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“Orbital Design: Space Showers”

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3.2 Tourism, Living, Sport, Art and Culture in Space, a Scifi futurologist- presentist narration

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[abstract]-----

ABSTRACT

“Creature comforts” are the little things that make life comfortable and enjoyable. It is time to take seriously the importance of creature comforts for human physical and mental well-being, especially for those living off-world for long periods of time. This includes Space Tourists and long term settlers on orbiting colonies.

This paper will touch upon one creature comfort: the shower. On Earth, when you immerse yourself into the falling waters, it is both invigorating for the soul and cleansing for the body. Unfortunately, the few attempts at shower design by NASA and the Russian Space Agency have been inadequate. Insufficient understanding of the surface tension of water made them cumbersome to clean, plus the water and air heating systems were primitive.

Onboard the International Space Station in 2021, astronauts and cosmonauts must resort to camping-style techniques to get clean: wet wipes, wash cloths, no-wash shampoo, and lots of cleaning up with dry towels. There is no enjoyment of the experience, except to get clean. This paper will review past attempts at using a shower in space, study recent research, and propose an extraordinary experience: “A Shower in the Garden.” Combining proper design, and a bit of hydroponics, humans can enjoy a shower experience combined with nature and an unforgettable view.

PAPER

1 Re-designing Creature Comforts for Space Travelers

crea-ture com-fort (*'krēCHər 'kəmfərts*) *noun*. *Something, such as food and warmth, that contributes to physical comfort. Often used in the plural.*

– American Heritage Dictionary of the English Language, fourth edition

This article will discuss one of the critical things which need to be developed to make long-term living in space more tolerable, and even enjoyable: a space shower, with a link to space gardening.

Other comforts, such as enjoying tea/coffee/espresso, drinking alcohol, cooking, farming/gardening, better toilets, music, dancing, sports, and a quiet space to enjoy the stars will be discussed in future papers.

Here is an unscientific list of things considered to be creature comforts (thanks to an informal survey from my friends):

- | | | | |
|---|----------------------------|----------------------------------|---------------------------|
| • Fresh coffee/
espresso/tea/
hot chocolate | • Plants/Gardens/
Farms | • Massage | • “420” |
| • Hot Showers/
sauna | • Pan fried bacon | • Toilets/Bidet | • Cold beer/
cocktails |
| • Heating/Air
Conditioning | • Fresh baked
cookies | • Sweat pants | • Indirect lighting |
| • Reading chair? | • Weight room | • Fluffy towels | • Silence |
| • Hot Meals/
Fresh food | • Washing hands | • Music from
GOOD
speakers | |
| | • Skin lotion | • Eye drops | |

Figure 1. Example creature comforts

2 The Art of the Shower

There are few things as peaceful and rejuvenating as taking a shower or a bath. Surrounded by water, cleaning the dirt off your body, washing your hair, and finally emerging from the tub feeling like a new person.

Imagine taking this shower in an exotic location, like a garden. You are surrounded by nature and feel one with the plants.

Now take this image a step further. Just outside of the shower is a window. This window has a view of the stars and the curvature of the Earth. You now feel one with the universe.

This fantasy vision could become possible with the development of Space Tourism and other private space endeavors. Space Tourism is all about the EXPERIENCE of living off-Earth. For people working in facilities in orbit, or on the Moon or Mars, this experience could be a daily occurrence!

During my research, I learned that past efforts by NASA and Russia with building and using a space shower seemed incomplete, or poorly designed. Sure, you can design a shower that (hopefully) does not leak, but what about the water and air temperature? How hard is it to set up and break down the shower? How do you clean it? How do you recycle the water? How do you simplify the shower experience while improving it?

This is more than an engineering issue. It is a design and human factors issue. Every person has their own preference of water temperature, sensitivity to air, and room to move. Then there is the aesthetics of luxury, the need for being close to nature. Water is the key to life, so how can you both enjoy it and share it?

2.1 Greywater

Greywater is the term used for water that is mildly contaminated with dirt, hair, skin cells, soap and shampoo and other debris from a shower. This much less toxic than Blackwater, which includes human feces or dangerous chemicals. Greywater can be cleaned and filtered via several means, such as Charcoal-based filters and UV light, but there is also a natural filtering system: plants!

