Design Review

Harvard SUITS

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

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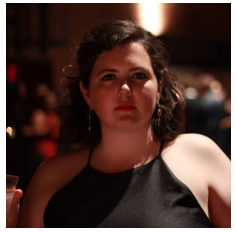
About the team



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Human-Centered Design & Engineering,
Space technology, Geology

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Industrial Design
EVA Crew Distress Warning & Biometrics

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Product Design

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Dance and Arts Management

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Psychology & Art
UX Research

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BSc. in Business Economics and a minor in Art History

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UX Design/Design Strategy

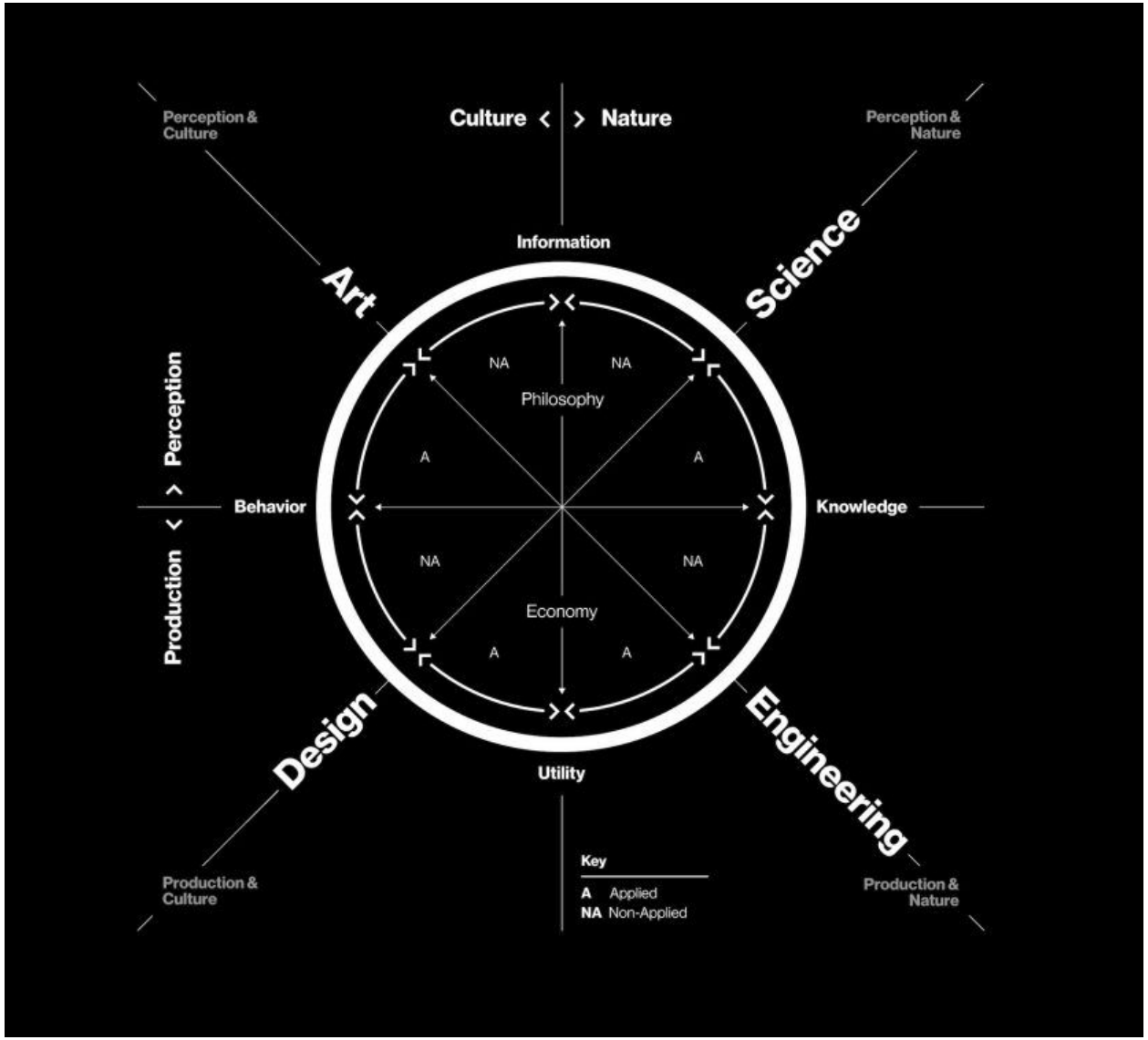
Zongheng Sun
Automotive Design & Engineering

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*, 105672S-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.

