



MPCV Exercise Operational Volume Analysis

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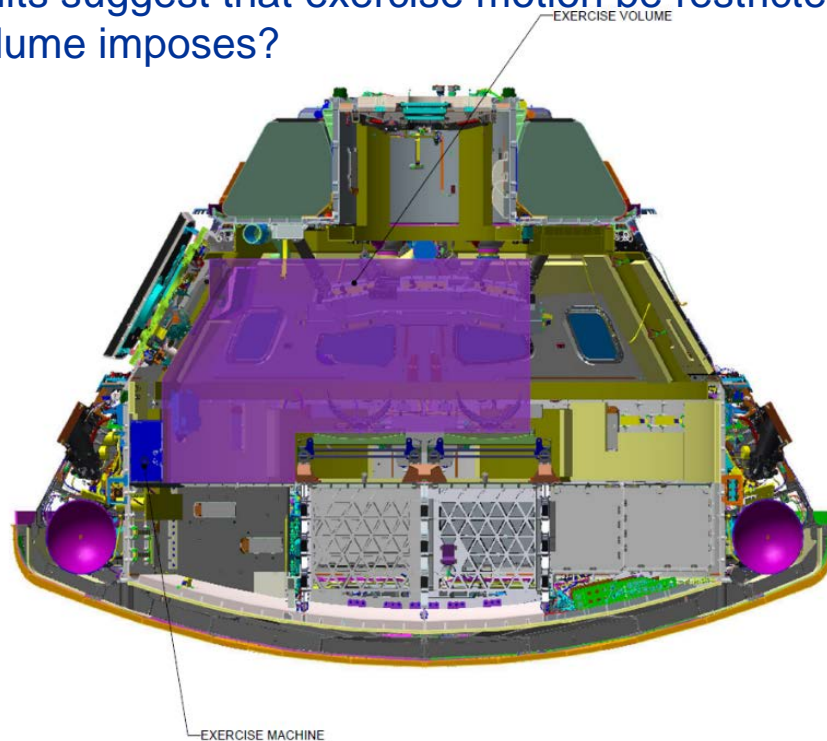