This is where space gardens and large-scale farming comes into play. As we have seen with successful “Veggie” program on the International Space Station, hydroponic gardening can work to grow healthy plants in zero gravity.

Another plant that has been successfully grown in space is Moss. Moss is one of nature’s water filters and is an ideal plant for inclusion inside the space shower.

2.2 Surface Tension

The biggest factor involved in both gardening and showers in zero gravity is surface tension. Without gravity to break it up, water and other liquids tend to stick together in large spheres, and stick to other surfaces, including walls, skin and plant leaves. For humans, we just use a towel to dry off the water blobs. For plants though, water blobs will just stick to the leaf, and the potential for suffocating the plant or promoting mold formation is possible.

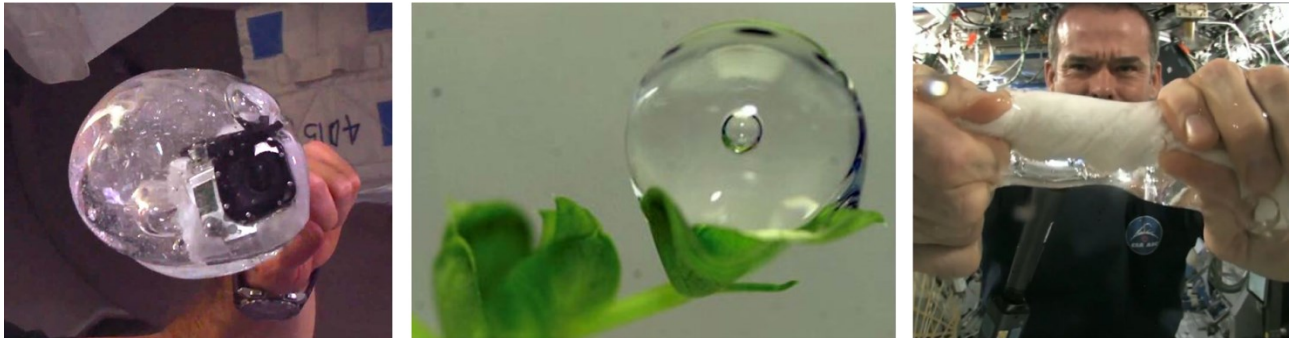


Figure 2. Surface tension effects of water in weightlessness is a unique off-world design challenge.

3 History of Space Showers



Figure 3. Left to right: NASA’s Skylab space shower, Russian Salyut 7 space shower, MIR Space shower/sauna.

3.1 Skylab

The most famous space shower is the one that flew on NASA’s Skylab space station in the early 1970s. It consisted of a collapsible tube that the astronaut would surround himself in to prevent water leaks. He would use a shower head to wash the body, use soap to clean, and then rinse off. While the showering itself was pleasant, the astronauts reported that the experience of cleaning and breaking down the shower was not. The issues they ran into include:

- The time-consuming nature of cleaning the excess water

- Inconsistency of water temperature
- Inconsistent air temperatures
- Limited amount of water allocated for the shower (3Liters / six pints)

The astronauts resorted to wet wash cloths for bathing.

3.2 Russia

Lesser known are at least two types of showers used on Russian (Soviet) space stations. There were attempts on Salyut 3, 6, and 7 to implement a type of shower shaped like a collapsible tube, similar to Skylab. As the Russians were new to dealing with the surface tension issues of water in space, the cosmonauts also had a hard time cleaning up the excess water. The cosmonauts, like the astronauts on Skylab, used towels to dry up the water that clung tenaciously to their bodies and the wall of the shower cubicle.

At least one version of the Russian shower required the use of an air mask. The reason may have been the engineer's concerns about the sticky water covering the cosmonaut's mouth and nose while bathing. From a report: "Fastened at the bottom of the shower are rubber slippers to keep the cosmonaut from floating upward. Above the cosmonaut's head are cellophane bags containing napkins and a towel. The cosmonaut will put a pipe that leads outside the chamber into his mouth and put a clip (like a snorkel) on his nose before turning on the water. Then he opens a package that contains a soap-filled cloth and switches on the water. Water comes out in a fine needle-like spray. The water air aerosol passes through holes in the floor and into the waste container."

