

NASA Marshall Space Flight Center Human Factors Engineering Analysis of Various Hatch Sizes

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NASA

Marshall Space Flight Center

Systems Analysis Branch

Human Factors Engineering Team

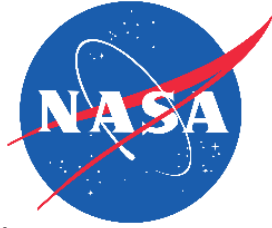
Becky Stewart

Mississippi State University

MS in Industrial and Systems Engineering,
Human Factors Concentration

Jacobs Summer 2018 Intern

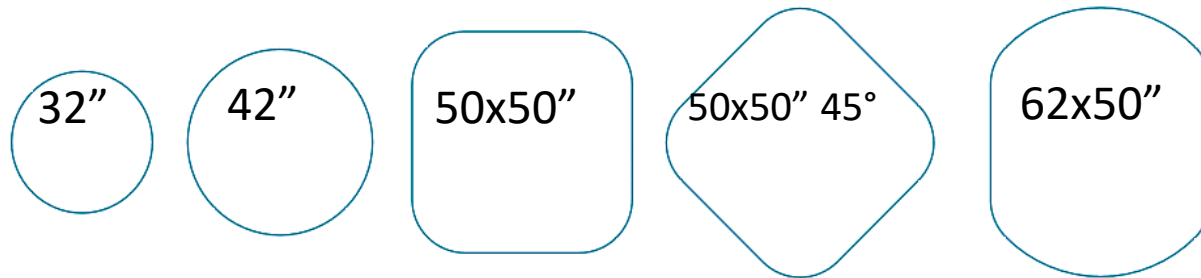
Overview



The Advanced Concepts Office needed human factors analyses on various hatches for future deep space modules. The current standard is the 32" hatch, and the goal of this analysis was to assess this hatch size compared to larger sizes for egress, logistics and safety.

Analyses Requirements:

1) 5 Hatch Sizes:

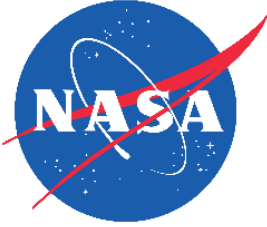


2) 2 Environments:

- Gravity
 - Analyses done in Building 4649
- Microgravity
 - Analyses done in the USSRC Underwater Astronaut Training Facility

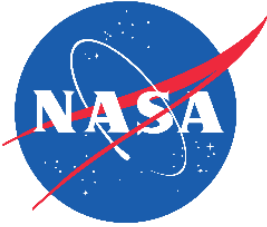
3) 2 Hatch Configurations:

- Docked (2 modules)
- Undocked (1 module)



Agenda

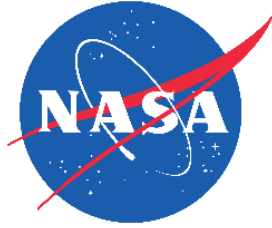
- Overview
- Participants
- Designs & Construction
- Surface Analyses
- Neutral Buoyancy Tank Analyses
- Results



Assessment Team

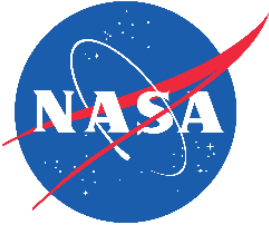
- Managed by: **Tanya Andrews**, EV74
- TE Partnership: **David Smitherman**, ACO
- HFE Assessment Intern: **Becky Stewart** (Jacobs), Mississippi State IE
- Wooden Mockup Intern: **Walter Deitzler** (Jacobs), UAH ME
- PVC Mockup Intern: **Jack Velazquez**, HS Intern
- CAD Intern: **Kaliq Wilson**, HS Intern
- Build Assistant: **Eric Glover**, HS Intern
- Tech Support: **John Smith**, EV74
- Participants: included **Brittani Searcy** (Jacobs), EV74

Safety



- Participant Consent Forms
- Surface Analyses (Building 4649)
 - Spotters
 - Safe conditions and surroundings
- Underwater Astronaut Training (UAT) Facility
 - Same process followed as Space Camp
 - Waivers
 - Instructed verbally
 - Hands-on training
 - Sufficient lifeguards and diving assistants inside and outside of the tank at all times
 - 2 EV74 Certified Divers were also in the tank
 - Jerry Wells
 - Brittani Searcy (Jacobs)

Participants



4 Participants

Height

Participant Height

1st percentile female
5th percentile female
95th percentile male
99th percentile male

4'10.5"
5'2"
6'2.8"
6'4.6"

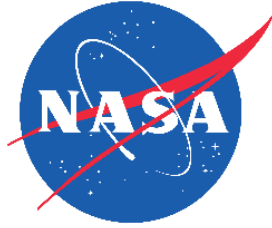
4'10.5"
5'3"
6'1"
6'4.5"

Accounting for all anthropometries to accommodate all astronauts.



Left to right: 99th percentile, 1st percentile, test conductor 5th percentile, 95th percentile

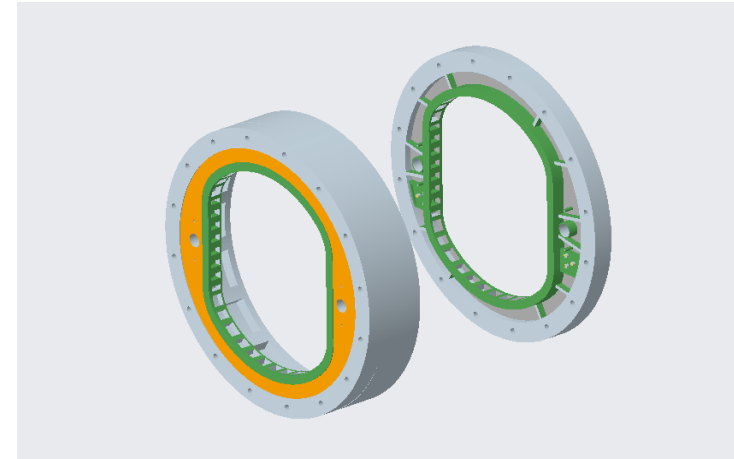
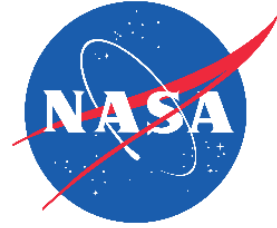
Surface Analyses



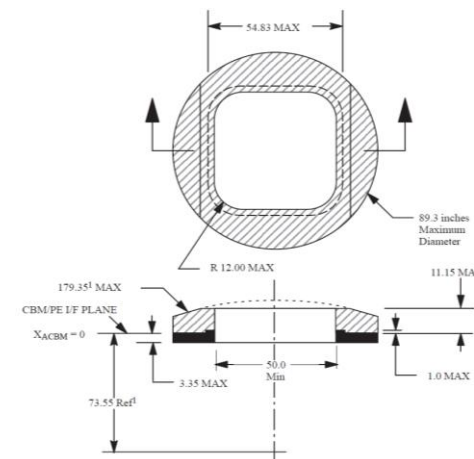
- Both docked and undocked configurations.
- Participants were asked to step through the hatches both frontwards and sideways.
- Docked configurations required participants to wear plain clothes.
- Undocked configurations required participants to wear SCAPE suits to simulate an EVA suit.
- Analyses were observed for :
 - 1) Task difficulty
 - 2) Adequate volume
 - 3) Reach difficulties
 - 4) Visual access
 - 5) Overall comfort

