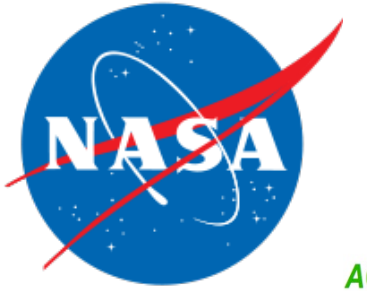
Horizontally Oriented Inflatable Deep Space Habitat

Oklahoma State University



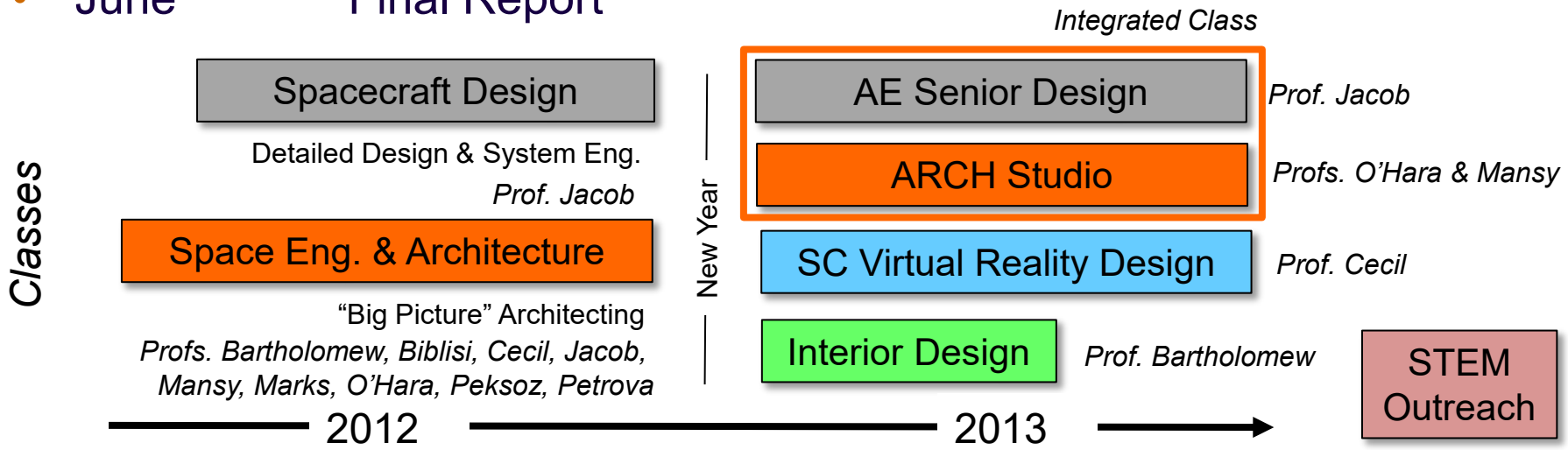
OSU Xhab 2013

OSU XHab Team
School of Mechanical & Aerospace Engineering
Oklahoma State University

Final Report

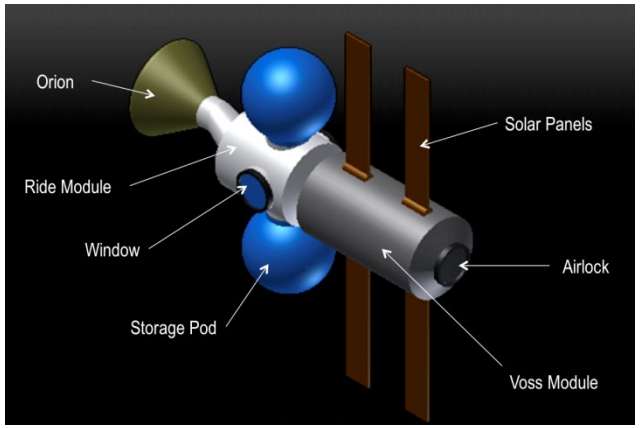
Schedule

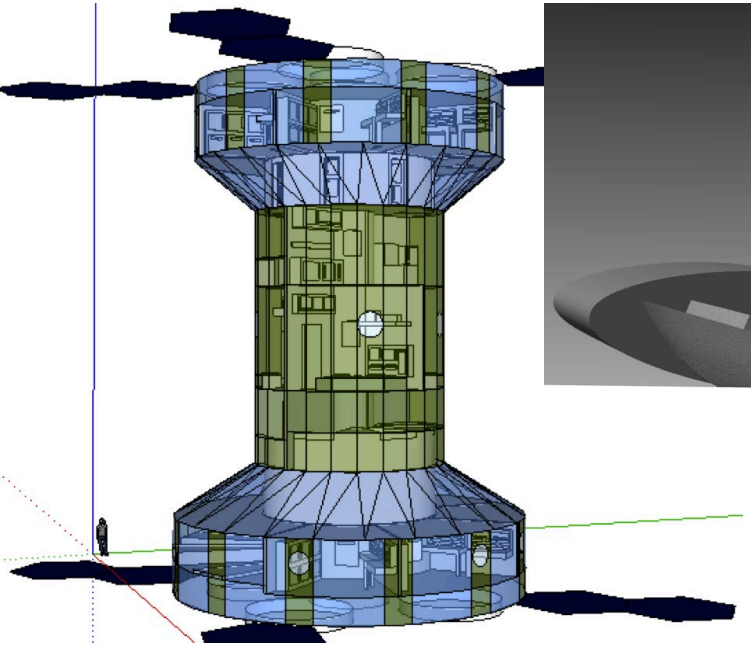
- Aug. 22 Space Engineering & Architecture Kickoff
- Oct. 23 SDR
- Nov. 27 PDR
- Dec. 13 CDR
- Jan. 15 Detailed Design Complete, Start Analog Construction
- Feb. 28 Progress Checkpoint Review 1
- Mar. 28 Progress Checkpoint Review 2
- *March/April* *Visit to NASA MSFC*
- May Demonstration
- June Final Report

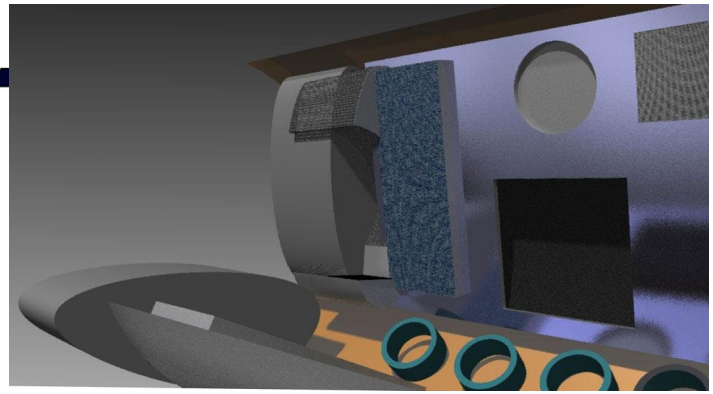


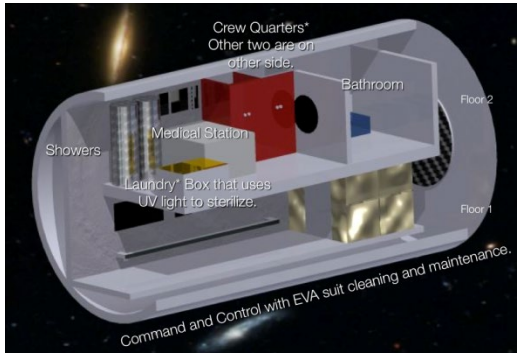
Outreach

- High School Space Habitat Innovation Challenge
- 25 groups involved (~125 students) from NASA INSPIRE and Explorer Schools
- 7 teams submitted proposals; down selected to top 3 – final presentations next week



