



Spaceflight for All

ACCOMMODATION, SAFETY AND PERFORMANCE

Han Kim, PhD, Leidos, Inc., NASA Johnson Space Center
February 26, 2024

This work was in part supported by NASA
Human Health and Performance Contract NNJ15HK11B.

Spacesuit for All Body Shapes and Sizes

CHANGES IN ASTRONAUT POPULATION

Body sizes used to be “homogeneous” in early space ages.
But today, crewmembers have a wide variety of body shapes and sizes



Crewmembers in 1960's



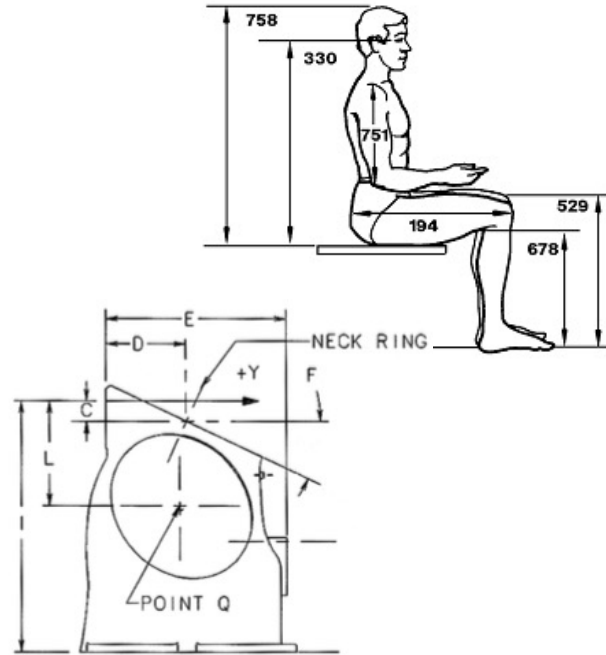
Crewmembers in 1990's



Artemis Crewmembers 2020's

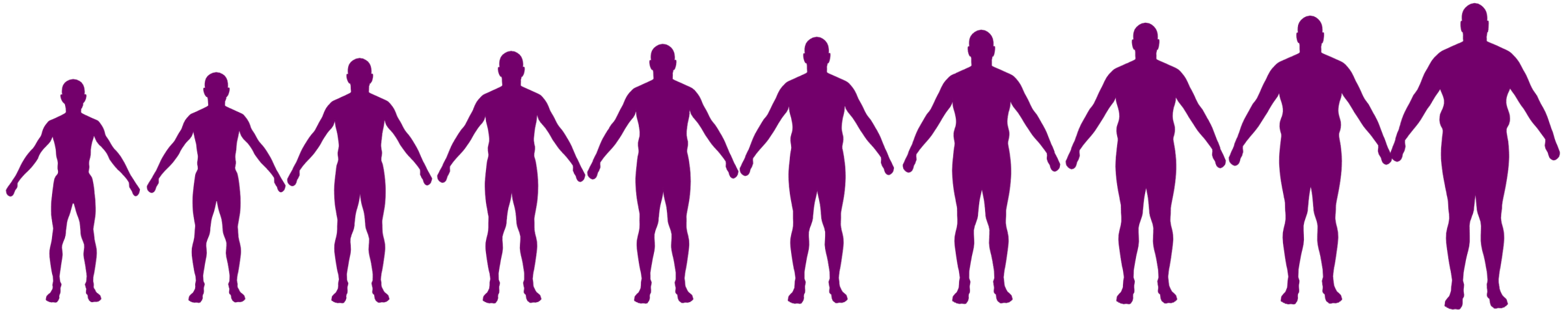
SPACESUIT DESIGN: A NEW CHALLENGE

- Spacesuits were custom fitted to each astronaut during early space programs
- In modern days, spacesuits are provided in modular components and sizes due to cost and logistics



