#### Lunar Biological Waste Management Expulsion System Architecture

There will, soon, be a permanent base on the moon. This base, although keyed to the bare necessities of life, will require efficient replicas of tools we need every day to satisfy our basic biological functions. We must eat, sleep, and produce waste. This plan hopes to address the problems of keeping biological waste in a sealed volume (in this case a lunar base) without it becoming a health risk, disposing of the waste in a way that lends itself to recycling as much as possible, and providing a clean, safe, comfortable, usable, and failure resistant solution for the astronauts, themselves.



This logo represents the waste expulsion system. It shows a super-simplified diagram of the system's function. It illustrates transporting matter from the sealed inner volume, to another volume outside, on the lunar surface.

# Lunar Biological Waste Management Constraints and Considerations

I began with the concept that you could use pressure differential between the habitat and the vacuum of space as a means of power. I thought that this brand of power lent itself especially to the problem of transporting waste out of the ship. From there, I determined that the most difficult application for this system (thinking that a sink, vacuum tools, and similar devices were very simple in comparison) would be a toilet. It is feasible that one of the voided fuel tanks be used to store the waste before it is processed by the water reclamation systems. I also had to consider disposing of bathroom wipes in a sanitary manner. I decided that they would be flushed along with the stool.



# Lunar Biological Waste Management Constraints and Considerations

To tailor my thinking, I looked to previous solutions to the problem of waste management. I considered a broad range of ideas, from composting toilets, to vacuum powered units like on the ISS, to bedpans. I found a large deal of inspiration in the mechanisms present in low-flow and low power toilets that use tap water pressure to flush.



Toilet system on the Soyuz and Salyut spacecraft

Stainless steel toilet/sink combination



Vacuum funnel urinal used in the Soyuz spacecraft

Wall-mounted ceramic low-flow toilet



## Lunar Biological Waste Management Normal Positions for BM

There is a marked distinction between these two postures as they relate to bowel movement. We all are familiar with the position on the left. This is the standard for American toilet users, however, it is not the most efficacious position for elimination. In this posture, waste exits the body with more force compared with the position on the right. This is crucial not only because of the necessity prevent a spray of fecal matter that could pollute the cabin, but also to create a solid, even stool, which would be easier for the proposed toilet system to remove.





Original image property of The Bathroom Book

Original image property of The Bathroom Book

### Lunar Biological Waste Management Male/Female Distinctions

The major distinction between male and female elimination process is in urination. It is a simple procedure for men to urinate in a variety of postures and wile defecating. There is also little risk of contamination between the urinary and anal orifices in males. It is simplest for females to urinate sitting down with the knees drawn together.

In men, the urethral opening is 4-6" away from the anus (while flaccid). In women, the urethral opening is 3-5" away from the anus.



Original image property of The Bathroom Book



Original image property of The Bathroom Book



#### Lunar Biological Waste Management Effects of Microgravity

It is important to note that gravity on the Moon is one sixth of that on Earth. This means that objects will have one sixth their weight on Earth there. If you threw a ball on the Moon with the same force as one on Earth, the terrestrial ball would fly one sixth as far. For the purposes of a toilet in a lunar base, this means that the splash generated by falling material will be more widespread, and objects will take longer to settle themselves out in terms of buoyancy.





#### Lunar Biological Waste Management Liquid Dynamics

On earth, you could expect a the spray from a stream of urine to reach a maximum height of 33" and a distance of 47". In lunar gravity, the spray is six times that. The same applies to any water, making the standard toilet into a kind of land mine. Because a splash in a basin like those used in standard toilets could reach astronomical heights, there need to be measures preventing this for the health and safety of the astronauts.





### Lunar Biological Waste Management OII Separation System

- An inorganic oil can serve as a barrier between the waste and the cabin area
- When combined with a slick wall surface (like a Teflon plastic) the toilet bowl will resist gathering particulate matter
- As and oil can have a higher viscosity and surface tension than water, it is less likely to splash, thus preventing the bathroom area from being contaminated

Oil

Feces

Water

Bouyancy Diagram (Gaseous Movement)



-Oil

Water Feces

The ideal oil would be a medium viscosity oil with a high surface tension, high burn temperature, low vapor levels, and be inorganic. An example would be quenching oil, which is used to cool steel parts after they are formed at high temperature.

#### Lunar Biological Waste Management Urine Collection

The proposed urinal is very similar to the current system used in the ISS. In this version, rather than having a funnel fit for each member of the crew, there is one plastic funnel that can be removed to clean. A vent at its bottom is connected with a hose providing suction, and the urine is moved into the holding area for water recycling.



Illustration of the incident angles of urine, funneled away assisted by vacuum



#### Lunar Biological Waste Management Water Reclamation





### Lunar Biological Waste Management





### Lunar Biological Waste Management





#### Lunar Biological Waste Management Initial Mechanical Diagram

#### Click to play animation. (Clicking again will pause, double clicking will resume)



#### Lunar Biological Waste Management Revised Ideation



#### Lunar Biological Waste Management Revised Mechanical Diagram





#### Lunar Biological Waste Management Revised Mechanical Diagram

### Click to play animation. (Clicking again will pause, double clicking will resume)



#### Lunar Biological Waste Management Human Factors

This is a view of the support from the seat of a standard toilet.



Original image property of The Bathroom Book



This diagram shows the augmented support provided by the new plan.



### Lunar Biological Waste Management Overall Conception Ideation

One of the driving concepts for the overall form of this toilet was placing its user in a position suitable for defecation in a way that was natural. This model is backless, and slightly angled forward, to stimulate the "squat" position. While male users may urinate and defecate simultaneously, it is necessary for a female user to position herself over the forward hole, legs closed, to urinate.





#### Lunar Biological Waste Management Final Concept View

Modified from an original image, property of *The Bathroom Book* 





#### Lunar Biological Waste Management Wrapping Up



Thank you for viewing.



