Applying UNISEC Experience to Human Spaceflight

A Life Support Engineer's Perspective

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Oceaneering Space Systems

Background

- University of Tokyo, Japan
  - CubeSat teamwork mostly in my junior year (ISSL)
  - UNISEC
  - BS and MS in Aeronautics and Astronautics
    Prof. Machida's Lab
- Massachusetts Institute of Technology, USA
  - PhD in Aerospace Biomedical Engineering,
    Minor in Product Design
  - Cardiovascular research, system ID
- Smith & Nephew, USA
  - Advanced Surgical Devices Division
- Oceaneering Space Systems
  - Spacesuit, Environmental Control and Life Support Systems (ECLSS)

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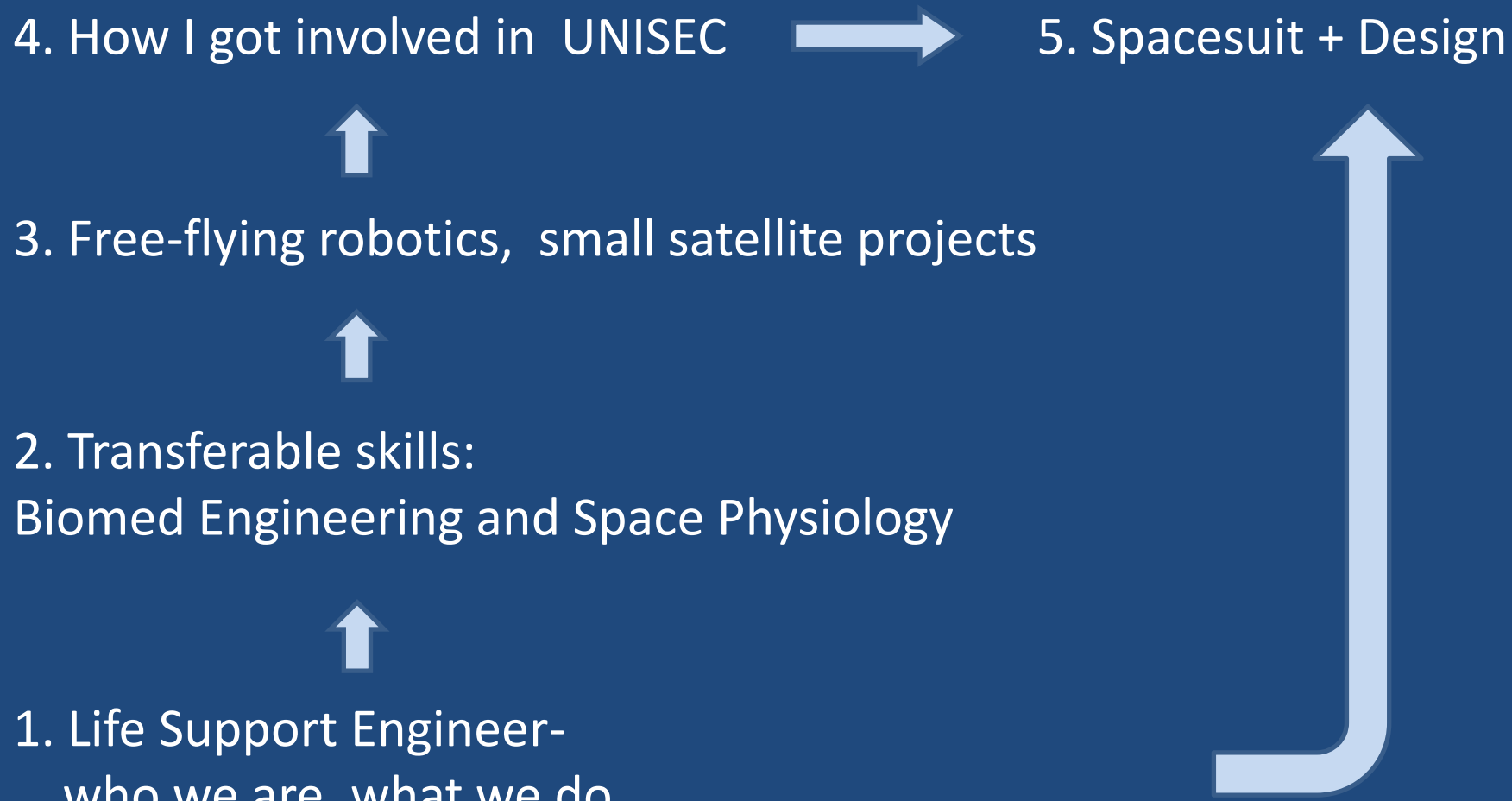
How hands-on experience can shape an engineer's career



1. Life Support Engineering

- Life Support Engineer – who we are, what we do
  - Design a system or subsystem to keep human comfortable in a harsh environment such as space (space vacuum, heat cycles ±250°C, micro/partial-gravity)

- Object: Spacesuit and ECLSS (Environmental Control and Life Support System)
  - Frankly speaking, it is about backpacks of the spacesuits, and things inside the racks of the space station

Life Support Systems

- Oxygen: tank, regulator
- Carbon dioxide scrubber
- Temperature control
- Humidity control
- Ventilation (fan, blower)
- Pump
- Trace contaminant control
- Water recovery (from urine)
- Sensors
- Liquid cooling and ventilation garment (LCVG)
- …

Spacesuits

- Protect astronauts from vacuum and thermal environment in space
  - "Articulated spaceship"
- Intravehicular (launch & reentry) and extravehicular space suits

SpaceX
(Launch and Entry Suit)
(2020 -)

NASA's
Space Shuttle, ISS
('80-'10)

The latest IVA & EVA suit

Artemis (2024-)

Extravehicular Space Suits

Apollo

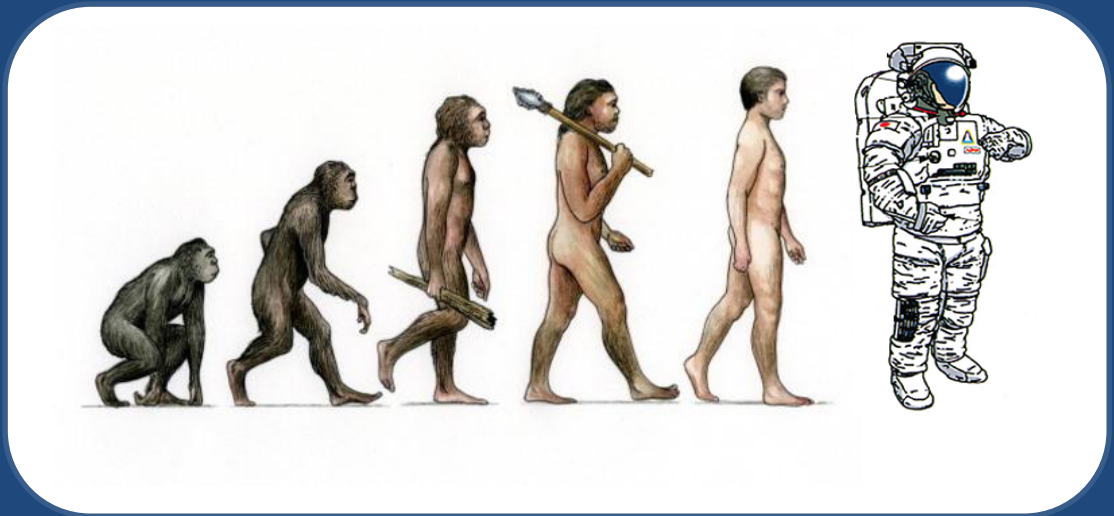
Space Shuttle &
International Space Station

Artemis

- Apollo and Artemis spacesuits are designed for exploration (walking, hopping)
- The current spacesuit is designed for microgravity (handrail, robot arm, and jetpack transfer)

