NASA Facts

National Aeronautics and
Space Administration

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FS-2004-12-175-MSFC **December 2004**

International Space Station Environmental Control and Life Support System

NASA's Marshall Space Flight Center in Huntsville, Ala., is responsible for the design, construction and testing of regenerative life support hardware for the International Space Station, as well as providing technical support for other systems that will provide the crew with a comfortable environment and minimize the resupply burden.

The Environmental Control and Life Support System (ECLSS) for the Space Station performs several functions:

- Provides oxygen for metabolic consumption;
- Provides potable water for consumption, food preparation and hygiene uses;
- Removes carbon dioxide from the cabin air;
- Filters particulates and microorganisms from the cabin air;
- Removes volatile organic trace gases from the cabin air;
- Monitors and controls cabin air partial pressures of nitrogen, oxygen, carbon dioxide, methane, hydrogen and water vapor;
- Maintains total cabin pressure;
- Maintains cabin temperature and humidity levels;
- Distributes cabin air between connected modules.

Background

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 done by artificial means.

The life support systems on the Mercury, Gemini and Apollo spacecraft in the 1960s were designed to be used

once and discarded. Oxygen for breathing was provided from high pressure or cryogenic storage tanks. Carbon dioxide was removed from the air by lithium hydroxide in replaceable canisters. Contaminants in the air were removed by replaceable filters and activated charcoal integrated with the lithium hydroxide canisters. Water for the Mercury and Gemini missions was stored in tanks, while fuel cells on the Apollo spacecraft produced electricity and provided water as a byproduct. Urine and waste-water were collected and stored or vented overboard.

The Space Shuttle is a reusable vehicle, unlike those earlier spacecraft, and its life support system incorporates some advances. But it still relies heavily on the use of consumables, limiting the time it can stay in space. Advances include removing carbon monoxide from the air by converting it to carbon dioxide and passing it through a reusable carbon dioxide removal assembly in place of the lithium hydroxide assembly initially installed on the Shuttle. This process greatly reducing the stowage volume and the crew time required, since no components require replacement during normal operation.

The International Space Station includes further advances in life support technology and relies on a combination of expendable and limited regenerative life support technologies located in the U.S. Destiny lab module and the Russian Zvezda service module. Advances include the development of regenerable methods for supplying oxygen (by electrolysis of water) and water (by recovering potable water from waste-water). These advances will help to reduce the cost of operating the Space Station because it is expensive to continue launching fresh supplies of air, water and expendable life support equipment to the Station and returning used equipment to Earth.

Providing Clean Water and Air

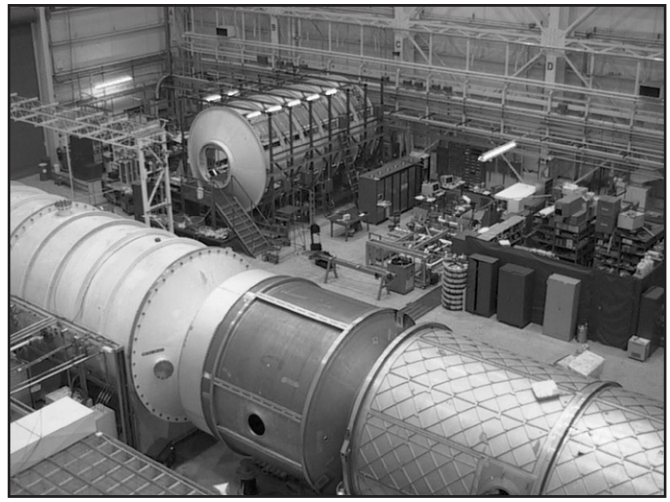
The Space Station Environmental Control and Life Support System consists of two key components — the Water Recovery System (WRS) and the Oxygen Generation System (OGS). These systems are being jointly designed and tested by the Marshall Center and Hamilton Sundstrand Space Systems International in Windsor Locks, Conn. They are packaged into three refrigerator-sized racks that will be located in the U.S. Lab of the Station.

