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ISS Ground Systems Capability at Kennedy Space Center

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ISS Ground Systems Capability at Kennedy Space Center

Abstract

Since the earliest conceptualization stage for an on-orbit Space Station, as the “Gateway to Space” the John F. Kennedy Space Center (KSC) was destined to perform a major role in pre-launch and post-landing processing. In order to accomplish the processing of Space Station elements and experiments, a variety of Ground Systems was needed. These included Facilities and Facility Systems, Ground Support Equipment, and Checkout Systems. Facilities and associated systems include the Space Station Processing Facility, Vapor Containment Facility, and Altitude Chamber. Ground support equipment includes over 140 separate items associated with access and handling, fluid and gas systems, electrical power systems, communication and data systems, and a new Shuttle landing convoy vehicle. Checkout systems include the Test, Control, and Monitor System for ISS resupply and return processing and the Payload Test and Checkout System for ISS experiment interface testing. Dryden Flight Research Center (DFRC) facilities were also modified and GSE was developed to support ISS operations there as well.

This paper provides an overview of the ISS Ground System Capability at the Kennedy Space Center and its role in the processing of elements and experiments for the ISS. It also discusses potential future ground systems activities as the ISS Program has moved into the operational phase.

Introduction

As this paper was being finalized, the tragic loss of the Shuttle Columbia occurred on February 1, 2003. The Ground Systems team has stepped up to providing whatever is required to support recovery and return to launch activities. What follows represents the status of Ground Systems Capability as it exists today at KSC.

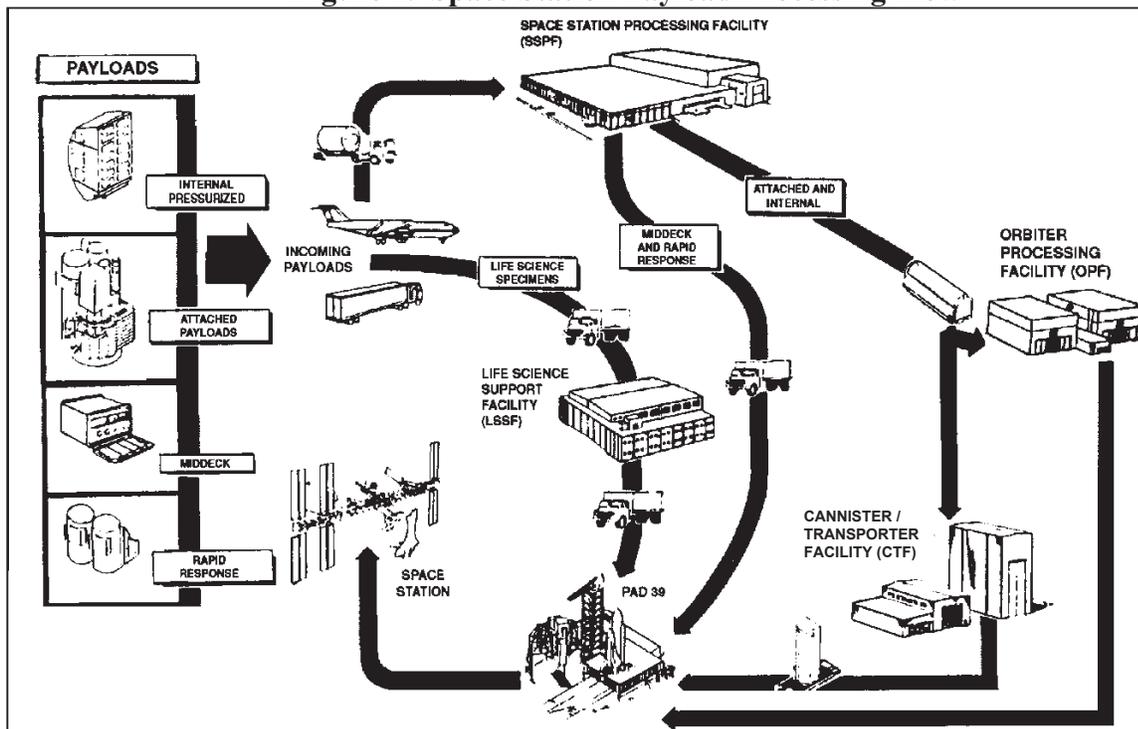
During his State of the Union Address on January 25, 1984, President Ronald Reagan directed NASA to build a Space Station within a decade. Since that time there have been various program redesigns including the transition to the Freedom Program in 1991 and subsequently the International Space Station in 1993. During these early phases there was an obvious focus on what the Station would look like on orbit and the capability it would provide. Kennedy Space Center would serve as the “Gateway to Space.” However, in the background were a number of technical issues that needed to be addressed concerning what support was required on the ground to support the successful launch and deployment of a Space Station. One of the major initiatives required to achieve this goal was development of ground systems capability to support launch and landing at KSC as well as experiment processing. This ground systems capability would be required in the areas of Facilities, Support Equipment, and Checkout Systems.