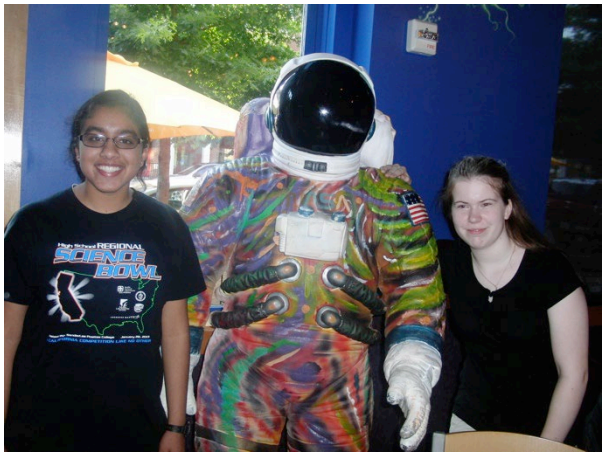






- https://www.youtube.com/watch?v=HHiAezyBI-k

Outreach



- Visit to MSFC in April and June

Spring Team

Team Members

Calvin Brown (Aero/Mech)
Chief Engineer

Kyle Bruggemeyer (Aero/Mech)
Electrical Sys.

Caleb Goulden (Aero/Mech)
Electrical/HVAC Sys.

Aaron Guthridge (Arch)
HVAC Sys.

Ethan Scott (Aero/Mech)
HVAC Sys.

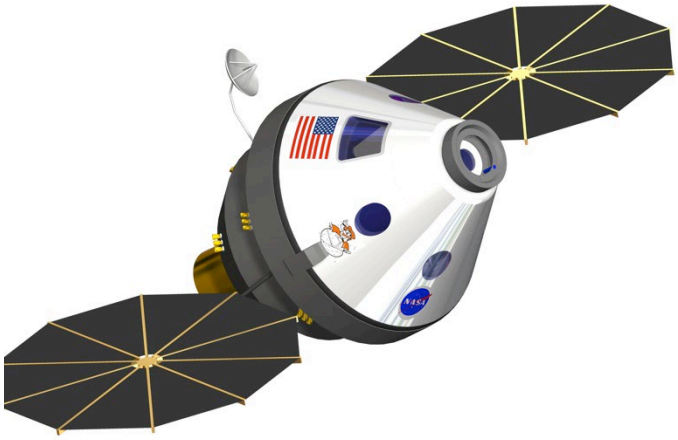
Sam Rose (Aero/Mech)
HVAC Sys.

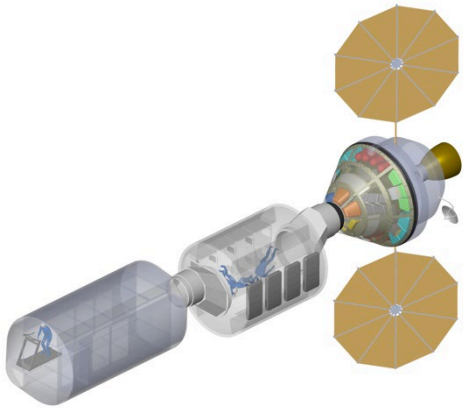
Colt Wilkens (Electrical Eng)
Electrical Sys.

Ben Loh (Aero/Mech)
Virtual Reality/Teaching Assistant

Habitation Functionality

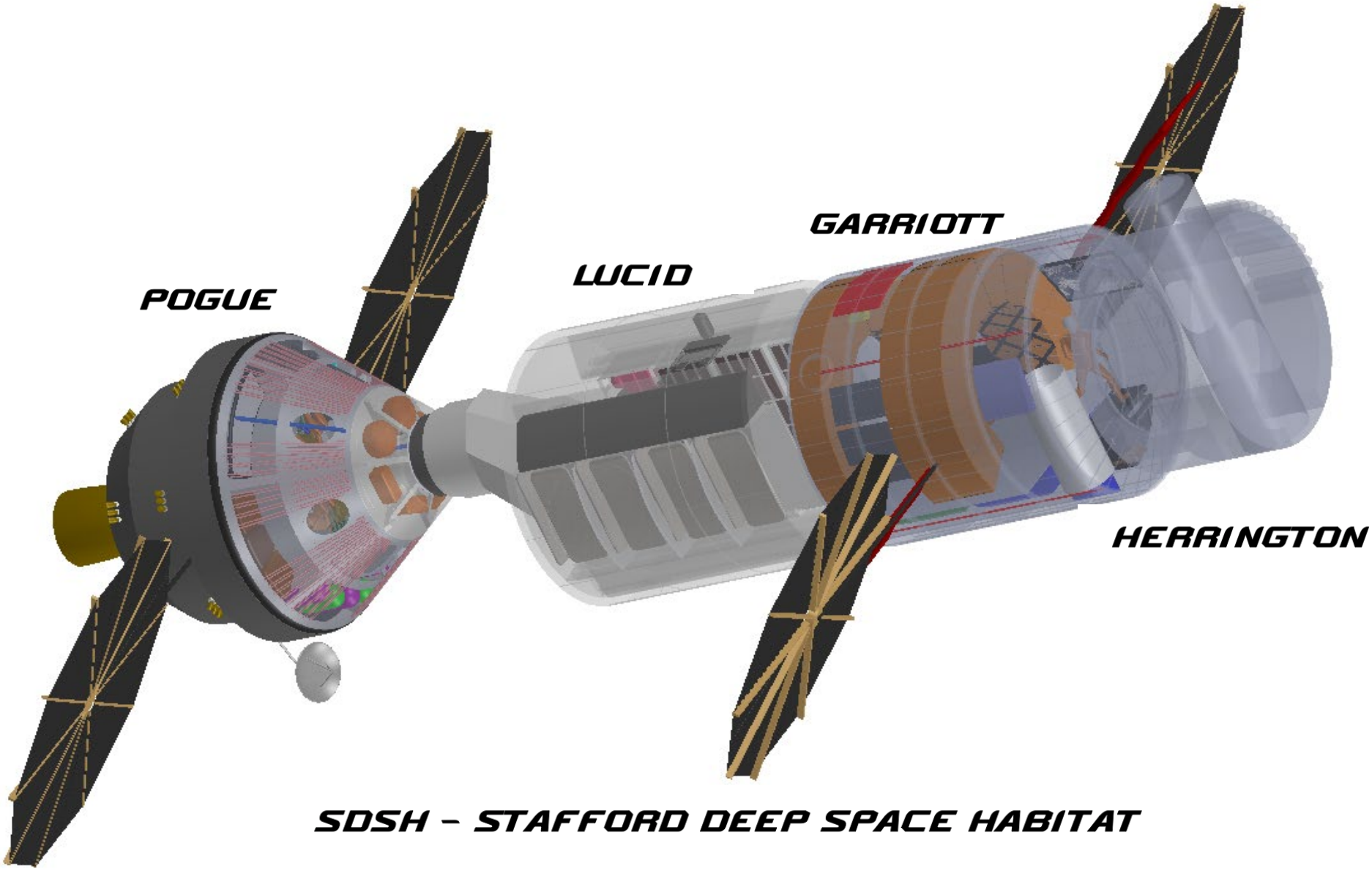
- Provide Living Accommodations for crew members for extended mission duration
  - *4 crews members on 60 day mission at Earth-Moon L2*
- ‘Core module' based on ISS Node 1 with avionics, power and simple air handling only -- will borrow ECLSS life support from the MPCV capsule or the 'augmentation module’
- ‘Augmentation module' based on a Multipurpose Logistics Module with a closed ECLSS (life support system)





