

Payload Operations and Telescience on ISS

Rickey D. Cissom¹, Barbara J. Cobb¹, Kristi S. Ramage²,

¹*George C. Marshall Space Flight Center/FPD, National Aeronautics and Space Administration,
Marshall Space Flight Center, AL 35812-001*

²*Teledyne Brown Engineering/Cummings Research Park
Huntsville, AL 35805*

¹*Phone: 256-544-2017, Fax: 256-544-5685, email:rickey.cissom@msfc.nasa.gov*

Abstract. The objective of this paper is to provide future International Space Station (ISS) scientists and/or engineers with an overview of the ISS payload operations and integration process. This process begins with the payload being manifested on the ISS and continued through the integration and operations process. Emphasis is placed on the interfaces and tools that the payload will utilize when going through the process. For each of the Data Sets, the Payload Operations and Integration Center (POIC) provides a Data Set Manager to work with the PD's.

RESPONSIBILITIES IN THE INTEGRATION AND OPERATION OF A PAYLOAD

To introduce the responsibilities associated with the integration of a payload into ISS operations, a clear definition of the processes and interfaces that a Principal Investigator (PI) and a Payload Developer (PD) will be required to support must be addressed. The PI and the PD are addressed together because, from a payload integration standpoint, they appear as a single team. The PI may also be the PD. The PI is in charge of the conduct of the experiment and is responsible for defining the data products required or desired for the operation of the experiment. The PI may define the performance requirements on equipment to be developed or define how existing equipment is to be used. The PI is responsible for providing scientific support during physical integration and flight operations. The PD develops the experimenter's instrument and is in charge of the conduct of the experiment. The PD is also responsible for defining the data or other products required/desired from the operation of an instrument or experiment facility and for providing scientific support during the physical integration and flight operation of the equipment. The PD is responsible for their payload's mission success and for all inputs of payload operational requirements. The PD is responsible for updating/maintaining the payload flight documentation and for team adherence to procedures and regulations documented in Payload (PL) Operations Handbook, Payload (PL) Regulations, and Flight Rules. The PD is also responsible for monitoring Space to-Ground (S/G) Communications during all active ops of the payload involving the crew.

PAYLOAD PLANNING

Payload Planning Services Data Set Management Requirements

The Payload Planning requirements data set provides the detailed pre-increment and real-time planning and payload resource requirements for the International Space Station Program (ISSP). The PD provides the detailed payload planning and resource requirements specifications to the payload operations mission planners. The Payload Planning data set collects detailed planning requirements for ascent/descent, transfer operations, on-orbit operational requirements for Earth-to-Orbit Vehicle (ETOV), and flights as well as Space Station resources such as crew time, power, thermal, commanding, and data and video downlink requirements. The ISS mission planners use these requirements to develop planning products. The PD inputs their payload planning information through the User Requirements Collection (URC) tool. The PD defines planning and resource requirements and the Payload Planning

Data Set Manager is responsible for collecting, assessing, processing, and coordinating payload planning requirements for the ISS. The PD provides the following three types of information into the Payload Planning Data Set defining requirements:

- General Information – Contains information about the payload and experiment name, identification, payload acronym, and contact information.
- Activity Information – Defines the resource constraints of tasks to be performed. Contains information on activities such as description, duration, resource requirements, and Onboard Short Term Plan (OSTP) parameters (procedure identification to be performed in the OSTP).
- Sequence Information – A sequence consists of one or more activities to be performed in a meaningful order of execution. Sequences describe the temporal relationships between activities. Activity sequences are developed by temporally relating two or more activities. Information on description, related activities, sequence scheduling windows, and temporal relationships (between activities or other sequences) are defined in this section. The sequence is the entity that will be planned and scheduled by the mission planners.

They also support the integration of the Payload Planning Data Set across the payload complement. Each Research Program is assigned a Payload Activity Requirements Coordinator (PARC) who collects payload-unique requirements data and assures that submitted requirements meet formatting criteria for planning and scheduling. The PARC contacts the primary and /or secondary planning contacts if there are any questions regarding the payload-unique planning requirements or if negotiation of the data is required to meet the integrated payload planning requirements for a given increment. The PD provides technical support to the PARCs to assure that the PD's requirements are complete and accurate before the payload planning process begins.

