An Aerospace Experience at ORBITEC
2016 WSCG Industry Internship Award

Brian Andryk [1]

UW – Madison Mechanical Engineering Department

Abstract
The objective of the 2016 Wisconsin Space Grant Consortium (WSCG) Industry Internship Award is to allow students to gain valuable aerospace involvement through an internship with an industry partner. During my industry partnership with ORBITEC, I experienced the aerospace industry through a variety of projects. Some of these projects include but are not limited to the Vegetable Production System (VEGGIE), Zero Gravity Mass Measurement Device (ZGMMD), and Plastic Melt Waste Compactor (PMWC). My internship opportunity not only gave me important insights into engineering, but it also led to a full time engineering position with the company.

Introduction & Background

The Wisconsin Space Grant Consortium (WSCG) Industry Internship Award gives students the opportunity to partner with an industry sponsor to gain experience in the aerospace industry. Starting in May of 2016, I received the WSCG Industry Internship award to work with ORBITEC, an aerospace engineering company in Madison. While ORBITEC is deeply rooted in many aspects of the aerospace industry, the company mostly specializes in human life support and propulsion systems. Their mission statement is to: "Develop, demonstrate, and deploy innovative technologies and advanced products that enhance the quality of human life and support mankind's exploration of the universe." The following sections summarize the projects that I worked on during my tenure as well as my contributions.

Vegetable Production System (VEGGIE)

The Vegetable Production System (VEGGIE) is used to produce vegetable (salad) crops to supplement prepackaged foods during long stays in space. The innovation of the VEGGIE is in providing, within a single middeck locker, a plant growing facility with a growing area of 0.25m2 to 0.5m2, a light source sufficiently intense for crop production, a compressible nutrient and water delivery system, and a semi-passive atmospheric control system that minimizes water use without limiting gas exchange (ORBITEC, 2012). The system is deployed using an expandable enclosure, as shown in (Fig. 1).

Fig. 1: Flowers growing inside a VEGGIE unit

[1] Special thanks to the Wisconsin Space Grant Consortium (WSGC) who provided the necessary funding for student involvement on these projects Introduction & Background

To minimize complexity, VEGGIE utilizes the ambient environment for temperature control and as a source of CO_2. Plants can be grown in several root mat modules that are filled with a nutrient rich soil simulant as depicted in (Fig. 2). The primary goals of VEGGIE are to provide the crew with a nutritious and safe source of fresh food as well as tool for relaxation and recreation (ORBITEC, 2003).

My contributions to this project were assisting in the build and delivery of four ground units for NASA. Specifically, I was responsible for the assembly and fabrication of the test stand that holds the light assembly above the plants. NASA will use these units as a test control to study the effects of gravity as an identical VEGGIE unit grows plants in space.


Fig. 2: VEGGIE root mat modules growing cabbage

Zero Gravity Mass Measurement Device (ZGMMD)

The Zero Gravity Mass Measurement Device (ZGMMD) provides the ability to measure the mass of samples in a microgravity environment such as that found on the International Space Station (ISS). One of the primary measurements often taken during science experiments is mass. This is even more relevant in biology where mass is often one of the key measurements taken for analysis. However, scales on earth rely on gravity to measure mass. This creates a need for a scale that can measure the mass of small objects within a high degree of resolution in microgravity environments.

The ZGMMD, shown in (Fig. 3), is innovative in that it can provide the ability to measure mass in the range of 5 to 1,000 grams in microgravity, lower than any other microgravity mass measurement devices currently on the ISS.

The fundamental principle behind the ZGMMD is Newton's second law, which states that the acceleration of an object is proportional to the resultant force acting on it and inversely proportional to its mass. With the assumption that mass does not change with respect to time then:
*Force = Mass * Acceleration (F = m * a).*

Fig. 3: Top View of the Zero Gravity Mass Measurement Device (ZGMMD)

By utilizing Newton's second law, it can be seen that mass could be derived if you knew that an object was being accelerated, and you were able to quantify both the acceleration and the forces acting upon it. The resulting equation (upon rearranging the previously shown equation) would be: $m = F / a$.

Where the mass is found from the measured force (F) on load cells in the unit; and the acceleration (a) is exerted by an actuator, which controls the acceleration.

During my internship, I was responsible for studying the consistency of the ZGMMD across multiple cycles. A major issue I discovered was that earth's gravity caused the system to shake during operation and thus would provide inconsistent results. To overcome this issue, we redesigned the mass mounting bracket to provide more stability during operation. Additionally, I assisted in the assembly of two flight units either by drafting drawings and work instructions or by performing the assembly myself (ORBITEC, 2013b).

PMWC

The Plastic Melt Waste Compactor (PMWC) is a trash dewatering and volume reduction system that uses heat melt compaction to remove nearly 100% of water from trash and reduce the volume by up to 11 times. The full PMWC system incorporates novel methods to compress the trash, recover water, and remove the melted plastic tile. This system is designed as a standalone system and only requires access to power, data, and air cooling interfaces. The system is suitable for recovering water and compacting all trash sources on the ISS. Additionally, the system has also been designed to recover water from brine solutions produced by water-processing spaceflight life support systems. This fills acritical water recovery need for the ISS as water, like all expendable resources on the ISS, is an incredibly expensive resource.

The PMWC, depicted in (Fig. 4), works by heating and compressing trash simultaneously to first remove water and then to melt plastic in the trash. The melted plastic encapsulates the trash into a 16-inch square tile, approximately one inch thick. In addition to making it easier to store the compressed trash, the polyethylene in the melted plastic gives the tile the ability to act as a radiation shield (ORBITEC, 2014).

