Building and maintaining the International Space Station (ISS) is a very complex task. An international fleet of space vehicles launches ISS components; rotates crews; provides logistical support; and replenishes propellant, items for science experiments, and other necessary supplies and equipment. The Space Shuttle must be used to deliver most ISS modules and major components.

All of these important deliveries sustain a constant supply line that is crucial to the development and maintenance of the International Space Station. The fleet is also responsible for returning experiment results to Earth and for removing trash and waste from the ISS.

Currently, transport vehicles are launched from two sites on Earth. In the future, the number of launch sites will increase to four or more. Future plans also include new commercial transports that will take over the role of U.S. ISS logistical support.
<table>
<thead>
<tr>
<th>Launch Vehicles</th>
<th>Russia</th>
<th>Japan</th>
<th>Europe</th>
<th>United States</th>
</tr>
</thead>
</table>

**First Launch**
- Soyuz SL-4: 1965
- Proton SL-12: 1965
- H-II: 1965
- Ariane 5: 1996
- Space Shuttle: 1981

**Launch Site(s)**
- Soyuz: Baikonur Cosmodrome
- Proton: Baikonur Cosmodrome
- H-II: Tanegashima Space Center
- Ariane: Guiana Space Center
- Shuttle: Kennedy Space Center

**Launch Performance**
- **Payload Capacity**
  - Soyuz: 7,150 kg (15,750 lb)
  - Proton: 20,000 kg (44,000 lb)
  - Ariane: 16,500 kg (36,400 lb)
  - Space Shuttle: 18,000 kg (40,000 lb)
  - Orbiters only: 105,000 kg (230,000 lb)

**Return Performance**
- **Payload Capacity**
  - Soyuz: N/A
  - Proton: N/A
  - Ariane: N/A
  - Shuttle: 18,600 kg (41,000 lb)
  - Orbiters only: 105,000 kg (230,000 lb)

**Number of Stages**
- Soyuz: 2 + 4 strap-ons
- Proton: 4 + 6 strap-ons
- Ariane: 2 + 2 strap-ons
- Space Shuttle: 1.5 + 2 strap-ons

**Length**
- Soyuz: 49.5 m (162 ft)
- Proton: 57 m (187 ft)
- Ariane: 53 m (175 ft)
- Space Shuttle: 51 m (167 ft)

**Mass**
- Soyuz SL-4: 310,000 kg (683,400 lb)
- Proton SL-12: 690,000 kg (1,521,200 lb)
- Ariane 5: 570,000 kg (1,256,600 lb)
- Space Shuttle: 746,000 kg (1,644,600 lb)

**Launch Thrust**
- Soyuz SL-4: 6,000 kN (1,348,800 lbf)
- Proton SL-12: 9,000 kN (2,023,200 lbf)
- Ariane 5: 5,600 kN (1,298,900 lbf)
- Space Shuttle: 11,400 kN (2,562,820 lbf)

**Payload Examples**
- Soyuz: Progress (P), Service Module, Functional Cargo Block (FGB), Research Module (RM), Multipurpose Lab Module (MLM)
- H-II: Transfer Vehicle (HTV), Ariane Automated Transfer Vehicle (ATV)
- Space Shuttle: Nodes, U.S. Lab, Columbus, JEM, Truss elements, Airlock, SSRMS

The largest U.S. and Russian launch vehicles are used to place elements of the ISS, crew, and cargo in orbit. Eventually, Japanese and European launch vehicles will support cargo delivery. Currently, only the U.S. Space Shuttle provides the capability to return significant payloads.
**Soyuz**

S.P. Korolev Rocket and Space Corporation Energia (RSC Energia)

Soyuz spacecraft have been in use since the mid-1960s and have been upgraded periodically. Soyuz can support three suited crewmembers for up to 3 days. A nitrogen/oxygen atmosphere at sea level pressure is provided. The vehicle has an automatic docking system and may be piloted automatically or by a crewmember. The Soyuz TMA used for the ISS includes changes to accommodate larger and smaller crewmembers, an improved landing system, and digital electronic controls and displays.