Life Support Requirements

- Human physiology hasn't evolved at least in the last 50 years!
- The basic requirements are the same
  - Supply oxygen
  - Remove carbon dioxide (regenerable technology)
  - Control temperature and humidity
  - Mobility
- At each spacesuit design increment, new technologies are implemented to meet requirements efficiently



Useful Skills for Life Support Engineering

- Data acquisition (LabVIEW, Matlab)
- Wiring (analog, digital i/o)
- Engineering: A to Z
  - Plan tests, find/make sensors and actuators, design tests, execute tests safely, collect data, analyze data, report
- Concise communication
  - Emails, presentations, documenting (scientific writing)
  - Engineering diary (power point & excel for example)
- Dealing with frustration and challenges
  - Budget, testing schedule, decision-making with incomplete data, failed tests…

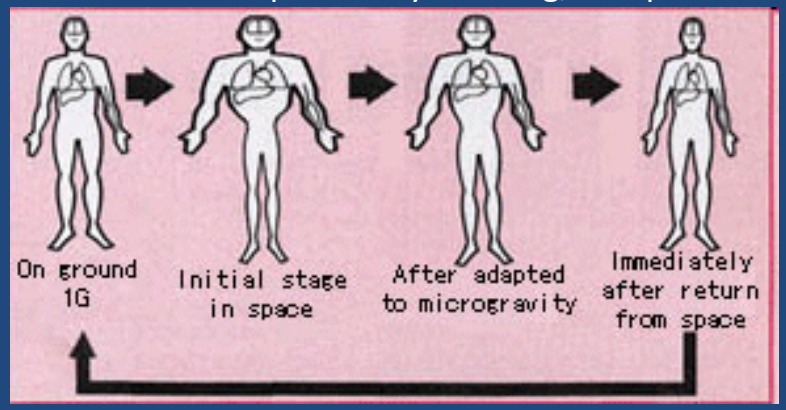
2-1. Transferable Skills: Biomed. Eng.

- Advanced Surgical Devices
  - CAD modeling
  - Mechanical testing: planning and execution
  - Statistics
  - Data analysis

2-2. Space Physiology

- Reverse-engineering human body
- Non-invasive data acquisition and analysis
- Microgravity causes
  - Relative fluid shift to upper body
    - Puffy face
    - Skinny legs
  - Motion sickness

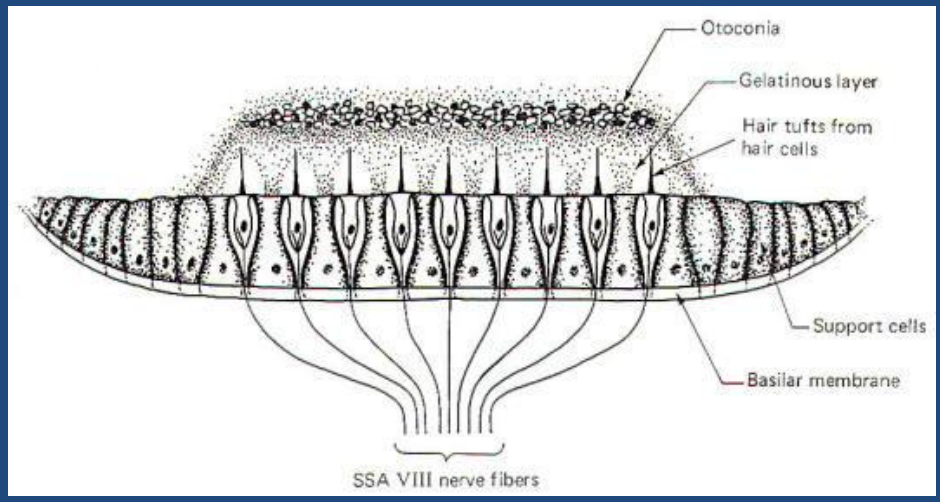
File:Space body fluid.svg, Wikipedia

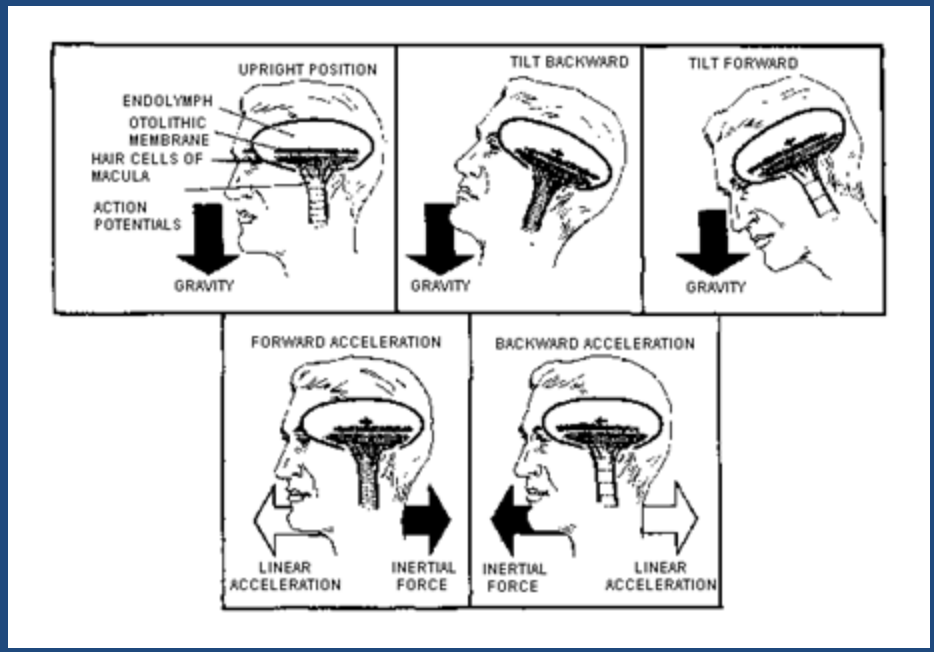


- Adaptation to Microgravity
  - Plasma volume loss
  - Bone loss (weight-bearing bones)
  - Inner ear

Otolith

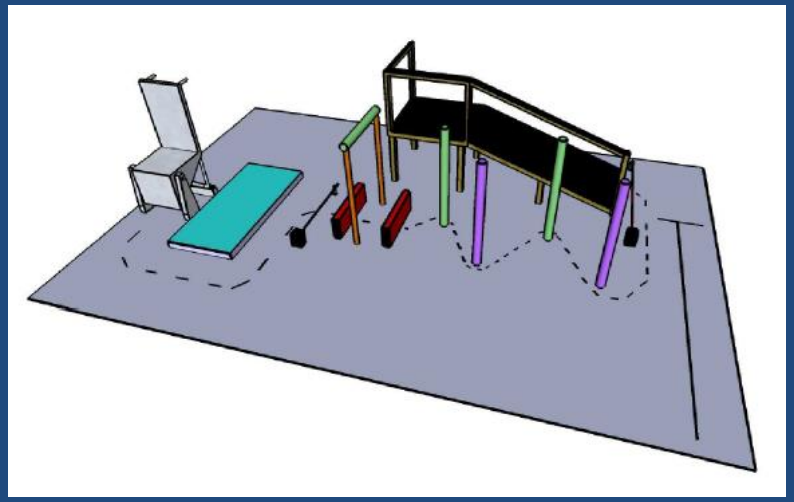
- Senses gravity and acceleration
- Senses acceleration in micro-gravity
- Once you got adapted in micro-gravity and came back to 1G
  - If you tilt your head back…
  - If you tilt your head forward…





