing material for potential Human Subject candidates. This template is applicable only to investigations requiring the use of Human Subjects (Astronauts/Cosmonauts). The template is filled after consultation between the PD and the HRP representatives following a series of candidate payload reviews at the MRPWG. It is during these MRPWG payload reviews that the payload community first becomes aware of the science requirements for human test subjects. This is the fifth required document that is provided on behalf of the PD by the Human Research Program team to the MRPWG.

3.2.3 Payload Candidate List Submittal and Review

At approximately I-17.5 months, Payload Sponsors/agencies or payload developers submit to MRPWG their list of candidate payloads, Experiment Summary, payload resource requirements and activities desired to be performed during the increment being planned. Required resource specifications include the requested resupply vehicle flights (both ascent and descent) to be used, Human Subjects (HS), if any, requiring Baseline Data Collection (BDC) for proposed investigations, and conditioned stowage/transport needs of investigation samples. Baseline Data Collection is a series of tests and evaluations performed pre-flight and post-flight on Human Subjects (HS) whereby the collected tests data are used as reference (earth data points) in comparison to in-flight and on-orbit data collected from HS. BDC is applicable only for human life science investigations.

3.2.4 Payload Requirements Review (2-Pager, PTP tables)

At approximately I-17 months, a review of the 2-Pager data and PTP submittals begins. The review of the data occurs at special Research Planning Working Group (RPWG) meetings some of which are MRPWG meetings with the International Partners. Support from the Mission Integration team members is provided in order to evaluate the PTP table inputs. The goal of these reviews is to get a good understanding of each investigation's requirements and constraints and to start formulating the requirements for the research complement, which will be baselined for the increment.

3.2.5 Human Use Life Science Research Complement Review

Specialists from the Johnson Space Center (JSC), International Space Station Medical Project (ISSMP), Canadian Space Agency (CSA), European Space Agency (ESA), and Japanese Aerospace Exploration Agency (JAXA), meet periodically as the International Human Research Complement Working Group (IHRCWG) to discuss human life sciences experiments proposed for crewmembers during the increment. The working group evaluates the experiment protocols for their specific pre, post and on-orbit crew time needs, blood volume collection needs, and when experiments should be performed relative to each another. Conflicts are identified and proposals for solution are developed. The results of the IHRCWG assessments are presented to the Increment Research Team (IRT) for evaluation and direction for resolution of unresolved conflicts. The IRT is a sub-group under the MRPWG chartered to work increment-specific research activities. The IRT provides a recommendation to the MRPWG on which of the human life sciences experiments should be included as part of the IRP.

3.2.6 Research Plan Development Support

Upon the submittal of the investigation requirement data, and throughout the formulation of the Integrated Research Plan, the Payload Sponsoring organizations or agencies and PDs are expected to participate in the reviews and assessments of the IRP. Assessments involve a comparison of the submitted investigation/payload requirements against the ISS Program specified utilization resource allocations.

Those allocations usually describe total up-mass, transport vehicle volume capability, and crew-time needs for on-orbit payload operations. The reviews focus on developing and evaluating proposed changes to the research requirements to ensure that the best IRP is formulated, given the ISS program specified utilization allocations. If the given allocations need to be exceeded in order to have a meaningful IRP, then, those changes are proposed as well.

3.2.7 Human Use Life Science Investigation Activity

3.2.7.1 Informed Consent Briefing (ICB)

For any proposed human life science investigation, an Informed Consent Briefing (ICB) is given to the increment crew member who might perform the investigation(s) in order that they may make an informed decision regarding their participation. These ICBs are conducted by the JSC ISSMP office under an agreement with the ISS Payloads Office. The Payload Sponsoring organizations' PIs are expected to provide ICB presentation material to the ISSMP office for each human life science investigations requesting the use of HS. The material should follow ISSMP office established guidelines and templates.

3.2.7.2 Baseline Data Collection Activity (BDC)

Once a human life science experiment has been approved as part of the IRP complement, and after the ICB has been conducted, and a crewmember has signed the informed consent form, the ISSMP office begins to coordinate and to schedule Baseline Data Collection (BDC) activities. The ISSMP office prepares a BDC plan for ISS expedition crewmembers, which summarizes their total BDC requirements. This BDC plan is based on the information provided by the payload Principal Investigators that describes experiment and related requirements. The crew time requirements for the BDC are included in the PTP.

3.2.8 MRPWG Approval of the Increment Research Plan

The MRPWG reviews the research plan, which has been formulated into a presentation report by the Chairman of the MRPWG. The presentation includes a listing and a description of the proposed investigations, specification of the resource allocations, investigation/payload transportation requirements (up-mass and return) , conditioned stowage needs, and on-orbit crew-time needs. Recommendations are made by each International Partner (IP) on changes to the presentation whether they are additions, deletions, and/or modifications. Consensus is achieved on the recommendation to proceed forward to management reviews of the proposed IRP.

3.2.9 Payload Boards Approval of the Increment Research Plan

The Chairman of the MRPWG presents the IRP to the Payloads Control Board (PCB), a NASA internal board, and to the Multilateral PCB (MPCB) for review and approval. Additionally, members of the Mission Integration team present the formulated basic version of the PTP, Increment Definition and Requirement Document (IDRD) Annex 5, for approval. The PTP contains the elements of the IRP plus additional increment integration data that describe the entire payload complement requirements including, crew training, Baseline Data Collection, payload power and data downlink needs, photographic and video needs, and payload on-board stowage requirements.

3.3 Other MRPWG Supporting Products

3.3.1 Input for ISS Stage unique Load Shed Table (LST)

The payload segment of the Load Shed Tables (LST) is an integrated and prioritized list of all the research facilities operating during an increment within the United States On-orbit Segment (USOS). The priority associated with a research facility does not necessarily correspond with the science priority being performed in that facility, but rather with the science samples and hardware shelf life, temperature constraint, total or partial science loss as well as other additional constraints. The Load Shed Tables science racks prioritization provides the Payload Operations community with priority guidance regarding sequences and actions required to minimize science loss during an on-orbit situation requiring sudden decrease in power consumption, and facilitate a successful rack/payload recovery. The IRT develops the payload segment of these tables based on inputs received from the PD team for each of the payloads on that increment.

3.3.2 Input for Pre-increment Science Symposium

A Pre-increment Science Symposium is organized and led by the designated ISS Lead Increment Scientist (LIS) for that increment usually 60 to 90 days before the increment begins. The increment-based science symposium is used to educate the science/payload community and other teams within the ISS community about the various research investigations to be performed during the increment. The symposium also provides a forum for the principal investigators (PIs) to discuss the main objectives of their science and educate the other PIs on the increment about the wide spectrum of research that will be performed both in and outside their field that could be beneficial to all.

4 Overall Mission Integration Process

4.1 Mission Integration Roles and Responsibilities

The Payload Mission Integration organization manages and integrates ISS payloads on launch vehicles, integrates payload flight and increment activities across the various increments, and coordinates the resolution of payload mission integration issues affecting all Partners across the increments.

4.2 Mission Integration Processes

Following the release of the approved PTP Annex-5, the Mission Integration team initiates work to successfully integrate and operate the payload complement.

4.2.1 Payload Integration Manager (PIM) Roles and Responsibilities

A Payload Integration Manager (PIM) is assigned to each payload by the ISS Payloads Office. The PIM functions as the primary point of contact between the Payload Developer (PD) and the ISS Program. Once a PIM is assigned to a payload, the PIM provides the PD with guidance during the entire integration process. The PIM is responsible for the successful integration of a payload to ISS and the launch vehicle.

The PIM assignment initializes customer interfacing and the development of the Payload Integration Agreement (PIA), payload-unique Interface Control Document (ICD), PIM schedule, and payload data products. During the development of these documents, the PIM discusses with the PD the requirements that the ISS places on the payload as well as the requirements and ISS Program services needed by the PD. The PIM negotiates the general roles and responsibilities, integration schedules, and top-level interface data with the PD. Also, the PIM is responsible for coordinating any engineering/technical support as required to support the development of the documents. In addition, the PIM is responsible for developing, managing and communicating the PIM schedule. That schedule is a payload specific schedule that defines PD integration work and ISS Program required data deliveries to meet requirements in support of mission preparation. The PIM ensures that the PD’s requirements are accurately defined, documented, and compatible with the ISS accommodations and that they are properly implemented.

As the payload design matures, it is likely that there will be changes to the estimated size, weight and resource requirements which were initially provided in the IRP/PTP planning products. A Change Evaluation Form (CEF) process exists to capture changes to payload requirements. The PIM will work with the PD team to capture and provide updates to the ISS Program as needed.

4.2.2 Payload Integration Agreement (PIA) letter

The Standard Payload Integration Agreement (SPIA) specifies the primary management and technical responsibilities for the PD and the ISS Program. The SPIA defines, either directly or by reference documentation, management roles and responsibilities, flight and ground safety requirements, interface design requirements, verification and testing requirements, operational requirements, launch/landing site processing requirements, resource and interface commitments, and schedule tracking commitments. Please refer to the following two documents: SSP 57072 for all pressurized payloads, and SSP 57061 for all attached/unpressurized payloads.

The payload-unique PIA is the signed agreement between the PD and ISS Program, committing the parties to fulfilling the requirements of the SPIA for a unique payload. The PIA documents agreed deviations from the SPIA requirements and/or unique agreements. The PIA also documents PD requirements or agreements concerning ISS resources, capabilities, and services required to provide the payload with accommodations to, from, and onboard the ISS. These items usually fall under one of the categories listed in the PIA: Cold Stowage requirements, Program Furnished Equipment (PFE), and Ground Data Services (GDS) requirements. The PIA includes customer and ISS Program points of contact and their separate and joint responsibilities.

4.2.3 Hardware Feasibility Assessment

A Hardware Feasibility Assessment is performed at the start of each IRP to provide visibility of potential Mission Integration (MI) issues. The Feasibility Assessment is an assessment of the payload readiness. It enables PCB to baseline appropriate payloads to be included in the IRP.

The process starts when the MRPWG Chair makes the formal request for submittal of the 2-Page summary and PTP inputs. The PIM coordinates and supports the PD in completing the 2-page summary and the inputs to the PTP. The PIM also fills out a payload feasibility checklist for each candidate payload. The Increment Payload Engineer (IPE) collects all the checklists and begins a multi-discipline review of all the checklists. The checklists are reviewed by Mission Integration, Payload Engineering, Payload Software Engineering, EXPRESS Project, Payload Safety and International Partners. Inputs from all the disciplines are consolidated into an increment feasibility assessment stoplight chart. The feasibility assessment Stoplight Chart is then reviewed by the Increment Payload Manager (IPM) and IPE. A Go/No-Go status is provided for each payload. The feasibility assessment Stoplight Chart is presented at the MRPWG for concurrence on the IRP.

4.2.4 Basic Understanding of the Increment Definition and Requirement Document (IDRD)--Annex 5--Development process

The Annex 5 Payload Tactical Plan (PTP) provides the multilateral research objectives, ascent/descent flight manifest, on-orbit requirements, resource sub-allocations, and payload topologies for the Utilization complement for a given increment. The Annex 5 PTP also documents and controls resource exchanges between NASA and International Partners/Participant (IP/Ps) payload programs. The Annex 5 PTP is owned by the Payload Mission Integration (PMIT), and the Increment Payload Engineer (IPE) is responsible for the book management. The Annex 5 PTP is the primary management and technical implementation for Utilization, as programmatically directed through the IDRD, and is the basis for the payload input to the IDRD main volume.

4.2.5 Certificate of Flight Readiness (CoFR) process

The ISS CoFR process consists of a series of detailed “readiness reviews” performed by NASA, the IP/Ps, and NASA contractors to demonstrate their readiness to support the launch, dock, undock, and return of an ISS Transportation Vehicle and the subsequent on-orbit activities planned throughout the flight, stage, and when warranted, the Increment. The series of CoFR readiness reviews performed by the various organizations culminate in the performance of the integrated ISS Program Stage Operations Readiness Review (SORR), which is chaired by the ISS Program Manager. The SORR typically occurs at Launch minus 3.5 weeks. In order for the ISS Program Manager to consider the Program “certified” as ready to support the flight, the various certifying organizations endorse to the ISS Program Manager via signature that they have satisfied each of the applicable Program-level ISS CoFR Endorsement Codes defined in SSP 50108 and that there are no other known issues that pose a constraint to flight or mission success.

Initial ISS Payloads Office CoFR preparation activities begin approximately between Increment minus 12 months (I-12 months) to I-9 months for the first flight within an Increment; around L-8 months for Shuttle flights scheduled within the Increment; and around L-6 months for non-Shuttle flights within the Increment. As the PD’s payload hardware launch is approaching, the PD will be required to participate in the CoFR process. The PIM will assist the PD. The PD participates in the ISS Payloads Office CoFR by responding to the call for inputs during the various stages of the CoFR process, and supporting meetings where the Open Work

Tracking Log (OWTL) is discussed. If issues get elevated to the Program Manager, the PD may also need to support the SORR.

4.2.6 Basic Understanding of the Change Evaluation Form Process

The Change Evaluation Form (CEF) is used for changing Mission Integration products managed by the ISS Payload Mission Integration Team (PMIT). These include the ISS PTP documented within the IDRD Annex 5 and associated payload manifest content in IDRD Annex 1.. A CEF is not required until after the IRP and the requirements in the IDRD Annex 5 PTP have been baselined and approved at the MPCB. Prior to MPCB approval, requirement changes are coordinated directly with the MRPWG. When a CEF is needed, The PIM will coordinate with the PD team to submit the CEF.

4.2.7 Hardware Delivery

A key milestone on the PIM's schedule, which is developed for the PD, is the PD's hardware delivery. The PD is responsible for shipping the payload hardware to the designated location. The designated location depends on the launch vehicle the payload is manifested on. Once a payload is manifested on a particular flight, the PIM's schedule shows when the hardware needs to be delivered to the launch site or to Flight Crew Equipment (FCE) in Houston, Texas, for bench review and payload integration with the launch vehicle. Normally, the hardware is delivered 2 weeks prior to bench review. The PIM coordinates with the PD to make sure all proper forms and documentation are in order prior to shipping.

4.2.8 Bench Review Process and Crew Equipment Interface Test (CEIT)

At the receiving site, the PD's hardware will go through the Bench Review process. The purpose of the Bench Reviews or the Crew Equipment Interface Test (CEIT) is to provide the crewmembers the opportunity for hands-on internal and external verification of hardware interfaces, inspection, functional testing of crew interfaces and equipment, and closeout photo documentation. Crewmembers are given the opportunity to perform prelaunch tool and equipment fit checks to verify access and to do an overall inspection of flight hardware in a near-flight configuration. It is also an opportunity for the ISS Payload Approval Team (IPLAT), training and other disciplines to inspect the hardware to make sure that it meets all the requirements prior to stowage and launch. All stowage hardware goes through bench review. The PD or representatives are required to be present during the Bench Reviews. Bench reviews may be held at the Johnson Space Center (JSC) or at the Kennedy Space Center (KSC), depending on which vehicle the payload is manifested. Bench reviews occur several days to months at the specified location depending on which vehicle the payload is manifested and whether late load access is required or not. All pertinent details will be contained in the PD's PIM payload schedule.

5 Overall Engineering Integration Process

5.1 Engineering Integration Roles and Responsibilities

5.2 Interface Requirements

The Payload Engineering and Integration (PE&I) team provides guidance and oversight based on the interface requirements documents and interface control documents as described below. However, it is the responsibility of the PD to design the payload/hardware to conform to the appropriate set of interface requirements specified by the ISS Program.

The interface requirements for pressurized (internal) payloads can be found in SSP 57000 "Pressurized Payloads Interface Requirements Document (IRD)". This Interface Requirements Document (IRD) is the principle source of interface design requirements. In order for a pressurized payload to be certified for integration into applicable ISS modules, the IRD shall be complied with. These include United States Laboratory (USL), Columbus (COL), Japanese Experiment Module (JEM), and Multi-Purpose Logistics Module (MPLM). The National Space Transportation System (NSTS) 1700.7, ISS Addendum, Safety Policy and Requirements for Payloads Using ISS, and NSTS/ISS 18798, Interpretations of NSTS/ISS Payload Safety Requirements, provide the safety requirements for payload design, certification and operation.

The IRD levies design interface and verification requirements on ISS pressurized payloads. These requirements are allocated to an integrated rack or pressurized payload through the applicability matrix in the unique payload ICD. The unique payload ICD defines and controls the design of the interfaces between the ISS and the pressurized payload, including module unique interfaces.

The unique Pressurized Payload Hardware ICD documents the payload implementation of the ICD blank book requirements. The unique payload ICD is used to determine if the hardware design remains within the interface design parameters defined by the IRDs. Limits of the ICD are established in a conservative manner to minimize individual payload and mixed cargo analyses. Exceptions to the IRD will be documented in the unique payload Interface Control Documents (ICDs). Exception is the general term used to identify any payload-proposed departure from specified requirements or interfaces. Any exception to requirements, capabilities, or services defined in the IRD shall be documented in Section 5.0 of the derived ICD and evaluated to ensure that the stated condition is controlled. Section 5.0 will document the specific requirement excepted, the exception number, the exception title, and the approval status. Note: *Exceptions to the requirements in this document require the use of the formal Exception Process as detailed in Section 5.0 of SSP 57001, Pressurized Payloads Hardware Interface Control Document Template.*

Interface requirements for unpressurized (external) payloads can be found in SSP 57003 "Attached Payloads Interface Requirements Document". The Attached Payload (AP) IRD is the principle source of interface design requirements for Attached Payloads on ISS. In order to certify that an external truss AP is ready for installation and operation on the ISS, the AP IRD shall be complied with. NSTS 1700.7B, ISS Addendum, Safety Policy and Requirements for Payloads Using ISS, and NSTS/ISS 18798, Interpretation of NSTS/ISS Payload Safety Requirements, provide the safety requirements for payload design, certification, and operation.

The physical, functional, and environmental design requirements associated with Attached Payload safety and interface compatibility are included herein. The requirements defined in this document apply to on-orbit phases of the Attached Payload operation. On-orbit requirements apply to all the external truss AP of the ISS located on the Integrated Truss Assembly (ITA). Attached Payload ground handling, processing, and ground transportation requirements are specified in KPL-HB 50001, Launch Site Accommodations Handbook for Payloads, and KHB 1700.7, Payload Ground Safety Handbook. Attached Payload requirements for launch, landing and payload bay interfaces are specified in NSTS 21000-IDD-ISS, International Space Station Interface Definition Document, and SSP 57061, Standard Payload Integration Agreement for Attached Payloads.

The AP IRD levies design interface and verification requirements on ISS Attached Payloads. These requirements are imposed on an Attached Payload through the applicability matrix in the payload unique ICD. The payload unique ICD defines and controls the design of the interfaces between the ISS and the Attached Payload. The AP IRD document serves to establish commonality with respect to interface design, analytical approaches, models, test methods and tools, technical data and definitions for integrated analysis.

The unique payload ICD documents the implementation of the AP IRD requirements and ensures that they remain within the interface design parameters as defined by this document. Exception to the IRD will be documented in the unique payload ICDs. Any exception to the requirements, capabilities, or services defined in the AP IRD shall be documented in the unique ICD. The ICD will document the specific requirement violated or excepted, a description of the existing condition, and a rationale for acceptance. Additional documentation and presentations to control boards containing cost, schedule, and technical impacts may be required for approval of deviations and waivers. SSP 57004, Attached Payload Hardware Interface Control Document Template, provides a description of the exception submittal and approval process and the form used. The definition of exceedance, waivers and deviations are contained therein.