LARGE VARIABILITY OF HUMAN BODY SIZES

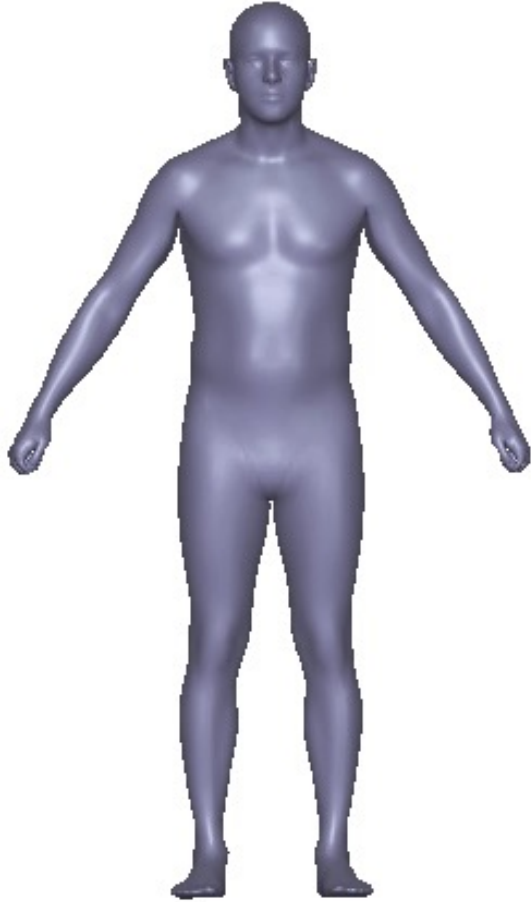
Modular sizing is however difficult due to the large variability in human body sizes



Short & Slim
62" 150 lbs

Tall & Wide
75" 250 lbs

HUMAN BODY SHAPE VARIABILITY



Males: 5 ft. 9 in. tall, 165 lb.