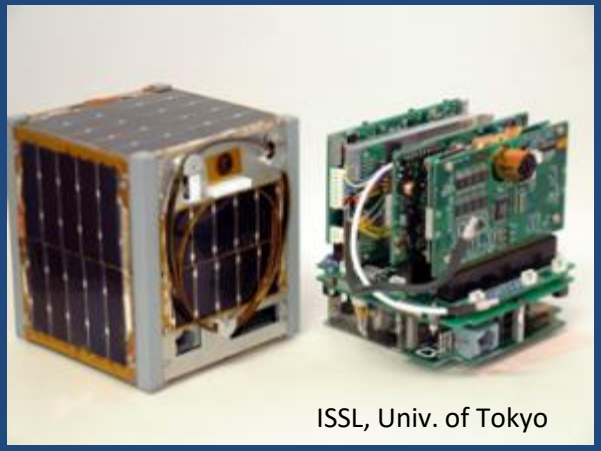
Functional Task Test (FTT)

- Check physiological changes and functional performance after spaceflight
  - Perform seat egress and walk (obstacle course)
  - Stand up quick and remain standing
  - Climb a treadmill ladder
  - Turn a heavy wheel
  - Transfer weights



J. J. Bloomberg et al., 2009
https://ntrs.nasa.gov/citations/20090029986

3-1. CubeSats



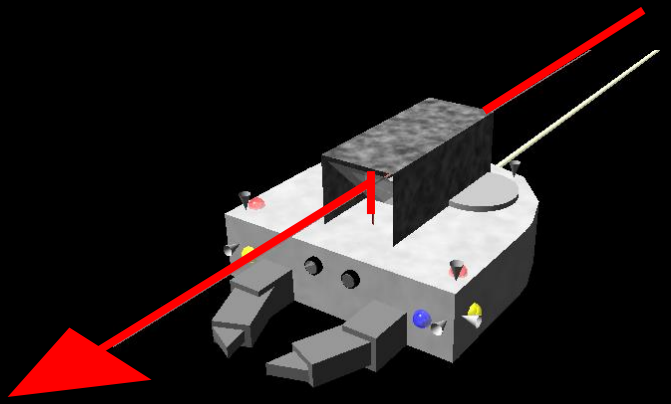
ISSL, Univ. of Tokyo

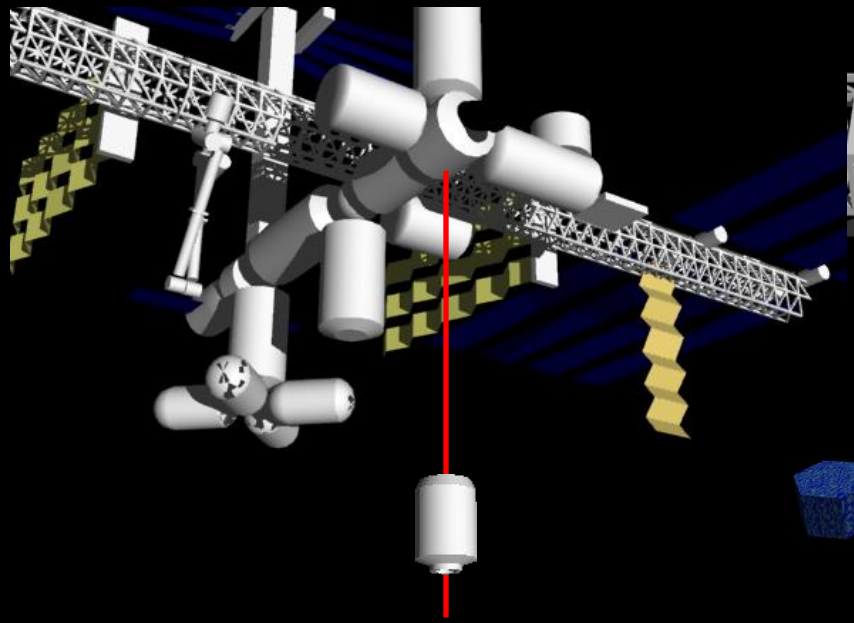
QSL Card

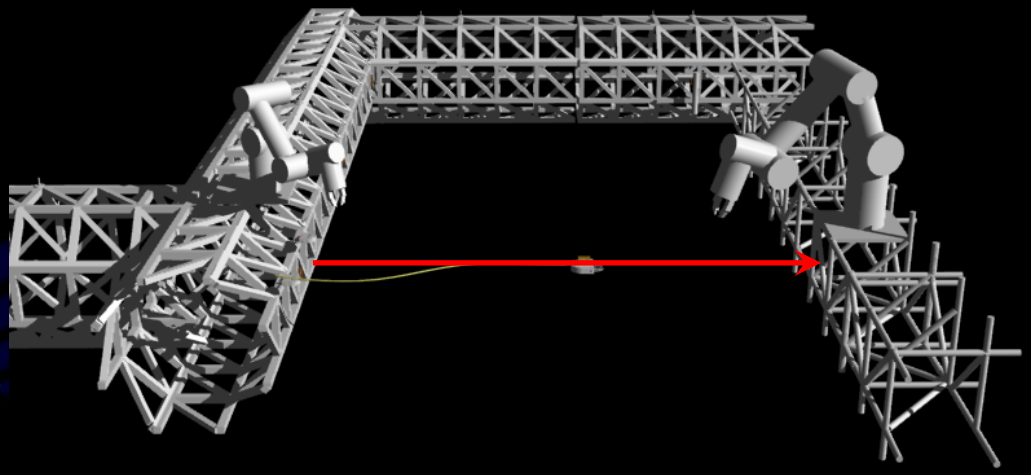
- Thermal subsystem for breadboard model of PRISM
- Morse code for XI-IV and XI-V
- Website design and QSL card

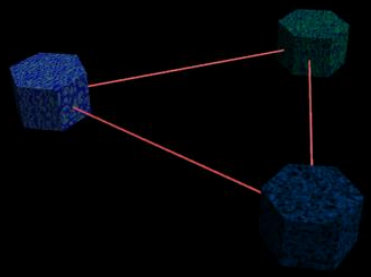
3-2. Space Robotics

- Professor Machida's Laboratory, Univ. of Tokyo
- Laser Guidance of Free-flying End Effector