Payload Engineering and Integration (PEI) supports payload feasibility studies and provides vehicle capabilities and interface knowledge to payload developers.

5.3 Hardware Interface Control Document (ICD)

Each individual payload will create an ICD to quantify and control its interfaces. Payload Engineering and Integration supports generation of the ICDs and maintains a compilation of payload ICDs and associated PIAs on the ISS Payloads Office (OZ) web page under the PEI (OZ3) link

5.4 Stage Analysis

Payload engineering and integration include stage products which cover all flights and individual increments. Guidelines and constraints apply to all flights as detailed below.

5.5 Guidelines and Constraints

The PD's payload may have some features that impact the on-orbit environment during the PD's payload operation. To understand impacts due to such payload the PE&I team analyzes the payload technical data package submitted by the PD to produce the SSP 57516 "Payload Operations Guidelines and Constraints Report". This report identifies generic payload engineering operational guidelines and constraints involving the operation of United States payloads in the United States Orbital Segment (USOS) element level, and the ISS level. This "All Flights" Payload Guidelines and Constraints (GLC) report is intended only to identify the generic operating guidelines and constraints, which are applicable to payloads that remain on-orbit for an extended period of time. Operational GLC for those payloads with a short duration on-orbit life are captured in the unique stage-specific payload guidelines and constraints reports. That report documents ISS payload on-orbit engineering restrictions. The Payload Operation Integration Function (POIF) utilizes these operational guidelines and constraints as stated in that report for the development of follow-on products including: payload regulations, flight rules, operational timelines, and detailed operational procedures.

5.6 Human Factors Integration Team (HFIT) Support

The Human Factors Integration Team (HFIT) performs the necessary verification activities (analysis, test, inspection or demonstration) for ISS PDs to certify that the payload hardware meets SSP 57000, section 3.12, requirements.

The HFIT team is a joint effort requiring teamwork by an Astronaut Representative, NASA Human Factors and Boeing Human Factors experts. Its intent is to provide the verification certification function to ISS NASA sponsored payloads for the SSP 57000, section 3.12, requirements with the exceptions of Section 3.12.3.2 Touch Temperature, Section 3.12.3.3 Acoustic Requirements, and Section 3.12.3.3.1 Noise Limits. These follow the existing Payload Interface Revision Notice (PIRN) process in SSP 57000.

The HFIT reports to the Payload Engineering Control Panel (PECP) those matters which the team and PD could not resolve that may affect the interface of the payload hardware with the ISS crew.

Authority for the HFIT is delegated from the PECP. Changes to this authority are reflected in updates to its charter. The HFIT has the authority to review all hardware and hardware drawings that have crew interface requirements listed in SSP 57000, section 3.12. HFIT performs the necessary verification activities to demonstrate compliance to these requirements for the PD and issues the necessary certifications to document compliance. HFIT collects the necessary data to demonstrate compliance with the applicable SSP 57000 requirements during hardware inspections, tests, demonstrations and Crew Consensus reviews and archives for future use as necessary. If compliance cannot be achieved, HFIT may approve exceptions to individual SSP 57000, section 3.12, requirements through collection of payload hardware data, which indicate that the intent of the requirements was met. HFIT has approval control for Human Factors Implementation Team (HFIT) Verification/Certification Matrix, Form 881 ISS Payload Human Factors Requirements Compliance Feedback Form, Form 882 and Hardware Certificate of Compliance (COC) ISS Human Factors Final Disposition, Form 883.

5.6.1 ISS Payload Label Approval Team (IPLAT) Support

The ISS Payload Label Approval Team (IPLAT) is a sub-set of the HFIT, managed by the ISS Program. Label evaluations and verification are combined with the HFIT activities. The ISS Payload Label Approval Team (IPLAT) verifies that ISS payloads are meeting the label requirements in SSP 57000, Appendix C. IPLAT coordinates with the PD and the Astronaut Office to produce the crew interface labeling. IPLAT's goal is the standardization of payload labels to facilitate the crew's understanding of the hardware. This helps to increase the amount of time dedicated to science. IPLAT ensures payloads are properly labeled by providing direction and helping the PD by creating label drawings upon request.

5.7 Acoustics Support

Interior sound levels of the ISS are controlled to insure a habitable acoustic environment for the Space Station crew. Each payload has an allocated noise level which contributes to the overall payload noise allocation. The PECP controls the overall Payload acoustic noise allocation by reviewing and controlling each payload's contribution to the overall noise environment.

5.8 Verification Review/Approval and Tracking

Payload verification data is collected from the PD and reviewed by PEI. After the data has been approved, PEI creates a verification memo that details the verification for payloads launching and returning on a given stage.

5.9 Exceptions

Exceptions can be made to individual payload ICD requirements and are processed through the PECP.

5.10 Conditioned Stowage Assets and Integration

The physical, functional, and environmental design requirements associated with payload cold stowage sample safety and interface compatibility are maintained by PEI. The cold stowage requirements can be found in SSP 57070, which apply to ground handling and processing, transportation, and on-orbit phases of the payload cold stowage sample utilization. Transportation requirements for Multi-Purpose Logistics Module (MPLM), Shuttle Middeck, Shuttle soft stow, and Automated Transfer Vehicle (ATV) are included in that document.

6 Overall Software Integration Process

6.1 Software Integration Roles and Responsibilities

The Payload Software Integration team is responsible for the implementation of the US payload software and avionics portion of ISS. The Payload Software Integration office is responsible for chairing and conducting the Payload Software Control Panel (PSCP). The PSCP schedules and controls payload flight software product deliveries, which support software configurations and end to end functionality in support of the PD operations.

The PD is responsible for payload software development. The ISS Payloads Office offers integration support so that the PD payload software interface functionality is in place to support the PD operations.

6.2 Software Architectures Description

There are many software architectures that can be established to conduct payload research. Two key factors should be considered during the PD payload software development: 1) the PD ISS host accommodations, and 2) various ranges of interaction which the PD payload desires during operations. These factors will influence the PD software architecture design, and will therefore impact the software integration process path.

Host facilities may be a pressurized facility (EXPRESS Rack, Microgravity Sciences Glovebox, Human Research Facility Rack, Materials Science Research Rack, etc.) or an unpressurized host such as the EXPRESS Logistics Carrier (ELC). Each host facility has established software interface documentation that specifies interfaces with payloads it may support.

The following tables (Tables 1 through 4) represent a broad range of payload software architectures and software integration considerations. The PD payload software implementation may ultimately be a "blend" of the architectures discussed below. When a PIM is assigned to a payload, the PIM will develop the software integration section of the PIM schedule appropriate for that payload.

Table 1 – Software Integration Considerations for Highly Autonomous Payload Software

Payload Software High Level Architecture Overview	Key Payload Software Integration Information
Highly Autonomous Software resides on payload processor with no interactive capability ▪ Payload software may self initiate when the payload is powered to collect data on the payload processor ▪ Data collection results (files) are returned when the	**<u>Health and Status Data</u>** Although this architecture sounds completely independent, a software interface to ISS may still be required. Powered payloads may be required to provide Health and Status information for insight to the Payload Operations and Integration Center (POIC) real-time operators that the payload is operating safely and as expected. Health and Status data typically includes voltage and/or current measurements, temperature measurements, etc. If the PD's payload is hosted in a facility, the PD may provide these measurements to the host via the host facility interface requirements. To define the PD payload Health and Status definitions, the ISS Payloads Office has built a database system, the

<table>
<tr><th>Payload Software High Level Architecture Overview</th><th>Key Payload Software Integration Information</th></tr>
<tr><td>payload is returned to earth</td><td>Payload Data Library (PDL), available through this link.

Information about the PD’s payload Health and Status parameters that are entered in the PDL is used to build two other important sets of integration products:

▪ Command and Data Handling (C&DH) Dataset, which configures the ground data systems to capture, route and convert the Health and Status Data to meaningful values to be displayed at the POIC for ground operators.
▪ Health and Status data is routed onboard via the Payload Multiplexer Demultiplexer (PLMDM) avionics; special files are built to route the PD’s payload Health and Status data. If required by the Payload Safety Review Panel, the PD’s payload Health and Status data may also be monitored by the PLMDM.

<u>Automated Procedures</u>

A highly autonomous payload may require monitoring by onboard avionics (PLMDM) to take automatic action to deactivate the payload if payload operations are not nominal. The PD will be required to provide appropriate data input and technical support to the development of this capability.</td></tr>
</table>

Table 2 – Software Integration Considerations for Semi-Autonomous Payload Software

Payload Software High Level Architecture Overview	**Key Integration Information**
Semi-Autonomous Software resides on payload processor and interactive capability exists from the ground	As discussed above, the PD typically needs to define Health and Status data parameters in PDL. The PD also needs to define commands to be sent to their payload, as well as near real-time telemetry data to be routed to the PD's operations location. Adding the PD's command and telemetry definitions to PDL will ensure that the C&DH Dataset is configured to properly route this data from/to the PD's ground operations location. Reference MSFC-STD-1274 Vol. 2 App. B for data types and MSFC-DOC-1949 Vol. 4 (telemetry) and Vol. 5 (command) for database definitions. To plan and establish the PD's ground operations location(s) to interact with their payload, the PIM will help the PD coordinates with the Ground Systems Requirements Team. This team works with the PD to establish secure accounts and data routing between the PD's operations location and the Huntsville Operations Support Center (HOSC) location, which is the PD interface for uplink and downlink routing. Reference section 7.6 of this document (POIC Ground Systems Services Products and Development) for further information. Additionally, NASA has also developed Telescience Resource Kit (TReK) software that the PD can use to interact with their payload from the PD's ground operations location. The TReK is also a useful tool for software development testing. Information about TReK is available through this link.

Table 3 – Software Integration Considerations for Flight Interactive Payload Software

Payload Software High Level Architecture Overview	Key Integration Information
Flight Interactive Software resides on a payload processor and a display is available for crew interaction with the payload ▪ Display may be integral to the payload and easily accessible by the crew ▪ Laptops are available onboard to host the PD's payload application (host facility may provide a laptop; common use laptops are also available)	**<u>Displays and Procedures</u>** Development of the displays and crew procedures to interact with the PD's displays is a PD responsibility. Usability Assurance of the PD developed displays is the responsibility of the Payload Display Review Team (PDRT). For US payloads and payloads flying under a US science program, the PDRT provides design support throughout the displays and crew procedures development process to ensure payload on-orbit Crew interfaces are usable (ISO 9241-11 definition), standards compliant, and certified flight ready. Payload displays must be compliant with the Integrated Displays and Graphics Standards (IDAGS); more information can be found through this link. More information about the PDRT is available at the following URL (from the POIF web site (account required)). **<u>Onboard Laptops and Compatibility</u>** Information about the laptop models available onboard may be found through this link. The PDs need to be aware of the operating system and capabilities of the onboard laptops if the PDs choose to use an existing, common use, onboard laptop. The PDs are responsible for testing their laptop applications and to system-test their device with the common use laptops. Additional coordination will be required with the ISS Avionics Group (NASA/OD). If the PDs' laptop applications will operate on a host facility or on onboard laptops, compatibility testing will be performed by the integration team.

Payload Software High Level Architecture Overview	Key Integration Information
	<u>Software Media</u> If the PDs payload software implementation requires that media be launched to the ISS, the ISS Payloads Office will develop the flight copy of the software media that is manifested for launch. It is the PDs responsibility to develop the source media that is copied onto flight media. The PDs are reminded that crew procedures need to be developed for the crew to load the software media onboard.

Table 4 – Software Integration Considerations for Software Based Research

Payload Software High Level Architecture Overview	Key Integration Information
Software Only Investigation - research is conducted with software ▪ No unique payload hardware exists ▪ May be loaded on an existing computer and operate autonomously, semi-autonomously, or with crew interaction ▪ Ground operators can downlink files from some onboard laptops to the ground	Typically, no health and status data are required for onboard laptop hardware; other methods are used by ground controllers to monitor laptop operations. Some host facility laptops provide hard drive space for payloads and the functionality for ground controllers to downlink stored payload files. Depending on the level of interaction desired (ranging from near autonomous to crew operated), key integration factors discussed in Tables 1 through 3 also apply for a Software Only investigation: o The PDL definition of C&DH Dataset for command and telemetry routing o Ground Systems Requirements for a remote payload ground operations location o TrEK software to implement at a remote payload ground operations location o Crew Displays and Crew Procedures for interacting with payload software o Onboard Laptops and Compatibility to host payload software o Software Media for payload applications

6.3 Payload Software Integration Products

In addition to flight software a PD may develop, flight and ground software products are built by the ISS Program to enable the flight and ground systems to accommodate the transfer of PD commands and telemetry. The PD must provide input to the ISS program via the following mechanisms to enable flight and ground system product development and integration.

6.3.1 Command and Data Handling (C& DH) Dataset Development

Description - A C&DH Dataset is needed to provide insight of the Health and Status of the payload to the real-time control team, and to enable an interface with the PD's ground operations location to command and receive science data. The C&DH Dataset is generated by the ISS Payloads Office based on inputs the PD provides to the Payload Data Library (PDL). The PDL collects information about:

- Instrumentation telemetry to be collected and processed to monitor operations and science
- Instrumentation commands to be relayed to the ISS to operate payload equipment
- Miscellaneous data services

C&DH Dataset information is used to build POIC Command and Telemetry Databases to support ground testing prior to launch, and real-time operations. C&DH Dataset information also provides inputs to build the Payload Multiplexer Demultiplexer (PLMDM) Configuration Files (PCFs) which enable routing of payload Health and Status data through the PLMDM and to the Payload Operations and Integration Center (POIC) for monitoring by the realtime team.

The PD is requested to provide input to the PDL as early as possible. C&DH Dataset input provided by the PD at approximately 16 months (Preliminary PD input), 9 months (Interim PD input) and 6 months (Final PD input) prior to the planned transition of the flight and ground systems is required.

6.3.2 Ground System Requirements Development via Ground Data Services Dataset

Description – The PD coordinates the need for remote ground operations locations with the Ground Systems Requirements Team. (Note – The Ground Systems Requirements Team is not within the Payload Software Integration (PSI) organization. Reference section 7.6 of this document (POIC Ground Systems Services Products and Development) for further information.)

6.4 Laptop Software Products

Laptops are available onboard the ISS to host PD's payload applications (host facility may provide a laptop; common use laptops are also available onboard). PD needs to be aware of the operating system and capabilities of the laptops onboard the ISS if the PD chooses to use an existing, common use onboard laptop. The PD team is responsible for testing its laptop applications and to system-test its device with the common use laptops. If the PD's laptop applications will operate on host facility or on onboard laptops, compatibility testing will be performed by the integration team. Information about the laptop models available onboard the ISS is available at this link.

6.4.1 Display Development and Review

Description - Development of software displays and crew procedures to interact with laptop software applications is the PD's responsibility. Payload displays must be compliant with IDAGS. Usability Assurance of the PD developed displays is the responsibility of PDRT. The IDAGS and PDRT personnel provide design support throughout the displays and crew procedures development process. Reference Section 7.4.1 of this document (Crew Operations Procedures) for further information. It is desirable for software display review by the PDRT to initiate as early as possible in order to prevent display software rework by the PD team.

6.4.2 Compatibility Testing

If the PD's laptop application will operate on host facility laptops or onboard general purpose laptops, compatibility testing of the PD's payload software applications on those platforms needs to be performed by the integration team. It is the PD's responsibility to coordinate testing with help from the PIM.

6.4.3 Media Processing for Launch

The ISS Payloads Office will develop the flight copy of the software media that is manifested for launch. It is the PD's responsibility to develop the source media that is copied onto flight media. The PD's PIM will typically allot eight (8) weeks on the payload integration schedule for the flight software media build, transportation, and integration for launch.

6.5 Software Testing

It is the responsibility of the PD to conduct payload software unit testing during the payload development life cycle phase. Error-free payload software applications and software interfaces are key to successful operations. Mission success risk is reduced by conducting thorough software unit testing, followed by integration testing. The PD's host facility may provide software development and integration test tools and/or accommodations. The TReK software tool mentioned previously is a valuable integration tool. The PD should take advantage of available software integration testing capabilities as early as possible during the payload development cycle.

The ISS Payloads Office is responsible for simulations (see section 7.5.2 of this document - Cadre/PD Simulations) and other testing (see section 10 – Overall Testing Integration Process) which may include the PD's payload data interfaces.

7 Overall Payload Operations Integration Process

The payload operations integration template may begin as early as Increment minus 24 to 30 months depending upon the specific requirements for the payload. The intent of the overall payload operations integration process is to ensure that the crew and ground teams are adequately trained and operational products are developed and integrated to promote successful on-orbit operations.

7.1 Payload Operations Roles and Responsibilities

Once the payload's operational concept is well underway, integration activities to support the development of products and procedures for on-orbit operations can begin. An Operations Lead (Ops Lead) and Payload Activity Requirements Coordinator (PARC) will be assigned to the payload to assist in accomplishing this task. The Ops Lead will be the payload Point of Contact (POC) for crew training and crew procedure development as well as other operational products that may be required to ensure successful operations. The PARC will assist the PD in developing detailed requirements for scheduling on-orbit operations. Payload Operations integration processes, procedures, and payload points of contact are available on the Payload Operation Integration Function (POIF) website. Instructions for acquiring an account can be found through this link. Increment/Flight preparation processes are documented in the Payload Operations Handbook, Volume 1 (POIF-1004).

7.2 Crew Training Process

Development and execution of crew training is a joint effort among the Ops Lead, PD, JSC Astronaut Office Representative, Procedure Author (Ops Lead or PD), PDRT POC, and Crew Training Coordinator (CTC). Personnel responsible for displays, procedures, crew training, and scheduling must continually work together in order for payload crew training to occur.

7.2.1 Training Strategy Process

The Training Strategy Team (TST) process involves a structured planning and decision-making group who determine crew training requirements for each payload. Those training requirements and what will be needed to fulfill those requirements are discussed, defined, and agreed upon by the Ops Lead, the PD, and the Astronaut Office rep. These requirements are the basis for trainer development, lesson development, and scheduling. Procedure and display milestones that affect crew training are also discussed and agreed upon. A TST may be held for either a new payload, an increment payload complement, or if changes to an existing payload warrant a change to existing crew training requirements.

7.3 Planning Process

The PARC is the interface with the PD. The POIF planners participate in operations preparation planning by developing the NASA payload section of the Increment-specific Execute Planning Groundrules and Constraints (Gr&C), collecting the PD activity requirements, and producing the NASA payload On-orbit Operations Summary (OOS). The POIF planners also lead the station-wide payload planning effort by combining the OOSs and Gr&C inputs from the ESA and JAXA elements into integrated payload products. In order to ensure that station-wide planning is conducted on schedule, the POIC planners, IP planners, and users must provide inputs at designated times during each development cycle.

7.3.1 Planning Requirements Submittal

For the operations preparation planning cycle, the NASA PD submits payload activity requirements for the upcoming increment/flight in the User Requirement Collection (URC) tool. These requirements are called the Planning Data Set. Planning requirements are submitted in URC for the use of ISS and/or Shuttle resources (power, on-orbit crew time, thermal, data, etc.). The Planning Data Set is reviewed by the POIF and NASA payload community. An Engineering Change Request (ECR) is submitted to the NASA Payload Operations Control Board (NPOCB) to baseline the Planning Data Set. A URC account can be acquired by contacting the assigned PARC.

