Space Shower for Zero-g

Space Kettle, an Electrical and Robotic Subcontractor has issued a Request for Proposal for a new Microgravity Shower System (MSS). Other subcontractors' and settlements' products may be used in the design. Credit will be given for innovation or similarity to terrestrial equipment.

1. The MSS must feel luxurious, offering a range of comfortable shower temperatures for a minimum shower duration of 5 minutes with a constant, high-pressure water flow.

2. The MSS must be designed so as to be easily integrated into any private residence in a microgravity environment where there is access to a cold water supply (at 10°C). Show how the MSS can be easily integrated into an existing structure, ensuring necessary attachment points, plumbing architecture, and electrical infrastructure can be installed without significant impact on existing structural features.

3. The MSS must use less than 10 litres of water per person, maximising water retention and reuse. Identify methods and procedures to minimise water loss, and highlight areas where losses still occur, with a brief explanation as to why they cannot be prevented.

4. The MSS must ensure the safety of users above all else. Showering must not require users to stretch excessively or otherwise enter abnormal body positions that could result in injury, nor provide any elevated risk of drowning. Identify and explain how the MSS design limits the risk to users.

5. Designs must show dimensioned depictions (either hand drawn or CAD modelled) of the MSS. Designs must also describe the manufacturing processes used, ensuring these are suited to the materials being used, and are economically sensible options for mass production.

A Compact Air-lock System

Lossless Airlocks, the leader in airlock technology, has commissioned a new design for a vacuum facing, crew and cargo airlock. This system will be used in zero-g modular structures installed as crew residences during the construction of small orbitals.

1. The airlock must allow clearance for a single hard-upper-torso or advanced rigid-shell spacesuit* to easily enter and exit with hand-tool-sized equipment. The airlock should have the smallest dimensions that will allow this.

2. The airlock must operate between vacuum and full Earth atmospheric pressure. Design a structure able to safely support these loads while being as lightweight and inexpensive to manufacture as possible. The structure must reliably operate at sun-facing temperatures at the orbit of Earth and with a 50% duty-cycle in the sun at the orbit of Mercury. Lossless Airlocks will favour designs that are also resilient to particle-radiation damage.

3. Show the mechanism for cycling the airlock, which must be electrically actuated but with an option for mechanical operation in case of emergency. Describe the style and materials to be used for sealing the airlock. Consider that large amounts of force may be necessary to provide an adequate seal.

4. The airlock should be usable for safely storing equipment, including two spacesuits, while it is not being used for ingress and egress. Describe provisions for storage, indicating the volume of equipment that can be stored in an accessible fashion.

5. In the event of catastrophic accidental depressurisation of the living volume attached to the airlock, the airlock must be able to support four individuals for up to three days while they await rescue. Life support arrangements and stored provisions should be appropriate to this length of time. The stored spacesuits and equipment can be removed to increase the available volume.

Glossary:
Hard-upper-torso spacesuits are of the class used from 1977-2030, including the Kretchet-94 (1967), Orlan and variants (1977-), EMU and variants (1981-). They have a rigid structure around the torso to which soft (rubber, plastic, and fabric) limbs are attached.

Rigid spacesuits include the EST-3X series (2030-), which can be assumed to have the same range of motion and the xEMU. Rigid suits are incompressible everywhere, using mechanical interfaces to allow movement at all joints.

Duty-cycle is the measure of how much time a system is exposed to a loading condition. It is most commonly used in electronic circuits, where a 5 volt source with 25% duty-cycle would provide 5 volts for 25 % of the time and zero volts for 75% of the time, giving an average voltage of 1.25 volts. In the context of thermal radiation exposure, voltage would be replaced by heat-flux, meaning that the structure would be exposed to a heat-source for some of the time and would radiate into space the rest of the time.

Hermian Power Infrastructure

A Hermian prospecting company has issued a request for proposal for a consistent and reliable power infrastructure to fulfil the demands of their new subterranean lava-tube settlement. The settlement is located in a lava-tube in the walls of Mercury's Prokofiev Crater at a depth of 30 m, accessible through a 100m horizontal tunnel which comes out into the crater wall, and a 500 m sloping tunnel which comes out on the Hermian surface outside of the crater.

1. The system must provide a constant power output of 3 MW, with the capability to deal with expected variations in demand throughout this period. These variations will be of no more than +1.5 MW or less than -2.5 MW for a total of 3 hours in a 24-hour period.

2. The system must make use of a minimum of three separate, demand-responsive power supplies and two separate power storage systems to ensure a fail-operational, fail-safe, fail-soft system for any combination of three failures out of the five required systems. The minimum safe period must be at least 24 hours. Systems should also have high failure transparency to allow for rapid repairs.

3. Consider all products offered by subcontractors and settlements for this application, with analysis of the benefits and limitations. Custom solutions should also be considered, although this choice will likely result in extended project delivery times, which must be justified to the client.

4. Show diagrams of power infrastructure, including locations of power sources relative to the lava-tube, and the infrastructure for transferring power between locations.

5. Describe manned maintenance and procedures that must be followed for crew safety when operating on power generation systems. Consider alterations and assistive devices for the most common maintenance procedures.