Contest Response IC_2018_0162_ICR_241: Screwing Around With Trash: A Novel Approach To Space Waste Processing

Response Title	Screwing Around With Trash: A Novel Approach To Space Waste Processing
Proposed Technical Approach	The trash processor features a shredder that will reformat trash into manageable pieces and move it to the feed mechanism. The feeder mechanism will consist of an Archimedes screw apparatus that will transport the waste into the reactor.
Component Addressed	Composite system: both receptacle and feeder
Description	The trash processor is a mechanized process of modular apparatuses: 1. The Waste Entry Zone: The trash bags will be loaded through a circular opening, and a plug will be used to prevent the trash bags from egressing out of the trash receptacle. To do so, the plug will be pushed inwards by the astronaut following the insertion of the trash bag, which will push the trash bags toward the shredder. The entry zone will have a radius of approximately 9 inches, and a thickness of approximately 8 inches. (See Fig. 1 and 2) 2. The Shredder: This component operates like an industrial shredder (See Fig 3.). it is a miniaturized shredder with two axles filled with quadruple hook blades. The axles will spin at a slow speed - about 0.2 revolutions per sections. This rotation will tear large waste into smaller bits, as well as hook and pull waste inward. The shredder will reduce the thickness of the waste pieces to 0.5 inches. In order to insulate the shredder from noise, a lubricant such as Tungsten Disulfide heated with hydrogen in vacuum can be used to minimize the sound produced by the shredder. Tungsten Disulfide as a compound is durable, effective, and very thin (only half a micron thick). In addition, when heated with hydrogen, the compound is light and dry, making ideal to coat over a device such as a shredder. Also, Tungsten Disulfide does not bind to itself, allowing it to spread an even coating over the shredder. Tungsten Disulfide is already a dry lubricant approved by NASA, meaning that it can easily be implemented into a device meant for a spacecraft. 3. The Funnel: The funnel helps expedite the delivery process to the reactor by focusing shredded waste towards the Archimedes screw (See Fig 4 and 5), through the 2" diameter. This design feature makes use of any velocity generated in the waste by the shredder to help direct shredded waste towards the final delivery component