7.3.2 Planning Product Development

An On-orbit Operations Summary (OOS) is developed prior to the start of the increment to lay out the payloads planned to operate during the increment on a weekly basis. This product shows the PDs when their payloads will be activated and operated on-orbit during the increment. The PDs are responsible for on-console staffing support during the PDs' payload on-orbit operations if on console support is part of the PDs' ground operations. During the OOS development, a Preliminary and Final OOS are developed. For both the Preliminary and Final OOS, the Payload Planning Managers (PPMs) generate a payload OOS for the NASA element. Using the payload resource allocations and payload OOSs for the ESA and JAXA elements, the PPMs develop a USOS Payload OOS. A Technical Interchange Meeting (TIM) is conducted for both the Preliminary and Final OOS. The TIM is supported by NASA and IP Planners to develop the integrated OOS which includes systems activities/requirements as well as payload activities/requirement. Upon completion of the Payload OOS, the POIF, LIS, IPM, IP Planners and the PDs review the OOS and Groundrules and Constraints (Gr&C).

7.3.3 Real Time Usage of the On-Orbit Summary (OOS) by the LIS for Operations Decision/Execution

As an increment progresses, the LIS makes use of the final OOS to review the progress of payload activities with the Increment Research Team (IRT) members, the Increment Payload Manager (IPM) and the Payload Operations Manager (POM) to develop recommendations on changes to payload activity sequencing and priorities that may be needed as a result of payload performance, completion, and/or non-execution. This is because many on-board payload activities may not be accomplished as were planned due to various reasons including but not limited to, hardware anomalies, lack of manifested items, vehicle flight delays, lack of available crew time, payload performance, etc. Therefore adjustments in payload activity scheduling and execution priorities need to be made. The LIS leads the IRT in the development of changes to payload execution priorities to maximize science return when changes to the OOS are needed.

7.4 Flight Product Development

7.4.1 Crew Operations Procedures

The PD team may choose to have POIF provide a procedure writer for its payload crew procedure product development. This procedure writer, Payload Ops Lead, is responsible for all crew procedure product deliveries as a representative of the PD team. Manual procedures are viewed and executed, step-by-step, by the crew and viewed by the flight controllers. The crew may execute a procedure by opening a hatch, flipping a switch, or changing out samples. The crew also executes procedures by using a computer to control payloads, Payload Support Systems (PLSS), and Laboratory Support Equipment (LSE). The operations concept for the payload should list the payload objectives and associated tasks that are organized to accommodate traditional operational phases such as installation, setup, operations, maintenance, and shutdown. The operations concept will be developed by the PD team and provided to the payload operations lead. These task groupings are then developed into crew procedures.

7.4.2 Ground Command Procedures

The Ground Command Procedure (GCP) Book contains the step-by-step instructions for the cadre to command, control and monitor payloads as well as the ISS systems supporting those payloads. The GCP consists of a total of seven volumes. Volume 3, Payload Procedures, contains the ground command procedures for the safing of individual payloads and the limited payload operations that the PD has delegated to the POIC. The limited payload operations delegated to the POIC must be accompanied by a corresponding ISS Payload Regulation authorizing the POIC to perform these operations on behalf of the PD.

7.4.3 Flight Rules/Payload Regulations

Flight Rules documents are developed and maintained under the authority of MOD DA8/Flight Directors' Office. The primary objective of the Flight Rules documents is to provide guidelines to flight control personnel that expedite necessary decision-making processes. These guidelines are based on expert analysis of flight equipment configuration for support of Orbiter or Station systems operations and constraints, crew procedures, and Station assembly and operations objectives. The PD is responsible for providing Flight Rule inputs relating to the overall management of payload for off-nominal conditions that affect crew and/or vehicle safety, particularly operational controls of hazardous conditions.

NASA Payload Regulations provide established priorities for payload activities, preplanned responses to nominal or off-nominal situations, as well as any payload-unique information that enhances the POIF's ability to provide immediate operational responses and to make operations decisions that do not have safety or vehicle integrity implications. The PD is responsible for providing Payload Regulation inputs relating to the operations of a payload.

7.5 Ground Support Team Training

The Payload Developer Team training process is documented in the Payload Ground Support Personnel (GSP) Training and Certification Plan, Volume 3. The PD team will identify specific team member responsibilities and the associated training requirements in training plans that are to be provided to the POIC Ground Training Integrator (GTI). The PD team "interface" training addresses the training of particular PD team members on their interfaces with POIC cadre and systems within the HOSC as applicable to their position.

7.5.1 Payload Developer (PD) Team Training

The PD Team is expected to be knowledgeable on its internal process and systems as well as on the POIC interfaces necessary for operating the payload. It is incumbent upon the PD team to provide training internally to all of its team members. This training should include, but is not limited to, knowledge of experiment objectives, mission experiment operations, equipment familiarization, facility support, and all other information, activity, or knowledge which will ensure safe and successful payload operations support. This training can be provided in a hands-on environment, classroom, courseware, or other media. Additionally, the PD Team "interface" training addresses the training requirements of a particular PD Team member on POIC interfaces appropriate to their functional position. This training will be offered to all PD team members by POIF, or provided to the PD team representatives who will then transfer that training to the remaining team members in a "train-the-trainer" philosophy. With either approach, it is the responsibility of the PD team to provide evidence of training for all team members. Trainees meet these requirements through payload overviews, increment configuration overviews, simulations, and increment-unique position training. Operators must maintain position knowledge and skills, or position proficiency, in order to keep their position certification. Furthermore, they must meet new and changing positional knowledge and skills that evolve over time (referred to as position currency).

7.5.2 Cadre/PD Simulations

Simulations are an effective training tool in which a PD Team member can practice the skills necessary for performing the functions of an assigned position. By practicing the skills in a learning environment, the team member can gain experience and confidence while not risking error in the real work environment. Along with on-the-job training, simulations allow the team member to develop skills necessary to assume the responsibility of flight tasks appropriate to the position. It is expected that team members participate in a simulation in a manner consistent with his/her flight position. The Cadre/PD Simulations are conducted in the L-6 to L-3 Months timeframe and are increment and flight specific. This type of simulation offers the PD team and the POIC cadre an opportunity to work payload off-nominal conditions that could occur during flight. These simulations also give the PD teams a chance to interface with the POIC cadre and become more familiar with real-time operations using payload procedures, payload hardware/software, and ground procedures.

7.6 POIC Ground Systems Services Products and Development

The Ground Support Requirements Team (GSRT) provides multi-task integration of the PD requirements to support ground operational data and communication systems. The GSRT receives ground support service requirements per the appropriate program approved requirements collection processes, integrates support service requirements to provide a consolidated assessment of required services, and coordinates service support approval with all implementing agencies.

POIC Services provided to the PD include the following: commanding, telemetry/science data distribution, payload health and status distribution, mission planning tools, crew procedures, mission operations voice communications, and payload operations information management systems. These services are provided by MSFC's Payload Operations Integration Center and can be remotely accessed by the Payload Operations teams.

7.6.1 Ground Support Capabilities

Ground Support capabilities primarily provide the PD with direct distribution of downlinked science data, ISS ancillary data (vehicle attitude, cabin pressures, cabin temperatures, etc.), payload command and control services, and access to mission operations voice (Space-to-ground, etc.). Ancillary services include reviewing crew procedures associated with payload operations, mission timeline (on-board short term plan), pre-mission resource identification (Payload Planning System's User Requirement Collection System), and access to information management systems services (Payload Information Management System-PIMS).

7.6.2 Ground Support Services Standard Template

The Payload Operations Template for Ground Data Services (GDS) implementation is a listing of the milestone dates, shown as Increment minus Month (I-Month) dates. This schedule is required in order to process the Payload requirements and implementation necessary for flight readiness.

7.6.3 Ground Data Services (GDS) Blank Book

The GDS Blank Book Tables contain the detailed information required for the GSRT to make arrangements for POIC Services and the HOSC resources necessary to support the Payload. The GDS detailed requirements include payload services required from POIC, including network and/or hardware connectivity requirements, for PDs located in the United States Operations Center (USOC), a Telescience Support Center (TSC), or other operating locations. Requirements submitted in the GDS Tables outside the scope of the PIA Letter will not be considered valid for implementation without prior coordination and approval of the ISS Payloads Office.

7.6.4 Network Interface Support Configuration Process

The HOSC provides the PD with the necessary network configuration information so that their network administrators can configure their local networks to allow access to HOSC provided services. HOSC Network Engineer team will work directly with the PD's Network Management and Engineering staff to develop an appropriate network interface that will mitigate any security compromise risks for both the HOSC's and the PD's network infrastructure and associated systems.

7.6.5 Ground System IT Security Requirement Certification Process

All remote sites must submit a "Remote Site Security Plan Checklist" prior to obtaining a HOSC account and remote site connectivity to HOSC resources. New PDs will work with the HOSC Operations Planning & Integration (HOPI) Team during the HOSC account request process. The Remote Site Security Plan Checklist is available in the POIC Generic User Interface Definition Document (PGUIDD), SSP 50305, Volume I, section 4

7.6.6 Ground Service Capability Training

Once the PD interfaces to the HOSC have been verified, training on HOSC-provided client software applications can be scheduled through the POIC Training Coordinator (Ph. 256-961-2219). PDs are required to certify that their operations team is adequately trained to support their mission.

7.6.7 ISS Downlink Video

ISS downlink video is a standard POIC service that is requested by the PD during the PIA process. If approved, the video will then be implemented according to the GDS Standard Template process and schedule. Any video request outside the approved PIA process will be worked through the PIM.

7.6.8 Account Request Process

Account request process is still under investigation due to Homeland Security Presidential Directive 12 (HSPD-12) support requirements. The HOSC is working towards a more simplified process of acquiring these accounts that include totally electronic requests for accounts versus the current paper process.

8 Overall Payload Safety Review Process

8.1 Payload Safety Review Panel (PSRP)

8.1.1 Roles and Responsibilities

The Payload Safety Review Panel (PSRP) is a Shuttle/ISS Safety Review Panel (SRP) located at the Johnson Space Center. The purpose of the PSRP is to ensure that the PD complies with the technical and process safety requirements as established by Federal, Agency, Program and Local authorities. More specifically, the PSRP performs the following functions:

- Assists the PD in the interpretation of safety requirements
- Conducts safety reviews during appropriate phases of the payload development to assess the payload compliance to the relevant program safety and process requirements
- Evaluates hazard assessment revisions resulting from modifications to payloads that may affect a safety critical subsystem or create a potential hazards to the crew, ISS, Space Shuttle, or other ISS/IP visiting vehicles;
- Evaluates the safety analyses, safety reports, and waiver/deviation requests prepared by the PD and elevates to Program Management (for approval) those non-compliances that are above the delegated authority of the PSRP
- Ensures the resolution of payload safety issues, including (as required) the formation of splinter groups, subpanels, and/or coordination with other organizations to perform technical activities required to accomplish assigned responsibilities

Although it is the responsibility of the PSRP to audit the PD safety assessments, the PD is responsible for the safety of the payload for all mission phases. The PD is also responsible for not compromising the safety of other payloads, launch vehicles that are used to transport the payload, ISS transfer, and ISS operations.

8.1.2 Initial Contact Briefing

Once a PD starts the Payload Integration Process, an initial contact briefing should be requested by the PD via the PIM or PSE for that payload. This briefing provides the PD insight into the data and technical requirements to ensure a successful safety review as well as a forum for the PD to discuss logistics, hazard development, deliverables, and PSRP contact points. The depth, number, and scheduling of reviews will be negotiated with the PD and they will be dependent on complexity, technical maturity, and hazard potential.

8.1.3 Process Requirements

The process requirements define the path and deliverables to complete the safety process. The Payload Safety Process requirements are contained in NSTS/ISS 13830, "Payload Safety Review and Data Submittal Requirements". NSTS/ISS 13830 further defines the deliverables and safety review activities. Payloads at a concept design phase should include a Phase 0 safety review (hazard causes defined). Payloads should complete the Phase I safety review in the Preliminary Design activities (hazard causes refined and hazard controls defined with preliminary verifications). Payloads in the Critical Design Review timeframe should complete the Phase II safety review to identify any design changes, new hazard causes and controls, and well-defined safety verification methods. The Phase III review is focused on completion of hazard report safety verification method (prior to shipping to the launch site). The key to the overall process is early contact with PSRP Executive Officers. Once a candidate payload is identified and requesting PSRP review, a Payload Safety Engineer (PSE) for that payload is assigned. The PSE will work with the PD through the safety process.

8.1.4 Technical Requirements

There are also technical safety requirements that a PD should be most familiar with. These are found in the following documents:

- NSTS 1700.7B
- NSTS 1700.7B ISS ADDENDUM
- NSTS/ISS 18798

NSTS 1700.7B contains the core payload safety shuttle requirements. NSTS 1700.7 ISS ADDENDUM contains the ISS payload safety technical requirements. The ADDENDUM provides ISS references for the applicable core NSTS 1700.7B requirements. NSTS/ISS 18798 is a book of interpretation letters to clarify requirements related to and including thermal extremes, electrical, payload operations, pressure, pyrotechnics, structures, and hazard control verification activities. Although these requirements address all systems, compliance with particular sections is based on the payload.

8.1.5 Safety Data Packages

The PD is required to produce a Safety Data Package (SDP) in parallel with design review milestones. The SDP usually contains two parts. Part one is descriptive text that contains information to describe the payload, its systems, sub-systems, and interfaces, as well as flight and ground operations. It also summarizes hazard analyses used in the identification and control of payload hazards. Part two of the SDP is typically a hazard report. The hazard report is used to summarize controls and verifications to ensure compliance to safety requirements. Elements of a hazard report include technical requirement references, description of hazard, hazard category, hazard cause, hazard controls, and safety verification methods. Guidelines for the development of SDPs can be found in JSC 26943 "Guidelines for the Preparation of Flight Safety Data Packages and Hazard Reports". Forms for hazard reports can be found on the payload safety website.

8.1.6 Hazard Reduction Precedence

Per NSTS 1700.7B, the PD is responsible to perform safety analysis in a systematic manner for each payload, its GSE, related software, and ground and flight operations to identify hazardous subsystems and functions. Safety analysis shall be initiated early in the design phase and shall be kept current throughout the development phase. A safety assessment report which documents the results of this analysis, including hazard identification, classification, resolution, and a record of all safety-related failures, shall be prepared, maintained, and submitted in support of the safety assessment reviews conducted by the NSTS. Hazards are classified as either critical or catastrophic. Critical Hazards can result in damage to STS/ISS equipment, a non-disabling personnel injury or the use of unscheduled safing procedures that affect operations of the Orbiter or another payload. Catastrophic hazards can result in the potential for a disabling or fatal personnel injury, loss of the ISS/Orbiter, ground facilities or STS equipment. Actions for reducing hazards shall be conducted in the following order of precedence:

- **Design for Minimum Hazard -**The major goal throughout the design phase shall be to ensure inherent safety through the selection of appropriate design features. Damage control, containment, and isolation of potential hazards shall be included in design considerations.
- **Safety Devices -** Hazards which cannot be eliminated through design selection shall be reduced and made controllable through the use of automatic safety devices as part of the system, subsystem, or equipment.
- **Warning Devices -** When it is not practical to preclude the existence or occurrence of known hazards or to use automatic safety devices, devices shall be employed for the timely detection of the condition and the generation of an adequate warning signal, coupled with emergency controls of corrective action for operating personnel to safe or shut down the affected subsystem. Warning signals and their application shall be designed to minimize the probability of wrong signals or of improper reaction to the signal.
- **Special Procedures -** Where it is not possible to reduce the magnitude of an existing or potential hazard through design or the use of safety and warning devices, special procedures shall be developed to counter hazardous conditions for enhancement of personnel safety.

8.1.7 Certification

The Phase III safety reviews must be completed 30 days prior to delivery of the payload, Airborne Support Equipment (ASE), and GSE to the launch site. The flight safety certificate of safety compliance shall be submitted at least 10 days prior to the Stage Operations Readiness Review (SORR). The flight safety certification shall include statements that the payload design and flight operations are safe, in compliance with the safety requirements, and clearly define payload safe design and safe life operations.

8.1.8 Post Phase III Safety Review and Safety Verification Tracking Log (SVTL)

When the flight certification statement is submitted, it shall be included with an updated payload safety verification tracking log that documents the closeout of all required safety verification. The verification tracking log and the certification statements must reflect the final configuration of the payload that includes all post Phase III safety activity.

8.1.9 Website and Data Management System Access

The payload safety website is a resource that provides information related to scheduled activities, links to the Data Management System (DMS), PSRP Charter, requirements and forms, training, and flight status per launch vehicle.

Access for International Partners, Universities, and private companies unable to access the JSC Internet must go through the Access Control Plan (ACP) process in order to obtain an account to tunnel through to JSC network. The ACP can be obtained through the PIM.

8.2 Ground Safety Review Panel (GSRP)

8.2.1 Roles and Responsibilities

The Ground Safety Review Panel (GSRP) is a Shuttle/ISS Safety Review Panel located at the Kennedy Space Center. The purpose of the GRSP is to ensure that PD complies with safety requirements as established by Federal, Agency, Program and Local authorities. Although it is the responsibility of the GSRP to ensure this is accomplished, it is the PD’s responsibility to complete the process and certify that their payload complies with appropriate requirements that are applicable to them. The PDs are always responsible for the safety of their own systems (including the Flight Hardware) and personnel throughout the process. They are also responsible for not compromising the safety of other payloads, the vehicle, launch site facilities and personnel.

8.2.2 GSRP Process Overview

The GSRP Process parallels that of the Payload Safety Review Panel, previously discussed, and is described in NSTS/ISS 13830, “Payload Safety Review and Data Submittal Requirements”. The significant difference between the Panels is that the GSRP generally only requires one safety review and that is usually done by mail rather than in person. The key to this process is early contact with the Lead Ground Payload Safety Engineer (PSE) for the flight assigned. The PSE will help the PD team through the process.

The safety requirements for ground processing are found in KHB 1700.7, “Space Shuttle Ground Safety Handbook”. Although this requirements book covers all systems, compliance with any particular section is based on the payload. If the section does not apply to the payload, it does not need to be addressed. (NOTE: KHB 1700.7 is being significantly re-formatted and revised. When this occurs the PD will be notified by the assigned PSE for that payload.)

There are two key documents related to the ground safety process. The first is the Ground Certificate of Safety Compliance, where the PDs certify that they are in compliance with the Ground Safety Requirements and the second is the Ground Safety Data Package, which provides the data supporting the certification. Obviously the most effort is put into the data package. The GSRP recognizes that the initial submission may be difficult, but the PSE will work with the PD to correct any errors and missing information in order for the PD to successfully complete the review process. The GSRP web site can be accessed via this link.

8.2.3 Pre-Arrival

The timing of ground safety review is critical to the start of ground operations. Per NSTS/ISS 13830, submission of the safety data package is due 45 days prior to the safety review. The safety review must be completed 30 days prior to the start of ground operations. This means that the package must be submitted 75 days prior to ground operations. Additionally, the payload’s flight safety review must be completed 30 days prior to the start of ground operations. It is the responsibility of the PD to complete the review in a timely manner. Failure to do so will result in the delay of operations and possible flight impact.