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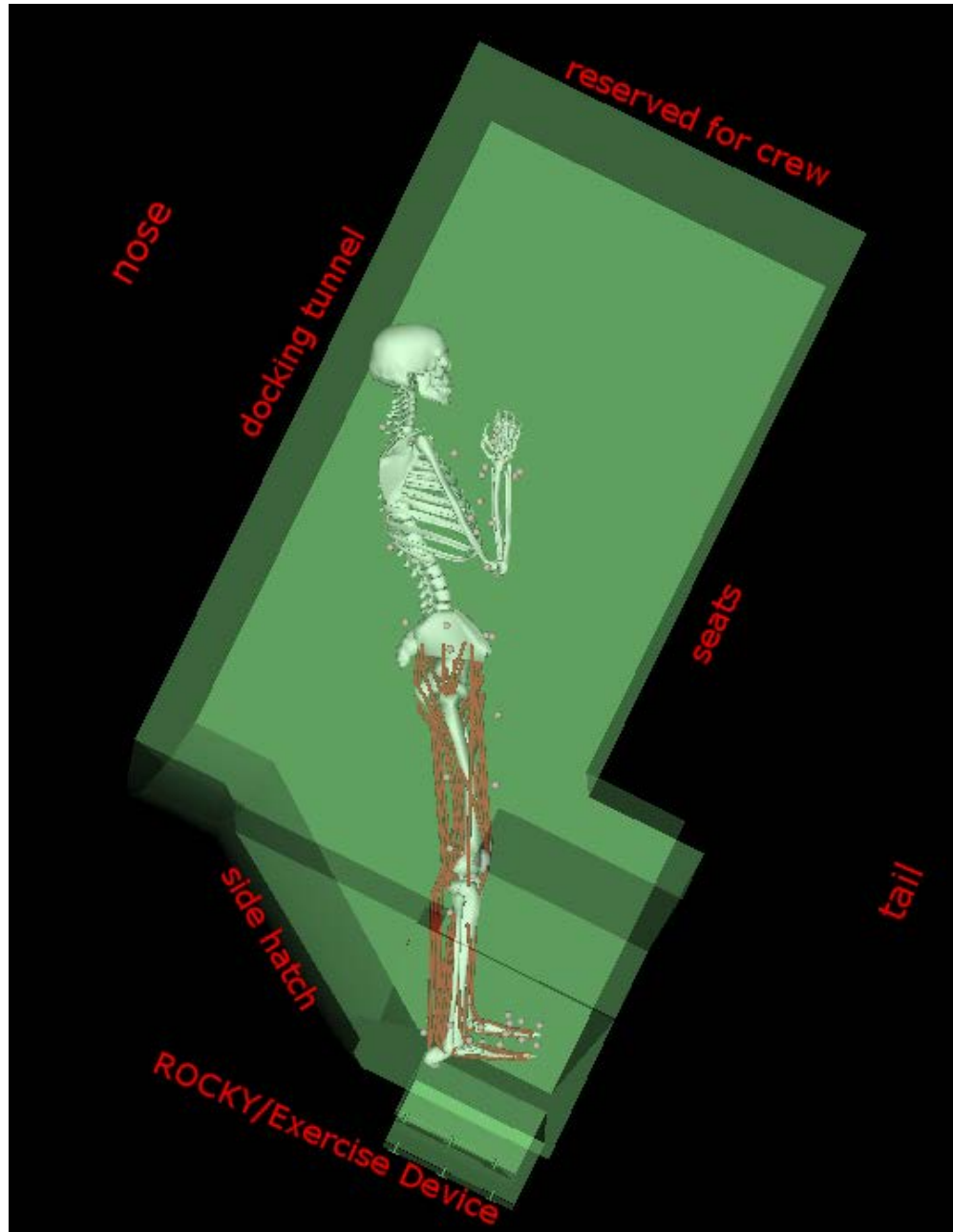
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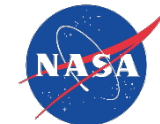


