→ ENVIRONMENT CONTROL AND LIFE SUPPORT SYSTEM (ECLSS)

Several Life Support systems are accommodated at the ISS to safely sustain its crew in conditions similar to those on the Earth. They are distributed amongst the ISS modules. Specific differences exist between the equipment located in the US and Russian Segment.

On-Orbit ISS ECLS Hardware Distribution as of February 2010

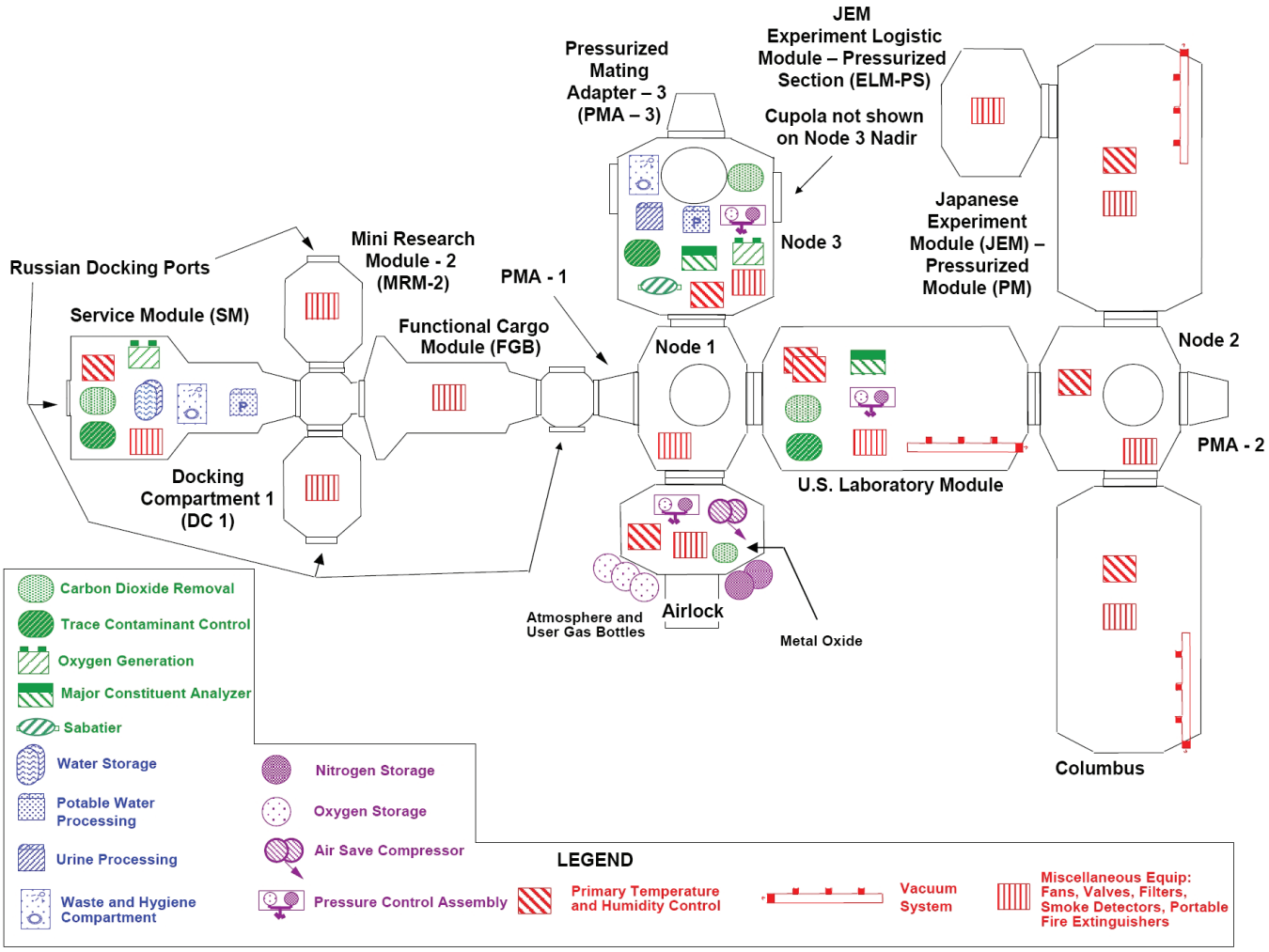


Diagramme: NASA/ISEC

ECLSS in US On-Orbit Segment

1) WATER RECLAMATION SYSTEM, COMPOSED OF:

Urine Processing Assembly (UPA):

- Located in Node 3;
- Re-cycles pre-treated urine and flush water coming directly from the WHC;
- Can also process urine and flush water transferred in a container from the US WHC or the Russian equivalent;
- Produces purified water;
- Designed for 6-7 crewmembers.

Water Processing Assembly (WPA):

- Located in Node 3;
- Process UPA distillate, condensate from the CCAA and system waste water;
- Produces iodinated water which is delivered through a potable water bus to the OGS for oxygen production, the PWS for crew consumption and other systems/payloads;
- Designed for 6 - 7 crewmembers.

2) OXYGEN GENERATION SYSTEM (OGS)

- Located in Node 3;
- OGS is an electrolyser which uses water to produce oxygen (inserted in the cabin) and hydrogen, which is vented over-board until activation of the Sabatier unit;
- Sized for a crew of 11 (continuous mode, normally operated in day/night mode sized for crew of 7);
- Uses water from the WPA or stored in containers.

3) OXYGEN AND NITROGEN TANKS located on the Airlock to compensate for:

- Module leakage (overall ISS leakage of 0.195 kg/day);
- Losses during EVAs;
- A limited number of Solid Fuel Oxygen Generation (SFOG) cartridges are available on-orbit to produce oxygen in case of OGS failure;
- After Shuttle retirement smaller internal tanks will be used.

4) CARBON DIOXIDE REMOVAL ASSEMBLY (CDRA)

- Two units, one located in the US-Lab and one in Node 3.
- Each unit designed for removing carbon dioxide for 7 crew-members.
- A limited number of lithium-hydroxide canisters are available on-orbit to support carbon dioxide removal in case of complete CDRA failure.

5) TEMPERATURE AND HUMIDITY CONTROL (THC)

- Each module on the USOS is equipped with a fan and heat exchanger to control the temperature and humidity in the module;
- Distribution system to provide fresh air to the crewmembers;
- Generally sized for the loads of 3 - 6 crewmember according to the location;
- Condensate is transferred to the WPA for processing.

6) WASTE AND HYGIENE COMPARTMENT (W&HC)

- Located in Node 3;
- To a large extent a copy of the unit located in the Russian Service Module;
- Interfaces with the UPA for water recovery;
- In principle used only by the USOS crew.

7) FIRE DETECTION AND SUPPRESSION (FDS)

- Each module is equipped with smoke detectors (laser type).
- Fire suppression is performed by applying carbon dioxide with a portable fire extinguisher tank.
- In general two fire extinguishers are located in each module.
- Two Portable Breathing Apparatuses (PBAs) dispensing oxyen are available in each module to support the crew during fire fighting emergencies.

8) AIR CONTAMINATION CONTROL (ACC)

- Two units, one located in the US-Lab and one in Node 3.
- Each unit is composed of a Trace Contaminants Control Assembly (TCCA) and a Major Constituent Analyzer (MCA).
- Sized for a crew of 6.
- The TCCA controls concentration of trace contaminants from the cabin air using a charcoal bed (to remove high molecular weight contaminants), a high temperature catalytic oxidizer (to remove low molecular weight contaminants like methane, hydrogen, carbon monoxide) and a lithium-hydroxide sorbing bed (to remove any acid by-products generated in the previous oxidation process).
- The MCA is a mass spectrometer that continuously monitors the partial pressures of oxygen, carbon dioxide, hydrogen, methane, nitrogen and water vapour in the Space Station atmosphere. It can individually sample each module of the USOS.
- Other hand-held equipment is available on-board to measure specific compounds (in particular those related to the presence of combustion products).

