



NovaWurks Case Study  
Prepared by Clouddesign Inc.

## DISCOVERY

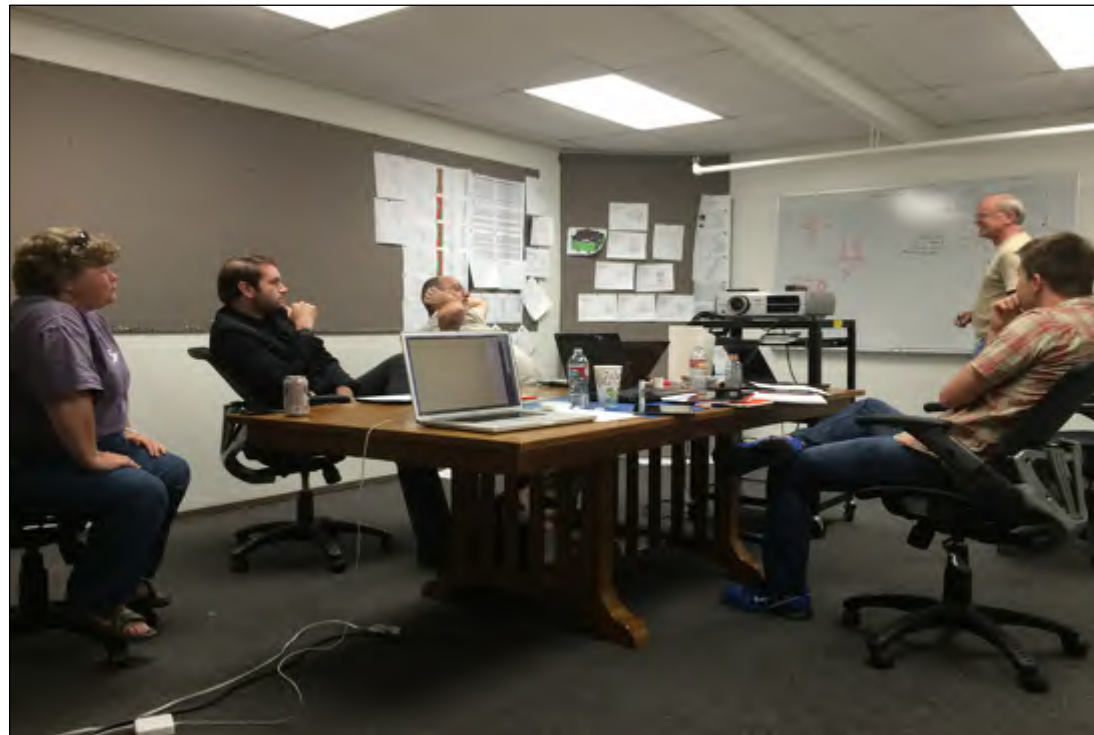
Our core goals during discovery are:

- Learning about our users
- Modeling our users
- Analyzing our users' tasks
- Eliciting and defining clear product requirements

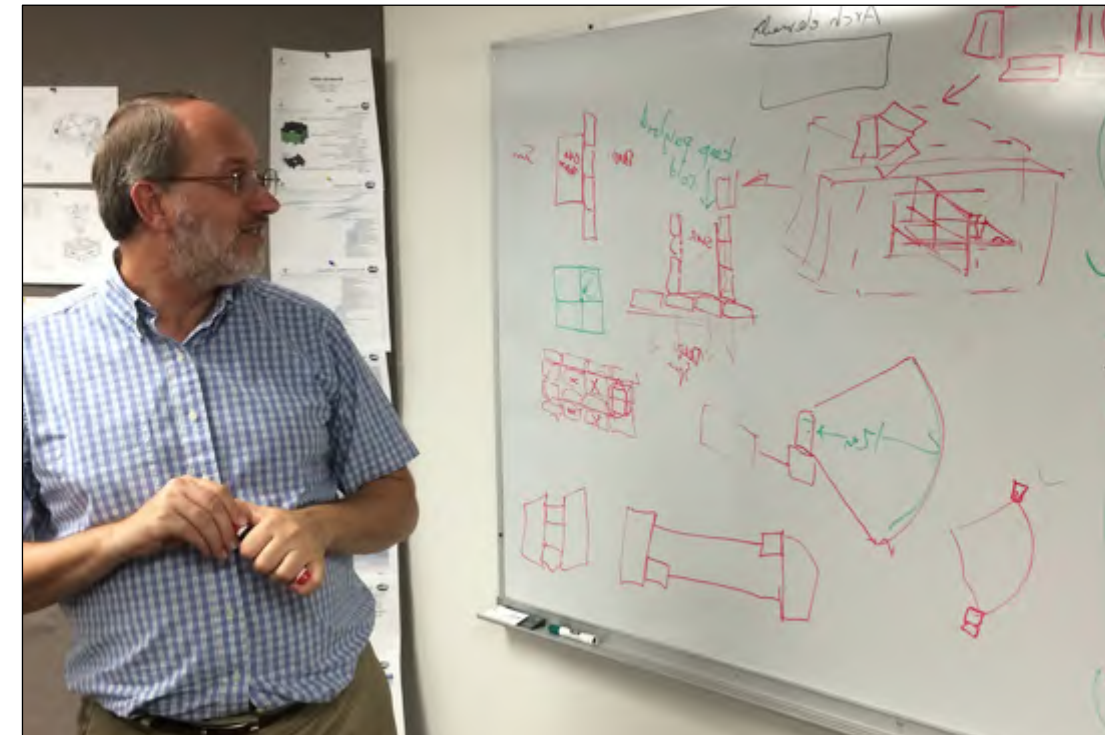
As our team gathers data we endeavor to be:

