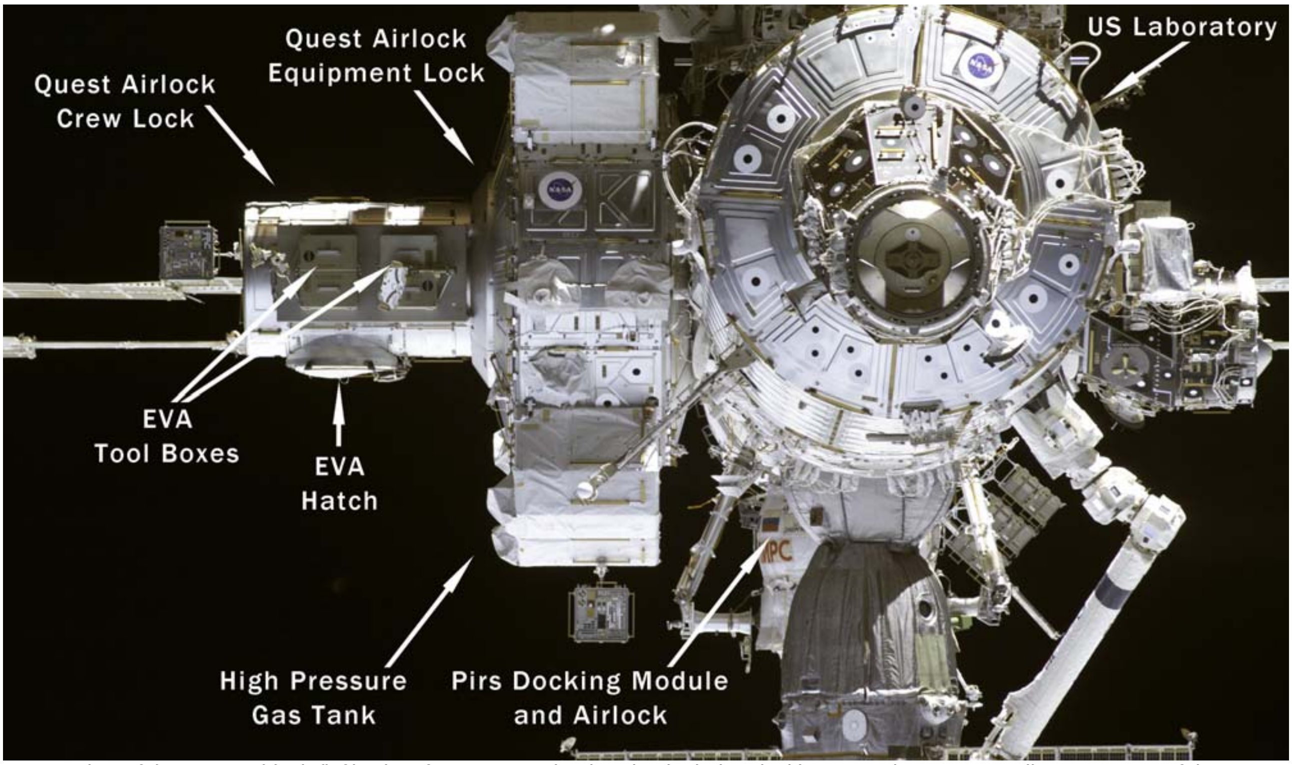
ISS Quest Joint Airlock



View of the Quest Airlock (left) taken from Space Shuttle Atlantis during docking procedures on 9 April 2002 as part of the STS-110 mission to the International Space Station. (Image: NASA)

The ISS Joint Airlock 'Quest' is attached to the ISS on the starboard or right-hand side of the ISS Node 1. The six-tonne Airlock was attached to the ISS in July 2001 as part of the STS-104 mission on Shuttle Atlantis. It is known as the Joint Airlock since it is possible for EVAs to begin from the Airlock using either the US EVA suits known as Extravehicular Mobility Units (EMUs) or the Russian Orlan-M spacesuits. The Station also has another airlock called Pirs (also pictured above) which is further to the back of the station on the Russian segment of the ISS, but this only supports spacewalks using the Orlan spacesuits.

