The International Space Station (ISS) is an experiment in the design, development, and assembly of an orbital space facility. It serves as a habitat for its crew, a command post for orbital operations, and a port for the rendezvous and berthing of smaller orbiting vehicles. It functions as an orbital microgravity and life sciences laboratory, a test bed for new technologies in areas like life support and robotics, and a platform for astronomical and Earth observations.

PMA 2 berthed on Node 1 serves as a primary docking port for the Space Shuttle.
The U.S. Lab Module Destiny provides research and habitation accommodations. Node 2 is to the left, the truss is mounted atop the U.S. Lab. Node 1, Unity, is to the right. Node 3 and the Cupola are below and to the right.
Why does the ISS look the way it does? The design evolved over more than a decade. The modularity and size of the U.S., Japanese, and European elements were dictated by the use of the Space Shuttle as the primary launch vehicle and by the requirement to make system components maintainable and replaceable over a lifetime of many years.

When the Russians joined the program in 1993, their architecture was based largely on the Mir and Salyut stations they had built earlier. Russian space vehicle design philosophy has always emphasized automated operation and remote control.

The design of the interior of the U.S., European, and Japanese elements was dictated by four specific principles: modularity, maintainability, reconfigurability, and accessibility. Interior modular hardware racks and utilities could be replaced as needs or age dictated. Racks could be swung away from the pressure hull of the module in case a meteoritic puncture necessitated a repair. Crew preferences dictated that module interiors be arranged with distinct floors, ceilings, and walls.

Architecture Design Evolution

Module Design and Layout

1979—Modules with connecting tunnels.
1982—Common modules.
1986—Habitation Module, Laboratory Module (Hab, Lab), spherical nodes, and tunnels.
1988—Boeing Phase C/D Nodes, Logistics Module, and 45-ft Hab, Lab.

Module Architecture Early Concepts

1980—Horizontal layout.
1986—Central core.

Module Architecture Racks with Four Structural Standoffs

1980—Horizontal layout.
1986—Central core.
1992—Central beam.

Loft concept
Modular outfitting
Standard racks (2 sizes)
Standard rack (1 size)
Access to module pressure shell
Intravehicular EMU access
Access to utility runs in standoffs
Access to module pressure shell
Intravehicular EMU access
**Functional Cargo Block (FGB)**

**Zarya (Sunrise) and Russian Research Modules**

**NASA/Khrunichev Production Center**

The FGB was the first element of the International Space Station, built in Russia under a U.S. contract. During the early stages of ISS assembly, the FGB was self-contained, providing power, communications, and attitude control functions. The FGB module is now used primarily for stowage and propulsion. The FGB was based on the modules of Mir. The Russian Multipurpose Modules planned for the ISS will be based on the FGB-2, a spare developed as a backup to the FGB. The Russian Research Module may be based on the FGB design.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Dimensions/Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>12,990 m (42.6 ft)</td>
</tr>
<tr>
<td>Maximum diameter</td>
<td>4.1 m (13.5 ft)</td>
</tr>
<tr>
<td>Mass</td>
<td>24,968 kg (55,045 lb)</td>
</tr>
<tr>
<td>Pressurized volume</td>
<td>15 m (49 ft)</td>
</tr>
<tr>
<td>Solar array span</td>
<td>24.4 m (80 ft)</td>
</tr>
<tr>
<td>Array surface area</td>
<td>32 m (105 ft)</td>
</tr>
<tr>
<td>Power supply [avg.]</td>
<td>3 kW</td>
</tr>
<tr>
<td>Propellant mass</td>
<td>3,800 kg (8,377 lb)</td>
</tr>
<tr>
<td>Launch date</td>
<td>Nov 20, 1998, on a Proton rocket</td>
</tr>
</tbody>
</table>

---

**Service Module (SM)**

**Zvezda (Star)**

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

The Service Module was the first fully Russian contribution to the ISS. The Module provided the Station’s early living quarters, life-support system, electrical power distribution, data processing system, flight control system, and propulsion system. Its communications system still enables remote command capabilities from ground flight controllers. Although some of these systems were subsequently supplemented or replaced by later U.S. systems, the Service Module remains the structural and functional center of the Russian segment of the International Space Station.