- Flexible
- User centered

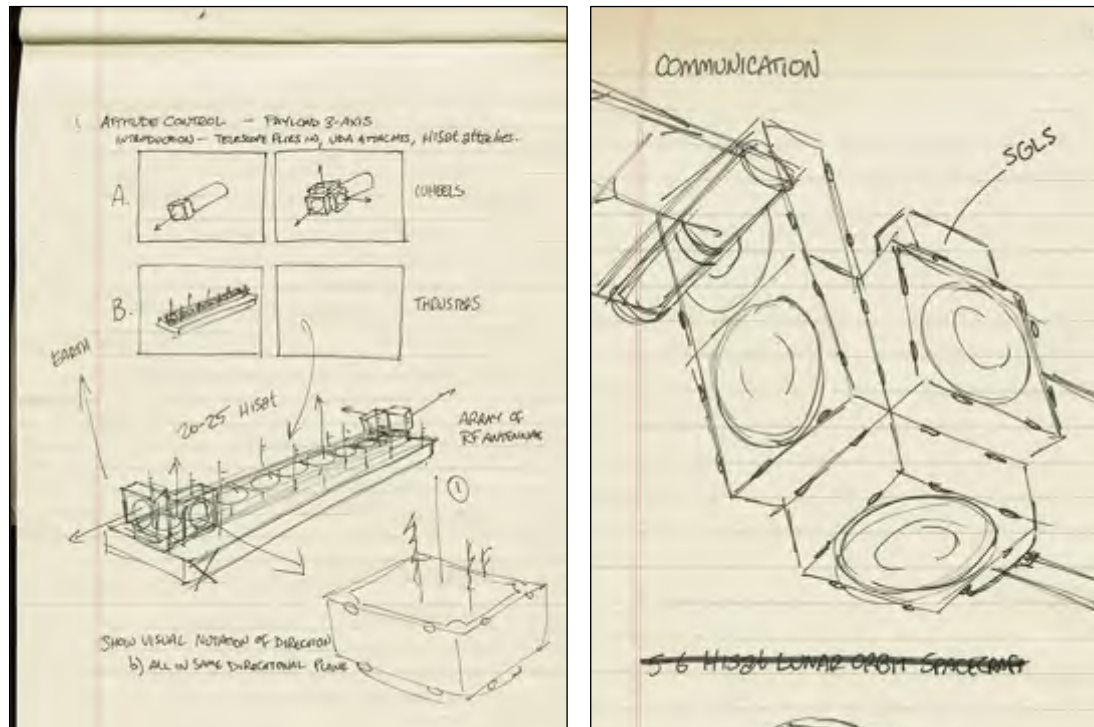
Discovery Process conducted onsite



CDI team leads a discovery session with client's lead engineers



CDI and client NovaWurks distill the process of Satellite design into exercises



CDI designers attend discovery and provide iterative rough visuals




3D printed mock ups provide context for their digital counterparts

Personas Developed based on Groups most likely to engage with product

Number	First Name	Last Name	Occupation	Area of Aerospace	Expertise	Email Address	Contact?	Project Highlights	Design	Presentation	Simulation	Collaboration	3D Visualization Important?	Effective Apps	Roundtable Discussion
1	Bob	Hanel	Systems Engineer / NASA	Space Missions		robert.p.hanel@nasa.gov	Yes	Space Science Missions - IR Telescopes, Lunar & Mars Missions, Biology Payloads in ISS	MATLAB, Simulink. Homemade Excel spreadsheets for Mass/Power allocations & budgets	Office products. Additional graphics are good for presentations but are typically hard on the processing power or make the files too large to email.		WebEx	Yes, they are important.	I liked the gauges idea (not functional in our setting) - Rotation point is fixed to first element - Export to a 3D printer	<ul style="list-style-type: none"> <li>• Needed some context for why the group was being led to assemble various types of PACs during the workshop - Felt a bit in the dark</li> <li>• Needed a lot more context - would have appreciated a mission style layout to the workshop.</li> </ul>
2	Cedric	Priscal	Software Engineer	Small Satellites	Embedded Software Dev	cedric.priscal@nasa.gov	Yes	PhoneSat project (Android-based cubesat)	Software development tools	Power Point	MATLAB, Custom tools	Sticky Notes, Mind Mapping Software ('Cloud' one would be nice)	Important for the mechanical design and for project communication	Not using iPad at work	<ul style="list-style-type: none"> <li>• I like the UI</li> <li>• I think it has limitations as a tool for design - I would like to see a desktop app</li> <li>• I think it's a very good tool for visualization - to communicate ideas</li> <li>• As an educational tool, it needs clear 'game play' and exercises to be effective</li> <li>• Finding how objects connect is confusing - edges vs. sides</li> <li>• The GUI highlight that displays connection possibilities was not different enough</li> </ul>
3	Watson	Attai	Aerospace Engineer	Mechanical, Electrical, Comm, Testing	Same	watson.attai@nasa.gov	Yes	Helped build, test, fly, and operate PhoneSats	Comm's hardware - radios, cliftonut (sp?) cables, connectors, etc.	Power point, PDFs, Excel, Word, Whiteboard	CAD, Breadboard (protoboard), cables, resistors, etc.	Verbal & electronic communication, White board	Somewhat	Maps, Weather	<ul style="list-style-type: none"> <li>• Export to a 3D printer</li> <li>• Ability to import/export to other programs</li> </ul>
4	Hilda	Palencia	Aerospace Engineer, SSMA/ESD Manager	Systems, Safety, & Mission Assurance	SSMA - ESD - Quality	hilda.palencia@nasa.gov	No		For electrical designs, MATLAB, Fault Tree Analysis (FTA) software (don't have name), STK (Systems Tool Kit - formerly Satellite Tool Kit)	Microsoft	Not necessary in my organization, but projects I have been involved with use CATIA, MATLAB, and Mentor Graphics	Most of the sharing ideas are done through meetings, graphics using microsoft office tools - Yes, there is an opportunity for improvement.	It is extremely important.		
5	Brian	Lewis	Systems Engineer / NASA	Thermal, Systems Engineering, System Architecture	Systems Engineering	brian.s.lewis@nasa.gov	Yes	LADEE Spacecraft S.E., BioSentinel mission S.E., GPS III Staff S.E.	In house tools (ATLAS, Team-X, Aerospace CDC), DOORS, Improvement - Ability to transition levels of details without full rebuild of work	Power Point, Word, Improvement: Direct transition of information from models to presentation materials without manual re-entry.	STK, SOAP, Pro-E, Solidworks	WebEx, Adobe Comment, S.E. tools listed above, Improvement: Ability to read presentation with notes and audio? > Package like a slide deck.	Somewhat to very depending on the tasks. Very useful for Attitude and power profiling. Useful for presentations and sales.	Xbox smartglass? (Windows Phone Version) One note. Accessibility of models over multiple platforms.	<ul style="list-style-type: none"> <li>• XML or JSON export that could be read by other programs where you can get a head start with the components</li> <li>• Would allow users to build and then export to modify or analyze.</li> <li>• One Note from Office is an app to study</li> <li>• Would be nice to be able to use a mouse (effort may not justify the end result)</li> <li>• CAD export would be cool but not realistic for a small company</li> <li>• Allowing for the importing of third party devices opens a can of worms - right away we don't know basics like thermal protection, etc.</li> <li>• A good tool for STEM programs.</li> <li>• Submit button would submit a design for review by experts, and they would contact you with comments</li> <li>• Have designs evaluated based on mission simulation</li> <li>• See a running summary of how close you are to fulfilling your mission goals</li> <li>• UX Great</li> <li>• Interesting, fun - Did not have the depth for spacecraft or systems design</li> <li>• Problematic parent/child relationship with attached objects - deleting one takes a portion of the craft with it - consider a graph structure</li> <li>• Appropriate tool for education, early mission design, and an introduction to the technology.</li> <li>• Game-like levels would be appreciated</li> <li>• Build a system and see it function as a payoff</li> <li>• Finish a config - it would be helpful to set an orbit and see how the sun affects the craft, etc. - simulations to aid in visualization</li> <li>• Visualize aggregate torque on each axis</li> </ul>
6	Richard	Golding	Software/ Systems engineering - consulting	Small spacecraft	Software, Project management, SE	richard.golding@kinseytech.com	Yes	DARPA F6 Program NASA Ames EDSN mission	CAD tools Requirements tracking Issue/Schedule management Optimization packages Software engineering tools STK Custom/proprietary analysis packages	Largely power point and video; occasionally data visualization tools	STK FEA/Thermal packages (not sure of specifics)	Some IM and wiki packages Some document/code repository systems	Most important in orbit design/guidance design CAD for hardware design	I have not found that touch/iPad apps have ended up useful in design. The promise seems to be there but never quite seems to be realized.	<ul style="list-style-type: none"> <li>• Tried to understand gauges - found them to be non-functional</li> <li>• Could have used a mission profile</li> <li>• Screen size is limiting - As you build a lot of these building blocks, the screen size is too small - Needs to be on a workstation.</li> <li>• Really needed real time feedback - add a device and see how the power requirement changes - without feedback it becomes a toy</li> <li>• Wanted to see orientation arrows for Comms system to consider orbit</li> <li>• Wanted to be able to export the data out in a known format so it can be used in other programs. STK or MATLAB</li> <li>• Wanted to be able to move Sun in orientation to craft for Comms analysis</li> <li>• Point analysis over the course of an orbit - May not be appropriate for a tool like this - Another reason for the import/export strategy</li> <li>• Modify GUI so basic connections are clear.</li> <li>• Can a mouse be added for precision? Fingers are imprecise.</li> </ul>
7	Craig	Pires		C+DH (Command & Data Handling) Hardware & Software, SE	C&DH architecture Flight software	craig.pires@nasa.gov	Yes	Lead LADEE C&DH, Lead EDSN FSW	Mainly programming tools. I would like better SIM tools.	Power point is main. Other tools that are more (sp?) Tem driven.	Simulink.	Better links between simulink, SYS ML, and Flight SW			

**User Class 2**  
Power User / Engineer



**Bob Hanel**  
Systems Engineer NASA  
robert.p.hanel@nasa.gov

**Career Highlights:**  
Space Science Missions - IR Telescopes, Lunar & Mars Missions, Biology Payloads in ISS

**Current Design Tools:**  
MATLAB, Simulink. Homemade Excel spreadsheets for Mass/Power allocations & budgets

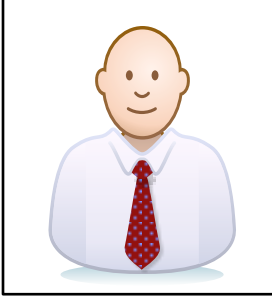
**Quote:**  
*I liked the gauges idea (not functional in our setting) - Rotation point is fixed to first element - Export to a 3D printer*

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Office products. Additional graphics are good for presentations but are typically hard on the processing power or make the files too large to email.

**Round table points:**

- Would have appreciated a mission style layout to the workshop.

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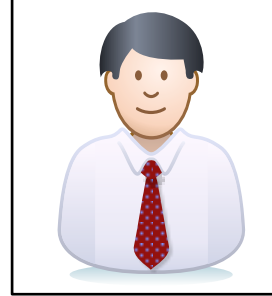
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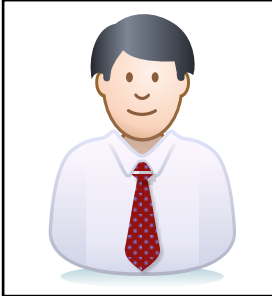
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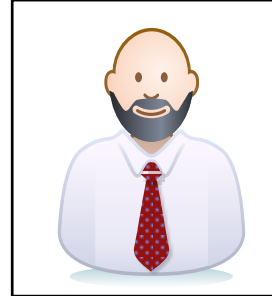
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**Brian Lewis**

Power user / Engineer

“  
One note.  
Accessibility of  
models over  
multiple  
platforms.”

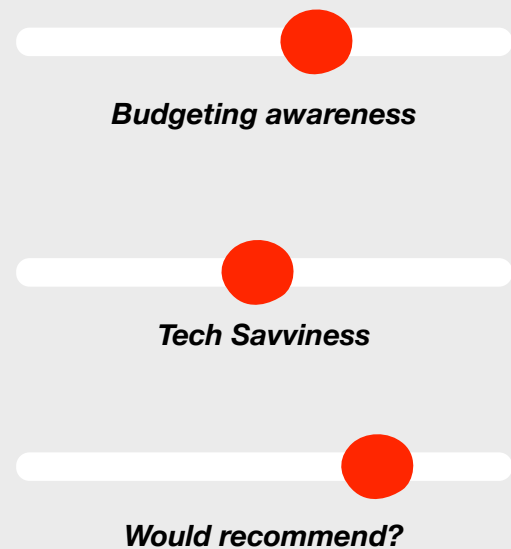
**DEMOGRAPHICS**

<b>Age</b>	45
<b>Works For</b>	NASA Ames
<b>Job Role</b>	Systems Engineer
<b>Highlights</b>	LADEE Spacecraft S.E., BioSentinel mission S.E., GPS III Staff S.E.
<b>Family Status</b>	

**NEEDS & ROUND TABLE POINTS**

- XML or JSON export that could be read by other programs where you can get a head start with the components
- Would allow users to build and then export to modify or analyze.
- One Note from Office is an app to study
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**RANKINGS**



