Apr 24th, 2:00 PM - 5:00 PM

Paper Session II-B - U.S. Launch Site Processing of Space Station Hardware

Gary L. Johnson

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by Gary L. Johnson

Introduction

There are many challenges to overall planning and management for processing Space Station hardware at the Kennedy Space Center (KSC).

Presently, as requirements are being defined for processing Space Station hardware at the Kennedy Space Center, there are many challenges trying to develop ground support equipment, facilities, integrated schedules, plans and processes in parallel with hardware design and development. The Integrated Product Teams and Analysis Integration Teams at the Kennedy Space Center have met the challenges presented by budgetary cuts, manifest changes and new or changing requirements.

The Space Station Processing Facility construction is completed. The facility systems are being installed and activated. Kennedy Space Center personnel are working well with the various Launch Package/Stage teams, defining launch site requirements. Kennedy Space Center supplied support equipment is in various of stages of design, fabrication and activation. The Test, Control and Monitor System has undergone a major change in design direction. Management of this entire process brings about unique challenges.

Only 20 months away from the first U.S. launched Space Station element, the Space Station Program is well into defining launch site requirements and their implementation. An examination of the organizations and processes involved reveal the complexity of requirements from the Prime Contractor, International Partners/Participant and NASA that must be integrated to provide successful hardware processing at the launch site.

Organization

The Space Station Program has adapted the Integrated Product Team/Analysis and Integration Team concept for management. Integrated Product Teams (IPTs) are teams that are focused on the development of a product. Each IPT consists of people with the complete complement of skills needed to accomplish the team's responsibilities. Each team is delegated authority and allocated budget and schedule to perform the assigned work. The membership of a team can either be permanently assigned to that team, or may be matrixed from other organizations on either a full or part time basis. Analysis and Integration Teams (AITs) perform integration tasks across Integrated Product Teams.

The Space Station Program organizational structure is shown in Figure 1. The Operations and Utilization IPT is responsible for the management of Kennedy Space Center institutional resources in support of the Space Station Program.

The Operations and Utilization IPT organization is shown in Figure 2.