Kennedy Space Center has been actively processing payloads as a government/contractor team since the mid-1980’s. This team included employees of both NASA and the Payload Ground Operations Contractor (originally McDonnell Douglas Space & Defense Systems and later a part of Boeing). There was already a basic ground processing capability that had to be significantly enhanced and broadened to encompass the requirements of the new Space Station payloads. This combined government/contractor team, managed and led by the Engineering Development Directorate at KSC, envisioned what would be needed at the launch site and worked with the Station program in finalizing the requirements. There was

a determination that a new Space Station Processing Facility would be required which would be designed with maximum flexibility and reconfigurability, including air-bearing pallets, mobile processing stands, tunnels, facilities systems, etc. In addition, over 140 pieces of ground support equipment was required. Of this approximately half was designed and developed at KSC while the remainder was developed elsewhere but certified and sustained by KSC. A major management challenge included interfacing and integration with seven different customers, including Station development work packages and international partners. Major technical challenges included end-to-end checkout of MPLM interfaces, interfacing with the orbiter, and significant mechanical challenges. Checkout of assembly elements processing at KSC, and systems needed to accomplish the task, went through a number of iterations and the role KSC would play continued to be revised.

Today, Ground Systems capability at KSC exists in the three major areas of Facilities, Support Equipment, and Checkout Systems. In addition, there is a Customer Processing Support Management team.

Figure 1. Space Station Payload Processing Flow



Launch Site Ground Systems

Ground Systems at KSC provide the infrastructure required to support the International Space Station (ISS) processing activities. The payload processing flow is depicted in Figure 1. The primary function of ISS ground systems, including Facilities, Ground Support Equipment, and Checkout Systems, is to provide support for pre-launch/post-landing processing to ensure successful processing of Space Station payloads.

The Facilities team provides the facilities and facility systems. The team is primarily responsible for the facilities described below and their associated ancillary equipment necessary to meet the team's mission. The team manages the operations and maintenance (O&M), configuration control, and sustaining engineering tasks required to meet program requirements. In addition, there are Customer Processing Support Managers providing customer support in the Space Station Processing Facility (SSPF), Operations & Checkout Building (O&C), and off-line labs in both facilities.

The Support Equipment team provides the launch site ground support equipment. The team performs requirements definition, design, development, acquisition, fabrication, activation/validation, configuration accounting, and O&M planning and sustaining for all support equipment used in ISS element processing at KSC. The goal of KSC participation is to ensure that all launch and landing site support equipment will satisfy both Space Station and Space Shuttle Program requirements, is safe, cost effective, and will be operationally efficient.

The Checkout Systems team provides the Test, Control and Monitor System (TCMS) and Payload Test and Checkout System (PTCS). These serve as the primary checkout systems for supporting pre-launch testing of Space Station components at the launch site for assembly missions, resupply/return missions and experiment processing. These systems are also used for post-landing checkout capabilities at the KSC and Dryden Flight Research Center (DFRC) landing sites for resupply/return missions.

