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Paper Session III-B - Research on ISS and KSC's Role in Processing ISS Payloads

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Abstract

The International Space Station (ISS) will provide the means for a variety of research in space. For over 30 years, Kennedy Space Center (KSC) has processed payloads for numerous NASA Programs and is adapting to the needs of the ISS Program. This paper provides an overview of ISS research capability and KSC's role in processing payloads for the International Space Station. Best practices and lessons learned from Station's predecessor, the Spacelab Program, have been adopted for the processing of ISS payloads at the launch/landing site, and some of these are highlighted in this paper.

Research on the International Space Station (ISS)

The ISS will provide a long-term space-based research facility for a wide variety of scientific disciplines, including Earth Science, Life and Microgravity Science, Space Science, Engineering and Technology Development, and Commercial Applications. This affords much greater opportunities for Payload Developers to work in a true laboratory environment, not constrained by the limited timeline of a Space Shuttle mission.

The ISS provides a significant number of resources for the Payload Developer. The ISS research capability in a pressurized environment includes: 13 payload rack locations in the United States Lab; 10 payload rack locations in the Japanese Experiment Module (JEM); 10 payload rack locations in the Columbus Orbital Facility (COF); as well as accommodations for a centrifuge, Life Science Glovebox, and Habitat Holding Racks in the Centrifuge Accommodations Module (CAM). In addition, the Russian Segment provides two Research Modules.

There are also a number of sites on the ISS for payloads that operate in an unpressurized environment: the ISS truss has 4 attach sites for payloads; the JEM Exposed Facility can accommodate 10 payloads; and the COF Exposed Facility will be able to accommodate 4 payloads. Truss unpressurized sites can accommodate up to 6 payloads at a site, using payload accommodations as noted below.

Payload Accommodations

The ISS provides a range of rack accommodations, for pressurized payloads, and ISS exterior accommodations for unpressurized payloads.

An innovation for long-term ISS research is the Facility Class Payload, a rack permanently located on the ISS, which provides standard accommodations for research in a given scientific discipline. These Facility Class Payloads range from one to three racks in size. A number of researchers can use these Facility Class Payload accommodations at any one time. Examples of some of the Facility Class Payloads which will fly on the ISS include: the Human Research Facility (HRF), the Materials Science Research Facility (MSRF), the Fluids Combustion Facility (FCF), and the BioTechnology Facility (BTF). The first Facility Class Payload, HRF, is currently manifested for ISS Assembly Flight 5A.1. An example of a Facility Class Payload can be found in Figure 1.

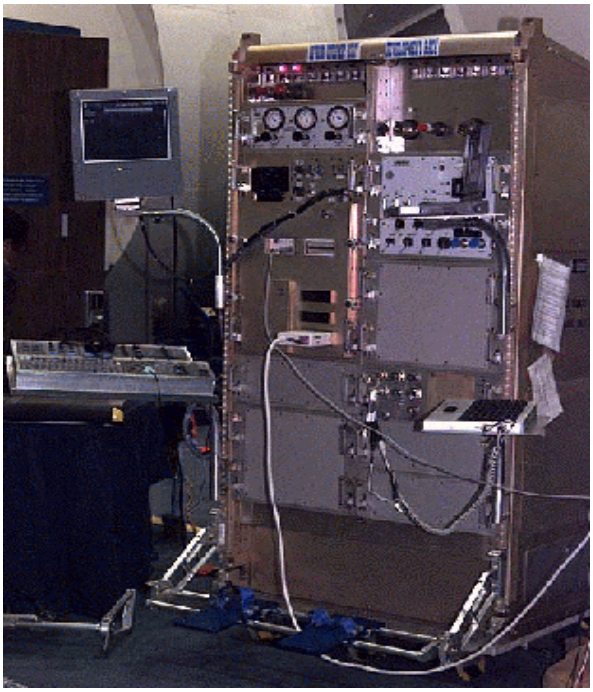
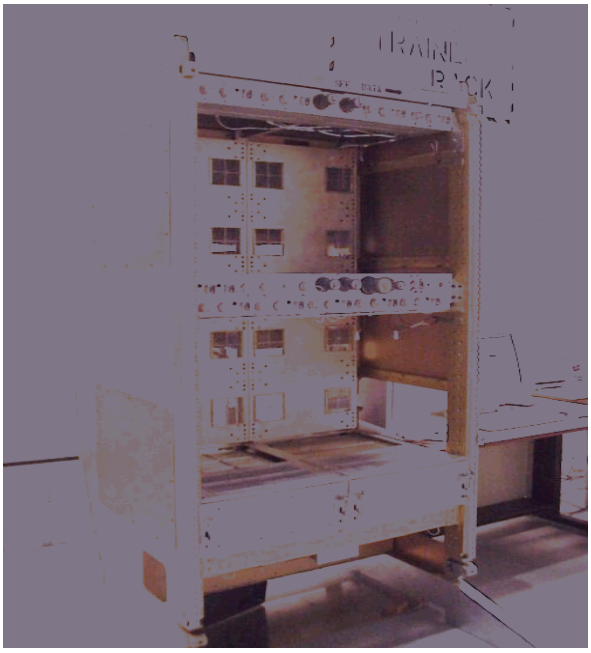