Upon approval of the safety data package and acceptance of the Certificate of Compliance, the GSRP will issue letters of approval for the start of operations. Sometimes, at this point, the PD will have a Safety Verification Tracking Log with open items that are constraints to ground operations. The PD needs to work closely with the PSE to ensure the proper operations are constrained and that the items are closed in a timely manner.

8.2.4 Ground Processing

It is critical that during ground operations, the PD complies with operations as described in the approved ground safety data package. Any changes to the data in the package (e.g. processing locations, new equipment or existing equipment being used in a different manner) shall be assessed and that assessment must be approved by the GSRP prior to the start of the “new” operations. This assessment only needs to be as complex as the proposed change. These “Deltas” or changes can be done in real time; but the preferred time submission is 14 days prior to the new operations.

8.2.5 Post-Flight

Post-flight operations shall be described in the original safety data package. The description shall include operations at all potential vehicle landing sites, not just Kennedy Space Center (KSC).

8.2.6 Ground Safety at International Partners Launch Sites

The process described in this section applies to processing at KSC only. If the payload is to be launched to the ISS from an IP launch site (French Guiana, Japan, Russia), compliance with those launch site’s process is required. NASA will assist the PD in completing the appropriate process.

8.2.7 Ground Safety at Non-KSC U.S. Launch Sites

For launch at non-KSC U.S. launch sites, the PD shall provide such data as required by the launch vehicle provider in order for the provider to complete their safety process. If the PD requires processing at a non-KSC launch site, NASA will assist in completing the appropriate process.

9 Overall Export Control Process

9.1 What is an Export?

An export is any shipment, transfer, or transmission of an item, i.e. hardware, software, technology, technical information, technical assistance or hand carried equipment (including laptops, blackberries, memory devices, and other handheld devices, Personal Digital Assistant (PDA)), and software out of the United States, or to a foreign national or a representative, including U.S. citizens, of a foreign government or company (within or outside the U.S.).

Re-export of items that have been imported into the United States, as well as the transfer of control over a satellite or on-orbit objects are also considered exports.

9.2 Payload Developers Responsibilities

The PD is responsible for complying with the U.S. Government Export Control Regulations by knowing the requirements that affect an export of hardware, software or technical data (for more information on Export Compliance, please refer to this link). The PD is responsible to provide detailed export information to the Export Control Representative (ECR) of the ISS Payloads Office, using the appropriate export control forms. The PDs are also responsible for identifying milestones in their program/project plans to ensure that export compliance matters are considered. Milestones should be identified and documented as early as possible in the program/project schedules. The information you provide must be made in accordance with the latest version of the JSC Work Instructions 2190.1. The most current version is located at http://server-mpo.arc.nasa.gov

9.3 Additional Resources for Exporters

The following websites are provided below as additional resources that PDs might find useful if further information on Export Control is desired.

NASA Export Control Program (ECP) website
The Department of Commerce (DOC) regulations are located at the Bureau of Industry and Security (BIS) website
The Department of State (DOS) regulations are located at the Office of Defense Trade Controls (ODTC) website

10 Overall Testing Integration Process

When a payload must interface with other facilities (payload racks or external payload sites) on the ISS, integration and interface testing is performed prior to launch. Kennedy Space Center (KSC) and Marshall Space Flight Center (MSFC) provide the infrastructure for this testing. The primary purpose of payload testing is to obtain the data required to close verification items identified in the Verification Applicability Matrix in the Payload to Facility ICD. Further purposes are to perform final functional interface testing to ensure compatibility between ISS and the payload (which includes verification of new hardware and software interfaces established during KSC/MSFC integration) and to verify joint operations with other payloads. Rack-based payloads will primarily complete interface testing at MSFC, while external/ELC-based payloads will test at KSC. The test process is similar at the two centers.

10.1 Testing Process

The determination of flight readiness of a payload is composed of the certification that each hardware and software element meets specific ISS requirements and the certification of these elements as an integrated payload. The integrated certification is accomplished by testing the payload with a ground rack or ground equipment that is equivalent to the rack or facility on-board the ISS.

Most integrated payload testing is performed via a Payload Rack Checkout Unit (PRCU). Additional ground support equipment are available to provide a simulated interface to the EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Rack, Window Observational Research Facility (WORF), Microgravity Science Glovebox (MSG), Materials Science Research Rack (MSRR), EXPRESS Logistics Carrier (ELC) and Attached Payload classes of payloads. These include the EXPRESS Rack Functional Checkout Unit (FCU), the MSG Engineering Unit (EU), the ELC Simulator, and the Active Common Attachment System Simulator (ACASS). This hardware is configured and checked out by the host site as required to support payload testing.

Environmental testing such as vibration, Electromagnetic Interference (EMI), offgassing, etc. can be performed prior to arrival at the test site. If desired, the PD can make special arrangements to perform environmental testing using KSC or MSFC test facilities.

The overall flow for the testing process is shown below in Figure 10.1.

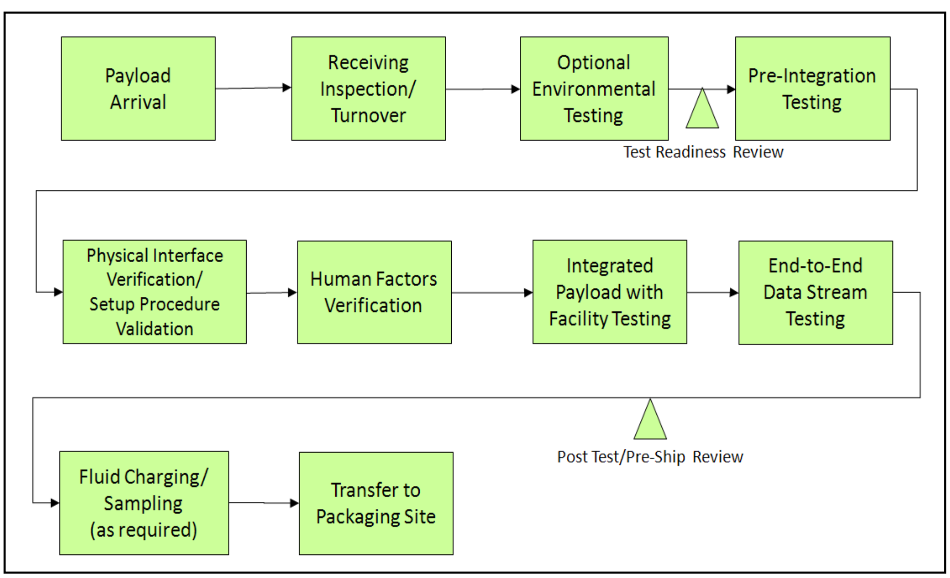


Figure 10.1 Payload Testing Process Flow

10.1.1 Payload Rack Checkout Unit

The Payload Rack Checkout Unit (PRCU) is an integration and test environment that provides a high fidelity emulation of the data and resource interfaces between an International Standard Payload Rack (ISPR) and ISS. The PRCU supports test verification of a payload's interface to the C&DH system, the electrical and optical Internal Video (IV) system, the Electrical Power System (EPS), the Nitrogen gaseous interfaces, the fire detection and maintenance system, the Thermal Control System (TCS), and the Vacuum System (VS). The PRCU allows the PD to complete development and verification, and to perform a post-shipment health check.

10.1.2 Hardware and Software Turnover

Strict configuration control of all payload items is maintained from the delivery to the test site until departure for the launch site. Shipping and Receiving will inspect the hardware and ensure that all items are identified and undamaged. At MSFC, if the payload developer will not be onsite, a Customer-Supplied Product Agreement (CSPA) per MPR 4000.1 must be completed in order to process payload hardware without direct onsite help by the payload developer. Facility (EXPRESS/MSG/MSRR/WORF) personnel will work with the payload developer to draft the CSPAs and obtain approvals.

For payloads that will operate in the EXPRESS rack, application software should be delivered to Boeing-PSIV and a request submitted to deliver a copy to the EXPRESS Lead Test Engineer. For payloads operating in all other ISS racks, software must be delivered to the facility Lead Test Engineer. The Lead Test Engineer will maintain configuration control of all hardware and software items during the testing process.

10.1.3 Payload Software Revision Verification

After baseline release by PD and verification of the Payload software by the facility test team, any revisions of the executables that interface with the facility software system are highly undesirable. If a revision of the payload software takes place after baseline release and verification has been performed, the software must be re-verified in a flight-like environment in the flight-like facility, or equivalent, prior to launch. This requirement does not apply if changes are data table revisions and not software executable revisions.

10.1.4 Off-line Testing

KSC has hardware and science laboratories available for off-line processing activities (reference section 11.1.1). If the payload can be tested in a standalone mode, then the PD may choose to perform testing off-line at KSC, using PD's own procedures. This is frequently performed as part of a post-ship functional test before turnover for integration or further testing. KSC will provide resources as necessary to test in an off-line laboratory and/or to operate the PRCU systems.

10.1.5 Pre-Integration Testing

Pre-integration test verification activities must be completed prior to interfacing with the test hardware to preclude damage to the facility. The requirements for these tests and/or inspections are identified in the Verification Matrix in the payload to facility ICD.

10.1.6 Integrated Testing Process

Prior to testing, the PD's Ground Support Equipment (GSE) and flight hardware are properly configured to support the test. Additional flight hardware preparations that are needed, such as required electrical cable checks, installing portable computers and/or stowage hardware, and loading software, are also performed.

An Integration Readiness Review/Test Readiness Review IRR/TRR will be held prior to integrating the payload into the facility for testing. The purpose of the review is to assess pre-integration verification data submitted by PD, to review test plans and procedures, and to make the decision to proceed with integrated testing. Minutes of the meeting will be written and distributed to the facility Project Manager and participants. A sample TRR plan from MSFC is included in Appendix B of this document.

Unless otherwise agreed to, all verification will be performed using flight hardware and software.

10.1.7 Physical Interface Verification/Setup Procedure Validation

The first step in the integrated testing process will be the verification of all physical interfaces. The payload will be installed in or mated to the facility using the flight setup procedures. This will validate the flight setup procedures and ensure that the payload meets all physical interfaces. The facility operations personnel and test engineers will perform the setup per the setup procedures.

10.1.8 Human Factors Verification

Human Factors verification activities may be scheduled as part of integrated verification testing. See section 5.6, Human Factor Integration Team (HFIT) Support, for further information.

10.1.9 Integrated Payload with Facility Testing

Integrated testing will be performed using the flight payload hardware and software in a flight equivalent facility such as the MSG Engineering Unit (EU). The requirements for testing are taken from the Verification Matrix included in the Payload to Facility ICD. The test will cover the worst case operating conditions. Details of the testing to be performed are described in the Test Readiness Review plan developed by the facility team.

10.1.10 End-to-End Data Stream Testing

End-to-end data stream testing will be performed to ensure data generated from the payload operating in/with the flight facility will be properly displayed on the computer screens at the HOSC and the appropriate payload telescience centers. In addition, any commands that the PD plans to send from the ground to the payload during on-orbit operations will be tested using the flight hardware and software in the flight-like facility and C&DH systems.

KSC and MSFC have implemented the capability to test and verify high-rate data streams. This capability allows the data to be verified locally, sent to the HOSC for processing, then distributed to the PD’s Enhanced Personal Computer (EPC) or Telescience Resource Kit (TReK) workstation.

10.1.11 Fluid Charging/ Sampling

Payloads that require on-orbit water cooling will be serviced to provide the proper fill quantity of ISS quality water.

10.1.12 Post-Test Review

A post test review will be held when all testing is complete. The purpose of the review will be to evaluate the test results for completeness and to review any test discrepancy reports (TDRs) that were generated during the testing process. Minutes of the meeting will be written and distributed to the facility Project Manager and participants. Once the post test review is complete and all open items have been closed, the payload will be shipped to the packaging site for final launch preparations.

10.1.13 Test Reports

When the testing process is complete, the facility Lead Test Engineer will submit an Integrated Verification Test Report and any Integrated Test Discrepancy Reports (TDRs) to the facility PIM and PD.

10.1.14 Escort Policy

10.1.14.1 MSFC

MSFC is located within a military establishment, the Redstone Arsenal, therefore, strict adherence to the associated badging and escort policies is necessary. All visitors require a visitor's badge to gain access to the MSFC testing facilities. Please note that Foreign Nationals require an approved escort at all times. In addition, all Foreign Nationals must submit the required information no less than 20 working days before the requested dates of access. MSFC personnel will work closely with PD to assure all access requirements are met.

10.1.14.2 KSC

KSC visitors who are issued an Escorted Foreign National Temporary Pass are required to be escorted the entire time they are on KSC property. This includes their arrival and departure through the security gates. An escort is required to have either a KSC picture badge or a NASA civil servant/contractor badge with PIV (Personnel Investigation Verification).

Escorted Temporary Area Access (TAA) can be issued for controlled areas such as the Space Station Processing Facility (SSPF) high bay, Orbiter Processing Facility (OPF) bay and the Vehicle Assembly Building (VAB). An escort for a TAA is only required while in the controlled area.

11 Launch and Landing Support at KSC

Prelaunch activities include: advanced planning; off-line preparations; payload integration; test and checkout; Interface Verification Test (IVT); and late access to install conditioned cargo and time-critical experiments into the vehicle at the launch pad. Post-landing activities include support of early access to remove time-critical experiments and conditioned cargo from the vehicle.

During off-line payload ground processing operations, the PD works according to processing methodology and implementing instructions as agreed to by the ISS Program and KSC NASA Safety, as appropriate. On-line Payload ground processing operations are conducted within the context of current KSC payloads processing methodology. KSC implementing instructions (e.g., nonconformance reporting, etc.) will govern those activities for which KSC has lead responsibility.

11.1 Basic Understanding of KSC Support Requirements

11.1.1 Support Requirement Generation

Support for payloads processing in the Space Station Processing Facility (SSPF) is divided into two categories based on the level of biological science processing required at KSC. Payloads requiring very minimal or no biological science processing document their support requirements in the PDL within the KSC Support Requirements Data Set (SRDS) and work directly with the NASA Launch Site Support Manager (LSSM). Support requirements include lab space, office space, common test equipment available in the KSC Instrument Library, consumable supplies such as alcohol, cleaning wipes and services such as shipping or NASA Quality Assurance (QA) coverage. Support requirements encompass off-line testing, pre-launch activities and post-flight requirements for KSC and the contingency landing sites. Refer to Support Requirements of SSP 52000-PDS, section 7.3, for more detailed information on support requirement generation using the SRDS in PDL. KPL-UG-50001, Requirements/Guide for Spacecraft Processing at KSC, provides additional information in section 3.1.3 Host Role Services.

Payloads processing at the Space Life Science Lab (SLSL) and requiring biological science processing in the SSPF develop their specialized support requirements primarily with the Life Science Services Contract (LSSC). The LSSC works with PD to develop and document the payload support requirements in a Ground Support Requirements Document (GSRD). Support requirements encompass pre- and post-flight support at KSC and the contingency sites and include lab space, office space, consumable supplies, chemicals, biohazardous waste management, equipment temperature monitoring (CMDS) and shipping support. A minimal level of support requirements such as NASA QA or shipping may go into the PDL for biological-based payloads.

11.1.2 Equipment Support

Common test equipment and tools such as torque wrenches, digital multimeters, and power supplies are available in the Instrument Library for payloads processing in the SSPF. Consumables such as non-flight tape, cleaning wipes, cleaning swabs and small quantities of solvents are also available.

11.1.3 Facility Requirement

Off-line laboratories in the SSPF building are class 300,000 clean rooms. Additional cleanliness can be achieved using laminar flow benches. All labs are equipped with sinks, hot and cold water, cabinets, and vacuum system, and some have one-ton crane support. Most labs are also equipped with additional capabilities such as compressed air, fume hoods, vents, two-ton crane support to accommodate a variety of payload requirement needs. There are eight hardware labs and seven science labs in the SSPF; the science labs are not equipped with crane support.

11.1.4 Shipping

Domestic and international shipping support is available to the PD. Shipments should be initially coordinated with the LSSM or LSSC.

11.2 Acceptance Data Package/Integrated Data Package (ADP/IDP)

For permanent turnovers, Acceptance Data Packages (ADPs) shall be prepared by the responsible organization to satisfy applicable ISS/SSP Program requirements as outlined in SSP 30695, JSC SN-D-0007 and JSC SN-S-0008 as appropriate. ADPs are not used for the temporary turnover of the ISS payloads processed by NASA KSC Utilization. Such items shall be turned over to Utilization temporarily using an Integration Data Package (IDP). Required content of an IDP can be found in section 7.4 of SSP 52000-PDS.

11.2.1 Turnover Process

After off-line operations are complete, the PD's flight hardware is ready for custodial turnover to KSC for on-line integration and/or testing. KSC performs a thorough review of the flight hardware and related IDP or IDP Supplement to the ADP. After turnover via a formal shipping document (e.g. DD1149), KSC has custodial responsibility for the PD flight hardware. Unless the PD's GSE such as integration slings, hoisting and handling adapters, and special tools are identified as a requirement for integration, the PD's GSE is usually not turned over to KSC.

11.3 Cargo Integration and De-integration

Cargo integration and de-integration is performed by the Cargo Mission Contract (CMC) as directed by the Launch Package Management team.

Physical integration (if required) begins after the formal turnover of hardware to KSC. After turnover, the payload is moved from the off-line lab/area to the on-line processing area for physical integration. Physical integration encompasses all operations required to assemble and prepare a payload for test and checkout, and prelaunch operations. Physical integration includes all of the following activities:

payload integration with the carrier, fluid system leak checks, payload stowage, payload closeouts, and payload servicing/maintenance.

Physical integration includes payload passive stowage integration into stowage trays/bags/racks. Payload stowage items are turned over to KSC for packing into dedicated payload trays/bags or mixed payload trays/bags which contain items from more than one payload. After turnover to KSC or after integration, integrated trays/bags go through bench review, and are then transferred for installation into the stowage rack. Facility Class Payload Racks are integrated by PD prior to rack turnover to KSC.

Physical de-integration encompasses all operations required to disassemble a carrier and subsequently turn over a payload to the PD.

11.4 Technical Requirements Development and Implementation

Payload requirements levied on KSC that are ISS Non-Standard Services or SSP Non-Standard Services will be negotiated and documented in the PIA letter. The corresponding details of these requirements, along with the ISS Standard Services, are initially entered as KSC Technical Requirements inputs by PD. The initial PD KSC Technical Requirements Data Set (TRDS) inputs reside in PDL until downloaded in the format of Operations and Maintenance Requirements Specification (OMRS) requirements or the Time Critical Ground Handling Requirements (TGHR) Table. These payload-unique technical requirement inputs are the detailed payload operations and maintenance requirements that are to be levied on KSC. These technical requirements are those which KSC is to perform on a payload during prelaunch, launch, recovery, and turnaround operations.

Integration and test requirements include physical integration, interface and verification testing, servicing and calibration. All payload processing technical requirements performed by KSC personnel must be documented in the OMRS system. Mission-unique time-critical and schedule driven crew compartment requirements to be performed at the launch and landing sites for middeck payload experiments, shuttle experiments and payload hardware are documented in the Time-Critical Ground Handling Requirements (TGHR) table.