Launch Site Facilities

At KSC there are a variety of launch site facilities and facility systems that ensure successful processing of Space Station payloads. These facilities are used to perform pre-launch/post landing processing, integrated testing, operations and maintenance, sustaining engineering, and storage of Space Station Payloads. The primary facilities and associated ancillary equipment include the following:

- **Space Station Processing Facility**
 - Ammonia Vapor Control Facility
 - Tech Support Annex
 - Near Term Storage Building
 - Off-Line Labs
- **Operations and Checkout Building**
 - Altitude Chamber
 - Off-Line Labs
- **Various Support Buildings**
 - Payloads Support Building
 - Transporter Canister Facility
 - Ground Support Building
 - Supply Warehouse #1 & #2
 - Petroleum, Oils and Lubricants Storage Facility
 - Storage Shed

The Space Station Processing Facility (SSPF) is the primary facility used to support pre-launch and post landing processing of horizontal space station elements, payloads and experiments. It is considered a non-hazardous facility but does support ammonia loading. Pre-launch activities include receiving, handling and assembling space station hardware; testing experiments for proper configuration; and verifying critical systems and system interfaces. Post landing activities include resupply operations,

logistics element unloading and loading, Space Station logistic element maintenance, repair and reconfiguration, and payloads and experiment de-integration. The SSPF also supports non-ISS NASA payloads.

The SSPF is a three-story structure containing 42,455 m² (457,000 ft²) of offices, laboratories and payload processing areas. It is located in the KSC Industrial Area immediately east of the Operations and Checkout (O&C) building. An aerial view of the SSPF is shown in Figure 2.

Other facilities that directly support the SSPF and associated activities are the Tech Support Annex, Ammonia Vapor Control Facility, and Near Term Storage Building.



Figure 2. Space Station Processing Facility

The Operations & Checkout (O&C) Building is a five-story structure containing 55,926 m² (602,000 ft²) of offices, laboratories, astronaut quarters, and payload bay areas. It is located in the KSC Industrial Area immediately east of the KSC Headquarters Building. The O&C Building bay area was used for assembly and test of the Apollo spacecraft during the Apollo Program and has been modified for the Space Shuttle era. The facility is also being used by ISS as a storage facility and contains the Altitude Chamber. An exterior view of the O&C Building from the northeast is shown in Figure 3.

The Altitude Chamber was originally developed and used in the Apollo program. In 1998, the Altitude Chamber was reactivated for use by ISS. It is 33 feet in diameter, 100 feet tall and has the capability to produce a vacuum of 100 milli torr. The Altitude Chamber is maintained as a class 5 clean work area. The Altitude Chamber was successfully used during leak testing of the US Laboratory element and the US Airlock element. At this time the Altitude Chamber has been placed in a stand-by mode with minimal maintenance and there are currently no operational activities scheduled.



Figure 3. Operations and Checkout Facility

The Customer Processing Support Manager (CPSM) function is a joint NASA/contractor effort with the responsibility for customer interface and facility oversight for the SSPF, O&C, and their respective off-line lab processing areas. The CPSMs participate in the planning and technical integration for the payload customer's processing requirements within the facility; ensure proper coordination between the payload customer, NASA/ISS mission managers, security, and NASA facility managers during processing activities; ensure preparedness of all facility systems required for payload processing; and ensure all payload support items are properly identified and scheduled.

Launch Site Ground Support Equipment

At KSC there is a large variety of support equipment for pre-launch/post landing processing of International Space Station (ISS) elements. Systems have been developed which support access and handling/mechanical, fluids and gases, electrical power, and communication and data.

There are approximately 140 line items of GSE required to support ISS processing. To date, development and/or certification have been accomplished on 130 items and 10 are currently in development. Key capability and products are as follows:

- **MPLM Rack Processing:** Provides certified capability to access horizontal MPLM to stow and de-stow flight racks, platforms, Orbital Replacement Units (ORUs)
 - Rack Insertion Device (RID), End Effectors, RSP Integration and Tilt Table (RSPITT), Hatch Ops Kit (HOK), MPLM Hatch Restraint Device (HRD)
- **Shuttle Runway Operations (MPLM Early Access):** Provides certified capability to power, communicate with, cool, and control experiments while the MPLM is still in the Orbiter payload bay after landing