Figure 1. Human Research Facility (HRF) Rack 1

Another innovation is the EXPRESS (EXpedite the PRocessing of Experiments to the Space Station) Rack. A prototype of the EXPRESS Rack was flown on the MSL-1 Spacelab mission. The purpose of the EXPRESS Rack is to provide a rack structure and subsystems for smaller, less complex payloads. The standard interface of the rack (mechanical and electrical) allows for quicker payload integration, test, and deintegration. The flight EXPRESS Racks will remain on-orbit. EXPRESS Payloads can be easily changed out and replaced with other payloads on-orbit. Once all the flight EXPRESS Racks are on-orbit, ground testing of EXPRESS payloads will be accomplished against an EXPRESS Rack simulator. The first EXPRESS Racks will be flown on Assembly Flight 6A. An example of an EXPRESS Rack is shown in Figure 2.



EXPRESS Rack Standalone Trainer, built at Marshall Space Flight Center

Figure 2. EXPRESS Rack

For ISS Payloads, there are two freezers which will be used on the ISS and also on the Space Shuttle for launch and return of conditioned cargo samples (e.g. biospecimens): the Minus Eighty Degree Freezer for ISS (MELFI) and the CRYOSYSTEM (-183 degree) Freezer. Both freezers are being developed by the European Space Agency (ESA) for NASA.

For unpressurized payloads, those which require exposure to the space environment for scientific research, there are several options for accommodation on the ISS.

Large unpressurized payloads will be located on the ISS truss, and will interface directly to the power and data services provided at the attach point. A prime example of this type of payload is the Alpha Magnetic Spectrometer (AMS), which previously flew on a shuttle mission. Figure 3 shows an artist representation of AMS on the ISS truss.