STAFFORD DEEP SPACE HABITAT

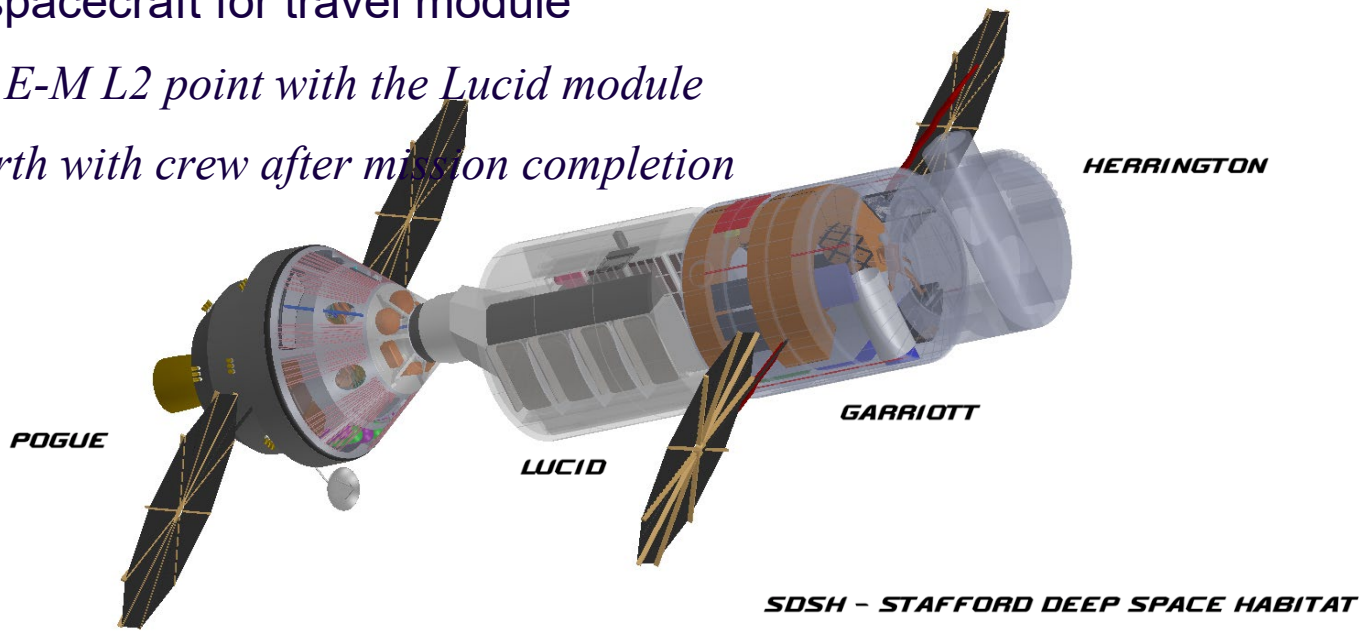
ACADEMIC INNOVATION CHALLENGE



SDSH – STAFFORD DEEP SPACE HABITAT

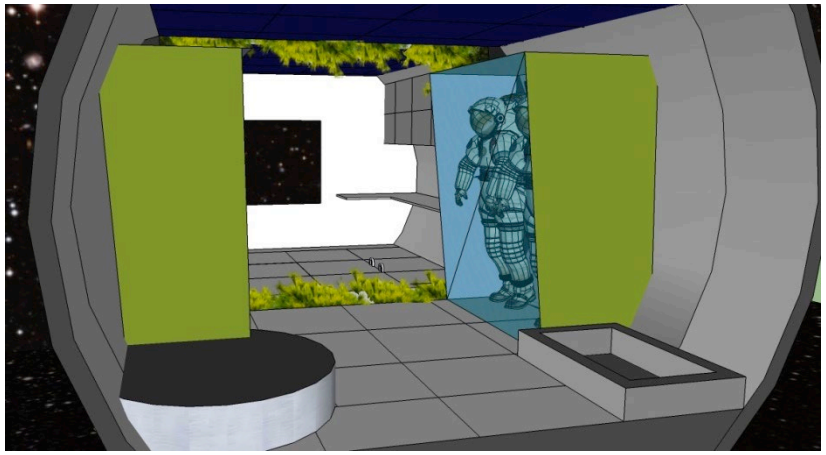
Concept

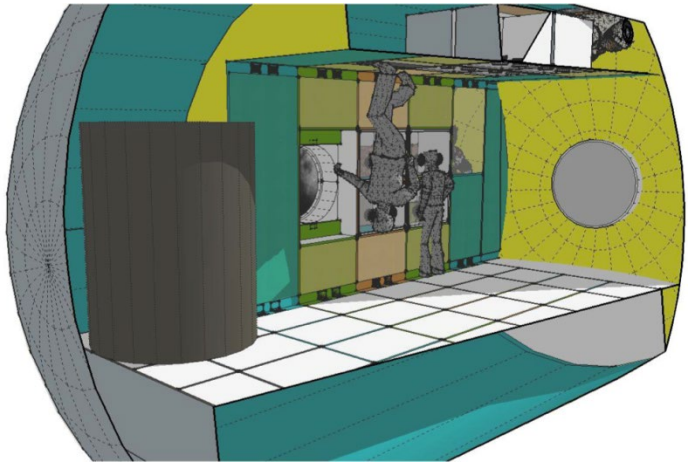
- Lucid (Node 1) as the living module
  - *This will contain the galley and all sleeping quarters*
  - *It will be attached to Pogue during transit*
  - *Left at E-M L2 with Garriott*
- Garriott (MPLM) for labs and equipment
  - *Contains separate life support system for extended use*
  - *Stays at E-M L2 with Lucid module*
- Pogue (MPCV) spacecraft for travel module
  - *Travels to the E-M L2 point with the Lucid module*
  - *Returns to Earth with crew after mission completion*