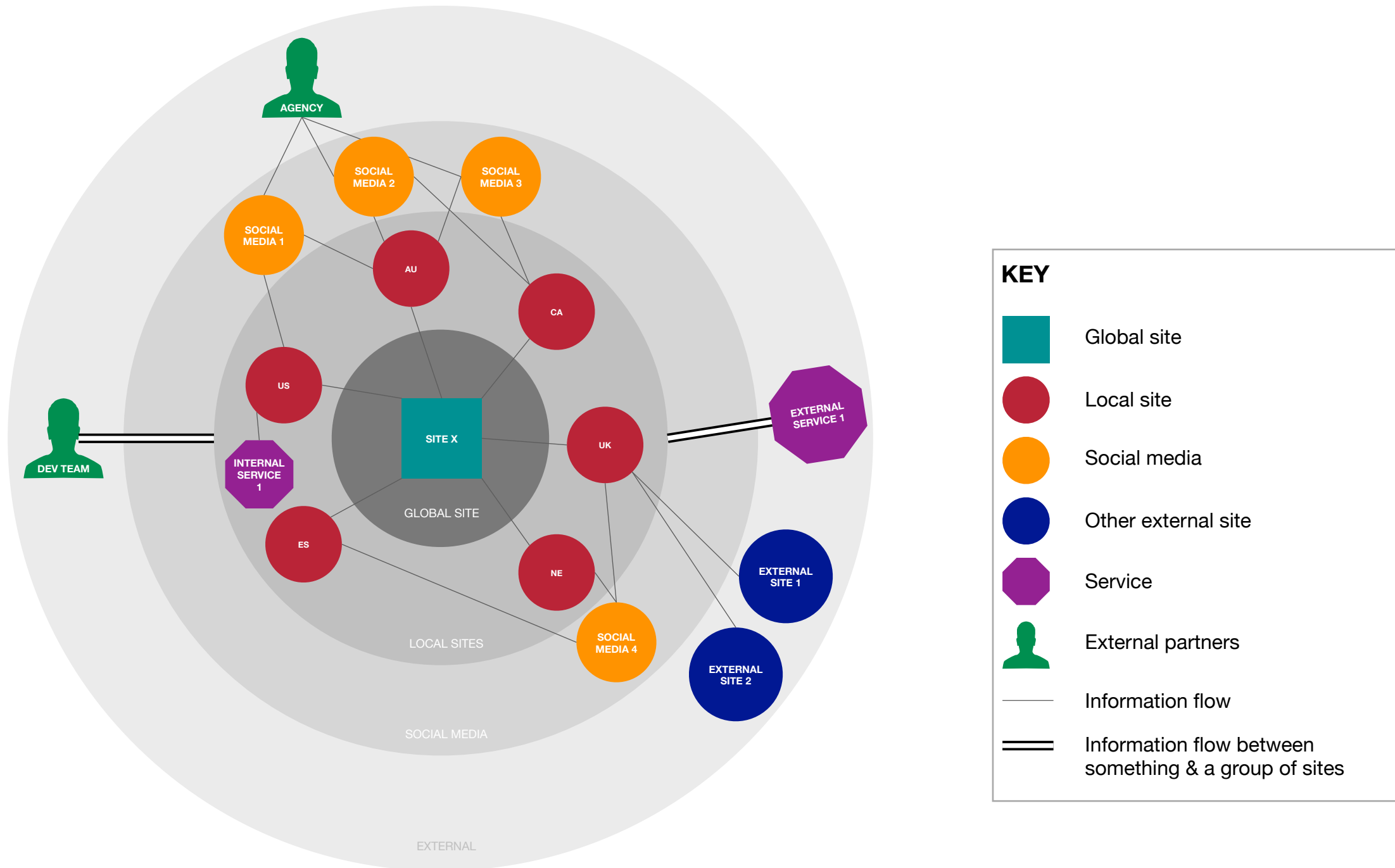
**BEHAVIOURS**

**TOOLS**

- In house tools (ATLAS, Team-X, Aerospace CDC), DOORS,
- Improvement - Ability to transition levels of details without full rebuild of work
- Power Point, Word,
- Improvement: Direct transition of information from models to presentation materials without manual re-entry.

**3D VISUALIZATION**

Somewhat to very depending on the tasks. Very useful for Attitude and power profiling. Useful for presentations and sales.



## DESIGN

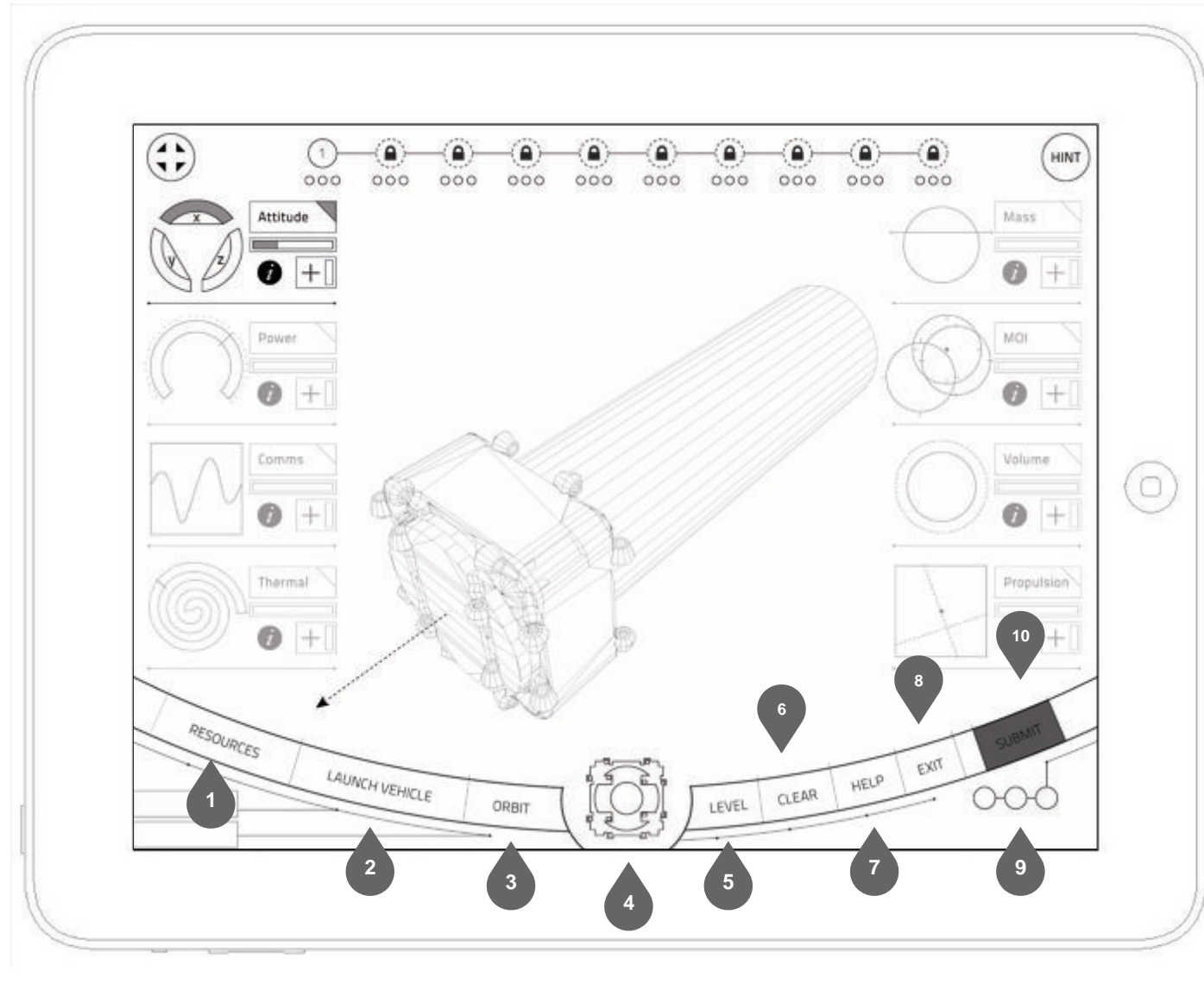
Our design process entails:

- Wireframing
- Design
- Prototyping



### 1.3 Persistent Workshop Navigation

This page calls out the workshop's persistent onscreen navigation. The bottom curved navigation bar contains primary game play controls and are available through all aspects of the workshop.