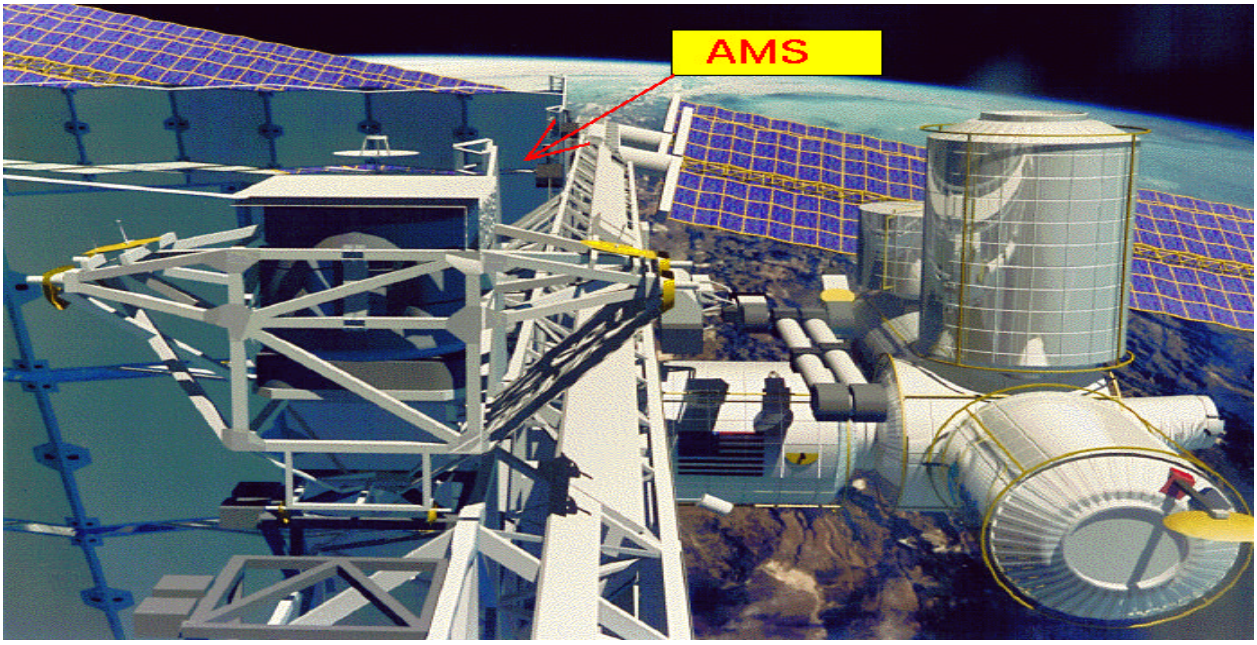


Figure 3. Alpha Magnetic Spectrometer (AMS)

Other unpressurized payloads will be considerably smaller, and if using a truss attach site, will do so mounted onto a carrier which will support multiple unpressurized payloads at one attach site. EXPRESS Pallet, which is being designed to operate under the same philosophy as the EXPRESS Rack, will provide a carrier which can accommodate up to 6 unpressurized payloads. These unpressurized payloads are mounted on pallet adapters that allow for easy installation and removal on-orbit. Each location is provided with power and data interfaces. The first EXPRESS Pallet is currently manifested to fly on Utilization Flight – 3 (UF-3). An artists conception of the EXPRESS Pallet is shown in Figure 4. Other smaller unpressurized payloads will mount on the JEM Exposed Facility or the COF Exposed Facility.

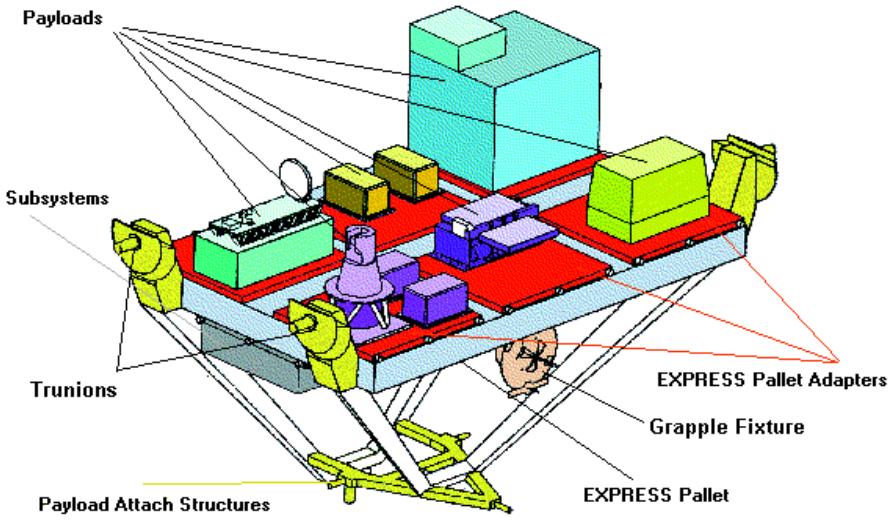


Figure 4. EXPRESS Pallet

Kennedy Space Center's Role in Processing ISS Payloads

For over thirty years, Kennedy Space Center (KSC) has processed payloads for both manned and unmanned Space Programs. As we embark on construction of the International Space Station (ISS), KSC is stepping up to the challenge of providing the launch and landing site capabilities and services for payloads destined for the ISS. While our focus has always been on assisting our payload customers and safety and mission success, we are taking a renewed look at our customer focus. One of KSC's guiding principles is "Satisfy our Customers' Needs Anytime, Anywhere".

Historically, payload ground processing has usually been one of the last items considered during a payload's development. Once manifested, the focus was on getting the payload through the myriad of flight qualification wickets in order to meet its manifesting milestones. Pre-and Post-flight ground processing at the launch and/or landing site was considered a relatively short time prior to arriving at the launch site. As this important phase of a payload's life cycle was not given adequate thought during the payload design, necessary pre-launch maintenance and testing and/or post-launch retrieval had to be accomplished using sometimes difficult workarounds, or could not be accomplished at all.

