Abstract—The Department of Defense (DoD) Space Test Program (STP) is the organization responsible for providing launch services for all of DoD’s R&D space experiments and has used NASA’s Manned Spaceflight capabilities (the Space Shuttle) extensively in the past for its experiments. With the Shuttle expected to retire in the 2010 timeframe a concerted effort is underway to find alternate means to send experiments to the International Space Station and, if possible, return them from the ISS. With some success STP has found alternatives to the shuttle for access to the ISS, specifically using the Russian Progress vehicle.

This paper will provide a survey of ISS access methods in the post-shuttle era, focusing on capabilities of interest to the experimenter as well as processes required in the areas of manifesting, integration, and safety. Specifically it will address current alternatives to the shuttle, including Soyuz, Progress, ATV, and HTV vehicles as well as the proposed Rocketplane-Kistler and SpacEx servicing vehicles.  

TABLE OF CONTENTS

1. INTRODUCTION ...........................................1
2. MANIFEST PROCESS ...................................1
3. INTEGRATION PROCESS .................................1
4. VEHICLE DESCRIPTIONS AND CAPABILITIES ........2
5. SUMMARY ..................................................2
REFERENCES ...................................................5
BIOGRAPHY .....................................................5

1. INTRODUCTION

According to the National Aeronautics and Space Administration’s current planning the Space Shuttle will be retired after 2010. This will leave the research community with a shortfall in transportation to and from the International Space Station. This shortfall is expected to be filled, according to NASA, by several alternative means. This paper provides a general survey of the available ISS access alternatives currently proposed. The paper will focus on capabilities of interest to the research payload community as well as processes required in the areas of manifesting, integration, and safety. ISS visiting vehicles, as they are called, cover a wide range of capabilities and services.

The Department of Defense (DoD) Space Test Program (STP) is the United States organization primarily responsible for providing launch services for DoD’s research and development (R&D) community and has used NASA’s Manned Spaceflight capabilities (the Space Shuttle) extensively in the past for its experiments. Since the beginning of the shuttle program the DoD has flown many experiments and with the inception of the International Space Station era, STP has been at the forefront of the ISS user community. With the Shuttle expected to retire in the 2010 timeframe a concerted effort is underway to find alternate means to send experiments to the International Space Station and, if possible, return them from the ISS. With some success STP has found alternatives to the shuttle for access to the ISS, specifically using the Russian Progress vehicle. Additionally, STP has worked to integrate experiments bound for the ISS on the European Space Agency’s (ESA) ATV vehicle and the Japanese Exploration Agency’s (JAXA) HTV.

The process of using any launch vehicle is complicated. For a manned or man-rated vehicle the process can be especially daunting as the requirements are many and diverse. STP has spent over 20 years integrating payloads on manned space vehicles, and is possibly the most experienced organization outside of NASA in this area.

2. MANIFEST PROCESS

The Progress, Soyuz, ATV, and HTV are considered standard means of access to the ISS by NASA. As such the first priority for manifesting cargo is ISS system needs (food, spare parts, etc...) not payloads. However, for every ISS mission there is usually some up mass available for payloads. This mass is allocated by the NASA Research Planning Working Group (RPWG). The RPWG is the forum responsible for performing research discipline management and research requirements integration in the ISS. What this means specifically is that the RPWG decides who flies on what vehicles and provides “front door” function for manifesting all NASA payloads. If the vehicle is not US controlled then the RPWG proposes to the
other nation and that nation approves the manifest. It also provides a means and method for representing the research requirements to the Space Station Program, and for representing the Space Station Program to the Research Community. The RPWG is a multinational forum with representation across the ISS Research Community. If you do not know who would represent your organization at the RPWG, you most likely belong to the Space Operations Research Program.

All other vehicles, at this point at least, are non-standard vehicles and there is currently no manifesting process that we know of.

3. INTEGRATION PROCESS

There are several issues with flying to the ISS on a non-US launch vehicle for US payloads. Any cargo entering the ISS Russian Segment or flying up on a Russian vehicle is subject to joint certification and there is a NASA organization that is supposed to help you with this. In reality the effort is mostly on the payload side, with guidance and oversight by the NASA team. Joint certification is accomplished through SSP50578 “Joint Cargo Certification Process” which requires compliance with several other documents for safety and interface compatibility. Functional performance certification is the responsibility of the cargo developer and a Safety Transportation Certificate is required for all cargo. If equipment was certified for the Shuttle, the different Russian Progress/Soyuz launch requirements for g-loads, shock, vibration, temperature, loading, and space availability must be taken into account. There are possible technology transfer issues (export control compliance) with providing required data to the Russians as well as the actual exporting of payload hardware to the launch site. In addition, the transportation environment to the Russian launch site is more severe than to the US site.