The 6-metre long Quest Airlock is composed of two connected cylindrical chambers: the larger Equipment Lock and the smaller Crew Lock.

Quest Equipment Lock

The Equipment Lock is 4 metres in diameter and has stations to assist astronauts getting into and out of their spacesuits before and after EVAs and to perform periodic maintenance. Most of the EVA equipment is stored here. This includes two full EMUs and one EMU upper torso section (which contains the life support systems), the Simplified Aid for EVA Rescue (SAFER) units that allow an astronaut to return to the ISS if he comes untethered during the EVA, ancillary equipment, batteries, power tools, and other important supplies. Two Orlan spacesuits may also be stored in the Equipment Lock in the event of an Orlan-based EVA.

NASA astronaut Michael Gernhardt in the Equipment Lock of the Quest Airlock with EMU space suits during the STS-104 mission to the ISS (12-24 July 2001). On the right is the upper torso section, which contains the life support systems. (Image: NASA)

The Equipment Lock contains: systems for converting ISS power supply to the necessary voltage for the EVA suits and portable equipment;

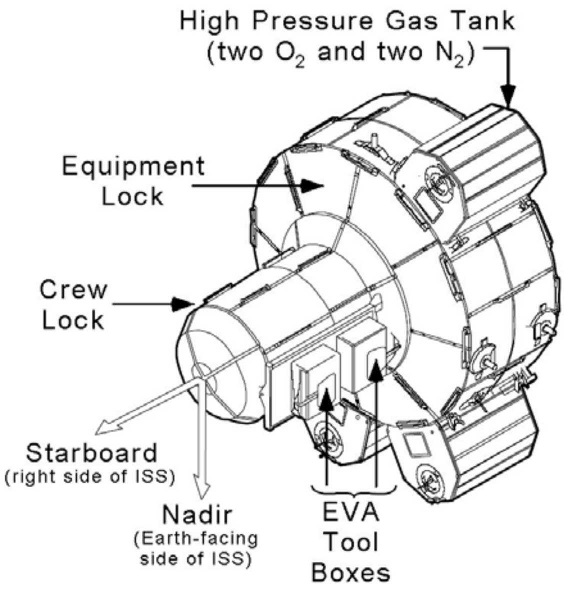


Diagram of the Quest Airlock. (Image: NASA)

units for charging and storing batteries used for powering EVA spacesuit systems and power tools; and pumps for transferring water to the EMUs via the Crew Lock used for thermal stability whilst on EVA.

The Equipment Lock is also used by astronauts for 'camping out' prior to an EVA. This means that the astronauts spend a night in the airlock at a reduced pressure to help purge nitrogen from their blood in order to avoid decompression sickness.

Quest Crew Lock

The Quest Crew Lock is that part of the airlock that is depressurised to a vacuum so that the crew can exit the airlock's EVA hatch to start their spacewalk.

NASA astronaut Charles Hobaugh closing the hatch to the Quest Crew Lock prior to the start of final STS-104 space walk on 20 July 2001. (Image: NASA)

The Crew Lock contains the major interface for supplying consumables to the EVA spacesuits known as the Umbilical Interface Assembly. The EVA spacesuits are connected to this via an umbilical through which they are provided all the necessary consumables: This includes a water supply line for suit cooling, a waste water return line and an oxygen supply line. The assembly also provides a power line for the suit to maintain batteries prior to start of an EVA and a communications line. Two suits can be serviced simultaneously in the Crew Lock.