Background

- This study was initiated to determine whether or not the volume allocated for exercise within the MPCV would adequately accommodate crew members performing resistive and aerobic exercises.
 - Given a list of exercises to be performed by a crew in flight, which are contained within the volume?
 - If an exercise is not contained within the volume, what part of the body passes outside of the volume? How severe is the situation/is it reconcilable?
 - Will those results suggest that exercise motion be restricted, given the limits the operational volume imposes?







Exercises Under Study

Upright
Row

Bent-over
Row

Shoulder
Press

Squat

Heel
Raise

Aerobic
Rowing

Single-cable
Thrust

Power
Clean

Deadlift

Experimental Setup: 1g

- The motions of the resistive exercises were studied as performed by two subjects, 99th (~194 cm) and 50th (~179 cm) percentile in stature. Resistive exercises were performed in the Exercise Countermeasures Lab at GRC.
- Motion capture data were acquired during exercise.
 - The subjects were not told to restrict their motion in any way, but were instead allowed to exercise freely.
- Marker numbers varied from 28 markers (99th percentile) to 56 markers (50th percentile).
 - Virtual markers were used for the head on the 50th percentile subject.



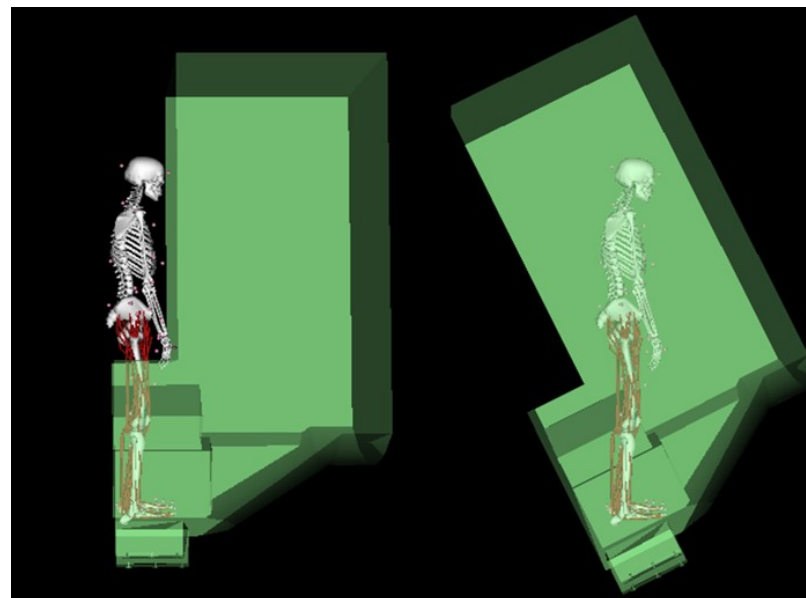
Experimental Setup: 0g

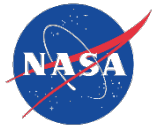
- Rowing was performed during a parabolic flight.
- Limited motion capture data was acquired and analyzed for this study.
 - Available viewpoints only allowed analysis of markers on the front and front-right of the subject.
 - Digital Astronaut developed software which was used for analyzing motion capture data from parabolic flights.



Subject Orientation

- Initially, the subject was expected to face the nose of the MPCV, with their backs against the seats.
- The exercises were modeled and evaluated in two orientations: with the subject facing both the nose and the tail of the MPCV. They were also evaluated with different footplate angles.
 - Without the footplate being tilted, the subject would immediately collide with the seats.
- Current requirements for ROCKY do not include a mechanism to make orientation user-specific.