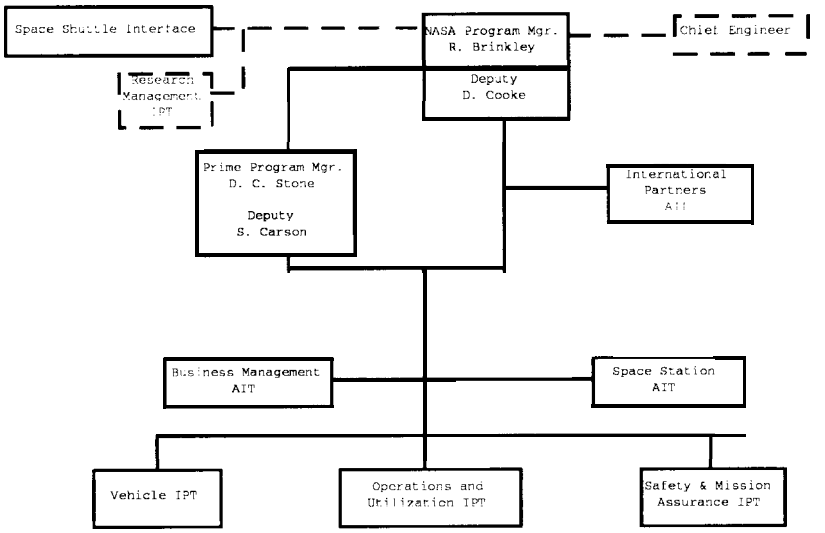


Figure 1
Space Station Program Organizational Structure

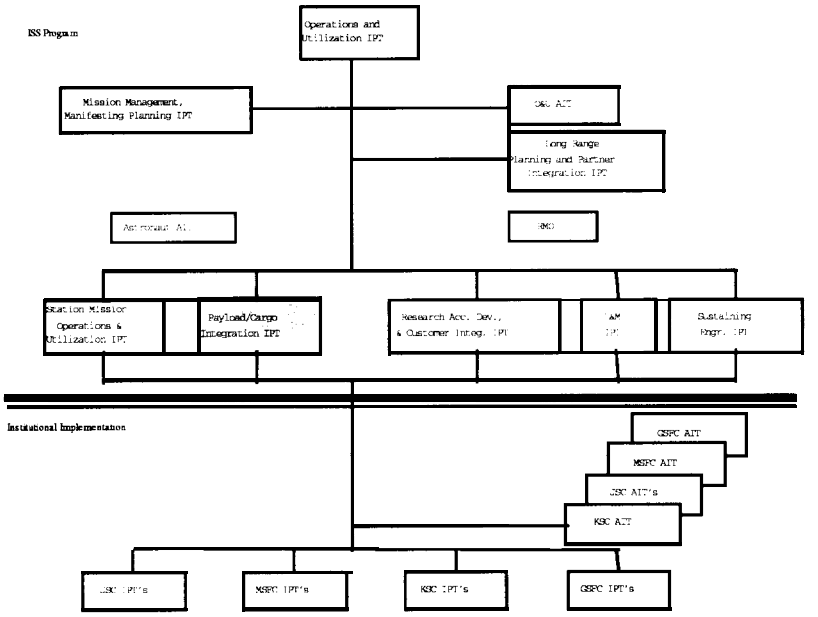


Figure 2
Operations & Utilization IPT Organizational Structure

The Payload/Cargo Integration IPT has the organizational structure shown in Figure 3. The Launch Site Processing Lead is the day to day interface between the Space Station Program and the Integrated Product Teams (IPTs) and Analysis and Integration Team (AIT) located at the Kennedy Space Center. The Space Station Program institutional support at Kennedy Space Center is managed through the various IPTs/AIT that are shown in Figure 3. Each IPT/AIT consists primarily of membership from NASA and McDonnell Douglas Space& Defense Systems (Payload Ground Operations Contractor (PGOC)). In addition, personnel from Boeing (Space Station Prime Contractor), the Product Groups, Rockwell-Downey, the Shuttle Processing Contractor and other organizations are included on the teams.

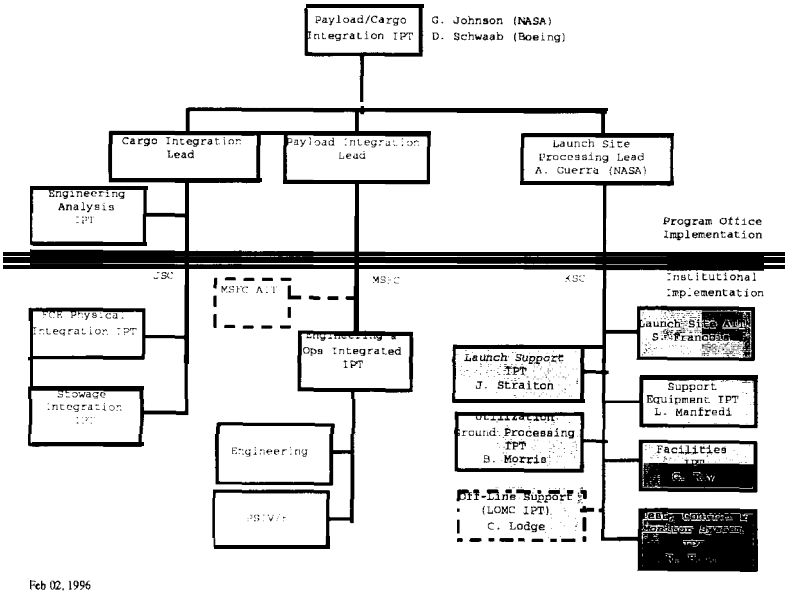


Figure 3
Payload/Cargo Integration IPT Organizational Structure

Each team is responsible for a set of products that is defined in the team charter. The planning document for execution of the team responsibilities is a Team Execution Plan (TEP) that' defines the team charter, membership, interfaces, budget, schedule, products, rnetrics, and risk management. The institutional support provided by the Kennedy Space Center is managed through the use of Technical Task Agreements (TTAs). The TTA is the "contract" between the Space Station Program and the institution providing resources (KSC, MSFC, JSC) that defines the expectations of the Space Station Program in terms of products, workforce levels (contractor and civil service), schedule, and the resources provided to the institution in terms of budgetary dollars. The TTA is a product of the annual Program Operating Plan process.