Interior Design

- Interior design presentations on Feb. 5
- Focus on overall interior design concepts for Node 1 and MPLM

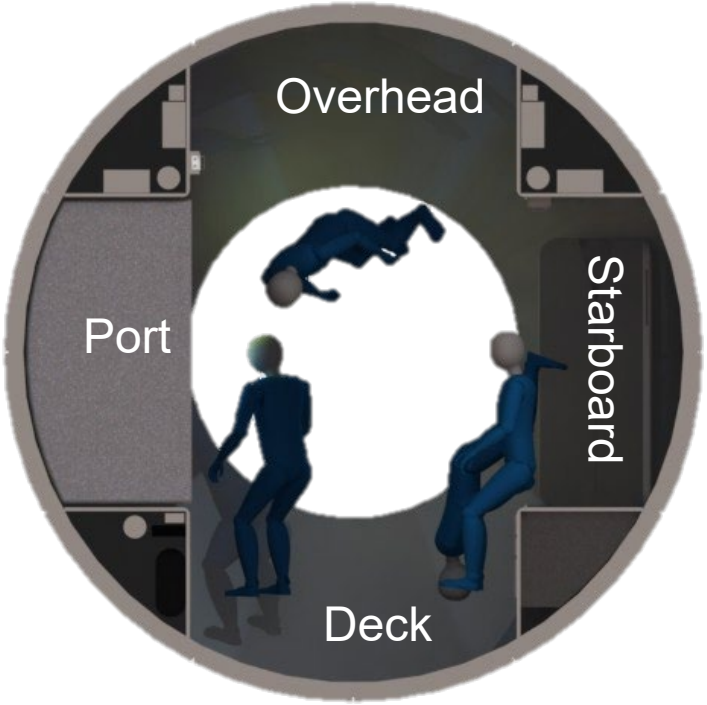




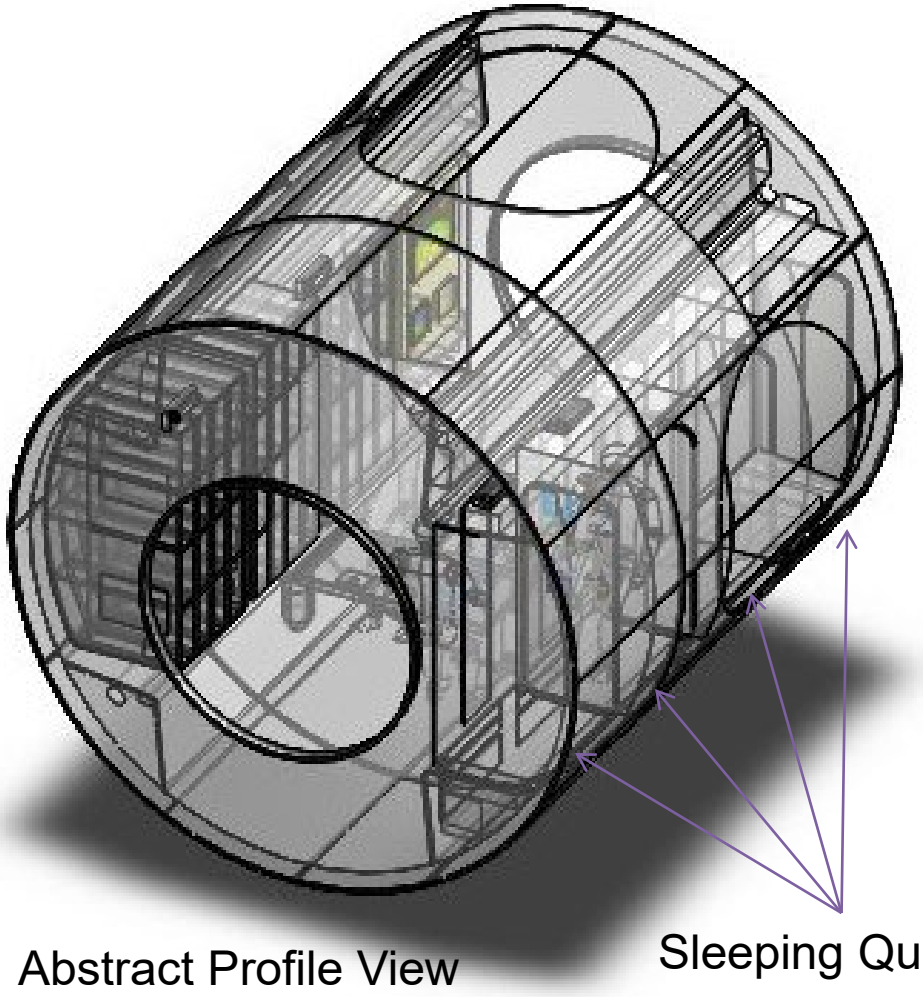
- Individual presentations can be viewed at the links below:
  - http://ra.okstate.edu/STW_HES/NASA_Presentations/Atlas/video.html
  - http://ra.okstate.edu/STW_HES/NASA_Presentations/Group4/video.html
  - http://ra.okstate.edu/STW_HES/NASA_Presentations/Luna/video.html
  - http://ra.okstate.edu/STW_HES/NASA_Presentations/Rhea/video.html
  - http://ra.okstate.edu/STW_HES/NASA_Presentations/Group3/video.html

Node 1 (Original Design)