The SM is under construction at Khrunichev State Research and Production Space Center in Moscow.

The SM under construction at Khrunichev State Research and Production Space Center in Moscow. Leroy Chiao exercises in the SM.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Dimensions/Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>13.1 m (43 ft)</td>
</tr>
<tr>
<td>Diameter</td>
<td>4.2 m (13.5 ft)</td>
</tr>
<tr>
<td>Wingspan</td>
<td>28.7 m (97.5 ft)</td>
</tr>
<tr>
<td>Weight</td>
<td>24,604 kg (54,242 lb)</td>
</tr>
<tr>
<td>Launch date</td>
<td>July 11, 2000, on a Proton rocket</td>
</tr>
<tr>
<td>Attitude control</td>
<td>32 engines</td>
</tr>
<tr>
<td>Orbital maneuvering</td>
<td>2 engines</td>
</tr>
</tbody>
</table>

---

*Image: Compilation of diagrams and text excerpts from the International Space Station Guide.*
Pressurized Mating Adapters (PMAs)

NASA/Boeing

Three conical docking adapters, called Pressurized Mating Adapters, allow the docking systems used by the Space Shuttle and by Russian modules to attach to the Node’s berthing mechanisms. PMAs 1 links the U.S. and Russian segments. The other two adapters serve as docking ports for the Space Shuttle and will do the same for the Crew Exploration Vehicle (CEV) and later commercial vehicles.

Nodes

Node 1 (Unity), Node 2, Node 3

NASA/Boeing, Alcatel Alenia Space

Nodes are U.S. modules that connect the elements of the ISS. Node 1, called Unity, was the first U.S.-built element of the ISS that was launched, and it connects the U.S. and Russian segments of the ISS. Node 2 will connect the U.S., European, and Japanese laboratories. Node 3, still in development, will provide additional habitation functions, including hygiene and sleeping compartments. Nodes 2 and 3 are slightly longer than Node 1.
Internal Research Accommodations

Several research facilities are in place aboard the Station to support science investigations.

Standard Payload Racks

Research payloads within the U.S., European, and Japanese laboratories typically are housed in a standard rack, such as the International Standard Payload Rack (ISPR). Smaller payloads may fit in a Shuttle middeck locker equivalent and be carried in a rack framework.

Active Rack Isolation System (ARIS)

The ARIS is designed to isolate payload racks from vibration. The ARIS is an active electromechanical damping system attached to a standard rack that senses the vibratory environment with accelerometers and then damps it by introducing a compensating force.

External Research Accommodations

Many locations are available for the mounting of payloads or experiments on the outside of the Station: on the U.S. Truss, on the Russian elements, and additional accommodations will be provided when the Japanese Experiment Module (JEM) Exposed Facility (EF) and Columbus modules are attached.

External Payload Accommodations

External payloads may be accommodated at several locations on the U.S. S4 and P3 Truss segments. External payloads are accommodated on an Expedition the Processing of Experiments to the Space Station racks (EXPRESS) Logistics Carrier (ELC). Mounting spaces are provided, and interfaces for power and data are standardized to provide quick and straightforward payload integration. Payloads can be mounted using the Special Purpose Dexterous Manipulator (SPDM), Dextre, on the Station’s robotic arm.

Research Rack Locations

<table>
<thead>
<tr>
<th>INTERNATIONAL PRESSURIZED SITES</th>
<th>STATION-WIDE</th>
<th>U.S. SHARED</th>
<th>U.S. Lab prior to launch</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Laboratory</td>
<td>13</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Japanese Experiment Module</td>
<td>11</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>European Columbus Research Laboratory</td>
<td>10</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>34</strong></td>
<td><strong>23</strong></td>
<td></td>
</tr>
</tbody>
</table>

Installation of a rack in the U.S. Lab prior to launch.
## U.S. Laboratory Module (Destiny)

**NASA/Boeing**

The U.S. Lab provides internal interfaces to accommodate the resource requirements of 24 equipment racks. Approximately half of these are for accommodation and control of ISS systems, and the remainder support scientific research.

Destiny was the first research module installed on the Station. The side of Destiny that usually faces Earth contains a large circular window of very high optical quality.