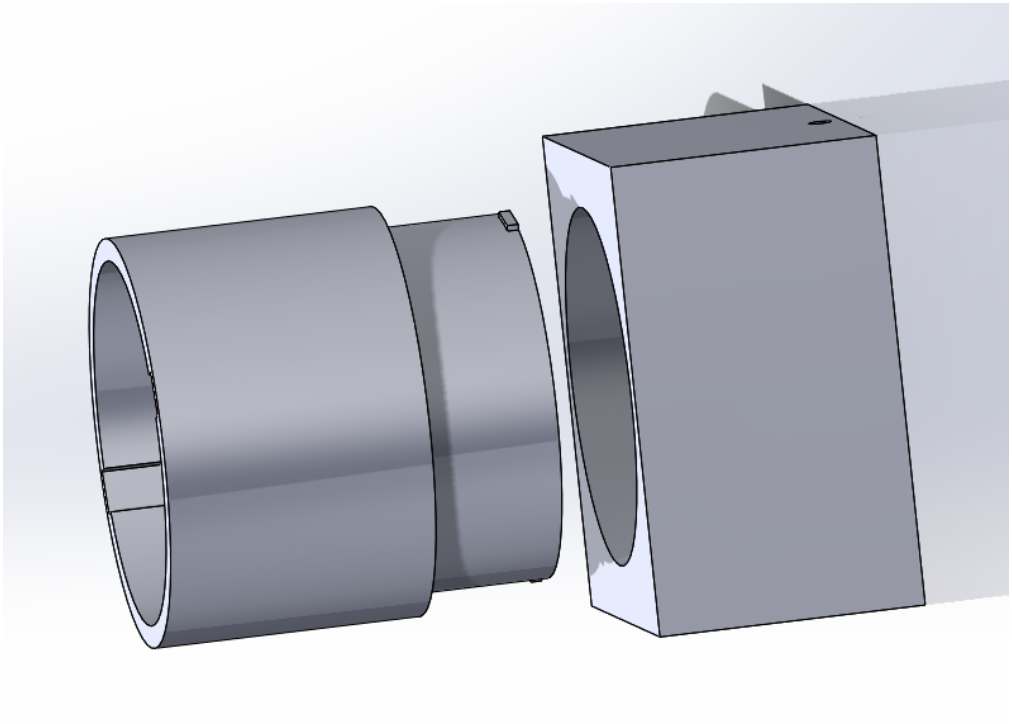

Figure 1: The Waste Entry Zone

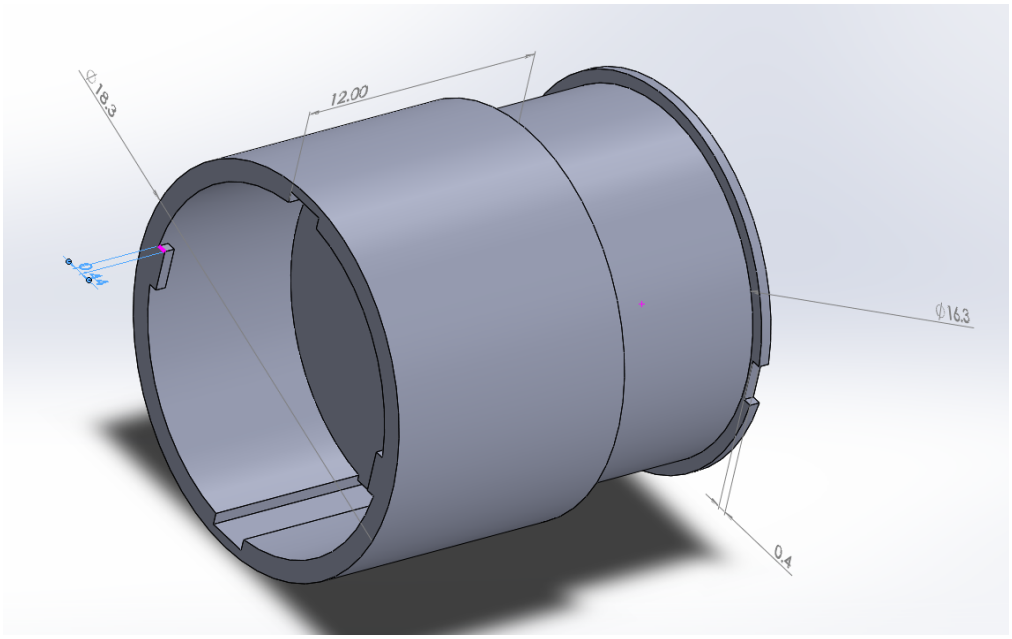

Figure 2: The plug

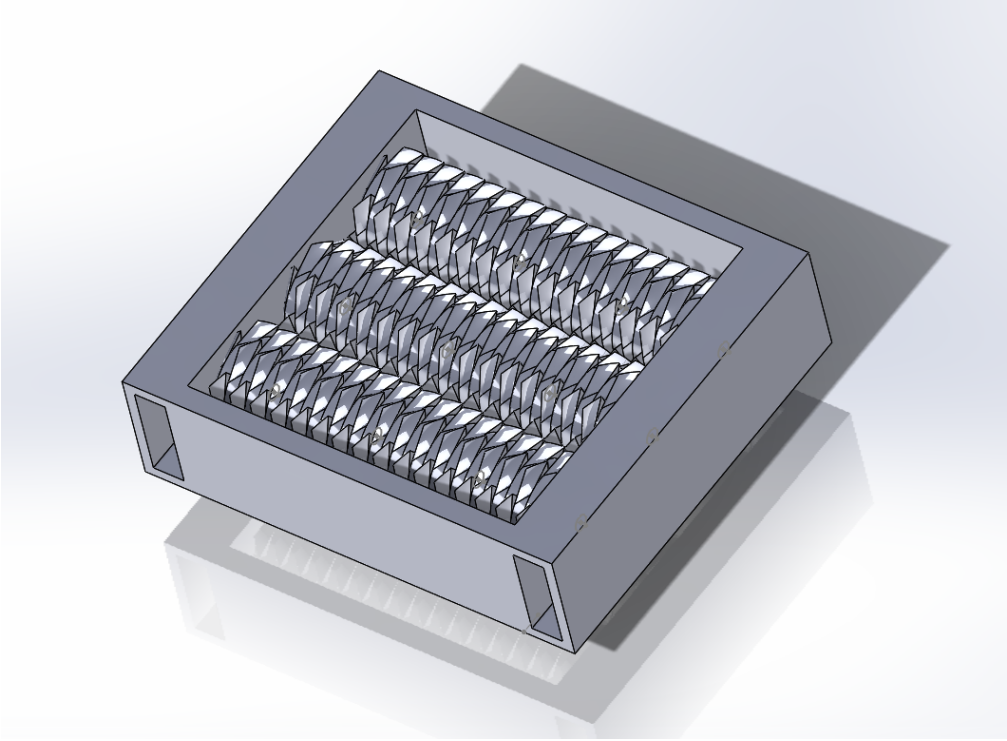

Figure 3: The Shredder

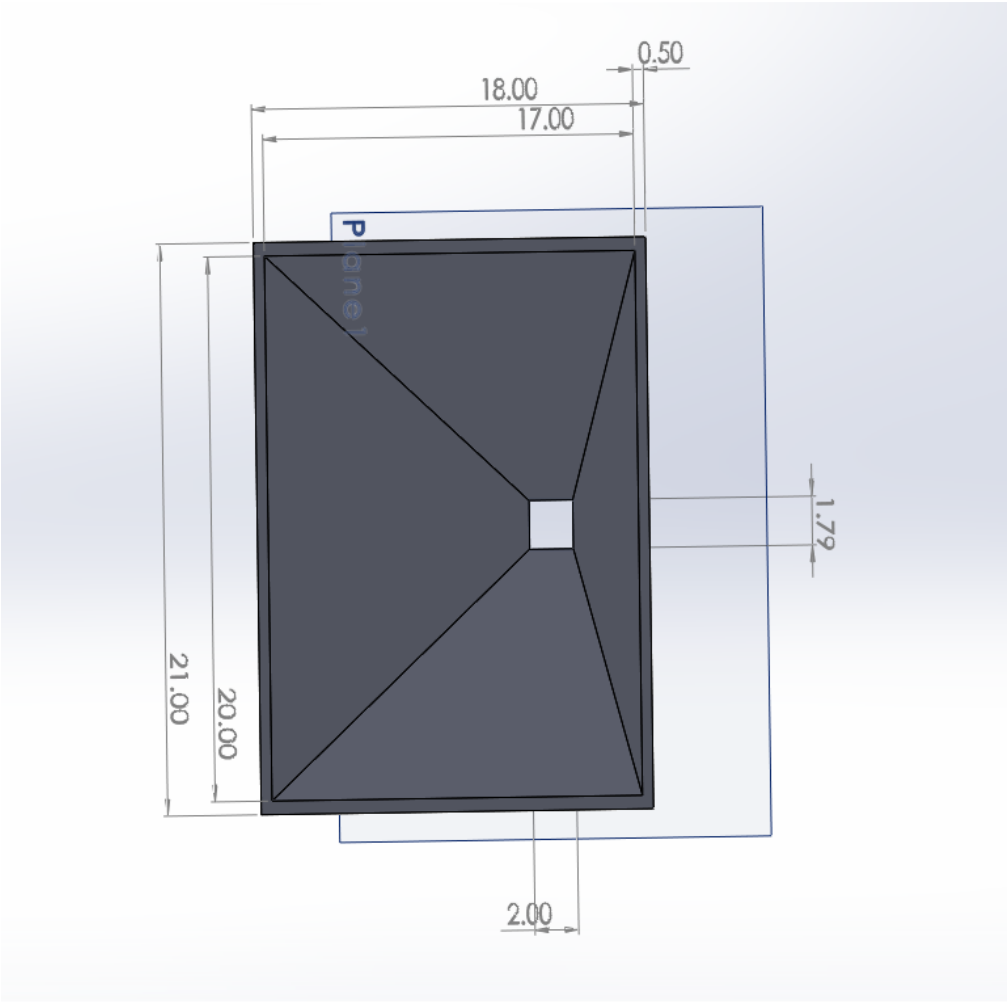

Figure 4: Viewing the Funnel from the shredder

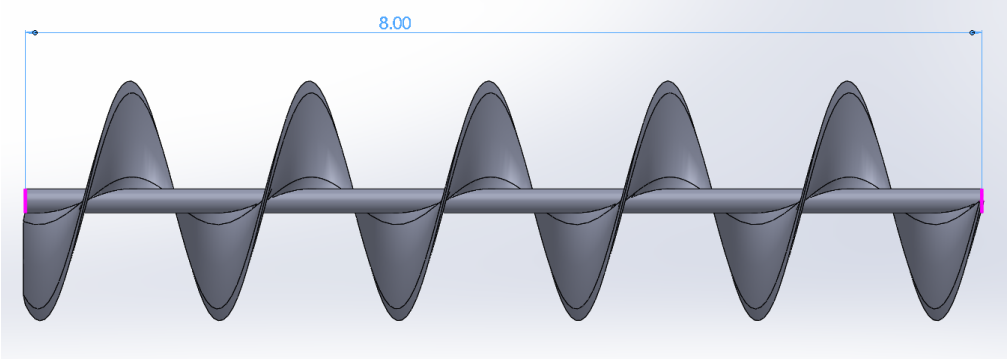

Figure 5: The Archimedes Screw

Suitability

We will simulate microgravity environments by submerging the device in a body of water and testing if the pre-processing techniques employed are effective. Different types of trash (i.e. liquids, food waste, fabrics, soft plastics, etc.) will be fed into the device. The instrument should push all types of trash through the shredder, and into and out of the screw where we will collect data and evaluate the device's effectiveness by analyzing the size of shredded waste, noise produced, power used, and degree of thermal insulation.