OSU Xhab's Node 1



Front Plane View



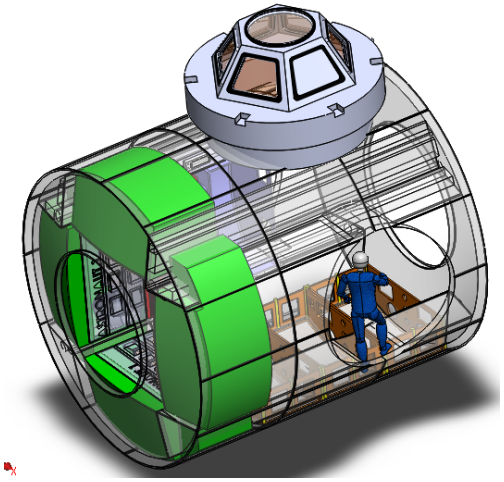
Abstract Profile View

Sleeping Quarter

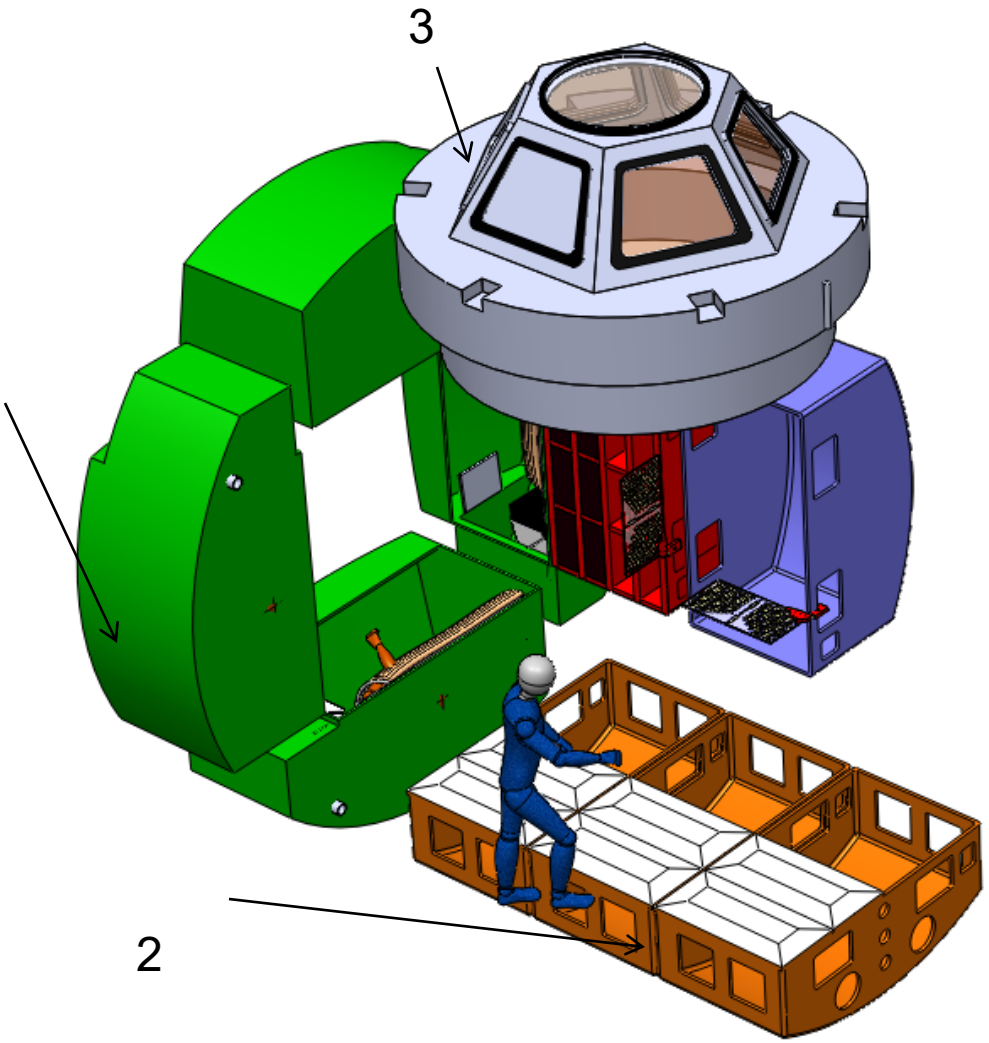
Team Node 1 (Overview)

Goal: Enhance OSU Xhab's components in Node 1 and create virtual environment to simulate astronaut's activities

1. Sleeping Quarter
2. Floor Storage Rack
3. Added Cupola



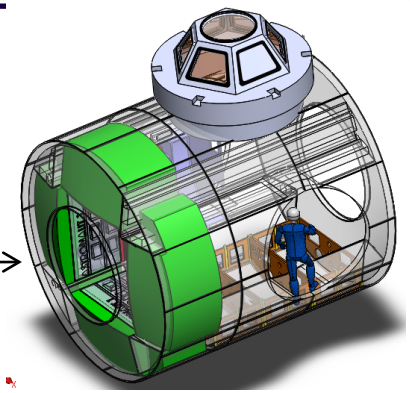
Overview



Sleeping Quarter "Box"

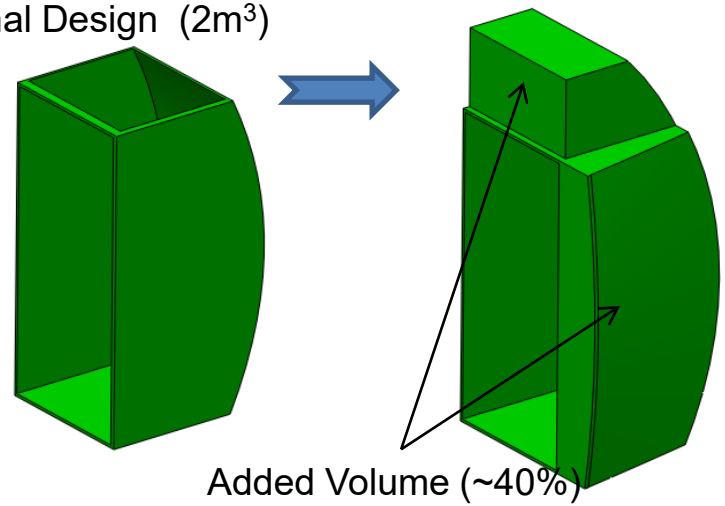
- **Original design concerns**
  - Rack bay design
  - Acoustic and lighting disturbance
  - Proper air circulation prevent asphyxiation

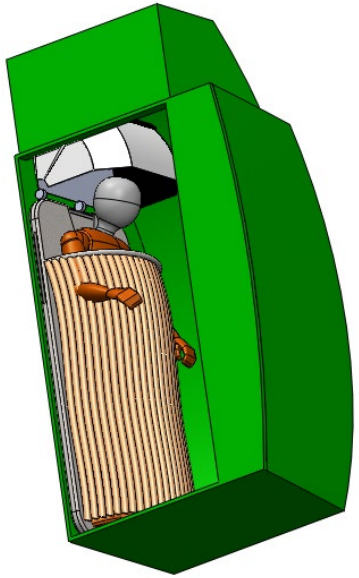
End of the dome →

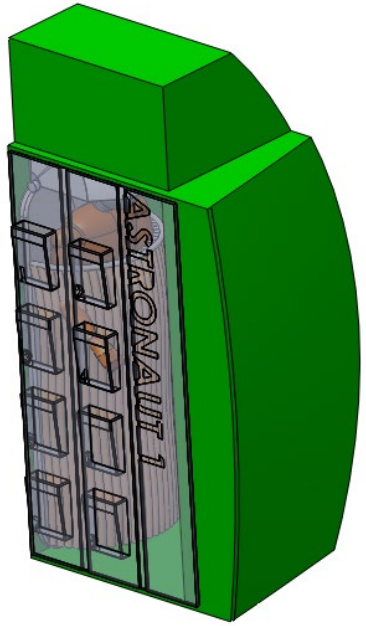


- Re-located at the end-dome
- Hinged composite door panels with storage pockets

Original Design (2m^3)