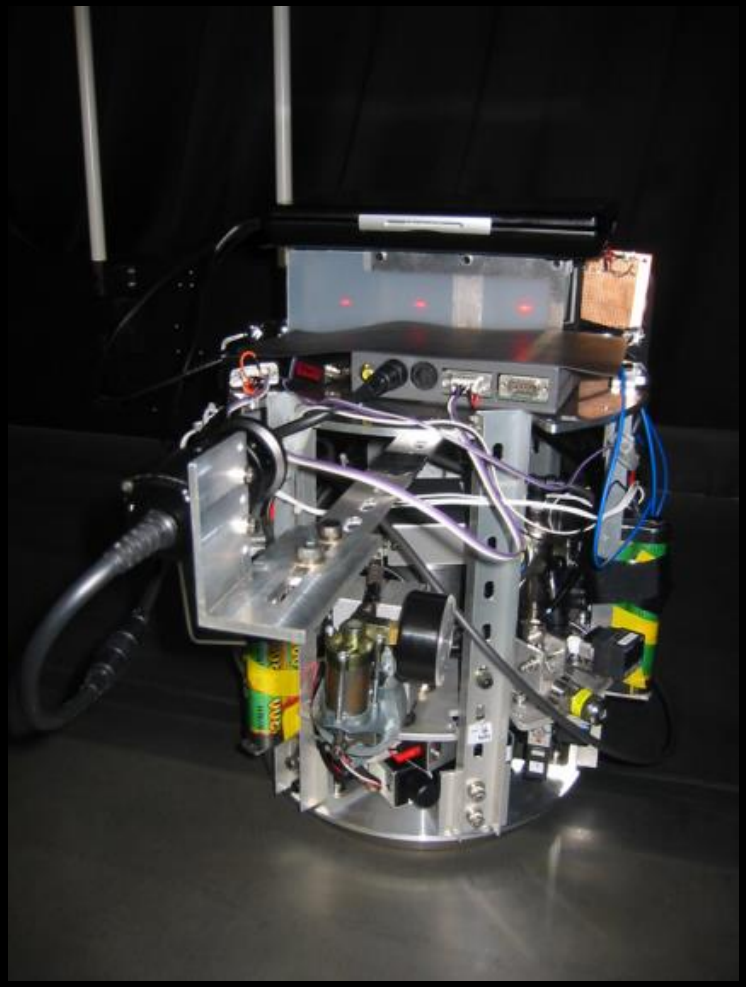


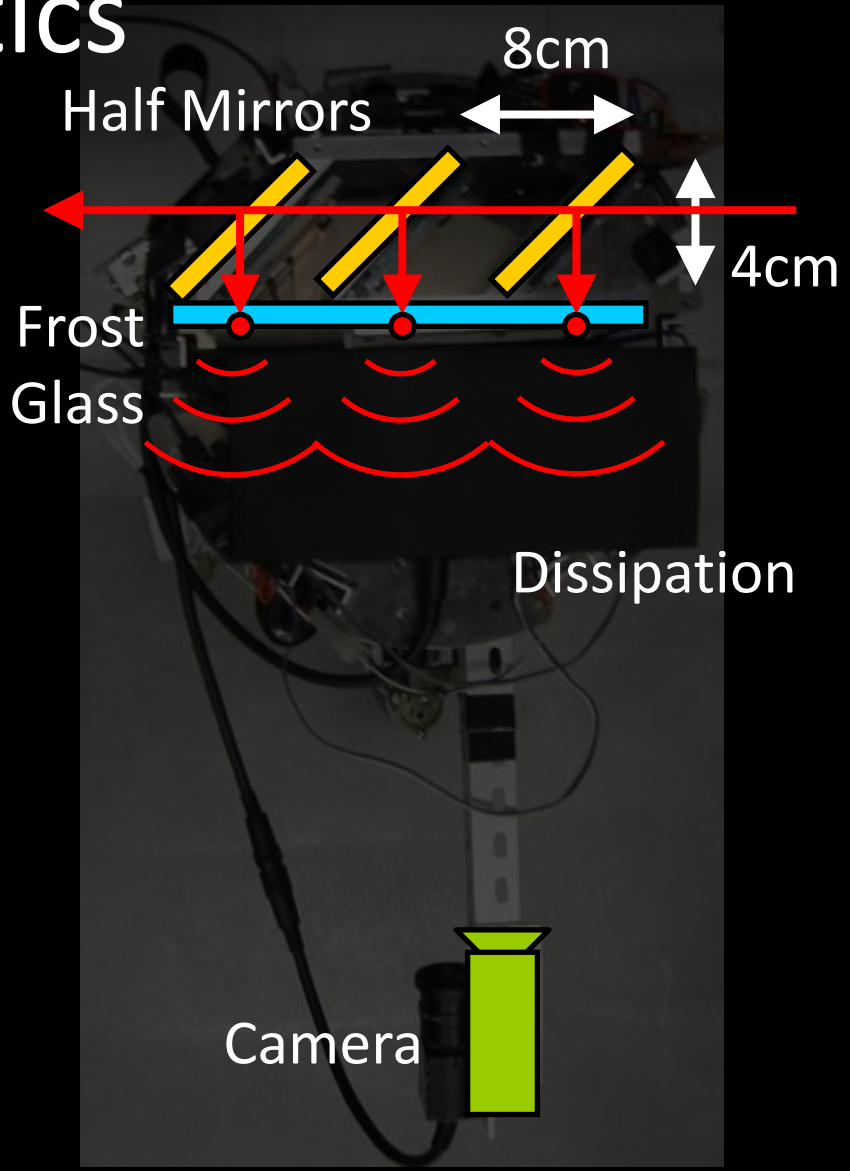




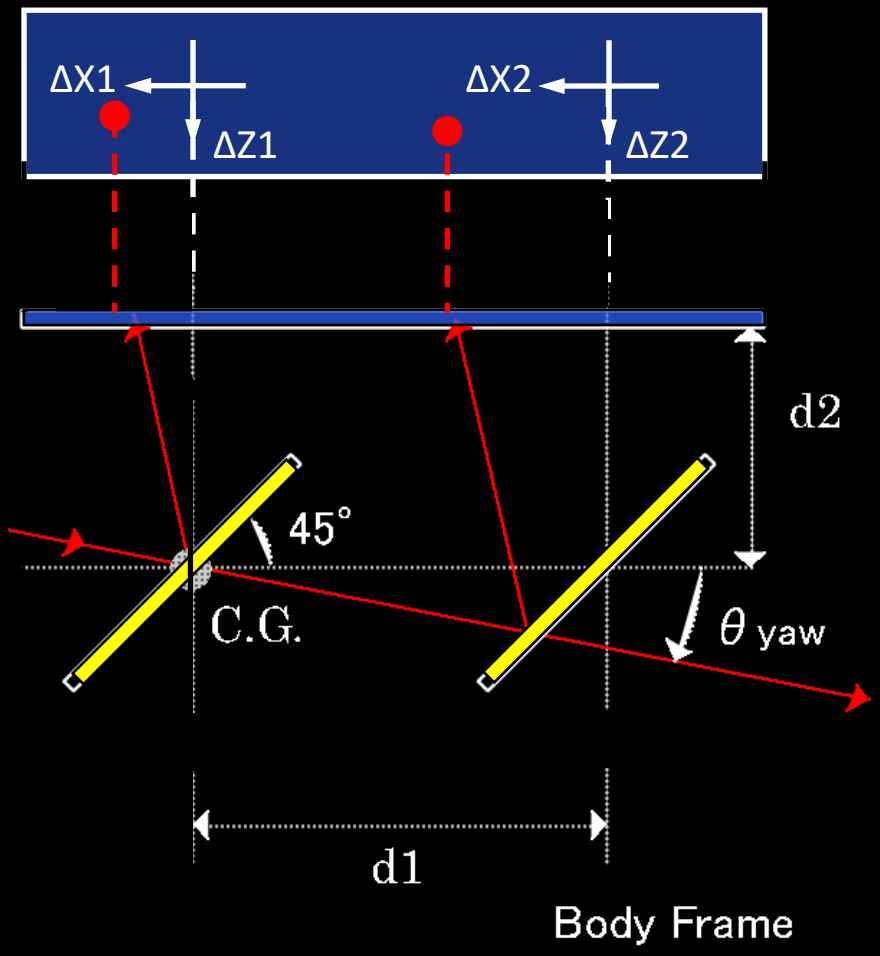


3-2. Space Robotics





3-2. Space Robotics



$$\begin{pmatrix} \Delta X1 \\ \Delta X2 \\ \Delta Z1 \\ \Delta Z2 \end{pmatrix} = z$$

$$z = H x + v$$

$$\begin{pmatrix} \Delta X \\ \Delta Y \\ \Delta\theta pitch \\ \Delta\theta yaw \\ d\Delta X/dt \\ d\Delta Y/dt \\ d\Delta\theta pitch/dt \\ d\Delta\theta yaw/dt \end{pmatrix} = X$$

Hands-on Experience

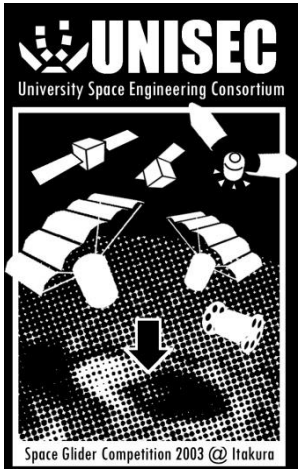
- Look for immersive hands-on experience, rather than try to get hands-on skills
  - Move your hands to try to solve real problems!
  - Put yourself in a project!