Designs – *Surface Analyses*

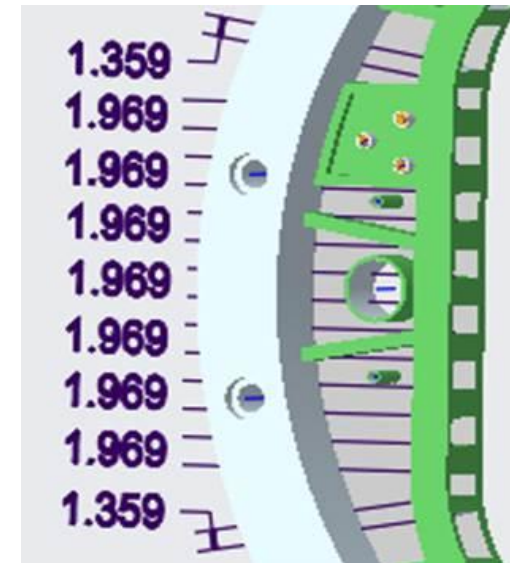
- 32" and 42"
 - Undocked wooden mockups already completed for a previous assessment
- 50x50"
 - Sent in as a PDF by HP-25
 - Gave the proper corner radius and thickness
- 62x50"
 - Sent in as a CAD file by the Advanced Concepts Office
 - Had to dimension model



62x50" CAD



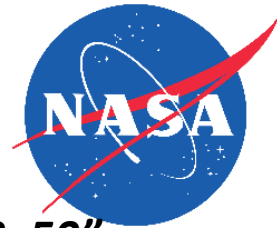
50x50" Design



62x50" Dimensions

Surface Analyses

Docked - 1st Percentile



32"

42"

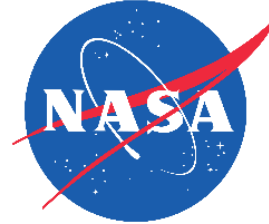
50x50"

50x50" 45°

62x50"



Surface Analyses Undocked - 99th Percentile



32"



42"



50x50"



50x50" 45°

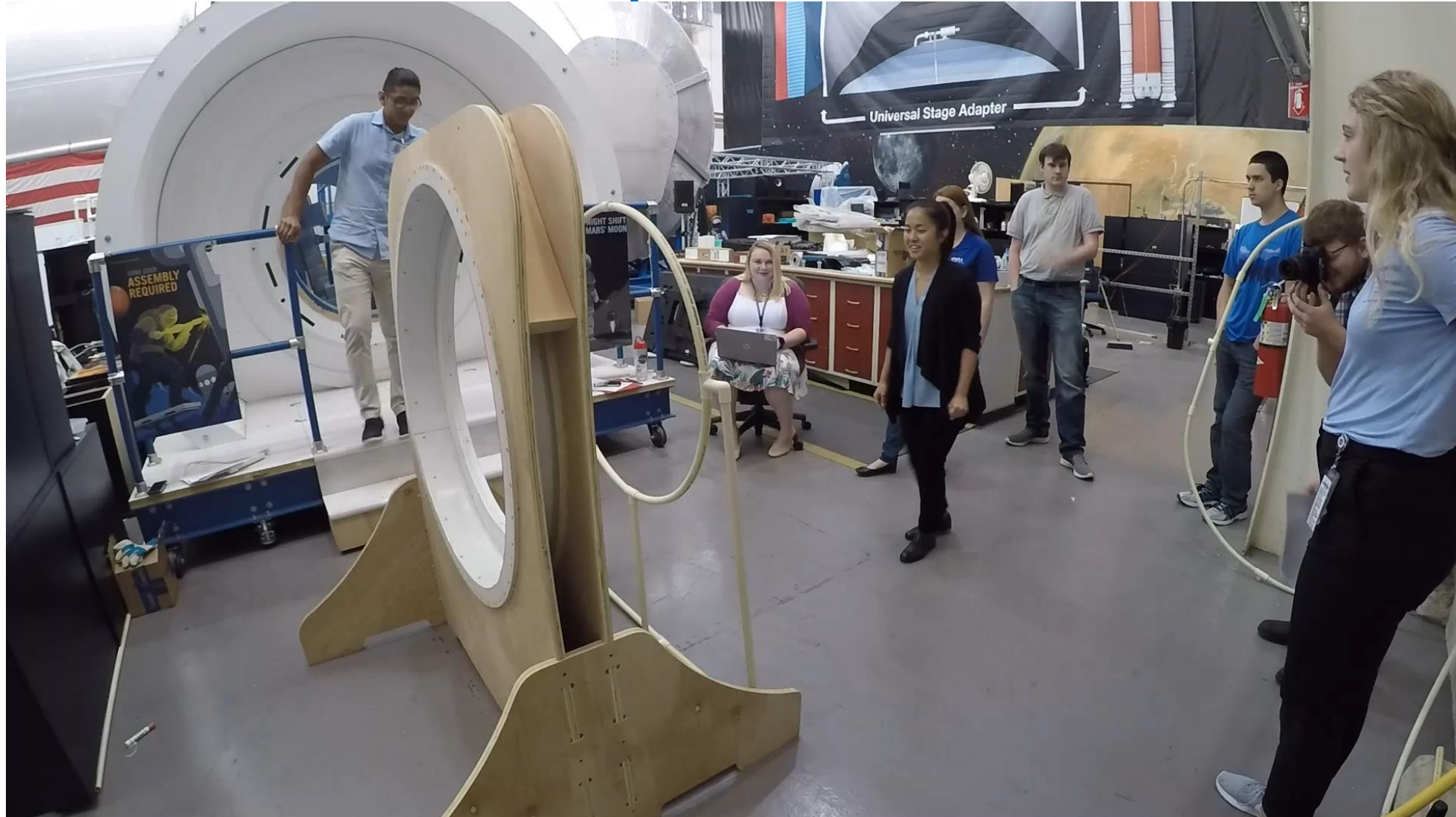
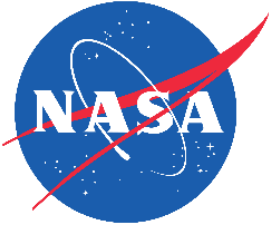


62x50"