Technical and operational requirements for a given mission may consist of time/life cycle requirements, assembly, test, inspection, and servicing. These requirements are conveyed to KSC for implementation by either the OMRS system or the TGHR system. KSC participates in the requirements definition and development to ensure the launch and landing site's capability to satisfy those requirements. Upon satisfactory completion of these processing activities, KSC provides requirements closure status (at whatever levels that are required) to the originator(s) of those requirements. The Integration Engineer is the PD's KSC interface to the OMRS manager for development of Shuttle and ISS integration requirements.

11.4.1 Late Access/Launch Delay

For payloads with time-critical or conditioned samples, late access may be negotiated for integration into the vehicle within a designated period (e.g. 24 hours) prior to launch. The PD will turn over the payload to KSC personnel for final packing and integration in order to meet launch countdown timelines. In the event of launch delays, the payload may require refurbishment of hardware/samples to preserve science opportunities. Requirements will be listed in the OMRSD or in the TGHR table for Orbiter crew compartment items.

11.4.2 Recovery/Retrieval

The post-landing phase includes all payload activities required to support landing, orbiter de-integration at the Orbiter Processing Facility (OPF), and return complement/payload de-integration and testing. KSC personnel will be in place at KSC, designated as the primary End of Mission (EOM) landing site, to accomplish previously agreed-upon tasks in support of the orbiter and its payload. The first alternate landing site is designated as Edward Air Force Base/Dryden Flight Research Center (DFRC) for all orbiter flights. Early EOM (EEOM) landings will be supported on a best-effort basis. In the event of an early EOM and/or a landing at a site other than the primary EOM site, the post-landing activities will be subject to orbiter contingency operations/planning based on the reason for landing at that site.

12 Launch and Landing Site Support for the International Partners and NASA Commercial Resupply Service (CRS) Vehicles

The objective of this section is to discuss some of the Launch and Landing Support Facility Services that might be available, if negotiated by the payload developer team well in advance with the ISS Program, for payloads that will be manifested and flown on the International Partners (IPs) vehicles as well as the Commercial Resupply Service (CRS).

12.1 International Partners' Vehicles Launch and Landing Support

The International Partners' vehicles that will be discussed below are: (1) The Automated Transfer Vehicle (ATV); (2) The H-II Transfer Vehicle (HTV); and (3) The Russian Progress and Soyuz Vehicles. The Automated Transfer Vehicle is launched by the European Space Agency (ESA) out of Kourou, French Guiana. The H-II Transfer vehicle is launched by the Japanese Aerospace Exploration

Agency (JAXA) out of Tanegashima, Japan. Both the Progress and Soyuz vehicles are launched by the S.P Korolev Rocket and Space Corporation---Energia (RSC-E) out of the Baikonur Cosmodrome in Kazakhstan. From all of these four vehicles, only the Soyuz vehicle has a (very) limited payload return capability.
NASA's standard operating procedure for hardware manifested on all of these four vehicles is "Ship and Shoot", which is defined as no processing of hardware at the launch site. Specifically, the baseline is for hardware to be packed in its flight configuration before the hardware leaves the United States. If any cargo requires processing at the launch site, such agreement will need to be negotiated on a case by case basis.

12.2 NASA Commercial Resupply Service (CRS) Vehicles Launch and Landing Support

NASA has procured cargo resupply services to ISS from two commercial providers, Space Exploration Technologies (SpaceX) and Orbital Sciences Corporation (Orbital) under the Commercial Resupply Service contract. The Dragon spacecraft developed by SpaceX launches on a Falcon 9 rocket out of Space Launch Complex-40 at the Cape Canaveral Air Force Station, FL. Dragon has the capability to deliver both pressurized and unpressurized cargo to ISS and returns pressurized cargo to earth with a water landing off the coast of California. Unpressurized cargo can be carried from ISS however it will be jettisoned from Dragon prior to re-entry and is non-recoverable.

Orbital will launch its Cygnus spacecraft on a Taurus II rocket from Wallops Island, VA. Cygnus can only accommodate pressurized cargo, similar to ATV and HTV, Cygnus has a destructive re-entry and thus no recoverable downmass capability.

The "Ship and Shoot" methodology will also be the model for the Dragon and Cygnus vehicles as the cargo will be packed by NASA's cargo integration contractor and packed bags will be delivered to the CRS providers.

12.3 Launch Vehicles On Dock Date Requirements

The On-Dock Date is defined as the date that the Payload Developer's payload must be received by NASA for shipping to the required launch site on behalf of the Payload Developer.

12.3.1 ATV and HTV

For both ATV and HTV the hardware is required to be on dock (received by NASA) in the United States approximately six (6) months prior to launch.

Hardware that is approved for late load is required to be on dock approximately two (2) months prior to launch

12.3.2 Progress and Soyuz

For the Progress and Soyuz vehicles the hardware is required to be on dock approximately 9.5 weeks prior to launch for hardware that is being shipped via commercial shipment. Commercial shipment is when the hardware will be placed on a commercial carrier (as cargo) for transportation to Moscow. If an alternate shipment option is used, the hardware on dock date is approximately 6.5 weeks prior to launch. The alternate shipment option is one in which an individual (NASA or NASA Representative) hand carries the hardware to Moscow.

12.3.3 CRS Dragon (SpaceX) and Cygnus (Orbital)

Hardware is required to be on-dock for both CRS provider's at approximately L-3 months. The final hardware transportation method from NASA to the CRS provider is still being defined however it is expected to be via commercial carrier.

12.4 Launch Site Laboratory Support and Equipment Availability

If the Payload Developer's hardware or Science package requires further processing at the launch site, the equipment and laboratory space listed below can be provided through negotiations with the launch site provider. Note that such agreement needs to be in place many months prior to "on dock date" in order to secure the facility usage at the provider launch site.

Table 12.1 Launch and Support Services Available at the International Partners and CRS Launch Site Facilities

Equipment Availability	ATV & HTV	Progress & Soyuz	Dragon	Cygnus
Processing Facilities	100K class clean room laboratory/ies suitable for hardware processing activities • Power at various voltages and amperage • Fluids provided via tube banks or other means • Gases provided via tube banks or other	• No clean room	TBD	TBD

Equipment Availability	ATV & HTV	Progress & Soyuz	Dragon	Cygnus
	means • Tables and appropriate grounding equipment			
Power	Facility power for processing and on/off-line testing at 60 Hz	220 VAC 60 Hz with two prong European outlet **Note**: 120 VAC 60 Hz is not available	TBD	TBD
Gases	Filtered and regulated facility gases in accordance with ISS Program requirements, including O2 and N2. Maximum source pressure TBD		TBD	TBD
Fluids	Filtered and regulated facility liquids to meet applicable ISS Program standards. These include isopropyl alcohol and hydrogen peroxide		TBD	TBD
Tables	Tables to support hardware equipped with grounding plates		TBD	TBD
Electrostatic Discharge (ESD)	Provide ESD table and floor mat, ESD adjustable wrist straps, wrist strap tester and wrist strap grounding system with grounding cords	1 Electrostatic Discharge Workstation	TBD	TBD
Workstation Illumination	Access to illuminated processing workstations in the facilities		TBD	TBD
Grounding	1 to 3 grounding points		TBD	TBD
Laminar Flow Workbench	Access to laminar flow workbench/ table in clean room facility	• No clean room flow bench	TBD	TBD
Venting Hood	Filtration/aeration hood that vents directly to the exterior in clean room facility		TBD	TBD
Ultraviolet Lighting	UV lights in clean room facility		TBD	TBD
Maintain	Standard processing		TBD	TBD

Equipment Availability	ATV & HTV	Progress & Soyuz	Dragon	Cygnus
Environment	facility industrial environment conditions of 22° C + 3.2° C with a relative humidity of 60% or less			
Portable Access and Handling	Portable GSE for access to and handling of the payloads and experiments. Portable access equipment may include the following items: • Powered work platforms • Safety ladders • Access stairs for use at stands • Scaffolding • Lifting apparatus/slings		TBD	TBD
Mobility Equipment	Forklift and/or crane, plus the needed operators to assist in movement of equipment and GSE including in the clean room areas		TBD	TBD
Related Office Items		• 3 Computer work station • 3 Desks • 2 Printers, 2 Scanners 2 Copiers	TBD	TBD
Expendable flight Items		Ziplock bags, Kapton tape, Velcro, Label material, Barcodes and Label maker	TBD	TBD

12.5 On-Site Sample Processing and Sample Return

The Ship and Shoot baseline is for hardware to be delivered by NASA, on behalf of the Payload Developer, to the launch site ready to be loaded onto the launch vehicle. If a Payload Developer’s hardware or Science package requires processing at the launch site, then the details need to be negotiated and documented as appropriate between the Payload Developer and the ISS Program. No sample return is possible on ATV, HTV, Cygnus and the Progress vehicles.

The Soyuz vehicle provides hardware return capability in its descent module, but for only very limited amounts (approximately 50 kg). Critical hardware only is retrieved at the landing site per prior arrangement. All other hardware return items are de-integrated from the Soyuz vehicle approximately 2 weeks after landing and then turn over to NASA personnel for turnover to the Payload Developer.

Sample processing capabilities for Dragon and Cygnus vehicles are still being defined. It is likely that facilities at KSC (see Section 11) will be available to process samples for launch on Dragon which launches from SLC-40 at CCAFS, just outside the boundaries of KSC. Launch facilities for Cygnus at Wallops Island, VA, are currently under construction.

Dragon is capable of returning up to 10 CTBEs of unpowered cargo and 2 powered MLEs for early destow. Cold stowage items are planned to be deintegrated from the vehicle at Landing+6 hrs and transferred to refrigerated storage. Handover of early destow cargo is planned for Landing+48 hrs at a TBD port in southern California and post-flight sample processing will be the responsibility of the payload developer. Cygnus has no sample return capability.

12.6 Vehicles Late Load Access

12.6.1 ATV

For the ATV vehicle, late load access takes place over two days: (1) Launch minus 13 days (L-13 days) and (2) L-12 days. A total of twenty eight (28) individual bags of late load are available. This is equivalent to about 36 Cargo Transfer Bag Equivalents or 36 CTBE. Hardware must fit in a 2.0 CTBE or smaller bag. Each bag must weigh less than 25 kg, including packaging foam.

12.6.2 HTV

For the HTV vehicle, late load access can occur as late as Launch minus 80 hours (L-80 hours). Typically, the Japanese Aerospace Exploration Agency (JAXA) requests that late load be scheduled approximately one (1) prior to launch (L-1 week). If late load at L-1 week is not sufficient for a particular Payload Developer, then the Payload Developer needs to negotiate with the ISS Program and properly document such requirement so that late load closer to launch can be negotiated with the launch provider. A total of three (3) CTBE of late load is available for HTV. Hardware must fit in a 0.5 CTB or a 1.0 CTB. There exists a possibility for additional late load capability, but it has to be negotiated on a flight per flight basis. If such additional late load capability is negotiated, bags up to 2.0 CTB can be used. Regardless whether additional late load capability is negotiated or not, each bag must weigh less than 20 kg, including packaging foam.

12.6.3 Progress

Late load access for the Progress vehicle is approximately L-1 to 2 days, prior to the shroud being installed at the processing facility. Typically, fresh food and fruits are late load items that must fit through a small hatch (470x18.5 in) near the top of the module for early access by crew. Hardware can also be late load items, but must be negotiated on a case by case basis and such items must be very small (no larger than a ½ CTB).

12.6.4 Dragon

Dragon can accommodate up to 10 CTBEs of unpowered late load cargo limited to half and single CTBs accessed through a side hatch of the vehicle. Unpowered late load cargo will be loaded into Dragon at L-2 days. Up to two powered Middeck lockers can be accommodated and will be loaded at L-12 hours also through the side hatch. This can be either one GLACIER, equivalent of a double Middeck locker, or two single middeck locker equivalents like a MERLIN

12.6.5 Cygnus

The late load timeline for the Cygnus vehicle is yet to be determined.

12.7 Launch Vehicles Environment

The launch vehicle environment for the ATV, HTV, Dragon and Cygnus vehicles can be found in SSP 50835 ISS Pressure Volume Hardware Common Interface Requirement Document. The launch environment for the Progress and Soyuz vehicles can be found in SSP 50628 (RPO-3249) Requirements for International Partner Cargoes Transported on Russian Progress and Soyuz Vehicles.

12.8 Launch Site Escort Policy

Payload Developer teams will be required to work with the launch site owners for access. Unescorted access can be arranged with the launch site owners for ATV and HTV. The Baikonur facility where the Progress and Soyuz vehicles are launched is an Escort Only area. The launch site escort policy for the CRS vehicles is TBD.

13 Overall Real Time Support Process

13.1 Basic Understanding of Real Time Support Requirements

Real-time operations processes, procedures, and support documentation are located on the POIF website and instructions for acquiring an account can be found through this link. Real-time operations processes are documented in the Payload Operations Handbook, Volume 2 (POIF-1005). These processes have been designed to promote the safe and successful execution of planned on-orbit operations.

13.1.1 Payload Developer Operations Team Structure for on Console Support

PD Teams are required to support their payload operations during the following types of activities: scheduled crew-tended operations; crew-tended Task List operations that require ground interaction; hazardous operations; critical operations; during automated commanding. During unattended, quiescent or stand-by activities, the PD team may relinquish its monitoring responsibilities to the POIC cadre. However, the following conditions must be adhered to: monitoring services must be negotiated with the POIC cadre; a Payload Regulation authorizing the POIC cadre to assume these responsibilities must be developed and baselined; Ground Command Procedures identifying the specific payload parameters to be monitored and the appropriate response have been baselined; parameter limits must be provided in the C&DH data set in PDL. The PD should define his/her console support philosophy such that appropriate real time support can be provided as stated above. It should be defined early enough to complete both internal and POIC interface training.

13.1.2 Operations Change Request (OCR) Process

The Operations Change Requests (OCRs) process is used by the PD team to make real-time (once an increment begins, the operations phase is known as real-time or execution phase) temporary or permanent changes to currently executing flight documentation. The following are examples of items that require an OCR once the increment begins: crew procedure changes or additions; Ground Command Procedure changes; Payload Regulation changes; timeline changes for ground and crew activities that deviate from the activities' original intent in User Requirements Collection (URC) or new activities that are not documented; payload unique Orbital Communications Adapter (OCA) messages; Execution or Operations Note changes which express new operational constraints or procedural steps. The time it takes for the POIC cadre to evaluate and approve an OCR varies depending on the time-criticality and complexity of the change request. For change requests that affect IDRD resource allocations and payload priorities, it is prudent for the OCR requesters to pre-coordinate the development of the OCR with their Increment Scientist and/or the LIS Representative (Rep) prior to submitting the OCR for review. Payload Operations Handbook, Vol. 2 (POIF-1005) defines the amount of advance time needed to process OCRs. To increase the probability of approval and implementation, an OCR should be submitted as much in advance of the cutoff time as possible.

13.1.3 Payload Anomaly Report (PAR) Process

A payload anomaly is defined as an unexpected response during nominal operation of payload hardware. A Payload Anomaly Report (PAR) is the real-time POIC document used for collecting and summarizing anomalies. The purpose of a PAR is to: record off-nominal behavior with sufficient information of the circumstances surrounding the anomaly to enable experts to analyze the anomaly off-line; drive resolution of the anomaly or provide an operational workaround to avoid the anomaly in the future; and fully document all aspects of the operational anomaly analysis for future reference. In the event of an anomaly, the primary responsibility of the real-time cadre is to ensure the safety of the crew and vehicle. After crew and vehicle safety issues have been addressed, the real-time cadre will address complete or partial failure of system equipment, facilities, or payloads affected by the anomaly. In the event that the failed equipment is payload hardware, the PD will document the anomaly, analyze available data, determine troubleshooting for further diagnosis, develop resolution, provide necessary crew procedures (if needed), and seek scheduling for performance of troubleshooting using relevant POIC processes. The PD is also responsible to provide updates to the PAR to reflect status of anomaly resolution throughout until closure.

13.2 Real Time Increment Teams Structures and Functions

The real-time or execution phase of an increment begins after the on-orbit hand-over ceremony takes place between the previous increment crew (or departing crew)and the newly arrived crew. However, due to crew rotation overlap, a previous crew member may become a member of the new increment (so, it does not have to be, strictly speaking, a departing crew member). The section below will give a brief explanation of the roles and responsibilities of a few entities that both PDs and PIs may, at times, interface with in the context of payloads/science related issues during on-orbit operations. The brief description below will be limited to only payload on-orbit operations.

13.2.1 International Space Station Mission Management Team (IMMT)

The International Space Station Mission Management Team (IMMT) is the ISS real-time operations decision-making board. Here all real time on-orbit issues are addressed. The IMMT is responsible for providing programmatic oversight and decision authority for real time ISS operations (per ISSP-PPD-507). While the IMMT has numerous participants, the "core IMMT team", are those individuals responsible for ensuring that impacts to their systems and/or disciplines have been considered and conveyed to the IMMT to support its decision. All the International Partners (IP) representatives and many of the NASA ISS support teams are considered IMMT core members. The ISS Payloads Office is a core member of the IMMT. Any payload on-orbit anomaly that occurs during the real time or execution phase of an increment is addressed at the IMMT. All on-going investigations statuses are reported to that board. The IMMT meets twice per week during increment operations and as needed during Shuttle missions. The Payloads Office Increment Payload Manager (IPM) represents payloads interests at the IMMT. However, If there is an on-orbit anomaly with a complex payload which requires expert analysis to resolve the anomaly in order to return the payload to standard operations mode, the PD team might be required to present the analysis results at the IMMT meeting.

13.2.2 Increment Research Team (IRT)

The main tasks of the IRT are to manage the overall science planning, prioritization and overall science decision-making during real time operations for all four space agencies that make up the United States On-orbit Segment (USOS). Also, the IRT leads increment replanning activities that might arise after the IRP has been baselined. Replanning occurs rather often due to the fact that flights move in and out of an increment for a number of reasons associated with vehicle flights traffic plan, ground constraints and real time on-orbit maintenance needs, which require unplanned spare parts to be flown to ISS to repair/replace failed parts. The IRT is specifically chartered to do the following: "The IRT has the responsibility for coordinating science research activities during near real-time, real-time and post increment assessment period**.** The IRT also has the responsibility to ensure that all opportunities to increase science return are used optimally and done in an equable manner". The IRT is led by a Lead Increment Scientist (LIS) chosen by the MRPWG Chair. The LIS is assisted by an ISS Increment Scientist (IS) from each of the USOS partner agencies: NASA, ESA, JAXA and CSA. The IRT meets once a week, and on an as-needed basis as well.

13.2.3 Increment Payload Real Time Management Team

Within the NASA payloads community, the Payload Increment Real Time Management Team is often called the "Triad". The Triad consists of the Increment Payload Manager (IPM), the increment Lead Increment Scientist (LIS), and the

Payload Operations Manager (POM). The Triad works together to plan and execute the increment research complement across the USOS.

The IPM is responsible for integration of ISS payload operations. The IPM provides the IMMT with status of USOS payload operations and consolidated payload recommendation with respect to payload issue resolution, as needed.

The LIS manages the increment research complement resource requirements and science objectives. The LIS is responsible for working with all the USOS partner science offices (or Increment Scientists) to plan, coordinate and execute the increment research complement to maximize overall science return. The LIS supports and provides science guidance/recommendations to the IPM at the IMMT.

The POM, located at the POIC, is responsible for ensuring the planning and accomplishment of ISS mission management direction as related to NASA payload operations. The POM coordinates longer terms and non-real time activities such as increment science weekly planning and payload anomaly resolution.

