

Lunar Surface Systems Wet-Bath Design Evaluation

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OVERVIEW

- 21st century lunar missions are planned with crews of four living and working in lunar outposts and rovers
- Hygiene is an important feature of these longer duration missions
- With limited space, innovative hygiene concepts such as a wet-bath, which combines the functionality of a human waste and hygiene compartment, as well as, a shower, needs to be explored by interior, vehicle, and human factors designers
- Careful consideration needs to be taken as to the design of such areas within the habitats since this could significantly affect the crews' quality of life

OBJECTIVES

- Obtain preliminary human-centered data of several wet-bath design concepts to assist in later vehicle development which could preserve crew time, reduce mass and volume, and preclude the buildup of mold and mildew
- Given a predefined area by the Lunar Surface System group for a lunar core habitat (see Figure 1), several designs were evaluated that represented a trade-off between stowage and usable volume
- Results will be used to develop waste and hygiene compartment design requirements and guidelines

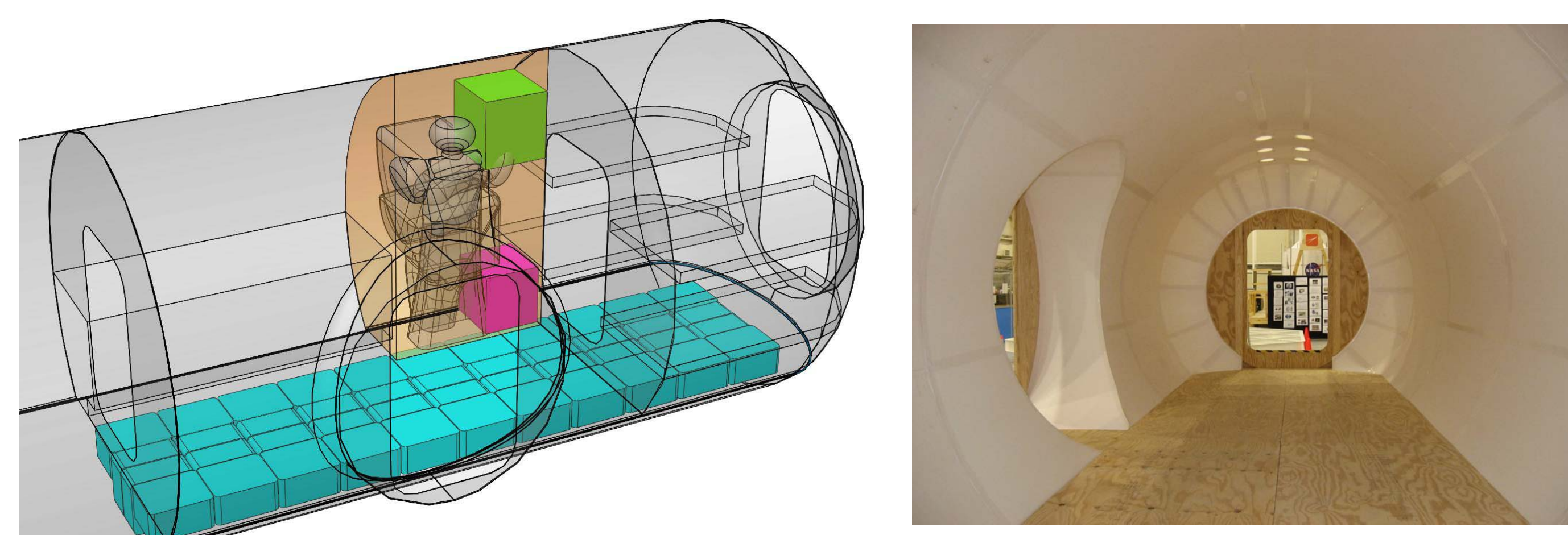


Figure 1. The predefined area given to the design team for the wet-bath (left image) and the interior of the core habitat mockup (right image).

