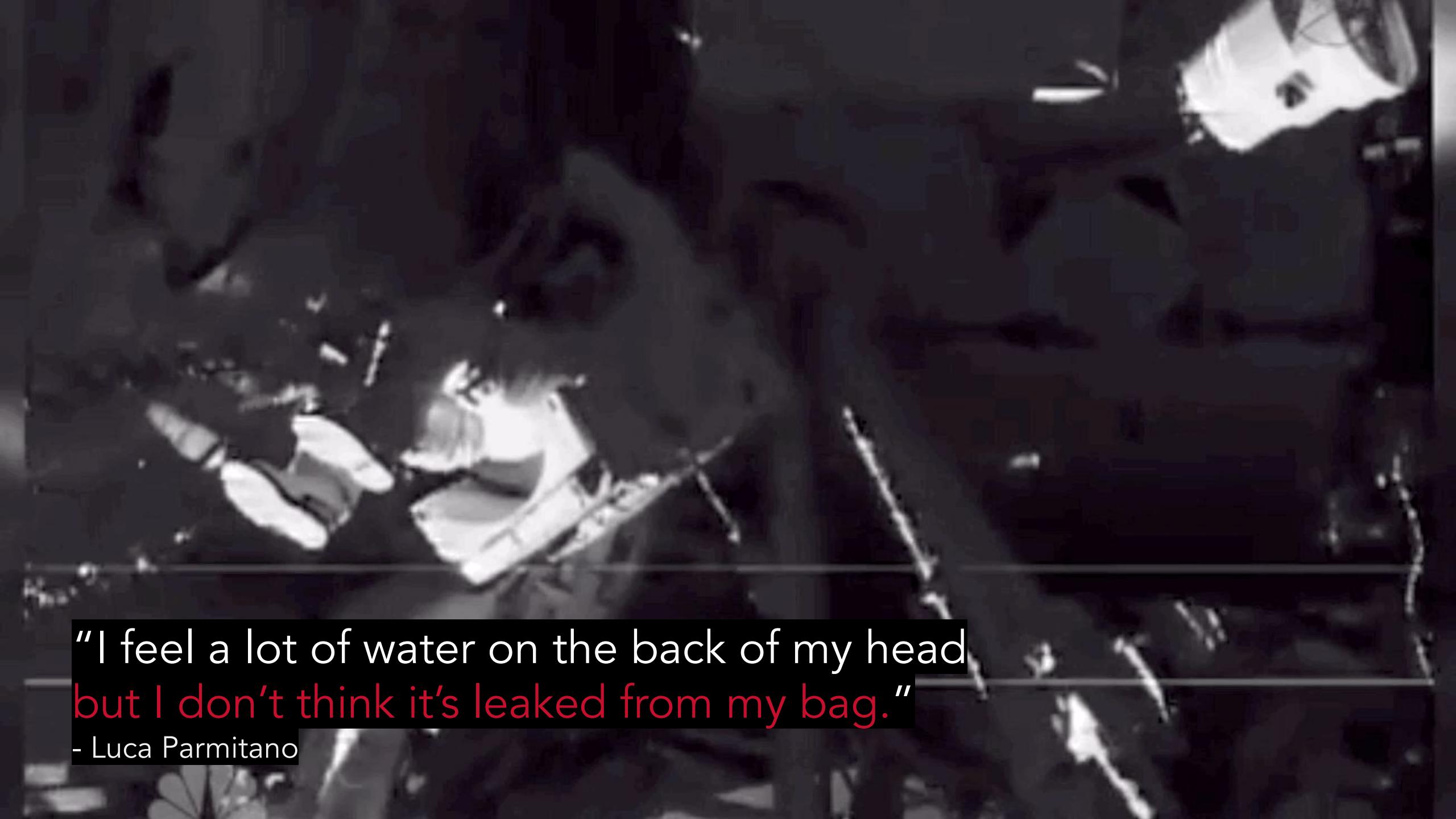




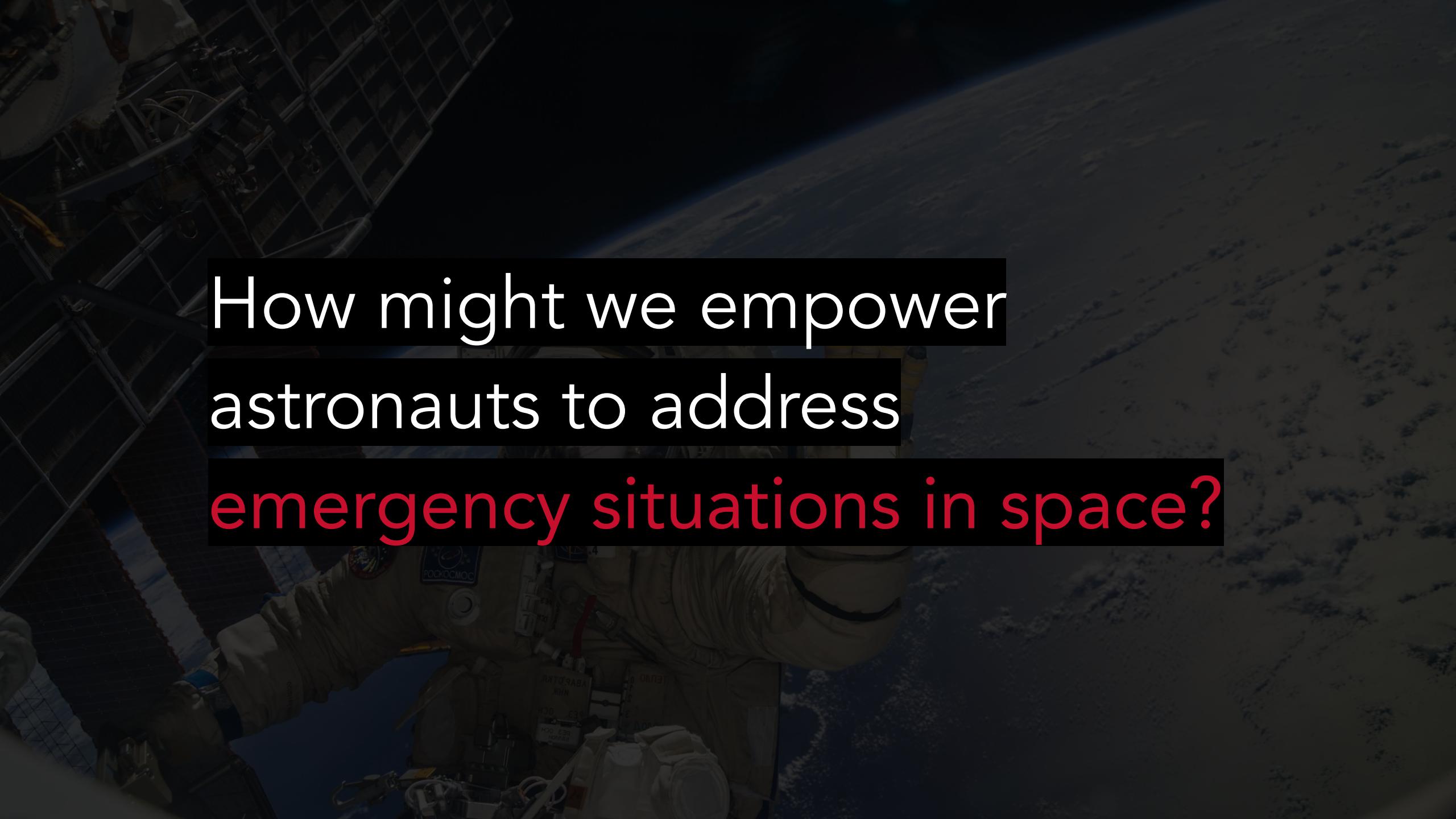
Designing for _____

Harvard NASA SUITS Team



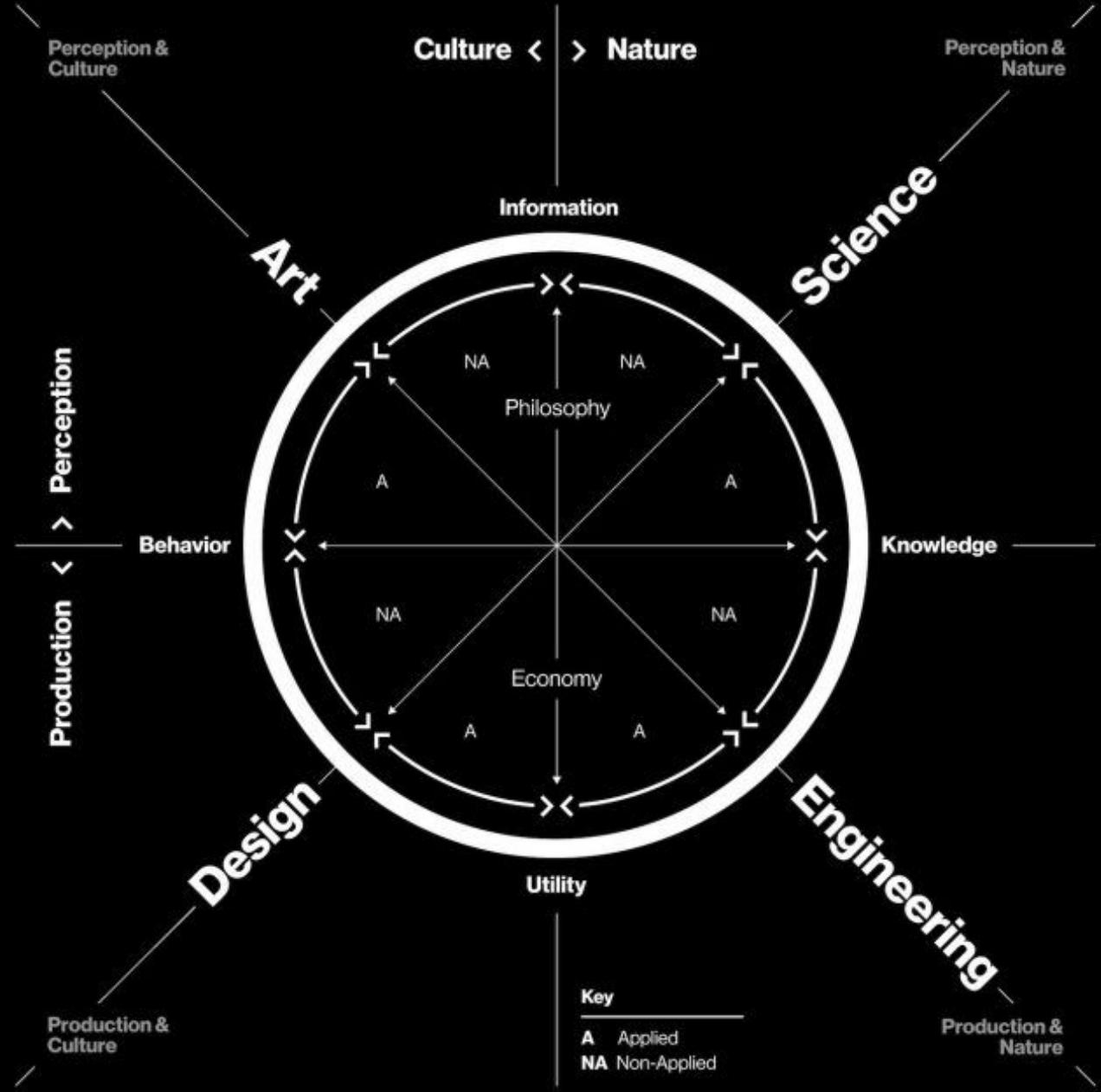
"I feel a lot of water on the back of my head
but I don't think it's leaked from my bag."