The Increment Payload Engineer (IPE) is the book manager for IDRD Annex 5 and is responsible for the technical integration definition of the payload products incorporated in that document based on the IRP and approved Change Evaluation Forms (CEF). During real-time operations, the IPE provides direct support to the IPM to resolve integration issues with the PDs and the ISS Program teams. The IPE reports current issues and concerns back to the payload community at the various payload boards and forums on a weekly basis.

13.2.4 Lead Increment Science Representative (LIS-Rep)

The LIS-Representative (LIS-Rep) position is staffed a JSC, but it reports for duty at the POIC. It is a console position, which represents the LIS at the POIC. This console position deals with all real time on-orbit science operations issues that fall under the purview of the LIS. That position coordinates as well all daily science activities and communication with the scientific community on behalf of the LIS.

13.2.5 Daily Science Tag (DST)

The Daily Science Tag is a teleconference forum for science related discussion that is managed by the on-console LIS-Rep, but the science forum discussion is led by the LIS of that specific increment. This forum focuses on the daily science/investigation operations; including science statuses from Payload Operations Leads, Principal Investigators or their representatives, communications or other issues which might have a science impact, identification of additional opportunities for investigations to perform extra science runs, when on-orbit crew time becomes available, and discussion of Voluntary Science opportunities (opportunity to perform extra science during crew's off days or weekend). On-orbit payloads anomalies and planned actions to restore payload to normal operations conditions are discussed in that forum as well. The participation of all the science teams that are performing real-time on-orbit science operations during that increment is expected at that forum daily.

14 Post Reporting

14.1 Post Reporting Requirements and Products

As described earlier, an increment is divided into three segments: (1) Pre-increment planning; (2) Real-Time Operations or Execution Phase; and (3) Post-Increment Reporting. The ISS Program has a post-increment reporting requirement for the PD teams to communicate to ISS Management what was accomplished during that increment from a science perspective. Information to be reported includes how the resources that were provided by the ISS Program to the Payloads Office were used and what is/was the preliminary results and return on-investment assessment. The goal of the post-increment reporting is to learn what worked as intended and what did not perform as designed in order to improve future increments operations. Accordingly, lessons learned are documented, debriefs are held with the increment crew members to get their feedback and preliminary reports are required from PD teams who performed science during that increment. For further information, please refer to SSP 50795 and SSP 50168 for post increment reporting requirements.

14.1.1 Payload Lessons Learned

The objective of the increment payload/science lessons learned is to document all lessons learned in the planning, integration and execution phases of the utilization requirements during the increment. Lessons learned can be both positive and negative (e.g., best practices, novel processes, etc.). Examples of lessons learned include, but are not limited to: misleading crew procedures, on-orbit hardware anomalies (off-nominal activities or complete failures), potential ground operations improvements, process and communication break-downs, real time operations process modification, and science team interactions. About two weeks before an increment ends, a call goes out from the LIS and the IPM of that increment to the payload community requesting lessons learned from all the PD teams. There exists a Lesson Learned Template for use by all PD teams, who wish to provide lessons learned. The template addresses two main aspects: (1) Root cause and (2) Recommended action. For more information, please refer to the Lesson Learned Template and previous examples located at this link.

14.1.2 Payload Crew Debrief Questions

The objective of the payload/science crew debrief is to give the increment principal investigators, hardware developers, research managers, mission integration, and operations and science teams the opportunity to discuss their payload on-orbit operations with the crew. The crew members who performed the science for the different teams and operated the on-orbit science facilities are asked specific questions by the teams in order to get the crew members' feedback. Operations teams and science lead operations teams take actions to make improvements to crew procedures, hardware and experiment design for future increments. The crew debrief provides a firsthand account by the crew describing to the increment teams how the science and hardware performed on-orbit. The payload crew debrief covers, but is not limited to: science observation, crew procedures/operations products, hardware performance/design, time allocated to perform science activities, crew training and operations support. About two weeks before the increment ends, a call goes out from the LIS and IPM of that increment to the payload community requesting crew debrief questions from all the PD teams of that increment. Normally, the payload/science crew debrief is scheduled within 15 to 45 days after the crew's return to earth.

14.1.3 Payload 30-day Report

The objective of the 30-day science report is to provide the ISS Program Management, the Increment Management Team, and the International Partners (IP) Science Management Team a preliminary look at what science was accomplished during the increment. The level of data contained in the 30-day report is very preliminary and does not contain any data analysis (unless an experiment has been on-orbit previously and collected data that can be analyzed independently from future data points.) Thirty days after the crew's return to earth, a high level science report is required from all principal investigators who performed science during the increment. The report highlights what worked and what did not, number of runs performed versus planned, as well as any science and engineering issue, which arose during the conduct of the experiment. Two weeks before the end of the increment, the LIS sends a request and a 30-day report template to all PIs and/or the ISS Research Program Offices, requesting the submittal of the 30-day report to the LIS office within 30 days after the end of the increment. If an experiment is continuing on the next increment or post flight Baseline Data Collection (BDC) is on-going, then that experiment is exempt from the 30-day science report requirement until the last experimental run and/or the last post-flight BDC session is completed.

14.1.4 Payload One-year Science Report

The purpose of the one-year science report is to document the scientific results obtained from the data collected during that increment. This is a scientific report since it deals primarily with the data analyses and the results obtained from those analyses. The report can contain equations, plots, on-orbit photos, discuss new discoveries, list related new publications or patents, and put forth new questions/ideas that need to be further investigated. Generally, one year after the crew's return to earth, the one-year science report is required from all the Principal Investigators (PI) who performed science during that increment. A report template is provided by the LIS. If an experiment is continuing on the next increment, or if post flight BDC is still on-going for a period of times after the crew's return to earth, that experiment is exempt from that one-year science report requirement until the last experimental run and/or the last post-flight BDC session is completed. Once those are completed, the one-year science report clock starts for that experiment.

15 Summary

The main objective of this document was to provide the payload developers a brief introduction to the complex world of payload planning, integration and operations. This primer, accordingly, only highlights the many activities that need to happen and the collaboration that is required from many organizations across several centers and the payload developers and/or principal investigators in order to successfully plan, integrate, launch, operate and return the payloads/samples to their providers. These activities are spread across four different NASA centers (JSC, KSC, MSFC and DFRC) with matrix organizations and supported by both civil servants and contractors. JSC, through the ISS Payloads Office, OZ, retains the overall payload integration management lead.

Even though this document describes each process in a succinct manner, the embedded links throughout this document provide the reader with a portal through which to obtain more detailed information. In many cases these links provide direct access to the documents needed, templates, points of contact email addresses and/or telephone numbers, to begin the processes briefly described above. It is highly recommended that the reader make use of these links when starting any of the processes discussed in this document. However, the PDs should rely on their assigned payload PIM to help them navigate the overall NASA Payload Integration Process.

Appendix A: Lean Payload Integration Process Description

Lean Payload Integration Process Description

Part 1 – General Lean Integration Process

A1 Payload Lean Integration Process Introduction

a. Overview and Purpose
b. Lean Operations Criteria
c. Traceability to Payload Planning and Operations Process Tutorial
d. Streamlined Integration Template Overview

A2 Lean Mission Integration Process

A3 Lean Operations Integration Process

A4 Lean Engineering Integration Process Overview

A5 Lean Software Integration Process Overview

Part 2 - Lean Payload Integration for ISS Host Facilities

A6 Lean EXPRESS Payload Processing

1. Hardware and Software Criteria
2. Engineering Integration
3. Software Integration

A7 Lean Microgravity Sciences Glovebox (MSG) Payload Processing

a. Hardware and Software Criteria
b. Engineering Integration
c. Software Integration

A8 Lean HRF Payload Processing - Reserved

A9 Lean CIR Payload Processing – Reserved

A10 Lean FIR Payload Processing - Reserved
A11 Lean MSRR Payload Processing - Reserved
A12 Lean Small Deployed Payload Processing - Reserved
A13 Lean Unpressurized ELC Payload Processing - Reserved

Part 1 – General Lean Integration Process

General information regarding the principles, manifesting approach, and required documentation for the Payload Lean Integration Process are discussed in Part 1.

A1 Payload Lean Integration Process Introduction

A1.1 Overview and Purpose

The International Space Station (ISS) Payloads Office has reviewed the payload integration process to assess ways in which to streamline or simplify the process, while maintaining safety for the ISS crew and equipment and maintaining the integrity of the payload interfaces to the ISS.

It is recognized that payload development and integration with the ISS can be complex. This streamlined integration approach is a first step toward simplifying payload integration; making it easier to fly payloads on ISS, thereby increasing feasibility and interest for more research and commercial organizations to sponsor ISS payloads and take advantage of ISS as a National Laboratory asset.

As a pathfinder for the Lean integration, previously flown payloads were analyzed with respect to operational, hardware, and software characteristics which enable streamlined integration. It is anticipated that the operational characteristics which enable lean processing will apply to all payload types as this process is evolved.

Hardware and software characteristics for payloads which enable the lean processing template are unique to the payload's host facility. Payloads to be accommodated by the Expedite the Processing of Experiments for Space Station (EXPRESS) Racks and Microgravity Sciences Glovebox (MSG) pressurized facilities have been addressed in Sections A6 and A7, respectively. It is hoped that the streamlined principles applied to these types of payloads will be analyzed and implemented in the future for other pressurized host facilities (e.g., Human Research Facility Rack, Combustion Integrated Rack, Fluids Integrated Rack , Materials Sciences Research Rack), ISS deployed payloads, as well as unpressurized payloads to be accommodated by the EXPRESS Logistics Carrier (ELC). This document summarizes unique hardware and software characteristics for payload types starting in Section A6. Subsequent sections for additional types of payloads have been marked "reserved" in this document for future addition.

A payload does not have to be classified as a National Lab payload in order to be processed according to the lean payload integration process. Any payload meeting the criteria defined herein can follow the lean payload integration process.

A Lean Payload's samples may require cold stowage accommodations for ascent, on-orbit, and/or descent. The PD's review of the standard cold stowage accommodations plan (http://iss-www.jsc.nasa.gov/nwo/payload/oz2/web/ColdStow.shtml) is recommended.. Identification of cold stowage requirements as early as possible within Gate 1 is part of the Lean Payload Integration process.

A1.2 Lean Payload Operations Criteria

In order to qualify as a Lean Payload, the following operational criteria apply for all payload types.

On-orbit Operations

- Payload operations require simple crew interaction. No unique crew skills are required to operate the payload. Standard host facility crew procedures can be used "as is" or slightly modified for payload unique needs. (For example: setup, stow, sampling, sample change out, data transfer, etc.)
- Any crew training required will be accomplished via the Payload Developer (PD) developed pre-flight self-study Computer Based Training (CBT) or Onboard Computer Based Training (OCBT).
- The crew will not interact with any software displays to operate the payload (i.e. no PDRT or IDAGS requirements).
- Payload operations will require no more than one (1) level of payload provided containment (for toxicity levels or frangibles)
- On-orbit requirements for resources must fall within a planning envelope that is pre-established for the payload type (host facility resources such as EXPRESS rack or MSG, or ISS resources for deployed or external payloads, etc.).

Ground Operations

- The PD operations team is limited to one (1) operating location with standard ground command services. No unique PD developed commanding services will be used to interact with the payload.

A1.3 Traceability to Payload Planning and Operations Process Primer

How does the lean payload integration process differ from the processes described in the main body of this document? Refer to Table A-1 for a summary of the impacts. The remainder of this appendix will detail the streamlined integration approach.

Table A-1. Primer Content vs. Lean Payload Processing

Primer Topics in the Table of Content	Does the Primer Topic Apply to a Lean Payload?	Lean Appendix Section Reference
Overall Research and Planning Cycle	Yes – The Research and Planning Cycle may be followed for Lean payloads or Lean payloads may fill "placeholder" research slots reserved during the research planning cycle.	N/A
Overall Mission Integration Process	The basic Mission Integration processes apply. However, a more streamlined integration template exists for Lean payloads. The streamlined template is reflected in the PIM Schedule.	A2 Lean Mission Integration Process
Overall Engineering Integration Process	The payload developer maintains responsibility for complying with all applicable requirements. However, an alternate engineering verification approach is used.	Unique per payload type, starting in Section A6.
Overall Software Integration Process	Software integration corresponding to the Command and Data Handling (C&DH) Database are applicable.	Unique per payload type, starting in Section A6.
Payload Operations Integration Process	Lean payloads will require simple interaction by the crew, which impacts some elements of operations integration.	A3 Lean Operations Integration Process
Safety Review Process	Yes – Lean Payload must fully comply with the Safety Review Process.	N/A
Testing Process	Testing is conducted as part of Ship and Shoot Processing.	Unique per payload type, starting in Section A6.
Real Time Support	Yes – Lean Payload Real Time Support does not differ from the standard process.	N/A
Launch and Landing	Yes – Lean Payload Launch and Landing	N/A

Primer Topics in the Table of Content	Does the Primer Topic Apply to a Lean Payload?	Lean Appendix Section Reference
Support	Support does not differ from the standard process.	
Post Reporting	Yes—However, there may be instances, for example some commercial payloads, where some of the post-increment reporting requirements or all might be waived.	N/A

A1.4 Streamlined Integration Template Overview

A high level overview of the Gate Process associated with the Lean Payload Integration is presented in Figure A-1. The time period of the Gates are not specified. The time periods may be well in advance of the payload's launch to orbit (per the standard integration template), or the Gates may occur much closer to launch.

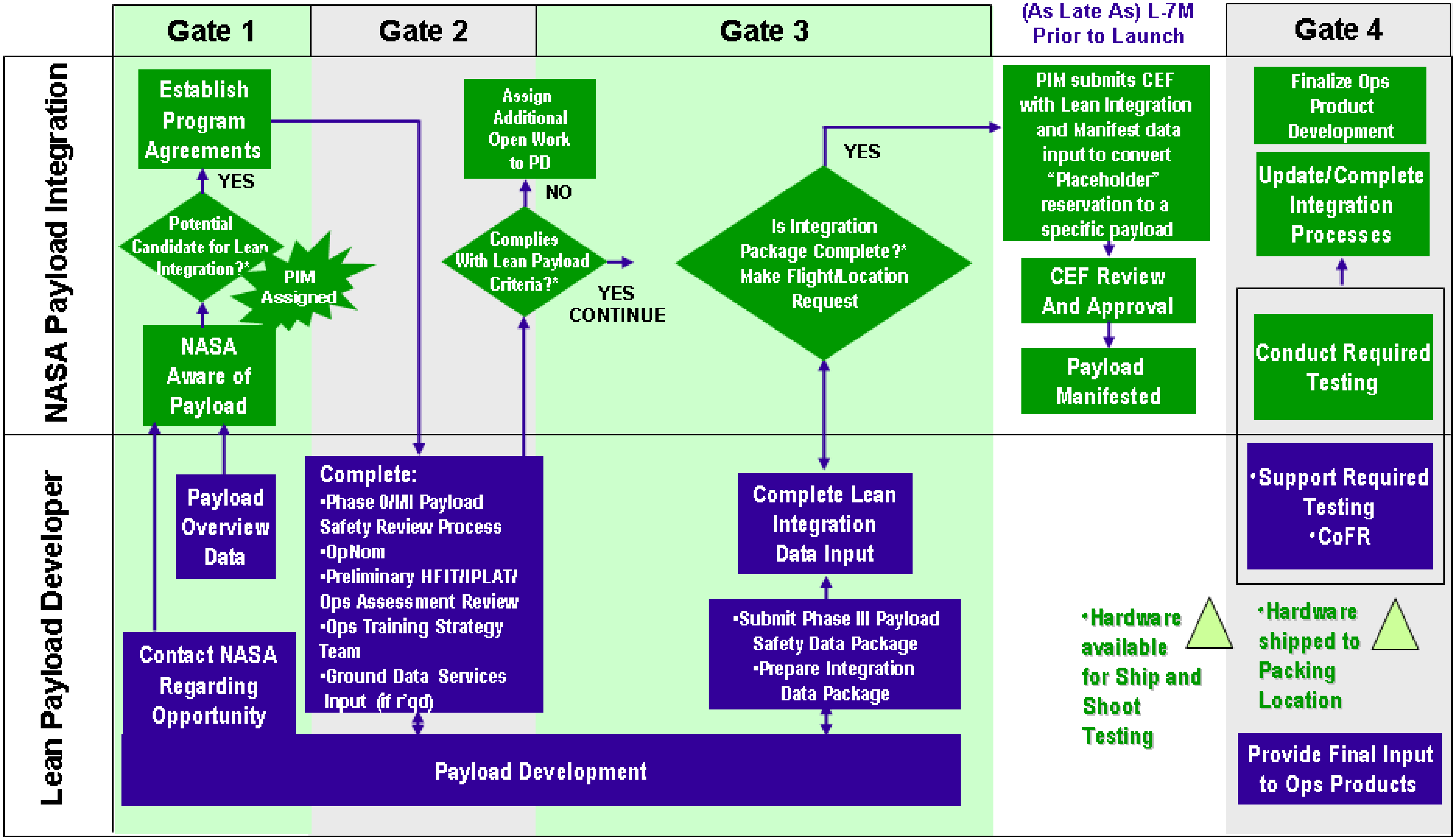
The process initiates with Gate 1 (see Figure A-1), when the ISS Payloads Office becomes aware of the potential payload. The ISS Payloads Office will provide a Payload Integration Manager (PIM) to review payload information and coordinate with technical representatives from the Host Facility and the operations community to exchange the operational concept for the payload and to learn more about the ground operations concept. The payload information review will determine if the payload meets the operational, hardware and software criteria for the Lean type. If those criteria are met, then the ISS Payloads Office and the PD will proceed with the Lean Payload Integration Process for the payload. If at any point during the integration process the payload is determined to be more complex than originally assessed during Gate 1, the payload integration plan will be updated and the payload may be processed instead through the standard integration template.

Gate 2 activities represent "early work" that the PD must accomplish as soon as possible. The payload PIM will work with the PD to address this early work. The Payload Safety Review Process remains intact. The PD should start the Safety Review Process as early as possible and need to complete Phases 0/I/II Safety Reviews by the end of Gate 2. Additionally, the ISS Program needs to establish the Operations Nomenclature (OpNom) for the payload. The OpNom is the official name used for the payload and it "ripples" though much of the payload technical documents. The OpNom definition process can be quite lengthy. The PIM will assist the PD in coordinating a Change Request (CR) to establish the OpNom as early as possible. A Training Strategy Team (TST) meeting should occur with the PD and the Operations Integration team to exchange the operational concept for the payload, confirming that crew interaction with the payload is simple. The PD coordinates the requirement for remote ground operations locations with the Ground Systems Requirements Team. (Note that only one remote ground operations location can be supported for a Lean Payload.) If a new ground operations location is to be established, NASA security clearances for the PD personnel must be established. This process can take up to nine (9) months.

Early work specific to EXPRESS Subrack payloads exists in Gate 2. If the payload has Health and Status (H&S) telemetry to be routed to the POIC, detailed information on those parameters is needed as early as possible to support the software integration. Refer to Section A6.3 for more information.

