

NCERA-101 Station Report
Sierra Space/ORBITEC, Madison WI

September 1, 2022 – April 15, 2023

Robert C. Morrow, 1212 Fourier Drive, Madison WI, 53717
Phone: 608 229-2728, E-mail: robert.morrow@sierraspace.com

1. Impact Nugget.

Sierra Space continues to develop environmental control technologies for space-based biological and physical-chemical life support systems, technologies that may have applications for terrestrial environmental control systems.

2. New Facilities and Equipment.

Sierra Space will be moving operations into a larger space over the next year and a half. This facility is in Middleton WI and provides about six times the volume Sierra Space currently has in our existing Madison and Middleton facilities. This facility will contain large assembly areas, cleanrooms, laboratories, controlled environment facilities, and extensive office space.



Figure 1. New Sierra Space facility scheduled to come online in early 2024.

3. Unique Plant Responses

Our XROOTS payload successfully demonstrated plant growth using aeroponics in microgravity.

4. Accomplishment Summaries

Microgravity Plant Growth

Veggie

The Veggie units fabricated by Sierra Space were delivered to the ISS in 2014 and 2017. The 2014 unit was replaced with a new unit in 2022. These units continue to be actively used to support plant research, crop production testing, and technology demonstrations on the ISS.

APH

Sierra Space also continues to support the Advanced Plant Habitat Unit on ISS. The APH was delivered to orbit in 2017 and is being regularly used for academic & government plant research.

XROOTS

XROOTS was designed with multiple independent growth chambers used in parallel to evaluate aeroponic and hydroponic nutrient and water delivery in microgravity. XROOTS was launched on NG-17 in February 2022. The Technology Demonstration completed operations on ISS at the end of October 2022 and components are in the process of being returned to Earth. As a middeck locker equivalent sized payload, XROOTS was mounted in an EXPRESS Rack below a Veggie lighting module. XROOTS allowed for root zone and plant observation through video and still images, and short periods of crew observations. Sierra Space monitored and controlled payload operations

from our Payload Operations Center (POC) in Madison, WI. Operations were conducted over a six-month period, with individual tests lasting between 10 and 80 days. Species grown during these tests included;

- Micro Tina Dwarf Tomato
- Cherry Belle Radish (Figure 2)
- Earligreen Dwarf Pea
- Apogee Dwarf Wheat (Figure 2)
- Mizuna Mustard (Figure 2)
- Outredgeous Lettuce
- Little Gem Lettuce

XROOTS demonstrated the feasibility of using aeroponic and hydroponic techniques for plant growth in microgravity (Figure 3). Results of these tests will help optimize design and performance of hydroponic systems for large scale plant production in space.



Figure 2. L>R Radish, Mizuna, and Dwarf Wheat plants grown in aeroponics system on ISS.



Figure 3. L>R Micro Tina tomatoes in XROOTS; Dwarf wheat, Outredgeous lettuce and Micro Tina tomato in XROOTS payload hardware, Outredgeous lettuce in XROOTS.

Aerospace Environmental Control & Life Support Systems

Sierra Space is collaborating with Blue Origin to develop a commercial space station called Orbital Reef (Figure 4). Part of the station core will be comprised of Sierra Space's Large Inflatable Fabric Environment (LIFE) habitat modules. The LIFE habitat plans include 2-3 Astro Garden modules (Figure 4, Figure 5). The Orbital Reef will be serviced in part by Sierra Space Dream Chaser vehicles.



Figure 4. L>R Orbital Reef design with LIFE inflatable habitats; Orbital Reef module concept with Astro Garden plant growth systems.



Figure 5. Sierra Space Large Inflatable Fabric Environment (LIFE) mockup. Interior view of habitat showing Astro Garden salad crop production system

5. Impact Statements

- Sierra Space is currently working on three large flight systems. These include Dream Chaser, a winged space vehicle (<https://www.sierraspace.com/space-transportation/dream-chaser-spaceplane/>), LIFE, a large inflatable habitat (<https://www.sierraspace.com/space-destinations/life-space-habitat/>), and Orbital Reef, a large integrated space station being developed in partnership with Blue Origin (<https://www.sierraspace.com/space-destinations/orbital-reef-space-station/>).
- Sierra Space is working toward development of hybrid life support systems for space applications, integrating biological and physical/chemical technologies, advancing this technology to meet the performance and quality needs of long duration space applications. Some of this technology may be transferable to terrestrial protected agriculture systems.
- Sierra Space continues to develop LED lighting configurations and control strategies for plant and human lighting applications to provide increased lighting system utility for aerospace and gravitational biology applications.
- Sierra Space continues to use its environmental control, gravitational biology, and human life support work in our outreach efforts to spark interest in middle school, high school, and college students toward STEM fields.

6. Published Written Works

None since last station report

7. Scientific and Outreach Oral Presentations

Wetzel, J., R. Morrow, G. Tellez, D. Wyman, and M. DeMars. 2022. XROOTS aeroponics and hydroponics nutrient delivery in microgravity. ASGSR Oral Presentation

Morrow, R., J. Wetzel, S. Moffatt, and M. Blair. 2022. The role of plants in a commercial space station. ASGSR Investigators Poster

8. Other relevant accomplishments, news, and activities.

The Space Systems Group of Sierra Nevada Corporation (which includes what used to be ORBITEC, then the Space Systems Group of Sierra Nevada Corp), is as of January 2023 a fully independent company called Sierra Space. Our applications group is still focused on Propulsion and Environmental Systems (including plant payloads), and continues to operate in our facilities in Madison, Middleton, and Baraboo Wisconsin.

9. Websites:

Sierra Space <http://www.sierraspace.com/>