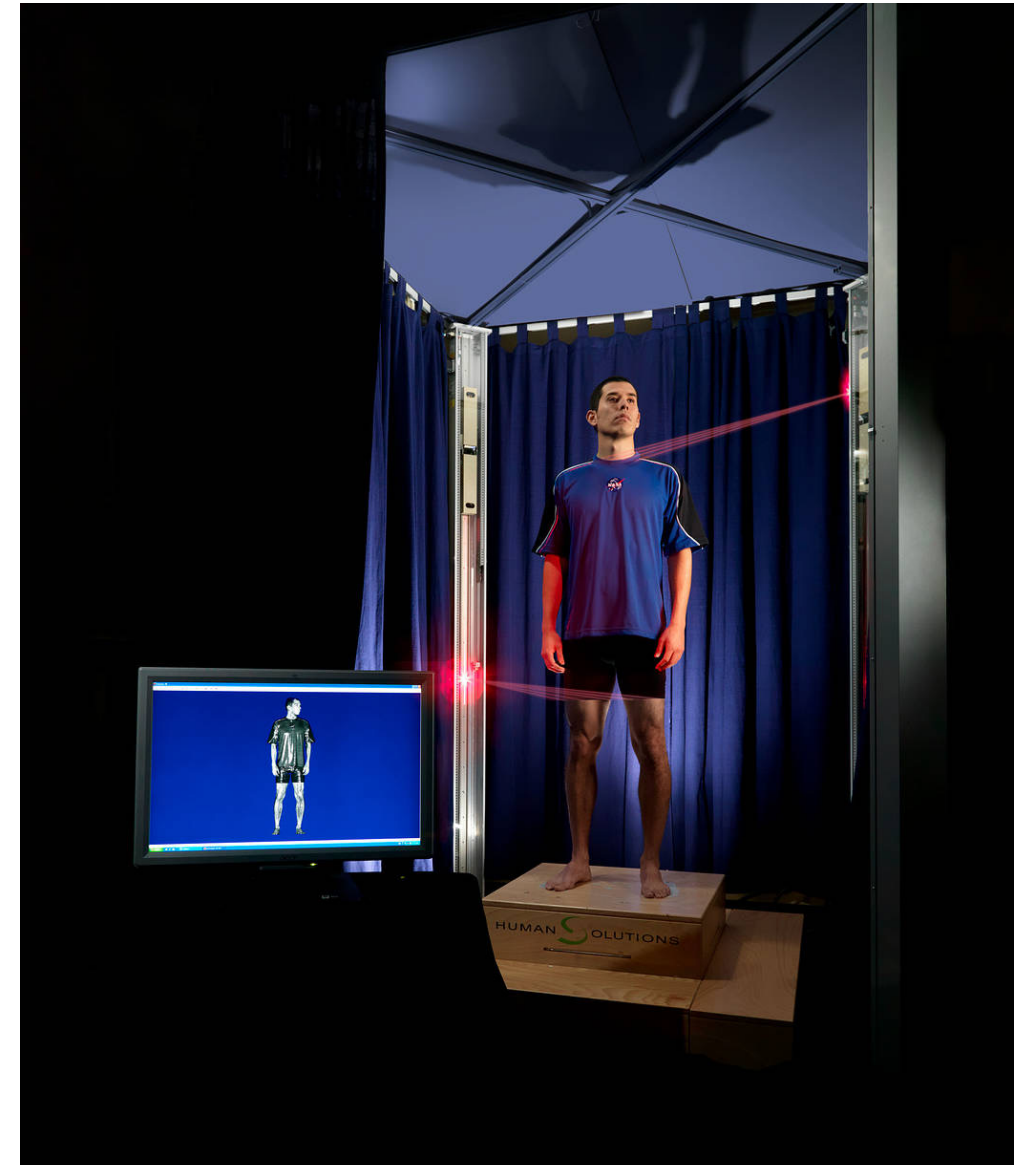
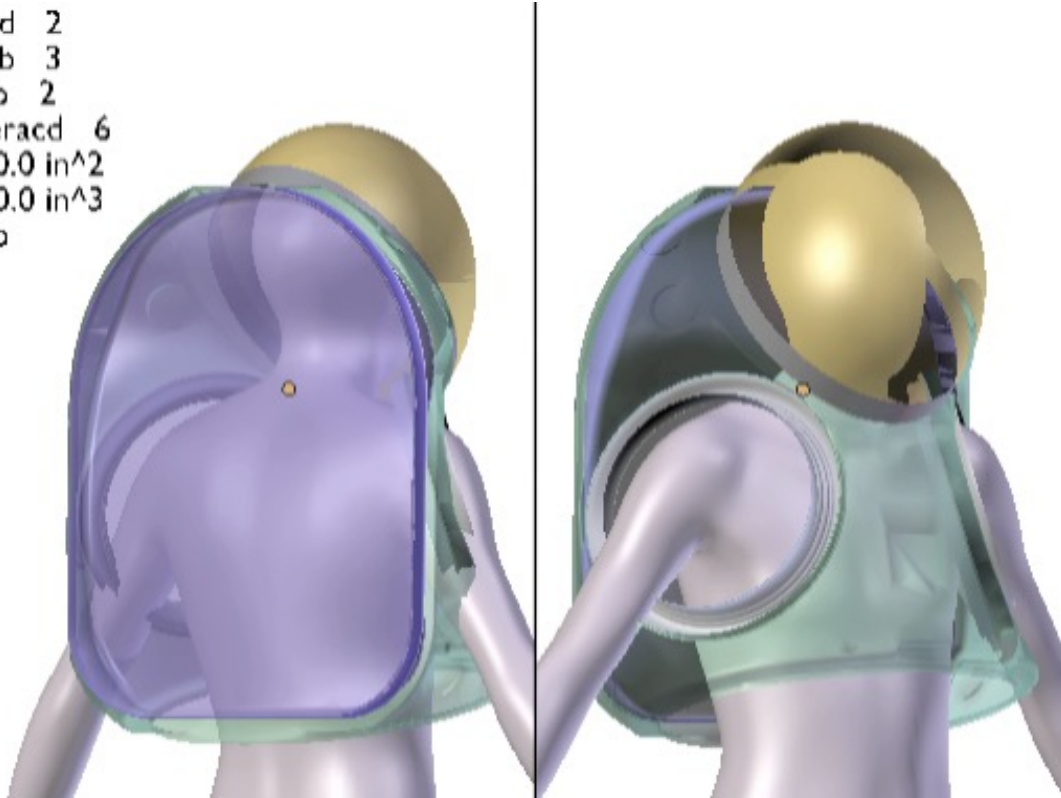
Females: 5 ft. 4 in. tall, 155 lb.