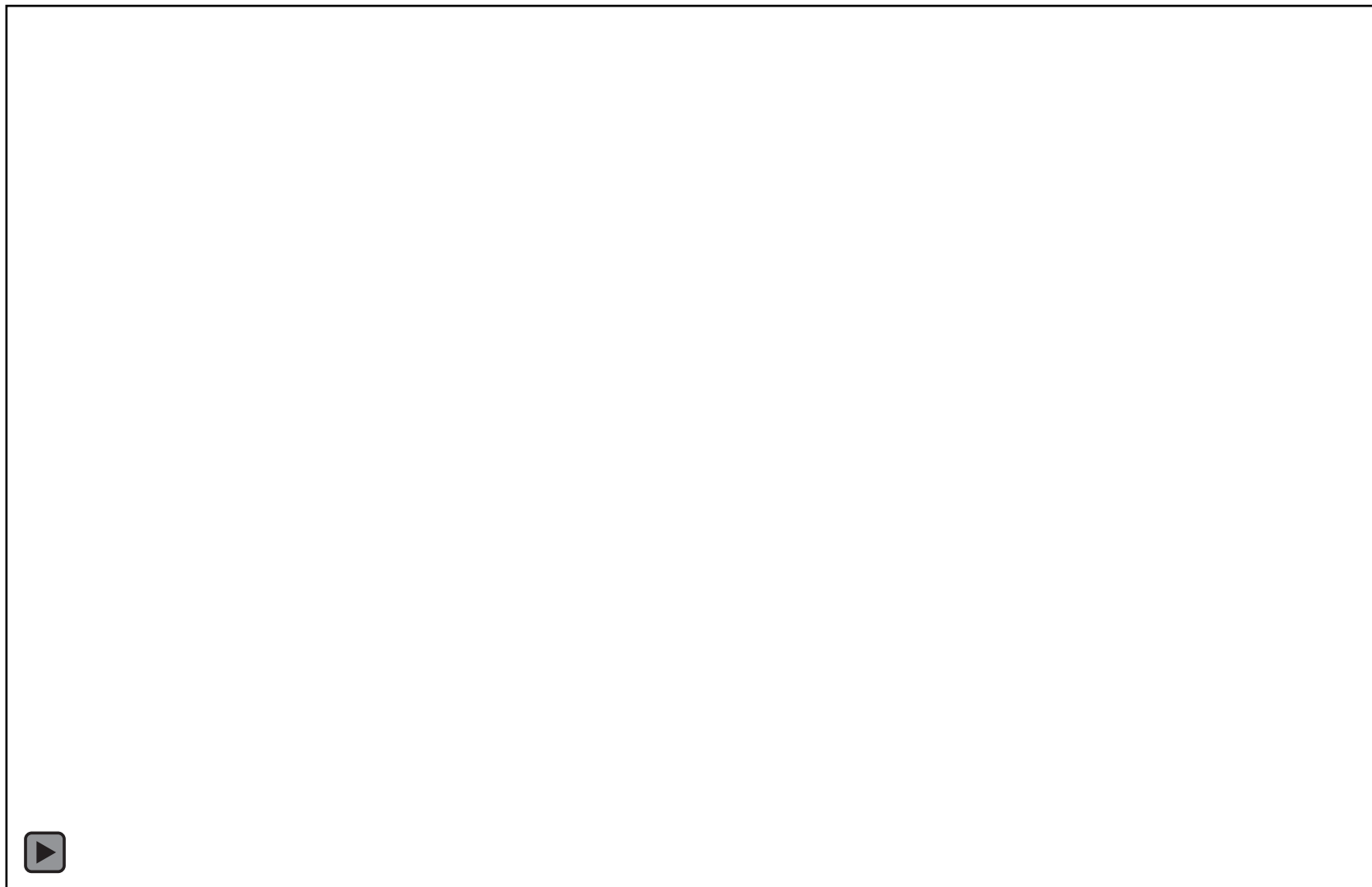


Results



Parabolic Flight Rowing Data: Facing Nose

(~50th Percentile)





Parabolic Flight Rowing Data: Facing Tail

(~50th Percentile)