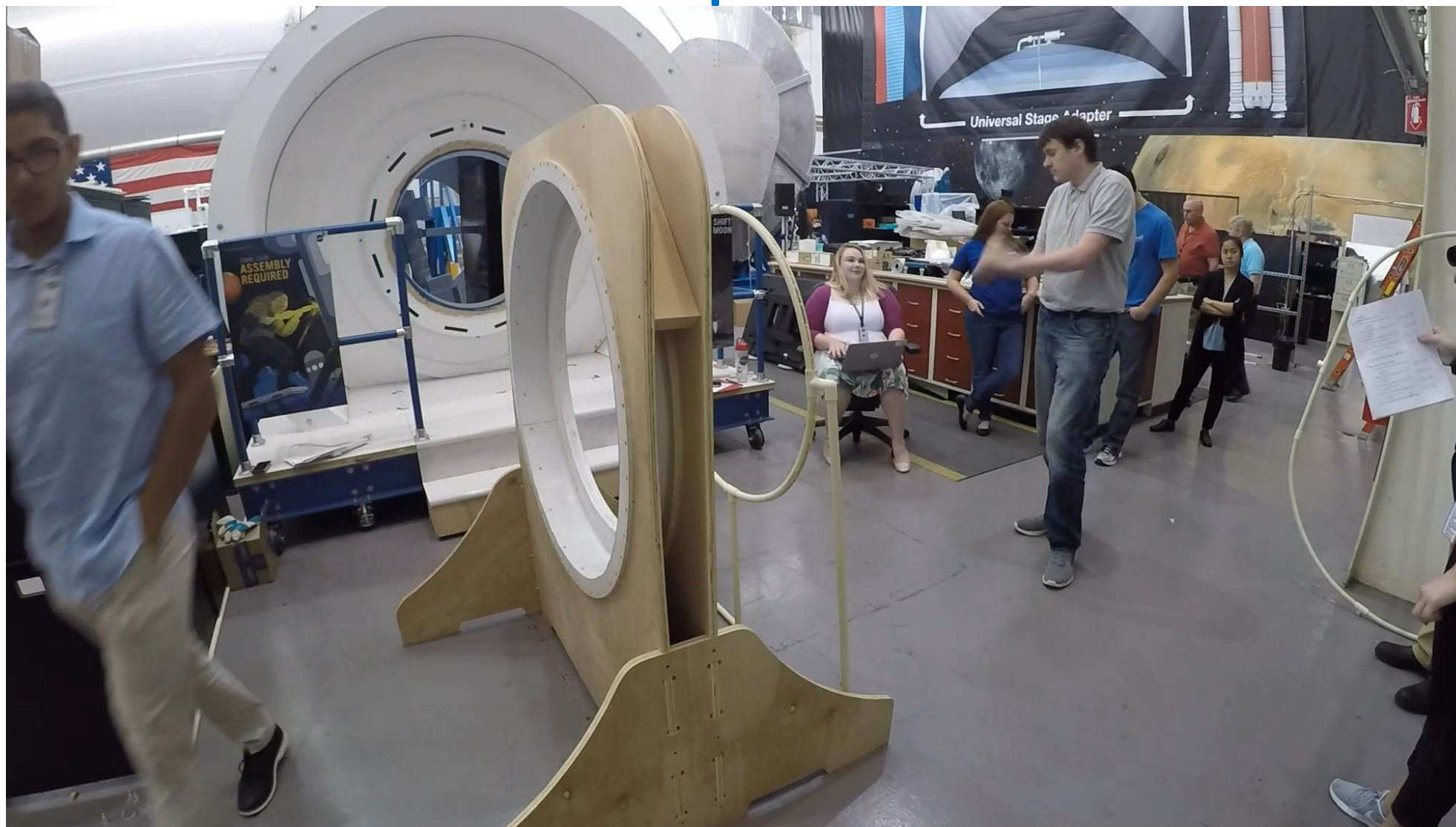
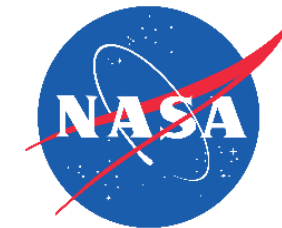
Surface Analyses

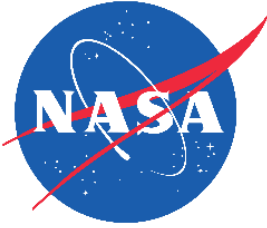
32" Docked – 1st percentile



Surface Analyses

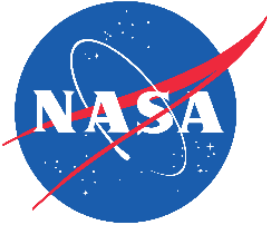
32" Docked – 99th percentile





Microgravity Analyses

- NASA MSFC utilized a Neutral Buoyancy Tank at the Space and Rocket Center to simulate Microgravity.
- Each hatch was analyzed by each participant.
- Participants were asked to push off of the wall/center structure to propel themselves through the hatches
- Analyses were observed for :
 - 1) Task difficulty
 - 2) Adequate volume
 - 3) Reach difficulties
 - 4) Visual access
 - 5) Overall comfort



Microgravity Analyses

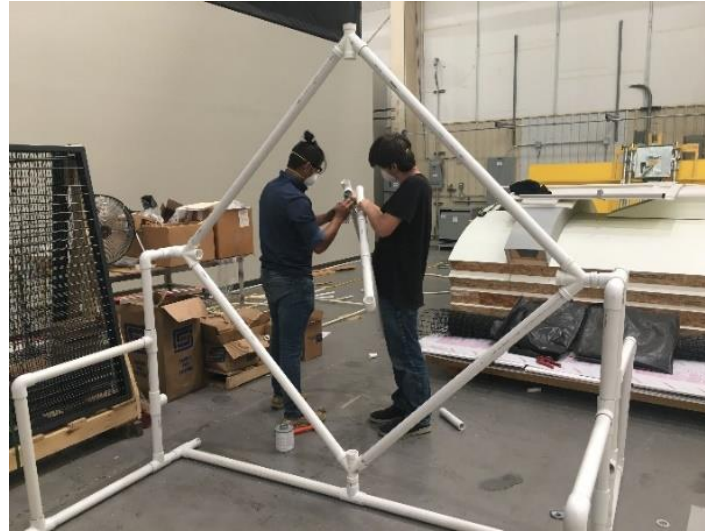
Constructed all hatches using PVC and CPVC.

Each hatch fit into the base.

The hatches were changed out under water during the assessment.