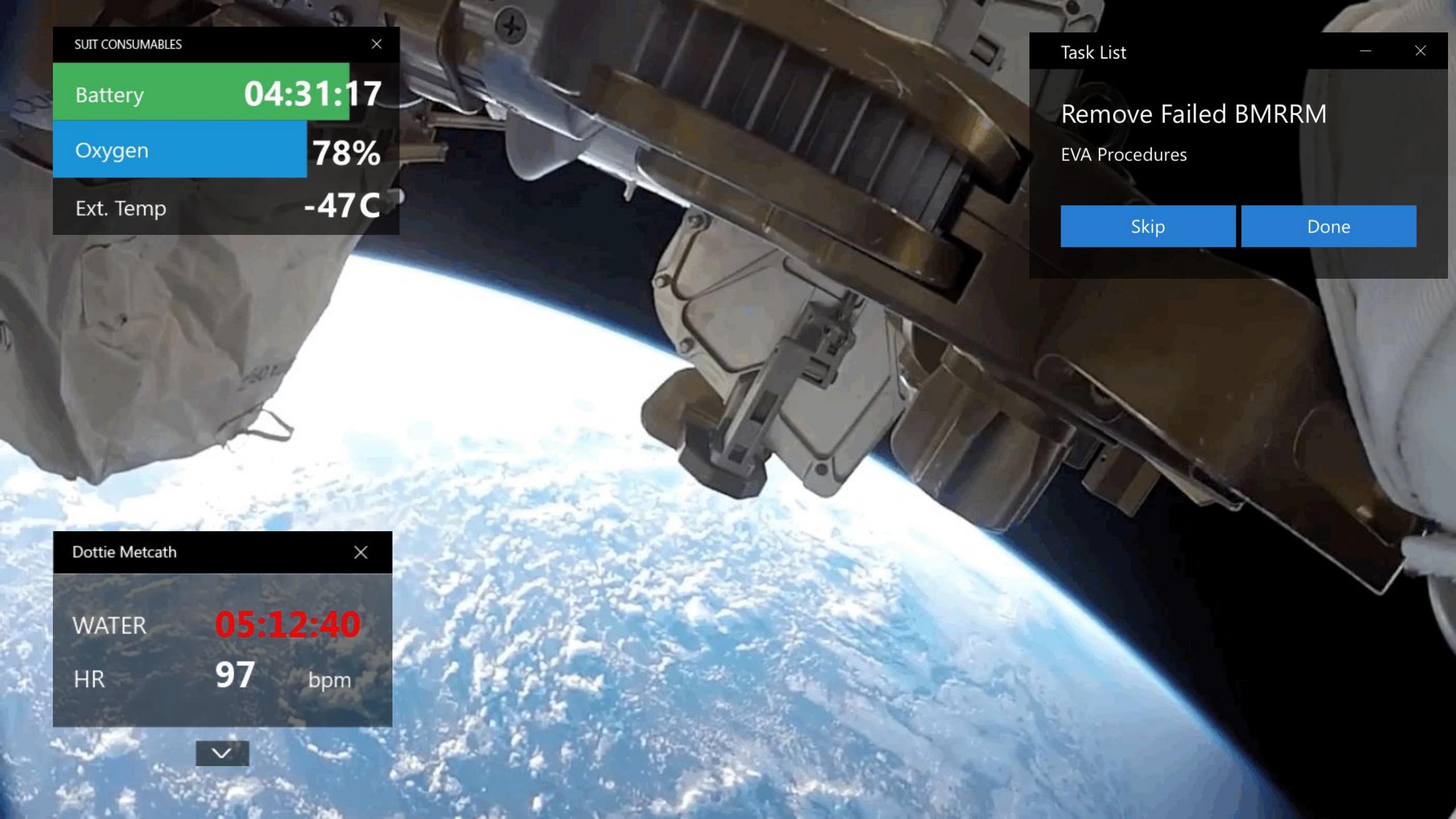
- Luca Parmitano

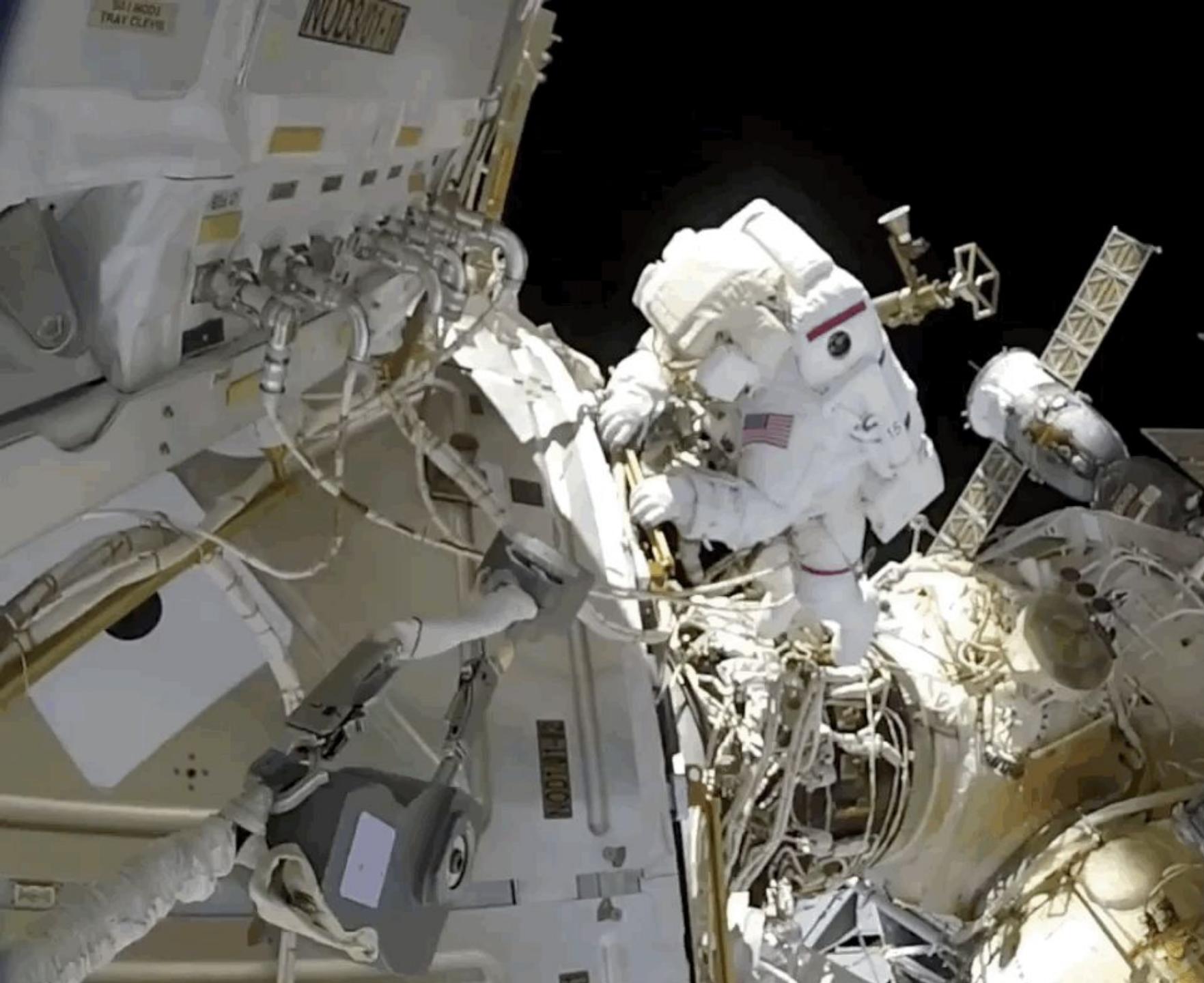
A photograph of an astronaut in a spacesuit working on the exterior of the International Space Station. The astronaut's gloved hands are visible as they handle equipment. The background shows the dark void of space and the blue and white atmosphere of Earth. A large solar panel array is visible on the left.

How might we empower
astronauts to address
emergency situations in space?