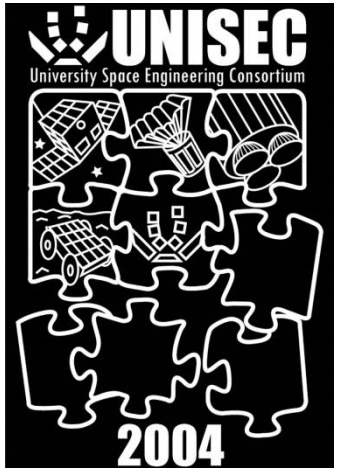
- If no hands-on opportunities are around you… join UNISEC!

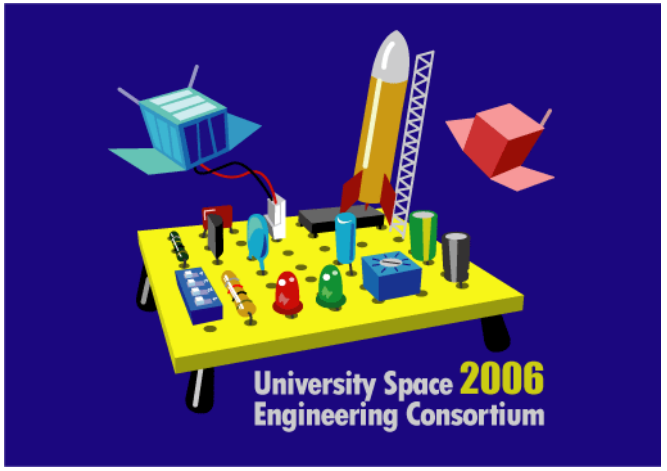
C10 M100 Y85 K5
M40 Y90
Y100 K10
C80 M20 Y40
C90 M60
C50 M100
K50
K25

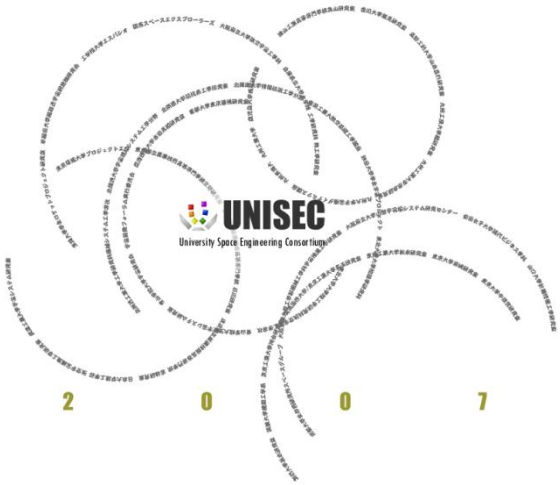
4. UNIESC: Design

T-Shirts (2003 – 2009)



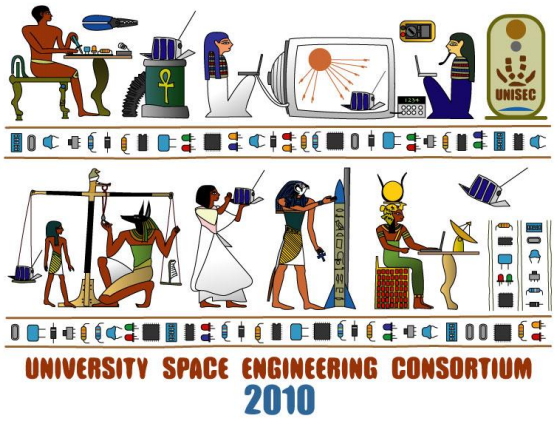


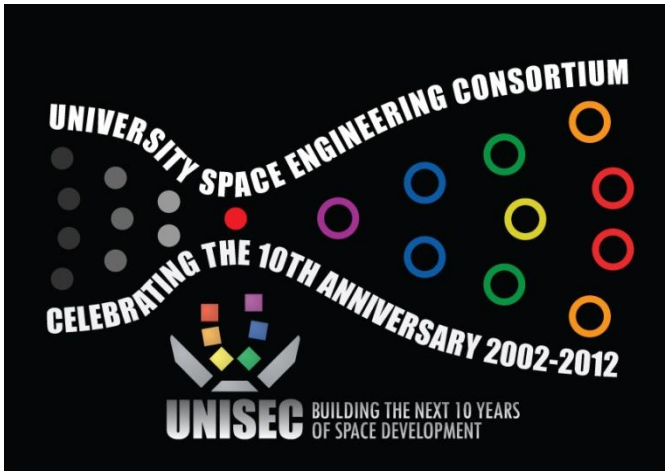




4. UNIESC: Design

T-Shirts (2010 – 2015)





4. UNIESC: Design

T-Shirts (2016 – 2020)