NASA astronaut James Reilly leaves through the Joint Airlock Quest during the first ever spacewalk from the International Space Station in July 2001. Clear view of Umbilical Interface Assembly at bottom of photo. (Image: NASA)

Prior to starting the EVA a depress pump is used to reduce the pressure in the Crew Lock to 0.2 bar. This is 20% of normal air pressure. The remaining atmosphere is vented to space through the pressure equalisation valve on the EVA hatch. On completion of the EVA, the high pressure oxygen and nitrogen tanks on the external surface of Quest are used to bring the airlock and EVA suit pressures back up to normal levels. Similar pressure valves on the hatches from the Crew Lock to the Equipment lock and from the Equipment Lock to Node 1 are also used to equalise pressure prior to opening of the relevant hatches. In between EVAs EMUs may also be stored in the Crew Lock.

Standard EVA Preparations

Before the airlock hatch is opened and the EVA gets underway there are lots of preparations that have to take place to make sure that the EVA proceeds seamlessly. What follows is an overview of some of the tasks that take place:

ESA astronaut Thomas Reiter (left) and NASA astronaut Steven Lindsey working in the Quest airlock on their first day aboard the ISS on 6 July 2006. (Image: NASA)

Airlock Preparation

With a Shuttle-based ISS assembly mission, after the Shuttle docks with the ISS, relevant equipment is transferred from the Space Shuttle to the Quest airlock in preparation for the EVAs that will take place during the mission. The day before the first EVA starts, the ISS Quest Joint Airlock needs to be configured and activated. The equipment has to be laid out to be easily accessible to the EVA astronauts during the EVA. This includes hardware for installation during the EVA and tools needed to carry out the relevant work, which will also need configuring before the start of the EVA (and during).

ESA astronaut Thomas Reiter (left) looking over a procedure checklist with NASA astronaut Jeffrey Williams in his Extravehicular Mobility Unit in the Quest Airlock of the International Space Station on 28 July 2006. (Image: NASA)

View of EVA tethers and tether lines in the Quest Airlock on the International Space Station. (Image: NASA)

EVA Suit Checkout

The EVA suits are known as Extravehicular Mobility Units or EMUs. These procedures are performed at least 1 day before the EVA. The

NASA astronaut Ed Lu undertaking periodic maintenance of an EMU in the Quest Airlock. (Image: NASA) purpose of EMU checkout is to ensure the integrity of the suits. This can include tasks such as powering up and installing the suits batteries necessary during the EVA, checking the Life Support Systems and Simplified Aid for EVA Rescue (SAFER) units that allow an astronaut to return to the ISS if he comes untethered during the EVA and checking that the suits communication devices are working.

Camping Out (Nitrogen Purge)

Astronauts have to be in very good physical condition in order to undertake an extravehicular activity. One of the potential risks relating to EVA work is decompression sickness. For this reason, prior to the EVA the astronauts go through a regime of breathing pure oxygen in order to purge nitrogen out of their blood systems.

NASA astronauts Piers Sellers (left) and David Wolf during pre-breathe exercises on the STS-112 mission on 10 October 2002. (Image: NASA)

The day before the EVA, the relevant astronauts will sleep in the airlock, which will be sealed and the pressure reduced from 1 bar to 0.7 bar. 1 bar is normal ISS (and earth sea-level) pressure. This process is known as camping out.

The following day after the camp out the airlock will be repressurised to 1 bar in order to open the hatch to the airlock so that the EVA astronauts can take breakfast and carry out their morning ablutions. Before the airlock is repressurised the EVA astronauts will don oxygen masks.

On returning to the airlock the hatch will be closed and the airlock depressurised again over 20 minutes to 0.7 bar. The EVA astronauts will then be assisted into their EVA suits during which process the oxygen masks will be removed.

Donning EVA suits

The EVA suits known as Extravehicular Mobility Units or EMUs are extremely complex, containing many different layers and systems in order to provide the astronaut with an as safe and comfortable environment during EVAs whilst remaining functional for performing the tasks at hand. The EVA astronauts are usually assisted in donning their suits by one or more astronauts, with relevant checks being carried out during this procedure.