Facilities IPT

The Facilities IPT has designed and constructed a facility at Kennedy Space Center, called the Space Station Processing Facility (SSPF). The SSPF is a three story, 42,499 square meter building, developed to process the International Space Station flight hardware. Construction began in April 1991 and was completed in August 1994. Activation and validation of the SSPF facility systems are nearly complete. The Operational Readiness Date (ORD) is scheduled for June 1997. The SSPF is shown in Figure 4.

Figure 4

Although the activation and validation of the facility is still in progress, the SSPF is presently being used to process flight hardware. The first cargo element processed through the SSPF was the Phase I MIR Docking Module in 1995. Use of the facility for Phase I Cargo Elements helps the overall NASA Program with the added benefit of helping to find any problems with the facility or facility systems prior to arrival of Flight 2A. The MIR docking module is shown in its support stand, in the SSPF in Figure 5.

Figure 5

The Facilities IPT is responsible for the completion of the SSPF activation and validation, to support modifications to any Kennedy Space Center facilities necessary to support Space Station operations, and provide sustaining engineering and maintenance for all Kennedy Space Center Space Station facility systems. Additional information on the Facilities IPT can be found on the internet (http: //www-ss.ksc.nasa.gov/facilities/default.htm).

Support Equipment IPT

The Support Equipment IPT is responsible for building ground support equipment that supports Logistics/Utilization Flights or that is used over multiple Assembly flight processing. This responsibility includes support equipment requirements development, manufacture, activation and validation, operations and maintenance, and sustaining engineering

In addition to the Kennedy Space Center supplied ground support equipment, the Support Equipment IPT is also responsible for ground support equipment being supplied by the Italian Space Agency (ASI) in support of the Mini-Pressurized Logistics Module (MPLM) or being delivered to the Kennedy Space Center as part of the Prime Contract by Boeing. Additional information on the Support Equipment IPT can be found on the internet (http://www-ss.ksc.nasa.gov/support_equipment/default.htm).

Test, Control and Monitor System IPT

The Test, Control and Monitor System (TCMS) IPT is responsible to provide a checkout system to support prelaunch testing of the Logistics/Utilization Flights and payload interface verification. The initial use of TCMS coincides with the initial delivery of the first of three MPLMs for use in post-delivery checkout activities. The first use of a MPLM is Flight 6A. Additional information on the TCMS IPT can be found on the internet (http://www-ss.ksc.nasa.gov/tcms/default.htm).

Launch Support IPT

The Launch Support IPT is responsible for the planning and execution of mission processing at the Kennedy Space Center. This includes definition of the requirements, schedules, plans and procedures. Excluding the Logistics/Utilization flight components, the Launch Support IPT is responsible to provide the host role support. For the Logistics/Utilization flight components, the Launch Support IPT is responsible for supplying the hands-on integration support. The Launch Support IPT is responsible for supporting the Shuttle Orbiter interface verification testing and the integration into the Orbiter. The Launch Support IPT participates in the development of the Space Station flight hardware by providing input to the design, to insure elements can be efficiently and

safely processed at the Kennedy Space Center. Additional information on the Launch Support IPT can be found on the internet (http://www-ss.ksc.nasa.gov/launch-support/default.htm).

Launch Site AIT

The Launch Site AIT facilitates the technical, budget, schedule integration across the Kennedy Space Center IPTs. The Launch Site AIT provides the Space Station Program interface to the Kennedy Space Center for negotiation of institutional and civil service resources to support Space Station activities. The Launch Site AIT manages those tasks that are common across the IPTs such as budget integration across the IPTs, schedule integration across the IPTs, configuration and data management support, Payload Data Management System support and Biomedical Support. Additional information on the Launch Site AIT can be found on the internet (http://www-ss.ksc.nasa.gov/ait/default.htm).

Management

From the Space Station Program perspective, management of the Kennedy Space Center activities is based on implementing the IPT/AIT environment, encouragement for the Launch Site IPTs/AIT to take ownership of their products, schedules, metrics and budgets, and working closely with the teams in the IPT/AIT environment to maintain a strong Program Management presence within the teams.

