NCERA-101 Station Report
Orbital Technologies Corporation, Madison WI

March 31, 2014-June 30, 2015

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

1. Impact Nugget:

ORBITEC continues to work with with NASA Kennedy Space Center on the development of controlled environment plant growth systems for research aboard the International Space Station.

2. New Facilities and Equipment.

All of our current facilities underwent refurbishment and renovation this year. We are also building an anechoic chamber as part of our test facility and have purchased a Coordinate Measuring Machine (CMM). We have modified one of our LED growth rooms with vertical LED lighting arrays.

3. Unique Plant Responses.

Nothing to report.

4. Accomplishment Summaries.

Greenhouse lighting

We developed a supplemental lighting system for greenhouse productivity testing that is about 80ft^2 in area with multiple control zones and waveband options. It is being used to investigate the impact of light quality on secondary plant metabolites.

Space Plant Biology

ORBITEC is working with the Kennedy Space Center (KSC) to support the Veggie plant growth system hardware that is on-board the ISS. Currently, Veggie has been used to grow one crop of lettuce and to conduct part of the APEX experiment series. The Veggie team continues to work toward the goal of obtaining clearance from NASA to allow ISS crews to consume crops produced in the Veggie hardware.

Veggie plant growth unit on the ISS. (L) Veggie flight unit installation, (R) 'Outredgeous' lettuce being harvested from Veggie unit.

ORBITEC continues to support KSC in the development of the Plant Habitat system that will be used for plant research aboard the International Space Station. When flown, this system will be the largest plant growth system put in space to date. It is expected to fly in 2016. The Plant Habitat Engineering Development Unit is currently undergoing testing in preparation for fabrication of the flight units.

Aerospace Environmental Control

- ORBITEC has fabricated and tested engineering development units for the Zero-g Mass Measurement Device (ZGMMD), designed to determine the mass of small specimens such as

mice on the International Space Station, and the Non-thermal sanitizing by atmospheric pressure plasma (NTSAPP), designed to sanitize fresh food in a space environment.

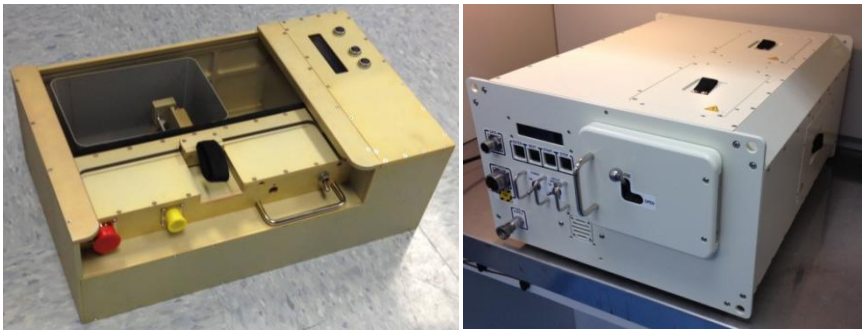

Figure 1. ZGMMD prototype (left) and NTSAPP prototype (right).

- ORBITEC continues to work with Commercial Crew Integration Capabilities partners for development of human Life Support and Thermal Control systems.

5. Impact Statements.

- ORBITEC 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 protected agriculture systems.
- ORBITEC is developing LED lighting configurations and control strategies that provide increased lighting system utility in addition to increased operating efficiency.
- ORBITEC is using its space biology controlled environment work to spark interest in high school and college students in protected agriculture technology and STEM.

6. Published Written Works.

Kopsell, D.A., C. E. Sams, and R.C. Morrow. 2015. Blue wavelengths from LED lighting increase nutritionally important metabolites in specialty crops. HortScience (Accepted for Publication).

Morrow, R. 2014. A Brief History of Growing Plants in Space. Resource Magazine May/June 2014 issue. Pg. 17-19. American Socienty for Agricultural and Biological Engineering.

Poulet, L., G. Massa, R. Wheeler, T. Gill, C. Steele, R.C. Morrow, and T. Swarmer. 2014. Demonstration test of electrical lighting systems for plant growth in Hi-Seas analog Mars habitat. IAC-14, A5, 2.0x25271.

Poulet, L., G.D. Massa, R.C. Morrow, C.M. Bourget, R.M. Wheeler, C.A. Mitchell. 2014. Significant reduction in energy for plant-growth lighting in space using targeted LED lighting and spectral manipulation. Life Sciences in Space Research 2:43–53.

7. Scientific and Outreach Oral Presentations.

University of Tennessee-Knoxville Dept. of Plant Sciences Seminar Series-Growing Plants in Space. June 26, 2014

Other relevant accomplishments, news and activities.

- **ORBITEC** has been acquired by Sierra Nevada Corporation (SNC), a prime systems integrator and electronic systems provider in high-tech electronics, engineering, and manufacturing. Sierra SNCs Space Systems Division has capabilities in spacecraft systems, propulsion, space exploration systems, and space technologies. SNC launches something into orbit every two to three weeks.
- ORBITEC provided tours of our facilities and projects, including those related to controlled environments, to several student groups during the last year. We continue to high several

interns each year, primarily engineering students but also an occasional biology student. We currently have about 20 engineering students and 1 biology student working as interns.

- ORBITEC continues to be a vendor for Space Gardens (an outreach/education plant growth system) and lunar and mars regolith simulant materials.
- ORBITEC supported a biological payload display at the 2014 annual meeting of the American Society for Gravitational and Space Research.

- ORBITEC continues to chair the ICES Life Science/Life Support Research Technologies session at the annual ICES meeting.

8. Websites:

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