- MPLM Support Vehicle (MSV), 120 VDC MPLM Runway Power, Cold Cargo transport Equipment (CCTE), Dryden Early Access Platform (DEAP) (USA), Removable End Access Platform (REAP)
- **Ammonia Servicing System:** Provides certified capability to test, fill, monitor, sample, and perform flight loads of NH₃ onto ISSP elements and ORUs
 - Flow Control and Instrumentation Cart (FCIC), Filter Cart, Supply Tanks, NH₃ Sensor Carts
- **Workstands and MPLM Late Access:** Provides certified safe stands for flight elements and associated work platforms with high visibility, high accessibility, and functional hookups for ISS elements
 - Launch Package Integration Stand (LPIS), Cargo Element Work Stand (CEWS), Element Rotation Stand (ERS), Payload Late Access Kit (PLAK), MPLM Overhead Access Rig (MOAR), Pad Hatch Opening Kit (PHOK), Pad Late Access Platform (PLAP) (USA), Removable Overhead Access Platform (ROAP), Payload Retention Fittings, Personnel Access GSE
- **Handling Devices:** Provides certified lifting devices, slings, transportation GSE, tilt assemblies, and associated kits to ensure safe ground handling of ISS elements, ORUs, and flight support equipment
 - Air Bearing Pallets / Castors, Cargo Element Lifting Apparatus (CELA), Strongback, Rotation Handling Fixture (RHF), ORU Handling, Tilt Platforms, Dollies, Lifting Bracketry, Rack Shipping Containers, Rack Handling Adapters
- **Integration of (USA) Shuttle facility mods for MPLM processing:** Provides ISSP interface to SSP ground system teams to ensure integrated ISSP/SSP approach to development of facilities and GSE in support of MPLM late access and early access operations
- **Special Power:** Provides certified power supplies and power delivery systems compatible with ISS elements, ISSP facilities, and SSP flight hardware, GSE and facilities
 - 120 VDC SSPF T-0 Power supplies, 60-Hz power sets, GSE power carts, cabling systems
- **Fluid systems:** Provides certified GSE delivery systems for test and flight loads of ISSP flight elements
 - Pressure Regulator Assemblies, Water Servicing Kits, Interface connections
- **Multi Mission Support Equipment:** Provides GSE essential for ISS mission processing.
 - Cargo Integrated Test Equipment (CITE), Ground Transportation GSE, Payload Strongback, fluid and electrical kitting, Canister (environmentally controlled, pressurized, 65-foot long module utilized for on-site transport of shuttle payloads), Payload Transporter (240-ton self-propelled manned vehicle)
 - Simulators such as the Node 2 Simulator and the US Lab Simulator to assure the compatibility of future ISS elements with existing on-orbit ISS systems

Launch Site Checkout Systems (TCMS and PTCS)

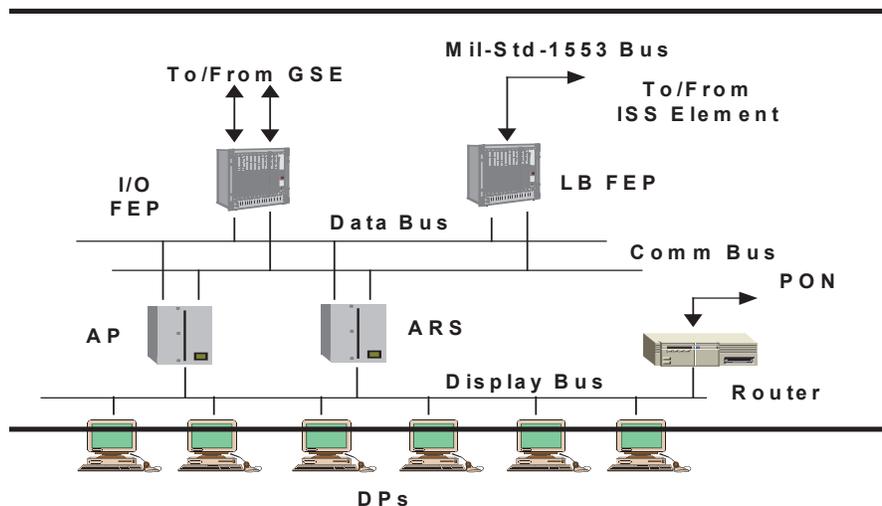
The Test, Control and Monitor System (TCMS) and Payload Test and Checkout System (PTCS) are the primary checkout systems for supporting pre-launch testing of Space Station components at the launch site for resupply/return missions. These systems are also used for post-landing checkout

capabilities at the KSC and Dryden Flight Research Center (DFRC) landing sites for resupply/return missions. These systems are also used to verify the compatibility between experiments and Space Station services.