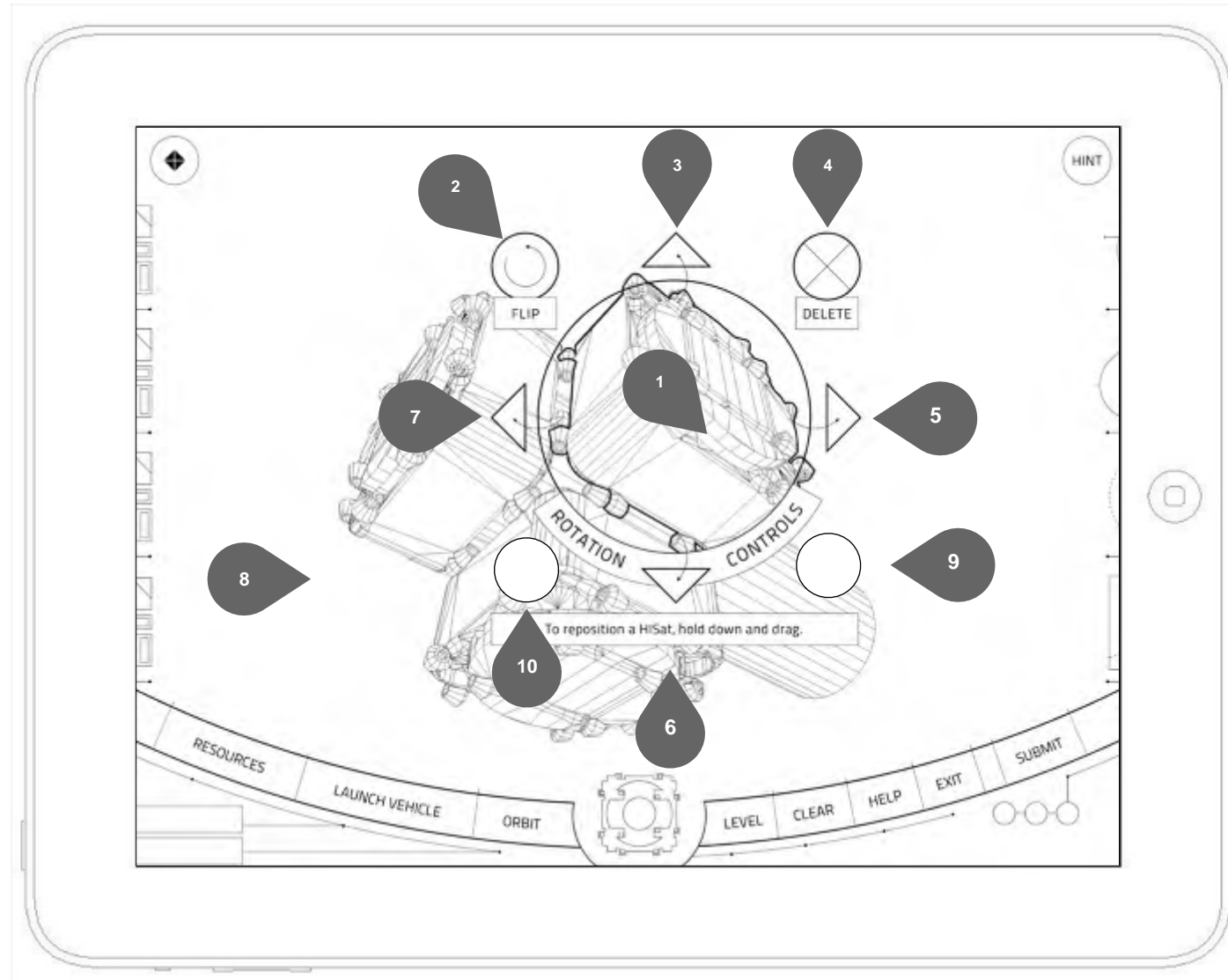


- 1 Tapping option displays available resources in a submenu (See detail 1.18). Note: Resources will be contextual based on exercise requirements. Based on exercise, option may be unavailable and button will be greyed out.
- 2 Tapping option displays available launch vehicles in a submenu (See detail 1.16)
- 3 Tapping option displays available orbits in a submenu (See detail 1.17).
- 4 User may tap and drag resources into the workshop environment. Default option is a HISat. If user selects a resource other than a HISat from the resource menu, it will appear here for a timed period, and user may drag it into the workshop environment.
- 5 Tapping level displays the level text overlay. Tapping option again dismisses text. NOTE: If user attempts to navigate away from an exercise in process, a dialogue will be triggered preventing them.

- 6 Tapping clear option triggers a conditional warning. When confirmed, any onscreen geometry is deleted.
- 7 Tapping Help option displays a contextual overlay that describe the GUI. Tapping Help again or anywhere onscreen removes the overlays.
- 8 Tapping Exit saves current state, and the user is returned to the main menu.
- 9 Rating GUI lights up with a rating when a solution has been achieved. Displays 1, 2, or 3 lights based on score.
- 10 Submit option is greyed out until a solution has been achieved. When a solution has been achieved, and the option is tapped, the next exercise is triggered and slides into position.

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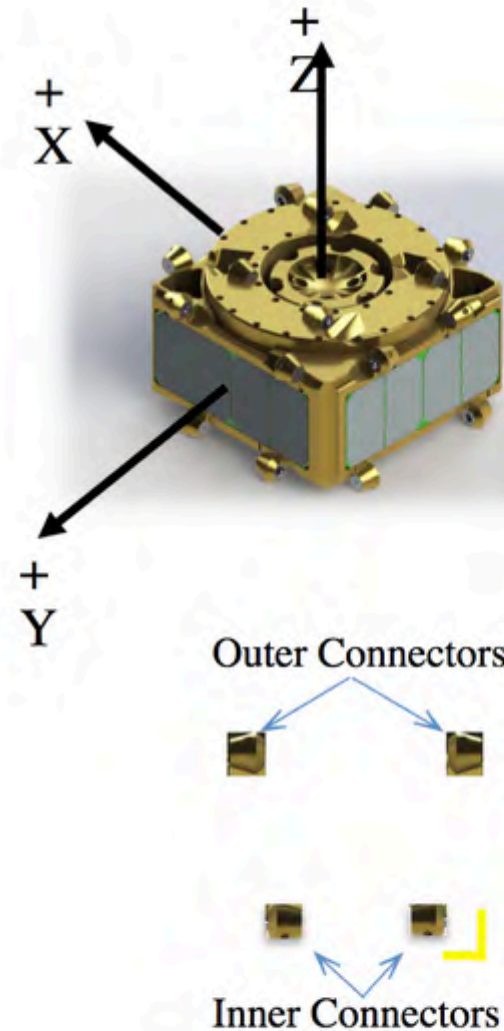