Our Unique Human-Centered & Cross-Disciplinary Approach







Guardian Angel Mode

— □ ×

GUARDIAN ANGEL MODE

Predicted Event: Water leak in helmet...

1. CONFIRM RADIO COMMUNICATION

Comm EVA Partner for status
If no response, NEXT TASK

2. CHECK STATUS W/ HAND SIGNALS

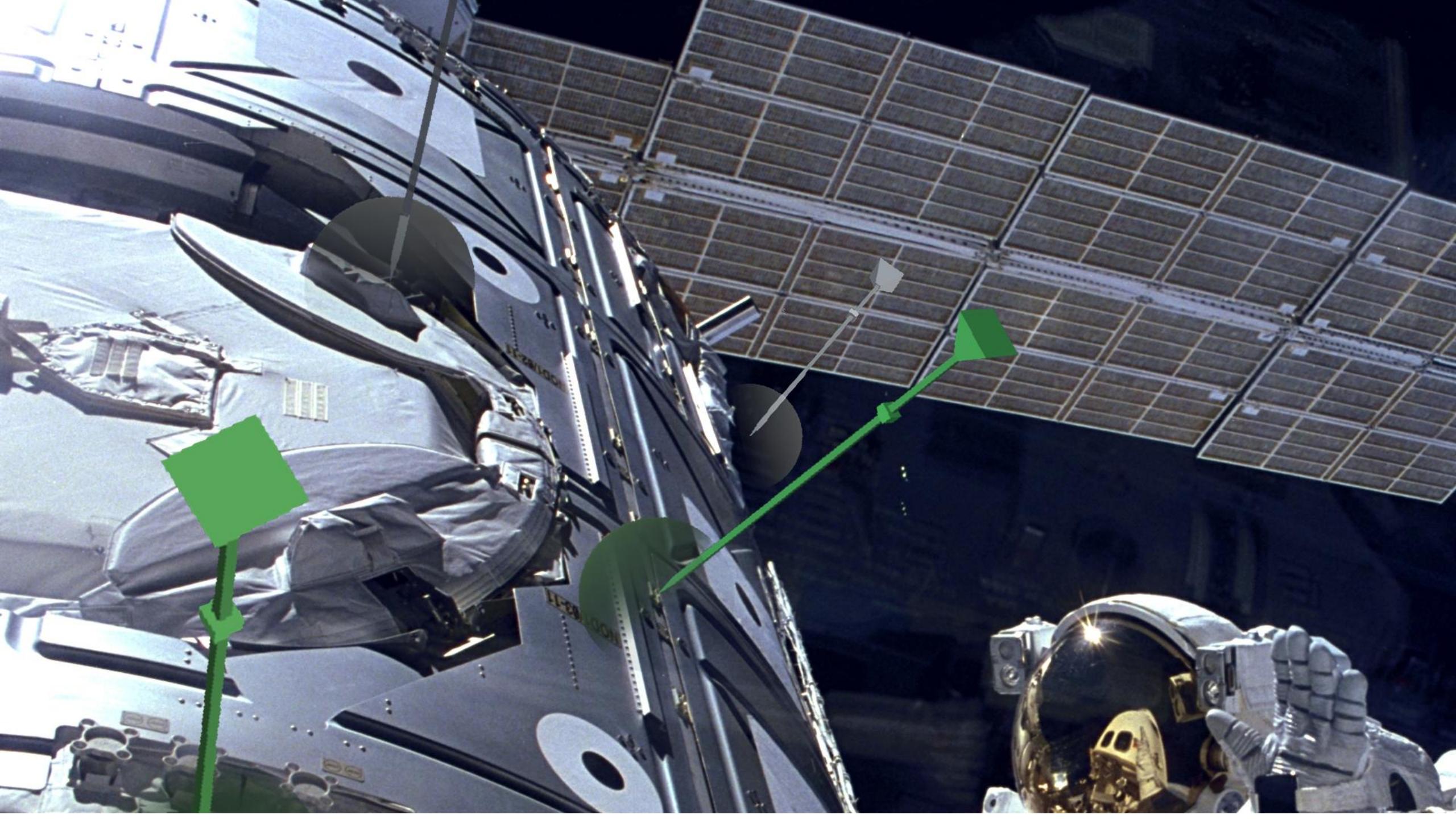
Use hand signals to ask EVA Partner
for status