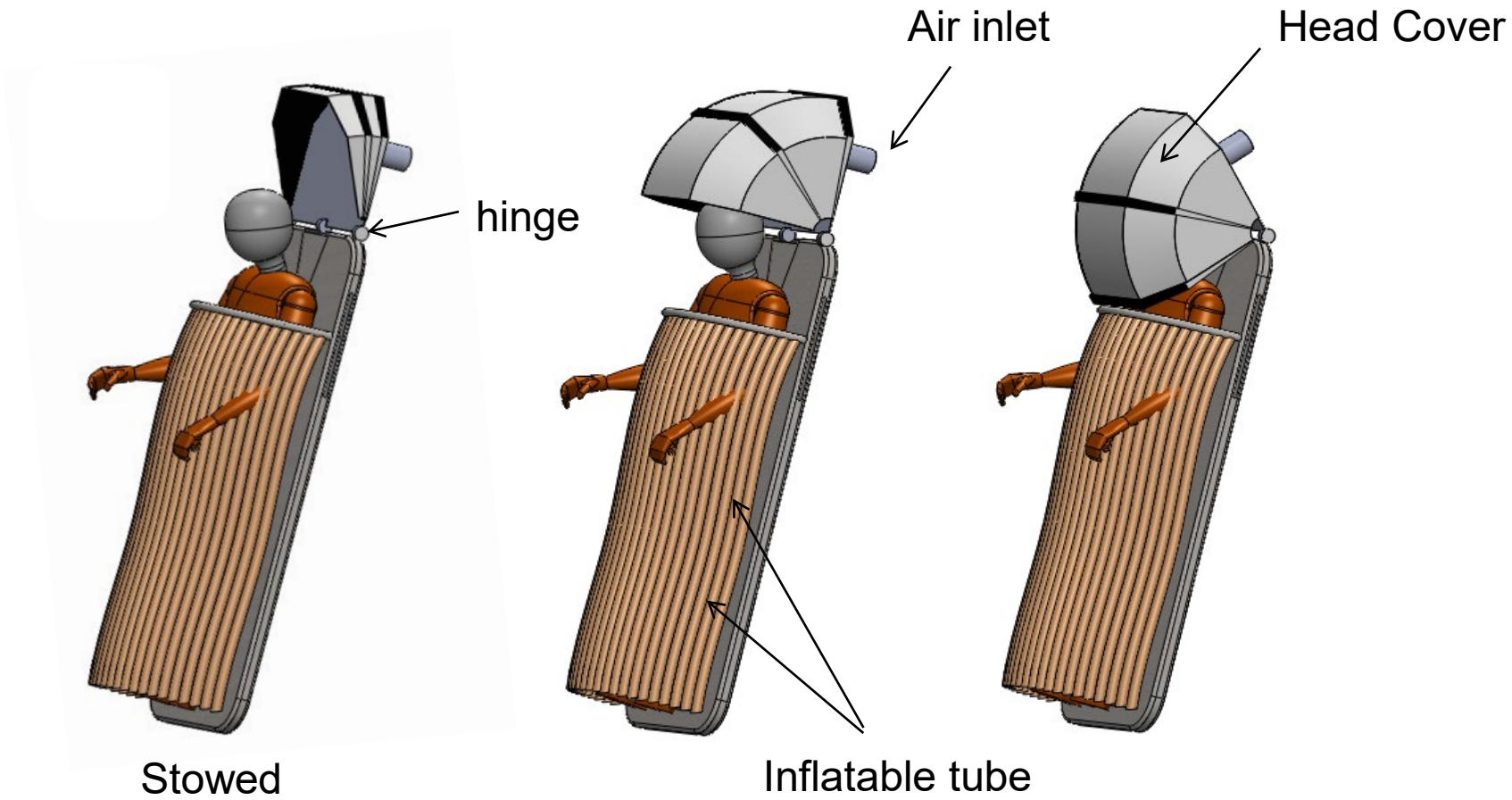






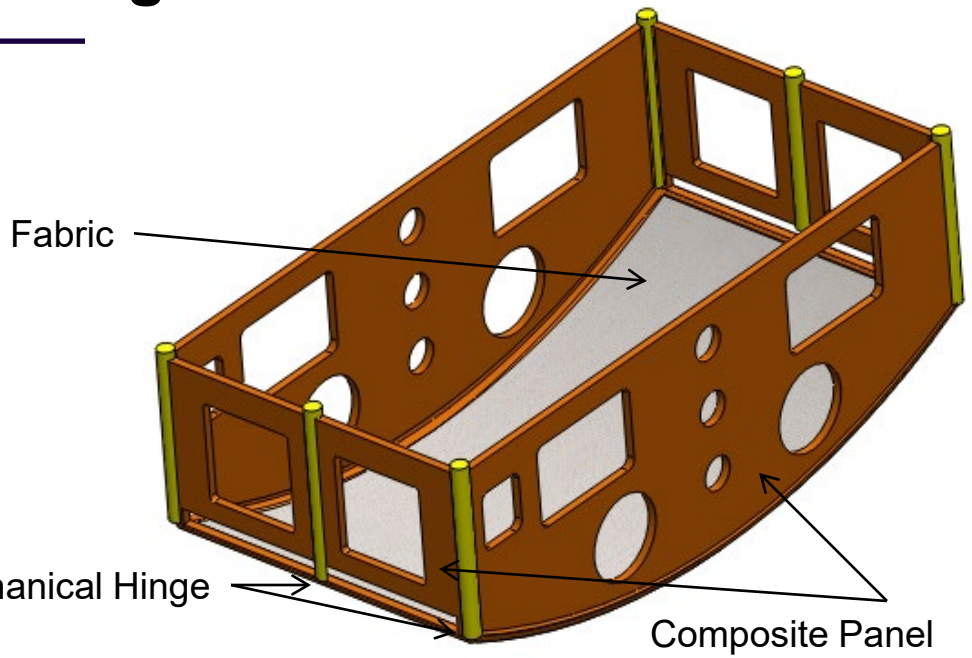
Sleeping Head Cover

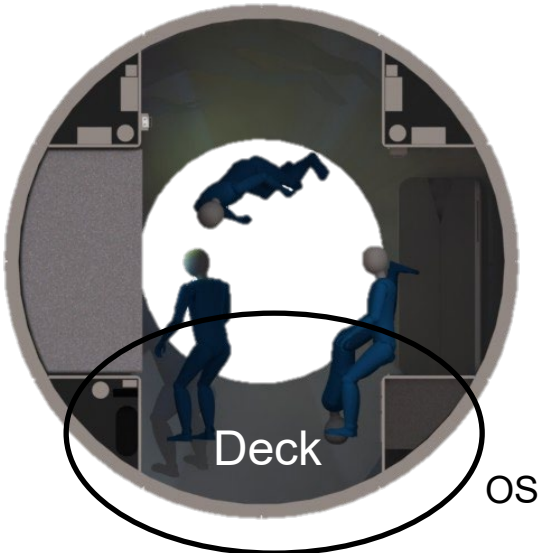
- A foldable head cover made of acoustic fabric/foam
- Completely cover the astronauts head and partial upper body section
- Air will flow into the cover to enhance air quality
- Blanket made of series of inflatable tubes with adjustable air pressure



Floor Storage Rack

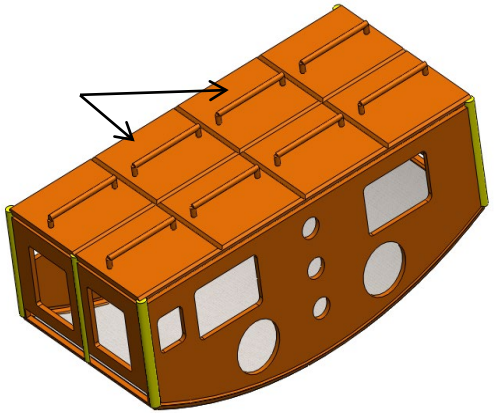
- Utilize floor space
  - Lightweight (composite panel + fabric)
  - Foldable
- Multiple storage components
  - Space suits
  - Equipment, food