# HISat Coordinate System

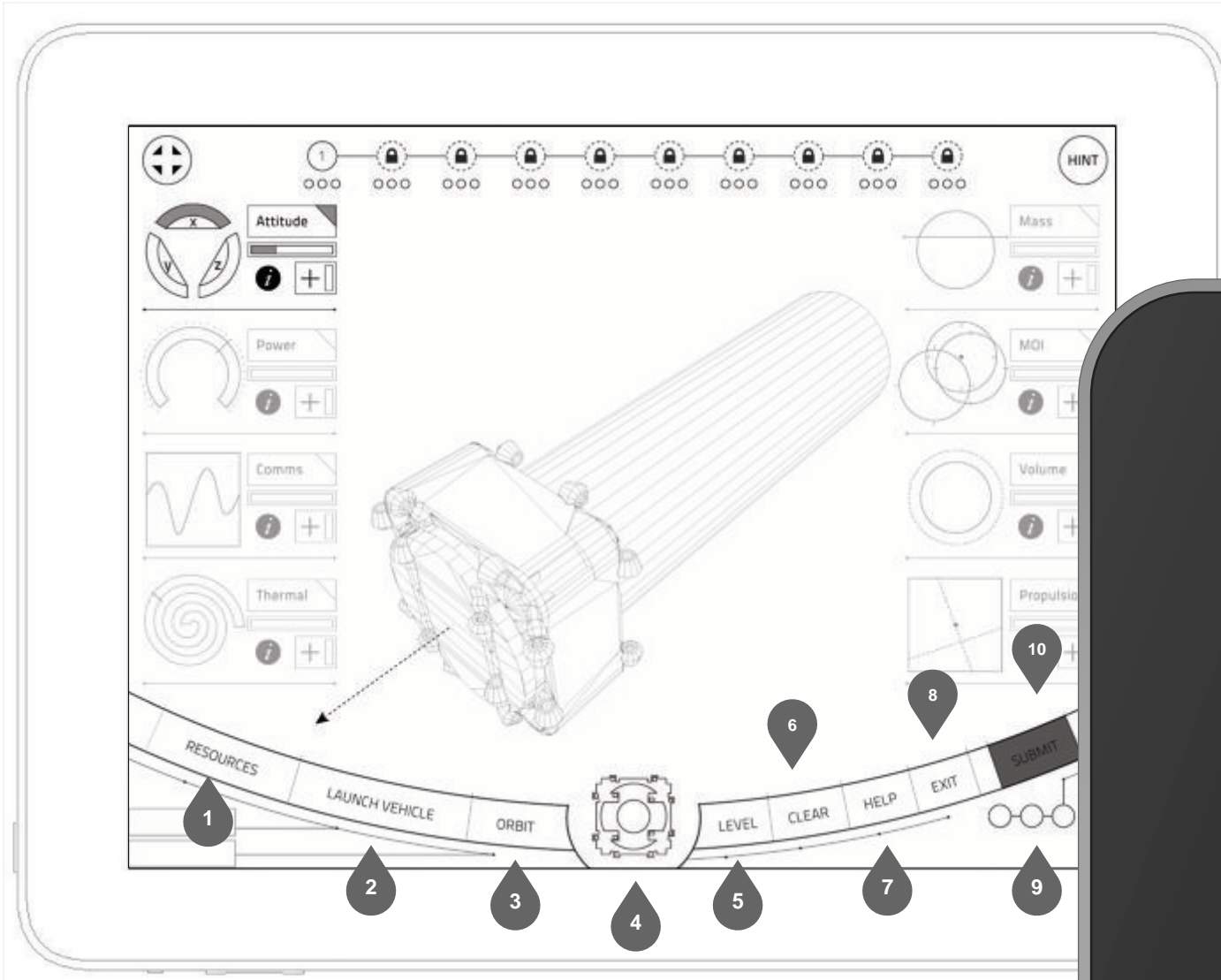


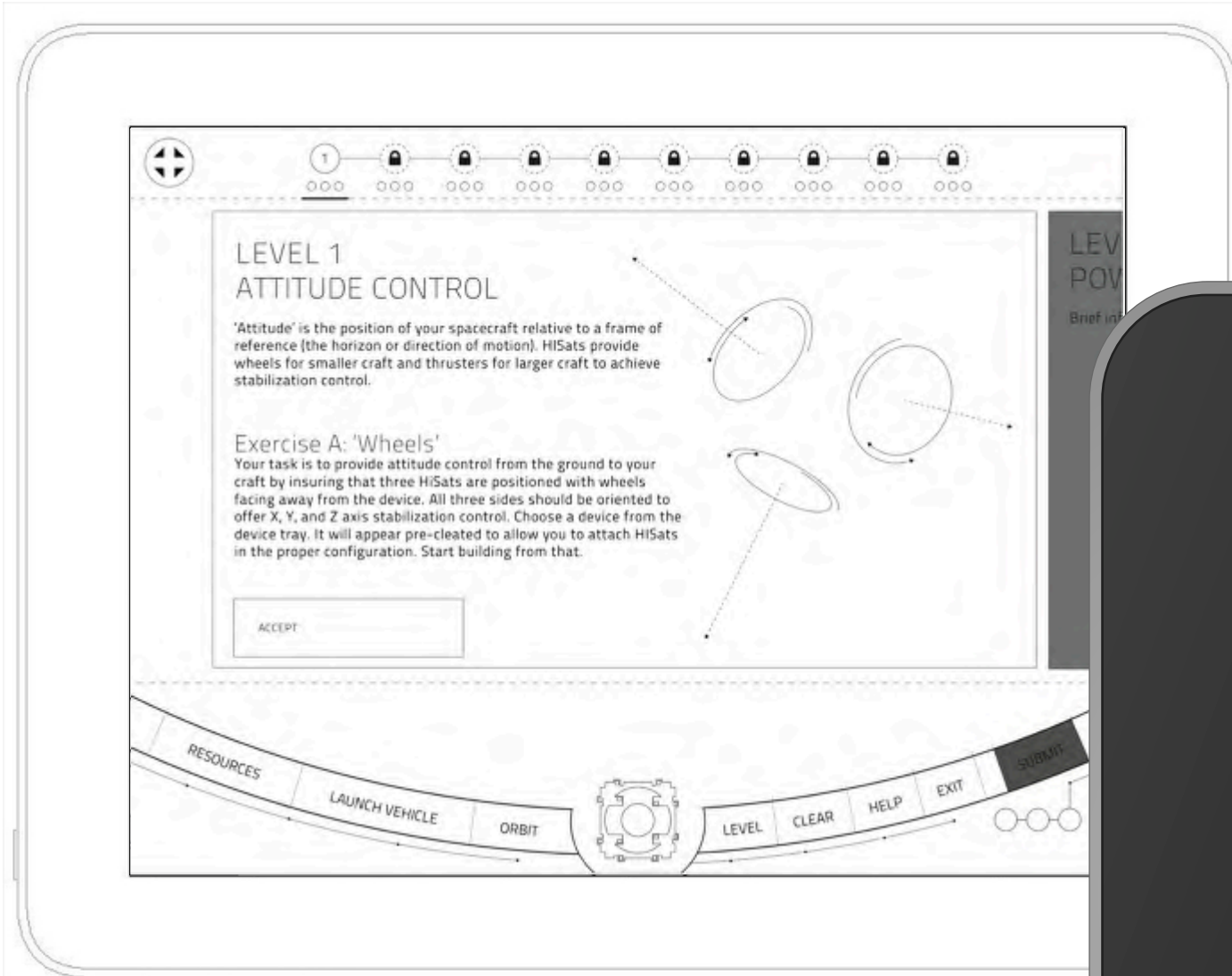
## How the Coordinate System is Defined:

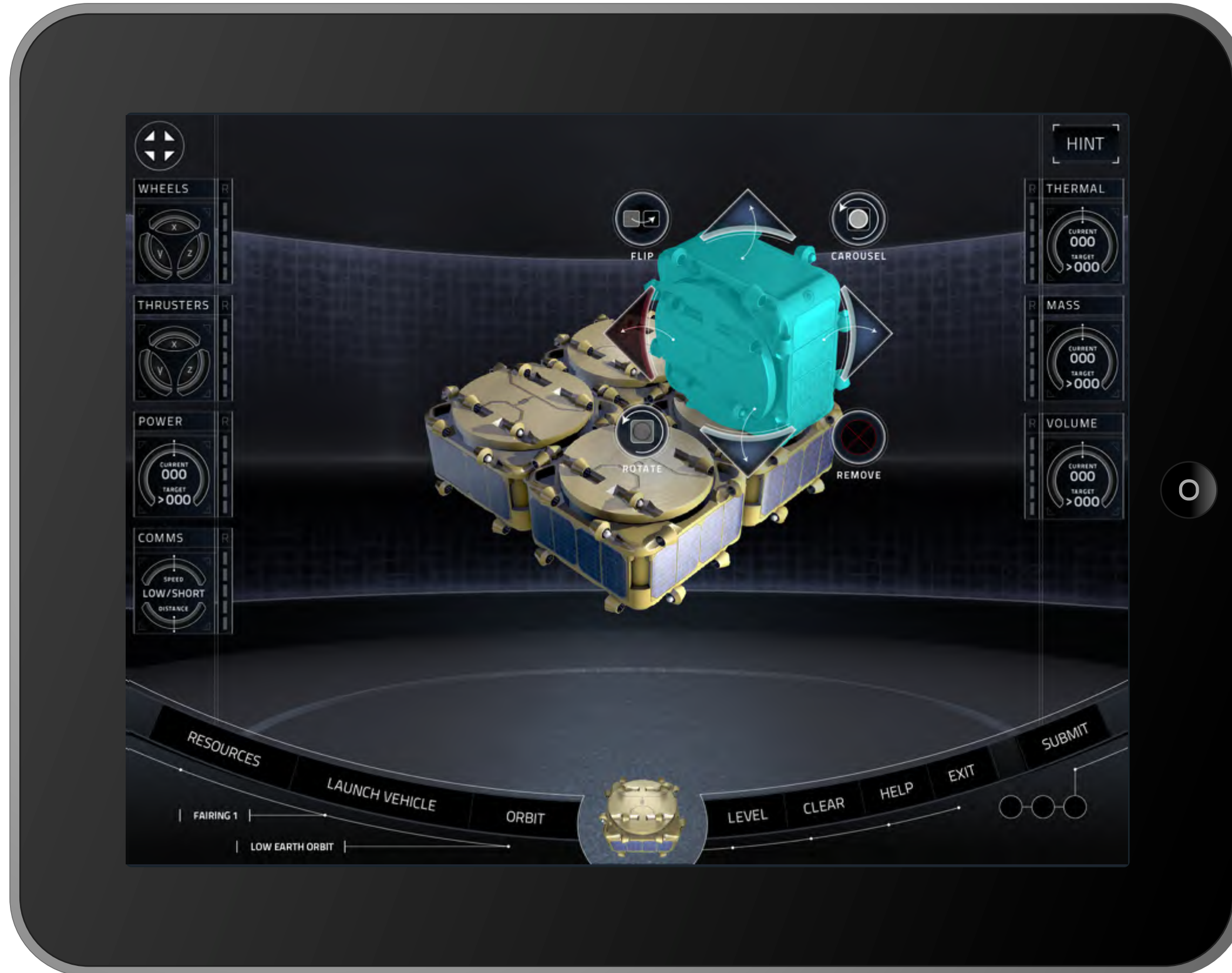
- Orthogonal right-handed system with x-y plane parallel to top and bottom faces of the HISat. Origin is at geometric center of an imaginary square formed by the centerlines of the 8 outer housing connectors.
- +Z axis is in the direction of the carousel side of a HISat
- Looking down the +Z-axis, +X axis is in the direction of a side with two "outer" connectors.
- Looking down the +Z-axis, +Y axis is in the direction of the other side with two "outer" connectors such that a right-handed system is formed.



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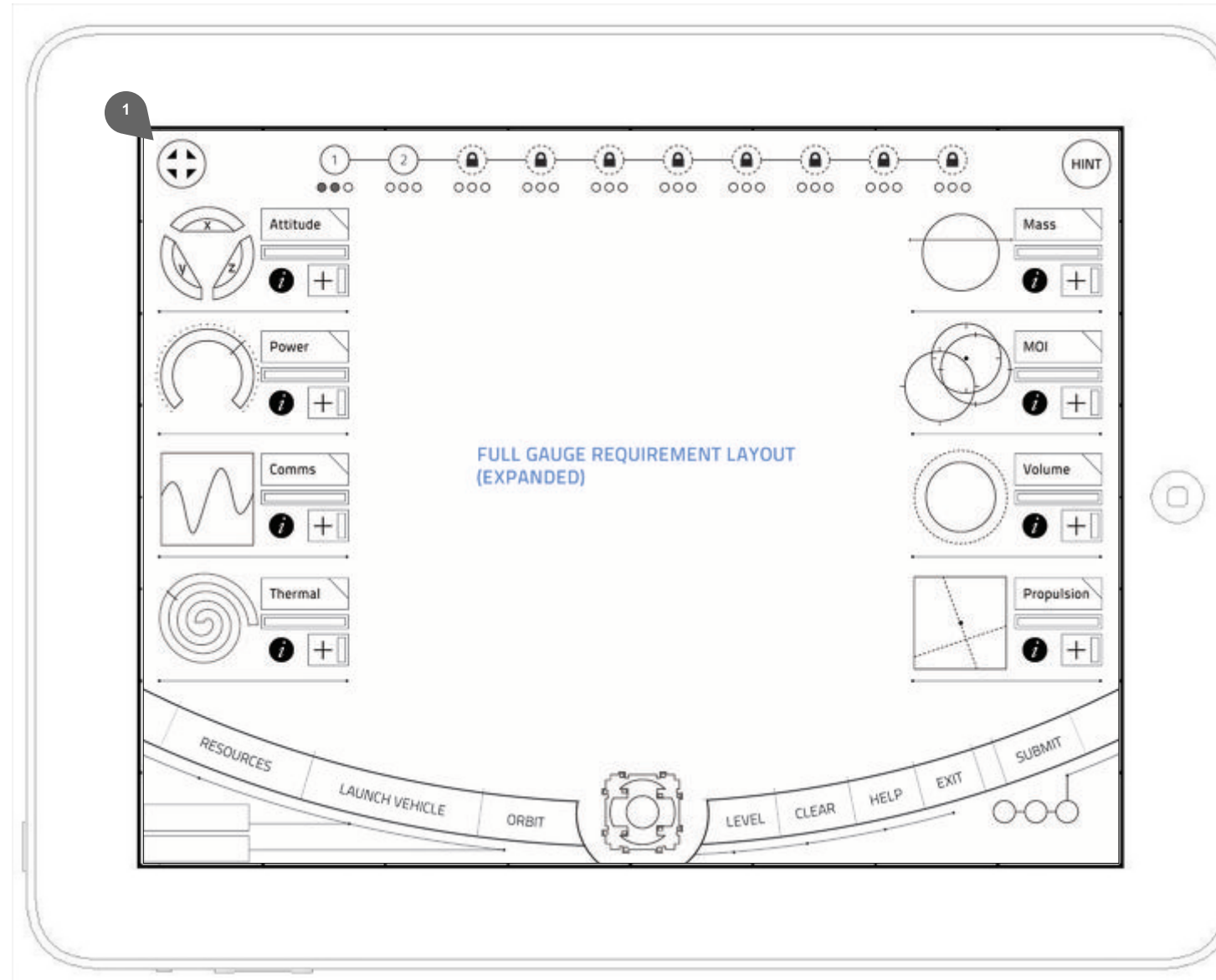