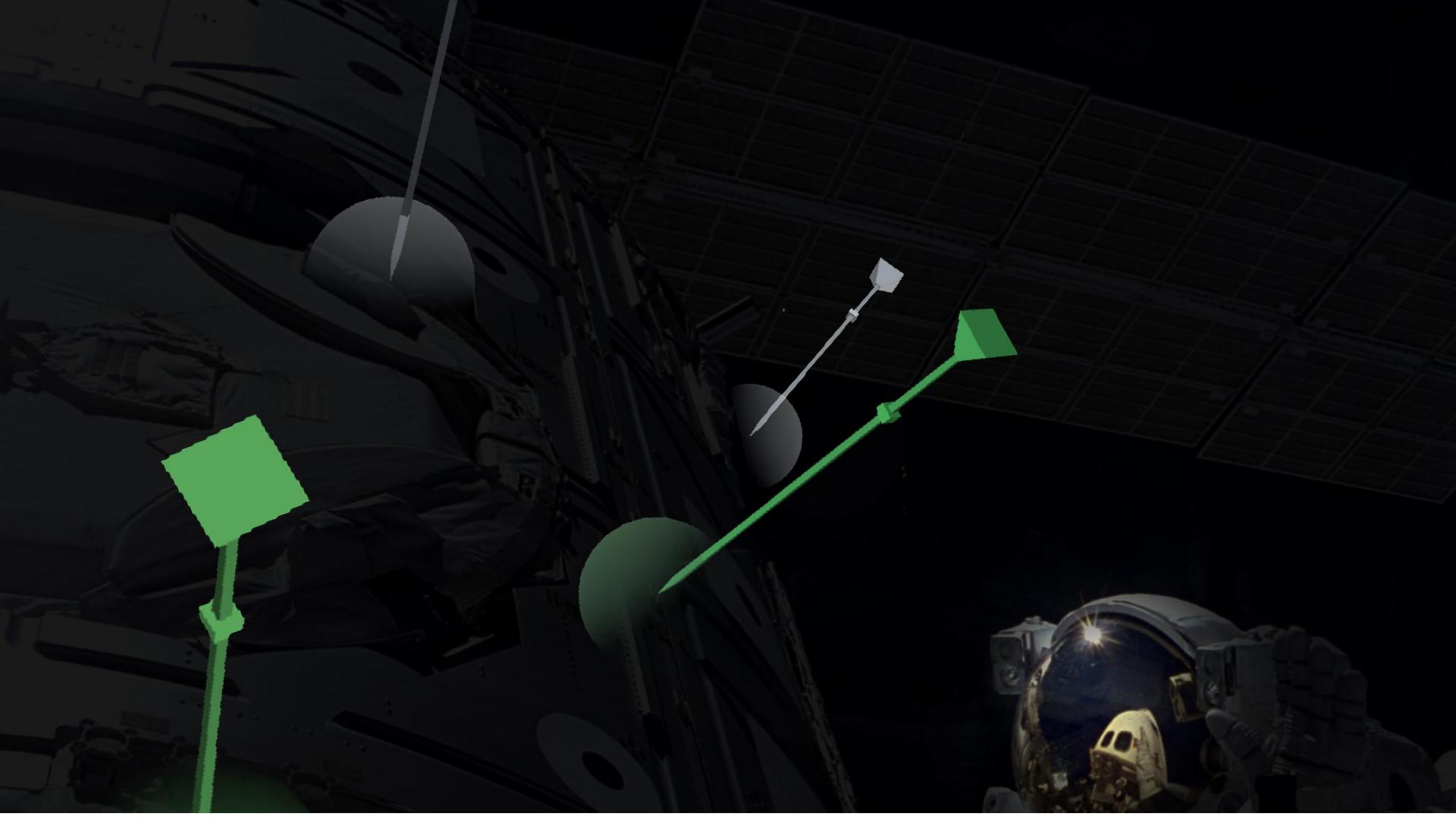


OK ->
Touch top of head



Next





Our Cross-disciplinary Team



Erin McLean
*Human-Centered Design & Engineering,
Space technology, Geology*



Hane Roh
UX Design



Hanif Wicaksono
Product Design



Lindsey Renee Derry
Dance and Arts Management



Audrey Haque
*Psychology & Art
UX Research*



Emily Yang
User Experience & Interface Design



Tyler Rogers
Architecture



Berlynn Bai
*Strategy and Operations
UX Design/Design Strategy*



Zongheng Sun
Automotive Design & Engineering



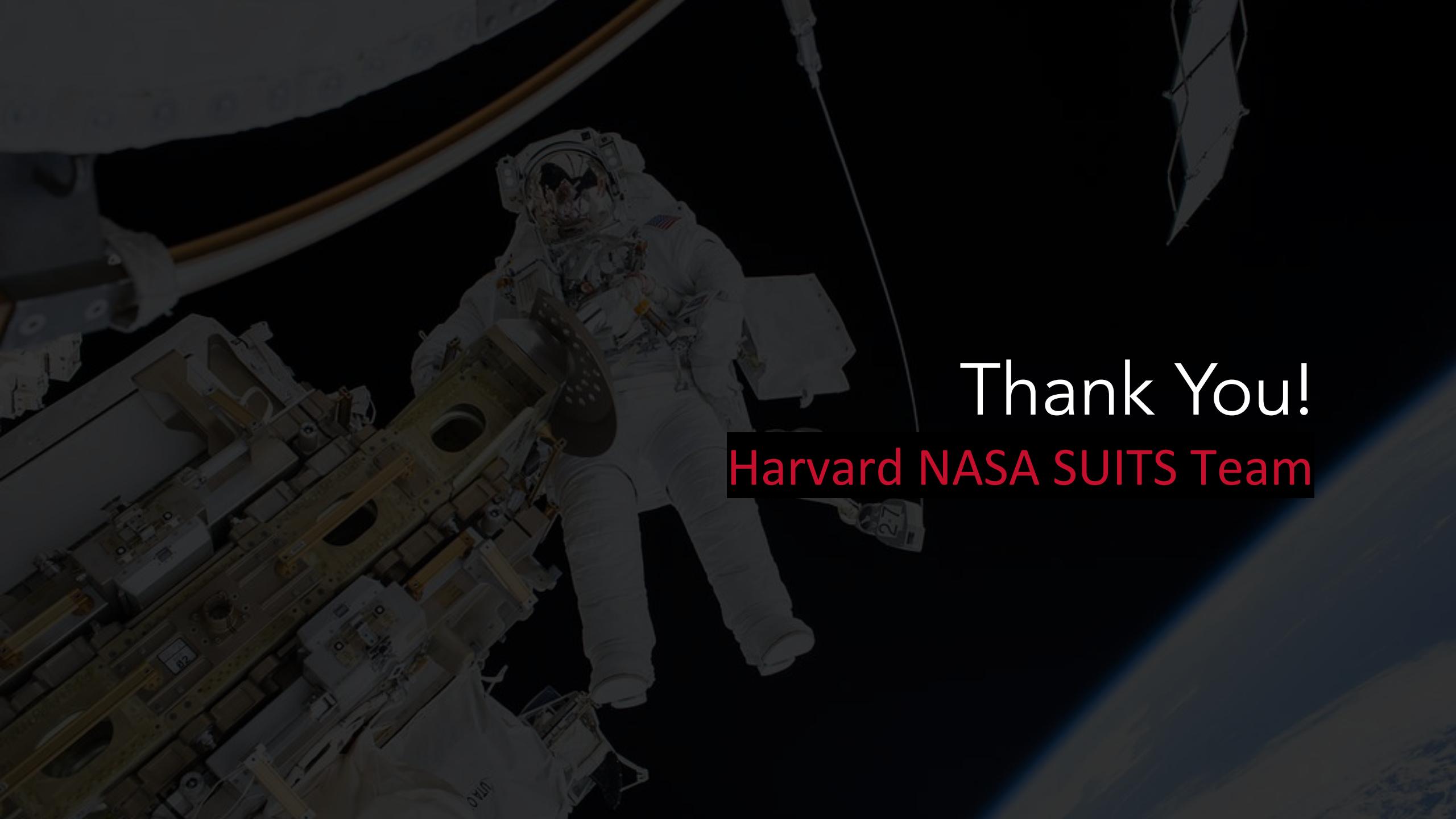
Nicolas Oueijan
*Architecture & Fabrication
Virtuality + Interactivity*



Anahide Nahhal
M.Arch Architecture



Agatha Park
Visual Art



Thank You!
Harvard NASA SUITS Team



harvardnasasuits

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DESIGN REVIEW

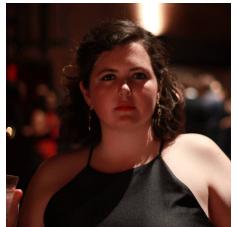
Harvard SUITS

Harvard University - Graduate School of Design, School of Engineering & Applied Sciences

Berlynn Bai, Lins Derry, Audrey Haque, Erin McLean, Anahide Nahhal, Nicolas Oueijan, Tyler Rodgers, Hane Roh, Zongheng Sun, Agatha Sunyoung Park, Hanif Wicaksono, Emily Yang

04.15.19

ABOUT THE TEAM



Erin McLean
*Human-Centered Design & Engineering,
Space technology, Geology*



Hane Roh
*Industrial Design
EVA Crew Distress Warning & Biometrics*



Hanif Wicaksono
Product Design



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Emily Yang
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Tyler Rogers
Architecture



Berlynn Bai
*Strategy and Operations
UX Design/Design Strategy*



Zongheng Sun
Automotive Design & Engineering



Nicolas Oueijan
*Architecture & Fabrication
Virtuality + Interactivity*

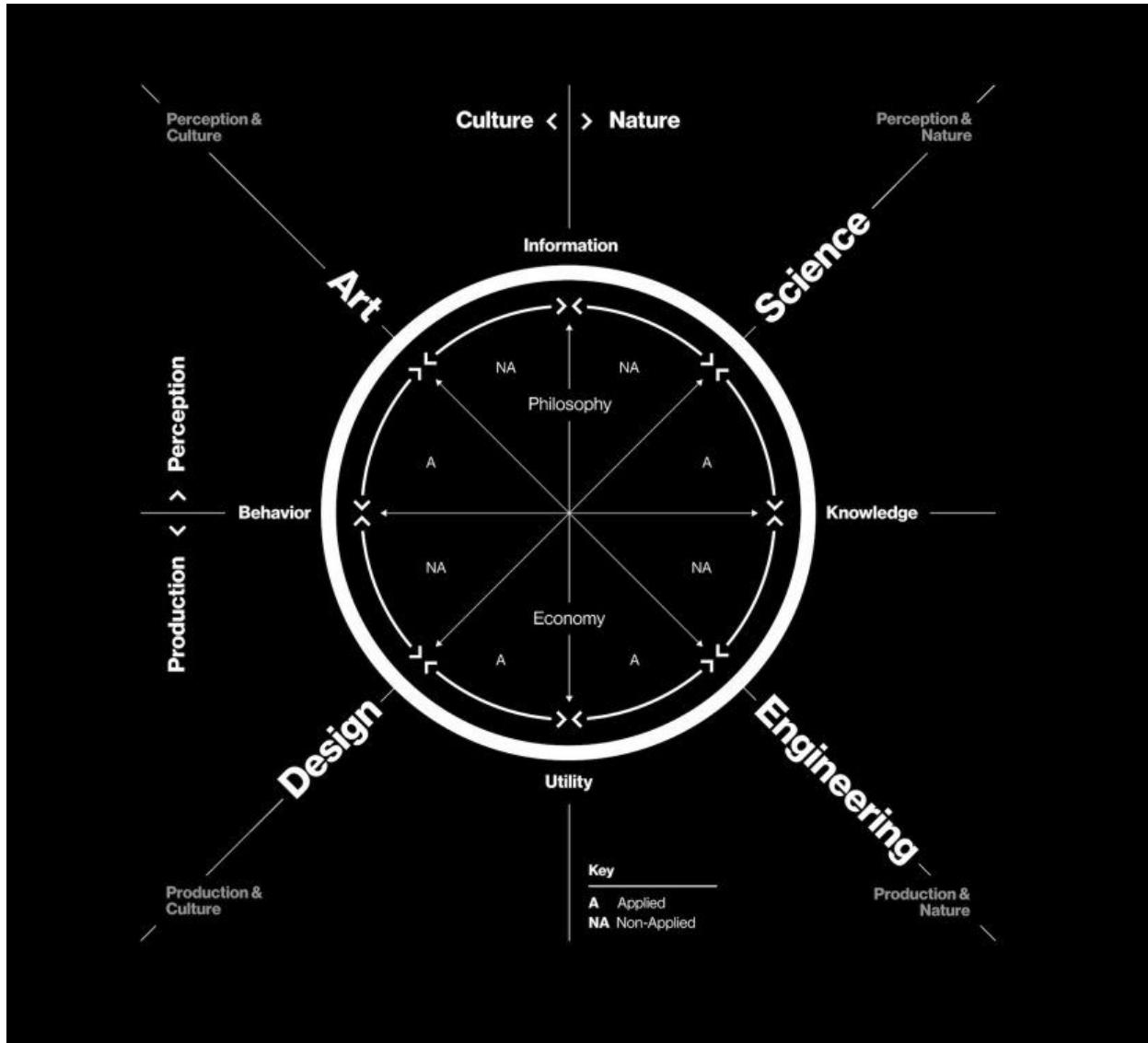


Anahide Nahhal
M.Arch Architecture



Agatha Park
Visual Art

CROSS-DISCIPLINARY DESIGN THINKING



Deep space crewed missions have stringent requirements for robust and flexible systems that can be built on a shoestring budget and operate in extreme environments and large distances from Earth, with the possibility of technological failure. These missions are large-scale, complex engineered systems that require the input of thousands of technical, subsystem experts and synthesis of their interconnections by mission planners. We will need designers to create these complex socio-technical systems.

PROBLEM STATEMENT

How might we improve
productivity and **safety** of EVA's
for near-future astronauts working in
deep space?

Emergency Procedures

1. Management of EVA activities
2. Communication
3. Navigation
4. Personal Health Monitoring
5. Scientific Experimentation & Exploration
6. Robotic Control
7. Construction & Repair

1. Shepherd, C K, J R. (1988). The helmet-mounted display as a tool to increase productivity during Space Station extravehicular activity. *Human Factors Society, Annual Meeting, 32nd, Anaheim, CA, Proceedings. Volume 1; UNITED STATES; 24-28 Oct. 1988*, 1, 40-43.
2. Skoog, A., Berthier, S., & Ollivier, Y. (1991). The European space suit, a design for productivity and crew safety. *Acta Astronautica*, 23, 207-16.
3. Pereira Do Carmo, J., Gordo, P., Martins, M., Rodrigues, F., & Teodoro, P. (2017). Study of a direct visualization display tool for space applications. *10567, 10567S-105672S-7*.
4. Griffin, B., & Hudson, P. (1992). Smart space suits for space exploration. *Mars: Past, Present, and Future; Proceedings of the Conference, Williamsburg, VA; UNITED STATES; 16-19 July 1991*, 297-306.

HOW IS THE EVA TASK BEING SIMULATED?

1. The nominal EVA task of inspecting a part of the ISS. We will use the task provided by NASA SUITS.
2. Navigation from one part of the ISS to another via waypoints.
3. The emergency EVA task, which involves communication without radio. This will be facilitated via the prototype.