Water Processing Flight Experiment

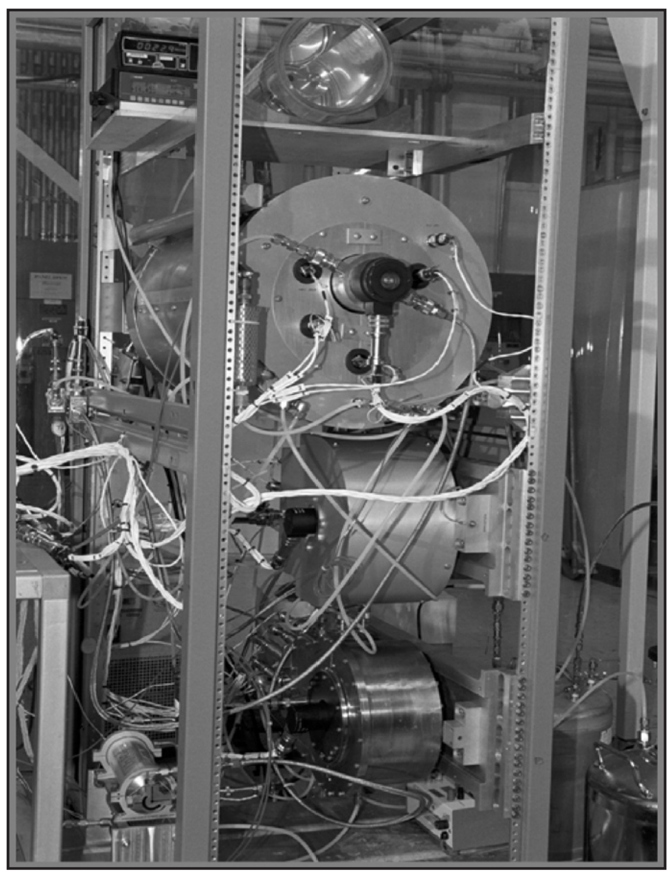
Space Station Water Processor Test Area

The Water Recovery System provides clean water by reclaiming wastewater, including water from crewmember urine; cabin humidity condensate; and Extra Vehicular Activity (EVA) wastes. The recovered water must meet stringent purity standards before it can be used to support crew, EVA, and payload activities.

The Water Recovery System is designed to recycle crewmember urine and wastewater for reuse as clean water. By doing so, the system reduces the net mass of water and consumables that would need to be launched



MSFC ECLSS Test Facility



Urine Processor Flight Experiment

from Earth to support six crewmembers by 6,000 pounds (2,760 kg) per year.

The Water Recovery System consists of a Urine Processor Assembly (UPA) and a Water Processor Assembly (WPA). A low-pressure vacuum distillation process is used to recover water from urine. The entire process occurs within a rotating distillation assembly that compensates for the absence of gravity and therefore aids in the separation of liquids and gases in space. Product water from the Urine Processor is combined with all other wastewaters and delivered to the Water Processor for treatment. The Water Processor removes free gas and solid materials such as hair and lint, before the water goes through a series of multifiltration beds for further purification. Any remaining organic contaminants and microorganisms are removed by a high-temperature catalytic reactor assembly. The purity of product water is checked by electrical conductivity sensors (the conductivity of water is increased by the presence of typical contaminants). Unacceptable water is reprocessed, and clean water is sent to a storage tank, ready for use by the crew.

The Oxygen Generation System produces oxygen for breathing air for the crew and laboratory animals, as well as for replacement of oxygen lost due to experiment use, airlock depressurization, module leakage, and carbon dioxide venting. The system consists mainly of the Oxygen Generation Assembly (OGA) and a Power Supply Module.

