NCERA-101 Station Report
Sierra Nevada Corporation/ORBITEC, Madison WI

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1. Impact Nugget.

SNC 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.

Murphy Drive Facility

SNC has just completed a third facility in the Madison WI area that will be used to develop flight hardware for life support and propulsion systems. In addition to office space, the facility provides several cleanrooms, a high bay assembly area, multiple specialty assembly labs (e.g. electronics, coatings, softgoods), and bonded storage. Some images from this building are shown in Figure 1 and Figure 2.

Figure 1. View showing high bay assembly area (left) and large-equipment cleanroom (right).

Figure 2. View showing bonded storage (left) and high bay assembly area (right).

Badger Large Scale Test Facility (LSTF)

This facility is a large scale propulsion test facility (Figure 3) to support SNC propulsion research and engine development. It is being constructed on the site of the former Badger Army Ammunition Plant in Baraboo Wisconsin and replaces an old test facility previously used by ORBITEC. It supports multiple test cells with associated fuel storage, control rooms, and other support facilities.

Figure 3. Badger Large Scale Test Facility (LSTF) for SNC propulsion testing.

SNC Controlled Environment Plant Facilities

SNC is continuing to recover from flooding that occurred last August and destroyed several of our controlled environment facilities in Madison. Figure 4 shows the status of the effort. These facilities should be fully on line by May 2019.

Figure 4. SNC "Orbiculture lab" immediately after flood (left) in August 2018 and in process of renovation (right) March 2019.

3. Unique Plant Responses.

Potatoes can grow well in soilless culture systems and are even grown in aeroponic systems commercially to produce seed stock. Challenges are primarily related to the large size of potato plants in traditional growing systems. We are investigating the growth of a red skin potato variety (cv. Norland) in a salad crop production module consisting of eight, one cubic foot growing zones. This module uses an aeroponics water and nutrient delivery system. During preliminary testing, we found that by constricting the shoot volume we could constrain an individual potato plant while still allowing tuber initiation and development. While not as productive as standard growth systems, we were able to produce over 14 tubers in a one cubic foot growing area over about 100 days, equivalent to 112 tubers in an eight cubic foot growing module (Figure 5). This provides the potential to grow potatoes, which require relatively little processing , as part of a salad crop diet architecture for hybrid life support.

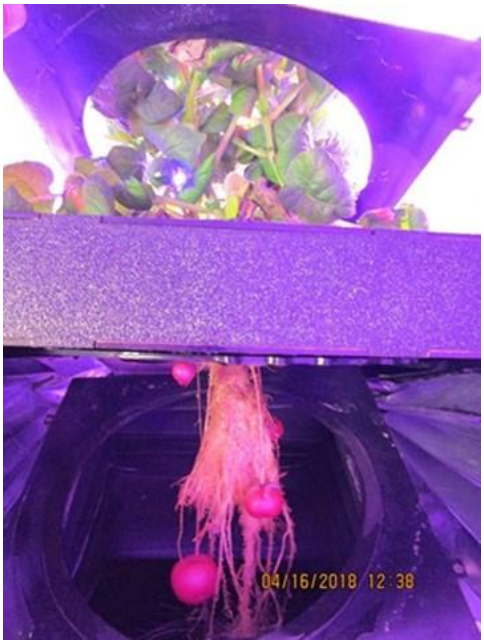

Figure 5. Potato Shoot and Root Growth, and Tuberization in Single Astro Garden Chamber.

4. Accomplishment Summaries.

Hybrid Life Support Systems- Plant Culture Units

SNC is continuing work on the development of Exploration Life Support Salad Crop production as an early stage implementation of hybrid life support systems (combination of bioregenerative and physical-chemical life support technologies). Current efforts include development of aeroponic and nutrient film technique (NFT) hydroponic systems for use in the space environment as a way to significantly reduce the mass, power, and volume of plant nutrient delivery systems while maintaining good plant productivity. This work consists of three components, a series of parabolic flights investigating aeroponic and nutrient film technique systems for use in microgravity, a technology demonstration experiment on the ISS looking at these same parameters, and development of a ground based high fidelity prototype with >6 m^2 of growing area for testing NASA identified salad crops.

Space Biology

SNC continues to work with the Kennedy Space Center (KSC) to support the two Veggie plant growth systems that are on-board the ISS.

The Advanced Plant Habitat that SNC delivered to the Kennedy Space Center is operating on the ISS to support a wide range of microgravity plant research. This system is the largest plant growth system put in space to date.

The SNC Mass Measurement Device developed to support animal and plant sciences is now operational on the ISS.

Aerospace Environmental Control & Life Support Systems

SNC continues to work with Commercial Crew Integration Capabilities partners for development of human Life Support and Thermal Control systems for space habitats. During the last year SNC completed a full scale mockup of its Large Inflatable Fabric Environment (Figure 6), designed for long-duration human activity in lunar orbit, as a potential component for NASA's planned moon-orbiting Gateway architecture. This Gateway vehicle is designed to support a 1,100-day mission orbiting the moon. It also can support deep space missions. The module can accommodate up to four astronauts at a time, who would typically be on board for missions of 30 to 90 days per year.

Figure 6. Sierra Nevada Corporation Large Inflatable Fabric Environment mockup. Top-view of inflatable structure. Bottom -Interior views of habitat showing Astro Garden salad crop production system.

5. Impact Statements

- SNC is working toward development of hybrid life support systems for space applications, integrating biological and physical/chemical technologies.
- SNC is advancing the technology of controlled environment systems to meet the performance and quality needs of long duration space applications. Some of this technology may be transferable and scalable to terrestrial protected agriculture systems.
- SNC 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.
- SNC continues to use its space biology controlled environment work and human life support work to spark interest in high school and college students in controlled environment technology and STEM.

6. Published Written Works.

- Accommodating Science and Technology Development Sortie Missions in the Post Space Shuttle Era. Robert C. Morrow, John P. Wetzel, Robert C. Richter, Kathy Benzin, and Christopher Allison. 48th International Conference on Environmental Systems. ICES-2018-304.
- Heat Melt Compactor Test Unit, John P. Wetzel , Robert J. Surdyk , Joe Klopotic, Krishnaswamy K. Rangan. 48th International Conference on Environmental Systems ICES-2018-318.

7. Scientific and Outreach Oral Presentations.

- Performance of potatoes in the Astro Garden salad crop production system. Robert C. Morrow, Nathaniel R. Smith, Jacob R. Schoville, John P. Wetzel. ASGSR 2018
- The done, the doable, and the daunting challenges of plumbing aboard spacecraft: Advanced water management for life support. M. Weislogel, J. Graf, C. Hinojosa, J. McQuillen, M. Sargusingh, K. Venkateswaran, J. Wetzel, R. Wheeler. ASGSR 2018

8. Other relevant accomplishments, news and activities.

The branch of Sierra Nevada Corporation that used to be ORBITEC is now referred to as "Sierra Nevada Corporation Propulsion and Environmental Systems". We continue to operate in our facilities in Madison, Middleton, and Baraboo Wisconsin.

9. Websites:

Sierra Nevada Corporation http://www.sncorp.com/