Showering was a complicated process — so much so that the showers, which were expected to be completed by noon, lasted until after 6 p.m.

Like their NASA counterparts, the cosmonauts resorted to wet towels for bathing on most occasions, and only once a month attempted to use the shower system.

3.3 ISU/NASA Space Shower Concept

In 1997 a Master of Space Studies student at the International Space University named Susmita Mohanty chose for her project the topic of space showers. She dived deep, deeper than NASA or the Russians did, into the design issues, and with a grant from NASA, developed a concept that was later tested onboard NASA's KC135 cargo test aircraft.

Focused on the "Zero-g Whole Body Cleansing" concept, she researched previous concepts, and interviewed several astronauts. Her concept emphasized flow control through vacuuming, temperature adjustment of the stall air and in particular the use of water-repellent coatings ("Lotus Effect" superhydrophobic surfaces) to minimize cleaning work.



Figure 4. Space Shower Concept being tested via parabolic flights onboard a KC135 aircraft.

3.4 ESA Concept

In 2008 the shower concept was further developed by researchers Marco C Bernasconi, Meindert Versteeg, and Roland Zenger. As part of the initial studies for ESA's "Space Haven" inflatable habitat, the team defined a crew shower, based on previous work from NASA and ESA. They observed that previous space showers "and items related to the support of the crew's wellbeing look like last-minute add-ons to the Space Station layout." They re-assessed the need for a shower for medical and psychological reasons, and how previous NASA researchers seemed to think "a sponge bath is enough." Their study calls out the challenge of cleaning up a temporary shower, plus poor-quality soaps, lack of air and water temperature controls, as factors in eschewing showers.

Bernasconi and team pushed back with on past criticisms and developed a permanent shower with more advanced vacuum and temperature controls. Plus, they emphasized easier shower cleaning.