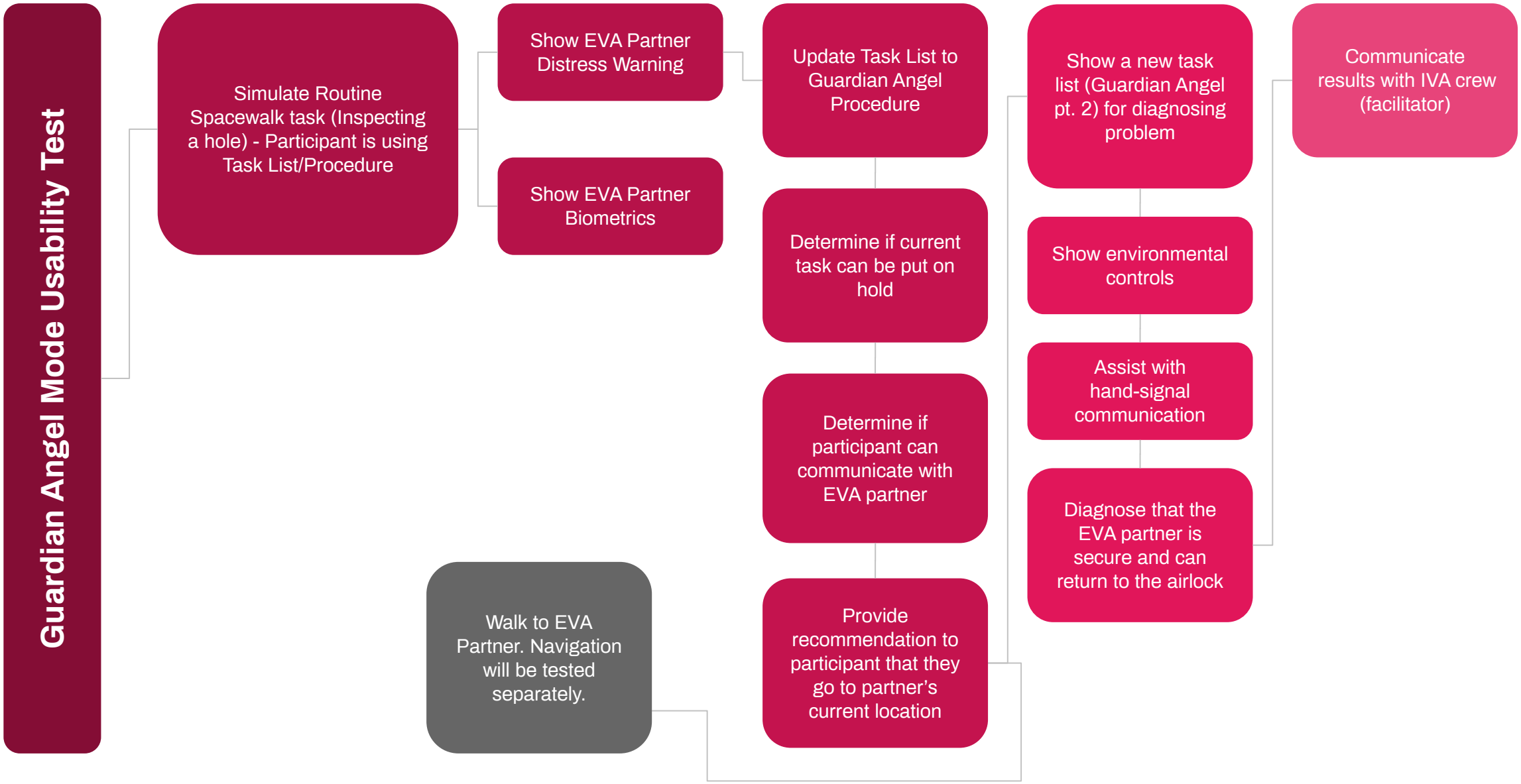
Design Values

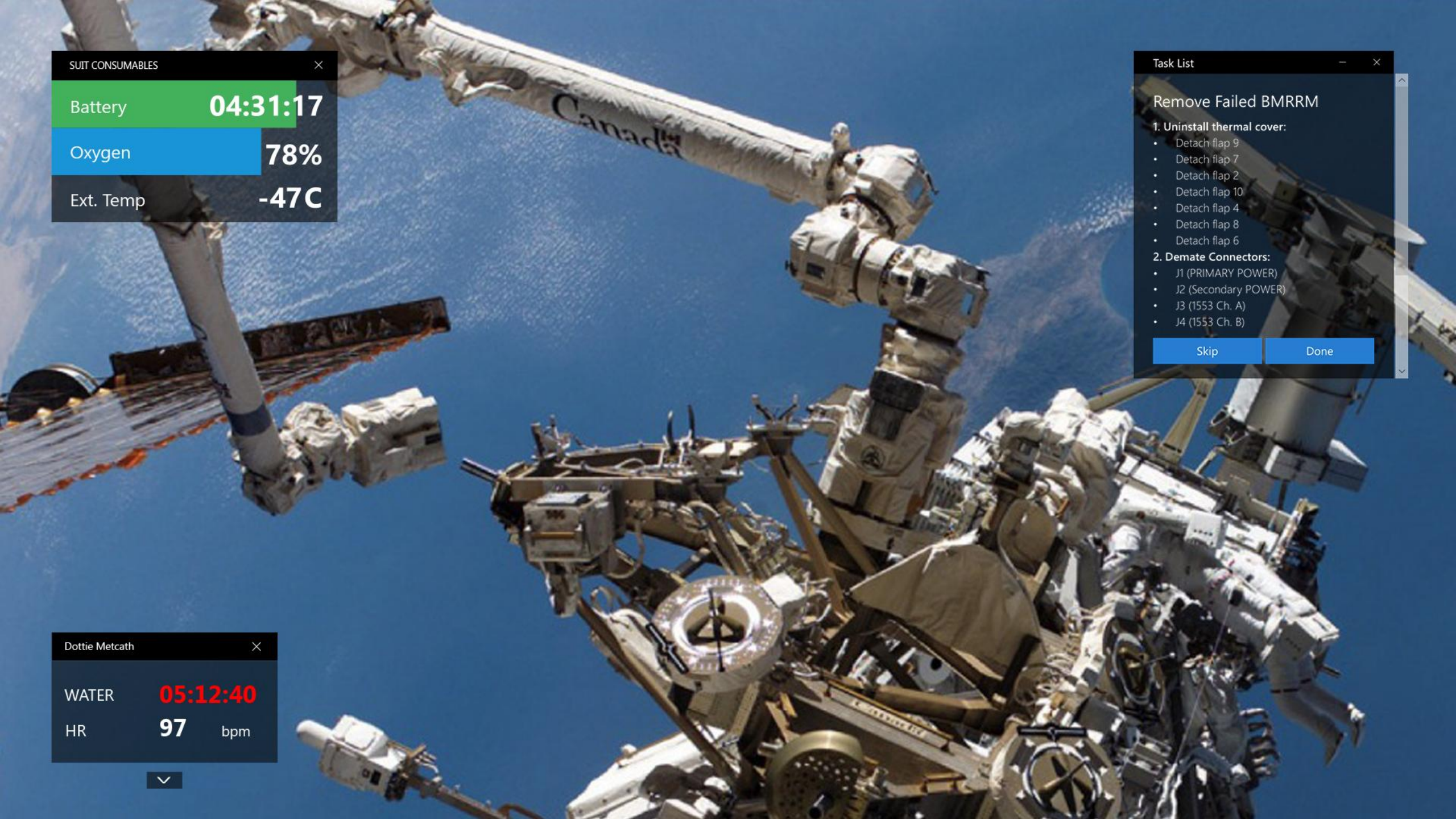
1. Keep Astronauts aware and focused on the task at hand
2. Improve Astronaut Agency: Reduce the cognitive load of EVA tasks without being patronizing
3. Prioritize procedure and details over intuitive usability
4. Design for limited mobility & muted senses
5. Extend cognition with flexible and responsive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