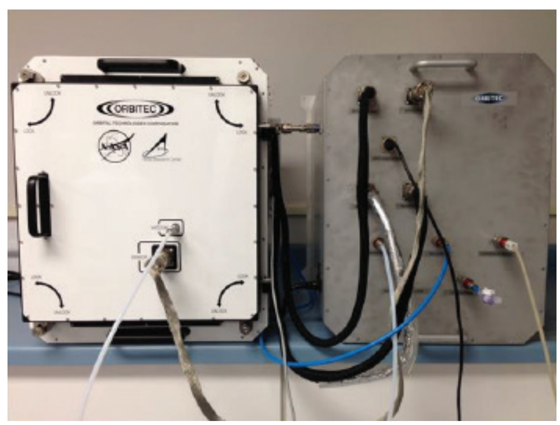

Fig. 4: Front view of the plastic waste melt compactor (left) and support equipment (right)

During my tenure, I worked extensively on testing and troubleshooting the system to improve water recovery and system efficiency. A persistent issue early on was the variable water output from test to test. To study this issue, I examined the effects of the trash packing arrangement. In the end, I found that packing arrangement played a large role in water recovery and could be optimized if the wettest trash was closest to the heat source.

Other ORBITEC Projects

The projects described in the previous sections of this report illustrate most of my involvement with ORBITEC. However, over my time with the company I was exposed to several other major projects described in the following sections.

Dream chaser. Sierra Nevada Corporation's Dream Chaser spacecraft is a reusable cargo resupply vehicle designed for transportation missions in low-Earth Orbit. The vehicle will mostlybe used to deliver both unpressurized and pressurized cargo to the ISS. Because of the unique design of the Dream Chaser, depicted in (Fig. 5), the spacecraft has the ability to land on runways and thus salvages expensive space equipment after each launch.

ORBITEC is responsible for the environmental/thermal control and reaction control systems. This includes but is not limited to thermal and oxygen regulation onboard the spacecraft as well as the reaction control thrusters that would direct the spacecraft on orbit.

Fig. 5: Assembly of Sierra Nevada Corporation's Dream Chaser Spacecraft

Advanced plant habitat. Advanced Plant Habitat (APH) is a large, enclosed, environmentally controlled chamber designed to support commercial and fundamental plant research onboard the ISS. It is configured as a quad-locker payload so it can be mounted in a Space Station (EXPRESS) Rack on ISS. APH, (Fig. 6), integrates proven microgravity plant growth technologies with newly developed fault tolerance and recovery technology to increase overall efficiency, reliability, and robustness. The design allows the user to control plant lighting, gas concentrations, and humidity within the growth chamber (ORBITEC, 2013a).

Vortex engine. The vortex combustion cold wall (VCCW) liquid rocket engine uses a stable vortex flow field to confine combustion products to a region in the core of a rocket engine. During launch, (Fig. 7) the chamber walls remain cool because they are heated only by radiant heat from the combustion products and are cooled by neat propellant that is caused to swirl along the chamber wall inner surface. A benefit of this technology is that the thrust chamber can be made of much less expensive materials by far less expensive processes. Also the service

Fig. 6: Plants growing inside of the advance plant habitat (APH)

life of the combustion chamber can be greatly extended so cost is further reduced and safety and reliability are improved (ORBITEC, 2001).

Future Work

The WSCG Internship Award gave me the opportunity to partner with ORBITEC to gain experience in the aerospace industry. This incredible experience not only taught me several lessons about the engineering problem solving process, but also led to a full time mechanical engineering position with the company. In a full time engineering position, I am now responsible for designing and building a plant tray assembly for the Advanced Plant Habitat. While majority of my time is spent on the Advanced Plant Habitat, I also do design work and consulting for several other projects described in the sections above like the Vegetable Production System and the Zero Gravity Mass Measurement Device.

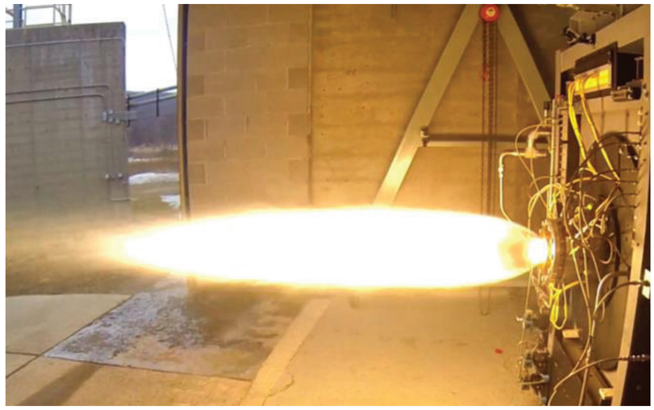

Fig. 7: Vortex Engine Test Launch

References

ORBITEC. (2001). VCCW III-B Proposal. Madison WI.

ORBITEC. (2003). VEGGIE Phase 1 Final Report. Madison WI.

ORBITEC. (2012). VEGGIE Fabrication Proposal Rev A. Madison WI.

ORBITEC. (2013a). Plant Habitat. Madison WI.

ORBITEC. (2013b). ZGMMDPhase II Proposal Rev 4. Madison WI.

ORBITEC. (2014). Aggregate Final Status Report. Madison WI.