### Module Specifications

- **Length:** 8.5 m (28 ft)
- **Length with attached Common Berthing Mechanism (CBM):** 9.2 m (30.2 ft)
- **Width:** 4.3 m (14 ft)
- **Mass:** 14,515 kg (32,000 lb)
- **With all tracks and outfitting:** 24,023 kg (52,962 lb)
- **Exterior Aluminum, 3 cylindrical sections, 2 endcones**
- **Number of racks:** 24 (13 scientific and 11 system)
- **Windows:** 1, with a diameter of 50.9 cm (20 in)
- **Launch date:** Feb. 7, 2001, assembly flight 5A, StS-98

### Rack Locations (24)

- **Hatch and Berthing Mechanism**
- **Endcone**
- **Corner Standoffs for Utilities and Plumbing (4)**

### Hatch and Berthing Mechanism

1. **Gas Analyzer System for Metabolic Analysis Physiology (GASMAP)**
2. **GASMAP Gas Calibration Module (GCM)**
3. **Power Switch and Data Interconnects**
4. **Stowage Drawers**
5. **Ultrasound Imaging System**
6. **Workstation Interface**

### Endcone

1. **Stowage or Payload Locations**
2. **5**
3. **4**
4. **4**
5. **4**
6. **4**
7. **4**
8. **4**

### Module in preparation at Kennedy Space Center (KSC).

### Astronaut Susan Helms at the 20-inch-diameter circular window.

### View of astronaut Ed Lu in the U.S. Lab.

### Human Research Facility (HRF)

The Human Research Facility (HRF) supports a variety of life sciences experiments. It includes equipment for lung function tests, ultrasound equipment to image the heart, and many other types of computers and medical equipment.

### Microgravity Science Glovebox

The Microgravity Science Glovebox provides a sealed environment for conducting science and technology experiments. It has a large front window and built-in gloves, data storage and recording capabilities, and an independent air circulation and filtration system.

### EXPRESS Racks

The five EXPRESS Racks provide subrack-sized experiments with standard utilities such as power, data, cooling, fluids, and gasses. The racks stay in orbit, while experiments are changed as needed.

### Pressurized Mating Adapter (PMA)

The Pressurized Mating Adapter (PMA) is located on the forward berthing ring.

### Stowage at Payload Locations

1. **Airlock**
2. **Control and Monitoring Panel**
3. **Power Distribution Box**
4. **Power Switches**
5. **Remote Power Distribution**
6. **Hatch and Berthing Mechanism**
7. **Video**

### Minus Eighty-Degree Laboratory Freezer for ISS (MELFI)

The Minus Eighty-Degree Laboratory Freezer for ISS (MELFI) provides refrigerated storage and fast-freezing of biological and life science samples. It can hold up to 300 L of samples ranging in temperature from 4 °C to a low of -80 °C.

### Refrigerated/Frozen Storage Dewars

1. **Stowage or Payload Locations**
2. **5**
3. **4**
4. **4**
5. **4**
6. **4**
7. **4**
8. **4**
9. **4**
10. **4**
11. **4**
12. **4**
13. **4**
14. **4**
15. **4**
16. **4**
17. **4**
18. **4**
19. **4**
20. **4**
21. **4**
22. **4**
23. **4**
24. **4**
Columbus Research Laboratory

European Space Agency (ESA)/European Aeronautic Defence and Space Co. (EADS)
Space Transportation

The Columbus Research Laboratory is Europe's largest contribution to the construction of the International Space Station. It will support scientific and technological research in a microgravity environment. Columbus, a program of ESA, is a multifunctional pressurized laboratory that will be permanently attached to Node 2 of the ISS to carry out experiments in materials science, fluid physics, and biosciences, as well as to perform a number of technological applications.

Columbus lab being prepared for shipment to the United States by ESA technicians.

Japanese Experiment Module (JEM)/Kibo (Hope)

Japan Aerospace Exploration Agency (JAXA)/Mitsubishi Heavy Industries, Ltd.