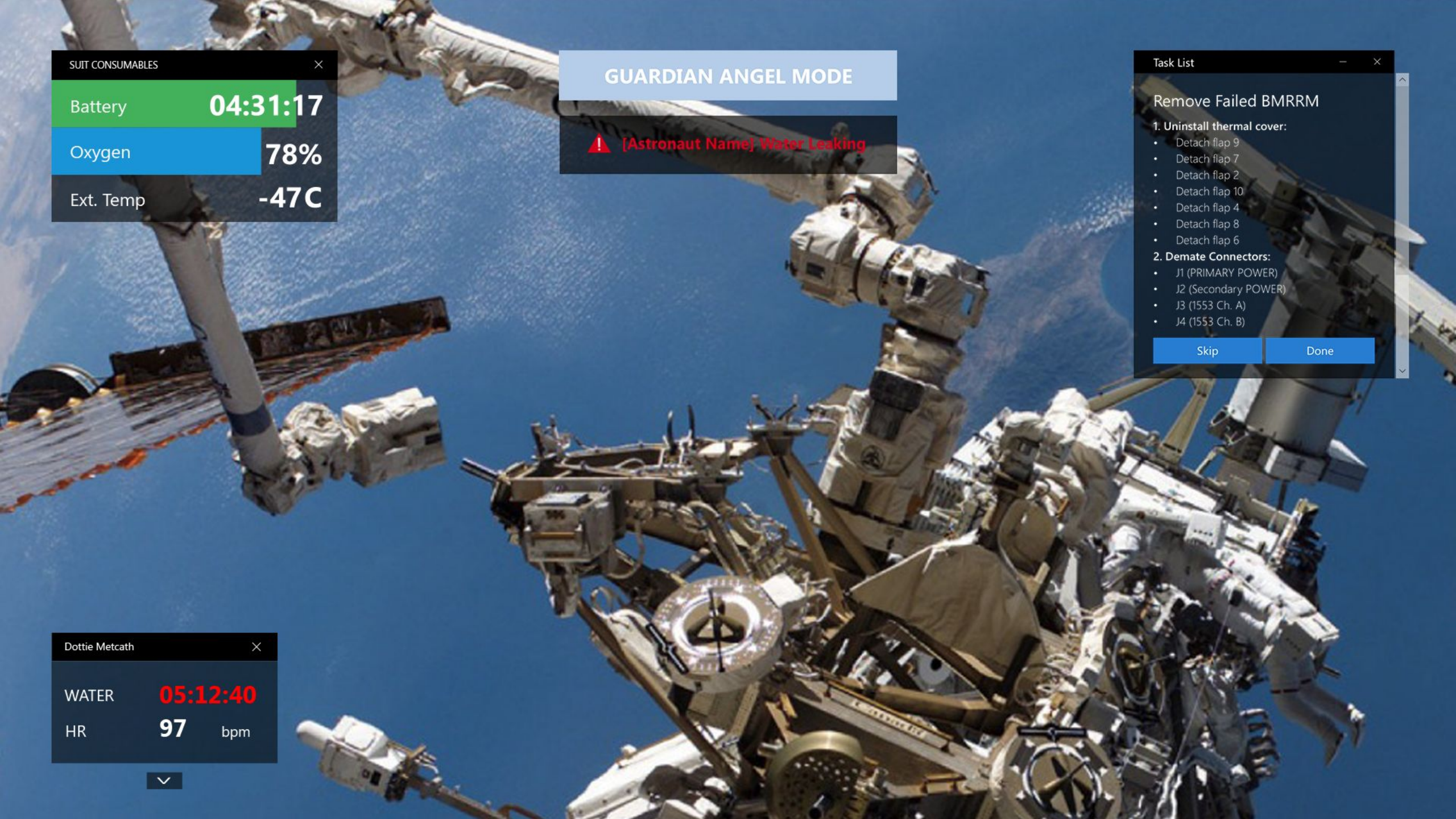
Prototyping Philosophy

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

Testing


Guardian Angel Mode Usability Test
Simulate Routine Spacewalk task (Inspecting a hole) - Participant is using Task List/Procedure
Show EVA Partner Distress Warning
Show EVA Partner Biometrics
Update Task List to Guardian Angel Procedure
Determine if current task can be put on hold
Determine if participant can communicate with EVA partner
Provide recommendation to participant that they go to partner's current location
Walk to EVA Partner. Navigation will be tested separately.
Show a new task list (Guardian Angel pt. 2) for diagnosing problem
Show environmental controls
Assist with hand-signal communication
Diagnose that the EVA partner is secure and can return to the airlock
Communicate results with IVA crew (facilitator)


SUIT CONSUMABLES
Battery 04:31:17
Oxygen 78%
Ext. Temp -47C
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
Dottie Metcath
WATER 05:12:40
HR 97 bpm