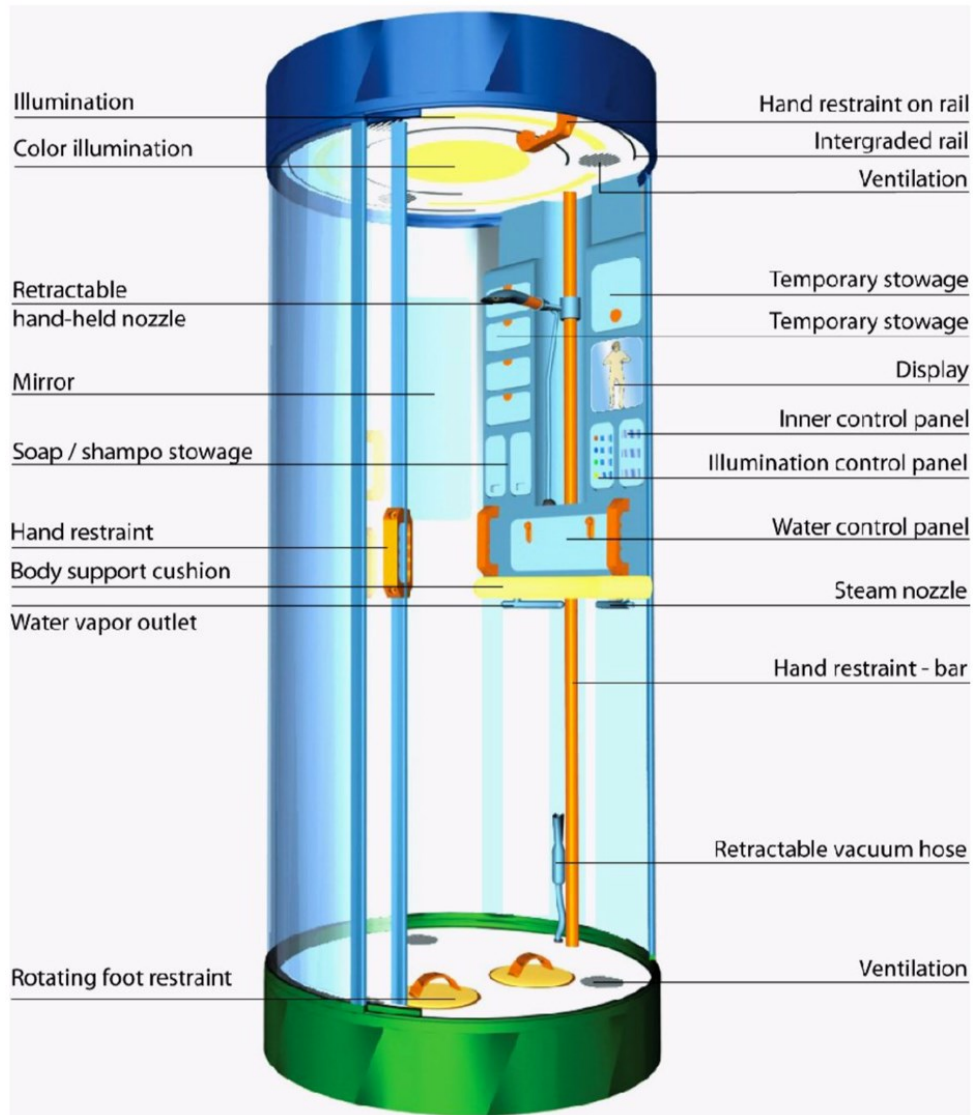


Figure 5. Space Shower Concept developed by Bernasconi et al. for ESA.

So how can we combine the awesomeness of a morning shower, among green plants, and recycling the water into a garden?

4 A “Shower in the Garden” Concept

This new zero gravity shower design is based upon the research done by Bernasconi, et, al. with several modifications by this author to improve ergonomics and ease of cleaning and advance a luxury element.

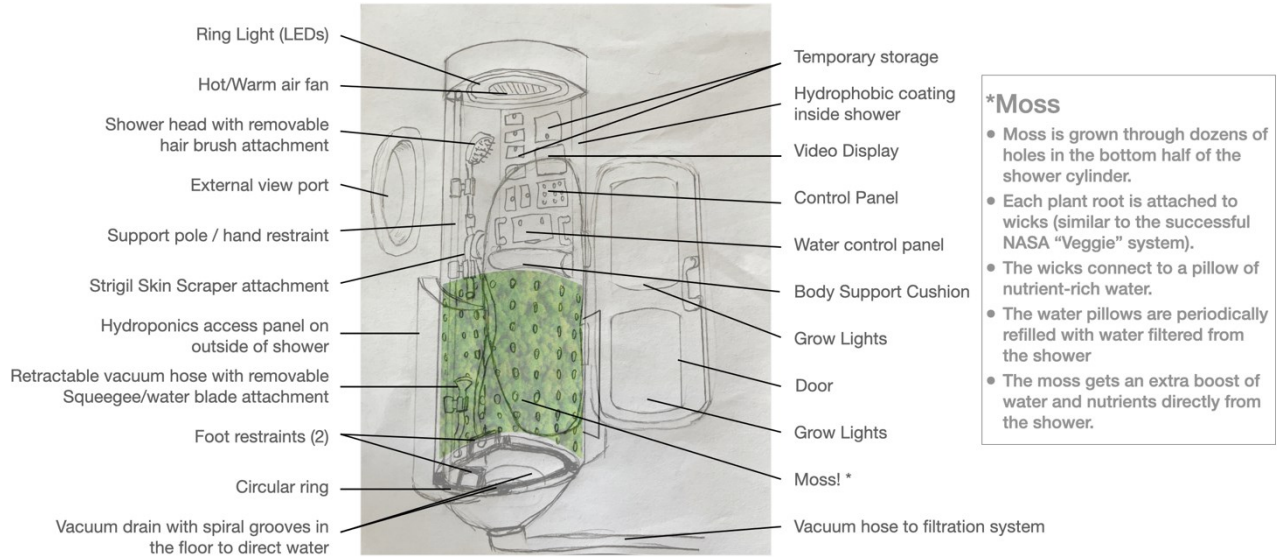


Figure 6. A “Shower in the Garden” Concept.