Bending CPVC to create hatches

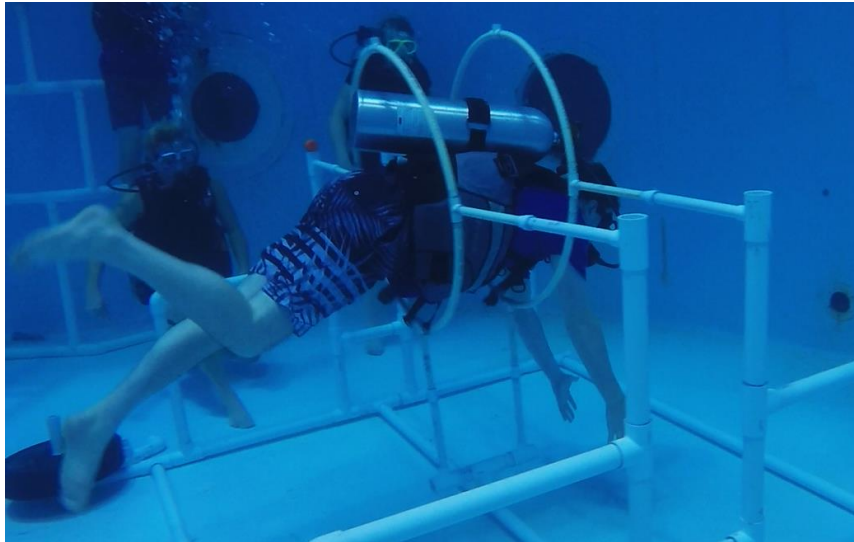
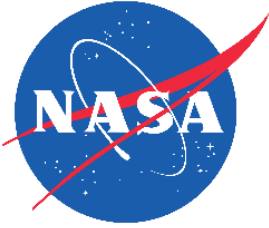


Using primer/glue to secure structures



Sinking base into tank

Microgravity Analyses



32": 99th percentile



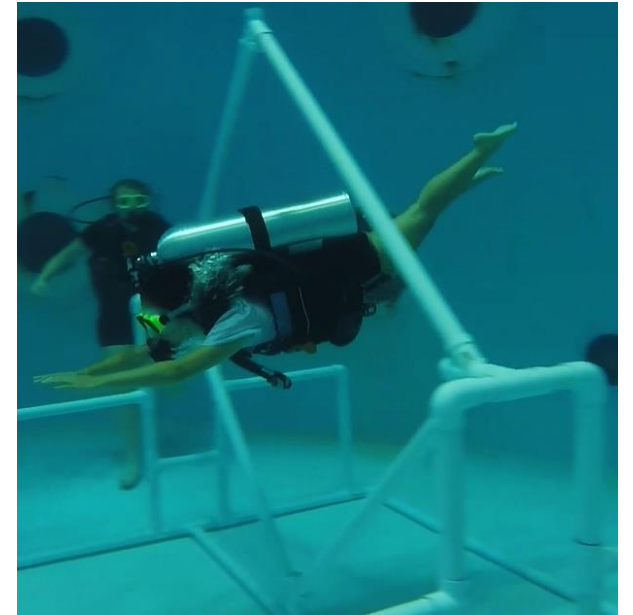
50x50": 5th percentile



42": 95th percentile

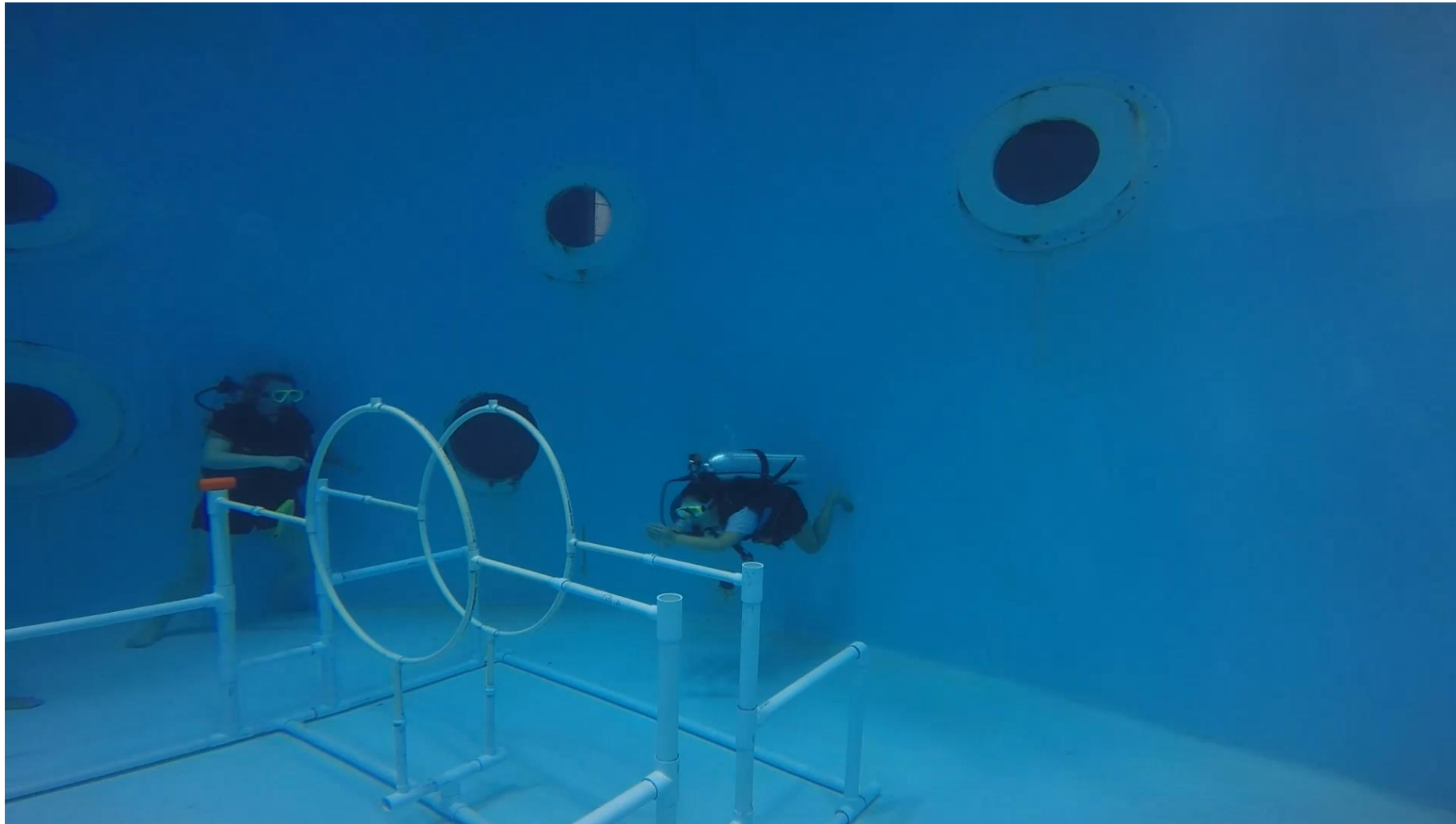
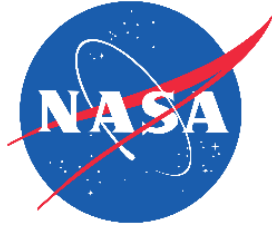