Same height and same stature,
but substantially different body shapes

VIRTUAL FIT CHECK

NASA developed a virtual fit technique, which ensure the new design spacesuit can accommodate 99% of the crew population

ched 2
cheb 3
bidb 2
interacd 6
oa 0.0 in²
ov 0.0 in³
fppp



Mobility, Safety and Performance

MOBILITY AND PERFORMANCE



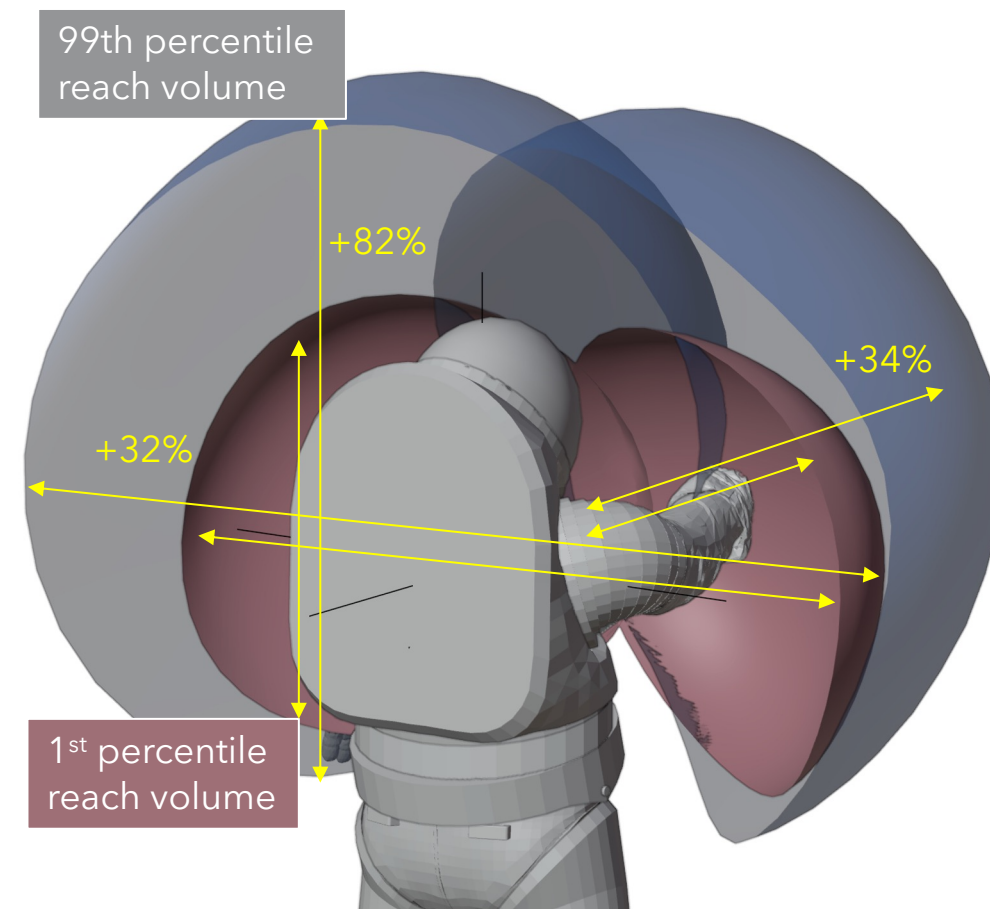
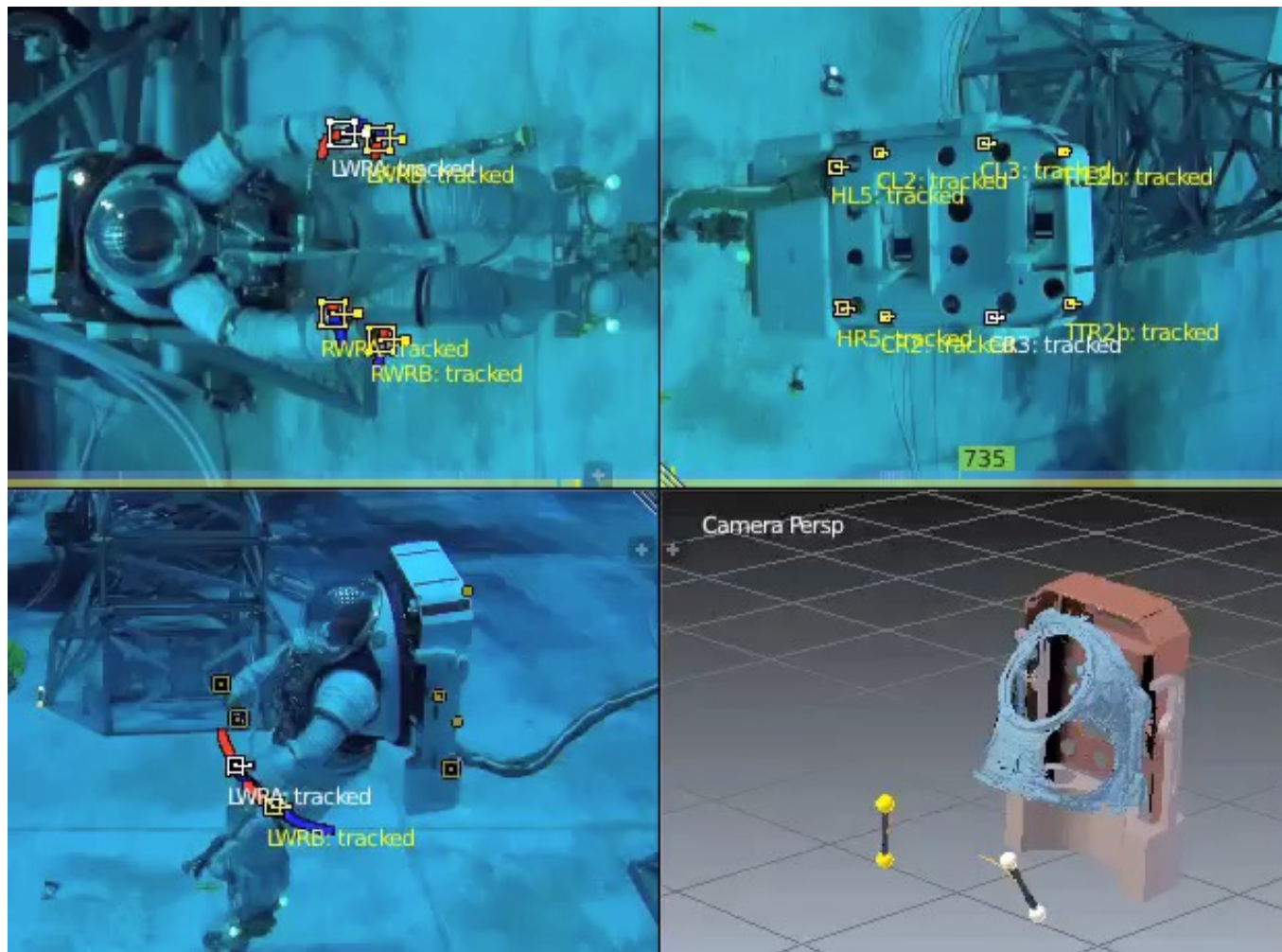
*Ergonomics: Fit the job to the people,
not fit the people to the job*