SUIT CONSUMABLES
Battery 04:31:17
Oxygen 78%
Ext. Temp -47C
GUARDIAN ANGEL MODE
[Astronaut Name] Water Leaking
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:
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Skip
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WATER 05:12:40
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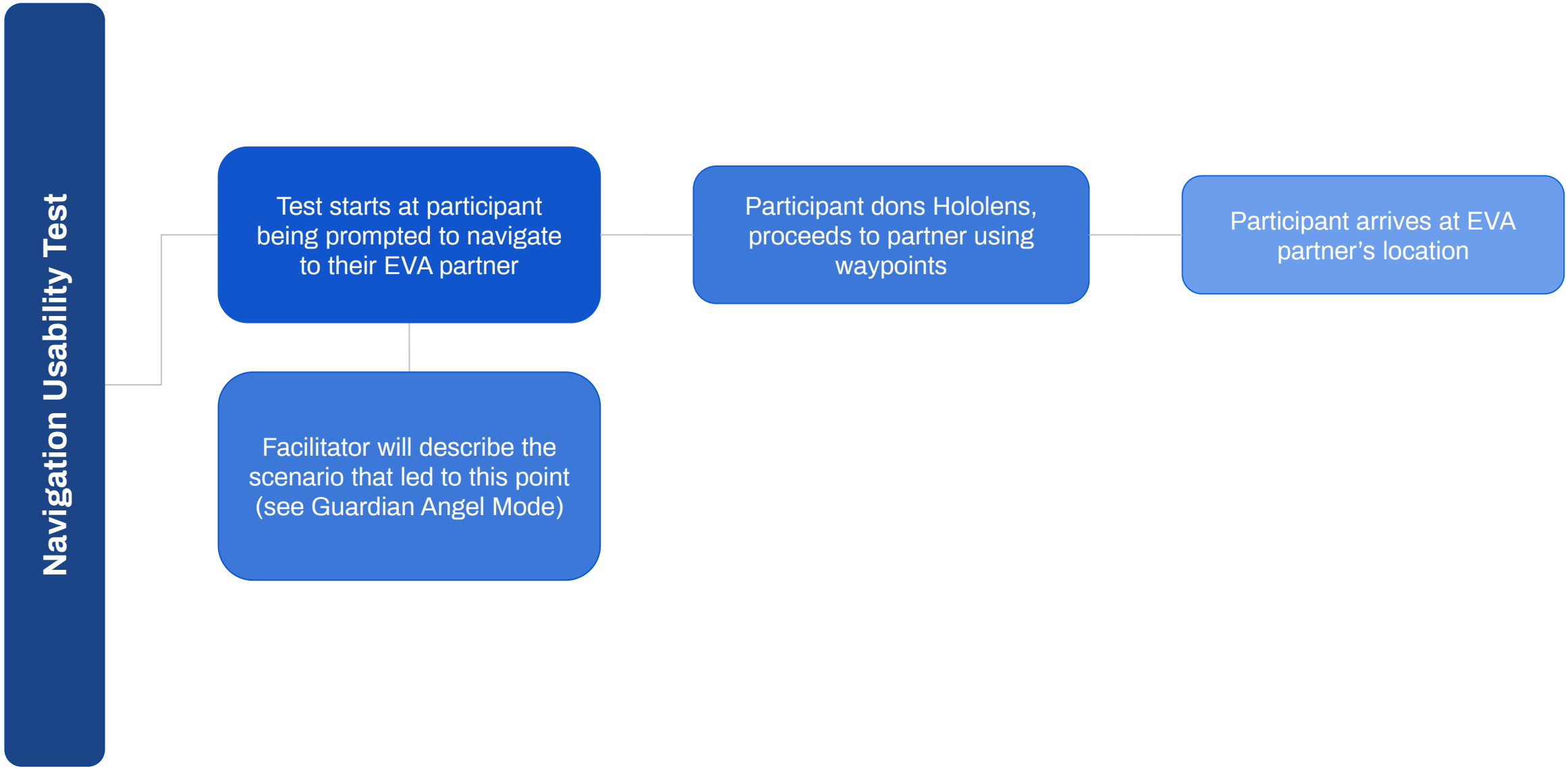
Testing


Navigation Usability Test
Test starts at participant being prompted to navigate to their EVA partner
Facilitator will describe the scenario that led to this point (see Guardian Angel Mode)
Participant dons Hololens, proceeds to partner using waypoints
Participant arrives at EVA partner's location

Testing

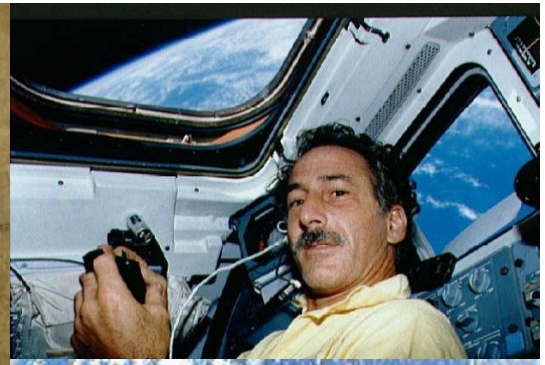
What will be measured during the test?

