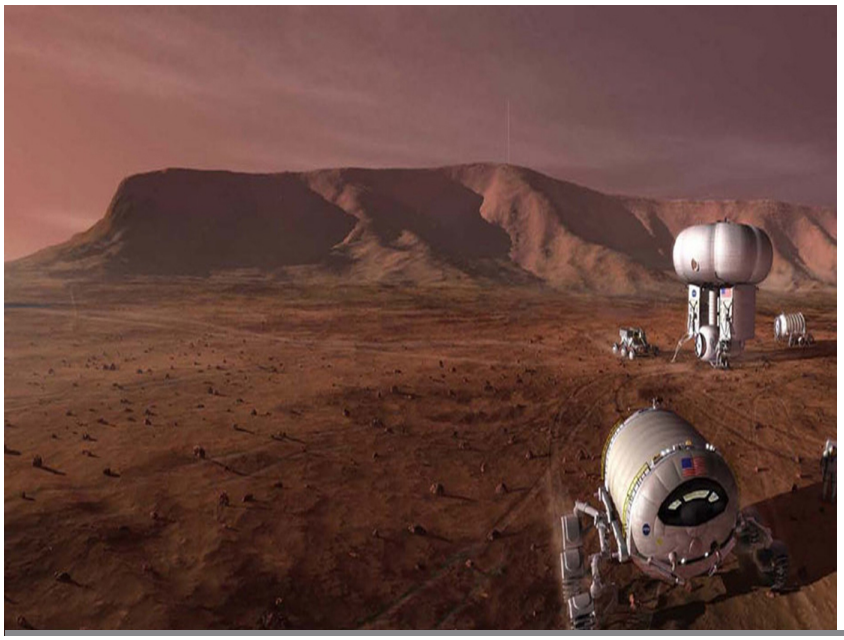


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Environment

Closed Ecological System Network Data Collection, Analysis, Control, and Optimization System

A Rapid, Low-Cost Approach to Permanently Extend Life Beyond Earth

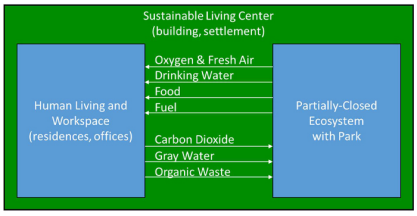
The Earth's biosphere is the most sophisticated complex adaptive system known to exist in the entire universe and has persisted for over 4 billion years. A complex adaptive system is a network of interacting adaptive systems whose nonlinear dynamics and emergent behaviors are difficult to predict and control; therefore, for such systems, past performance is no guarantee of future results, which is particularly the case for the Earth's biosphere during a period of exponential technological growth. NASA Ames Research Center presents a novel, patent-pending adjustable-autonomous intelligent systems approach for developing sustainable, small-scale reproductions of subsets of the Earth's biosphere that can be distributed both on and beyond Earth, for improving the quality of life for all life, expanding the diversity of life, studying and protecting life, as well as enabling life to permanently extend beyond Earth.

BENEFITS

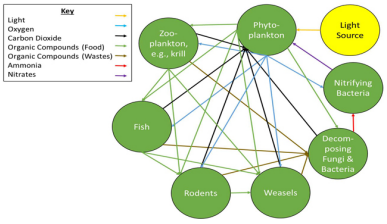
- Closed EcoSystems (CESs) can be used as spacecraft payloads or Earth test-beds to study the long-term effects of various sealed, dynamic environments, including changing gravity and radiation levels, on interacting populations of organisms
- Sustainability: Offers "reduce, reuse, and recycle" benefits
- Autonomous operation: Does not require flight crew attention; can function for long duration on manned and unmanned spacecraft
- Holds the prospect of permanently establishing life beyond Earth; initially with microbes, plants, and small animals, but ultimately in CESs with humans
- Reduction in cost and complexity: Brings monitoring and actuation to closed ecosystems to help automate and increase the sustainability of the environment
- Real-time monitoring: Uses cloud-based technology to monitor sensor arrays across multiple ecosystems in real time, allowing for long-term monitoring of sustainability experiments
- Algorithms and data: Adaptive algorithms and data derived from experiments will provide unforeseen insights

THE TECHNOLOGY

The technology relates generally to controlled ecosystems, and more particularly, to a Controlled Closed-Ecosystem Development System (CCEDS) that can be used to develop designs for sustainable, small-scale reproductions of subsets of the Earth's biosphere and the Orbiting Modular Artificial-Gravity Spacecraft (OMAGS). The technology encompassing a CCEDS includes one or more a Closed Ecological Systems (CESs), each having one or more Controlled Ecosystem Modules (CESMs). Each CESM can have a biome containing at least one organism, and equipment comprising one or more of sensors, actuators, or components that are associated with the biome. A controller operates the equipment to effect transfer of material among CESMs to optimize one or more CESM biomes with respect to their organism population health, resilience, variety, quantities, biomass, and sustainability. A CES is a community of organisms and their resources that persist in a sealed volume such that mass is not added or removed. The mass (food/air/water) required by the CES organisms is continually recycled from the mass (waste) produced by the organisms. Energy and information may be transferred to and from a CES. CES research promises to become a significant resource for the resolution of global ecology problems which have thus far been experimentally inaccessible and may very well prove an invaluable resource for predicting the probable ecological consequences of anthropogenic materials on regional ecosystems. In order to create CESs that are orders of magnitude smaller than the Earth that can function without the Earth, the desired gravity level and necessary radiation shielding must be provided by other means. Orbiting Modular Artificial-Gravity Spacecraft (OMAGS) is a fractional gravity spacecraft design for CES payloads and is depicted in Figures below. In tandem, the CCEDS and OMAGS systems can be used to foster gravitational ecosystem research for developing sustainable communities in space and on Earth.

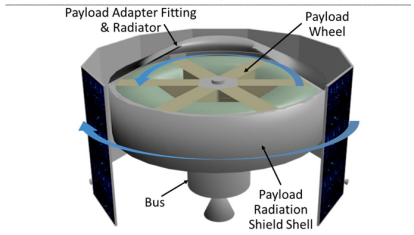


An Example of a Sustainable Living Center



An Example of a Sample CES with Mammals and Aquatic Organisms

OMAGS Preliminary Concept



OMAGS Concept Cutaway View

APPLICATIONS

The technology has several potential applications:

- Study of life under variable radiation and gravity conditions, both in space and on Earth
- Study of evolutionary adaptative trajectories taken by living organisms in persistent low-gravity and high radiation environments
- Long-term life sustainability in space environments and evolution in space environments
- Aquariums and bottle gardens industry
- Small pet industry (no feeding, cleaning, or smell)
- Commercial space industry
- Self-contained ecosystems
- Vertical agriculture
- Fermentation in pharmaceutical manufacturing
- "Artificial gut microbiome" to facilitate drug testing, antibiotic production

PUBLICATIONS

Patent Pending

https://ntrs.nasa.gov/citations/20190000114

https://ntrs.nasa.gov/citations/20180007936

technology.nasa.gov

NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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More Information

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