ASTRONAUT MOBILITY TESTING

NASA Neutral Buoyancy Laboratory
(NBL: 202 ft × 102 ft × 40 ft diving tank)



REACH VOLUME VARIABILITY ACROSS ASTRONAUTS

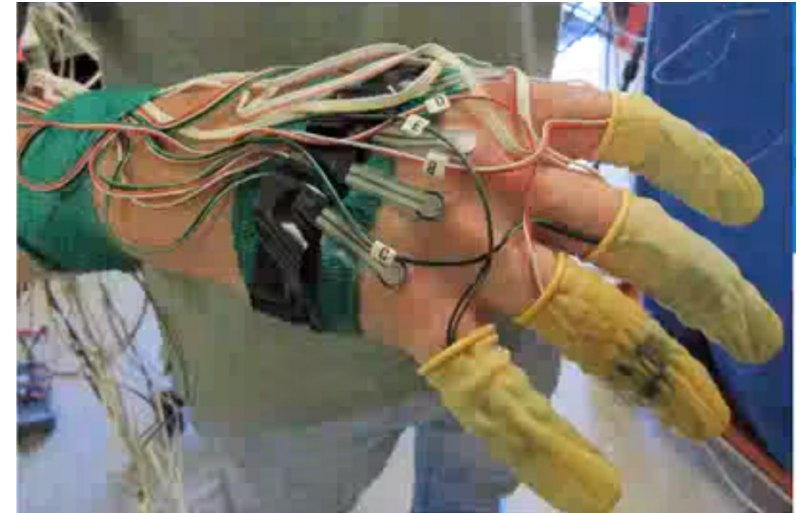
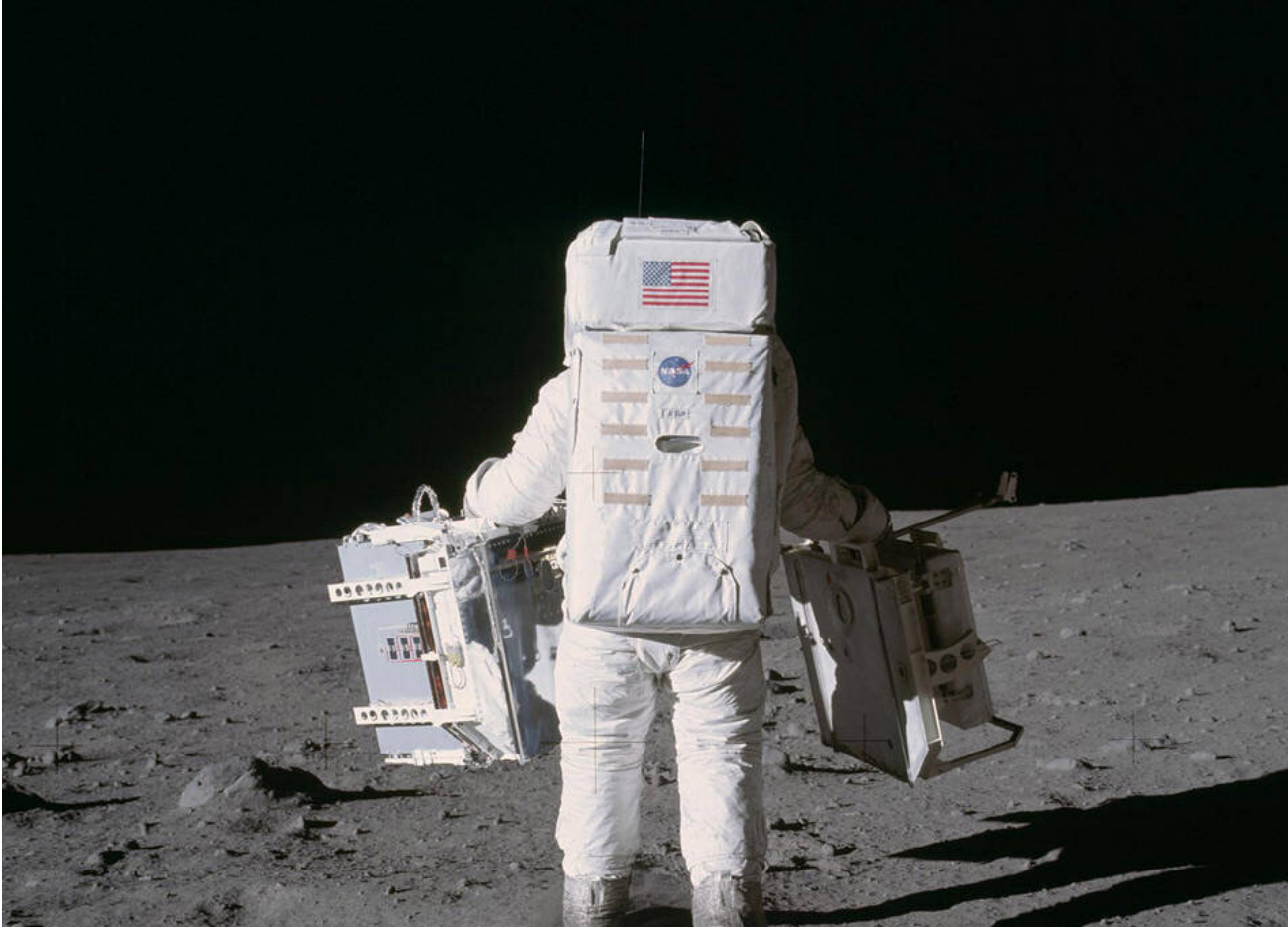