9) PRESSURE CONTROL

- Using a set of on-board sensors, including the MCA, oxygen (when required) and nitrogen are inserted in the cabin via pressure regulators.

10) SABATIER

- Located in Node 3.
- Uses hydrogen, a by-product from the OGS oxygen production and carbon dioxide removed by the CDRA to produce water and methane. Water is fed to the WPA for processing and methane is vented over-board.

ECLSS in Russian On-Orbit Segment

Most of the ECLSS equipment in the Russian Segment is concentrated in the Service Module, with the exception of:

- **Temperature and humidity control**, which is also distributed amongst the various modules of the Russian Segment.
- **Fire detection and suppression system**. The fire detection system in the Functional Cargo Block uses ionization-type smoke sensors, while the one in the rest of the Russian Segment uses infrared-type detectors. A foam mixture is used as fire extinguishing agent. Also the Russian system provides re-breathing masks to the crew to support fire fighting cases.
- A cabin air analyzer which is also present in the Fuctional Cargo Block.

In addition the following systems are present:

a) **Micro Purification Unit (BMP)**, which uses a mixture of charcoal and catalytic beds to remove trace contaminants from the cabin air.

b) **Elektron: an Electrolyzer used to produce oxygen from water**. Hydrogen is vented over-board. In general it is used to support a crew of 3. Also a system of oxygen generation candles (SFOG) is available as a back-up system for generation of oxygen.

c) **Vozduk: a carbon dioxide removal system using regenerable adsorbers**. In general it is used to support a crew of 3. Also a system of lithium-hydroxide cartridges is available as a back-up system for carbon dioxide removal.

d) A **Waste and Hygiene Compartment (toilet)**, where all the pre-treated waste (liquid/solid) are stored in disposable containers.

e) A **cabin air condensate regeneration system**, which purifies the condensate collected from the cabin air and dispenses it to the crew as cold/warm water.

f) **Pressure control**: to control the cabin air pressure by introducing nitrogen (and oxygen when required).

g) A **gas analyser of the cabin air** which continuously monitors partial pressures of oxygen, carbon dioxide, water vapor, and hydrogen.

European Development

The Advanced Closed-Loop System (ACLS), accomodated in an ISS rack, can be used for CO_2 concentration, CO_2 reduction and O_2 generation.

ADVANCED CLOSED-LOOP SYSTEM (ACLS)

The Advanced Closed-Loop System (ACLS) is a regenerative life support system for closed habitats. The ACLS uses regenerative processes to cover the following life support functions:

1. Carbon dioxide removal from the spacecraft atmosphere via a regenerative adsorption/desorption process,
2. Breathable oxygen supply via electrolysis of water,
3. Catalytic conversion of carbon dioxide with hydrogen to water and methane.

The ACLS will be accommodated in a double International Standard Payload Rack (ISPR) which will contain all main and support functions like power, data handling and process water management. It is foreseen to be installed onboard the International Space Station (ISS) in the Columbus Module. After an initial commissioning phase, ACLS will be operated as a supplement of the ISS Life Support Subsystems thus enhancing its redundancy. Due to the regenerative processes applied in the ACLS it will allow a significant reduction of water upload to the ISS.

The development of ACLS as an ISS ISPR rack facility started in 2003 with a Phase B.
ACLS is presently in Phase C1 comprised of design development activities supported by breadboard testing.