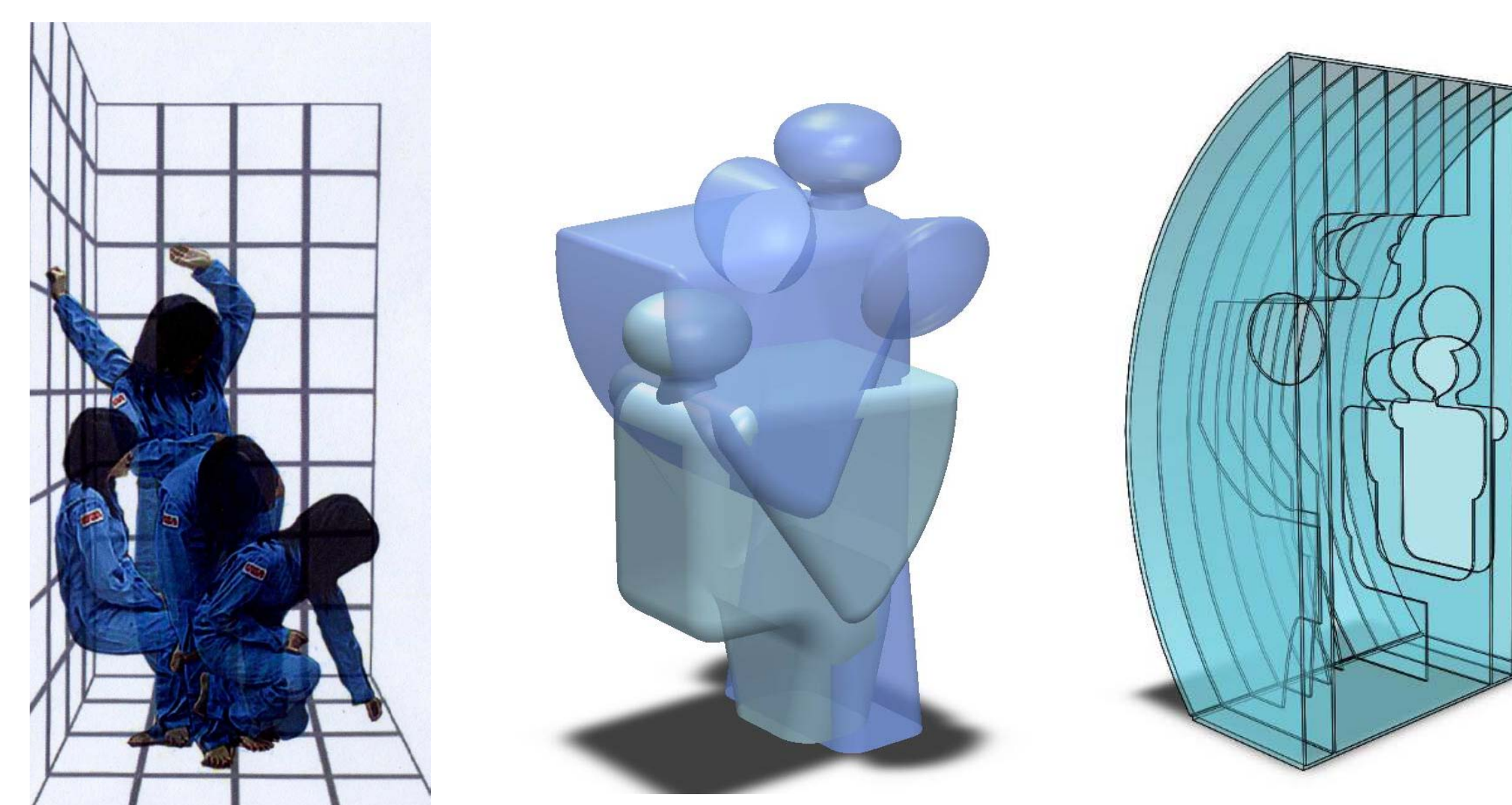


Figure 2. Body motion envelope volume was created, where by subjects "acted out" tasks that would be performed in the wet-bath (top-left). This information was then used to create the motion envelope (top-center), this was then subtracted from available waste and hygiene compartment volume (top-right). The mockup interior was shaped into a continuous smooth surface (bottom-left) and the interior will be lined with Velcro enabling different configurations (bottom-right).