4. UNIESC: Other Logos

Cansat Leadership
CLTP
Training Program

Pre-3rd
Mission Idea Contest
Workshop

Nano-Satellite
Symposium

Nano-Satellite Symposium

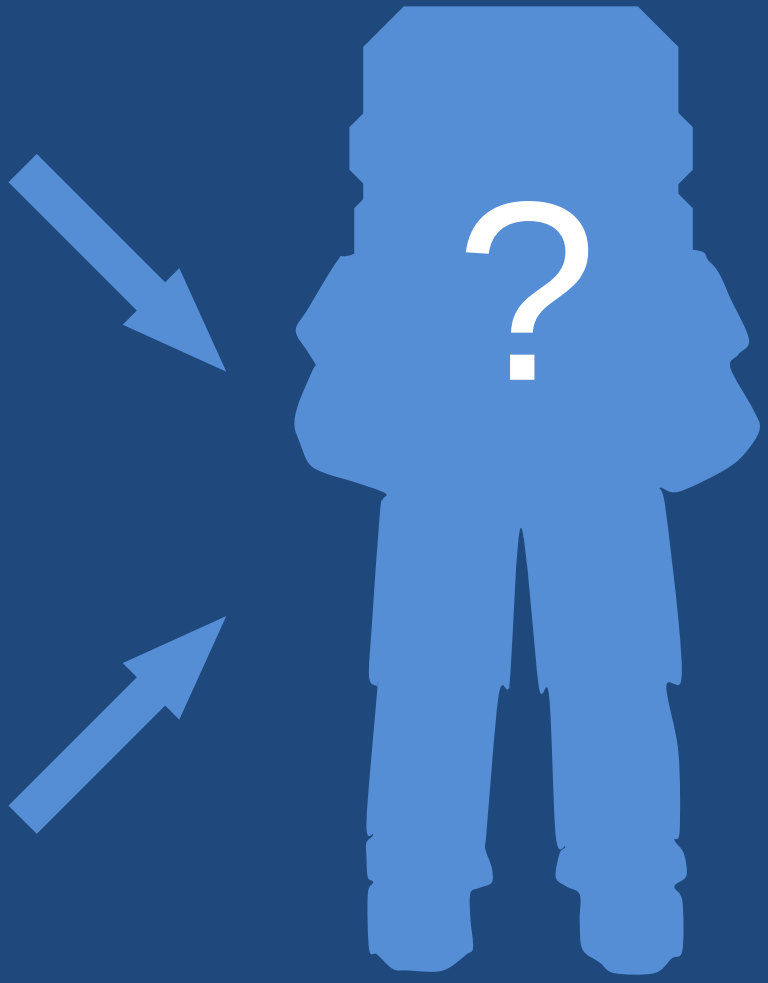
5. Where Spacesuit & Design Meet

1. **Spacesuit/ECLSS**
   Who we are, what we do

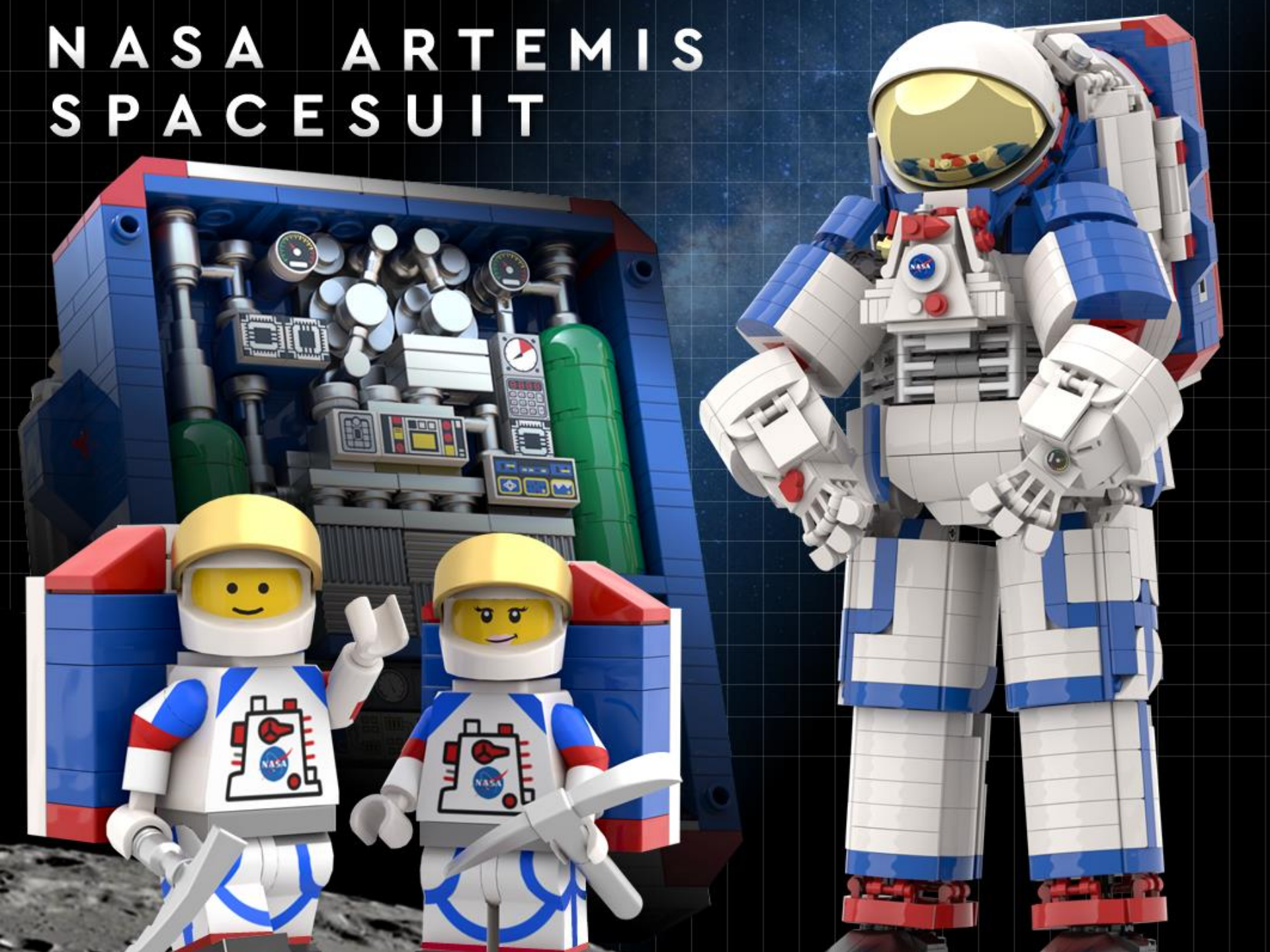
2. Space Physiology

3. Free-flying robotics,
   small satellite projects

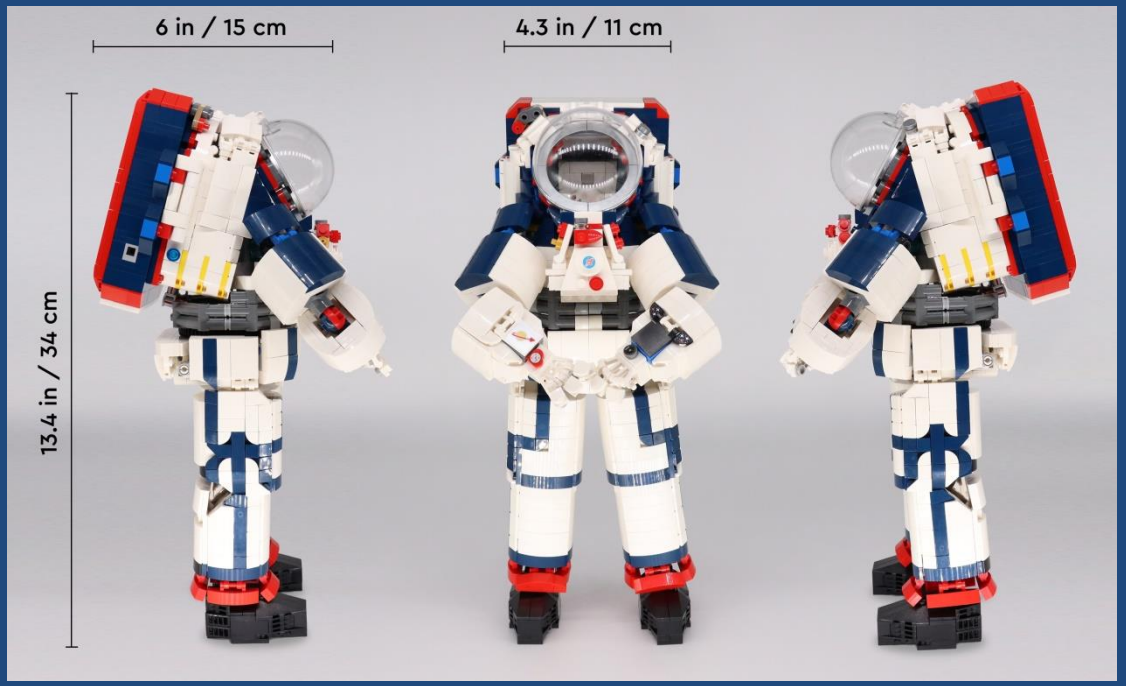
4. How I got involved in UNISEC
   (web, logo, T-shirt **design**)