Performance Criteria

Accept a minimum of 5kg of 100kg/m3 bagged waste (receptacle only)
Fit within a middeck locker (18" W x 21" D x 21" L)
Consume a maximum of 500W at peak power
Generate sounds less than 80 decibels
All user surfaces remain cool to the touch
Connect with 300C reactor through a 2" OD opening (feeder only)

Additional Performance

1. The processor is universal - both brittle and ductile, wet and dry waste items can be fed and processed.
2. Risk of injury is minimized because the interaction between the operator and the device is limited to waste input. The pre-processing mechanism is confined to a closed space and is unreachable during operation.
3. Shredders also clean themselves fairly well due to the motion involved, and hence require minimal maintenance by the staff on board the ISS.

Mass Estimation

Using the mass estimation feature on Solidworks, the estimated mass turns out to be 62.91 lbs. This was assuming that the solids had a density of 0.1 lbs/cc, which is the density of aluminium metal. With the addition of 7 AC motors at 0.5lbs/motor, and 18 spur gears at a 0.1 lbs/gear, the total estimated mass is 70.01 lbs.

Manufacturing

The plug of the device will be 3D-printed with ABS plastic accompanied by a metal coating to improve the mechanical properties of the print material. Our aim is to reduce the burden on the operator by reducing the weight of the plug without making significant sacrifices to its durability and strength. This approach is also cost-effective, and will allow quicker production, testing, and adjustments to the current plug design. The acoustic foam ring that will compress against the waste entry zone during operation will be cut and fitted to the plug from a sheet of material. We are currently considering a natural blend Echo Absorber acoustic panel (off-the shelf product) its lightweight design, durability, and resistance to mold and fungi. The shredder device will be comprised of light, high-strength metals to be both efficient and lightweight. We plan to purchase the necessary parts and assemble our own shredder. This approach will be more time-consuming and difficult than purchasing and modifying a commercially available shredder, but it will allow us to better design a device that can operate under the given parameters. The housing for the shredding device and the funnel will be built using rectangular and triangular metal panels respectively, and assembled in the shape of a cube attached to a pyramid using L-Brackets and corner brackets. One material we are considering for these pieces is Aluminum. It is lightweight, resistant to corrosion, and ductile, making it a great choice for our purposes. However, because of its high thermal conductivity, it may not be the best choice of material in terms of insulation, so operators should be

mindful and exhibit caution during operation. For the Archimedes screw, this issue of insulation falls more upon the casing material, so we will likely construct this component using Aluminum for the aforementioned properties. Construction of the screw may prove more challenging than expected, but the tentative plan of action is to build templates for the screw, cut out disks of Aluminum, and weld them to an Aluminum bar. For the casing of the screw, since insulation is important to consider, we will likely use steel due to its relatively low thermal conductivity. This material, while being significantly more dense than Aluminum, will insulate heat generated by the rotation of the screw as well as provide a durable shell to protect against accidental impacts and contain shredded waste.
7 AC Brushless motors will be used to power the shredder and the archimedes screw. One motor powered from the end facing the waste entry zone will be secured to the funnel walls. The other 6 motors will power the shredder. Each motor will power a small spur gear; each shredder axle will be powered by two of these gears with a gear ratio of 1:6. In this manner, the motors can output high torque. The wires for all motors will run inside the shredder's casing to the designated power source.

Video Recordings

Technical Maturity C. My technology has demonstrated proof of concept

Timeline to readiness Less than 1 year

Path to Readiness

1. Construct a miniature industrialized shredder and decrease the wattage to under 500W (a full-sized industrial shredder uses 2200W, and the miniature shredder will be approximately 1/10 of its size and manage much smaller types of trash
- The shredding end should be facing the waste entry zone which can be like a hollow tube the diameter of which is approximately equal to the diameter of the waste bag
- Optimize sensors so that shredder starts when the waste entry zone is closed and stops just as all trash is passed through
- Streamline construction of motorized Archimedes screw and assemble screw of 2" diameter to fit thermal reactor opening.

Experience Members of the team are members of Bruin Space, a space mission engineering club in UCLA, who have participated in prior NASA challenges, like Micro-g Next and other space-mission engineering contests. Many are pursuing degrees in engineering and therefore have experience in building and manufacturing new devices.
Our team has members who are fairly experienced in 3D-Modeling but who are not as experienced in machine work. Outside of the group, there are many members within the organization who are more experienced in these fields, and others who know how to implement the technologies described in the proposal.

Preferred Collaboration Types Joint Development
Research Collaboration

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	funnel-2.png	Jan 16 at 03:42 PM	31.29 kB	Maria Vincent
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	shredder-blade.png	Jan 16 at 03:42 PM	90.86 kB	Maria Vincent

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