Kenneth Bowersox (foreground) and Nikolay Budarin of the ISS Expedition 6 Crew wearing Liquid Cooling and Ventilation Garments in the Node 1/Unity on 12 May 2002. (Image: NASA)

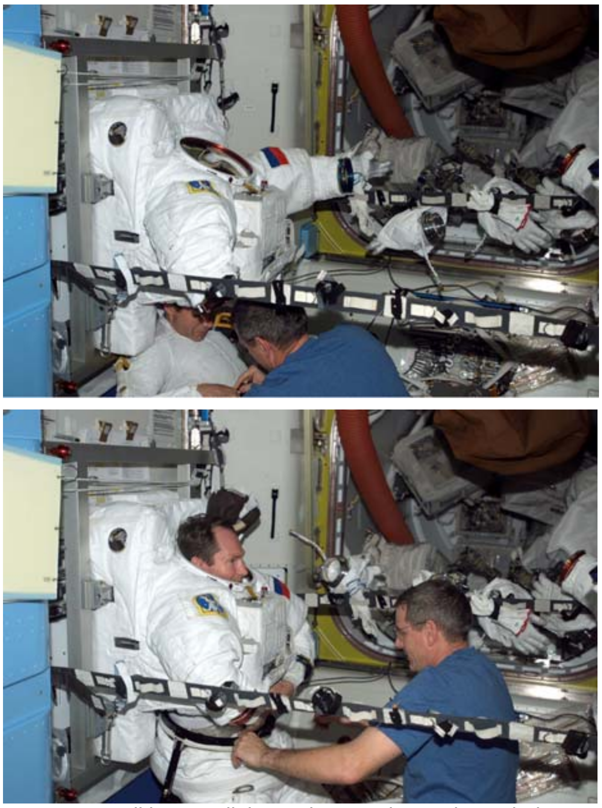
EVA Support Information

The EMUs are principally the same as the Shuttle EVA suit with a few adjustments. EMU-based EVAs are nominally planned for 7 hours, including 15 minutes to egress the airlock, 6 hours of useful tasks, 15 minutes to ingress the airlock, and 30 minutes of reserved unplanned time. In addition, the EMU is equipped with a 30-minute supply of emergency oxygen located in the Secondary Oxygen Pack at the bottom of the Primary Life Support System. This acts as a backup if the primary oxygen supply fails.

When suiting up the astronaut first puts on the urine collection device and then a Liquid Cooling and Ventilation Garment. This spandex garment has water-cooling tubes running through it and also supports a network of ducting that draws ventilation gas from the suit extremities and routes it back to the primary life support system.

NASA Astronaut Stephen Robinson in the Lower Torso Assembly of the Extravehicular Mobility Unit (EMU) space suit during the STS-114 mission on 1 August 2005. (Image: NASA)

The astronaut now gets into the Lower Torso Assembly of the space suit and then rises into the Hard Upper Torso section, which is attached to the airlock wall by an adaptor. The Lower Torso Assembly can be seen as the waist, trousers and boots of the EMU and has separation joints above the knee and above the ankle. The flexible waist section and waist bearing afford the astronaut a large degree of movement about the waist, e.g. bending and hip rotation.



ISS Expedition 12 Flight Engineer Valery Tokarev being assisted into the Hard Upper Torso section of an EMU by Expedition 12 Commander Bill McArthur on 23 October 2005. (Image: NASA)

The Hard Upper Torso is a rigid fibreglass vest onto which the Lower Torso Assembly attaches. It also acts as the attachment point for the helmet and the flexible arm sections, which have an arm bearing to allow for arm rotation. The Life Support System is attached to the back of this assembly with Life Support controls mounted to the front in easy reach of the astronaut. Connections between the two parts must be aligned to enable circulation of water and gas into the Liquid Cooling Ventilation Garment and return. The Life Support System provides the crew member with pure oxygen to breath, removes carbon dioxide exhaled, regulates the temperature in the suit, and keeps the pressure during EVA at 0.3 bar, this is 30% of the air pressure at sea level on Earth and 30% of the normal ISS air pressure. This low pressure is necessary to maintain suit flexibility. If the pressure level was higher the suit would become too stiff to work.