DESIGN VALUES

1. Keep Astronauts aware and focused on the task at hand
2. Improve Astronaut Agency: Reduce the cognitive load of EVA tasks without being patronizing
3. Prioritize procedure and details over intuitive usability
4. Design for limited mobility & muted senses
5. Extend cognition with flexible and responsive content, communications, and controls
6. Facilitate collaboration and extend awareness between IVA, EVA crew & ground

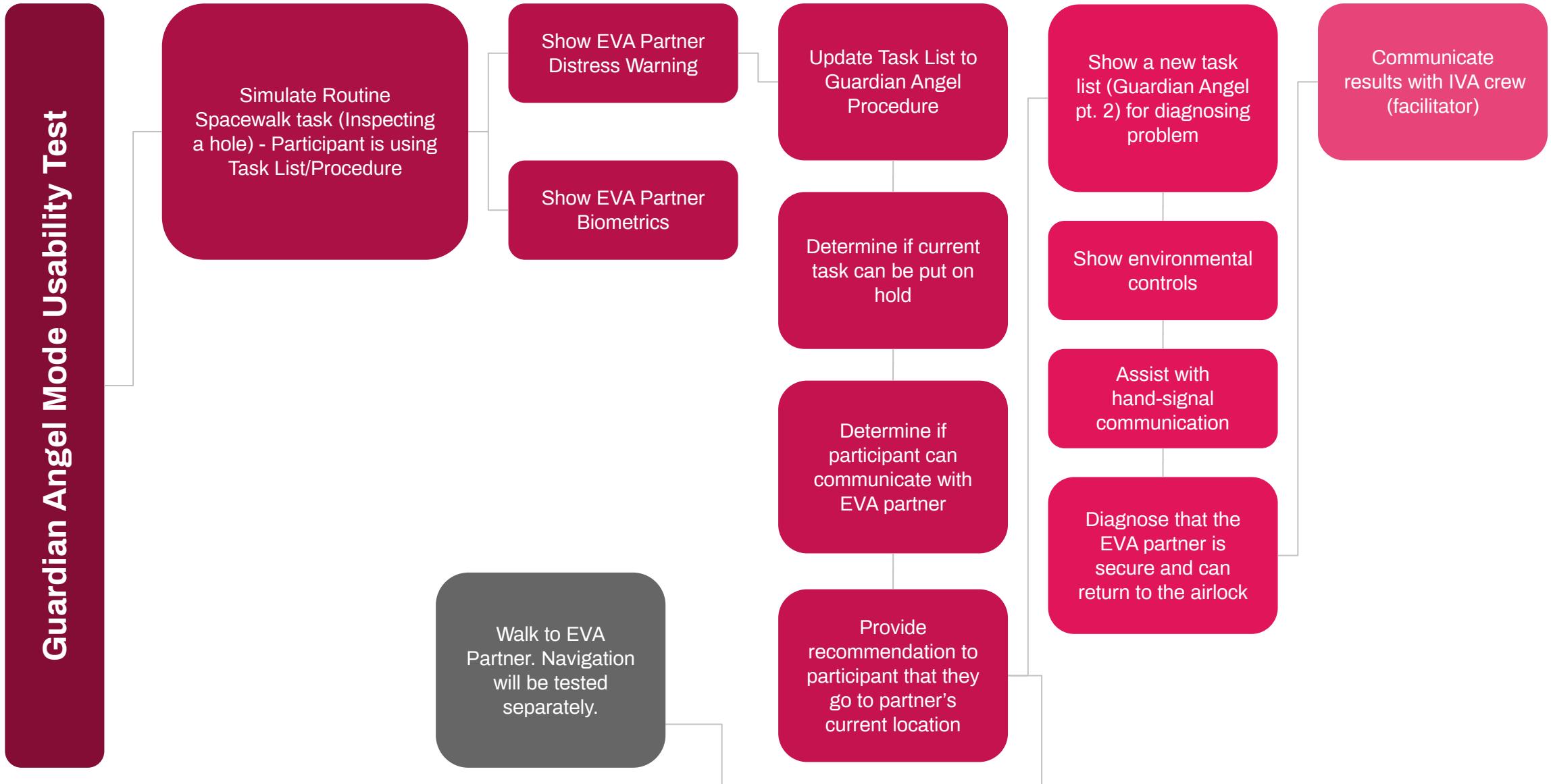
PROTOTYPING PHILOSOPHY

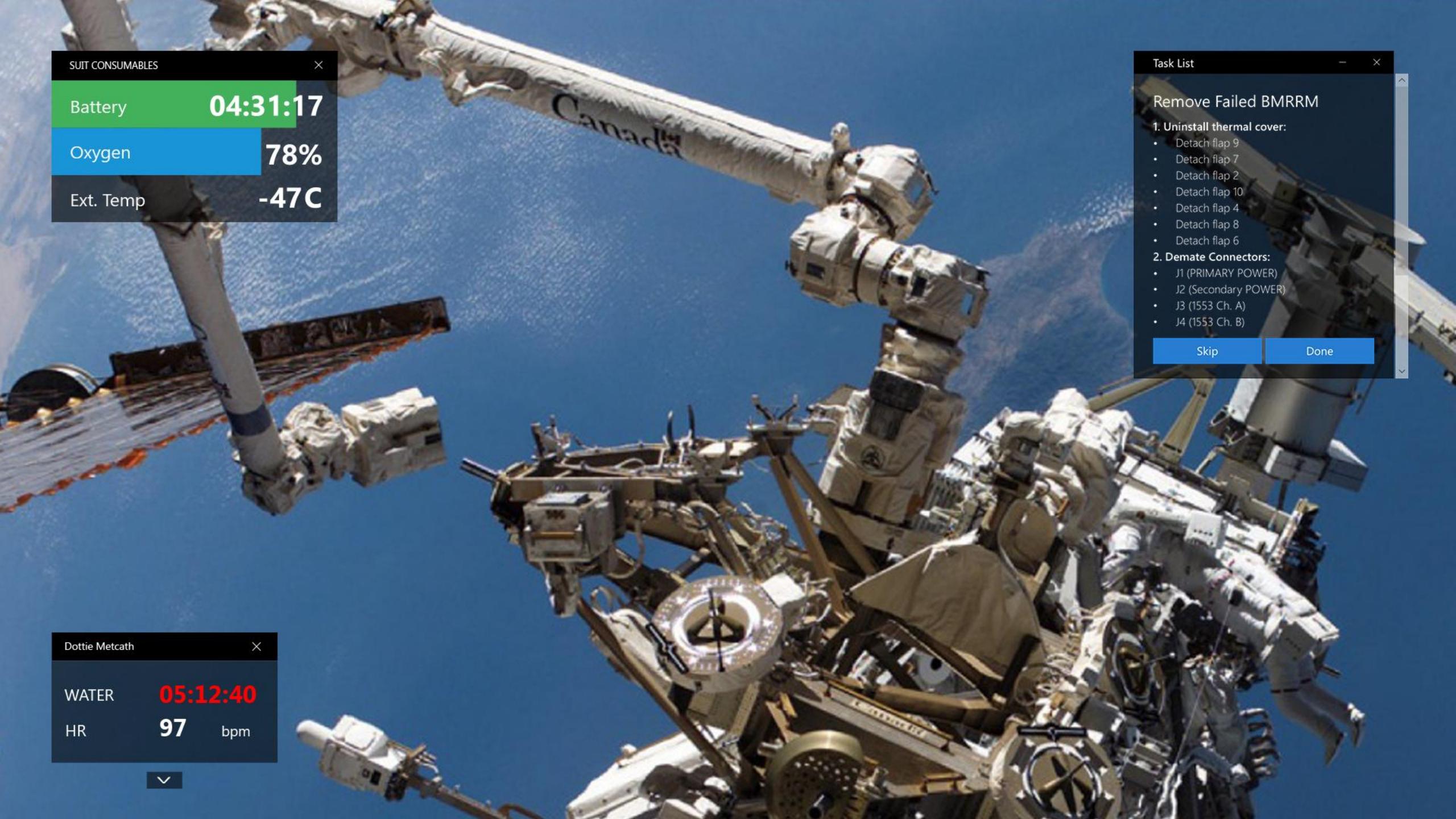
- Scrappy
- MVP
- Wizard of Oz
- Flow Over Function