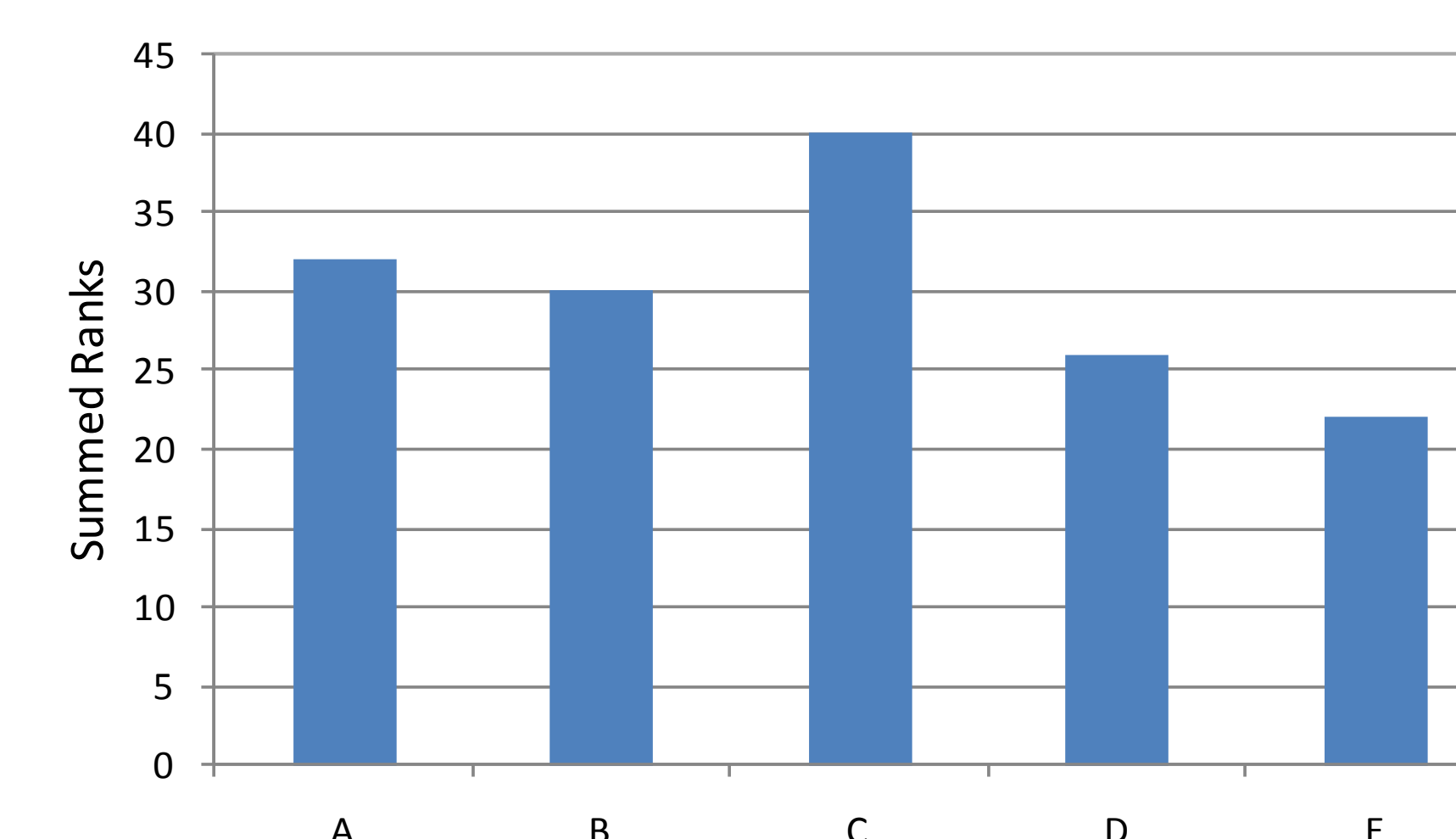
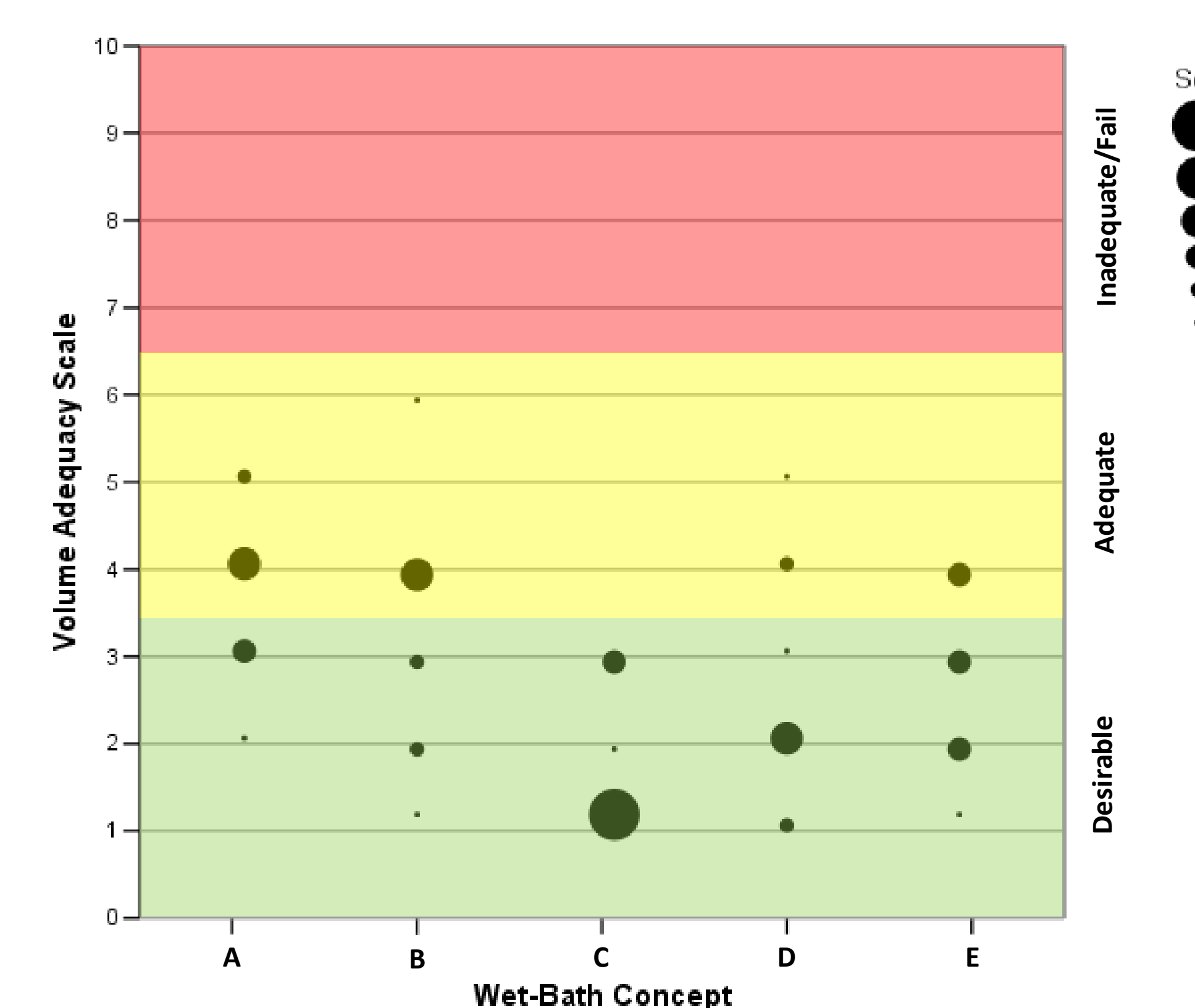
Evaluation Tasks and Questionnaires