### 1.13 Gauges GUI - Expanded

This detail page displays the gauges GUI in its full and expanded state.

Functional gauges are displayed to the user as needed for each exercise, while the rest of the gauges will be present in a lighter opacity if they are not required. Here, they are each shown as live gauges.

Tapping the icon in the upper left will expand and hide the GUI.



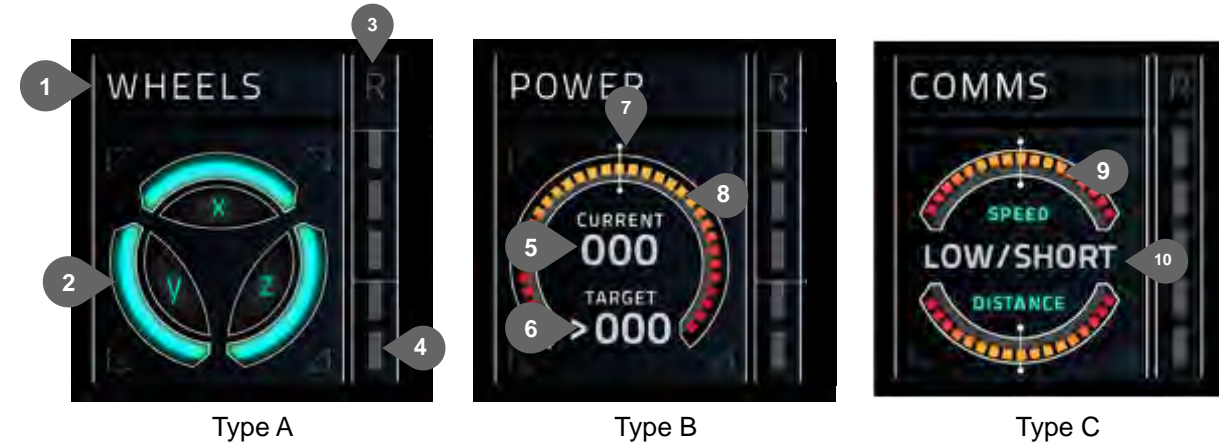
1 Onscreen toggle in current state denotes the expanded layout of gauges. Tapping toggle will contract the gauges (See detail 1.14)

Gauge Design Mood Images



### 1.15 Gauge Detail View

Each gauge will most often show progress towards completion. In certain cases, a gauge may only display a complete state (as in Communication). Note that the redundancy option will be disabled until redundancy becomes a feature towards the end of the workshop.



- 1 Gauge header denotes it's function
- 2 Gauge type A - A three part gauge for Attitude control. Each third lights up when attitude control has been achieved for that particular axis
- 3 Each gauge has a redundancy component that will light up based on the detection of a redundant component.
- 4 The dotted grey line will light up when redundancy has been achieved.
- 5 Gauge type B - The numerical value is live and updatable and displays a current percentage value towards fulfilling the target requirement.
- 6 The numerical value displays the target requirement. NOTE: Target requirement can update based on detected devices.
- 7 Threshold line denotes achievement of the target requirement.
- 8 Color gradient fills in clockwise and represents percentage of target requirement achieved.
- 9 Type C Gauge - Two part gauge - color gradient fills in left to right and represents percentage of target requirement achieved independently for each property.
- 10 Type C Descriptor - changes based on type of Comms package selected.
- 11 Threshold achieved detail: When threshold has been achieved - All gauges light up full to denote success. (See p.19)
- 12 Redundancy detail: When analytics detects the gauge has a redundant system, the dotted row and letter light up.

## BUILD

In the case of DARPA and NovaWurks, the CDI team built the application using agile methodologies.



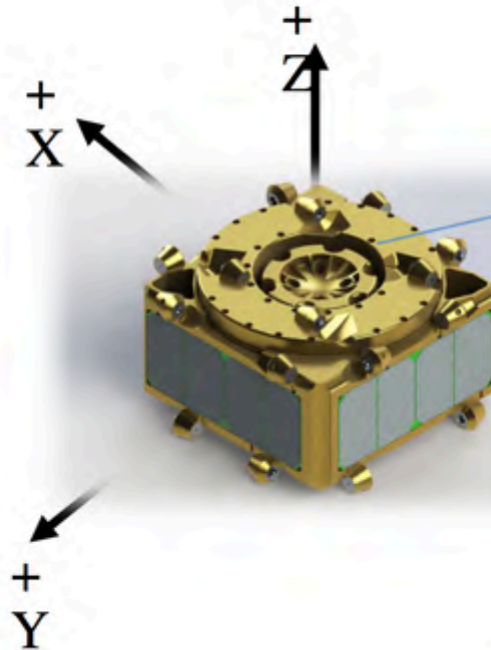
# Connector Layout Summary



Connectors are completely identified by a 4-letter designator.

**KEY:**

- |             |            |
|-------------|------------|
| P: Positive | S: Slave   |
| N: Negative | G: Ground  |
| M: Master   | V: Voltage |