The TCMS is used for ISS component pre-launch testing and support, Multi-Element Integrated Testing (MEIT), and Node 2 processing at the Space Station Processing Facility (SSPF) and the launch pads. In addition, the TCMS provides the capability to command, control, and monitor ISS flight systems and Ground Support Equipment (GSE). These capabilities are in direct support of KSC ground operations in the SSPF, in the Vehicle Assembly Building (VAB), in the Orbiter Processing Facility (OPF) using the Mini-Pressurized Logistics Module (MPLM) Support Vehicles (MSVs), and for post-landing runway operations using the MSV. TCMS system software provides the underlying platform to execute user application programs, process user commands, provide security for user access control, and provide the capability to monitor measurement values, status, and exception conditions. Each ISS element test may require specific specialized software applications. The TCMS Architecture is shown in Figure 4.

The PTCS provides a high-fidelity simulation of on-orbit Space Station utilities and resources available to the U.S. International Standard Payload Racks (ISPRs)/Express Racks. It is used for ISS experiment interface testing to verify the compatibility between experiments and Space Station services. The PTCS is comprised of the U.S. ISPR Checkout Unit (USICU), Command and Tracking Control System (C&TCS), Command and Data Handling (C&DH), Enhanced Huntsville Operations (EHS)-KSC, Payload Data Services System (PDS) at KSC, and associated GSE. It also has simulation and verification capabilities between ISS payload racks and the Enhanced Huntsville Operations Support Center (HOSC) through user GSE interfaces.

Figure 4. TCMS Architecture



The Future

The success of the deployment of ISS Ground Systems was accomplished with a highly proficient NASA/PGOC team. The Payload Ground Operations Contractor (PGOC) was McDonnell Douglas Defense and Space Systems, which was later acquired by Boeing. The follow-on contract to the PGOC, the Checkout, Assembly and Payload Processing Services (CAPPS) contract, was awarded to The Boeing

Company with a contract start date of October 1, 2002. This contract has a base of four years and two three-year option periods.

The ISS Program's near-term schedule includes one of its most significant milestones with US Core Complete. This will be accomplished with the launch of Node 2 on Flight 10A, currently scheduled for February 19, 2004 (ref. SSP 54100, IDRD Flight Program, Baseline, DCN001 – 12/20/02). After that milestone, however, a significant amount of work remains with the launch of the remaining elements as well as recurring flights associated with utilization and resupply/return.

Even though the Space Station is now moving into a primarily operational phase, the ability to process and deliver ISS critical spares to the ISS is still a task in development. Originally, critical ISS items were flown and processed as parts of integrated elements; the replacements for these critical items will fly as 'hitchhiker' type payloads to ISS missions, and the interfacing flight adapters and ground support equipment (GSE) are still being developed. The Ground Systems team is working with the External Carriers program to develop the GSE and ground processes to ensure critical Launch On Need (LON) Orbital Replacement Unit (ORU) spares can be quickly checked, integrated into late mission flows, and launched to ensure rapid response to problems with critical items on the ISS.

Ground Systems continues sustaining modifications as requirements are changed/enhanced, maintaining an aging infrastructure, and upgrading of ground simulators, support equipment and checkout systems as ISS systems are upgraded and enhanced to downlink greater volumes of scientific data. In addition, potential future opportunities exist with the Orbital Space Plane (OSP) initiative and with commercialization initiatives.

In conclusion, the Ground Systems team at the Kennedy Space Center remains committed to providing world-class Facilities, Support Equipment and Checkout Systems that provide safe, efficient, and cost effective support to ISS processing activities. There are potential future challenges and opportunities ahead but the team is ready to meet these and support the Space Station Program Vision for "A gateway to permanent human presence in space for the expansion of knowledge benefiting all people and nations."

Acknowledgements

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Further Information

For information on KSC ISS/Payload Processing Ground Systems go to the web site at <http://www-ss.ksc.nasa.gov/Ground Sys/default.htm>.

For information on KSC ISS/Payload Processing in general go to the web site at <http://www-ss.ksc.nasa.gov>.

For information on commercialization, contact Mark Terrone of the KSC ISS/Payload Processing Business Office, at Mark.Terrone-1@nasa.gov or 321-867-6149.