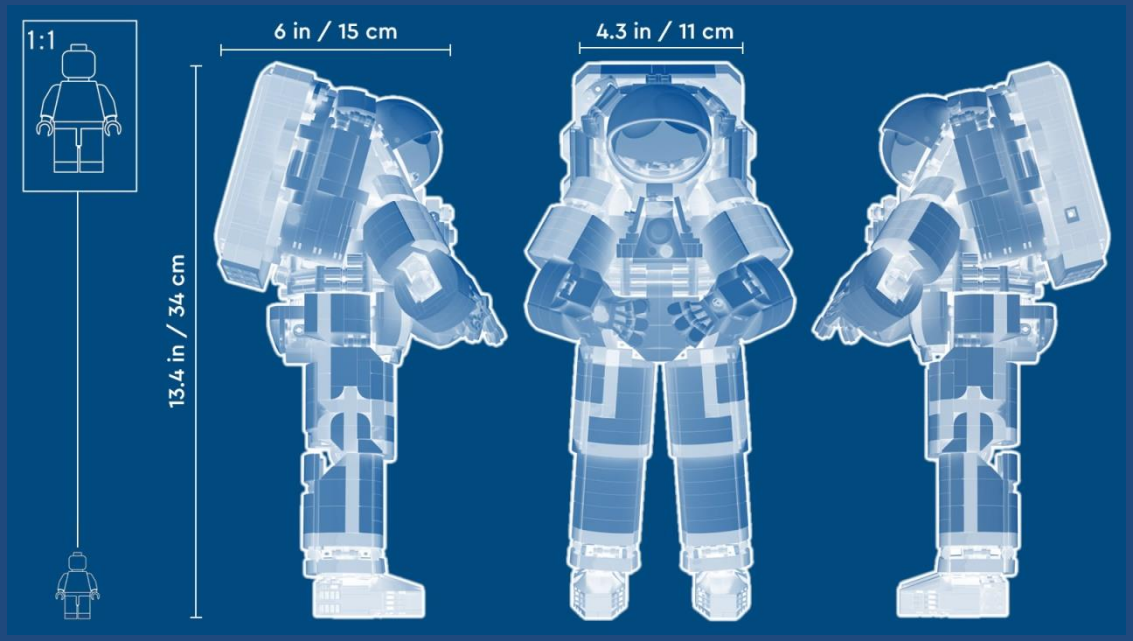


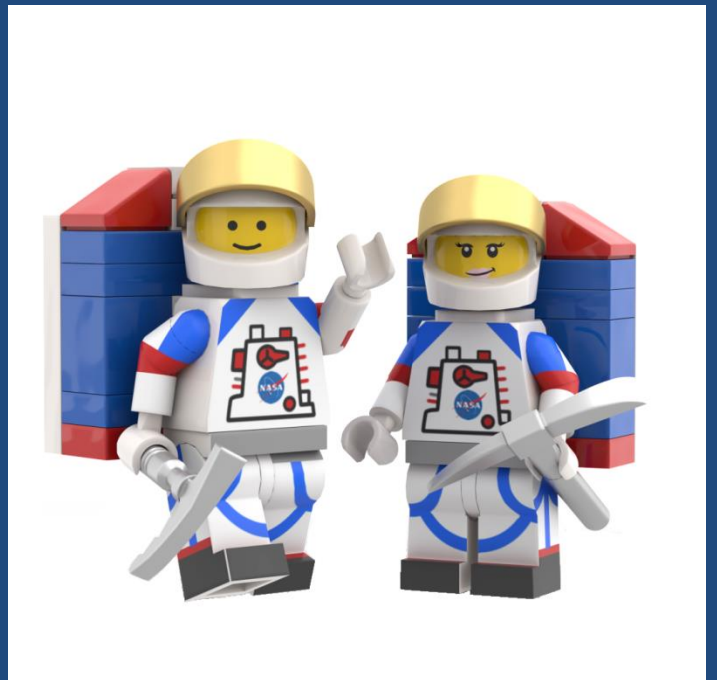
NASA ARTEMIS SPACESUIT



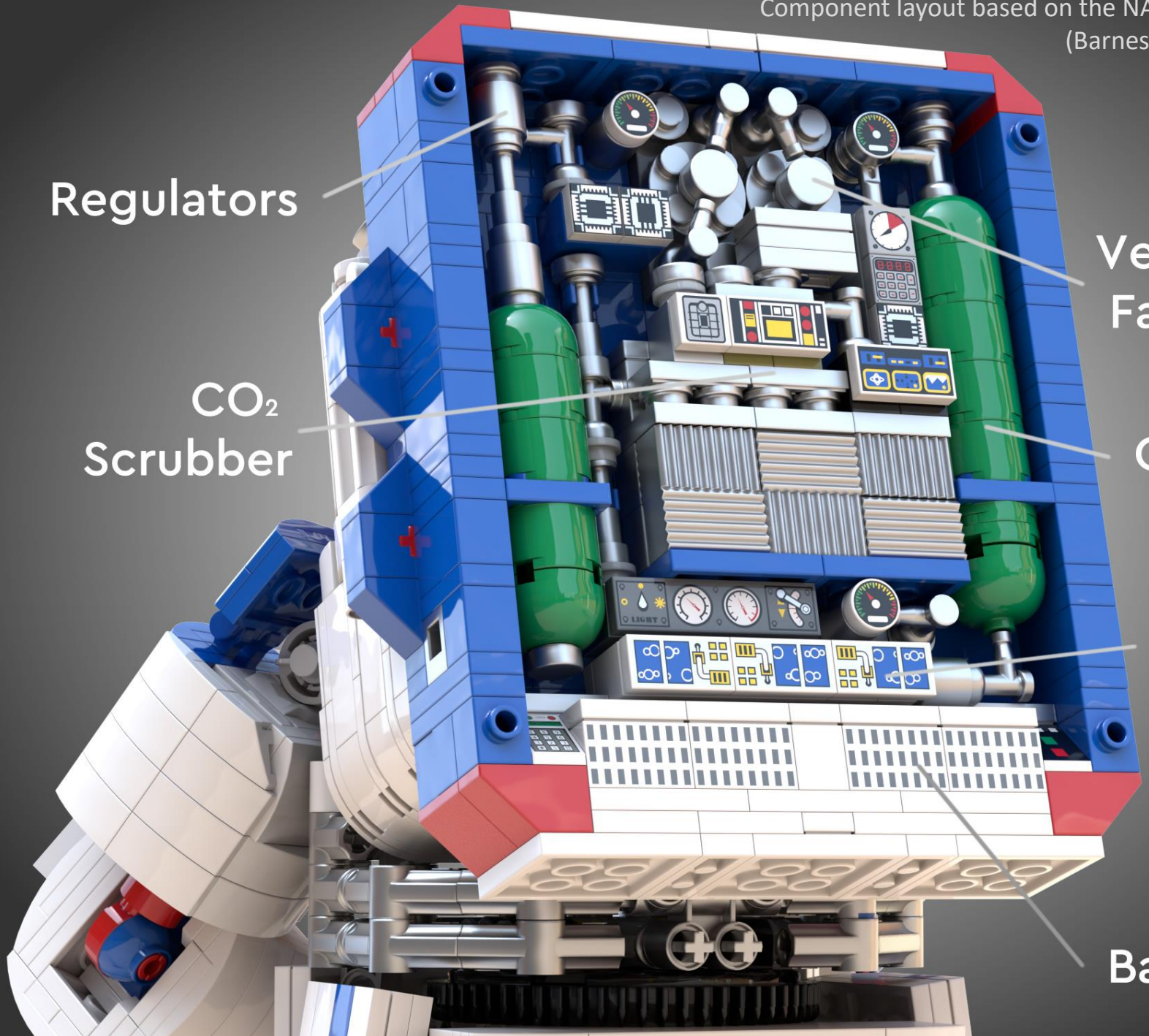

© NASA

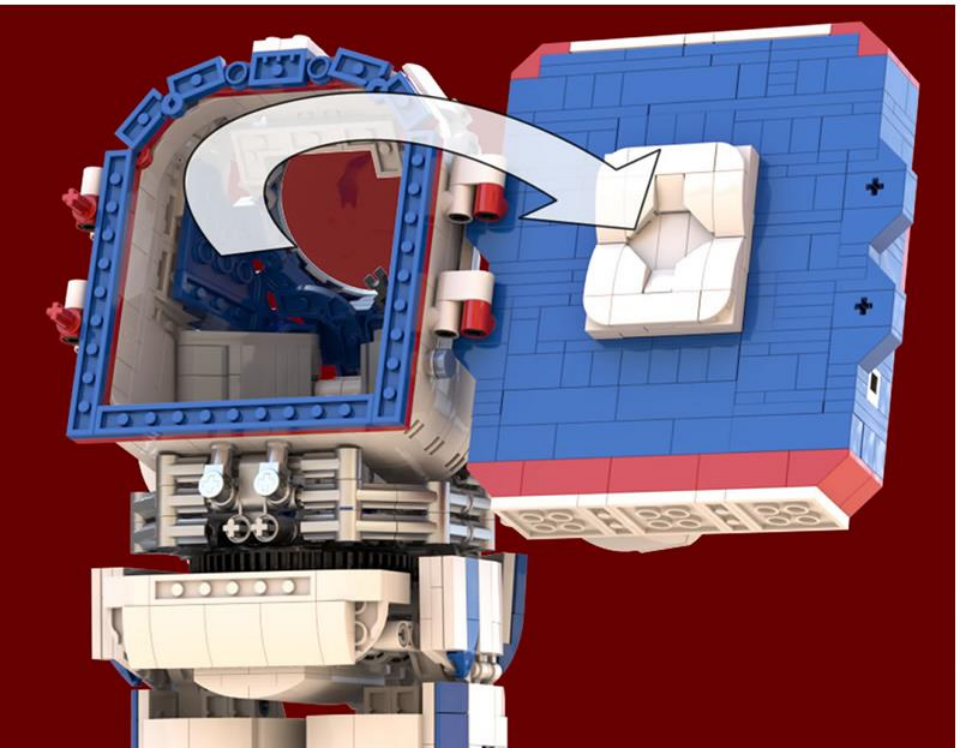

6 in / 15 cm
4.3 in / 11 cm
13.4 in / 34 cm

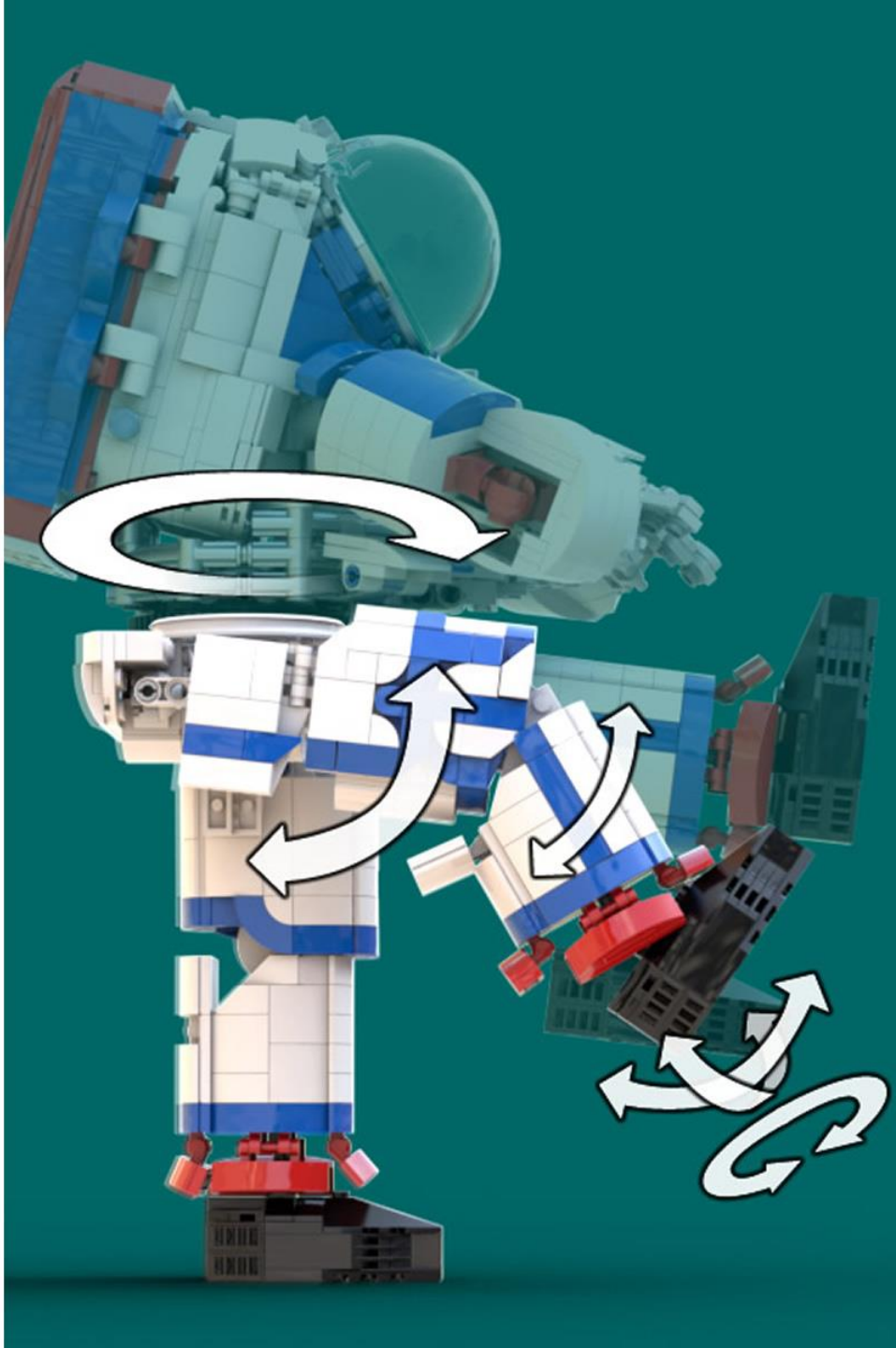

1:1
6 in / 15 cm
4.3 in / 11 cm
13.4 in / 34 cm



Component layout based on the NASA conference paper