OSU Xhab's Node 1

Hinged panel

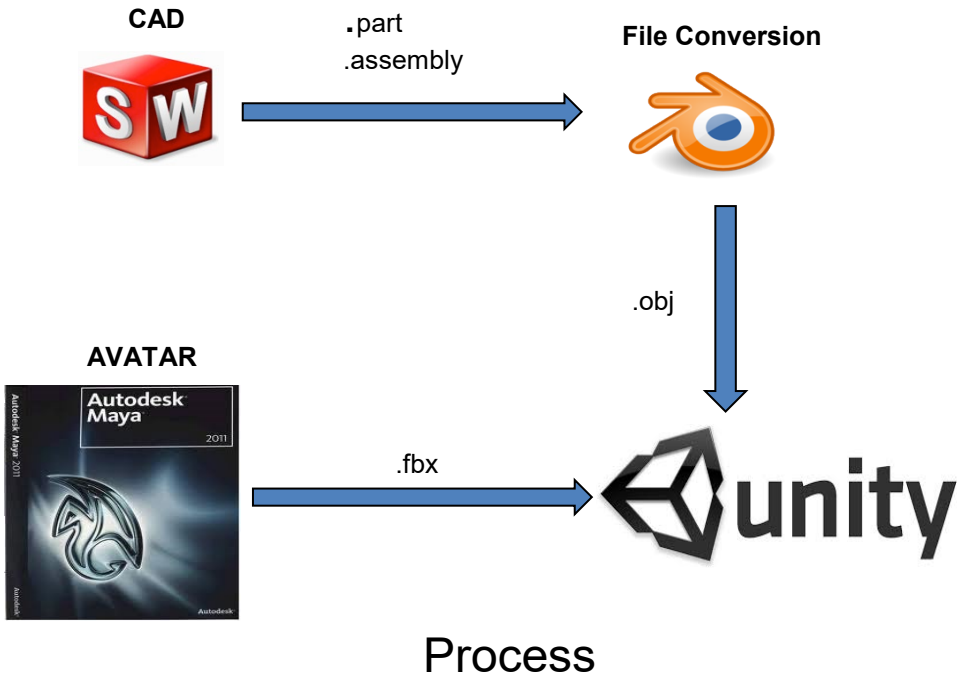


Installation of a rack in the U.S. Lab prior to launch.

Source: Reference guide to ISS

Simulation

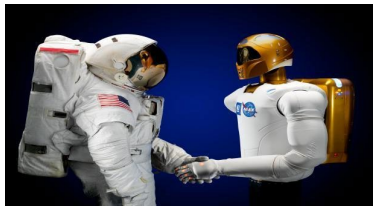
- Gaming Software
- Capabilities
  - *Import CAD Models*
  - *Simulation*
- Features
  - *Character presets*
  - *Animation presets*
  - *Great website software support*

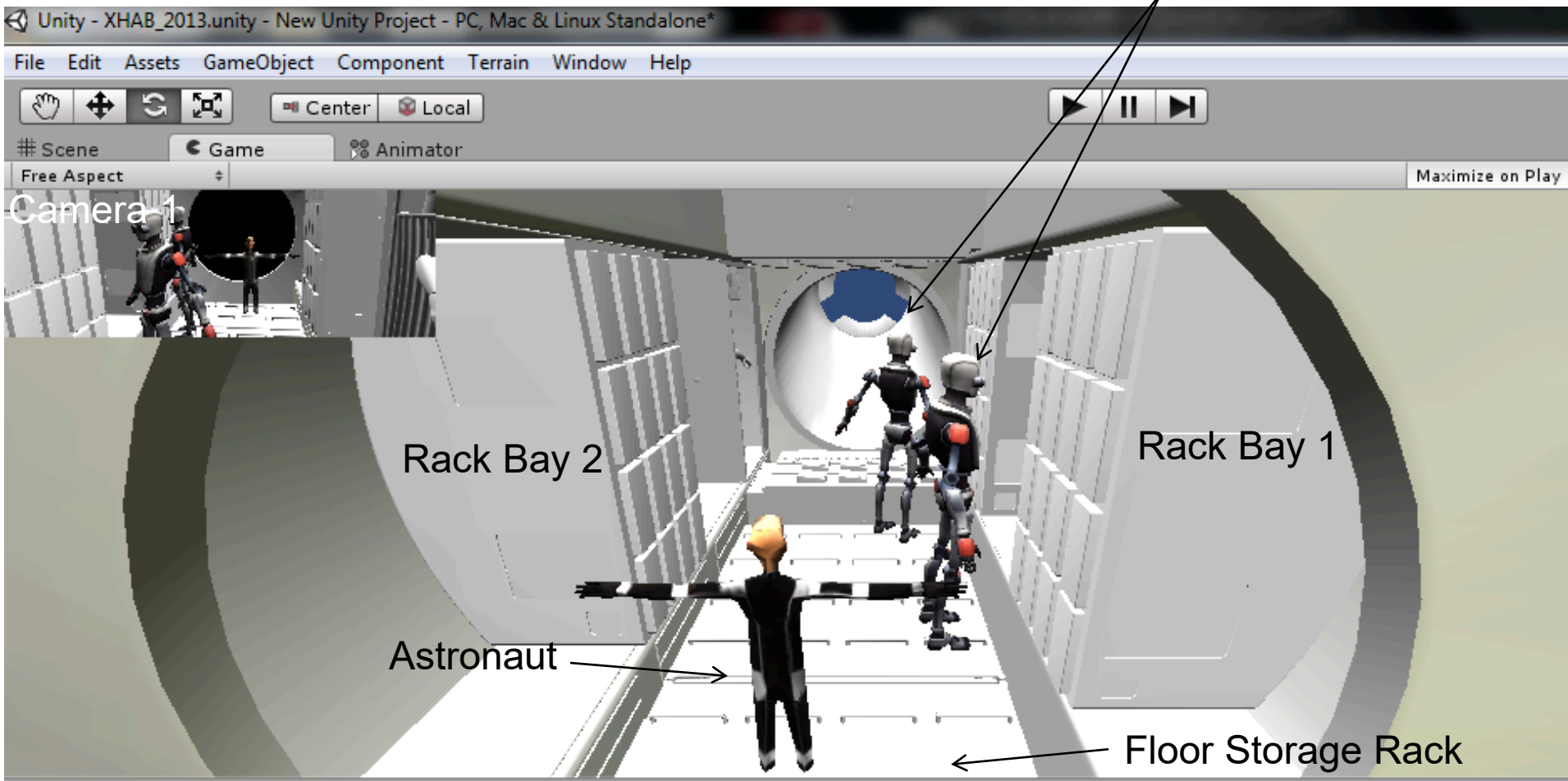


unity

Simulation

- Screen shoot from the simulation
- Simulate robot and astronaut activities inside the Node 1