GROUND DATA SERVICES

Ground Data Services Data Set Management Responsibilities

The ISS Program is committed to allow a PD to operate their payload from a variety of ground locations. The PD can command their payload from a Remote location, a Telescience Support Center, or at the POIC. The PD defines their ground data and communications services requirements in the Ground Data Services Data Set. The PD provides team member names and functions to the Ground Support Requirements Team (GSRT). The GSRT is responsible for collecting, processing, integrating, and coordinating the ground data and communications services requirements for the International Space Station (ISS) payload operations. The GSRT is made up of the following functional areas:

- Huntsville Operations Support Center (HOSC) Operations Planning and Integration
- Intercenter Operations Planning and Integration
- Ground Data Services Requirements Collection and Integration
- Requirements and Response Management
- Automated Software Reporting System (ASRS) Data Base Management for ISS On-Orbit Payloads
- Telescience Support Center Integration

The Ground Data Services Data Set Manager, working with the GSRT, will review the data for ISS implementation and will integrate the Ground Data Services Data Sets across the manifested payload complement. The Ground Data Services Data Set Manager will coordinate the implementation assessment with the appropriate boards, and will contact the customer if there are any questions of if negotiation of the data is required. The Ground Data Services Data Set Manager will recommend promotion of the integrated payload Ground Data Services data to the Payload Operations Control Board (POCB) for baseline control. Once a payload is manifested for a particular increment, the PD begins inputting their ground data and communication service requirements into the Payload

Data Library (PDL). The GSRT will coordinate with the PD as they input their requirements. Once the PD is satisfied with their requirements in PDL, the PD promotes their data to the integrated level within PDL. At this point, an initial review will be done by the GSRT in coordination with the Payload Operations Integration Function (POIF). An integrated set of requirements will then be generated from the ground data services requirements in PDL. Once the requirements are defined by the PD and the integrated set of requirements is generated, the requirements are assessed and forwarded to the POCB for assessment and approval.

Telescience Support Center Requirements

If a payload will be operated through a Telescience Support Center (TSC), the PD identifies the TSC requirements which will include ground support equipment information, communications resources, power needs, and network interfaces required by PDs to access operations voice, video data and general data service provided by the ISS Program. This section of Ground Data Services, should only be completed if the PD requires operations teams, engineering support teams or experiment teams to be located in the TSC during payload operations. A standard TSC work area consists of a user console (with documentation storage areas), chairs, 13" color video monitor, and an operations voice communications instrument. The PD provides the information to identify all equipment that the PD brings to the TSC and provide information on its size and weight. The PD provides the Ground Support Equipment (GSE). Physical Interface information to identify the type and number of interfaces required by the GSE for data transfer, video matrix, and power.

PAYLOAD OPERATIONS

Payload Operations Data Set Management Responsibilities

The Payload Operations Data Set provides the detailed flight operations requirements for the Payload Developer (PD) and International Space Station personnel. Data requirements for the Payload Operations Data Set have been generated as an aid to payload developers to understand how best to define payload flight operations support requirements for a particular payload. The PD supports the development of flight operation rules and regulations. These will contain constraints, guidelines, and alternate plans for the safe and successful operation of their payload. Operational constraints or activities that may adversely impact the science or hardware of other payloads or themselves will be integrated by the ISSP Payload Operations Integration personnel and documented as Payload Regulations. Payload activities that may adversely impact Shuttle, ISS systems, crew health or safety will be integrated by the POIC and documented in the appropriate Flight Rules document. The PDs utilize the PDL to input the data into the Payload Operations Data Set.

The ISSP Payload Operations Data Set Manager supports the integration of the Payload Operations Data Set across the payload complement. The Payload Operations Data Set Manager reviews the data for ISS implementation and integrates the Payload Operations Data Sets across the manifested payload complement. The Payload Operations Data Set Manager contacts the PD if there are any questions or if negotiation of the data is required, and will also coordinate and negotiate with the PD as required, to resolve any operational issues. The Data Set Manager will review the payload support requirements to determine whether they can be satisfied with ISSP resources.