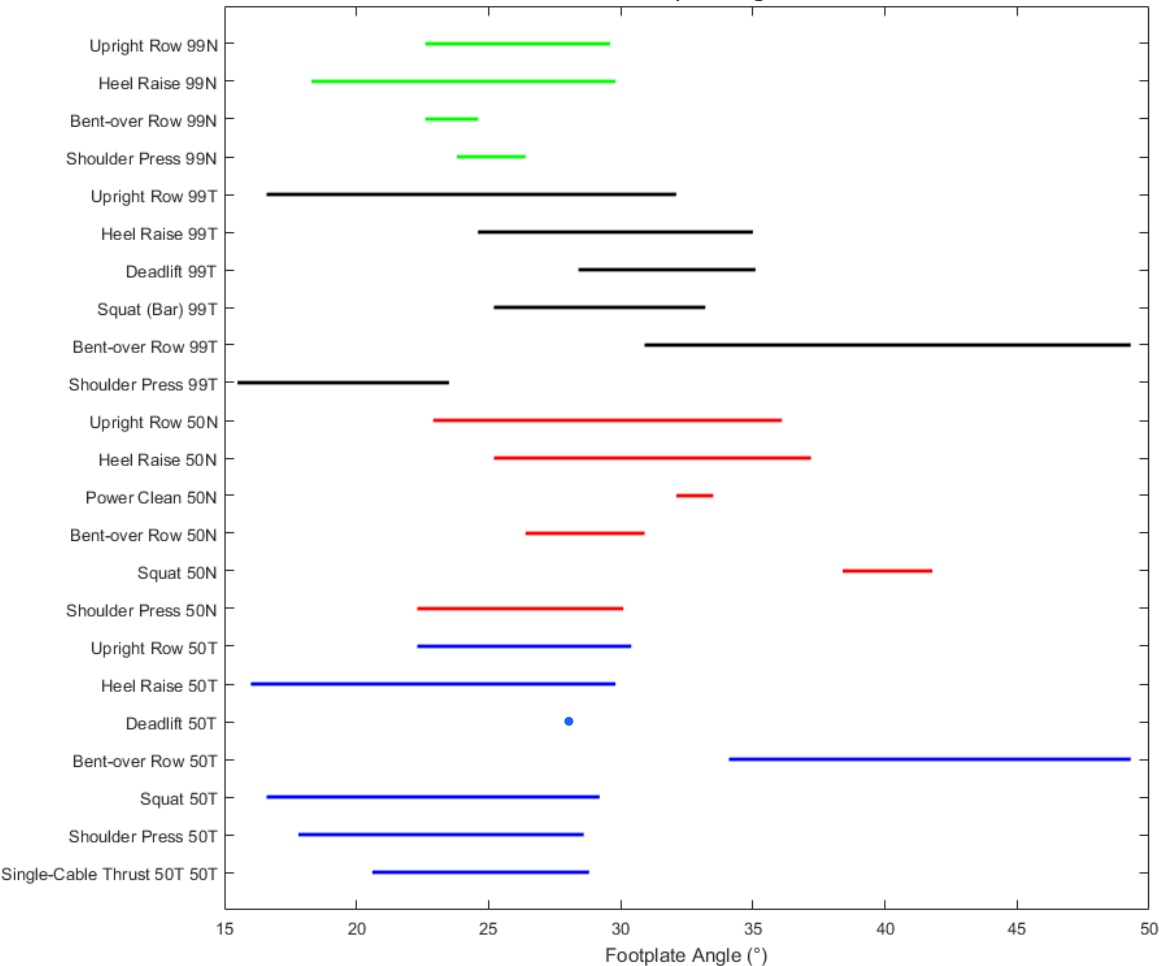




Comparison of Potential Footplate Angles for Contained Exercises

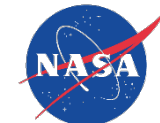
(Colors represent different orientation/stature combinations)

Valid Footplate Angles



Exercise	Orientation	Location of Interference
Single-Cable Thrust	99N	Hands in docking tunnel, hips in seats
Power Clean	99N	Either head or arms; tunnel or seats
Squat (Harness)	99N	Either head or hips; tunnel or seats
Squat (Bar)	99N	Either head or hips; tunnel or seats
Deadlift	99N	Either head or hips; tunnel or seats
Power Clean	99T	Arms, seats
Squat (Harness)	99T	head, tunnel; or hips, seats
Single-Cable Thrust	99T	Hands in tunnel, then seats
Single-Cable Thrust	50N	Hips through seats, hands through tunnel
Deadlift	50N	Hips through seats
Power Clean	50T	Head through tunnel and then seats

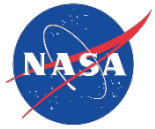
Summary of Results



- All of the exercises listed in the preceding chart remain contained within the volume as long as the footplate is adjustable to between approximately 20 degrees to 40 degrees and as long as the exerciser can face either the nose or the tail
 - The exercises in the accompanying table cannot fit regardless of angle because of a relatively extreme range of motion. In these cases, the exercise cannot be made to fit in one area without it poking out in another.
 - These exercises include the single cable thruster, power clean, and harnessed squat for the male exerciser with a 99th percentile stature.

If footplate angle and orientation adjustability is not possible, then the following info can inform decisions regarding user orientation and fixed/restricted footplate angle(s):

- **50th Percentile Resistive:** the greatest number of exercises remained contained with the exerciser facing the tail and the footplate angle between 25-30°
- **50th Percentile Rowing:** the exercise was contained when facing the nose and with the footplate at 26°
 - Facing the tail appears plausible, but there is more chance of forehead interference with the seats with the tail orientation (~50% of the motion analyzed indicated a risk for colliding with the seats)
- **99th Percentile Resistive:** the greatest number of exercises remained contained with the exerciser facing the tail and the footplate greater than 30°
- **In both subjects,** more exercises were contained, and within a more consistent range of footplate angles, when the subjects faced the tail.



Questions?