**Mission Sequence**

**Launch and Abort**
- Abort until escape rocket
- Main engines shutdown, nose shroud separation (900 seconds max)
- Main parachute deployment (186 seconds)
- Engines on, subsequent engines (526 seconds)
- Main parachute deployment

**Return**
- Parachute recovery, orbital module separation, crew module recovery
- Color parachute deployed
- Color parachute deployed
- Main parachute deployed
- Main parachute deployed
- Main parachute deployed
- Spectroscopic measurement
- Landing, retrorocket firing

**Specifications**

- **Launch mass**: 6,441 kg (14,200 lb)
- **Descent module**: 2,650 kg (5,800 lb)
- **Oriental module**: 1,179 kg (2,600 lb)
- **Payload**: 2,360 kg (5,200 lb)
- **Mass ratio**: 2,942 N
- **Volume of orbital module**: 1,179 kg (2,600 lb)
- **Volume of descent module**: 2,360 kg (5,200 lb)
- **Final landing speed**: 6 m/s (20.4 ft/s)

**Progress**

S.P. Korolev Rocket and Space Corporation Energia (RSC Energia)

Progress is a resupply vehicle used for cargo and propellant deliveries to the ISS. Once docked to the ISS, Progress engines can boost the ISS to higher altitudes and control the orientation of the ISS in space. Typically, three Progress vehicles bring supplies to the ISS each year. Progress is based upon the Soyuz design, and it can either work autonomously or be flown remotely by crewmembers aboard the ISS. After a Progress vehicle is filled with trash from the ISS, and after undocking and deorbit, it is incinerated in Earth’s atmosphere at the end of its mission.

**Mission Sequence**

**Docking**
- Progress approaches ISS
- Attitude control
- Docking system engaged
- Main parachute deployed
- Engine firing
- Main parachute deployed

**Launch and Abort**
- Abort until escape rocket
- Main engines shutdown, nose shroud separation (160 seconds max)
- Main parachute deployment (186 seconds)
- Engines on, subsequent engines (526 seconds)
- Main parachute deployment

**Return**
- Parachute recovery, orbital module separation, crew module recovery
- Color parachute deployed
- Color parachute deployed
- Main parachute deployed
- Main parachute deployed
- Main parachute deployed
- Main parachute deployed
- Spectroscopic measurement
- Landing, retrorocket firing

**Specifications**

- **Launch mass**: 7,150 kg (15,800 lb)
- **Crew**
- **Volume of orbital module**: 7,150 kg (15,800 lb)
- **Volume of descent module**: 2,360 kg (5,200 lb)
- **Final landing speed**: 9.1 m/s (30.0 ft/s)

**Cargo Load**

<table>
<thead>
<tr>
<th>Item</th>
<th>Typical</th>
<th>TYPICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry cargo upload</td>
<td>1,800 kg</td>
<td>1,070 kg</td>
</tr>
<tr>
<td>Water</td>
<td>422 kg</td>
<td>300 kg</td>
</tr>
<tr>
<td>Air</td>
<td>50 kg</td>
<td>47 kg</td>
</tr>
<tr>
<td>Refueling propellant</td>
<td>1,000 kg</td>
<td>800 kg</td>
</tr>
<tr>
<td>Main propellant</td>
<td>250 kg</td>
<td>250 kg</td>
</tr>
<tr>
<td>Waste capacity</td>
<td>2,000 kg</td>
<td>2,000 kg</td>
</tr>
</tbody>
</table>

*Measurements are from the 21 P flight.

