Building a Plastics Fabrication Laboratory on the ISS: FabLab, MANTIS, Refabricator, CRISSP, ERASMUS, and MAMBA

Rachel Muhlbauer[1], Nathan Britton[1], Nicole Bentzen[1], Allison Porter[1], Tim Pizzino[1], Robert Hoyt[1], Tracie Prater[2], Niki Werkheiser[2], Kim Hambuchen[3]

[1]Tethers Unlimited, Inc.
11711 N. Creek Pkwy S. Suite D113
Bothell, WA 98011
425-486-0100
muhlbauer@tethers.com

[2]NASA Marshall Space Flight Center
Huntsville, AL 35812

[3]NASA Johnson Space Center
Houston, TX 77058

The objective of NASA's In Space Manufacturing program is to develop manufacturing technologies and processes necessary to provide "on-demand, sustainable operations for exploration missions." Using the ISS as a test bed, in 2014, NASA installed and successfully tested a 3D printer for in-space operations, demonstrating the 3D printing process as well as sending digital files for printing from earth to the printer. The success of this technology demonstration has shown that on-orbit manufacturing technologies can be used to limit the earth reliance for cis-lunar missions. Because of this success, numerous opportunities have been provided by NASA to further in-space manufacturing by focusing on the development of highly autonomous manufacturing systems, recycling technologies, and robotics with the ultimate goal of building a fabrication laboratory now within reach.

From technologies developed for ISS activities and demonstration missions, Tethers Unlimited, Inc. (TUI) is building a Plastics Manufacturing Laboratory capable of fabricating parts on-demand and as-needed while recycling waste plastics with minimal human interaction required. Parts will be manufactured through additive manufacturing. Precision machining will ensure manufactured parts are in tolerance with the end-use requirements. Recycling waste plastics will enable both waste from the crew and waste from processing to be re-processed into something new. In addition, these manufacturing and recycling technologies are supported by part verification/validation technique and robotic servicing, minimizing human interaction with the system and eventually enabling unmanned off-world manufacturing.

In this paper, technology developments from each individual effort will be presented and shown how these individual efforts come together to create the eventual Plastics Manufacturing Lab. Results from initial work performed on new technologies, such as the Zero-G CNC developed in the MAMBA project (Metal Advanced Manufacturing Bot-Assisted Assembly) and the newly funded FabLab part verification/validation effort, will be presented. We will discuss updates to TUI's Refabricator ISS technology demonstration mission, slated for launch in 2018, which will demonstrate for the first time in space closed-loop recycling using an integrated recycler-3D printer. An update will be given for CRISSP (Customizable, Recyclable ISS Packaging) and ERASMUS, discussing the results of the on-going efforts to increase the number of materials recyclable and printable on the ISS, the sanitization and sterilization of those materials for food-safe and medical device applications, and the results of a 3D printed packaging

study. Finally, an update to TUI's KRAKEN technology, a compact modular robotic manipulator, and its potential ISS demonstration mission MANTIS (Modular Advanced Networked Telerobotic Interface System) will be shown. The MANTIS payload, bound for the ISS in 2020, is an EXPRESS Rack locker containing a deployable 7 axis, 1m configuration of the KRAKEN arm that will demonstrate teleoperation of adjacent EXPRESS Rack payloads such as Nanoracks' Microplate Reader; this demostration raise the TRL of payload automation in preparation for nominal use of KRAKEN in larger systems, such as the Plastics Fabrication Laboratory.