STS-113 Mission Specialist Michael Lopez-Alegria (left) being assisted with his communications headset chin strap by Expedition Six Flight Engineer Donald Pettit in preparation for Extravehicular Activity on 28 November 2002. (Image: NASA)

Once the upper torso section is donned the astronauts put on their communications headset otherwise known as a snoopy cap with headphones and microphones for two-way communications between crew members and to Mission Control. This is followed by the gloves and lastly the extravehicular visor and helmet assembly.

Expedition 12 Flight Engineer Valery Tokarev assists Commander Bill McArthur in donning EMU gloves on 23 October 2005. (Image: NASA)

Expedition Six Flight Engineer Donald Pettit assists STS-113 mission specialist John Herrington with his EMU helmet assembly in the Quest Airlock on 28 November 2002. (Image: NASA)

This provides protection from micrometeoroids and from solar ultraviolet and infrared radiation. This is made of a rugged, impact resistant polycarbonate material. A vent assembly, bonded to the inside rear of the polycarbonate shell, serves to diffuse the incoming gas over the astronaut's face.

The Extravehicular Visor Assembly is a light-and-heat-attenuating shell which fits over the Helmet Assembly. It is designed to provide protection against micrometeoroid activity and accidental impact damage, plus protect the crewmember

ESA astronaut Thomas Reiter with Visor Assembly in use during EVA on 3 August 2006. (Image: NASA)

from solar radiation. A special coating gives the sun visor optical characteristics similar to those of a two-way mirror; it reflects solar heat and light, yet permits the astronaut to see. Adjustable eyeshades may be pulled down over the visor to provide further protection against sunlight and glare.

EVA Support Information

An extra unit that is attached to the EMU once it is donned is the SAFER unit. This is a small, self-contained, propulsive backpack system used to provide a free-flying self-rescue capability for an EVA crewmember if he becomes separated from the ISS during an EVA.

Top: Expedition 13 Flight Engineer Jeff Williams holding the Simplified Aid for EVA Rescue (right in picture) prior to attachment. Bottom: STS-121 Mission Specialist Michael Fossum, holds arms aloft as SAFER unit is attached to his EMU by STS-121 Mission Specialist Stephanie Wilson and Jeff Williams. (Image: NASA)

So as not unnecessarily use up EMU battery power the EMUs will remain plugged into the ISS electrical power supply via an umbilical. The spacesuits will then be ventilated with pure oxygen and the airlock will be repressurised to 1 bar. The EVA crew members will continue the pre-breathe of pure oxygen inside their spacesuits for 50 minutes. The EVA astronauts will go into the crewlock of the Quest airlock where the hatch will be closed. The depressurisation of the crewlock will now be initiated.

Depressurisation

The usual pressure inside the ISS is 1 bar, though in the Quest airlock this is 0.7 bar during depressurisation in connection with nitrogen purging. When the astronauts are in the crewlock ready to start their EVA this pressure is reduced first to 0.35 bar when a leak check is performed on the suits. If this is ok the crewlock is reduced in pressure down to 0.2 bar. The final depressurisation to vacuum occurs through venting through a valve in the EVA hatch. The hatch can now be opened and the EVA can begin.

NASA Astronaut Michael Gernhardt in Extravehicular Mobility Unit during ISS spacewalk on the STS-104 mission on 21 July 2001. (Image: NASA)

NASA astronaut Piers Sellers exiting the Quest Airlock on the International Space Station during the STS-112 mission on 10 October 2002. (Image: NASA)