Logistics Reduction: Trash Compaction and Processing System (LR-TCPS)

Project Introduction

The Advanced Exploration Systems, Logistics Reduction project called the Trash Compaction and Processing System (TCPS) is a waste management technology. Currently, there are no trash management practices that are being implemented in the space environment other than manual compaction of waste into a plastic bag. The current practice does not recover critical resources such as water, does not prevent the growth of potentially harmful microbiological pathogens, and provides only limited volume reduction.

The objective of the TCPS task is to develop a reliable trash processing system to support long endurance human space missions (target TRL 8/9). NASA plans a TCPS technology demonstration on the International Space Station (ISS).

The TCPS objectives are to: *reduce volume of trash*, *safen* processed trash to reduce risk of biological activity, *stabilize* processed trash for efficient storage and disposal, and to *recover water and manage gaseous effluents*. The TCPS will process trash into tiles and can be used for radiation shielding augmentation. For a one-year, four-person crew mission, it is estimated that TCPS could recover ~8 cubic meters of habitable volume, produce over 900 kg of radiation shielding tiles, and recover 230kg of water from ~1,300 kg of trash. Additionally, the tiles could be jettisoned during a transit mission to reduce propellant needs.

FY2012-FY2018

This period saw the development of the Heat Melt Compactor (HMC). The HMC is a full-scale TCPS precursor that was developed to refine previous versions' trash processing capabilities, finalize operational parameters, and identify hardware issues. During the period between FY2012 and FY2016 various trash compactor prototypes were developed. This included an SBIR Phase 2 Plastic Melt Compactor System developed by Orbital Sciences Corporation (aka Sierra Nevada Corp), and the Generation 1 HMC developed at Ames. In FY2016, a Generation 2 (Gen2) HMC with an ISS "flight-like" design was designed and built at Ames. Limited Gen2 HMC ground testing began in 2017 but was not completed due to inability to reach desired compaction pressure and vacuum. In FY2018, the hardware was repaired to partially restore its desired capability. Several SBIR awards related to the HMC have occurred in the following areas: microgravity-compatible condensing heat exchanger designs, trash bag liners to allow hygienic tiles after HMC processing, and general HMC system design.

FY2019 – FY2021

In FY2019, two contractors were selected for Phase A contracts under the NASA Next Space Technologies for Exploration Partnerships (NextSTEP) Appendix F: Logistics Reduction in Space by Trash Compaction and Processing System (TCPS), Broad Agency Announcement (BAA). The two contractors were the Sierra Nevada Corporation (SNC) and UTC Aerospace Systems (UTAS), also known as Collins Aerospace. The BAA is given here: https://www.nasa.gov/feature/nasa-selects-two-companies-to-help-take-out-the-deep-space-trash/

Phase A was implemented in FY19-20 and completed in FY20. Phase A developed and validated TCPS flight concepts to inform future flight hardware development. Risk reduction activities at NASA's Ames Research Center (ARC) HMC facility in support of the Phase A contractors' work included: gas and water effluent analysis, system operations, product quality, and design analysis including 15 trash processing runs of various trash models. Collins completed their compactor development work in June 2020 and SNC completed their work on a compactor, water recovery, and effluent gas management in October 2020.

In FY2020 and FY2021, the ARC team continued risk reduction activities that included tests of the HMC Gen2 under different operational scenarios. The information gained was used to inform Phase A TCPS contractors as they developed their PDR-lite designs and prototypes. A HMC Generation 3 (Gen3) by SNC was delivered to NASA ARC as part of a SBIR Phase II by Materials Modification

Incorporated (MMI). MMI developed high-temperature, low outgassing, and semi-permeable bags for use with the HMC.

FY2022 – present

The knowledge accumulated in Phase A will guide the FY2022 Phase B TCPS NextSTEP procurement. Phase B is expected to be awarded as a three-year project (FY22-25), ending in an ISS flight demonstration planned for ~2025, with the possibility for continued use to support ISS operations.

The HMC Gen3 that was delivered to ARC in FY21 will be used to test the Source Contaminant Control System (SCCS) and a particulate matter measurement system.

The SCCS is designed to remove toxic gases such as CO, CH4, and volatile organic compounds. This system consists of adsorbent beds and a catalytic oxidizer. Precision Combustion Inc. (SBIR Phase II) sized the SCCS catalytic oxidizer for use with the Gen3 HMC. Testing will include using air and known ISS cabin toxins as part of the HMC inlet gases to characterize SCCS performance. Gen3 processing will also be tried at lower temperatures to see if a tailored Trash-to-Gas feedstock can be easily created.

The ARC team is working with Glenn Research Center's aerosol team to design a particulate matter system to measure and monitor particulates released during HMC operations: trash loading, tile removal, and handling of the product tiles. The particulate matter system consists of a SBIR Phase II analyzer, which is like current ISS flight hardware, Particulate Matter Experiment.

Additionally, semi-permeable trash containment bags from MMI and ISS-approved Sea-to-Summit bags will be tested for their ability to prevent the release of particulates during tile HMC operations while reducing gas and water contaminants and still allowing water recovery.

In FY2023, NASA will begin testing to determine a benign trash composition. In this case, only certain materials can be processed in the HMC with the assurance that any outgassing will be safe for crew to breath. The benign trash can be used for contingency experiments in the event of a SCCS failure on the ISS.