- **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



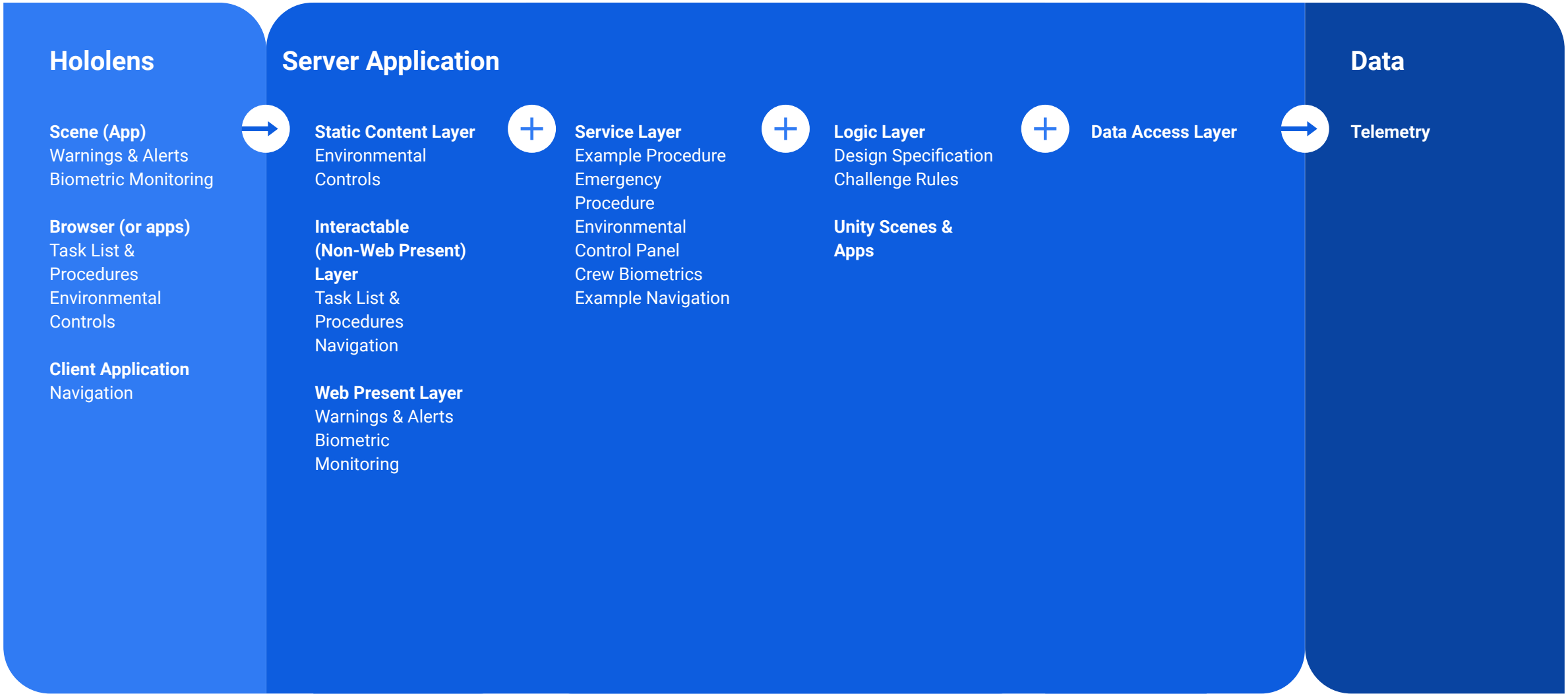
We tested our initial prototype with Jeff Hoffman, who provided valuable user feedback.

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.

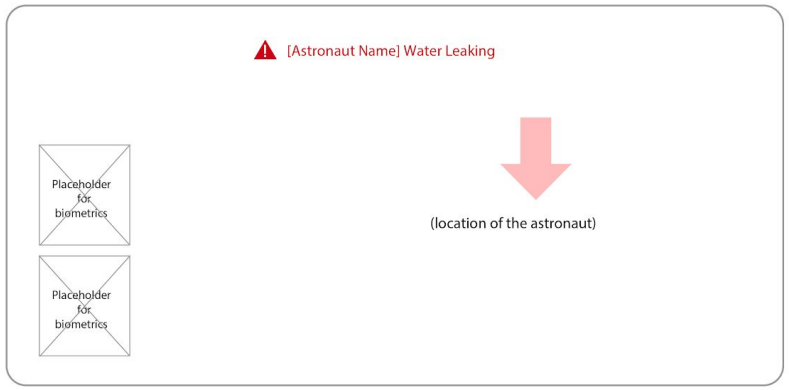
System architecture - Hardware

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 explaination of the danger (Question: does this matter at this stage?)
3. User can see the astronaut biometircs tp inform following tasks (placeholder for Hane)