PAYLOAD OPERATIONS DATA FILE

The PD provides payload operating procedures and reference materials for the payload. These inputs will include transfer, installation, checkout, nominal, malfunction, contingency, and automated procedures for both the Earth-to-Orbit Vehicle (ETOV) and on-orbit operations. Reference materials are non-executable support data used as reference for the successful execution of a procedure. This data may include lists of equipment lost when a bus is lost, inventory and stowage lists, Earth observation maps, and the definition of the text and icons used in the C&DH systems displays. This material also includes diagrams and drawings used for system familiarization and diagnostic troubleshooting and a complete list of error messages and their explanation. For payloads that have delegated operations responsibility, the PD provides operations analysis products to be used to develop their displays and procedures. For these payloads, the products may take the form of Decision/Action Diagrams (DAD)s, or other products. However, if an alternative product is used, then the PD must provide, as a minimum, a task list and a

sequence of operations/activities necessary to identify the payload functions allocated to the crew. These products should describe both nominal and off-nominal experiment operations and will be used (1) as a tool to evaluate payload displays and procedures and (2) to develop training material.

The PD inputs the payload's manual procedures directly into the Payload Information Management System (PIMS) tool. The PIMS is a subsystem of the Enhanced HOSC System (EHS). The PD inputs the Payload Operations Data File Procedures directly into the PIMS via electronic transfer of files created at the PD's facility. Manual procedures are provided by the PD/procedure developer. These procedures will be developed to Program standards and guidelines. Activation and checkout, nominal, alternate nominal, quick response, malfunction, and corrective manual procedures will be provided. This includes deactivation procedures (which are part of the nominal set) and reference information. The PD provides manual procedures to cover Orbiter and ISS failure scenarios for which emergency action is required to ensure the safety of the flight crew. The PD is responsible for the development of operational hazard controls as specified in the approved safety assessment hazard reports and is responsible to incorporate these operational hazard controls into the manual procedures.

Automated procedures may be used for payload operations to automate system operations including autonomous or interactive control, such as stepping through predefined procedures of a scientific experiment, performance of subsystem checkouts, or monitoring for anomalous conditions, such as subsystem failure, and executing contingency mission plans. The execution of the automated procedure may be monitored and controlled by a mission controller on the ground or by an onboard crew member. The PD inputs data for automated procedures with the designated procedure drops: Preliminary, Preliminary Rev. A, and Basic.

Ground Command Procedures

Ground Command Procedures are treated functionally identical to manual procedures, and are formatted the same as manual procedures. Specifically, payload procedures which may affect a payload safety or hazard control are required. These procedures may be nominal or malfunction and may or may not have associated error messages. The procedure of nominal Telescience commanding procedures, e.g. payload commands which alter science return but do not alter payload resources. All messages the crew may encounter during payload operations, whether indicating an error condition or an advisory, must be documented for crew and ground controller's reference. Message sources include front panel display messages, generated payload messages and payload laptop messages. This message listing shall be input via the Payload Data Library (PDL) and the comprehensive message listing will contain all payload messages with their corresponding action. While the PD maintains primary responsibility for recovery of their own payloads, it is necessary for the POIC personnel to be aware of the situation to ensure the proper safety actions are taken in response to any hazardous situations. Error messages drive utilization of crew time, command link, and station resources which are under control of the POIC for integrated payload operations.

PAYLOAD CONFIGURATION

Payload Configuration Data Set Management Responsibilities

The configuration data is used to configure the payload during all phases of flight, including ascent, on-orbit, and return. The Payload Configuration Data Set controls the format and content of selected Payload Engineering, Integration, and Configuration data required from the PD. The PD electronically inputs Payload-provided Engineering Drawings, Diagrams and/or Schematics into the Payload Configuration Data Set in PDL. Formats other than electronic must be coordinated and approved with the Configuration Data Set Manager prior to submission. The PD shall plan, develop, and deliver drawings and schematics in the data formats on the schedules defined in the Payload Generic Template and as negotiated and documented in the Payload PIA Addendum. The ISS Payload Configuration Data Set Manager is responsible for the management of the data contained within the Payload Configuration Data Set. The Payload Configuration Data Set Manager performs assigned configuration management duties as defined in the Payload Data Library Configuration Management Plan.

