Enabling Technology To Support Science in Space For Life On Earth

RFP No. CASIS 2014-2 | RFP Issued: February 26, 2014 | Proposals Accepted: March 10, 2014
Step-1 Proposals Due: April 10, 2014 | Step-2 Proposals Due: June 27, 2014

THR ARCHIMEDES PROJECT

Large Scale Zero-G Hydroponic Plant Growth for the Bigelow BEAM Module STEM Educational Tools for Elementary, Middle and High School Students

Thomas Lee Elifritz
Director of Research
The Archimedes Group
221 East Main Street
Marshall, Wisconsin, USA
elifritz@charter.net
(608) 541-8311

In the summer of 2011, NASA selected CASIS, a nonprofit organization, to maximize use of the International Space Station U.S. National Laboratory for improving life on Earth. While NASA continues to support ISS research to advance space exploration goals, the ISS National Lab space managed by CASIS is focused on research and technology development with ground benefits: exploiting the space environment to advance basic science and translational research with commercial application for the improvement of life on Earth. CASIS facilitates use of the ISS National Lab by non-NASA U.S. government agencies and by academic and private institutions, providing access to the laboratory's permanent microgravity setting and vantage point in low Earth orbit as well as the varied environments of space.

I. GENERAL INFORMATION

Hypothesis

Zero-g hydroponic systems can be quickly fabricated from inexpensive, lightweight plastic parts and assembled in the Bigelow BEAM module to make measurable and significant contributions to carbon dioxide management on the International Space Station (ISS), through large scale fast plant growth.

Any reductions in cabin carbon dioxide through rapid plant growth will relieve the mechanically complex and labor intensive Sabatier reactor, and free up valuable human resources for science. Water condensation is a considerably easier process to perform, and any food produced will greatly enhance lives of onboard scientists, and reduce the amount of resupply needed to conduct scientific operations.

Concurrent real time operational broadcasts to earth based analog operations in a large number of elementary, middle and high school laboratories, will bring crowd sourcing to bear on problems of large scale agriculture in zero gravity, while supplying valuable STEM educational experiences.

Key Words *(for indexing purposes)* Hydroponics, Plants, Environment, Science, Students

Clearly state the hypothesis. If the project is hardware development or technology demonstration, a short statement of objective is appropriate.

Team Members

1. *Name, Title* Thomas Lee Elifritz, Director *Entity* The Archimedes Group

Does your team include any NASA employees? No

Does your team include any international collaborators? No

Commercial Partners TBD - To Be Developed

Has this proposal previously been reviewed by another funding agency? No

Have you previously submitted a proposal to CASIS? No

Will your project require IRB/IACUC approval? No

Note: For proposals employing animals, assurance of compliance with animal care and use provisions is required as described in Section 3.5 sub-section V of this document.

Estimated Project Timeline in Months from Award Selection

Preflight development and testing 6 months

Time to flight 12 months

Time to completion 24 months

Proposed Implementation Partners Orbitec, Bigelow Aerospace, NASA *(optional)*

II. COMMERCIAL RELEVANCE

This section should describe the potential influence of the project on specific commercial sectors.

Downstream Applications ECLSS, CELSS, Food Production, Building Materials and Methods

Estimated Time to Market Immediate *(optional)*

(i.e., time for research to translate into commercial application)

List Relevant Commercial Sectors Estimate Addressable Market Size

Consumer Agriculture, Plastics Industry, Chemical Industry, Science Education, Space Tourism

Building Materials and Concepts

III. PROJECT DETAILS

Does this submission include proprietary information? No

Is the project ground-based or space-based? Space

What are the potential downstream commercial Earth applications of your project? If the research project addresses primarily fundamental science questions, explain the importance of the project toward knowledge advancement in applicable fields and the long-term path/timeline to a tangible product, healthcare advancement, or intangible benefit to the U.S. Population.

Science, technology, engineering and mathematics education in the classroom and in the laboratory.

Necessity of the National Lab

Full time, large scale, zero-g, hydroponic plant growth requires a full time zero-g laboratory.

Responsiveness to RFP

Life on Earth and in space is completely dependent upon plant growth. Certainly in space the science of plant growth should be the highest priority, and this appears to be a problem that can be readily solved.

Required Materials/Hardware

One kilowatt of power, hydroponic plastic wares, water and nutrient reservoirs, water condensing unit, LED lighting and plant grids, plants from Veggie, student supplied monitoring, diagnostics and control.