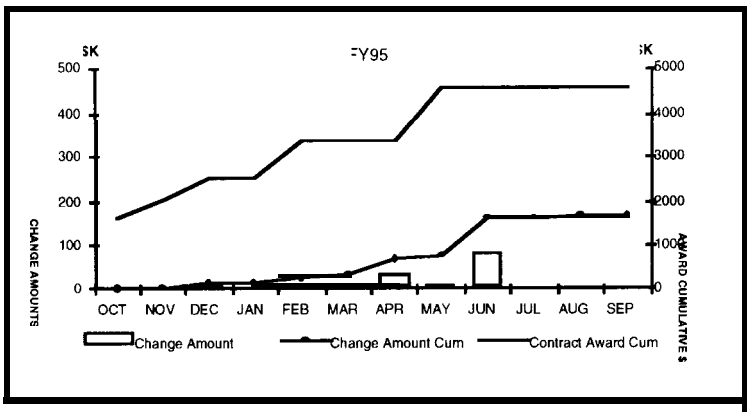
Communication is the key to successful management of any program or project. In the IPT environment, there is direct communication between the Program Office and the Kennedy Space Center teams. There is direct verbal communication between the Space Station Program Office and the Kennedy Space Center teams to work and status issues, provide data and feedback. The electronic age has provided E-mail, which is used extensively, and common servers where information can be kept, providing single source data for both the Space Station Program Office and Kennedy Space Center personnel. Meetings are kept to a minimum, but standard meetings consist of the weekly Launch Site AIT meeting where each team presents a status of activities, achievements and issues. Monthly, the Launch Site AIT meeting is used as the forum to present monthly achievements, planned versus actual budget metrics, planned versus actual schedules and team metrics. Internal to the Space Station Program Office, a monthly overview of launch site activities is presented to the Operations and Utilization IPT Manager. A newer form of communication is the use of the internet. Each Kennedy Space Center team has developed a web home page that is accessible by the public. The home page for the Kennedy Space Center teams is located at http://www-ss.ksc.nasa.gov/default.htm. Available to teams within the Space Station Program, Launch Site Processing status is also available on a web page (http://issa-www.jsc.nasa.gov/ss/issapt/opsipt/lanchipt/launch.html).

Risk management is accomplished through continual awareness that significant risk issues must be dealt with early. The goal is to work any risk issues that arise within the team and bring into the discussions members from other teams as needed. Should a risk be deemed such that visibility to the Program Management is necessary, the risk would be elevated to the Program Risk Assessment Board (PRAB) and entered into the electronic risk management tool called Risk Management Database Application (RMDA).

As mentioned earlier, the budget and schedule agreement between the Space Station Program and the Kennedy Space Center is documented in a Technical Task Agreement (TTA). The lTA constitutes the baseline that is used to measure work performance through an earned value system. Earned value is reported monthly, along with an explanation of any variances.

Each IPT has developed a set of metrics used internally by the team to measure their productivity. A subset of these metrics are also delivered monthly to the Space Station Program for visibility of team performance. An example of a monthly metric report is shown in Figure 6.

QUALITY OF SE DESIGN PACKAGES
($ Value of Fabrication Contract Changes)



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Contract Award Cum ($K)	**1576.0**	**2031.6**	**2526.6**	**2526.6**	**3351.6**	**3351.6**	**3351.6**	**4610.6**	**4610.6**	**4610.6**	**4610.6**	**4610.6**
- NASA	0.0	275.0	0.0	0.0	825.0	0.0	0.0	1259.0	0.0	0.0	0.0	0.0
- PGOC	1576.0	180.6	495.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Authorized Change Amount Cum ($K)	**0.0**	**1.6**	**13.8**	**15.3**	**24.1**	**33.8**	**66.4**	**75.7**	**160.6**	**162.0**	**166.3**	**166.3**
- NASA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.9	1.4	0.0	0.0
- PGOC	0.0	1.6	12.2	1.5	8.8	9.7	32.6	9.3	56.0	0.0	4.3	0.0
Ratio	0%	0%	1%	1%	1%	1%	2%	2%	3%	4%	4%	4%

As of 15 September 1995

GOAL:

Limit dollar value of fabrication contract changes to a benchmark of less than 3% of the total authorized amount of initial awards.

DEFINITION:

This chart reflects the dollar value of contract changes (not programmatic driven or contract options) to the initial award authorized amounts.

CALCULATION:

Cumulative design changes by NASA and PGOC are compared against cumulative authorized awards to measure quality of SE design packages awarded to fabricators. Only awards for fabrication of SE End Items are measured.