Guardian angel mode activited

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 biometircs tp inform following tasks (placeholder for Hane)

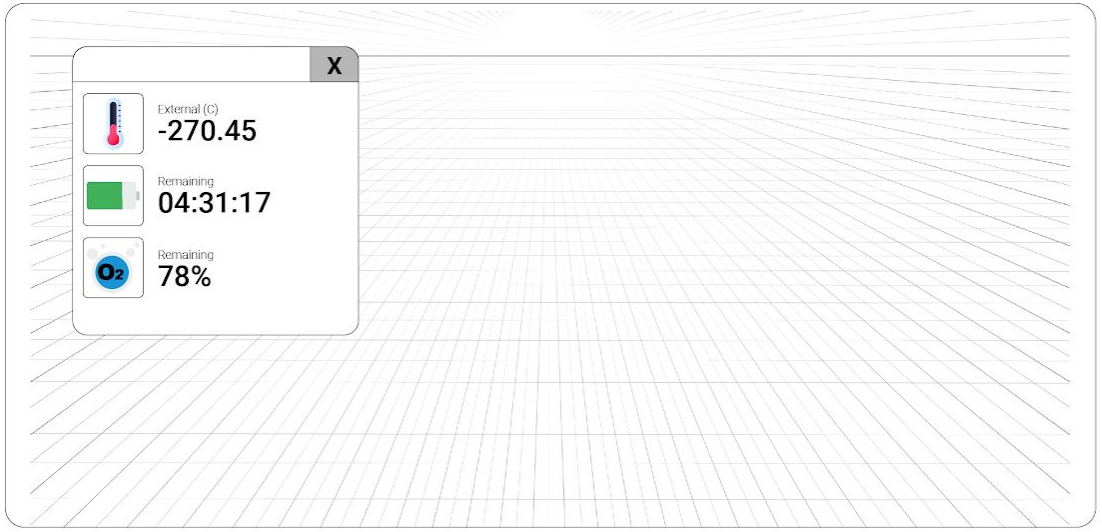
System architecture - Warnings + Alerts GUI

Software - Logic description of code for UI

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 UI

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 summerizes 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”