As we enter the ISS era, with payloads remaining on-orbit for extended periods of time, the focus on payload integration, maintenance, and testing is being more carefully considered. Payloads will need to be installed, removed, maintained, and tested on-orbit. Many of these same procedures will be performed during ground processing at the launch site. Post-landing retrieval of payload specimens and other products becomes more critical as a shuttle landing may contain the results of months of payload data.

Advanced Planning

During previous Programs, KSC made an effort to get involved with the payload customer early in their payload's development cycle, in order to assist in designing a payload that was not only flight-worthy, but also "ground-worthy". That is, the payload was designed so that it could be adequately integrated, tested, and maintained on the ground, where the 1G environment and access considerations leave limitations as to what and how operations can be performed on the payload.

KSC's involvement early in the payload development cycle is even more critical in the ISS era, as the carriers (racks, pallets, exposed facilities) in/on which the payload will reside may already be on-orbit prior to the payload's arrival at the launch site. Care must be taken that ground support equipment (including checkout and verification equipment) be of the fidelity and configuration to give confidence that a payload will perform adequately against the on-orbit flight interfaces. Installation, test, maintenance, and removal activities must be considered from both the ground and flight perspectives, incorporating as much commonality between the operations for more streamlined crew training.

Early involvement with the payload developer takes place in a number of forums including payload design reviews and early launch site planning meetings. Knowledge of the capabilities and services provided at launch and landing site allow the payload developer to more efficiently plan his ground processing activities. Capabilities that are already in place at the launch site may alleviate the need for the payload developer to bring additional equipment, consumables or personnel, thereby allowing the payload developer to focus his resources in other areas. Capabilities not already in place at the launch site can be identified in a timely manner and workarounds implemented or capabilities can be developed to support the unique requirement.

KSC Ground Processing

Many payload developers look upon their time spent at KSC with much trepidation. Too many rules and regulations to live by, too little flexibility, and too long a ground processing flow.

During the Spacelab Program, payloads would arrive as early as a year prior to launch in order to go through the step-wise build-up and test of the payloads to the carrier. During the early stages of the ISS Program, there was a

rallying cry to reduce the schedule template (not only at the launch site, but the whole template to prepare a payload for flight). In response, KSC developed launch site processing templates whereby payloads arrived at KSC less than six months prior to launch.

Best practices from the Spacelab Program for ground processing of both rack-mounted and attached payloads are being applied to ISS Payload Processing at the launch site; however, lessons learned from the Spacelab Program have been or are being implemented, as well. These lessons learned can be seen in everything from the payload accommodations in the Space Station Processing Facility (SSPF), to the Ground Support Equipment (GSE) being developed, to the processes being applied for ISS payload processing.

Space Station Processing Facility (SSPF)

The SSPF reflects a number of refinements in payload accommodations since the Spacelab Program. These refinements were incorporated into the design of the SSPF, which was completed in 1994. Off-line labs, where payload developers can perform post-delivery checkout and servicing prior to joining the on-line processing, are now located along two main corridors on either side of the on-line payload processing area. These corridors are separate from the main office hallways so that cleanliness levels in the corridors can be controlled. This eliminates the need to bag payloads to maintain cleanliness in order to transfer them to the online processing area. In addition, a number of the off-line labs have direct access to the on-line processing area. The on-line processing areas consist of the Intermediate Bay and High Bay. Both of these areas are unique in that most of the work area is flexible, with workstands and other GSE designed to be moved by air bearing pallets. This allows maximum utilization of the area available. The Intermediate Bay is where the bulk of the on-line payload processing will occur for ISS. This processing includes physical integration onto the payload carrier (if required), final functional interface testing, and closeouts. Once the payload is ready to be integrated with the rest of the Launch Package, the payload is transferred to the High Bay where final launch package integration occurs. An airlock is located at the west end of the High Bay to facilitate the transfer of large elements and the payload canister/transporter in and out of the High Bay while maintaining the cleanliness levels in the facility.

Specialized Science Support

As with Spacelab, the capability to support specialized science processing (e.g. life science, micgrogravity science) at the launch/landing site is essential. This support is mainly provided at the Hangar L facility, located at the Cape Canaveral Air Station (CCAS). Hangar L capabilities include specialized labs, Orbiter Environmental Simulation capability, and accredited facilities for Animal Care. As Hangar L is a 40 year old facility and not originally designed for its current use, KSC is looking at the construction of the Science Experiment Research Processing Laboratory (SERPL), a state-of-the-art facility that would be used by ISS and other entities, to provide the capabilities currently provided by Hangar L.