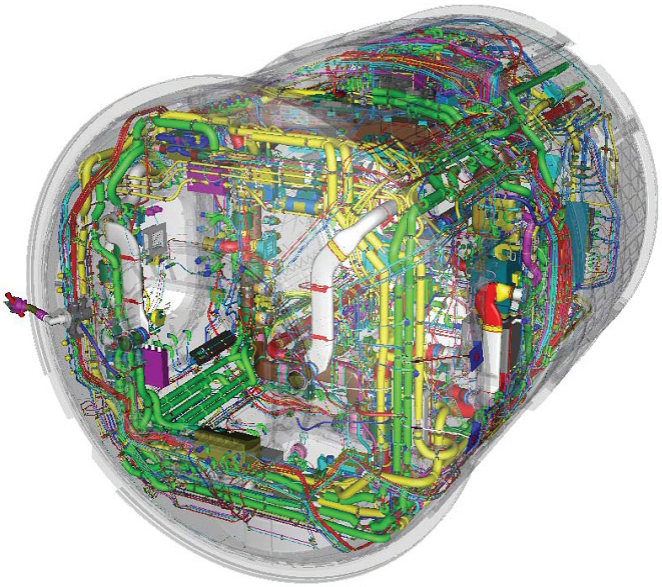
NODE 3 Specifications

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM MAIN DATA

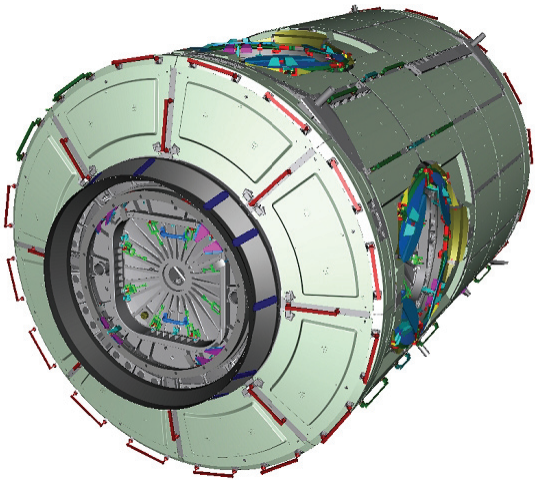
- Cabin pressure nominal range: T = 14.2 to 14.9 psi
- Oxygen and nitrogen distribution:
P = 93 - 120 psia, T = 60 - 113°F from Node 1
- Oxygen Recharge:
P = < 1050 psia (max 16 lb/h), T = 25 - 113 °F from PMA3
- Nitrogen recharge:
P = < 3400 psia (max 3 lb/h), T = 25 - 113 °F from PMA3
- Cabin Temperature nominal range:
T = 65 to 80°F
- Cabin air velocity: 10 to 40 feet per minute
- Atmospheric heat removal and humidity control:
CCAA CHX
- Airborne particulate and microbes removal and disposal:
CCAA Filters
- Waste water collection and distribution
- Fuel cell water and potable water distribution
- Pre-treated urine:
1 line from W&HC to WRS2, P < 5 psig, T = 65 - 105 °F
- Process Water: 4 lines from WRS1 to WRS2
- Cabin smoke detection: 2 Area smoke detectors
- External venting lines: CO_2/CH_4, H_2, MCA, Cabin air
- Air sampling: from Zen, Port, Stbd, Fwd ports to ARS rack (flow rate 100 - 400 scc/min)

ABBREVIATIONS

3WMV	3-Way Modulating Valve
ACC	Air Contamination Control
ACLS	Advanced Closed-Loop System
ARS	Air Revitalization System
BMP	Micro Purification Unit
CCAA	Common Cabin Air Assembly
CDRA	Carbon Dioxide Removal Assembly
CHX	Condensing Heat Exchanger
CTB	Central Thermal Bus
ECLSS	Environment Control and Life Support System
EVA	Extra Vehicular Activity
FDS	Fire Detection and Suppression
ISPR	International Standard Payload Rack
LTL	Low Temperature Loop
MCA	Major Constituent Analyzer
MTL	Moderate Temperature Loop
OGS	Oxygen Generation System
PMA	Pressurized Mating Adapter
PPA	Pump Package Assembly
PWS	Potable Water System
SFCA	System Flow Control Assembly
SFOG	Solid Fuel Oxygen Generation
TCCA	Trace Contaminants Control Assembly
THC	Temperature and Humidity Control
UPA	Urine Processing Assembly
USOS	United States On-Orbit Segment
WHC	Waste and Hygiene Compartment
WPA	Water Processing Assembly
WRS	Waste Removal System



Node 3 - external and internal structure.



Drawings: ESA/NASA