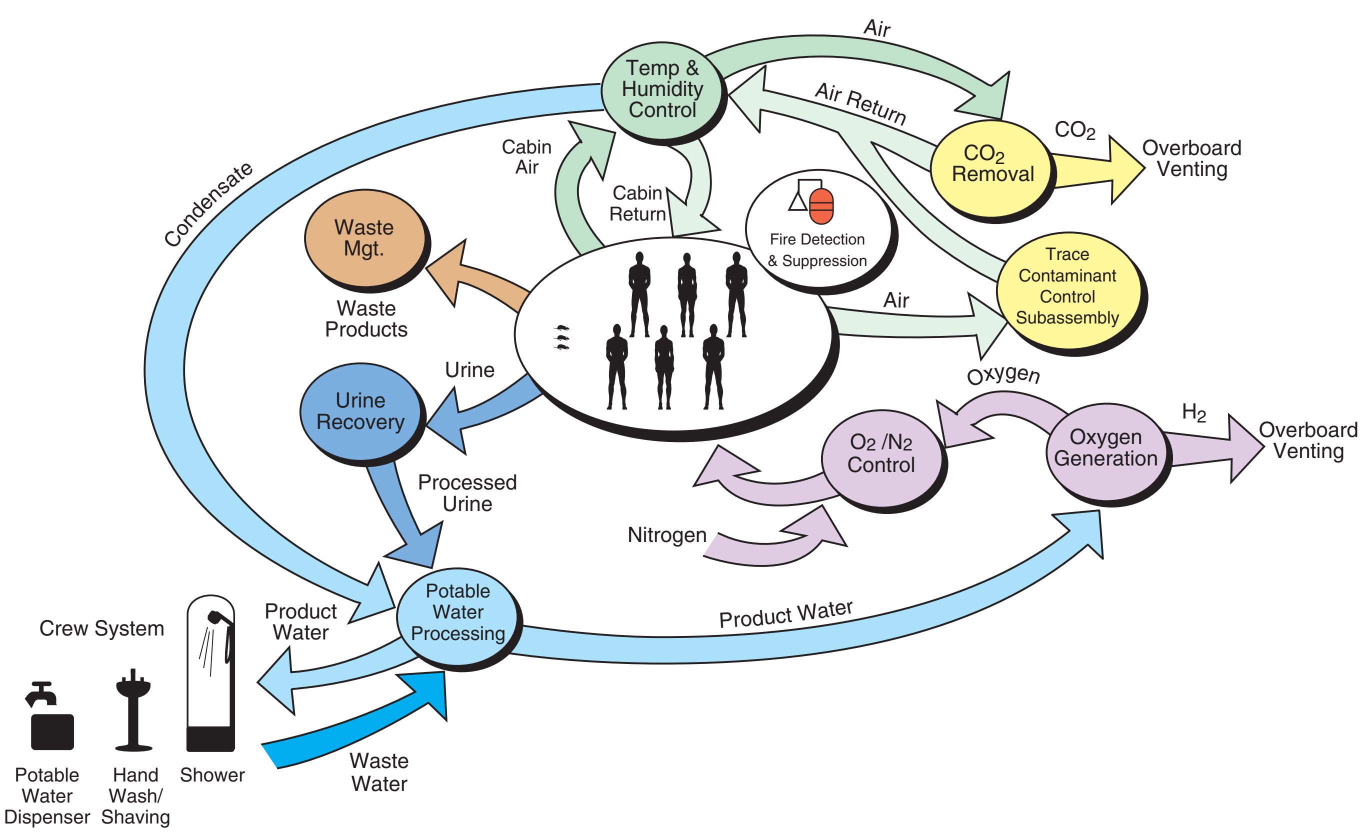
The heart of the Oxygen Generation Assembly is the cell stack, which electrolyzes, or breaks apart, water provided by the Water Recovery System, yielding oxygen and hydrogen as by-products. The oxygen is delivered to the cabin atmosphere while the hydrogen is vented overboard. The Power Supply Module provides the power needed by the Oxygen Generation Assembly to electrolyze the water.

The Oxygen Generation System is designed to generate oxygen at a selectable rate and is capable of operating both continuously and cyclically. It will provide from 5 to 20 pounds (2.3 to 9 kg) of oxygen per day during continuous operation and a normal rate of 12 pounds (5.4 kg) of oxygen per day during cyclic operation.