62x50": 5th percentile

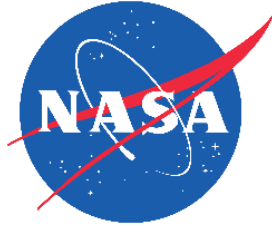


50x50" 45°: 1st percentile

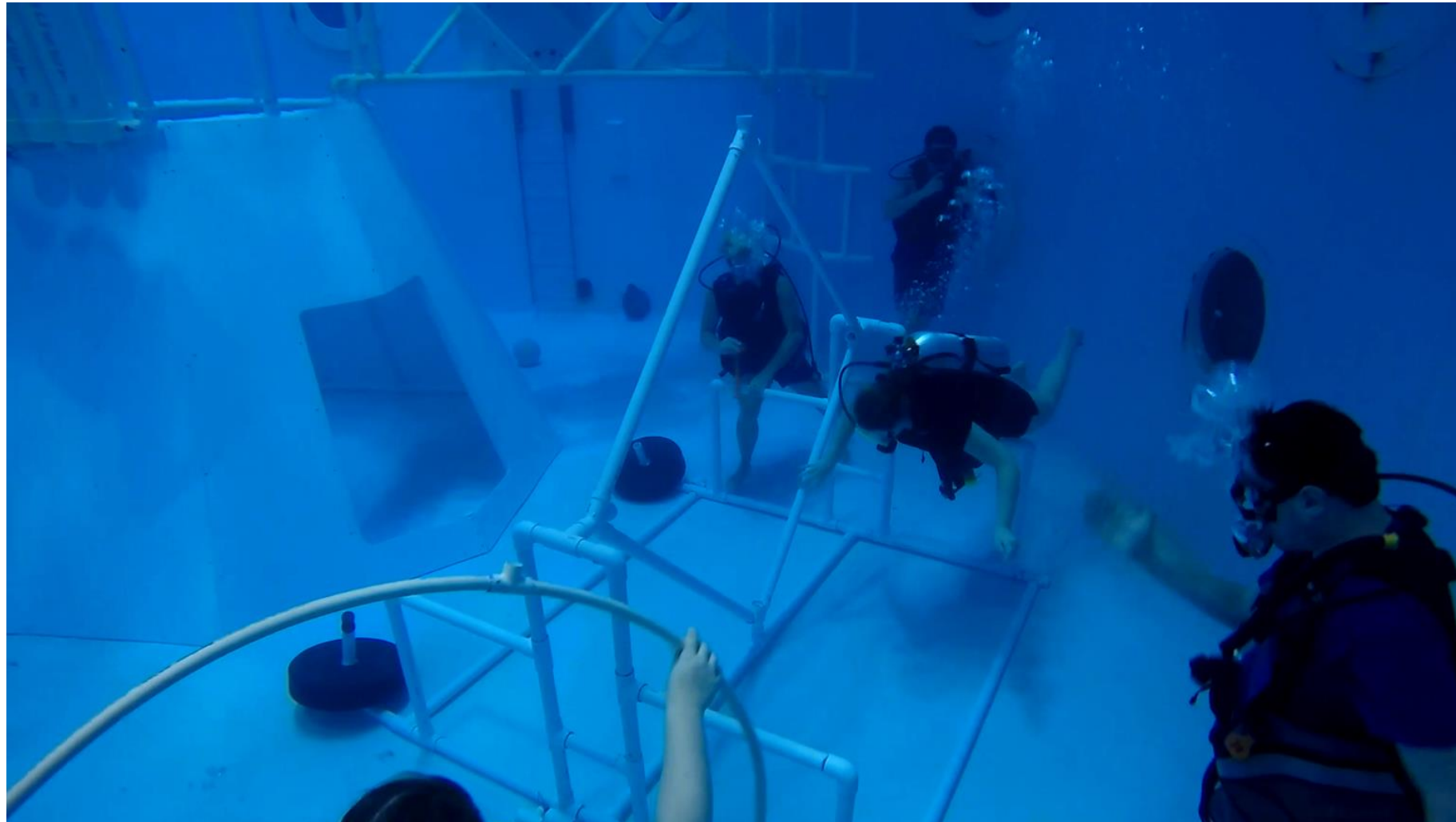
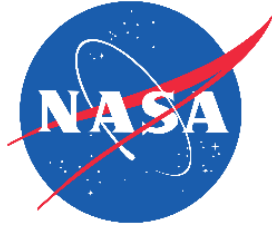
Microgravity Analyses 32", 1st Percentile



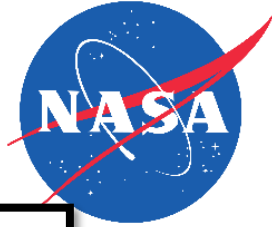
Microgravity Analyses 32", 99th Percentile



Microgravity Analyses Reconfigurations



Results



Human Factors Analyses were measured using surveys.

Each participant completed an subjective survey after each hatch configuration they completed.

Scoring System:

Strongly Disagree 1

Disagree 2

Neutral 3

Agree 4

Strongly Agree 5

Higher Scores = Higher Satisfaction

Please elaborate on any responses marked (Neutral), (Disagree), or (Strongly Disagree)

Please answer quickly; extensive thought should not be required, as these are first impressions.