DATA ISSUES

None.

METRIC ANALYSIS:

Analysis indicates that the "First Time Quality" goal is being supported by concurrent team member interaction.

Lakeesia C. Meyers, F154
29 September 1995

Figure 6

The Space Station Program has several levels of reviews that are supported either directly or indirectly by the Kennedy Space Center teams. These reviews include the Program Monthly Review, the Incremental Design Review, the Independent Annual Review and the Program Operating Plan review. The Program Monthly Review (PMR) is held to report to the NASA and Boeing Program Managers, program status and heath, areas of concern and abatement plans to resolve these concerns. Kennedy Space Center indirectly supports this review in that the monthly budget, schedule, and status reporting is used as inputs by the Operations & Utilization IPT Manager into the monthly PMR. The Incremental Design Review (IDR) is a yearly review of specified flights, to verify that the design maturity of those flights is what should be expected at either a Preliminary Design Review (PDR) or Critical Design Review (CDR), depending on which flights are being examined. Kennedy Space Center directly supports this review, by examining the maturity of the requirements definition, processing flow schedules, procedure development, ground support equipment availability, and facility readiness for each flight being examined The Independent Annual Review (IAR) is a yearly review by NASA Headquarters to assess the technical, schedule and cost performance against the Program Execution Plan. Kennedy Space Center indirectly supports this review by providing updated cost, schedule and technical status which is presented by the Operations & Utilization IPT Manager to the IAR panel. The Program Operating Plan (POP) review is held yearly to review the basis of estimate that the Kennedy Space Center has used to formulate its budget submit. This review is held by the Kennedy Space Center in direct support of the Operations & Utilization IPT Manager.

Multiflow Roles and Responsibilities

A generic operations flow is shown in Figure 7. This generic flow is used by multiple flights and thus, in order to process flights in parallel, a “multiflow” assessment must be done.

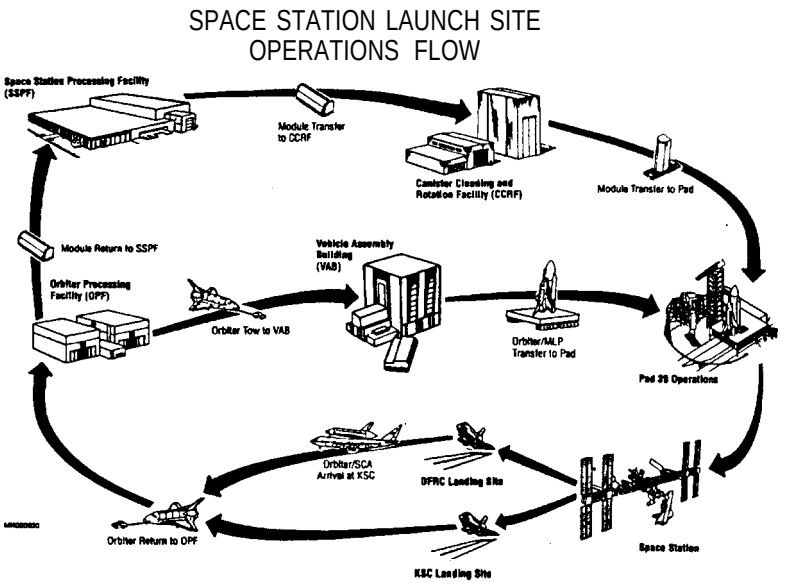


Figure 7
Overview of Launch Site Processing Operations Flow at Kennedy Space Center