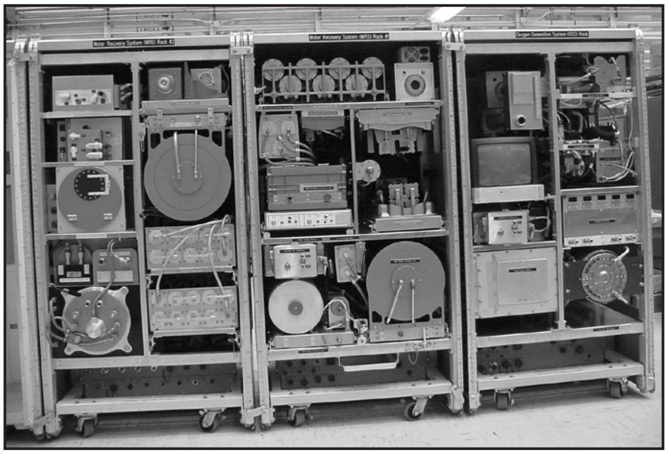
The Oxygen Generation System will accommodate the addition of a Carbon Dioxide Reduction Assembly (CReA). Once deployed, the reduction assembly will cause hydrogen produced by the Oxygen Generation Assembly to react with carbon dioxide removed from the cabin atmosphere to produce water and methane. This water will be available for processing and reuse, thereby further reducing the amount of water to be resupplied to the Space Station from the ground.

Ground testing before flight

Before the Environmental Control and Life Support System hardware is launched to the International Space



Regenerative Environmental Control and Life Support System Diagram



Prototype ECLSS Racks

Station and put into operation, it will undergo extensive testing on the ground and in space.

The Marshall Center maintains facilities for testing and evaluating life support technologies. These facilities also allow engineers on the ground to troubleshoot on the ground any problems encountered in space. Testing includes life cycle tests to determine maintenance and change-out requirements, operational tests, such as those using volunteers to generate waste-water for the Water Recovery System, and integration tests of flight hardware for the Space Station.

Space-proven hardware

Portions of the Environmental Control and Life Support System hardware will be flight-tested before being installed aboard the Station. The Volatile Removal Assembly, for example, flew aboard STS-89 in January 1998, to demonstrate the microgravity performance of the Water Processor Assembly's catalytic reactor.

The Marshall Center also is responsible for the Vapor Compression Distillation Flight Experiment, which flew aboard the Shuttle on STS-107 in 2003 to demonstrate the use of a full-scale Urine Processor Assembly in weightlessness.

Other Areas of Responsibility

The Marshall Center also provides technical support for U.S.-supplied life support equipment onboard the Station, which, together with the Russian-supplied environmental and life support equipment in the Zvezda service module, provide redundant systems for safety. This equipment, located in a payload rack in the U.S. Destiny laboratory module, Unity node, Airlock, and Multi-Purpose Logistics Module, includes:

- the Atmosphere Revitalization System and its components — the Trace Contaminant Control Subsystem, Major Constituent Analyzer, and Carbon Dioxide Removal Assembly — which removes carbon dioxide and trace contaminants from the cabin atmosphere and monitors the composition of the air;
- the Temperature and Humidity and Control subsystem, which helps maintain a habitable environment in the Station by removing heat and humidity, and circulating the cool dry air. Circulation of the atmosphere minimizes the temperature variations, ensures a well-mixed, breathable atmosphere and supports smoke detection;
- and the Fire Detection and Suppression subsystem, which provides fire detection sensors for the Station, fire extinguishers, portable breathing equipment and a system of alarms and automatic software actions to alert the crew and automatically respond to a fire.

Future

Ultimately, expendable life support equipment is not suitable for long duration, crewed missions such as the Space Station due to the resupply requirements. It is expensive to continue launching fresh supplies of air, water and expendable life support equipment to the Station and returning used equipment to Earth. On deep space missions in the future, such resupply will not be possible, due to the distances involved, and it will not be possible to take along all the water and air required due to the volume and mass of consumables required for a voyage of months or years. Regenerative life support hardware, which can be used repeatedly to generate and recycle the life sustaining elements required by human travelers, is essential for long duration trips into space.

To recover more usable mass from waste matter, an enhancement of the Oxygen Generation System is also under development by the Marshall Center that will recover additional water from carbon dioxide. Once completed, a Carbon Dioxide Reduction Assembly added to the Oxygen Generation System will allow the byproduct hydrogen produced by the Oxygen Generation Assembly to be reacted with carbon dioxide removed from the cabin atmosphere. The products of the reaction are methane and re-useable water. Such enhancements will further reduce the amount of expendables that must be resupplied, and enable longer duration missions to more distant destinations in space.