Gate 3 consists primarily of technical data submittal by the PDs. The PDs must submit their Phase III Safety Data Package and have submitted all of the data defined in the Lean Integration Data Package. If the Payload Operations Lead is required to author the crew procedures, the PD team needs to provide inputs for crew procedure development no later than launch minus 8 months. Submittal of the data package is key – when the Lean Integration technical Data Package is successfully reviewed with the PIM, the Host Facility and the operations team for completeness and accuracy, then the payload can be manifested for flight. To reiterate, a manifesting assignment can occur well in advance of flight. However, this approach only establishes an opportunity for a payload to be manifested as close as seven (7) months prior to a flight. Details regarding the Lean Integration Data Package are found in Table A-2.

Gate 4 consists of payload processing, unique to the payload type, to enable engineering verification of interfaces and procedure review. More details are provided in the payload unique sections of this appendix. Successful Gate 4 processing culminates with the shipment of the payload hardware to the packing site. During Gate 4, the PD will coordinate with the Operations Integration team on the final mission planning input to the User Requirements Collection (URC) tool; data which might require a Payload Regulation; and the final crew training CBT material. The PD must complete the payload Certification of Flight Readiness (CoFR) process as well.



.* PIM will conduct Gate Review technical assessments with Host Facility Lead, PEI, PSI, Operations, Payload Safety Review Panel, and Crew Office Representatives

Figure A-1 Lean Payload Integration Gate Process

Table A-2 Lean Integration Data Package

Data Item	Description	Use	User
Lean Integration Data Input			
•Payload Technical Data input, tailored per Host Facility streamlining	Captures streamlined engineering integration data • Lean Integration Data Sheet (LIDS) for EXPRESS • Interface Requirements Sheet (IRS) for MSG	Development of Payload ICD, Integrated Engineering Analysis, and Tailoring of Generic Ship and Shoot Test Plan	PEI and SSITF Test Engineering
Payload Hardware			
•On-Orbit Drawings	Drawings associated with payload on-orbit operational configuration	Topology Assessment and Stage Configuration Drawing Development	PEI
•MR Loader Manifest and Payload Tactical Plan (PTP) Table Updates	Both sets of data are needed to manifest the payload on a specific flight	Change Evaluation Form (CEF)	MI
•Cold Stowage Data	The Cold Stowage Form has been completed. Reference: http://iss-www.jsc.nasa.gov/nwo/payload/oz2/web/ColdStow.shtml	Cold Stowage Accommodation Planning	MI
•Waste Questionnaire Data	The Waste Manifest Form has been completed. Reference: http://iss-www.jsc.nasa.gov/nwo/payload/oz2/web/manifest_stowage.shtml	Waste Planning	MI
•Test Results	Results of any of the following tests performed prior to Ship and Shoot Testing at MSFC (Off Gas, Vibration, Acoustics, EMI/EMC)	Requirements Verification	PEI
Payload Operations			
•Training Material	Written and/or video training material established for ground-based self-study–based on Training Strategy Team review	Ground based crew training via "Self-Study DBT"	Ops Lead
•Preliminary User Requirements Collection (URC) Input	Preliminary definition of Payload operations activities, durations, sequences, and associated resource requirements	Development of Mission Planning Activity Models	Ops Lead
•Preliminary Crew and Ground Ops Procedures	Crew Procedures (Note – POIF is the Crew Procedure developer for EXPRESS and MSG payloads.)	Verification by Ops team during Ship and Shoot Processing	Ops Lead
Payload Safety			
•Phase III Safety Data Package	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.	Hazard Report review and approval. Hazard Reports are stand-alone documents that the Operational Console would use to make real-time decisions on-orbit.	PSRP and Ops Lead
•Ground Safety Checklist	Standard checklist provided to ground processing and launch processing facilities	Identification of information for ground processing locations and Tailoring of Generic Ship and Shoot Test Plan	PSRP and SSITF Test Engineering

A2 Lean Mission Integration Process

The elements of the Overall Mission Integration Process discussed in the document main body apply to a Lean Payload. The PIM (with the Host Facility and operations technical representatives) will evaluate the payload overview information to determine if the payload meets the Lean Payload Criteria. If so, the Lean template discussed in A1.4 will be used by the PIM to develop the payload integration schedule. If defined early, the Lean Payloads may be specified by name in the Payload Tactical Plan (PTP). However, the PTP also includes "placeholder" allocations for Lean Payloads. The Mission Integration organization will assign the Lean Payload to the "placeholder" allocations per the process described above in A1.4. If at any point during integration, the payload is discovered to be more complex than originally determined during the Gate 1 discussion, the payload integration plan will be updated and that payload may be redirected to the standard integration template flow.

A3 Lean Engineering Integration Process Overview

A more efficient method of closing engineering interface verification has been defined for Lean Payloads to benefit both the PD and the ISS Payload Integration Team. Verification closures for only the requirements impacting the payload interface to the Host Facility will be obtained. (Note: All Safety Related requirements and verifications are applicable for every payload type and will be addressed by the Payload Safety Review Process (PSRP)). Each Host Facility will identify a minimum set of interface testing to be conducted with the payload. The term "Ship and Shoot Testing" is used to capture this lean interface verification approach.

<u>What are the Benefits of Ship and Shoot Testing?</u> The ISS integration team gets exactly the data needed to verify interfaces through hands-on interaction with the payload. The collection and analysis of data obtained via Ship and Shoot testing will provide adequate verification closure of applicable interface requirements. (Note: In addition to interface testing, test results for EMI/EMC, Offgas, and Acoustics test are required.) The PD team will no longer have to organize their analysis and test data into closure packages and submit those packages to the ISS Integration Team. This approach eliminates the need for the PD to rework verification activities because they did not adequately address the requirements which the PD team was not familiar with. For the types of payloads analyzed to date, this approach translates to significant savings:

- approximately 300 requirements verification closures for EXPRESS Subrack payloads
- roughly 200 requirements verification closures for MSG payloads.

This approach will also benefit the Operations Integration team as it will allow the Crew Procedure and Ground Command Procedures to be validated as part of the testing. Lean Engineering Integration unique to each payload type is detailed in subsequent sections. Lean Engineering Integration unique to each payload type is detailed in subsequent sections.

A4 Lean Software Integration Process Overview

Host facility software implementations differ, therefore, lean software integration templates unique to each payload type are detailed in Section A6 through A13.

A5 Lean Operations Integration Process Overview

The operational criteria for a Lean Payload, discussed in Section A1.2, Lean Payload Operational Characteristics, were developed to identify the types of operations that could be integrated using a shorter template. Simple crew interaction, no crew interaction with software displays, and all crew training conducted via self-study CBT or Onboard CBT are key criteria.

Note that there are still several Operations Integration activities that are addressed in Gate 2 (i.e., the "early work" in Section A1.4 above) to be completed as soon as possible.

- A Training Strategy Team (TST) meeting should occur with the PD and Operations Integration teams as soon as possible to confirm that crew interaction with the payload is simple and to determine the implementation approach for crew training.
- The PD coordinates the need for remote ground operations locations with the Ground Systems Requirements Team as part of the Ground Data Services (GDS) Dataset. Only one new remote ground operations location can be established for a Lean Payload. If a new ground operations location needs to be established, NASA security clearances for PD personnel must be established. This process can take up to nine (9) months.

Applicable Computer Based Training input, Ground Command Procedures and Crew Procedure input are all submitted by the PD as part of the Lean Integration Data Package, as discussed in Section A1.4.

Mission planning for a Lean payload is accommodated slightly differently. For initial mission planning products, on-orbit resources for Lean Payload "placeholders" are carried as an envelope, or generic set of resources. When a Lean Payload manifest assignment is made at approximately seven (7) months prior to a launch, the PD provides more detailed mission planning information as User Requirements Collection (URC) input.

Other Operations Integration products are developed on the standard template discussed in the main body of this document. Figure A-2 summarizes the Operations Integration activities. The input products required by the PD are indicated as blue, down-facing triangles in Figure A-2. The data and products the Operations Integration team generates are shown as green, up-facing triangles.

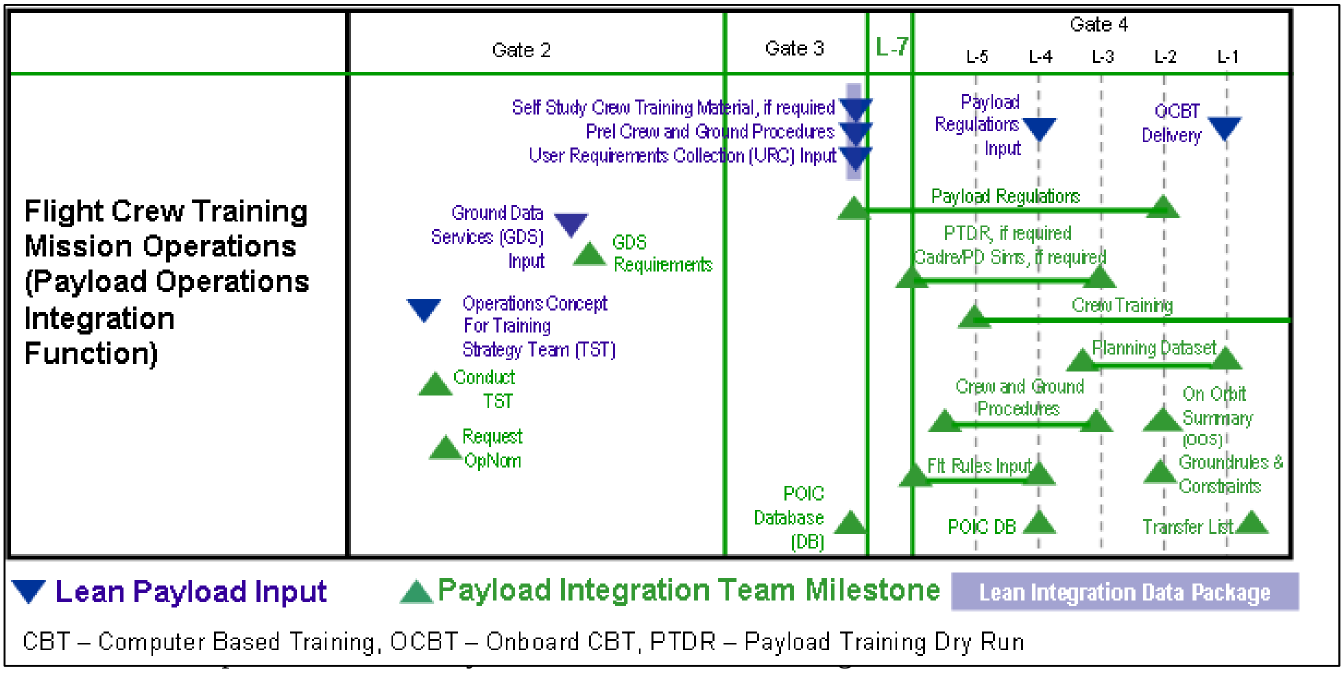


Figure A-2 Lean Payload Operations Integration Summary

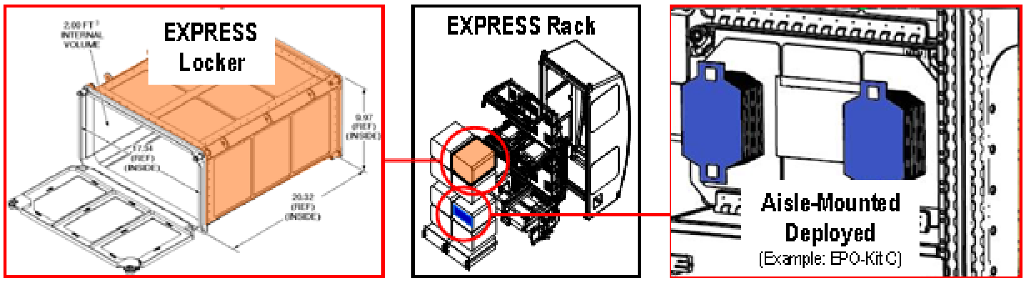
A6 Lean EXPRESS Payload Processing

A6.1 Lean EXPRESS Payload Hardware and Software Characteristics

A Lean EXPRESS payload may be a subrack locker replacement, locker insert, an ISIS drawer payload, or a small payload deployed at an EXPRESS rack utilizing EXPRESS rack power to operate. Table A-3 summarizes Lean EXPRESS Payload Interface and applicability and Figure A-3 summarizes Lean EXPRESS payload characteristics. EXPRESS Interface Requirements to which a payload must comply are detailed in SSP-52000-IDD-ERP.

Table A-3 Lean EXPRESS Payload Interfaces

Interface	Applicable?	Limitations
Mechanical	Yes	Transportation – Passive, Soft Stowed On-Orbit - Locker Insert or Replacement; ISIS Drawer, Small Deployed payload that does not violate on-orbit temporary protrusion requirements (Envelope – Extension from Rack GSE Plane: Reference Envelope guidelines found in SSP-53126, Lean EXPRESS Payload Interface Control Document, can be stowed in < 10 minutes)
Thermal	Yes	Rear Air Cooled or Water Cooled
Electrical Power	Yes	28 vdc
Command and Data Handling Data	Yes	Ethernet Payload Data to comply with Lean EXPRESS C&DH Dataset, or comply with a previously defined C&DH Dataset (reflight) If payload Parameter Monitoring is required, it is performed by payload software, not as a Special Service requested of the PLMDM No payload file transfers via the PLMDM Video is Ethernet embedded or NTSC
EXPRESS Laptop Computer (ELC)	See Limitation	Payload Application Software running on the ELC not supported. Payload use of ELC for file transfers for subsequent downlink can be supported.
GN2	No	Interface not supported for Lean EXPRESS Payload.
Vacuum Exhaust	No	Interface not supported for Lean EXPRESS Payload.



Lean EXPRESS Payload Types: (1) Subrack Locker; (2) EXPRESS Deployed

Resource Accommodations	(1) Subrack Locker Payload	(2) EXPRESS Deployed Payload
Structural	1 MLE	< 1 MLE
Volume	2 ft³	2 ft³ **
Mass	60 lbm	60 lbm
Power	150 W @ 28 Vdc	150 W @ 28 Vdc
Cooling	150 W air / water	150 W cabin air
Data*	Ethernet Only	n/a
Video (Analog)	NTSC/RS170A	n/a

MLE – Middeck Locker Equivalent
* Payload software must interface to a prebuilt Lean EXPRESS C&DH Dataset or be a Reflight Payload
** Envelope – Defined boundary exists, reference SS-53126, Lean EXPRESS Payload Interface Control Document

Figure A-3 Lean EXPRESS Payload Characteristics

A6.2 Lean EXPRESS Engineering Integration

EXPRESS Payload hardware will be integrated at the Space Station Integration Testing Facility (SSITF) at MSFC and tested to obtain acoustics and EMI/EMC, power, data, thermal, mechanical, and human factors interface verification data. The SSITF contains a Flight Equivalent Unit (FEU) of the EXPRESS Rack, interfacing through the POIC ground data systems. A TReK workstation is used to issue commands and view payload telemetry. The Human Factors Integration Team (HFIT) conducts their verification review of applicable HFIT requirements. The opportunity exists to review ground commands and simple crew procedures while interacting with the payload at the SSITF. Additional testing at MSFC can be arranged for off-gas Testing, and Vibration Testing, depending on the payload needs. (Note: In addition to interface testing, test results for EMI/EMC, Offgas, and Acoustics test are required.)

Ship and Shoot testing can occur as soon as the hardware and lean integration data are available (assuming the SSITF is available). This can be prior to a payload being manifested for flight. If the manifest is established as late as seven (7) months prior to launch, then the hardware needs to be delivered to MSFC no later than six (6) months prior to launch.. The PD is expected to have a representative at MSFC during the Ship and Shoot tests. The Ship and Shoot process is depicted in Figure A-4. Within Block 1.5 of Figure A-4, Ship and Shoot (S&S) Data Collection, the following tests will be performed:

1.5.1 Pre Operations Setup
1.5.2 Payload Activation
1.5.3 Ground Commanding
1.5.4 Downlink Telemetry
1.5.5 Power Profile Testing
1.5.6 Thermal Data Collection
1.5.7 Subrack Caution and Warning Functionality (if required)
1.5.8 Video Functionality (if required)
1.5.9 Payload Deactivation
1.5.10 Post Operations Tasks

Additionally, Operations Integration personnel will review relevant ground commanding and crew procedures, and the HFIT will review human factors related requirements and complete HFIT verification for the PD during the Ship and Shoot Data collection process.

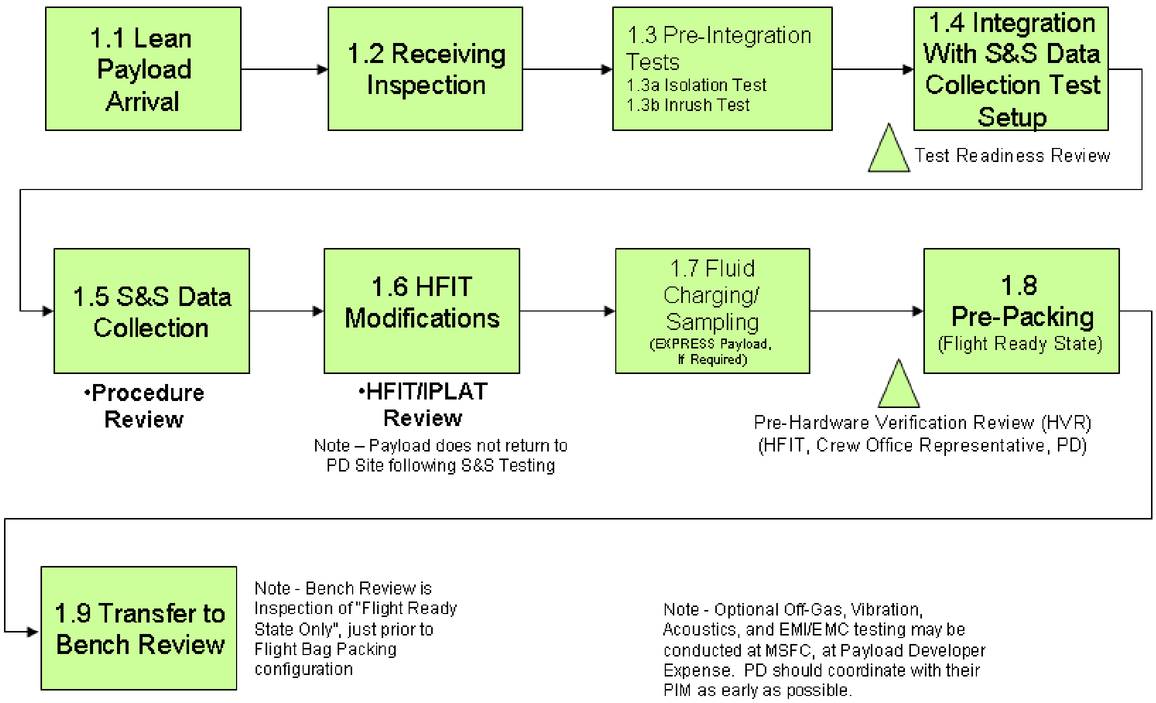


Figure A-4 Ship and Shoot Processing Functional Flow

For EXPRESS Subrack payloads, a Lean EXPRESS ICD template has been established which clearly identifies the requirements verification closures to be obtained via Ship and Shoot testing.

The data collected during Ship and Shoot testing, combined with test analysis results for environmental testing (Off-Gas, Vibration, Acoustics, EMI/EMC) will be reviewed by Payload Engineering Integration and will suffice as verification objective closure data.