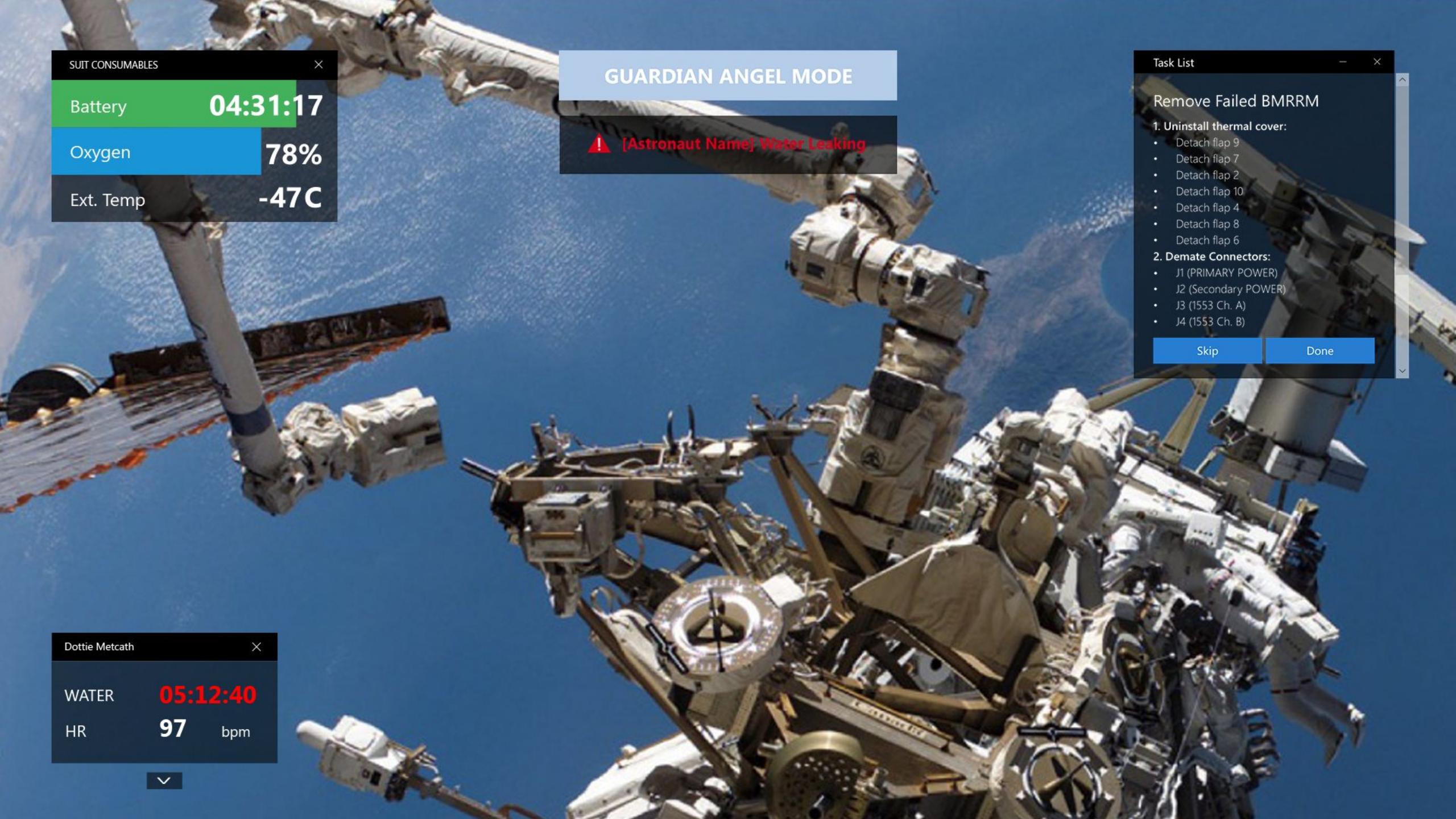


***Pay no attention to that
man behind the curtain!***

TESTING







SUIT CONSUMABLES

Battery **04:31:17**

Oxygen **78%**

Ext. Temp **-47C**

GUARDIAN ANGEL MODE

⚠ [Astronaut Name] Water Leaking

Dottie Metcath

WATER **05:12:40**

HR **97** bpm

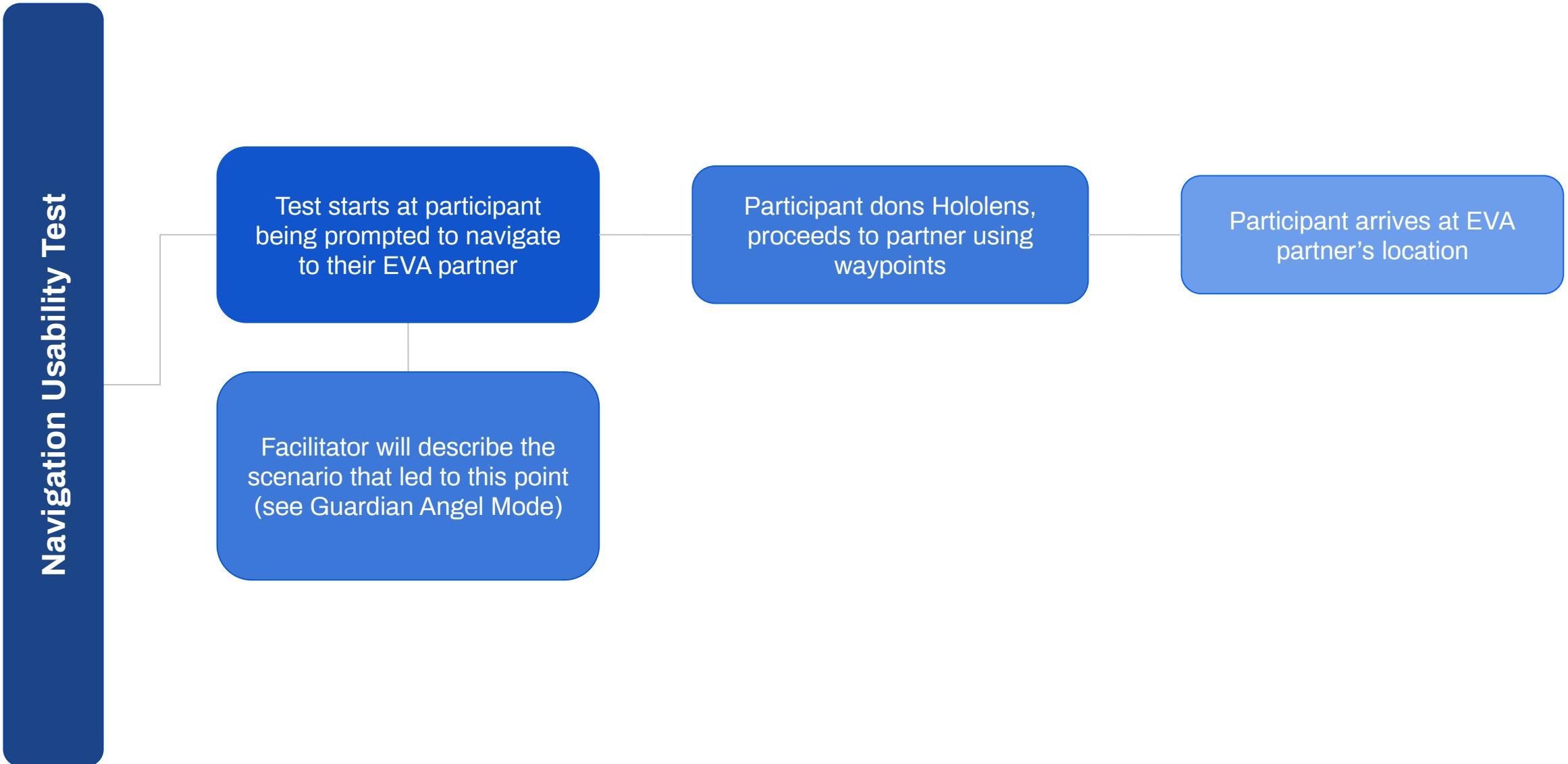
Task List

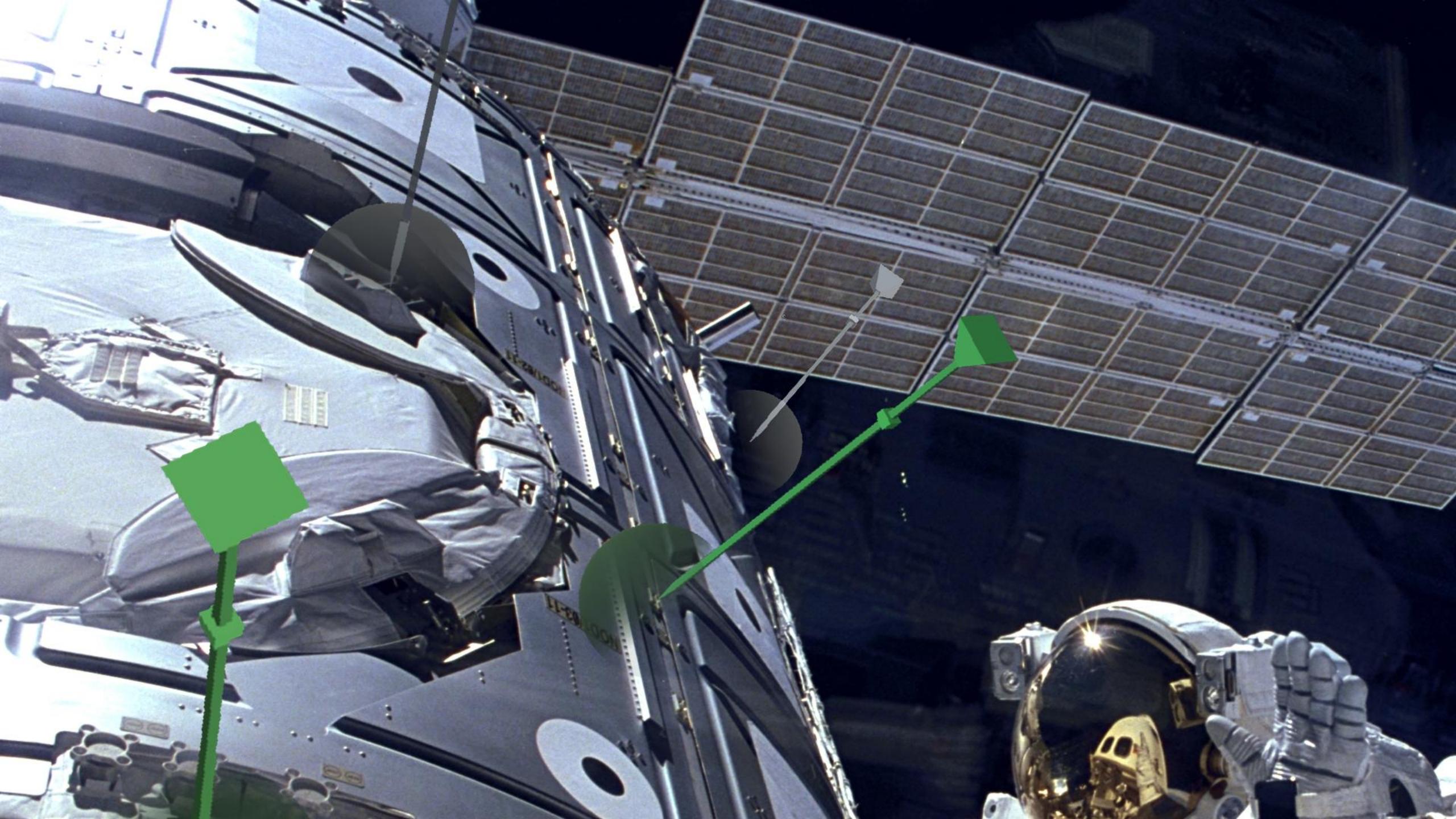
Remove Failed BMRRM

1. Uninstall thermal cover:
 - Detach flap 9
 - Detach flap 7
 - Detach flap 2
 - Detach flap 10
 - Detach flap 4
 - Detach flap 8
 - Detach flap 6
2. Demate Connectors:
 - J1 (PRIMARY POWER)
 - J2 (Secondary POWER)
 - J3 (1553 Ch. A)
 - J4 (1553 Ch. B)

Skip **Done**

TESTING





TESTING

What will be measured during the test?