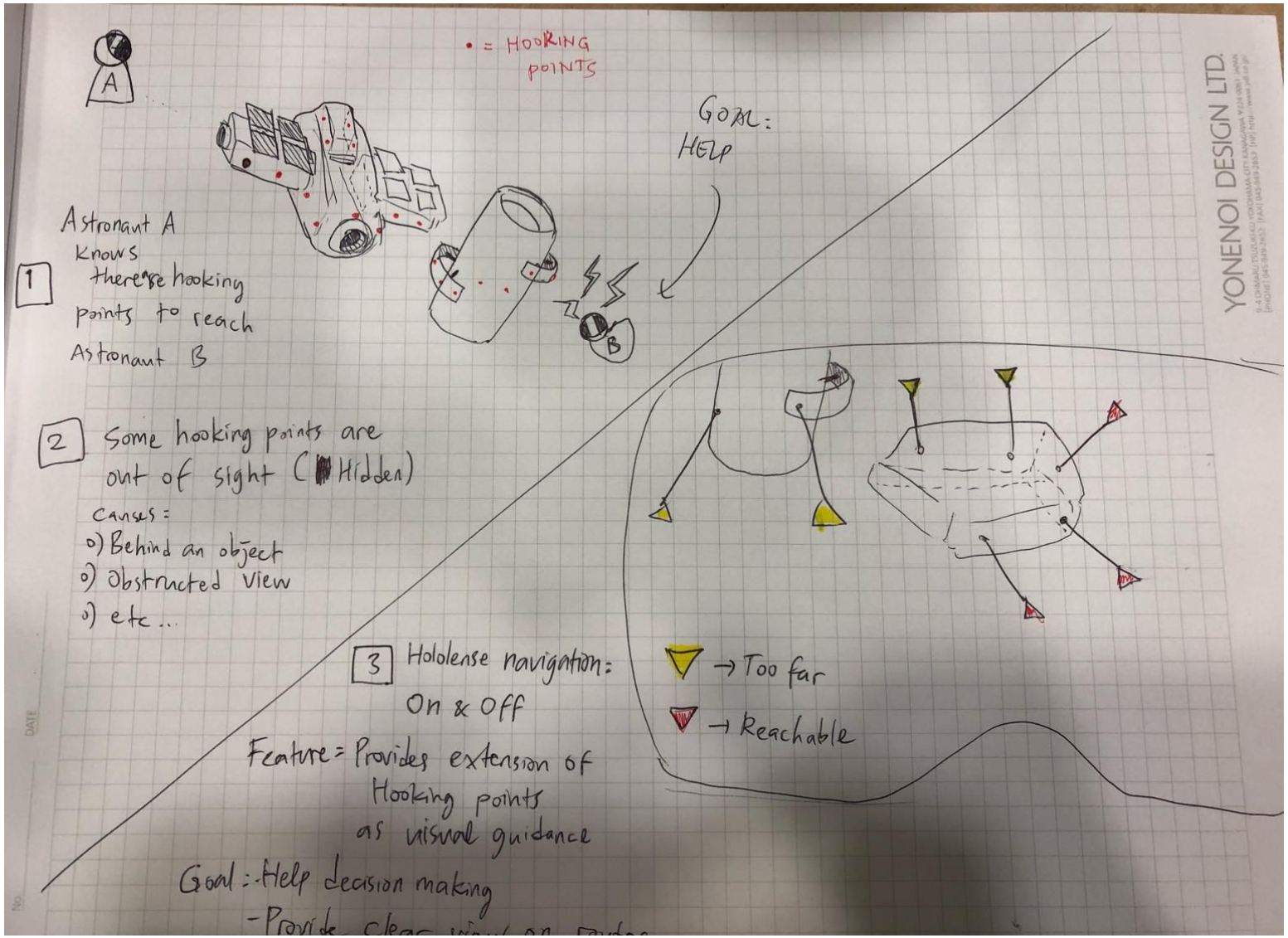
System architecture - Biometrics

Software - Logic description of code for UI

05

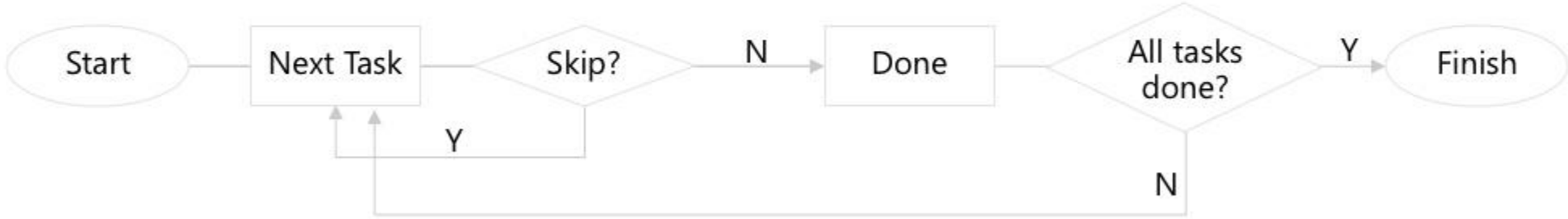
Navigation

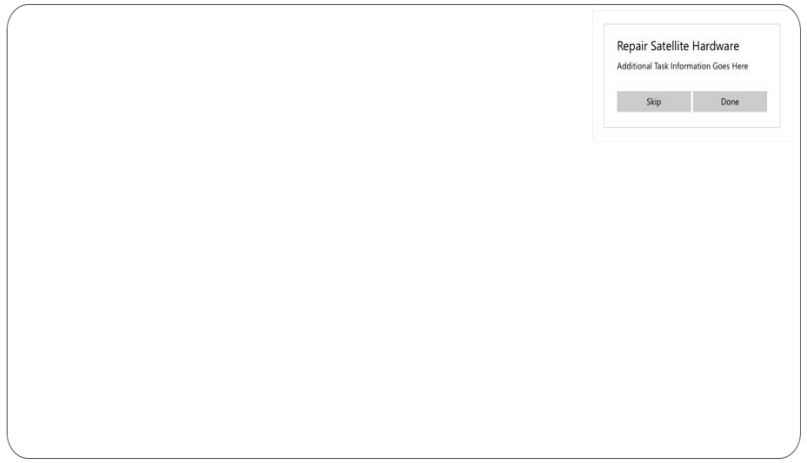
- When User commands ‘Navigate points’, ELSE When User selects the navigation control from the menu
  - Track surroundings
  - Show available hook points in space
  - Different visual cues based on user’s position
- When User commands ‘Hide points’, ELSE When User selects the navigation control from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