Payload Stowage

The stowage preparation representatives serve as the focal point for PD payload stowage operations. Throughout the entire preparation process, they perform a top-level assessment, and coordinate and integrate Stationwide payload stowage activities and requirements. ISS Stowage Integration personnel require a minimum set of data to perform stowage design and integration activities. Engineering sketches or engineering drawings are required to accurately and efficiently design the launch and return stowage configuration. For stowage items which have complicated shapes or are extremely heavy, Computer Aided Drafting electronic drawings are required to properly design the stowage accommodations for the hardware. For these complicated items, use of actual flight hardware or high fidelity training hardware, when available, are requested by Stowage Integration personnel. Hardware providers must provide any constraints in the event that soft goods, cables, or other items must be folded, rolled, stuffed, or stacked for the most efficient stowage. Payload developers identify stowage requirements by documenting them in the Payload Interface Agreements (PIA)/EXPRESS Interface Agreements (EIA), and into PDL according to the Configuration Data Set reflected in the Payload Data Set Blank Book. PDs identify stow/unstow requirements in crew procedures they develop and validate. The procedures are then loaded into a software package that is installed on a Space Station computer (SSC) on the on-orbit Local Area Network (LAN).

TRAINING

Training Data Set Management Responsibilities

The PD provides detailed crew payload training and simulator requirements, as defined in the Payload Data Set Blankbook. The PD also provides the PD Team member names and their functions into the Payload Training Data Set, and includes information for determining individual PD Team member training curriculums. The Payload Training Integration (PTI) with the cooperation of the Simulation Engineer, Simulation Director and/or the Ground Support Personnel (GSP) Training Coordinator will coordinate a series of Training Strategy Teams (TSTs) with the PD to determine specific training plans for the crew and the GSP. The TST meetings will be scheduled to provide for the timely acquisition of detailed information required by the PTI to support ISSP planning and documentation.

The Payload Training Data Set Manager task is performed by the PTI. The PTI/Training Data Set Manager will review the data for ISSP implementation and will integrate the Training Data Sets across the ISS payload complement. The Simulation Engineer will contact the PD if there are any questions, or if negotiations of the data is required. After concurrence from the PD, the Training Data Set Manager will recommend promotion of the integrated payload training data to the Payload Operations Control Board (POCB) for baseline configuration control. A Simulation Engineer will be assigned to each PD team and will serve as the primary contact for the PD to Payload Training. The Simulation Engineer will act as the integration engineer for the specific payload's training data set. Once the training data set has been promoted to the integrated level and has been reviewed by the Simulation Engineer, the PTI will be notified that the data set is ready for integration into an increment training plan.

Payload training is responsible for integrating the planning, scheduling and implementation of payload training for payloads in coordination with the users and the International Training Control Board (ITCB). They assign a Payload Training Integrator (PTI) who provides input for the purposes of ISS payload tactical planning and organizes Training Strategy Teams (TST) during the payload training development phase. The PTI implements the results and recommendations of the TSTs and team with the Increment Training Integrator (ITI) for scheduling and implementation purposes. Payload Training provides guidance to users to ensure compliance with overall crew and Ground Support Personnel (GSP) training and certification standards. Payload training further provides simulation engineering guidance to users for the requirements definition, delivery, and verification of Payload Training Units (PTU) for crew training. Payload training provides GSP Payload-Only Simulations to coordinate activities between the cadre members and the user team GSP.

SAFETY

A Payload Operations Safety Preparation Lead performs functions necessary to assure payload compliance with the ISS operational safety requirements. The Safety Prep Lead also maintains payload safety console products for us by Payload Operation Integration Center (POIC) personnel. The Safety Prep Lead maintains a library for all payload hazard reports and tracks implementation of all payload operational hazard controls into the operational flight products. Some of the functions in which the Safety Prep Lead is responsible for are to assess payload safety data packages for adherence to operational safety requirements. To integrate POIC/Safety comments to payload safety data packages and represent the comments at the Payload Safety Review Panel (PSRP) meetings. Also, they assess increment/flight specific payload safety telemetry and participates in the Independent Safety Verification Reviews (ISVR). The products that result from these functions are:

- Integrated POIC comments to payload safety data packages
- Maintain the Payload Operations Hazard Database (POHD)
- Generate Payload Hazard Control Matrices and make available to Increment Leads in support of operational hazard control verifications
- Maintain a library of all payload hazard reports

CONCLUSION

This document was to convey the payload operations and integration process to future scientists and/or engineers for International Space Station (ISS). Detailed information regarding input data requirements is available in the Payload Data Set Blank Book (SSP 52000-PDS Rev. B). For more on ISS resource availability and payload integration responsibilities, the Payload Integration Agreement [SSP 52000-PIA- Baseline (August 1999)] is available along with the Team Definition Document (SSP 58303 Rev. C).