- Each participant was asked to step in to the mockup and enact a typical bathroom task, for example, shaving, grooming, or maintenance activity (see Table 1)
- While performing the tasks, each participant was asked to complete a 5-point Likert scale ("1" unacceptable and "5" acceptable) rating the acceptability of the volume afforded for each task
- In addition, a volume adequacy scale (VAS) and maneuverability assessment scale (MAS) was completed rating the volume based on overall task performance, as well as ranking the concepts in order of preference

Table 1.

Wet Bath Task List

Task	Definition
Shaving	Simulated use of razor and shaving accessories
Grooming	Trimming, and combing or brushing hair
Oral Hygiene	Simulated use of toothbrush and toothpaste
Hand/Face Wash	Washing using the sink area
Shower	Simulated activities for cleaning body
Drying Off	Using a towel to dry off after shower
Changing Clothes	Ability to change clothes in wet bath
Maintenance Access	Ability to reach and perform maintenance
WCS Activities	Simulated toilet activities
Cleaning from Shower	Hand drying the wet bath area
Stowage Activities	Examining stowage of wet/dry towels and clothing, and hygiene items



METHODS

Participants

- Ten waste and hygiene subject matter experts (SMEs) from various facilities at JSC (e.g., the crew office, ECLSS system engineers, etc.) participated in the evaluation (7 females)

Wet Bath Design and Mockup

- The Wet-Bath mockup was designed and built by the Johnson Space Center's (JSC) Habitability Design Center (HDC)
- The mockup is constructed on ½ inch plywood and foam board – major objects within the mockup can be removed, replaced, or repositioned to form different interior design configurations
- A minimum volume and shape assessment of humans performing wet bath tasks generated an initial body motion envelope and internal volume dimensions (see Figure 2)
- Five designs were created so that various aspects of the wet-bath were more prominent than others (see Figure 3)
 - For example, concept E was low on internal stowage, but high on internal usable volume, while concept D was high on internal stowage, but low on internal usable volume
 - Doing so, allowed the participants to rate the stowage and usable volume based on comparison. In addition, some of the concepts allowed for limited maintenance access based on their interior design



Figure 3. The five wet-bath concepts evaluated during the current study. Notice how some of the designs exploited more stowage space, while others had more usable space.

RESULTS and CONCLUSIONS

- Overall, a concept in which an equal attention was placed on stowage and usable space was preferred (Concept C)
- Concept C was rated best on VAS (see Figure above) and MAS index, as well, as the highest ranking of acceptability (see Figure above)
- In terms of design, participants suggested that with concept C the toilet should be rotated 90° to where the front is facing the sink, rather than the outside wall – this would allow for more foot-space and elbow-room, while sitting on the WCS, and would increase the distance between the toilet and sink, which was desirable – in addition, this would allow space to add a curtain between the shower/sink area and the WCS to mitigate the amount of water to clean-up after showering within the compartment

