The International Space Station (ISS) flight systems make up the core functional infrastructure of the on-orbit ISS. The ISS flight systems consist of Habitation; the Crew Health Care System (CHeCS); Extravehicular Activity (EVA); the Environmental Control and Life Support System (ECLSS); Computers and Data Management; Propulsion; Guidance, Navigation, and Control; Communications; the Thermal Control System (TCS); and the Electrical Power System (EPS). These flight systems provide a safe, livable, and comfortable environment in which crew members perform scientific research. Payloads, hardware, software, and crew support items on the ISS operate within the capabilities of these flight systems.
Integrated Truss Assembly

The truss assemblies provide attachment points for the solar arrays, thermal control radiators, and external payloads. Truss assemblies also contain electrical and cooling utility lines, as well as the mobile transporter rails. The Integrated Truss Structure (ITS) is made up of 11 segments plus a separate component called Z1. These segments, which are shown in the figure, will be installed on the Station so that they extend symmetrically from the center of the ISS.

At full assembly, the truss reaches 108.5 meters (356 feet) in length across the extended solar arrays. ITS segments are labeled in accordance with their location. P stands for “port,” S stands for “starboard,” and Z stands for “Zenith.”

Initially, through Stage 8A, the first truss segment, Zenith berthing mechanism (Z1), was attached to the Unity Node. Then truss segment P6 was mounted on top of the U.S. Lab Destiny, and the horizontal truss members P1 and S1 were then attached to S0. As the remaining members of the truss are added, P6 will be removed from its location on Z1 and moved to the outer end of the port side.

2003–06 configuration, looking from nadir.

2003–06 configuration, looking from aft.
Habitation

The habitable elements of the International Space Station are mainly a series of cylindrical modules. Many of the primary accommodations, including the waste management compartment and toilet, the galley, individual crew sleep compartments, and some of the exercise facilities, are in the Service Module (SM). A third sleep compartment is located in the U.S. Lab, and additional exercise equipment is in the U.S. Lab and the Node. Additional habitation capabilities for a crew of six will be provided prior to completion of ISS assembly.
Crew Health Care System (CHeCS)/Integrated Medical System

The Crew Health Care System (CHeCS)/Integrated Medical System is a suite of hardware on the ISS that provides the medical and environmental capabilities necessary to ensure the health and safety of crewmembers during long-duration missions. CHeCS is divided into three subsystems:

- **Countermeasures System (CMS)**—The CMS provides the equipment and protocols for the performance of daily and alternative regimens (e.g., exercise) to mitigate the deconditioning effects of living in a microgravity environment. The CMS also monitors crewmembers during exercise regimens, reduces vibrations during the performance of these regimens, and makes periodic fitness evaluations possible.

- **Environmental Health System (EHS)**—The EHS monitors the atmosphere for gaseous contaminants (i.e., from nonmetallic materials off-gassing, combustion products, and propellants), microbial contaminants (i.e., from crewmembers and Station activities), water quality, acoustics, and radiation levels.

- **Health Maintenance System (HMS)**—The HMS provides in-flight life support and resuscitation, medical care, and health monitoring capabilities.

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**Crew uses medical restraint and defibrillator.**

**Leroy Chiao uses RED.**

**Volatiles Organics Analyzer (VOA)**

**From left to right:** Intravehicular Charged Particle Directional Spectrometer (IV-CPDS) (gold box) and Tissue Equivalent Proportional Counter (TEPC) detector (gold cylinder).

**Water Samples (taken for ground analysis of contamination)**

**Acoustics measurement kit.**

**Atmospheric Air Sampler Container.**

**Crew Medical Restraint System (CMRS).**

**Microbial air sampler.**

**Defibrillator.**

**Internationl Space Station GuIde SystemS 51 Crew Health Care system**
Earth’s natural life-support system provides the air we breathe, the water we drink, and other conditions that support life. For people to live in space, however, these functions must be performed by artificial means. The ECLSS includes compact and powerful systems that provide the crew with a comfortable environment in which to live and work.

**ECLSS on the ISS provides the following functions:**

- Recycle wastewater (including urine) to produce drinking (potable) water
- Store and distribute potable water
- Use recycled water to produce oxygen for the crew
- Remove carbon dioxide from the cabin air
- Filter the cabin air for particulates and microorganisms
- Remove volatile organic trace gases from the cabin air
- Maintain and control cabin air partial pressures of nitrogen, oxygen, carbon dioxide, methane, hydrogen, and water vapor
- Maintain total cabin pressure
- Detect and suppress fire
- Maintain cabin temperature and humidity levels
- Distribute cabin air between ISS modules (ventilation)

In the future, a new U.S. Regenerative Environmental Control and Life Support System will take additional steps toward closing the water cycle; it will take humidity condensate from the cabin air and urine from the crew and convert these into drinking water, oxygen for breathing, and hydrogen.
Computers and Data Management