Difference between small and large person's reach volume

Space Technology for the Future

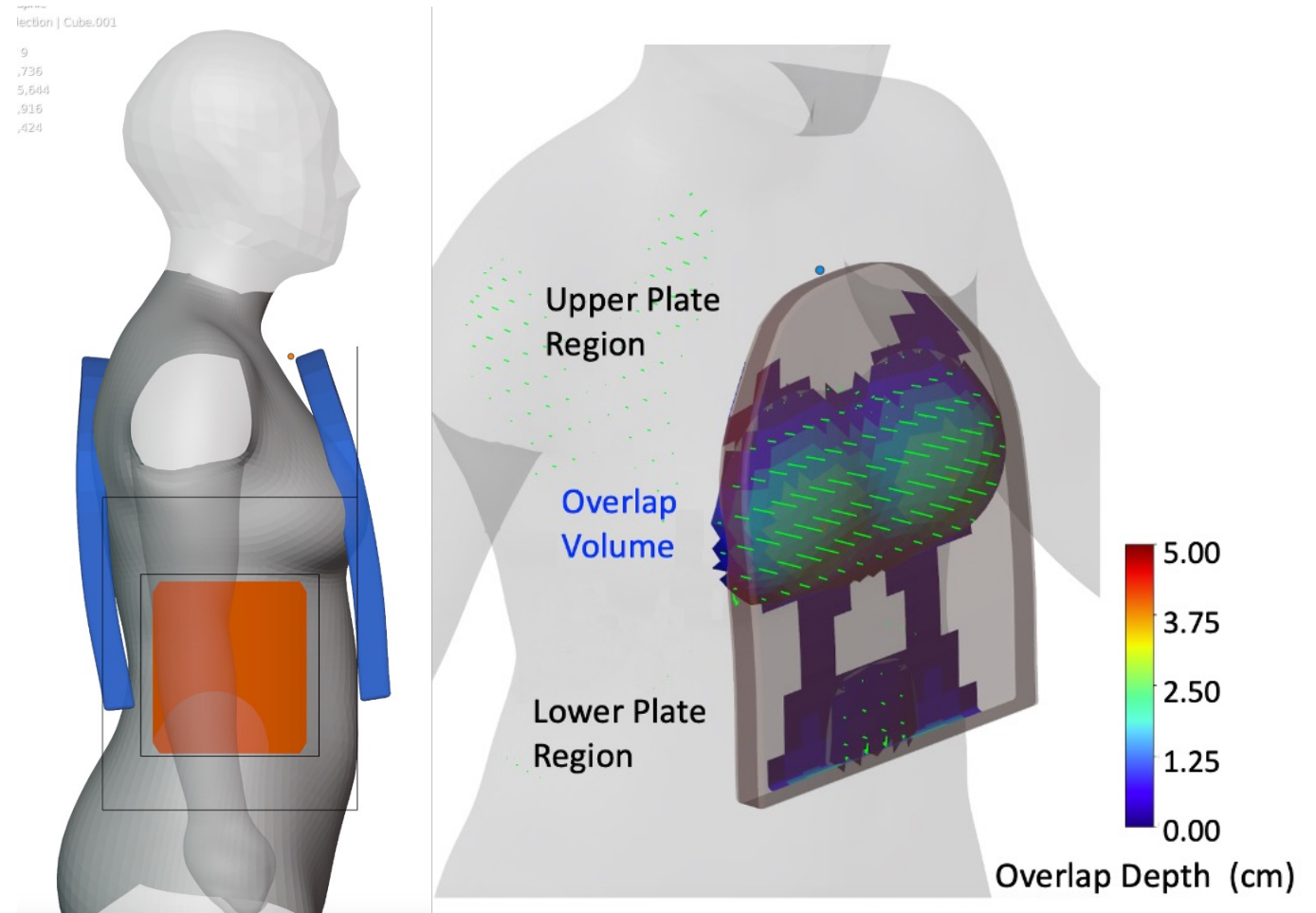
STRENGTH CAPABILITIES & SAFETY

Payload handling and strength capabilities for crew safety



MILITARY BODY ARMOR DESIGN IMPROVEMENTS

Virtual body armor fit to optimize body armor design



Work in collaboration with US Army DEVCOM

SPACE TECHNOLOGY TO MEDICAL APPLICATIONS

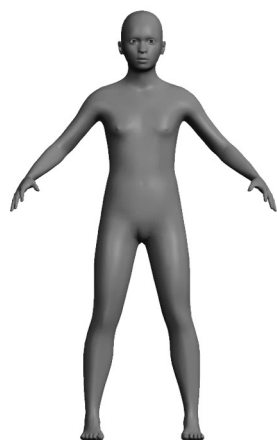
- Medication doses are determined by the patient's body surface area, which has been calculated by body weight and height