- **navigation:** time for each waypoint
- **guardian angel mode:** time for each task, VUI testing
- **global:** time from start to finish, error rate, error correction time, heart rate, facial expression, profile mood states rating scale, learnability of system

How will data be recorded?

- Video recording of entire setting, Hololens Spectator view, GoPro on participant (video and sound), face recording (if possible), 2 observers, heart rate monitor

PRELIMINARY TESTING



We tested our initial prototype with Jeff Hoffman, who provided valuable user feedback.

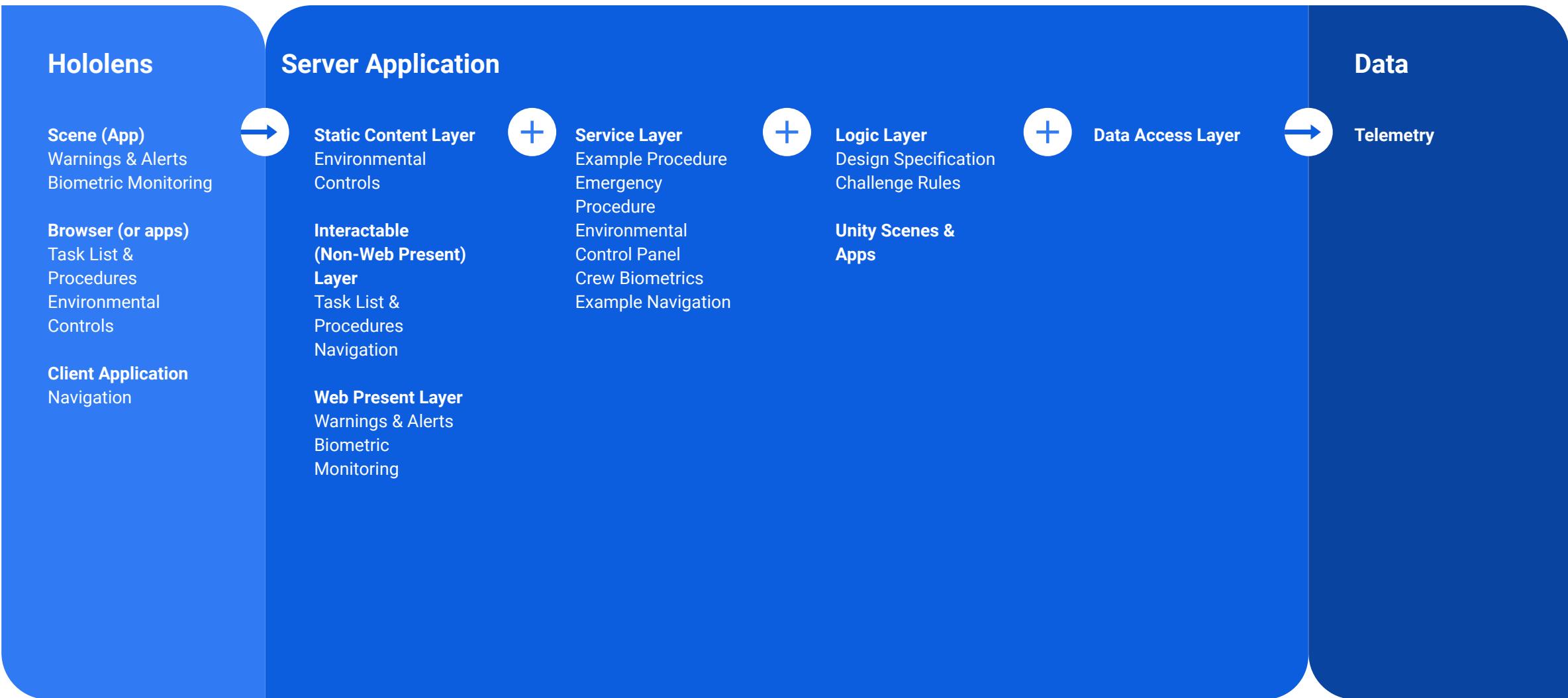
QUESTIONS



APPENDIX

OPEN QUESTIONS

1. How much time will we have to prepare for the usability test on Tuesday/Thursday?



SYSTEM ARCHITECTURE – SOFTWARE

Computer (server)

The computer will be used for brute force manipulation of the prototype in order to 'wizard of oz' specific events

Hololens

The prototype will be used on the Hololens platform. It will respond to the computer and user input.

SYSTEM ARCHITECTURE – HARDWARE

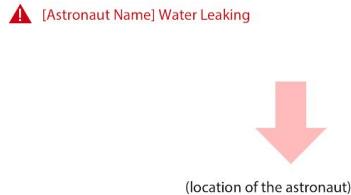


Warning alert 1: Danger detected

Show danger detected sign. Assessing situation.

UI/Interactions

1. Square grey shade on top of everything on the screen.
2. Hide everything else when the danger sign on.
3. Flash danger sign

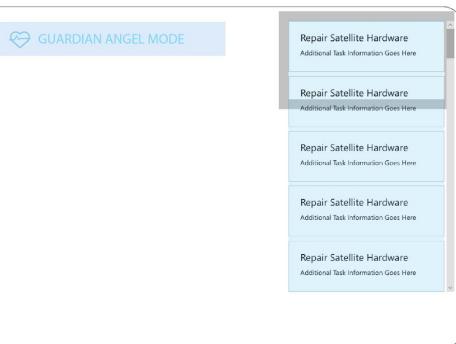


Warning alert 2: Danger assessed

Danger: water leaking. Show details of danger and astronaut biometrics

UI/Interactions

1. User can identify where the location of the other astronaut (shake up and down per second)
2. User can see the brief explanation of the danger (Question: does this matter at this stage?)
3. User can see the astronaut biometrics tp inform following tasks (placeholder for Hane)



Guardian angel mode activated

UI/Interactions

1. Showing guardian angel mode on the top with no flashing (fixed tab)
2. Show task list on the right hand side with guardian angel blue shade (
3. User can see the astronaut biometrics tp inform following tasks (placeholder for Hane)

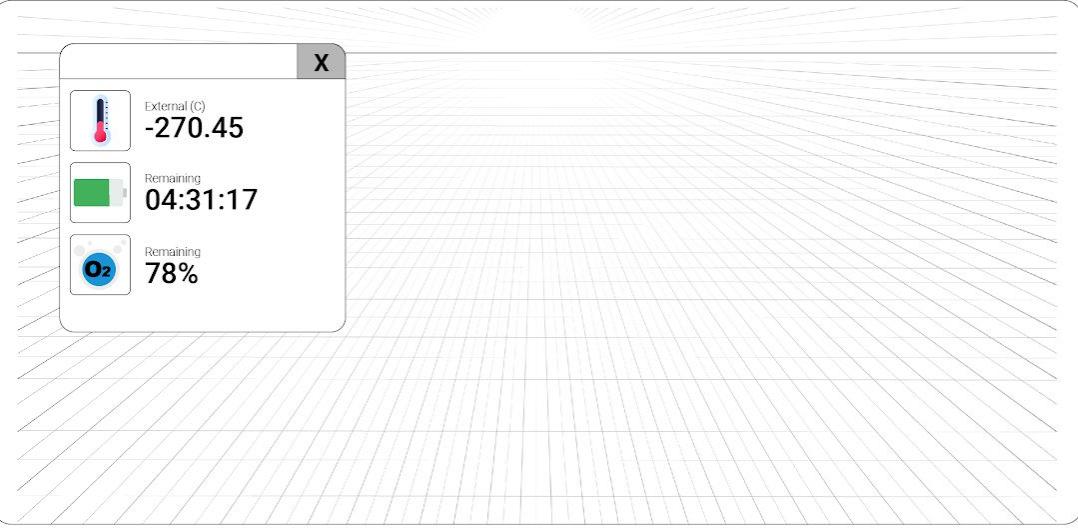
SYSTEM ARCHITECTURE – WARNINGS + ALERTS GUI

SOFTWARE - LOGIC DESCRIPTION OF CODE FOR VI

03

Environmental Controls

- When User commands 'open environmental controls'
 - Open the environmental control app
- When User commands 'exit',
 - Close the environmental controls



Single State

User can see SUB Temp, Battery Life, & Oxygen Life

Only available if user activates it

Interactions

VUI: Users says "Ok Cortana, Open Environmental Controls"

Gesture: User activates app menu via 'Bloom' gesture. User uses 'Drag' and 'Air Tap' to navigate to environmental controls app
If user no longer wants to see environmental controls, they can 'Air Tap' the 'X' or say "Cortana, Close Environmental Controls"

Logic

The module should use body-locking logic rather than billboard

Battery Icon Logic

- The battery icon has 4 states based off the 'Time life battery' telemetry data.
The data is given as time left, with a maximum of 6 hours.
- This data will be converted into a percentage and translate to 100%, 75%, 50%, and 25% battery icons,
as well as an emergency 10% one.