The system for storing and transferring information essential to operating the ISS has been functioning at all stages of assembly. From a single module to a large complex of elements from many international partners, the system provides control of the ISS from either U.S., Russian, Canadian, and soon the European and Japanese segments of the ISS.
The International Space Station (ISS) orbits Earth at an altitude that ranges from 370 to 460 kilometers (230 to 286 miles) and a speed of 28,000 kilometers per hour (17,500 miles per hour). Owing to atmospheric drag, the ISS is constantly slowed. Therefore, the ISS must be reboosted periodically in order to maintain its altitude. The ISS must sometimes be maneuvered in order to avoid debris in orbit. Furthermore, the ISS attitude control and maneuvering system can be used to assist in rendezvous and dockings with visiting vehicles, although that capability is not usually required.

Although the ISS typically relies upon large gyrodynes, which utilize electrical power, to control its orientation (see “Guidance, Navigation, and Control”), when force that is beyond the production capability of the gyrodynes is required, rocket engines provide propulsion for reorientation.

Rocket engines are located on the Service Module, as well as on the Progress, Soyuz, and Space Shuttle spacecraft.

The Service Module provides 32 13.3-kilograms force (29.3-pounds force) attitude control engines. The engines are combined into two groups of 16 engines each, taking care of pitch, yaw, and roll control. Each Progress provides 24 engines similar to those on the Service Module. When a Progress is docked at the aft Service Module port, these engines can be used for pitch and yaw control. When the Progress is docked at the Russian Docking Module, the Progress engines can be used for roll control.

Besides being a resupply vehicle, the Progress provides a primary method for reboosting the ISS. Eight 13.3-kilograms force (29.3-pounds force) Progress engines can be used for reboosting. Engines on the Service Module, Soyuz vehicles, and Space Shuttle can also be used. The Progress can also be used to resupply propellants stored in the FGB that are used in the Service Module engines. The ESA ATV and JAXA HTV will also provide propulsion and reboost capability.
Extravehicular Activity (EVA)

To date, there have been more than 69 EVAs (operations outside of the ISS pressurized modules) from the ISS totaling some 400 hours. Approximately 124 spacewalks, totaling over 900 hours, dedicated to assembly and maintenance of the Station will have been accomplished by Assembly Complete. Most of these EVAs have been for assembly tasks, but many were for maintenance, repairs, and science. These tasks were conducted from three different airlocks—the Shuttle Airlock, the U.S. Quest Airlock, and the Russian Pirs. Early in the program, an EVA was conducted from the Service Module Transfer Compartment. EVAs are conducted using two different spacesuit designs, the U.S. Extravehicular Mobility Unit (EMU) and the Russian Orlan.

The operational lessons of the ISS in the areas of EVA suit maintainability, training, and EVA support may prove critical for long-duration crewed missions that venture even further from Earth.
**U.S./Joint Airlock (Quest)**

NASA/Boeing

The Quest airlock provides the capability for extravehicular activity (EVA) using the U.S. Extravehicular Mobility Unit (EMU). The airlock consists of two compartments: the Equipment Lock, which provides the systems and volume for suit maintenance and refurbishment, and the Crew Lock, which provides the actual exit for performing EVAs. The Crew Lock design is based on the Space Shuttle’s airlock design.

- **Length**: 5.5 m (18 ft)
- **Width**: 4.0 m (13.1 ft)
- **Mass**: 9,923 kg (21,877 lb)
- **Launch date**: July 2001, on STS-104, ISS flight 7A.

**Extravehicular Mobility Unit (EMU)**

NASA/Hamilton Sundstrand/ILC Dover

The EMU provides a crewmember with life support and an enclosure that enables EVA. The unit consists of two major subsystems: the Life Support Subsystem (LSS) and the Space Suit Assembly (SSA). The EMU provides atmospheric containment, thermal insulation, cooling, solar radiation protection, and micrometeoroid/orbital debris (MMOD) protection.

- **Suit’s nominal pressure**: 0.3 atm (4.3 psi)
- **Atmosphere**: 100% oxygen
- **Primary oxygen tank pressure**: 900 psi
- **Secondary oxygen tank pressure**: 6,000 psi (30-min backup supply)
- **Maximum EVA duration**: 8 h
- **Mass of entire EMU**: 178 kg (393 lb)
- **Suit life**: 30 yr

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**Image Descriptions**

- **U.S./Joint Airlock (Quest)**: A detailed diagram of the Quest airlock, showing various components such as the Equipment Lock, Crew Lock, and associated systems.
- **Extravehicular Mobility Unit (EMU)**: A detailed diagram of the EMU, illustrating its various components and systems, including Life Support Subsystem, Space Suit Assembly, and associated equipment.