Task: pass through specified hatch

1. I was able to perform the task without difficulty.
(Strongly Disagree) (Disagree) (Neutral) (Agree) (Strongly Agree)

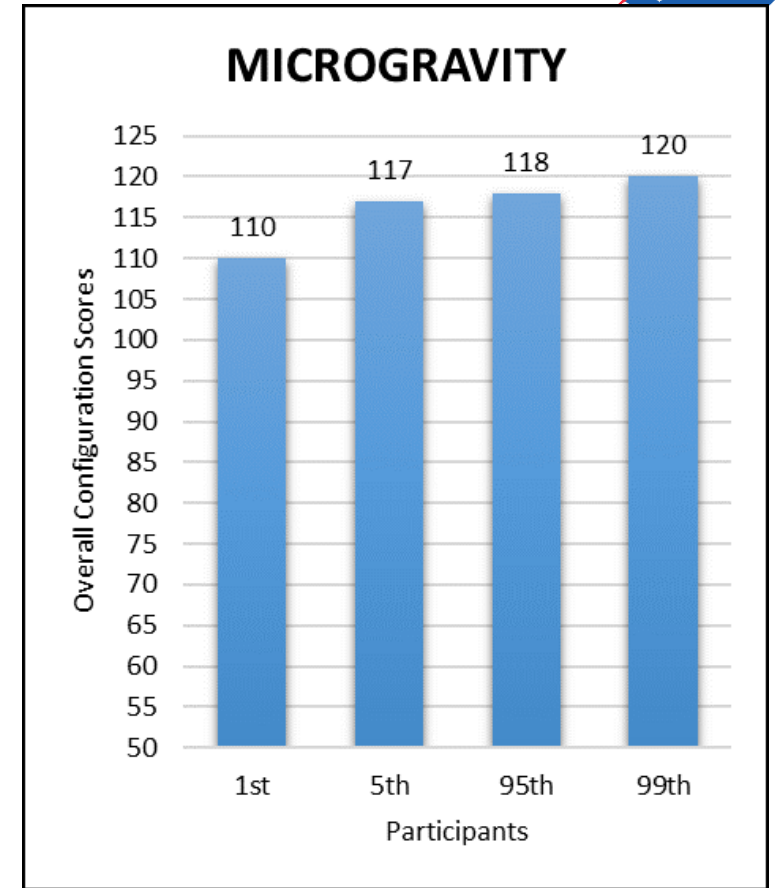
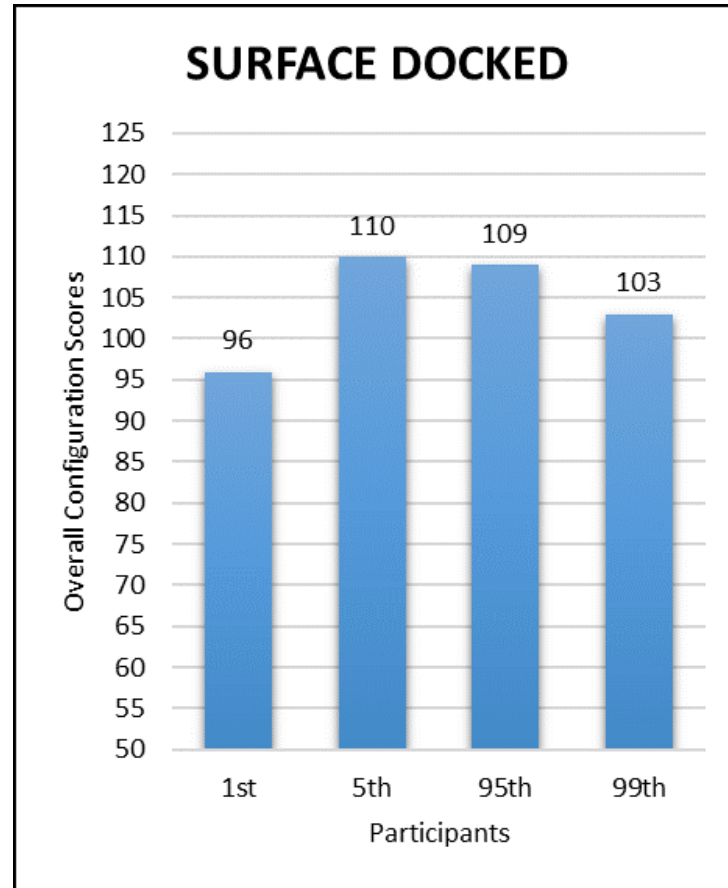
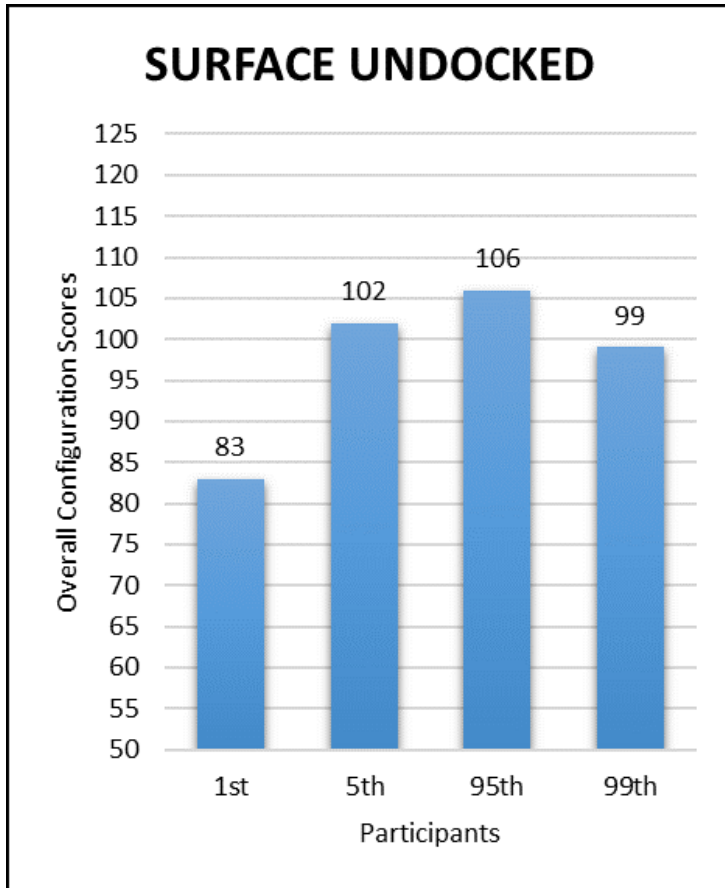
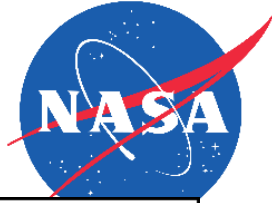
2. I felt I could complete the task in the allocated volume.
(Strongly Disagree) (Disagree) (Neutral) (Agree) (Strongly Agree)

3. I did not encounter any reach difficulties when completing the task.
(Strongly Disagree) (Disagree) (Neutral) (Agree) (Strongly Agree)

4. I had adequate visual access necessary to perform the task.
(Strongly Disagree) (Disagree) (Neutral) (Agree) (Strongly Agree)