Earth Benefits

Growing plants is fundamental to human existence.

Project Summary

All advanced life forms on planet Earth are biological. From a set of instructions encoded into DNA, plants perform photosynthesis using the energy of solar irradiance, carbon dioxide, water and nutrients to create molecular compounds such as free oxygen, proteins, sugars and carbohydrates, in a process called transpiration, and oxygen breathing organisms consume those plant products to use in metabolic processes such as respiration, thinking, exercising and science, producing carbon dioxide and wastes.

In a highly advanced technological society on a spacious planet with extraordinarily large quantities of raw materials, it's easy for citizens to lose sight of the understanding of this fundamental fact of nature. In a closed space station in a vacuum, however, it's impossible to escape fundamental biological reality. This problem transcends all others, and is defined by zero-g hydroponic plant growth in light irradiated, closed environmental space habitats, a remarkably different environment than one gravity planet Earth.

In some previous essays[1] I have codified this approach to sustainable space flight, in the form of large sun pointing inflatable habitats in pressurized upper stage fuel tanks, with light provided by deployable thin film solar parabolas and mirrors, concentrating and reflecting that light through the hatch windows. Plant habitats would be optimally placed into orbits with infinite orbital lifetimes and unlimited light.

The Bigelow Beam module and the Orbitec Veggie system offer advances by bringing this problem to the immediate attention of a large sector of the population through facility user broadcast participation. One gravity, earth analog, miniature, closed hydroponic laboratories may be established within ground based educational institutions and classrooms, supplanted with low data rate monitoring of space based hardware using the recently canceled Space Station Live format, with real time interactivity provided. Operations can be scaled up to the one kilowatt range, and radically cheaper hydroponic techniques developed, in order to facilitate a greatly expanded and permanently lit space habitation of the future. My hypothesis is that this project is necessary and critical to all space station science based efforts, that it is easily achievable within the facilities indicated, the time frames involved and costs anticipated, and that it is essentially immune to failure, since failures are expected from crowd sourcing of the problems to STEM students, and both the Bigelow Beam habitat and the Orbitec Veggie units are experimental. Furthermore, its relevance to science is indisputable, since plants sit at the bottom of our food chain.

Rather than just shipping more Veggie units to the ISS, I propose a one kilowatt continuous LED light system for the Bigelow Beam module (since continuous sun pointing light is not available on the ISS), a water condensation humidity removal unit and individual plant grid growing stations for the maturing plants, transferred over directly from the initial Orbitec Veggie hardware. In this manner large and long fruit and vegetable bearing vine plants can be allowed to flourish, greatly expanding the light collection and carbon dioxide absorbing capabilities of the system. This becomes a ready made and continuous student laboratory facility, encompassing every aspect of modern STEM education, and providing the necessary and critical introduction to the plant growth, production, decay and soil formation processes that we all depend upon for our lives; a topic sorely lacking in our K-12 and undergraduate schools. So, in addition to improving the lives of real and potential astronauts and scientists, I intend to create them.

[1] The Space Place – The Place for Space, http://webpages.charter.net/tsiolkovsky/Space_Place.pdf
The Space Colonization of Planet Earth, http://webpages.charter.net/tsiolkovsky/Earth_Space.pdf
The Future of Life on Earth, http://webpages.charter.net/tsiolkovsky/Life_On_Earth.pdf
The Archimedes Project, http://webpages.charter.net/tsiolkovsky/Space_Station.pdf (this document)

Please describe the proposed project (1000 words maximum).

If the project is space-based, why does your project require the ISS National Lab? Clearly state why the space environment is necessary and/or superior to a ground-based approach.

If the project is ground-based, how does your project enable and/or enhance utilization of the ISS National Lab?

Please be succinct: Describe why your project is responsive to the RFP; in this case, briefly state why your project enables future ISS National Lab research.

List any materials/hardware that must be flown to the ISS in order to complete the project.

What is the relevance of the proposed space-based research to ground applications (e.g., healthcare advancements, commercial product development—in agreement with the CASIS mission to use the ISS National Lab for benefits to life on Earth)?

Please be succinct: This may overlap somewhat with Section II. Reminder: Projects enabling space exploration goals are supported by NASA, not CASIS, and will be considered unresponsive to this RFP.