A6.3 Lean EXPRESS Subrack Payload Software Integration

An approach has been implemented to streamline EXPRESS payload software integration. A generic Lean EXPRESS C&DH dataset has been established for Lean EXPRESS Payloads. Further, the ISS Payloads Office has pre-staged many EXPRESS subrack locations to accommodate the Lean payloads. Therefore, the payload software interface for the pre-staged Lean EXPRESS subrack location is “pre-built”. To qualify as a Lean EXPRESS payload, the PD will need to implement payload software that interfaces via the Lean EXPRESS C&DH dataset.

Previously flown EXPRESS payloads are considered reflight payloads. A C&DH dataset exists for a reflight payload. The PD should inform the ISS Payloads Office of relight payloads as soon as possible so that the reflight dataset information can be included early in the software integration products. The ISS Payloads Office assumes that no changes are required to the reflight C&DH dataset.

Note: If the payload software environment can incorporate standard industry protocols for Ethernet data transmission (UDP, TCP/IP), a toolkit has been developed that the PD can choose to implement. The Software Toolkit for Ethernet Lab-Like Architecture (STELLA) interfaces to the Lean EXPRESS C&DH Dataset, and provides command, science telemetry, and H&S parameter formatting and routing services. STELLA also enables simple commanding from your TReK ground workstation, and provides many utilities for simplified file transfer between your ground workstation and on-orbit payload.

A7 Lean Microgravity Sciences Glovebox (MSG) Payload Processing

A7.1 Lean MSG Payload Hardware and Software Characteristics

A Lean MSG payload must not exceed two (2) Middeck Lockers (MDL) in size, meet power/cooling criteria, and be operated from the ground using standard MSG payload command interfaces. Table A-4 summarizes Lean MSG Payload Interface and applicability.

Table A-4 Lean MSG Payload Interfaces

Interface	Applicable?	Limitations
Mechanical	Yes	Transportation – Passive, Soft Stowed
Thermal	Yes	Requires less than 500 watts of cooling
Electrical Power	Yes	Requires less than 500 watts of power
Data	Yes	Operated from the ground with very little commanding. All data transfer and commanding is done via the MSG Laptop Computer Server (MLCS)

A7.2 Lean MSG Engineering Integration

Interface verification data will be obtained for Lean MSG Payloads during a Ship and Shoot Process, similar to the EXPRESS Lean Payload processing. Reference Section A.6.2.

A7.3 Lean MSG Payload Software Integration

A Lean MSG Payload interfaces through the MSG Laptop Computer Server (MLCS) – therefore, no unique lean MSG software integration processes are necessary.

A8 Lean HRF Payload Processing – Reserved

A9 Lean CIR Payload Processing – Reserved

A10 Lean FIR Payload Processing – Reserved

A11 Lean MSRR Payload Processing – Reserved

A12 Lean Small Deployed Payload Processing – Reserved

A13 Lean Unpressurized ELC Payload Processing - Reserved

Glossary of Terms

Health and Status (H&S) data are defined as: information originating at the payload/subrack payload and passed to the Payload MDM that provides the crew and ground confirmation of payload performance, operational state, resource consumption, and assurance that the payload is operating within safety guidelines as defined by the Payload Safety Review Panel (PSRP) and the ISS Flight Rules. Some examples of payload H&S data are subsystem status (power, voltages, currents, temperatures, pressures, fluid flow velocities, warning indicators, error messages/codes, etc.), digital communications systems statistics (1553, ethernet, and high rate system status, etc.), and video system status (camera and video recorder on/off indications, synchronization indicators, etc.). (Reference SSP-52050, Revision G, International Standard Payload Rack to International Space Station, Software Interface Control Document Part 1)

Appendix B: SAMPLE TEST READINESS REVIEW (TRR) PLAN

SAMPLE TEST READINESS REVIEW (TRR) PLAN

Test Readiness Review (informal) for Integrated Testing of Intravenous Fluids Generation and Mixing (IV GEN) with the Microgravity Science Glovebox (MSG) Engineering Unit (EU)

Purpose of Testing

This testing is intended to perform verification testing of the IV GEN Investigation as required by MSFC-RQMT-2888 that must be performed with the MSG Engineering Unit and/or the Payload Rack Checkout Unit (PRCU).

Test Requirements

The requirements for this testing are taken from the IV GEN Investigation Interface Control Document, MSFC-ICD-3553. The applicable requirements are listed below along with the test documentation that will address each requirement.

MSFC-RQMT-2888 RQMT.	VDS No.	Requirement	Test Documentation.
3.3.1.2.1 thru 3.3.1.2.2.1.2	CD-002	RS422 Direct Experiment Interface	EU-139
3.3.1.2.2.2.2	CD-002	RS422 Experiment H & S	EU-139
3.3.1.2.2.2.3	CD-002	RS422 Experiment LRT	EU-139
3.3.1.2.2.2.6	CD-002	RS422 MSG Commands from Exp.	EU-139
3.3.5.2	CD-009	MLCS Ethernet Interface	EU-139
3.3.5.3	CD-009	MLCS Socket Interface	EU-139
3.3.7.2.1	CD-014	Video Interface Commands	EU-139
3.3.8	CD-015	Real Time H&S Monitoring	EU-139
3.1.1.3	ME-046	Fit Check with facility	MTCP-303
3.10.2.2.3	EN-006	Acoustics	BT-115
3.2.1	El-006	Integrated Power Draw	EU-138
3.2.4.2 thru 3.2.4.2.6.3.2	EL-022	Electrical Bonding	MTCP-303
3.6.1.1.B	FD-027	Nitrogen Physical Interface	EU-137
3.6.1.2	FD-024	Nitrogen Flow Control	EU-137
3.7.3 D & E	ME-046	Exclusion Zones & Side Ports	MTCP-303
3.9.1.2.A	MP-004	Toxicity Offgassing	BT-116
3.1.1.3	ME-046	Thread Engagement	BT-114
3.2.2.2.b & c	EL-007	Secondary Power Connector	BT-114
3.3.1.1.2	CD-01	RS422 Interface Connector	BT-114
3.3.4.1.2	CD-007	MLC Ethernet Connector	BT-114
3.6.1.1 A	FD-027	Nitrogen Physical Interface	BT-114

Overview of Test Article

IV GEN is a compact water purification system to produce Sterile Water for Injection (SWI) and to provide a pharmaceutical mixing capability in a reduced gravity environment with minimal dependency on spacecraft power resources. The IV GEN hardware is composed of (1) Accumulator, (2) Purifier, (3) Mixer, (4) Data Acquisition and Control Unit, (5) Power Converter, (6) Saline and Collection Bags, (7) Hoses and (8) Electrical Cables.

Test Article Configuration

IV GEN is provided to MSFC as Customer Supplied Product (CSP) that will be maintained under customer during testing at MSFC with the exception that Offgas Toxicity Testing will be performed after the customer leaves. MPR 4001.1, the MSFC requirement for the Control of Customer Supplied Product requires a Customer Supplied Product Agreement (CSPA) since the hardware will not be under customer control during the last (Offgas) test. This customer agreement will be signed before the customer leaves MSFC and is not a constraint to any testing except the Offgas Toxicity test performed after the customer departs. Configuration control will remain with the customer while under testing at MSFC and the MSFC test documentation does not change configuration.

Test Procedure Status

All test procedures are MSG Systems Test Group (ES61) standard procedures for integrated testing with MSG and have been performed by the test group numerous times. History shows that the procedures are sufficient to meet the intended requirements. Command and Data Handling Testing and some project required inspections will be performed on Test Preparation Sheets (TPS) instead of standard procedures for integrated testing due to the unique nature of these tests/inspections. These requirements are taken from the IV GEN ICD and have been distributed to the customer and project for agreement with no negative comments received.

Test Facilities and Support Systems

All testing except Toxicity Offgassing will be performed in the Space Systems Integration and Test Facility (SSITF), Building 4493. The Payload Rack Checkout Unit (PRCU) and MSG Engineering Unit will be used for integrated tests and have been reserved for IV GEN from July 20^{th} thru July 24^{nd}.

Mitigation of Risks to Hardware and Personnel

Hardware Risks

All connections are uniquely keyed to prevent improper connection and second person verifications are called out in test procedures to verify test sets up prior to operations. The TPSs in this test sequence do not call for Test Readiness Inspections (TRIs) for the above reasons, the only TCP to be run is unpowered and thus does not require a TRI.

All testing will operate the IV GEN hardware as intended and do not stress the hardware any more than normal usage. The Hardware Developer will be present during all powered testing and will operate the IV GEN hardware.

Personnel Risks

Personnel risks are documented in ES61 Job Hazard Analysis (JHA) and thus mitigated. No personal protective equipment (PPE) is required during this testing. The following JHA's apply:

ES61-JHA-003	Electrical/Mechanical Operations
ES61-JHA-005	Hardware Handling
ES61-JHA-014	Small Hand Tools

Test Staffing Support

ES61 Systems Test Group personnel will be present during all testing and will be responsible for coordinating with other disciplines for coverage as needed. Safety and Mission Assurance (QD11) will provide Quality personnel to cover all test activities. The customer will provide knowledgeable personnel to operate the SODI hardware during testing. As we intend to adjust the schedule (number of hours daily and days worked weekly) depending on test progress the schedule will be adjusted as needed to fit all activities into the allotted time.

Training Certification

All ES61 MSG test personnel are certified in manual movement of Program Critical Hardware (PCH). IV GEN is not designated PCH but the higher level certification will ensure hardware safety during movement.
Additionally all ES61 MSG personnel are certified in Electrostatic Discharge Control per MSFC-RQMT-2918.

Test Sequence Control, Redlines and Shutdown Modes

The ES61 person running a particular test will be considered the Test Conductor and will have the authority to change test sequences as needed and in compliance with ES61-OWI-001. Redlines and Procedure Deviations will be in accordance with ES61-OWI-001.

MSG activation/deactivation will be per MSG standard operating procedures. Usually IV GEN personnel will control their experiment hardware activation/deactivation; however in the event that ES61 needs to perform IV GEN activation/deactivation the current crew procedure will be followed.

Test Data and Video Documentation:

During testing data will be made available to the experiment developer as requested. Additionally all MSG Health and Status data (with IV GEN H&S embedded) will be captured on the MLC and maintained in the ES61 electronic data storage area.

Constraints to Testing:

The following matrix identifies the MSG Project requirements that must be met before any hardware can be installed in the Engineering Unit. The Experiment Developer must meet these requirements prior to integrated testing either at this TRR or by prior submittal to the MSG Integration Payload Investigation Manager (IPIM).

3.2.1	P	Electrical Power Draw	EL-006
3.2.1.1	P	Steady State Voltage	EL-001
3.2.2.3.A, B & C	P	Surge Current	EL-010
3.2.2.5	P	Circuit Protection Devices	EL-012
3.2.4.1 A-E thru 3.	P	Electrical Grounding & Isolation	EL-020 &
3.3.1.1.1	P	RS422 Cable Characteristics	CD-01
3.3.1.1.3	P	RS422 Signal Characteristics	CD-01
3.3.1.1.4	P	RS422 Port Settings	CD-01
3.3.4.1.1	P	MLC Ethernet Cable Characteristics	CD-07
3.3.4.1.3	P	MLC Ethernet Signal Characteristics	CD-07

IPM Signature here signifies the above matrix requirements have been met.

IPM______________________

Date ___________

Additionally, TPS ES61-MSG-BT-114 must be successfully completed prior to placing any hardware in the MSG Engineering Unit. Performance of this TPS may occur before or after this TRR.

Authority to Proceed:

Signature below signifies approval of pre-test planning and concurrence that testing may begin subject to the Constraints to Testing section above.

____
John Smith
MSG Test Engineer

____
Jane Doe
IV GEN IPIM

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QD11 Representative

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IV GEN Project Manager

Appendix C: Acronym List and Definition

Acronyms used in this document are listed below. A more extensive list of NASA ISS-related acronyms can be found at the two links below:

http://www6.jsc.nasa.gov/AcronymCentral/scripts/index.cfm

http://spaceflight.nasa.gov/station/reference/index.html

ACRONYM	DEFINITION
ACAS	Active Common Attach System
ACP	Access Control Plan
ADP	Acceptance Data Package
AP	Attached Payload
ASE	Airborne Support Equipment
ATV	Automated Transfer Vehicle
B/L	Baseline
BDC	Baseline Data Collection
BIS	Bureau of Industry and Security
Boeing PSIV	Boeing Payload Software Integration and Verification
CBT	Computer Based Training
C&DH DS	Command and Data Handling Dataset
C&DH	Command and Data Handling
CCL	Commerce Control List
CEF	Change Evaluation Form
CIR	Combustion Integrated Rack
COC	Certificate of Compliance
CoFR	Certification of Flight Readiness
COL	Columbus
CR	Change Request
CSA	Canadian Space Agency
CSPA	Customer Supplied Product Agreement
CTC	Crew Training Coordinator
DB	Database
DFRC	Dryden Flight Research Center
DMS	Data Management System
DOC	Department of Commerce
DOS	Department of States
DST	Daily Science Tag
ECP	Export Control Program
ECR	Engineering Change Request
ECR	Export Control Representative
EEOM	Early End of Mission
ELC	EXPRESS Logistics Carrier
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference

EOM	End of Mission
EPC	Enhanced Personal Computer
EPS	Electrical Power System
ESA	European Space Agency
EST	Export Services Team
EU	Engineering Unit
EXPRESS	Expedite the Processing of Experiments to Space Station
FCE	Flight Crew Equipment
FCU	Functional Checkout Unit
FEU	Functional Equivalent Unit
FIR	Fluids Integrated Rack
GCP	Ground Command Procedure
GDS Dataset	Ground Data Services Dataset
GDS	Ground Data Services
GFE	Government Furnished Equipment
GLC	Guidelines and Constraints
Gr&C	Groundrules and Constraints
GSP	Ground Support Personnel
GSRD	Ground Support Requirement Document
GSRP	Ground Safety Review Panel
GSRT	Ground Support Requirements Team
H&S	Health and Status
H/W	Hardware
HFIT	Human Factors Integration Team
HOPI	HOSC Operations Planning and Integration
HOSC	Huntsville Operations Support Center
HRF	Human Research Facility
HRP	Human Research Program
HS	Human Subject
HSPD-12	Homeland Security Presidential Directive 12
IAV	Internal Audio/Video
ICB	Informed Consent Briefing
ICD	Interface Control Document
IDAGS	Integrated Displays and Graphics Standards
IDP	Integrated Data Package
IDRD	Increment Definition and Requirement Document
IHRCWG	International Human Research Complement Working Group
IM	Increment Manger
IMMT	International Space Station Mission Management Team
IP	International Partner
IPE	Increment Payload Engineer
IPLAT	ISS Payload Label Approval Team
IPM	Increment Payload Manager
IRD	Interface Requirement Document
IRP	Increment Research Plan
IRR/TRR	Integration Readiness Review/Test Readiness Review
IRT	Increment Research Team
ISIS	International Subrack Interface Standard

ISS	International Space Station
ISSMP	International Space Station Medical Project
ISSP	International Space Station Program
ITA	Integrated Truss Assembly
IVT	Interface Verification Test
JAXA	Japanese Aerospace Exploration Agency
JEM	Japanese Experiment Module
JSC	Johnson Space Center
KHB	Kennedy Space Center Hand Book
KSC	Kennedy Space Center
LIS Rep	LIS Representative
LIS	Lead Increment Scientist
LRU	Line Replaceable Unit
LSE	Laboratory Support Equipment
LSSC	Life Sciences Support Contractor
LSSM	Launch Site Support Manager
LST	Load Shed Table
MDM	Multiplexer/Demultiplexer
MDS	Mission Design Specialist
MI	Mission Integration
MLCS	MSG Laptop Computer Service
MOD	Mission Operations Directorate
MPCB	Multilateral Payload Control Board
MPLM	Multi Purpose Logistics Module
MRPWG	Multilateral Research Planning Working Group
MSFC	Marshall Space Flight Center
MSG	Microgravity Sciences Glovebox
MSI	Maintenance Significant Item
MSSR	Materials Science Research Rack
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NPOCB	NASA Payload Operations Control Board
NSTS	National Space Transportation System
OBT	Onboard Training
OCA	Orbital Communications Adapter
OCBT	Onboard Computer Based Training
OCR	Operations Change Request
OD	ISS Avionics Group Organization Code
ODTC	Office of Defense Trade Controls
OMRS	Operations and Maintenance Requirements Specification
OOS	On-orbit Operations Summary
OPF	Orbiter Processing Facility
OpNom	Operations Nomenclature
OWTL	Open Work Tracking Log
OZ	Space Station Program Organization Code for the Payloads Office
P/L Laptop Apps	Payload Laptop Applications
PAR	Payload Anomaly Report
PARC	Payload Activity Requirements Coordinator

PCB	Payload Control Board
PCF PLMDM	PLMDM Configuration Files
PCF	Configuration File Development
PCF	PLMDM Configuration Files
PD	Payload Developer
PDA	Personal Digital Assistant
PDL	Payload Data Library
PDRT	Payload Display Review Team
PE&I	Payload Engineering and Integration
PECP	Payload Engineering Control Panel
PEI	Payload Engineering and Integration
PFE	Payload Furnished Equipment
PGUIDD	POIC Generic User Interface Definition Document
PI	Principal Investigator
PIA	Payload Integration Agreement
PIM	Payload Integration Manager
PIRN	Payload Interface Revision Notice
PIV	Personnel Investigation Verification
PLMDM	Payload Multiplexer De-Multiplexer
PLSS	Payload Support Systems
PMIT	Payload Mission Integration Team
POC	Point of Contact
POIC DB	Payload Operations and Integration Center Database
POIC	Payload Operations Integration Center
POIF	Payload Operation Integration Function
POM	Payload Operations Manager
PPM	Payload Planning Manager
PRCU	Payload Rack Checkout Unit
PSCP	Payload Software Control Panel
PSE	Payload Safety Engineer
PSI	Payload Software Integration
PSRP	Payload Safety Review panel
PTDR	Payload Training Dry Run
PTP	Payload Tactical Plan
QA	Quality Assurance
RP	Research Plan
S&MA	Safety and Mission Assurance
S&S	Ship and Shoot
S/W	Software
SDP	Safety Data Package
SIA	Society for International Affairs
SLSL	Space Life Science Lab
SORR	Stage Operation Readiness Review
SPIA	Standard Payload Integration Agreement
SRDS	Support Requirements Data Set
SRP	Safety Review Panel
SSCB	Space Station Control Board
SSE	Station Support Equipment

SSITF	Space Station Integration Test Facility
SSP	Space Station Program
SSPF	Space Station Processing Facility
STELLA	Software Toolkit for Ethernet Lab-Like Architecture
SVTL	Safety Verification Tracking Log
TAA	Temporary Area Access
TCS	Thermal Control System
TDR	Test Discrepancy Report
TGHR	Time Critical Ground Handling Requirements
TIM	Technical Interchange Meeting
TRDS	Technical Requirements Data Set
TReK	Telescience Resource Kit
TSC	Telescience Support Center
TST	Training Strategy Team
URC	User Requirement Collection
USL	United States Laboratory
USML	Recommended United States Munitions List
USOC	United States Operations Center
USOS	United States Orbital Segment
VAB	Vehicle Assembly Building
VS	Vacuum System
WORF	Window Observational Research Facility

Appendix D: Contact and Contributors Acknowledgments

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