5. I felt comfortable inside the hatch.
(Strongly Disagree) (Disagree) (Neutral) (Agree) (Strongly Agree)

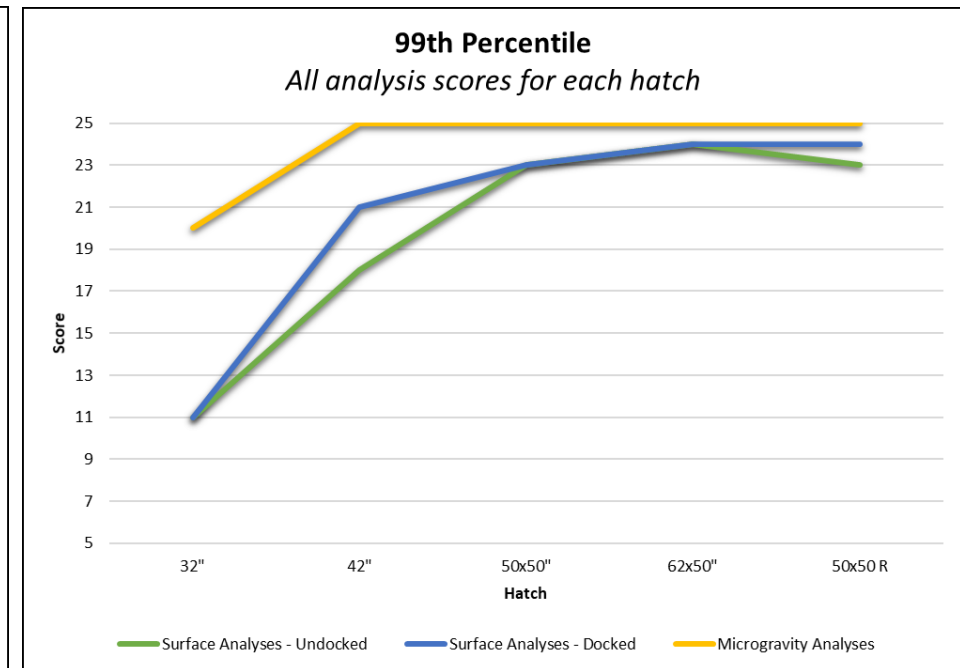
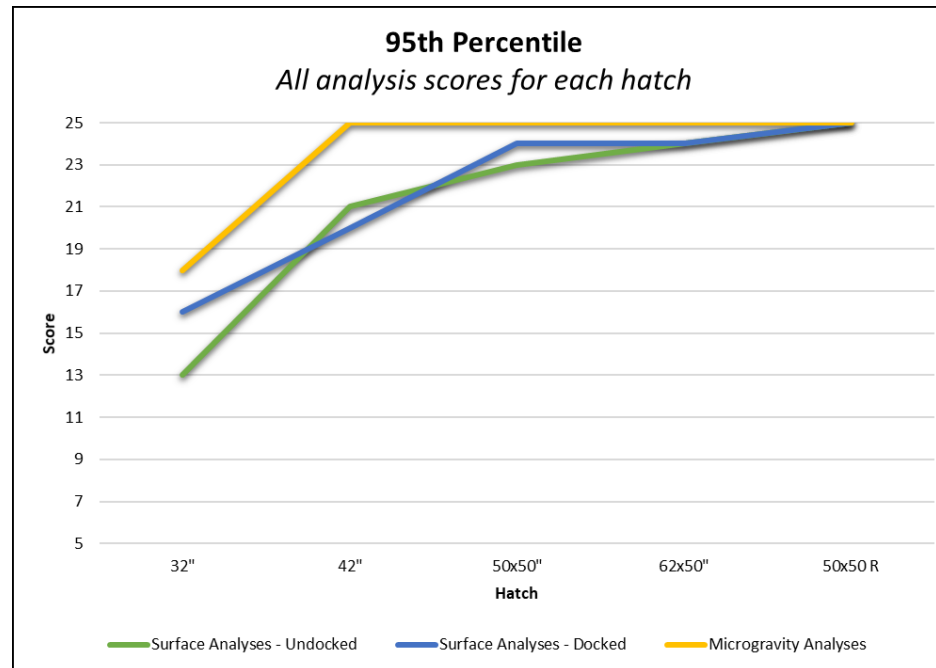
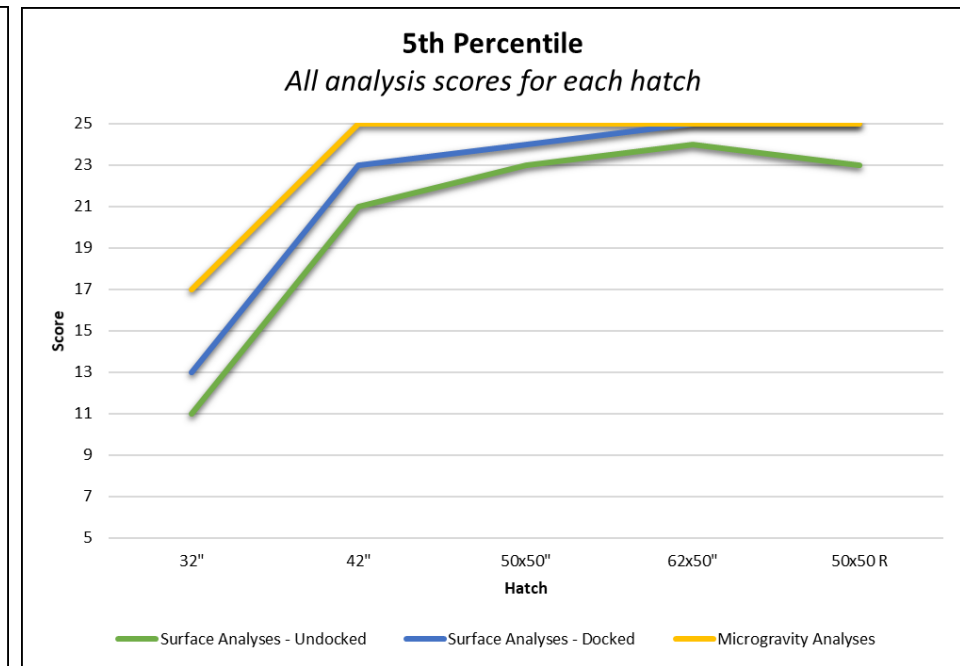
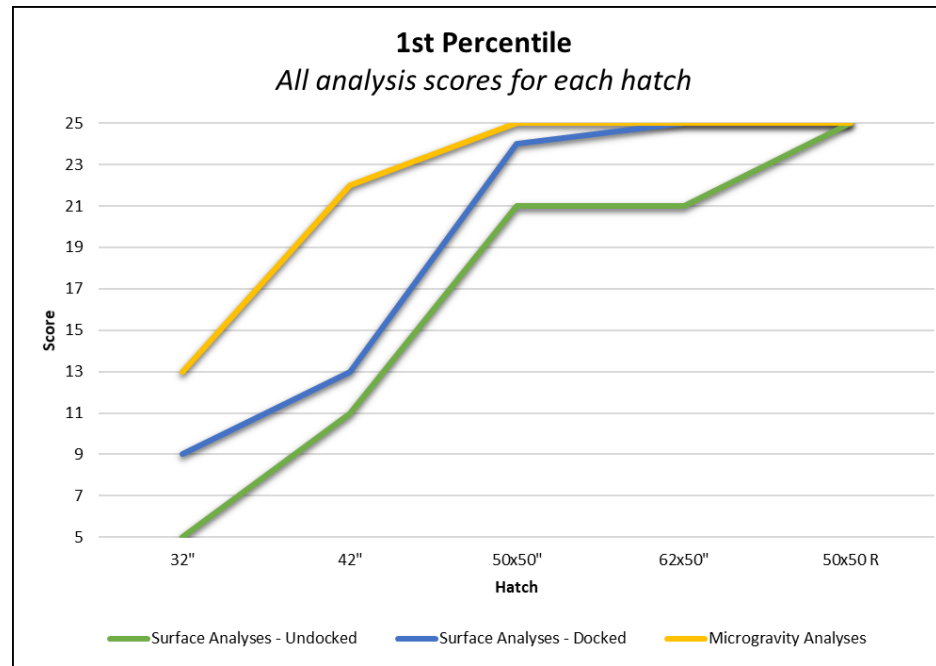
Results