The Japanese Experiment Module is the first crewed space facility ever developed by Japan. The Pressurized Module (PM) is used mainly for microgravity experiments. The Exposed Facility (EF) is located outside the pressurized environment of the ISS. Numerous experiments that require direct exposure can be mounted with the help of the JEM remote manipulator and airlock. Logistics components will be launched in the Experiment Logistics Module Pressurized Section (ELM-PS). Experiments may be mounted on the JEM-EF using the Experiment Logistics Module Exposed Section (ELM-ES). All of the JEM modules will be launched on the Space Shuttle.

Columbus lab at Kennedy Space Center in preparation for launch.
Cupola
NASA/Boeing, ESA/Alcatel Alenia Space

The Cupola (named after the raised observation deck on a railroad caboose) is a small module designed for the observation of operations outside the ISS such as robotic activities, the approach of vehicles, and extravehicular activity (EVA). It will also provide spectacular views of Earth and celestial objects. The Cupola has six side windows and a top window, all of which are equipped with shutters to protect them from contamination and collisions with orbital debris or micrometeorites. The Cupola is designed to house computer workstations that control the ISS and the remote manipulators. It can accommodate two crewmembers simultaneously and is berthed to a Node using the Common Berthing Mechanism (CBM).

###カップラ
NASA/Boeing, ESA/Alcatel Alenia Space

カップラは、鉄道カボステッカーの上部展望台を名乗り、地球および宇宙の広がりを観察するためのモジュールです。EVAやロボット活動、乗り組みのアプローチの観察にも利用されます。カーテンについては地球の汚染およびミクロメートロイドと衝突から保護するためのシャッターが装備されています。カーテンは2名の乗客を収容することができ、ISSのコモンベルティングメカニズム（CBM）を用いてノードに接続できます。

###规格
- **長さ**：3m（9.8ft）
- **高さ**：1.5m（4.7ft）
- **直径**：3m（9.8ft）
- **質量**：1,880kg（4,136lb）
- **容量**：2名の乗客と携帯ワークステーション

###主要接続
- **接続ノード**：ノード3

###ビュー
- **カップラからノード3を観る**
- **カップラの内部開発**
- **カップラからノード3への進入アストロナヴェイターが見せる観点**

Mobile Servicing System (MSS)
Space Station Remote Manipulator System (SSRMS) and Special Purpose Dexterous Manipulator (SPDM/Dextre)
Mobile Base System (MBS), Canadian Space Agency (CSA)/MacDonald, Dettwiller and Associates, Ltd.

The Mobile Servicing System (MSS) plays a key role in the construction of the ISS and general Station operations. It allows astronauts and cosmonauts to work from inside the Station, thus reducing the number of spacewalks. The MSS Operations Complex in Longueuil, Quebec, is the ground base for the system.

### MSSの主要な3つの部分
- **Space Station Remote Manipulator System (SSRMS)**
  - **Length/height**: 17.6m (57ft)
  - **Maximum Diameter**: 3.6m (11.4ft)
  - **Mass**: 1,800 kg (3,969 lb)
  - **Capacity**: 2 crewmembers with portable workstation

- **Mobile Base System (MBS)**
  - **Length/height**: 3.5m (11.4ft)
  - **Maximum Diameter**: 0.88m (2.9ft)
  - **Mass**: 1,450 kg (3,196 lb)

- **Special Purpose Dexterous Manipulator (SPDM)**
  - **Length/height**: 2.8m (9.2ft)
  - **Mass**: 1,662 kg (3,664 lb)

###接続
- **接続ノード**: ノード3

###ビューア
- **SSRMS中のテスト**
- **MBSキャプチャーレッ치**
- **視覚データグラップフィックス（PDGF）**
- **カメラ、ライト、およびパントルーツユニット**

###詳細
- **接続ノード**: ノード3
- **接続**: コモンベルティングメカニズム（CBM）
- **質量**: 1,800 kg（3,969 lb）
- **質量**: 1,450 kg（3,196 lb）
- **質量**: 1,662 kg（3,664 lb）

###詳細
- **接続**: コモンベルティングメカニズム（CBM）
- **質量**: 1,800 kg（3,969 lb）
- **質量**: 1,450 kg（3,196 lb）
- **質量**: 1,662 kg（3,664 lb）
Scott Parazynski removes orbital debris shield to connect SSRMS wiring.