PXS G V

PXM G V

PYS G V

PYM G V

NXM Y G

NXS V G

PZS G

PZM G

PZS V

PZM V

NYM V G

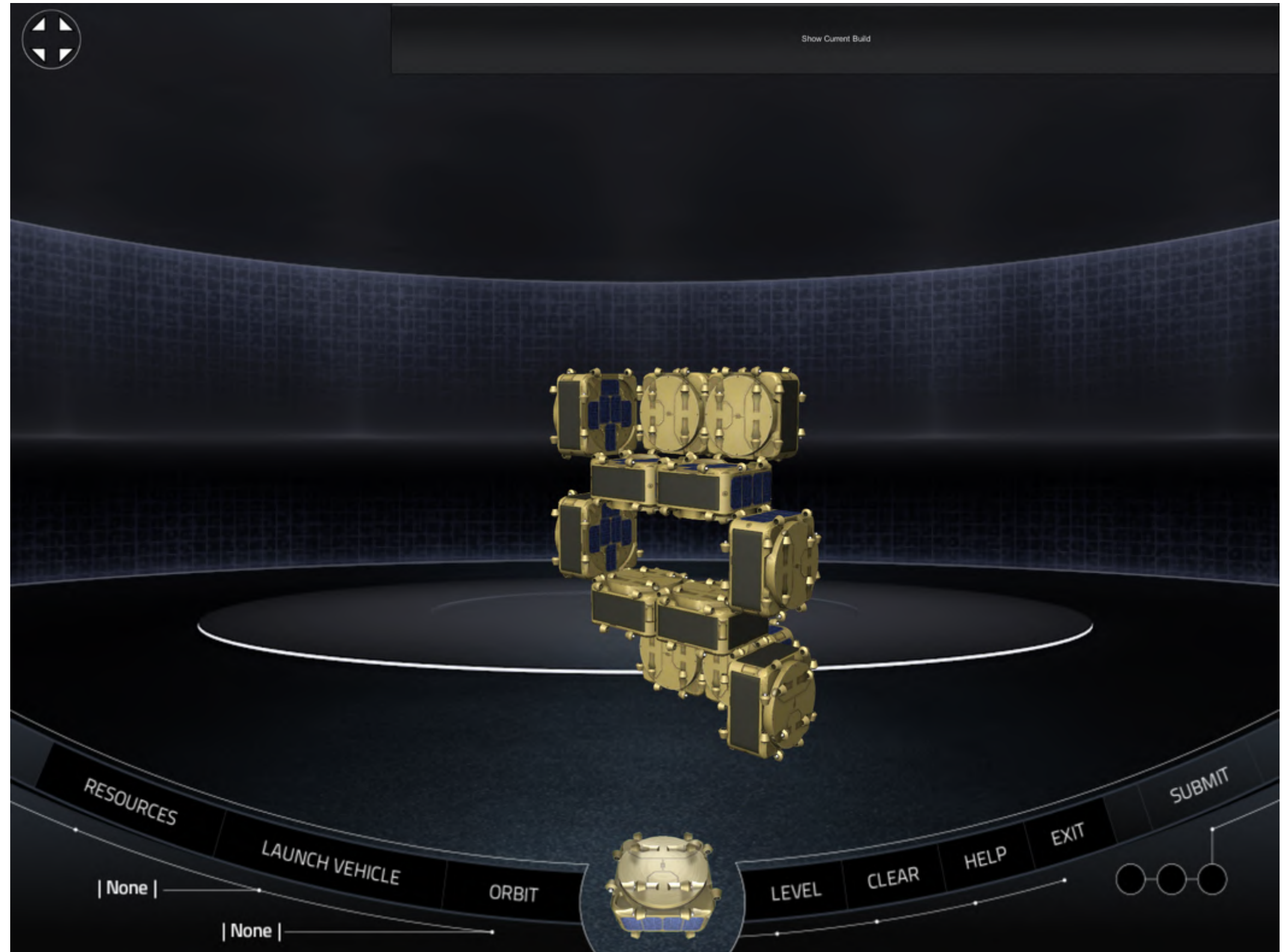
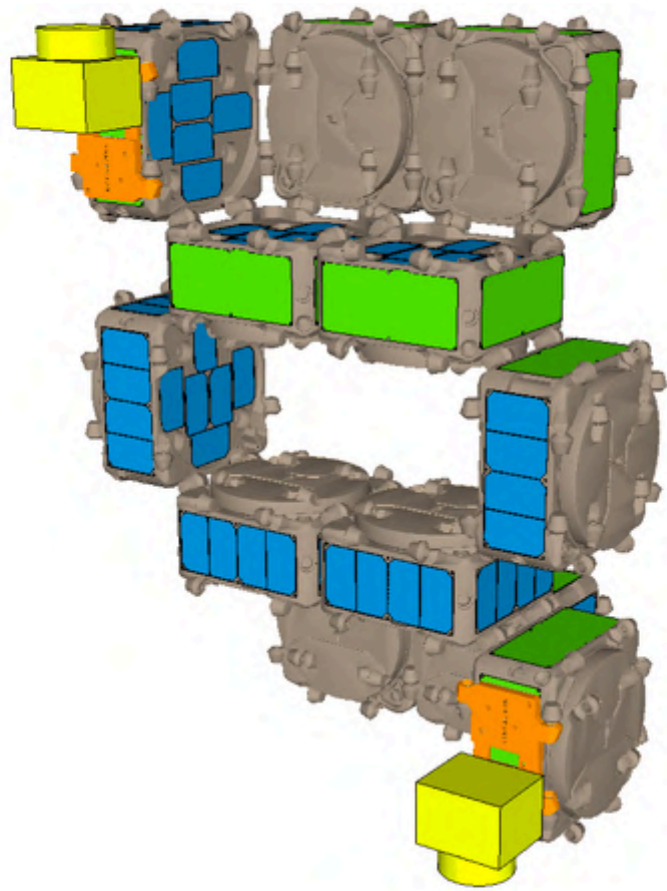
NYS V G

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User Story Macro	US number	US Title	US Description	Acceptance Criteria
Initialize workshop	001	Select Workshop (ART)	As a user, I want to select the Chapter 4 workshop so I may take it.	<ul style="list-style-type: none"> <li>• Modify existing floating menu text to read 'NovaWurks HISat Workshop'</li> <li>• Display top menu in initial state (002)</li> </ul>
		Select Workshop (PROG)		<ul style="list-style-type: none"> <li>• When tapped, play sound effect</li> <li>• Display top menu in initial state (002)</li> <li>• Initialize the game</li> </ul>
	002	Start workshop (ART)	As a first time user, I want to start the workshop.	<ul style="list-style-type: none"> <li>• Top menu (initial state) loads (UI)</li> <li>• Menu Layout for Unlocked exercise, intro video, initial state</li> </ul>
		Start workshop (PROG)		<ul style="list-style-type: none"> <li>• Top menu (initial state) loads (PROG)</li> <li>• If first time user, display initial text/button state 'TAKE WORKSHOP'</li> <li>• Tapping button option initializes workshop and launches intro video</li> <li>• When intro video completes, first exercise is unlocked and displayed</li> </ul>
	003	Continue workshop (ART)	As a returning user I want to continue from where I left off.	<ul style="list-style-type: none"> <li>• If returning user, load top menu - returning state (UI)</li> </ul>
		Continue workshop (PROG)		<ul style="list-style-type: none"> <li>• If returning user, load top menu - returning state (PROG)</li> <li>• If returning user elects to continue, and taps continue option, then last saved state is opened and displayed</li> <li>• Implementation of levels has to be complete for this</li> </ul>
	004	Retake workshop (ART)	As a returning user, I want to start from the beginning and retake the workshop.	<ul style="list-style-type: none"> <li>• If returning user, load top menu - returning state (UI)</li> <li>- Returning state should already be done from 003</li> <li>• Warning 'Are you sure? Y/N?'</li> </ul>
		Retake workshop (PROG)		<ul style="list-style-type: none"> <li>• If returning user, load top menu - returning state (PROG)</li> <li>- Returning state should already be done from 003</li> <li>• If returning user elects to retake, and taps retake option, then workshop is reinitialized and first exercise is displayed</li> <li>- If workshop in progress and user elects to retake workshop, first issue a warning: 'Are you sure? Y/N?'</li> </ul>
Persistent Bottom Navigation bar	005	Resource tray - selecting and using a device (ART)	Resource tray - selecting and using a device	<ul style="list-style-type: none"> <li>• Tap resource button in bottom navigation bar</li> <li>- Check against final design for visual strategy</li> <li>• Tapping an available submenu opens an additional tray with device options. (ART)</li> </ul>
		Resource tray - selecting and using a device (PROG)		<ul style="list-style-type: none"> <li>• Tap resource button in bottom navigation bar</li> <li>- General sub-menu animates out</li> <li>- Available options are displayed 'full color'</li> <li>- Unavailable options are 'greyed out'</li> <li>- Check against final design for visual strategy</li> <li>• Tapping an available submenu opens an additional tray with device options. (PROG)</li> <li>• Tapping a device temporarily adds it to the center position of the bottom navigation tray</li> <li>• Once in the center position, the user can tap and drag it into the workshop environment</li> <li>• If Launch Vehicle, Orbit, Help, Level text are on screen, triggering the resource tray will cause all other overlays to be removed.</li> <li>• There are exercises where the user may not select a resource. In this case, the option will be 'greyed out' and non-functional</li> </ul>
	006	Launch Vehicle tray - choosing and selecting a launch vehicle (ART)	As a participant, I want to choose a launch vehicle and have it considered as part of my mission parameters	<ul style="list-style-type: none"> <li>• Tap Launch Vehicle button in bottom navigation bar</li> <li>- Check against final design for visual strategy</li> </ul>
		Launch Vehicle tray - choosing and selecting a launch vehicle (PROG)		<ul style="list-style-type: none"> <li>• Tap Launch Vehicle button in bottom navigation bar</li> <li>- Sub-menu animates out</li> <li>- Available options are displayed 'full color'</li> <li>- Unavailable options are 'greyed out'</li> <li>- Some code should be re-useable from 005</li> <li>- Check against final design for visual strategy</li> <li>• If Resource, Orbit, Help, Level text are on screen, triggering the Launch Vehicle tray will cause all other overlays to be removed.</li> <li>- Can re-use code from 005</li> <li>• There are exercises where the user may not select a Launch Vehicle. In this case, the option will be 'greyed out' and non-functional</li> </ul>