For the ESA or JAXA vehicles this process is not as well defined, but includes the foreign organizations participation in the certification process. This requires foreign participation in integration activities and the safety process - considerations that may greatly affect the amount of effort those activities consume.

4. VEHICLE DESCRIPTIONS AND CAPABILITIES

Progress

The Russian Space Agency is a cargo version of the Soyuz space vehicle, adapted for cargo missions. The materials and supplies for the International Space Station crew are placed into pressurized section of the craft, which loosely resembles the habitable module of the Soyuz. The docking port equipped with a hatch would allow the crew loading and unloading spacecraft in the pressurized environment.

The reentry or descent module of the Soyuz was replaced with unpressurized propellant and refueling compartment. When docked to the station, the poisonous propellants are stored safely outside the pressurized compartments and any leaks of gaseous supplies would have no effect on the station's atmosphere. After docking, the propellant tanks of the station and refueling tanks onboard the cargo ship are linked through a sophisticated refueling system. As in Soyuz, the propulsion and service systems were installed in the tail section of the vehicle.

Unlike Soyuz, the cargo ship was inseparable during its entire flight and upon conclusion of its supply mission to the station would be directed into the atmosphere to burn up. The maximum pressurized (dry) cargo capability of the Progress is 1,800 kg.

Soyuz

The Russian Soyuz is a manned version of the Progress vehicle with almost the entire capability of the vehicle is devoted to supporting people. That being said, you can get some stuff up and down via the Soyuz, it just isn't much. All Soyuz cargo is "soft stowage", which must meet the following requirements:

- Maximum allowable size for a cargo delivered to ISS is 400x400x400 mm, for returning cargo the size is 200x200x200 mm.
- Maximum mass up is 50 kg (3 people) and 80 kg (2 people)
- Maximum return mass is 40 kg (3 people) and 120 kg (2 people)
- Cargoes with a mass up to 5 kg, as a rule, are stowed in vehicle containers (if there are no specific transportation requirements); if the mass is more than 5 Kg, the cargo must be hard mounted using a plate or frame and fasteners provided with the deliverable unit.
ATV

The European Space Agency’s Automated Transfer Vehicle (ATV) is a pressurized module, which provides contribution to the logistic servicing of the International Space Station (ISS) through: re-boost and support to attitude control for the ISS; delivery of items (dry pressurized cargo, water, gases and propellant); disposal of ISS wastes, solid and liquid. The ATV Flight System consists of two main elements: the Integrated Cargo Carrier (ICC) and the Spacecraft (S/C). The ICC includes the Russian Docking System (RDS), the Equipped Pressurized Module (EPM), or simply Pressurized Module (PM), and the Equipped External Bay (EEB). The S/C includes the Equipped Avionics Bay (EAB), the Equipped Propulsion Bay (EPB) and the Separation and Distancing Module (SDM). The ATV has a dry cargo capacity of 750kg and is only used for delivery to the ISS. Cargo is either soft mounted or hard mounted into the rack assemblies.

HTV

The Japanese Exploration Agency HTV is designed to transport cargo to the ISS. Pressurized cargo can be received at the rack level (e.g. an International Standard Payload Rack (ISPR)) or sub-rack level; such as Cargo Transfer Bags (CTBs). Sub-rack level cargo is then integrated into HTV resupply racks (HRRs) and, subsequently, all HRRs and ISPR equivalents are integrated into the HTV Pressurized Logistics Carrier (PLC). Unpressurized cargo is integrated onto an exposed pallet and, subsequently, into the HTV Unpressurized Logistics Carrier (UPLC). These carriers are then attached to the other HTV systems. The HTV is launched by the JAXA H-IIB launch vehicle. After the HTV has delivered cargo to the ISS, waste cargo from the ISS is loaded into the HTV; the HTV departs from the ISS and is destroyed upon reentry into the Earth’s atmosphere. The HTV can carry 4500kg of pressurized and 15000kg of unpressurized cargo. The HTV consists of a Pressurized Logistics Carrier (PLC) Module, an Unpressurized Logistics Carrier (UPLC) Module, an Avionics Module, and a Propulsion Module. The avionics module provides guidance, control, and power supply to other HTV systems. The propulsion module provides flight and attitude control based on commands received from the avionics module. The PLC is loaded with integrated cargo racks and payload racks. The UPLC is loaded with the integrated exposed pallet, consisting of unpressurized cargo and unpressurized payloads. HTV unpressurized cargo is classified according to the exposed pallet interface mechanism used. The four classifications are as follows: HCAM Type EF Payload (Japanese payload), FRAM Type EF Payload (NASA payload, FRAM Type Cargo (SHOSS box, etc.) and Unique Interface Type Cargo (e.g. USOS Battery).