4.1 Shower cylinder

The center part of the shower is shaped like a cylinder, roughly about 2.15 meters (7 feet) tall and 1.22 meter (4 feet) in diameter. This leaves room for drainage and other equipment. There is an LED ring light on the top part of the shower. This light is adjustable in color and brightness. In the middle of the top is a hot air vent. The air temperature can be adjusted by the user. The blower from the vent can be adjusted in its speed as well. Two handles are available for the user to grab on to.

At the bottom of the shower is a cone with a spiral groove in it, that focuses liquids down to a vacuum drain. This vacuum drain is adjustable in speed and power. A circular ring is located near the widest part of the cone; adjustable foot straps are connected to this ring. Please note at the intersection of the spiral cone and the cylinder are ports for two retractable hoses: one for vacuum and one for water.

The cylinder itself is a clear Plexiglass. It is coated with a hydrophobic material so that the water droplets will not stick to its surface.

4.2 Shower Controls and storage

The upper half of the cylinder contains the controls for the shower. This includes water temperature, water flow speed, air temperature, airflow speed, and vacuum speed. There will be a digital touchpad for controlling the systems, plus there will be manual physical controls just in case the electronics go down.

There will be several storage containers for shampoo, soap and other personal hygiene items. This control and storage area should only block 1/4 to 1/3 of the plexiglass. The rest of the upper half of the cylinder should be clear, to allow viewing outside the cylinder and the external window with the stars outside.

4.3 Moss garden

The bottom half of the cylinder will have dozens of small holes about 1 cm in diameter. This is where the moss will be grown. Using the technology based on NASA’s successful Veggie system, each moss plant will stick out the hole. Each plant will be connected to a wick which sticks into a pillow-shaped bag of nutrient filled water. This wick will relay water from the bag to the plant. This technique is a common form of hydroponic gardening. On the outside of the cylinder is a maintenance hatch to check on the hydroponics system.

4.4 Using the shower

When the shower is not in use, the hatch door on the side of the cylinder is left closed. The air fan and vacuum are continuously running at slow speeds to prevent mold or mildew from forming inside the chamber. The hatch door includes two sets of LED light panels, which brightness and color controls can be manipulated. These LED lights double as greenhouse lights when they not being used as shower lights.

When the hatch is closed, the controls are available to manipulate air and water. The person can grab onto a long handrail (vertical pole) that stretches the entire length of the cylinder. Then the person can strap in their feet to the footrests at the bottom of the cylinder.

4.5 The shower process

The person turns on the hot air to a comfortable temperature. They then turn on the vacuum to a moderate speed. With their feet strapped in, they can grab the showerhead and remove it from its holder on the pole.

The showerhead can be swapped out for a variety of different types of heads. The default showerhead doubles as a hairbrush. The user can turn on the water, adjust the temperature and pressure, and then press the on/off button on the shower head handle to start getting wet. Because the water will collect together via surface tension, the user should start with a small amount of water.



Figure 7. Shower head with integrated hairbrush. Example: OXYGENICS COMB SHOWER HEAD Note: other shower heads could be used per personal preference.

It is recommended to use glycerin-based soaps and shampoos which are less harmful to plants. Only a small amount of each is necessary for cleaning the body.

Note: The user could attempt to try to take a shower without feet attached the straps, but the propulsive force of the water coming out the showerhead might end up with hilarious results!

4.6 Cleaning up

Once the person has completed washing and rinsing, now comes the cleaning part.

In ancient Greece and Rome, the baths were filled with nobleman and slaves that used an interesting technique for removing oils from their skin. The device was called a strigil. It looks like a tiny sickle with a handle. Because soaps were not available at that time, the Greeks and Romans used olive oil to cover their body. Then the after the bath, and the oil, dirt, and dead skin would be scraped off with the strigil. (It is also rumored that this icky combination of fluids was sold in the black market for its dubious medicinal benefits, but that is another story for another time.) Modern versions of this device are available today as an exfoliation tool.