Issue type	Number	Summary	Priority	Status	Description	Notes
Bug	1	Devices are able to make illegal connections	Critical	CLOSED / fixed / verified	<p>Steps to reproduce</p> <ol style="list-style-type: none"> <li>1. To reproduce, start with a HISat as the parent object.</li> <li>2. Drag solar arrays onto all four sides. Two of these solar arrays will be oriented correctly with the master connectors mating to corresponding slave connectors. However, on two sides, the master connectors of the solar array cleat sit on top of the master connectors of the HISat (the same is true for the slave connectors).</li> <li>3. The fix for this issue would be to rotate the solar array 180 degrees along its long axis (Z axis) when it is attached.</li> </ol> <p>Expected: Master should never connect to Master and Slave should never connect to Slave</p>	iPad 2 w/ iOS 8.1.1
Bug	2	Position of parent object is not 0,0,0	Critical	CLOSED - Fixed / verified	<p>The position reported for the parent object (1st HISat) appears not to be referenced to center at (0,0,0). Since the origin of the HISat is at the geometric center of the box (minus the added carousel height), we believe that the position should at least have zero values for the x and y components of position. Since these values are non-zero, we would like to know why and also the location of the origin of the workspace. This may be a non-issue if the entire build is referenced to this point, but could be an issue if the origin of the HISat is not what was described in the Anatomy of a HISat document.</p> <p>To reproduce, drag a single HISat into the workspace and then show the current build's JSON data.</p>	iPad 2 w/ iOS 8.1.1
Bug	3	HISats cannot stack correctly	Critical	CLOSED / fixed / verified	<p>A user cannot stack HISats correctly. Currently, HISats only attach carousel-to-carousel (4 connection points) or side-to-carousel (4 connection points). If the user flips the HISat over, they can connect bottom-to-top (8 connection points). However, additional HISats cannot be added to the top of the stack, nor can a HISat be connected to the bottom of the stack in the same carousel-up orientation. In addition, the user should be able to connect devices to the carousel of the HISat on top of the stack (valid connection), but instead the user is only able to connect devices to the carousel of the bottom HISat that is covered (invalid connection).</p> <p>Steps to reproduce</p> <ol style="list-style-type: none"> <li>1. To reproduce, start with a single HISat.</li> <li>2. Add a second HISat to the carousel of the first. Flip the top HISat over using the top left button so they are in a stack.</li> <li>3. Now try to add a third HISat to the top of the stack. The user cannot.</li> <li>4. However, the app will allow the user to attach a third HISat to the carousel of the first (bottom) HISat, which is an invalid connection (this is tricky, but can be done). Finally, try to add the third HISat to the bottom of the stack. It will connect, but the carousel is not oriented in the same way as the rest of the HISat carousels in the stack. The user cannot flip this object over to line up all three carousels in the same orientation.</li> </ol> <p>Consistent issue for stacking, Inconsistent (or tricky) to attach the third HISat to the carousel of the first.</p>	iPad 2 w/ iOS 8.1.1
Bug	4	HISat cannot attach to the bottom of another HISat	Critical	CLOSED / fixed / verified	<p>1. In general, the user cannot attach HISats to the bottom of another HISat using the 8 edge connectors. This is true unless the user is building in a stack where every HISat's orientation is flipped in comparison to the ones mating to it.</p> <p>Steps to reproduce</p> <ol style="list-style-type: none"> <li>1. To reproduce, start with a single HISat.</li> <li>2. Drag a second HISat into the workshop and note that it can attach to all 6 sides of the parent object.</li> <li>3. If the user attaches the second HISat to the side of the first HISat, the user will no longer be able to attach to the bottom of either HISat. If however, the user attaches the second HISat to the top or bottom of the first, the second HISat will attach and have its carousel oriented opposite of the parent HISat.</li> <li>4. The user can in this fashion create a stack of HISats mated carousel-to-carousel and bottom-to-bottom. Consistent issue</li> </ol>	iPad 2 w/ iOS 8.1.1
Bug	5	HISats cannot attach edge to edge, only complete sides	Critical	CLOSED / Fixed / Verified	<p>Steps to reproduce</p> <ol style="list-style-type: none"> <li>1. To reproduce, start with two HISats mated side-by-side.</li> <li>2. Rotate the second HISat by 90 degrees so that the two form an L.</li> <li>3. Now flip the second HISat over using the button in the top left corner. Now it is possible to add a third HISat to the side of the HISats where the connection was made (in actuality, this is an invalid connection because there are only two free connectors, not the four required for a side connection). Now rotate this third HISat so that the three together form a T shape. It is now impossible to connect a HISat to the other three to form a + shape using two connectors from each of the first and third HISats.</li> </ol>	iPad 2 w/ iOS 8.1.1
Bug	6	Wrapping devices in HISats is currently not possible	Critical	CLOSED / Fixed / Verified	<p>Building a ring around devices for thermal protection is not currently possible. The large RF dish transceiver and the telescopes do not connect in a way that is conducive to wrapping them with HISats.</p> <ol style="list-style-type: none"> <li>1. To reproduce, start with a HISat and connect a large RF dish to one side.</li> <li>2. From the way the dish attaches to the HISat on one edge, it is not possible to wrap the base of the dish with a simple ring.</li> <li>3. The same is true for a telescope as the device.</li> </ol>	iPad 2 w/ iOS 8.1.1
Bug	7	HISat connection issue - Side to carousel issue	Critical	CLOSED / FIXED / Verified	<p>Steps to reproduce</p> <ol style="list-style-type: none"> <li>1. To reproduce, start with a HISat.</li> <li>2. Rotate the carousel on this first HISat 45 degrees.</li> <li>3. Now drag a second HISat into the workshop and attach it to the carousel of the first. The two carousels will be mated.</li> </ol>	iPad 2 w/ iOS 8.1.1

Double Loveseat Configuration





Focus groups conducted at NASA Ames Research Facility



Focus group conducted at NASA Ames Research facility



CDI team provides novel visualization tools utilizing Oculus Rift - where engineers can study space configurations at full scale.



# APPENDIX

Concept Art

'Art of the Possible' Concept Design for TALOS



01



02



03



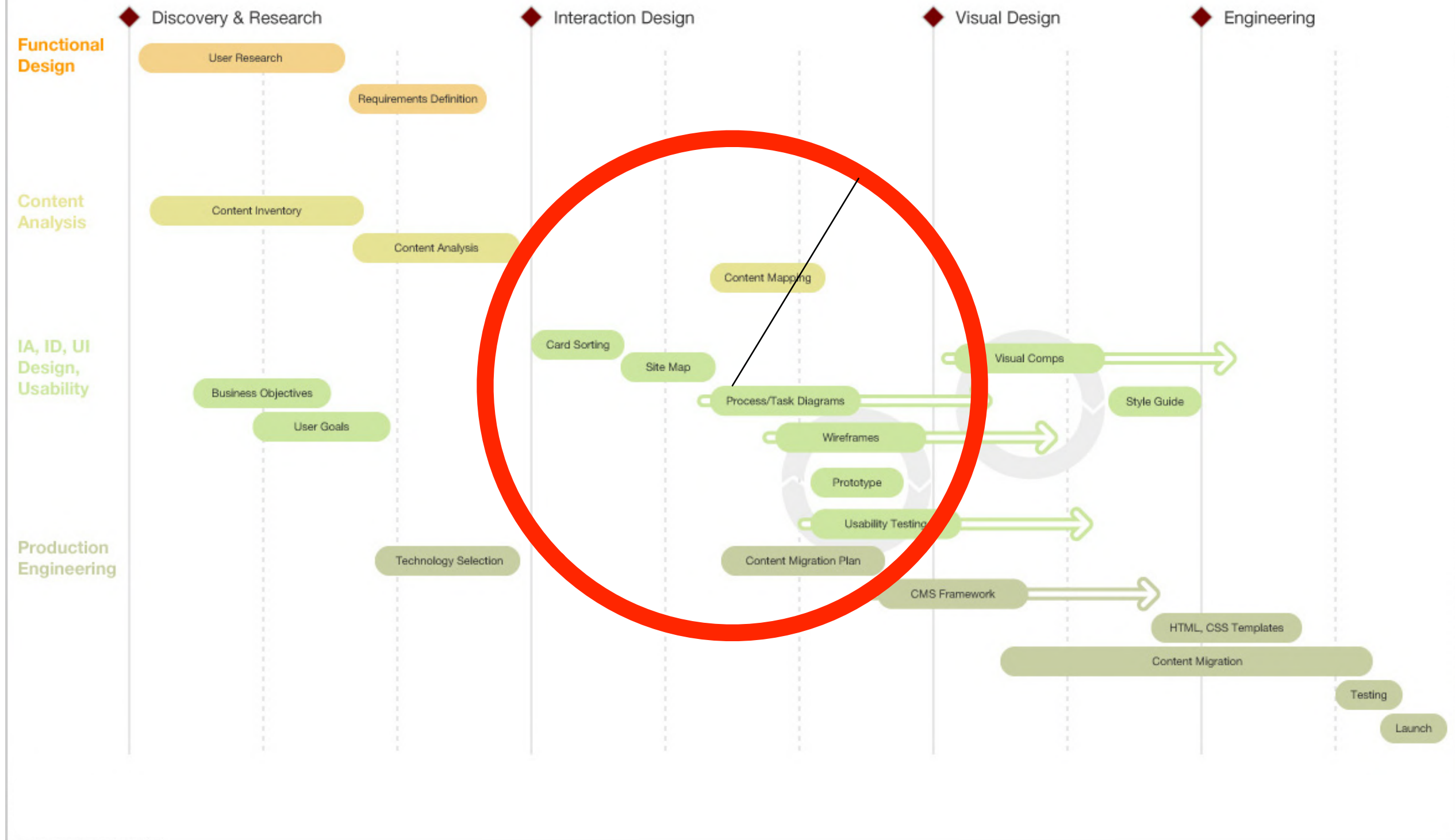
04

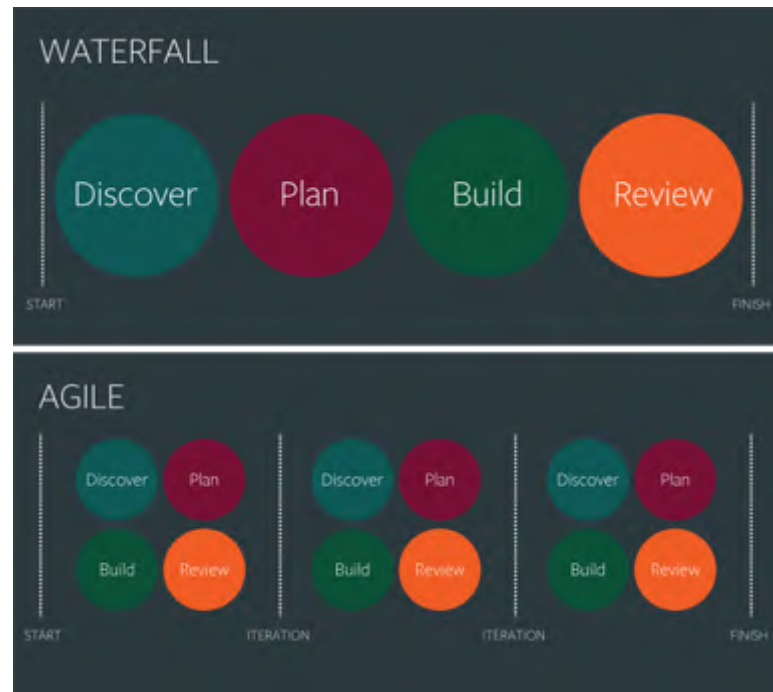


05

## PROCESS & DESIGN FLOW

## Design Process Diagram





## The UX Design process

Agile methodology needs a different design workflow