Configuration scores based on each anthropometry

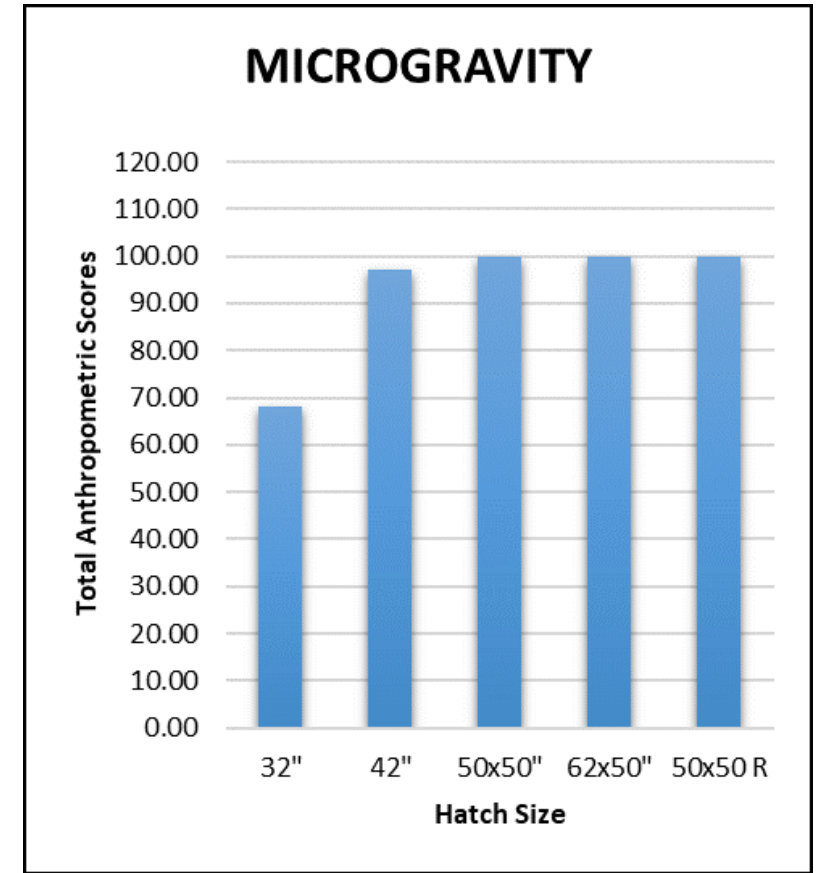
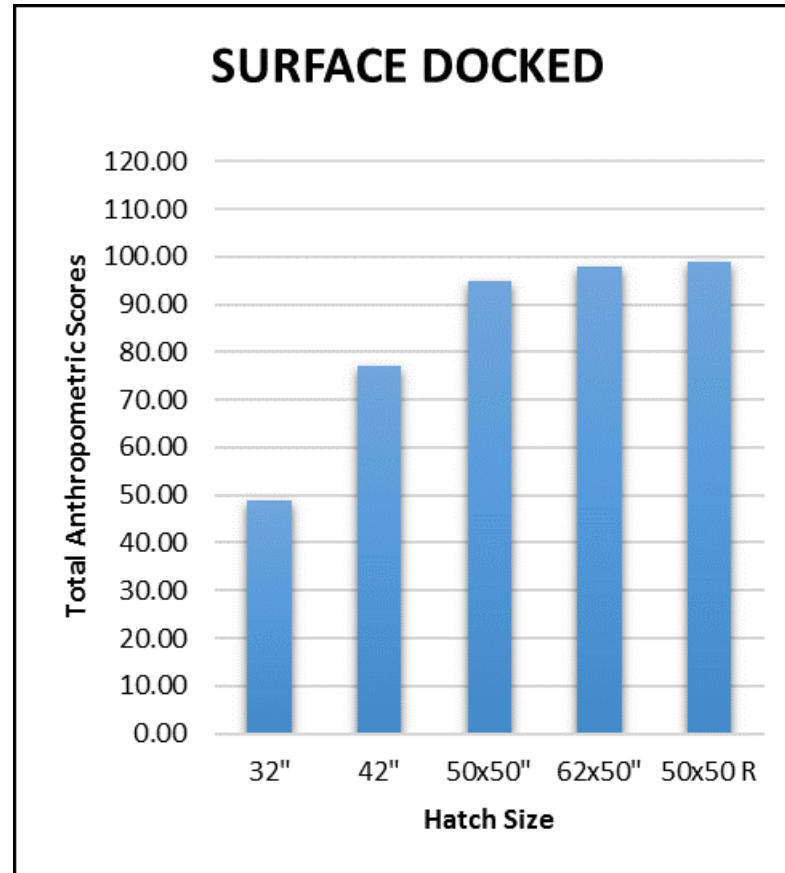
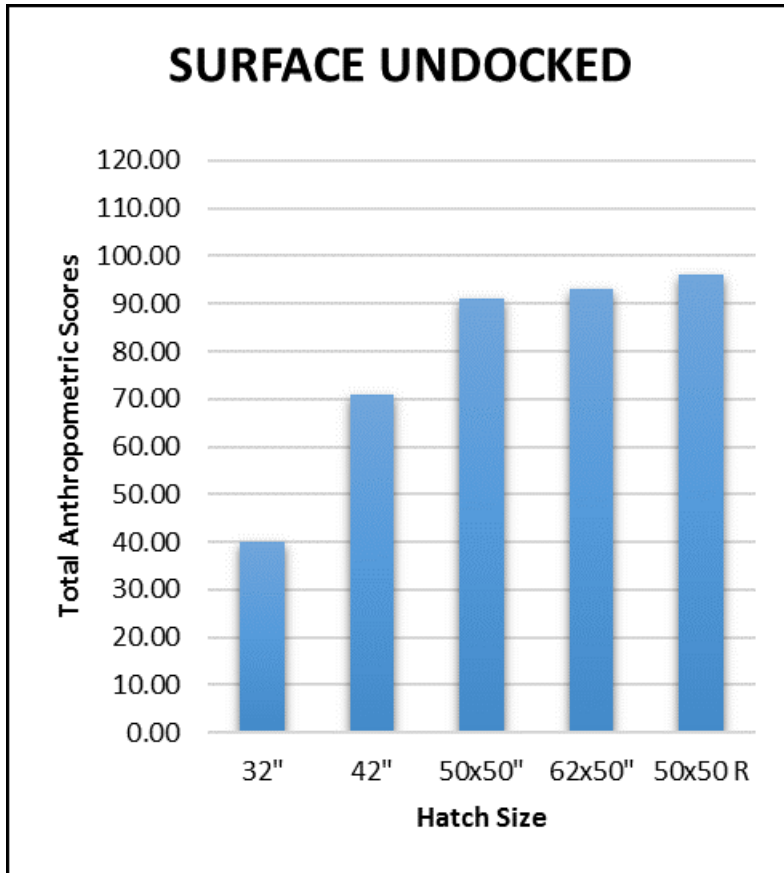
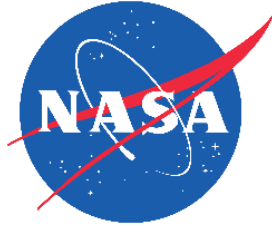
Results

Hatch scores based on anthropometry

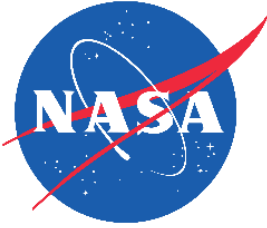


- Surface Analyses – Undocked
- Surface Analyses – Docked
- Microgravity Analyses

Results



*Configuration scores based on **ALL** anthropometries*



Key Findings

- 32” hatch does not accommodate all percentiles.
 - It scored low in all survey categories. It was the least favorite of each participant in each analysis. Concerns were stated by participants because of the small circumference.
- The project results show that scores remain the same once the size reaches the 50x50” hatch.
 - This means a 50x50” or greater size hatch will better accommodate all anthropometries.

QUESTIONS?