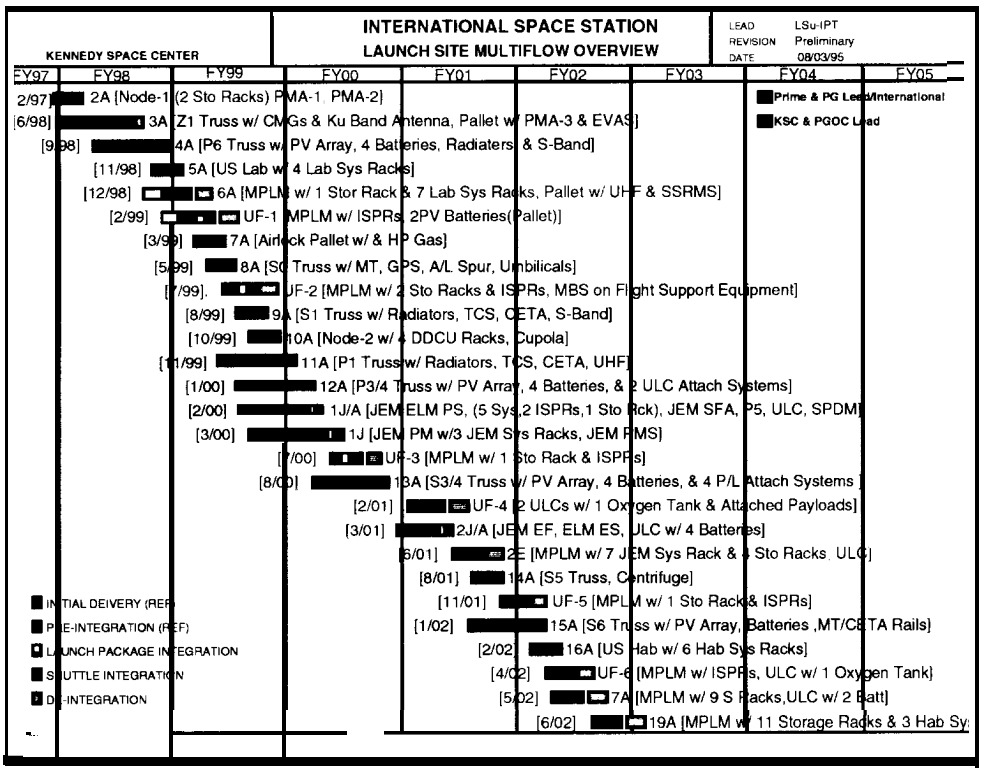


Figure 8
Launch Site Multi-Flow Overview

Figure 8 shows a Multi-Flow schedule which graphically depicts the flights and the responsibilities of the Prime Contractor or International Partner and the Kennedy Space Center for processing. Items colored blue are Assembly Flights and are the responsibility of the Space Station Prime contractor (Boeing) or an International Partner (CSA, NASDA or ESA). Items colored in red are Logistics/Utilization Flights and are the responsibility of NASA and the Payload Ground Operations Contractor (McDonnell Douglas Space & Defense Systems).

Examining Figure 8 closely, will show that designation of who is responsible for a particular flight is not clear-cut. As an example, UF-1 which would be considered a Logistics/Utilization Flight, also has assembly hardware being flown. Each of these categories has the teams at Kennedy Space Center in a particular role with different responsibilities.

For Assembly Flights, the Prime Contractor and Product Groups are responsible for performing flight hardware assembly and functional testing through the "Pre-Shuttle Integration" phase. The hardware is turned over to NASA, approximately two weeks prior to roll-out to the launch pad. Hardware turnover marks the start of the "Shuttle Integration" phase, which lasts from hardware turnover until launch. For Assembly Flights, NASA and its PGOC contract will perform final close-outs, weight and e.g. measurements during the Shuttle Integration phase, prior to delivery to the pad. For Assembly Flights, NASA and its PGOC contractor will work with the Prime and Product Groups through a sustaining engineering contract (contractor TBD) to perform Orbiter Interface Verification Testing and final close-outs for flight.

For International Partner Flights, the International Partner is responsible for performing flight hardware assembly and functional testing through the Pre-Shuttle Integration phase. For International Partner Flights, NASA and its PGOC contract will perform final close-outs, weight and e.g. measurements during the Shuttle Integration phase, prior to delivery to the pad. NASA and its PGOC contractor will work with the International Partner to perform Orbiter Interface Verification Testing and final close-outs for flight.

For both Assembly Flights and International Partner Flights, the role of the Kennedy Space Center has been defined as a "host role". Host role defines that the Product Groups (PG- 1, PG-2, PG-3), Prime or International Partner is responsible for processing flight hardware and that the Kennedy Space Center will provide basic services such as a facility for processing in, workstands, common ground support equipment (power supplies, GN2, air, chilled water, crane support).