Other Vehicles

SpacEx Dragon

The Dragon spacecraft is made up of a pressurized capsule and unpressurized trunk used for Earth to LEO transport of pressurized cargo, unpressurized cargo, and/or crew members. Initiated internally by SpaceX, Dragon will be utilized to fulfill NASA needs for cargo re-supply of the ISS. The Dragon capsule is comprised of 3 main elements: the Nosecone, which protects the vessel and the docking adaptor during ascent; the Pressurized Section, which houses the crew and/or pressurized cargo; and the Service Section, which contains avionics, the RCS system, parachutes, and other support infrastructure. In addition an unpressurized trunk is included, which provides for the stowage of unpressurized cargo and will support Dragon’s solar arrays and thermal radiators. Dragon will have a pressurized Cargo/Crew capacity of >2500 kg and 14 cubic meters with an equal down capability. In its crew configuration Dragon will support up to 7 passengers.

To ensure a rapid transition from cargo to crew capability, the cargo and crew configurations of Dragon are almost identical, with the exception of the crew escape system, the life support system and onboard controls that allow the crew to take over control from the flight computer.
This focus on commonality minimizes the design effort and simplifies the human rating process, allowing systems critical to Dragon crew safety and ISS safety to be fully tested on uncrewed demonstration flights. For cargo launches the inside of the capsule is outfitted with a modular cargo rack system designed to accommodate pressurized cargo in standard sizes and form factors. For crewed launches, the interior is outfitted with crew couches, controls with manual override capability and upgraded life-support.


SpaceDev Dream Chaser

SpaceDev’s Dream Chaser is derived from the NASA HL-20 lifting body design and will be capable of providing ISS servicing for both crew and cargo operations. It will be launched via a United Launch Alliance (ULA) Atlas 5 launch vehicle, as is currently envisioned.

5. SUMMARY

When the NASA Space Shuttle is retired in the 2010 timeframe, there will still be access to the International Space Station for science experiments. The processes are still not completely worked out, but as the systems become more mature, so will the processes. Each of the vehicles will have its own particular idiosyncrasies that will have to be factored into the effort to use them. Also, the safety assurance processes are still being worked
out for them. But, overall the picture looks pretty good for getting science done on the ISS. Below is a summary table of each access method, rating it in the areas of maturity, experience, ability, and difficulty. These ratings are subjective, but will provide a first order evaluation for the potential science user. A High rating means that the processes or methods are well known and a US payload has used the vehicle already. Medium ratings means that the processes are known, but still have issues to be worked and very little US payload experience is available. A low rating indicates there is very little information available on the integration process and no experience using the vehicle for payloads.

<table>
<thead>
<tr>
<th>System</th>
<th>Integration Ease</th>
<th>Experience</th>
<th>Ability to Meet Needs</th>
<th>System Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soyuz</td>
<td>High</td>
<td>High</td>
<td>Not much capability</td>
<td>High</td>
</tr>
<tr>
<td>Progress</td>
<td>High</td>
<td>High</td>
<td>Good Capability</td>
<td>High</td>
</tr>
<tr>
<td>ATV</td>
<td>Medium</td>
<td>Low</td>
<td>Good Capability</td>
<td>Medium</td>
</tr>
<tr>
<td>HTV</td>
<td>Medium</td>
<td>Medium</td>
<td>Good Capability</td>
<td>Medium</td>
</tr>
<tr>
<td>Dragon</td>
<td>Low</td>
<td>Low</td>
<td>Good Capability</td>
<td>Low</td>
</tr>
<tr>
<td>K-1</td>
<td>Low</td>
<td>Low</td>
<td>Good Capability</td>
<td>Low</td>
</tr>
<tr>
<td>Dream Chaser</td>
<td>Low</td>
<td>Low</td>
<td>Good Capability</td>
<td>Low</td>
</tr>
</tbody>
</table>

REFERENCES

8. NASA Johnson Space Center, Houston, Texas, September 2007


BIOGRAPHY

Perry Ballard is the Chief Engineer of the DOD Human Spaceflight Office at the Johnson Space Center in Houston, Texas. He specifically integrates military related experiments on to the Space Shuttle and International Space Station. A veteran of the US Air Force, Perry has been working with the Space Shuttle and International Space Station for over 10 years. He has guided experiments through the NASA integration.
and safety process for internal and external usage on the station and is currently working to place and experiment on the JapaneseExposed Facility in 2009.