National Aeronautics and
Space Administration

Life Support Systems Design and Development

Robust Life Support for Human Exploration of Space

Life support is foundational to human exploration of the solar system, whether during launch, on orbit in the ISS, or beyond Earth orbit. As Marshall partners pursue the ultimate goal of fully closed-loop, regenerative, integrated air/water life systems, the Center is also focused on reducing system complexity and emphasizing precision assembly to improve the reliability of future systems.

Marshall has the infrastructure in place to support life-support systems capabilities — from chemical laboratories and machine shops to environmentally controlled flight hardware testing laboratories and simulators for future mission hardware testing. The unique facilities, along with extensive experience and expertise, advance technology capabilities for future human space missions as well as follow-on spinoff applications on Earth.

At-A-Glance

To extend the International Space Station (ISS) and for future exploration missions to reach beyond low-Earth orbit (LEO), environmental control and life support systems require improving cost, mass, and efficient technical assembly of future systems. Marshall Space Flight Center leverages its expertise in life support systems and close collaboration with research and industry partners to advance toward a goal of fully closed-loop, regenerative, and integrated air/water life support systems.

Spinoff Technology

While the ISS environmental life support system makes it possible to live in space and is essential for future exploration, the technologies developed have resulted in practical, tangible benefits on Earth.

Advanced Bosch CO2 technology leads to reduced climate threat and increased brick strength

Learning how to homestead Mars is also helping Marshall and commercial partners develop techniques to reduce CO2 emissions on Earth. Studies have shown that the presence of well-dispersed carbon nanofibers or nanotubes in cement results in concrete with dramatically improved material characteristics. That knowledge combined with Marshall's experience with Bosch-based life support CO2 technology will enable long-duration missions to recover 100 percent of the oxygen from metabolic CO2.

Regolith could also be used in 3D printing materials to support a Mars base. Rather than releasing carbon produced in the process, the new approach incorporates carbon as nanotubes and fibers that strengthen the bricks. Using an in situ catalyst for life support and re-using the materials to further support base construction and operations, will greatly reduce supply and resupply needed from Earth.

While advancing the Bosch process for exploration, Marshall is partnering with companies in the cement industry, currently the fourth-ranked global emitter of CO2. Capturing carbon and incorporating it into the cement product would help reduce a climate threat while improving brick tensile strength.

Adsorbent coating technology benefits trace contaminant control

Today, the ISS refreshes the cabin atmosphere by using physical adsorbent pellets to remove CO2 at room temperature and pressure and then release it when exposed to a higher temperature and the vacuum of space. However, dust from the adsorbent pellets presents challenges.

NASA, industry, and academic partners are testing alternative approaches to prevent dust release, such as coating adsorbent materials onto a microscopic metal lattice, leading to a more robust CO2 removal process design. This adsorbent coating has spinoff benefits for trace contaminant control and water vapor removal.

Water reclamation supports worldwide water purification efforts

By efficiently recycling wastewater aboard the space station, the need to resupply water is reduced. A component of the ISS regenerative environmental control life support system is the Water Recovery System (WRS), which conducts the water purification and filtration process. Commercial companies have adapted the WRS to an Earth-based water treatment system. The commercialization of this station-related technology has provided aid and disaster relief for communities worldwide.

The Atmosphere Revitalization Recovery and Environmental Monitoring project is advancing current state-of-the art CO2 removal systems.

Extending ISS Life Support Systems

Marshall designs, constructs, and tests regenerative life support hardware for the ISS. For example, before its 2008 launch, the Water Recovery System (WRS) and Oxygen Generation System (OGS) in the station's U.S. segments underwent extensive design, development, and testing on the ground at Marshall and in space.

The ISS WRS and OGS have each recycled more mass in consumables than sent to orbit.

	Mass Reduction to Mass Launched (lbs)
WRS	5:1
OGS	2.6:1

Potentially higher mass-based ROIs that will enable and enhance long-duration human missions beyond LEO will require reductions in both the initial system masses and their recurring mass replacement rates. The basic challenge with reducing initial system mass is to develop smaller and lighter equipment that can provide the same level of performance and functionality as is provided by today's state-of-the-art equipment. Marshall is addressing this by reducing recurring mass to develop longer-life equipment that is not expended as it operates (e.g., filters) and that is less prone to failure.

Marshall's extensive systems development and integration expertise, spanning all phases of the station's environmental control and life support life cycle, will allow the Center to continue major roles to evolve state-of-the-art environmental control and life support systems and technologies meeting NASA strategic priorities (high reliability, reduced logistics, higher efficiencies, etc.) for human exploration.

Enabling Future Human Exploration Missions

A challenge for life support systems is "closing the loop," for evolving advanced technologies that convert human waste into pure consumables. These will reduce the costs of supplying permanent operations in Earth orbit and enable missions deep into the solar system.

Today's ISS life support system recycles about 88 percent of the wastewater and 50 percent of the oxygen. The balance is lost and must be replenished from Earth. Marshall and its partners are evaluating new catalyst materials and techniques to develop a highly reliable, robust integrated air/water system. This work builds on two established chemical processes, Sabatier, converting hydrogen and CO2 into methane and water, and Bosch process, converting CO2 and hydrogen into carbon and water.

Marshall's module simulators allow testing of future environmental life support systems.

Marshall leverages its deep expertise in these kinds of systems and its close collaboration with research and industry production partners to combine air and water into an integrated, closed-loop, regenerative system.

Unique Facilities

Marshall's ECLSS Test Facility allows side-by-side testing for quantitative, objective comparisons. Support services include distributed control/data acquisition systems interfaced to a centralized data archiving system, a chemistry laboratory, a machine shop, and an environmentally controlled room for flight hardware testing.

ECLSS system engineers and scientists on the ground can troubleshoot any problems encountered in space. Examples include:

- Bench-top, assembly, subsystem, and system tests to determine performance and reliability and to assess alternative ECLSS architectural approaches
- Operational tests using volunteers in daily activities such as exercise and showering to generate wastewater for reuse
- Qualification and acceptance tests of flight hardware for the space station

In future mission profiles, astronauts are expected to live in modules below standard sea-level pressure, but with the equivalent oxygen level, to reduce spacecraft mass. Marshall has two module simulators, the Exploration Test Chamber (E-Chamber) and the Vacuum Test Chamber (V-Chamber), to mimic that living environment to test future ECLSS hardware.

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