**Launch and Abort**
- Abort until escape rocket
- Main engines shutdown, nose shroud separation (900 seconds max)
- Engines on, subsequent engines (526 seconds)
- Main parachute deployment

**Return**
- Parachute recovery, orbital module separation, crew module recovery
- Main parachute deployed
- Main parachute deployed
- Main parachute deployed
- Main parachute deployed
- Main parachute deployed
- Spectroscopic measurement
- Landing, retrorocket firing

**Specifications**

- **Payload**: 2,000 kg (4,409 lbs)
- **Volume of orbital module**: 1,179 kg (2,600 lb)
- **Volume of descent module**: 2,360 kg (5,200 lb)
- **Final landing speed**: 6 m/s (20.4 ft/s)
**Space Shuttle Orbiter/Discovery, Atlantis, Endeavour**

NASA/Boeing/Rockwell

The U.S. Space Shuttle provides Earth-to-orbit and return capabilities and in-orbit support. The diversity of its missions and customers is testimony to the adaptability of its design. As of mid-2006, the Shuttle had flown 115 times. The Shuttle’s primary purpose during the remaining 4 years of operation will be to complete the assembly of the ISS. By 2010, it will be retired.

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**Multi-Purpose Logistics Module (MPLM)/Leonardo, Raffaelo, Donatello**

NASA/Alcatel Alenia Space

The Italian-built Multi-Purpose Logistics Module (MPLM) serves as the International Space Station’s “moving van” by carrying laboratory racks filled with equipment, experiments, and supplies to and from the Station aboard the Space Shuttle.

Mounted in the Shuttle’s cargo bay for launch and landing, the modules are transferred to the Station using the Shuttle’s robotic arm after the Shuttle has docked. While berthed to the Station, racks of equipment and stowage items are unloaded from the module, and racks and equipment may be relaoded to be transported back to Earth. The MPLM is then detached from the Station and positioned in the Shuttle’s cargo bay for the trip home.

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**Specifications**

**Space Shuttle Orbiter**

- **Length**: 37.2 m (122.2 ft)
- **Height**: 17.3 m (56.7 ft)
- **Wing span**: 23.8 m (78 ft)
- **Typical mass**: 104,000 kg (230,000 lb)
- **Cargo capacity**: 16,000 kg (35,000 lb) (typical launch and return to ISS)

**Cargo Bay**

- **Length**: 18.3 m (60 ft)
- **Diameter**: 4.6 m (15 ft)

**Multi-Purpose Logistics Module (MPLM)**

- **Length**: 6.6 m (21.7 ft)
- **Diameter**: 4.2 m (13.8 ft)
- **Mass (structure)**: 4,685 kg (10,329 lb)
- **Mass (payload)**: 9,400 kg (20,700 lb)
- **Racks**: 16, 5 active
- **Pressurized habitable volume**: 31 m³ (1,095 ft³)
JAXA H-II Transfer Vehicle (HTV)
Japan Aerospace Exploration Agency (JAXA)/Mitsubishi Heavy Industries, Ltd.

The H-II Transfer Vehicle is an autonomous logistical resupply vehicle designed to berth to the International Space Station using the Space Station Remote Manipulation System (SSRMS). HTV offers the capability to carry logistics materials in both its internal pressurized carrier as well as in an unpressurized carrier for exterior placement. It is launched on the H-II unmanned launch vehicle and can carry dry cargo, gas and water, and propellant. After fresh cargo is unloaded at the ISS, the HTV is loaded with trash and waste products; after unberthing and deorbit, it is incinerated during reentry.

Automated Transfer Vehicle (ATV)
European Space Agency (ESA)/European Aeronautic Defence and Space Co. (EADS)

The European Space Agency Automated Transfer Vehicle is an autonomous logistical resupply vehicle designed to dock to the International Space Station and provide the crew with dry cargo, atmospheric gas, water, and propellant. After the cargo is unloaded, the ATV is reloaded with trash and waste products, undocks, and is incinerated during reentry.
Crew Exploration Vehicle (CEV)/Orion

NASA has initiated the development of the Orion Crew Exploration Vehicle (CEV). The first Orion flights are planned for 2012–2014 and will support the ISS.

Commercial Orbital Transportation Services (COTS)

NASA is seeking commercial providers of launch and return logistics services to support the ISS after the Space Shuttle is retired. The first COTS demonstration missions are planned for 2010.