(Barnes et al., ICES2019-389)

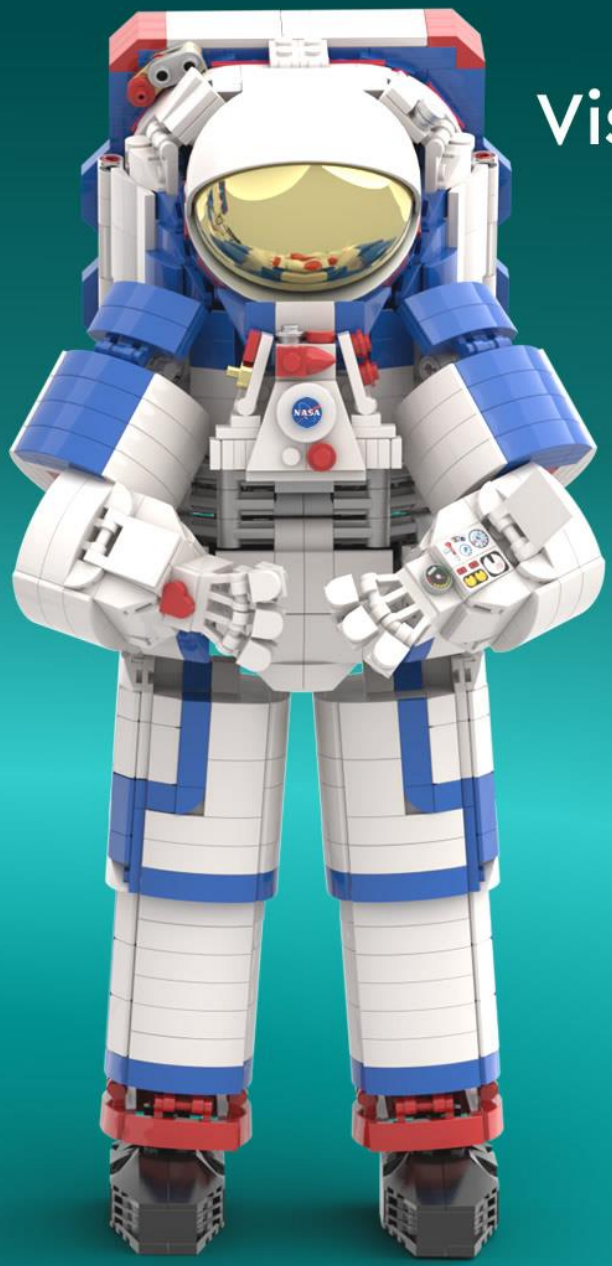






Accessories

Display Stand



Visor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LEGO IDEAS

Please Support!

https://ideas.lego.com/projects/4b24ba08-2d51-4709-80c2-3469be59c292

PRODUCT IDEA

NASA Artemis Space Suit

1 / 15









SUPPORT

1,001
supporters

362
days left

220

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