$$\text{Body Surface Area} = \sqrt{\frac{\text{Body Weight (lb)} \times \text{Height (in)}}{3.131}}$$

- However, the errors tend to be larger for small children



25 years old
6 % Error



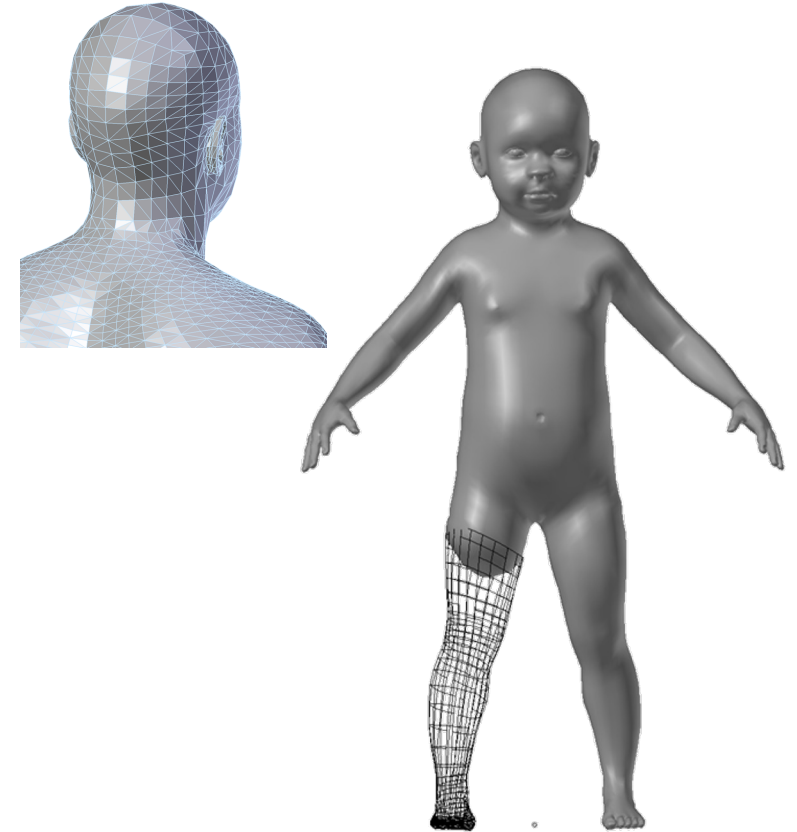
12 years old
15 % Error



3 years old
29 % Error



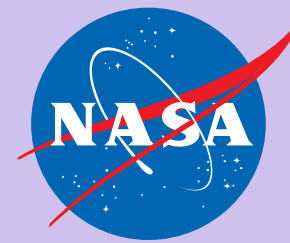
3D BODY SCANNING TECHNOLOGY FOR MEDICINE



3D body scanning technology can enable for innovations in clinical applications

Han Kim, PhD

han.kim@nasa.gov



leidos