SYSTEM ARCHITECTURE – ENVIRONMENTAL CONTROLS

SOFTWARE - LOGIC DESCRIPTION OF CODE FOR VI

04

Biometrics

Normal

- When User commands 'Overall bio'
 - Summarize overall telemetry status
- When User commands [specific telemetry]
 - Summarize [specific telemetry] and time remaining

Caution

- When cautious level of telemetry is detected
 - Alert mild visual and audio notification
- When User taps Icon_Alert
 - Show telemetry value and time remaining

Emergency

- When dangerous level of telemetry is detected
 - Alert full blinking visual and audio notification (dismissed after 5 sec)
 - Telemetry value and time remaining

1. Health Urgency S1: Normal - overall checkup

Intrusive lvl : Audio

Interaction:

1.Request overall status with voice command when in need.

2.Interface summarizes overall status and points to several telemetry to look out for.

Command Example:

[User]: "Cortana, overall bio"

[Cortana]: "Normal. Look out for Time life Oxygen in 3 hours"

2. Health Urgency S1: Normal - specific checkup

Intrusive lvl : Audio

Interaction:

Request specific health information with voice command when in need.

Command Example:

[User]: "Cortana, Time life Oxygen"

[Cortana]: "hh:mm:ss"

 Water Leaking

-  [H2O is off]
00:11:32
-  [Suit pressure] 1 psid
00:12:48
-  [Time life water]
00:23:52

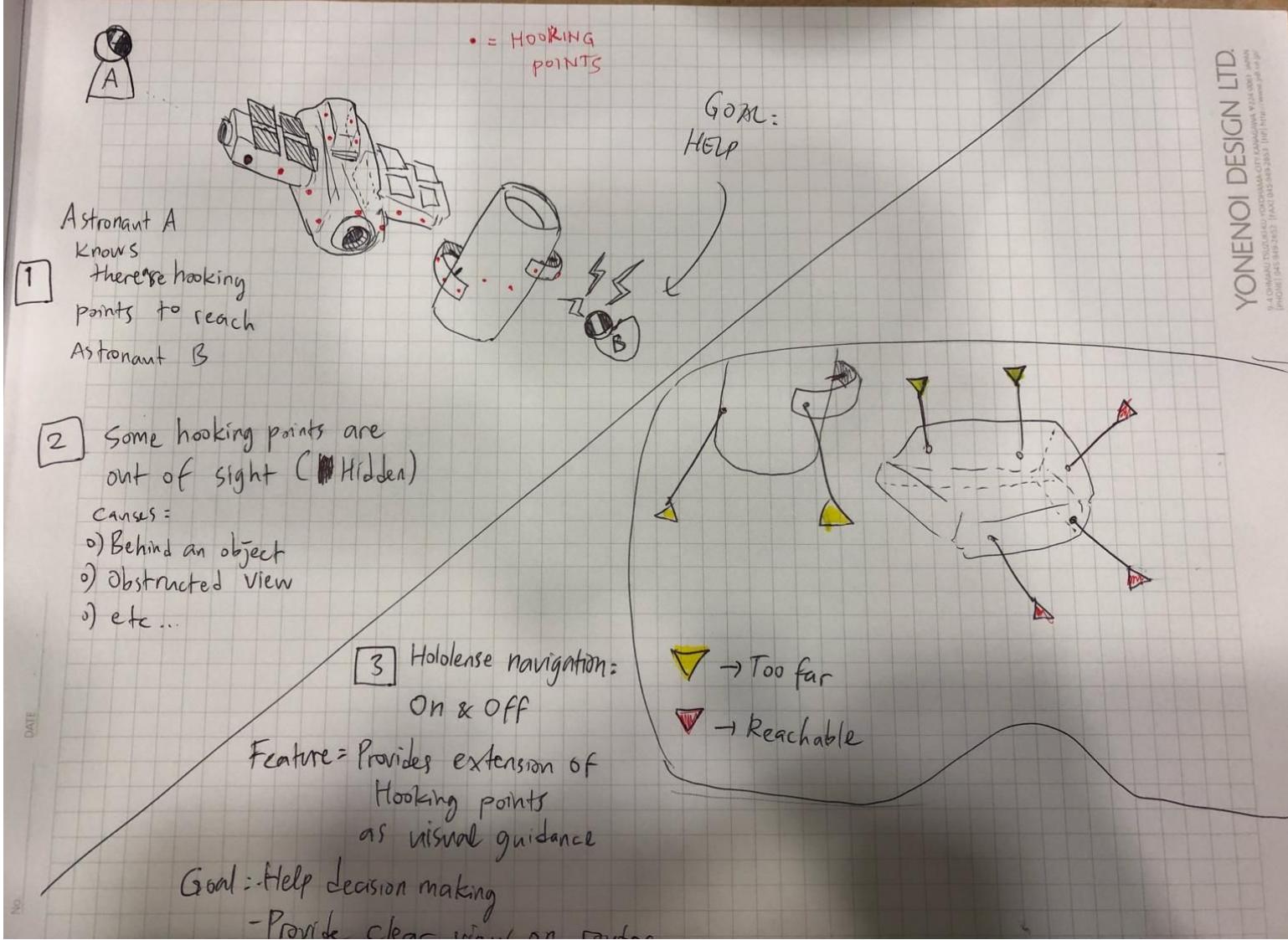
SYSTEM ARCHITECTURE – BIOMETRICS

SOFTWARE - LOGIC DESCRIPTION OF CODE FOR VI

05

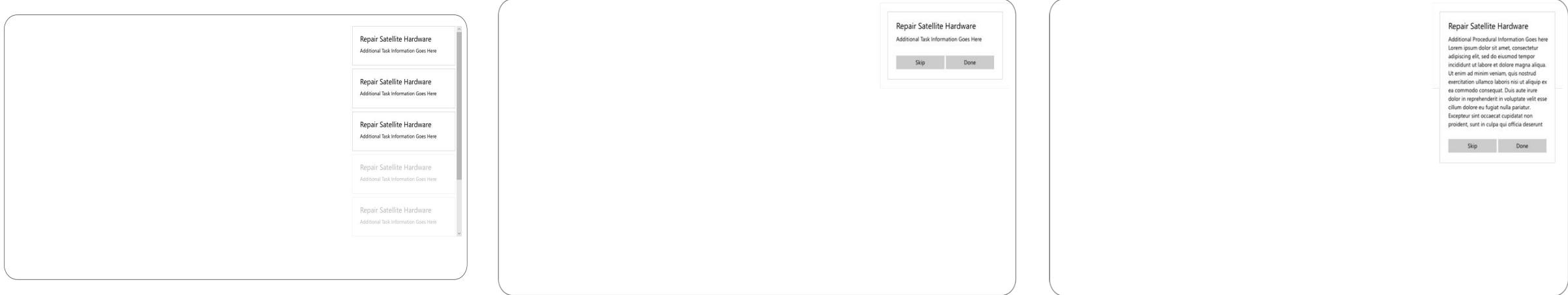
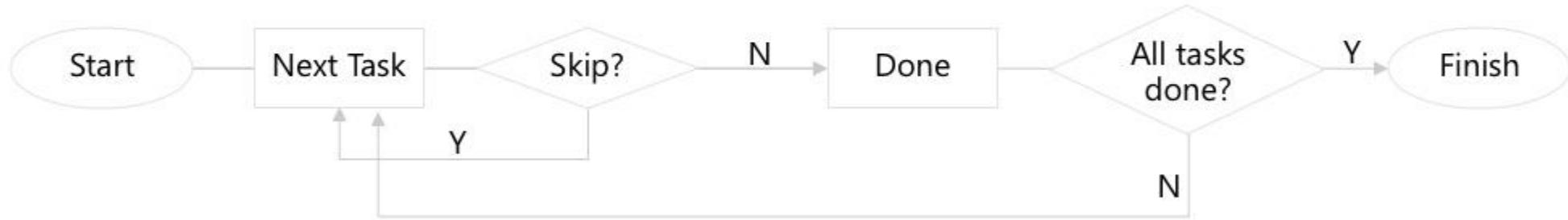
Navigation

- When User commands 'Navigate points', ELSE When User selects the navigation control from the menu
 - Track surroundings
 - Show available hook points in space
 - Different visual cues based on user's position
- When User commands 'Hide points', ELSE When User selects the navigation control from the menu
 - Hide hook points



SYSTEM ARCHITECTURE – NAVIGATION GUI

Task List - Flow



SYSTEM ARCHITECTURE – TASK LIST

SYSTEM FUNCTIONALITY

02

Warnings & Alerts

- Brute Force Manipulation
 - Facilitator (Administrator) pushes warning to user at will

TELEMETRY STREAM

How is telemetry stream handled

1. Call the stream at __ time intervals, parse the JSON file, reflect updated data in UI

How are warnings and anomalies handled

1. Warnings and Anomalies in our testing scenario are not dependent on the telemetry stream

Reliability

1. Open Question: Waiting for access to final telemetry stream
2. Descale Gracefully: Prototype should be testable without a working telemetry stream

HARDWARE

Hololens

The test participant(s) will be interacting with the prototype on the Hololens platform. The Hololens will not be directly interacting with other hardware, though the apps in the prototype ecosystem will be calling to the telemetry stream running on the team's computer.

SOFTWARE

Development Environment

Unity -> Visual Basic -> Hololens (or Emulator)

TODO

1. Feature Development
 - a. [IN DEVELOPMENT] Navigation
 - b. [IN DEVELOPMENT] Task List & Procedures
 - c. [IN DEVELOPMENT] Environmental Controls
 - d. [IN DEVELOPMENT] Biometrics
 - e. [IN DEVELOPMENT] Warnings & Alerts
2. Telemetry Stream
 - a. Integrate with features
3. Usability Test
 - a. Finish final draft
 - b. Beta test (with astronaut Jeff Hoffman)