For Logistics/Utilization Flights, the Kennedy Space Center is responsible for the entire processing flow. The Logistics/Utilization Flights involve the development of a Test, Control & Monitor system to support Mini-Pressurized Logistics Carrier (MPLM) check-out and operations, development of Ground Support Equipment (GSE) to support MPLM operations, receipt and post delivery verification of the Flight hardware, integration of racks into the Mini-Pressurized Logistics Carrier (MPLM), development and operations of late and early access capabilities, and integration of logistics/resupply hardware to the Unpressurized Logistics Carriers (ULCS).

Challenges

The challenges in managing the overall planning and management for processing Space Station hardware at the Kennedy Space Center are many.

The use of the Integrated Product Team/Analysis and Integration Teams has provided benefits to the Space Station Program but there are challenges in implementing and sustaining these teams. The use of an IPT/AIT structure is a change to the normal organizational structure found at the Kennedy Space Center. Without true implementation of the IPT/AIT, the team member can easily be pulled between priorities of the team they are matrixed to and the functional organization that they are assigned to. This has not been a widespread problem in the Kennedy Space Center implementation. Additionally, there is always a potential problem with the use of concurrent engineering principles in that if the organizations are concurrently developing hardware or software, poor communication or a product start that later is found to be based on bad requirements can be costlier. It is important that the Kennedy Space Center teams have excellent communication back to the Space Station Program Vehicle teams, to remain in synch with requirements. The biggest problem in this area has been that the Kennedy Space Center teams have had problems penetrating into some of the vehicle development teams, which provides the opportunity for either the vehicle or the Kennedy Space Center team to be out of synch with existing requirements.

Major changes to the Space Station Program provide challenges to everyone. As this paper is being written, major changes are taking place in the Program. The Russians have verified their commitment to provide the FGB and Service Module as planned, but due to the desire to maintain the MIR for a period of time, longer than expected, have changed their plans for development of the Russian segment of the Space Station. This effects the Kennedy Space Center in several ways, including the addition of a Space Shuttle flight to carry the Russian Space Power Platform to orbit. With this flight comes the additional processing involved in the SSPF and the juggling of the assembly sequence to accommodate the flight. Additionally, the changes in the Program indicate that the Space Shuttle may be used to take additional Russian supplies/experiments to orbit, which requires additional effort to plan and execute. In addition to the changes announced by Russia, the European Space Agency, in a change in financial priorities, has moved the addition of the Attached Pressurized Module (APM), until the year 2003. Previously on a Ariane launch vehicle, this flight has also moved to the Space Shuttle as the launch vehicle.

Budgetary pressures have provided yearly change in the scope of the work to be accomplished at the Kennedy Space Center. In 1995, a major Program review was held by the Utilization, Operations and Training Assessment Team (UOTAT). The charter of the team was "to assess the requirements that drive the processes and to develop bold and innovative proposals that would reduce costs, enhance efficiency and performance, and eliminate program redundancies". Resulting from this review, a decision was made to eliminate Orbiter pre-mate interface testing for the MPLM after testing the first of a kind. Previously, the baseline had been to do Orbiter pre-mate testing on each of the three MPLMs to be delivered. In addition, the Test, Control and Monitor System was rescoped to remove the robust architecture that would have allowed for more requirements to be met with the architecture than in the baseline. Each of these areas that were reduced in scope carry risk in order to achieve budgetary savings. Removal of the additional Orbiter pre-mate interface testing has a risk that if the delivered flight hardware is not exactly the same as the first, problems will arise that could have been caught early. Should the Prime Contractor require the use of TCMS to do test and verification check-out, it is possible that TCMS would not have the capabilities needed in the reduced scope version.

Conclusion

While the challenges involved with bringing the Space Station Program together are many, the entire team is driven by the desire to fulfill the Space Station Program Vision, to provide "A gateway to permanent human presence in space for the expansion of knowledge, benefiting all people and nations". The next 20 months will be filled not only with challenges, but also very visible signs that we are about to achieve this vision. In June 1997, the Space Station Processing Facility will official declare its Operational Readiness; Kennedy Space Center provided support equipment will be procured, installed and validated; the first Space Station major elements for Shuttle launch, the Node, PMA 1, and PMA 2 will arrive on dock at Kennedy Space Center in August 1997; and launch will occur in December 1997. Together, as a team, we will achieve the Vision of the International Space Station; a orbital research facility that is safe, productive, affordable and on schedule.