Ground Support Equipment (GSE)

GSE designed for ISS and ISS Payload processing has also incorporated lessons learned from Spacelab, in addition to accommodating the new and unique requirements of the ISS Program. Of particular note are some of the larger pieces of GSE: the Rack Insertion Device (RID), which is used to install racks into the Multi-Purpose Logistics Module (MPLM); the Payload Changeout Room Late Access Platform (PLAP) and Payload Logistics Module Late Access Kit (PLAK), which are used to provide access to the MPLM for late installation of time critical stowage; and the Dryden Early Access Platform (DEAP), which is used to facilitate early access to the MPLM to retrieve critical hardware should the shuttle land at Dryden Flight Research Center (DFRC).

KSC's experience in ground checkout systems has been used in the development of the Payload Test and Checkout System (PTCS), which provides the final functional interface check for all US payloads going into the US Lab, International Partner Labs, on the truss, or on an Exposed Facility. The system provides an "end-to-end" checkout of the payload to its GSE, using a number of ISS Flight Equivalent Units (FEU's). The system was used to check out the Human Research Facility Integrated Flight Prototype Rack (HRF IFPR) prior to its participation in Multi-Element Integration Test (MEIT) I.

KSC is also the home of one of the five Payload Rack Checkout Units (PRCU's), an ISS Program- Provided, Boeing Prime developed, distributed verification system for payloads, allowing for payload verification/reverification at the launch site, if required.

Requirements Development and Implementation Process

An example of a process that has evolved over the years is the requirements development and implementation process. During the Spacelab era, the Ground Integration Requirements Document (GIRD) was the way in which payload developer requirements were communicated to KSC. These requirements translated into support requirements documented and agreed to in the Launch Site Support Plan (LSSP) and test requirements which were implemented by Work Authorization Documents. Later in the Spacelab Program, a closed-loop tracking system for technical requirements was implemented using the Operation Maintenance Requirements Specification (OMRS) system, a system also used by the Shuttle Program.

In order to ensure a common method for entry and location for requirements and data, the ISS Program authorized the development of the Payload Data Library to allow the payload developer to directly enter requirements and data necessary to support all facets of payload activity in the ISS Program. KSC uses the Payload Data Library for the KSC Support Requirements Data Set (SRDS), one of two KSC data sets to the Payload Integration Agreement (PIA). The KSC SRDS feeds the LSSP, which initiates implementation of the support requirements for the payload at the launch/landing site. Support requirements include such items as Off-Line Lab space, transient office space, and consumables.

The second KSC data set to the PIA is the KSC Technical Requirements Data Set. Data for this Data Set is initially entered in PDL and then transferred to a KSC site to be implemented as Operation Maintenance Requirements Specification or Time Critical Ground Handling (TGHR) requirements. For the Payload Developer, the user interface to these technical requirements is always through the PDL. An example of a technical requirement would be the final functional interface test performed in the PTCS.

Integration of support and technical requirements for a particular payload mission complement is performed by KSC, as opposed to the Mission Manager in the Spacelab era. This facilitates early dialog between KSC and the Payload Developer to better ensure that KSC meets the requirements imposed for payload processing.

Conclusion

The ISS offers a unique opportunity for long-term science research in a microgravity environment. It is anticipated that the payload accommodations on the ISS will support a wide range of scientific disciplines. Considerable thought has been given in order to provide standard discipline-specific accommodations, as well as accommodations that will more easily facilitate payload installation, operation, and removal on-orbit.

The key to success of any Program is to take best practices and lessons learned from related Programs and apply them to the current Program, thereby eliminating "reinventing the wheel". KSC, in an effort to further serve its customers (in this case the ISS Payload Developer), has taken best practices and lessons learned from the Spacelab Program, as well as new efforts defined by the ISS Program, and applied them at KSC to meet the challenges of ISS Payload processing. KSC will continue to evaluate its processes and procedures in order to make them even more streamlined and customer oriented.

Acknowledgements

Photos from Web links to payload presentations or web sites.

References

International Space Station User's Guide, Release 1