The space shower version of the strigil uses a concave blade, not sharp at all, which is attached to a handle. This handle could optionally be attached to the vacuum pump to help suck away the fluids. The user would slowly and gently scrape away the soap, water and other fluids that are sticking to the skin. On Skylab and the Salyut/MIR space showers, the astronauts/cosmonauts had to spend a long period time using towels to wipe off the water from their skin. Using a strigil bypasses the skin cleaning issue. The hydrophobic material on the cylinder rejects the floating water bubbles, and the combination of warm air blowing from above and the vacuum from below naturally forces them down to be sucked out.



Figure 8. Based on the Ancient Greek Strigil, used to scrape dirt, oils and water off the skin. Example of a modern version on right: Esker body plane.

For cleaning the shower cylinder, there is a vacuum attachment for a squeegee, also known as a rubber water cleaning blade. Since the interior of the tube will be covered with a hydrophobic surface, there should be few places needing to be cleaned. The vacuum system can be increased to force more air through and bring along water and other debris.



Figure 9. Example of a commercially available squeegee/water blade: BLACK+DECKER Squeegee & Hand Vac, Cordless. For the space shower, we recommend a corded vacuum hose with multiple blade options. Hose sucks water into the filter system, that eventually feeds the plants.

The adventure of taking a shower with green plants can be luxurious. But like with human skin, surface tension will cause the water to stick to the leaves of the plant. Fortunately, the moss leaves are very tiny, and should be easy to brush off. This act of brushing the plants with your hands in the space shower while floating should be a fantastic tactile experience. All the while, the vacuum system will be guiding the water droplets to the drain.

The goal of this new shower system is to reduce the cleaning time and increase the experience. It is unknown how long the whole shower process would take, but the goal is to make it fun and enjoyable while you are in it.

4.7 Filtration

In most closed loop systems, you could filter the grey water with a combination of exposure to UV-C light for sterilization and charcoal for filtration. There is another option: plants!

Plants that thrive on greywater include edible shrubs and vines such as raspberries, thimbleberries, blackberries and their relatives, currants, gooseberries, filberts, rhubarb, elderberry, passion fruit, kiwi, hops, and grapes. Marsh plants like reeds, water hyacinth, iris, and duckweed can also help conserve and treat greywater.

Moss was chosen because its small size and its ability to filter a wide variety of chemicals. As you will see in the next section, the greywater can also be used to water an entire garden!

4.8 Linking showers to gardens

This permanent shower design with the integrated moss garden should be enough for tenants of a next generation space station. For the longer-term space habitats, and especially for Space Tourism, an integrated shower system with a hydroponic garden would take the experience to the next level.

Onboard the International Space Station, astronauts have stated they enjoy working with the plant experiments, and they enjoy the experience of gardening.

There are many space farming experiments in progress around the world. Long-term living off world demands that large scale farming is needed in order for space travelers to survive, if not thrive off-world.

It may be a given that future space habitats have multiple modules devoted to farming, so why not have showers, which use lots of water, inside the gardens? An exciting garden concept is the Prototype Lunar Greenhouse at the University of Arizona. Their design includes a collapsible cylinder that is expanded in orbit where hydroponic gardens can be developed.



Figure 10. Concept: "Prototype Lunar Greenhouse (LGH)", University of Arizona, Controlled Environment Agriculture Center, College of Agriculture and Life Sciences, 2012. Right: This could be your view from the shower!

The author's proposal of a "Shower in the Garden" becomes a much more enticing prospect when you take a shower inside the garden! The shower's greywater can be directed to the plants for filtration and use.

5 Shower with a view!

The final component of this space shower concept is of course, a window! Though physically having nothing to do with the shower itself, from a design standpoint, it should not be hard to set up the shower in close proximity to a viewport aboard a space habitat.

Imagine this: being naked, soaking in a hot shower while looking out the window at earth from orbit would be such a peak experience. That would definitely be worth the millions of dollars for a space tourist trip.



Figure 11. An amazing view while you are taking a shower!

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