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**Text Descriptions**

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Russian Docking Compartment (DC) and Airlock (Pirs [Pier])

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

Pirs provides the capability for extravehicular activity using Russian Orlan suits. Pirs also provides contingency capability for ingress for U.S. EMU EVAs. Additionally, Pirs provides systems for servicing and refurbishing the Orlan suits. The nadir Docking System on Pirs provides a port for the docking of Soyuz and Progress logistics vehicles. When the final Russian science module arrives, Pirs will be moved to the zenith Service Module port.

Orlan Spacesuit

Science Production Enterprise Zvezda

The Orlan-M spacesuit is designed to protect an EVA crewmember from the vacuum of space, ionizing radiation, solar energy, and micrometeoroids. The main body and helmet of the suit are integrated and are constructed of aluminum alloy. Arms and legs are made of a flexible fabric material. Crewmembers enter from the rear via the backpack door, which allows rapid entry and exit without assistance. The Orlan-M spacesuit is a “one-size-fits-most” suit.

The suit operates at a nominal 0.4 atm (5.8 psi) with a 100% oxygen atmosphere. The suit’s maximum EVA duration is 7 hours. Orlan is designed for an on-orbit lifetime of 12 EVAs or 4 years without return to Earth.
Guidance, Navigation, and Control (GN&C)

The International Space Station is a large, free-flying vehicle. The attitude or orientation of the ISS with respect to Earth and the Sun must be controlled; this is important for maintaining thermal, power, and microgravity levels, as well as for communications.

The GN&C system tracks the Sun, communications and navigation satellites, and ground stations. Solar arrays, thermal radiators, and communications antennas aboard the ISS are pointed using the tracking information.

The preferred method of attitude control is the use of gyroscopes. Control Moment Gyroscopes (CMGs) mounted on the Z1 Truss segment. CMGs are 38-kilogram (86-pound) steel wheels that spin at 6,600 revolutions per minute (rpm). The high-rotation velocity and large mass allow a considerable amount of angular momentum to be stored. Each CMG has gimbals and can be repositioned to any attitude. As the CMG is repositioned, the resulting force causes the ISS to move. Using multiple CMGs permits the ISS to be moved to new positions or permits the attitude to be held constant. The advantages of this system are that it relies on electrical power generated by the solar arrays and that it provides smooth, continuously variable attitude control.

CMGs are, however, limited in the amount of angular momentum they can provide and the rate at which they can move the Station. When CMGs can no longer provide the requisite energy, rocket engines are called upon.

Communications

The radio and satellite communications network allows ISS crews to talk to the ground control centers and the orbiter. It also enables ground control to monitor and maintain ISS systems and operate payloads, and it permits flight controllers to send commands to those systems. The network routes payload data to the different control centers around the world.

The communications system provides the following:

- Two-way audio and video communication among crewmembers aboard the ISS, including crewmembers who participate in an extravehicular activity (EVA);
- Two-way audio, video, and file transfer communication between the ISS and flight control teams located in the Mission Control Center-Houston (MCC-H), other ground control centers, and payload scientists on the ground;
- Transmission of system and payload telemetry from the ISS to the MCC-H and the Payload Operations Center (POC);
- Distribution of ISS experiment data through the POC to payload scientists; and
- Control of the ISS by flight controllers through commands sent via the MCC-H.

* Luch not currently in use.

The Rate Gyroscope Assemblies (RGAs) are the U.S. attitude rate sensors used to measure the changing or extraction of the ISS. RGAs are installed on the back of the Truss, under the GPS antennas, and they are impossible to see on the ISS unless shielding is removed.

Forces are induced as CMGs are repositioned.
Electrical Power System (EPS)

The EPS generates, stores, and distributes power and converts and distributes secondary power to users.

- Solar Array Wing (SAM) has 2 arrays and 32,800 solar cells; converts sunlight to DC power, producing a maximum of 31 kW at the beginning of its life and degrading to 26 kW at 15 years (had state-of-the-art efficiency at time of design)
- Nickel-Hydrogen Batteries (store electrical energy for use during the night; Battery Charge Discharge Unit [BCDU] controls the charge)
- Photovoltaic Radiator (circulates coolant to maintain EPS/battery temperature)
- Solar (Array) Alpha Rotation Joint (SARJ) (tracks the Sun through Earth orbit)
- Remote Power Controllers (RPCs) (control the flow of electric power to users)
- Power Coming in from Arrays

Crewmember Mike Fincke replaces the Remote Power Controller Module (RPCM) on the S0 Truss.

Thermal Control System (TCS)

The TCS maintains ISS temperatures within defined limits. The four components used in the Passive Thermal Control System (PTCS) are insulation, surface coatings, heaters, and heat pipes.

- The Active Thermal Control System (ATCS) is required when the environment or the heat loads exceed the capabilities of the PTCS. The ATCS uses a mechanically pumped fluid in closed-loop circuits to perform three functions: heat collection, heat transportation, and heat rejection.
- Inside the habitable modules, the internal ATCS uses circulating water to transport heat and cool equipment. Outside the habitable modules, the external ATCS uses circulating ammonia to transport heat and cool equipment.