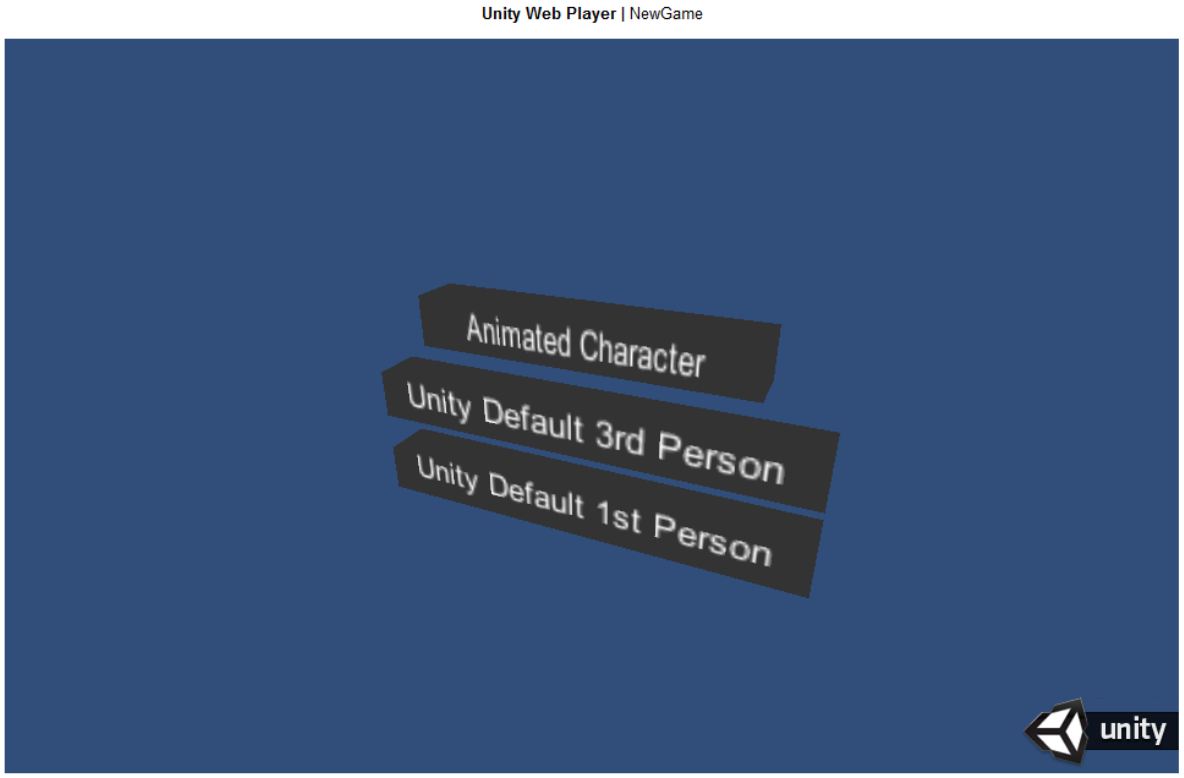




Team Node 1

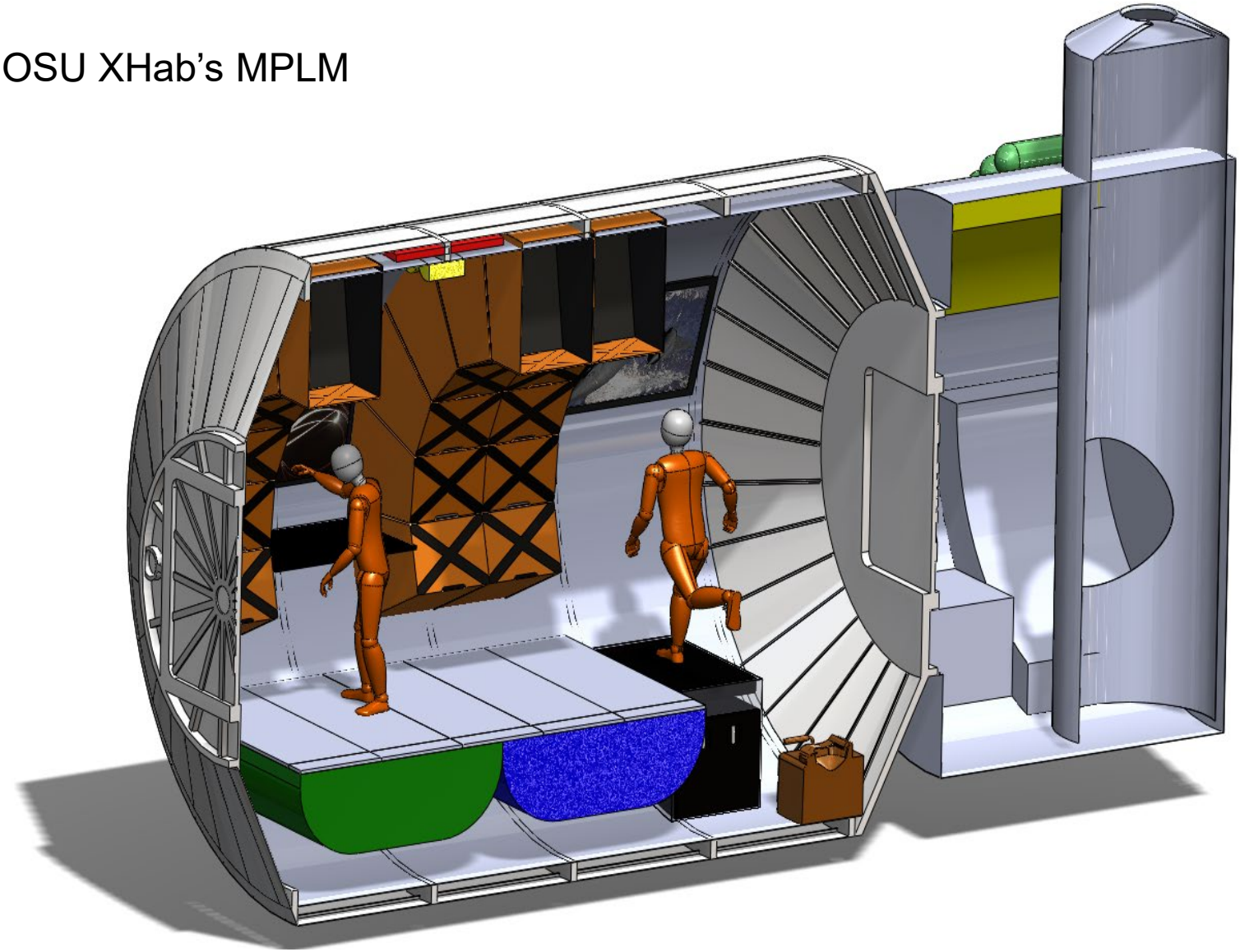
Future work

- Simulate object interaction inside the space habitat
  http://fpst.atwebpages.com/CharactersPresentation.html



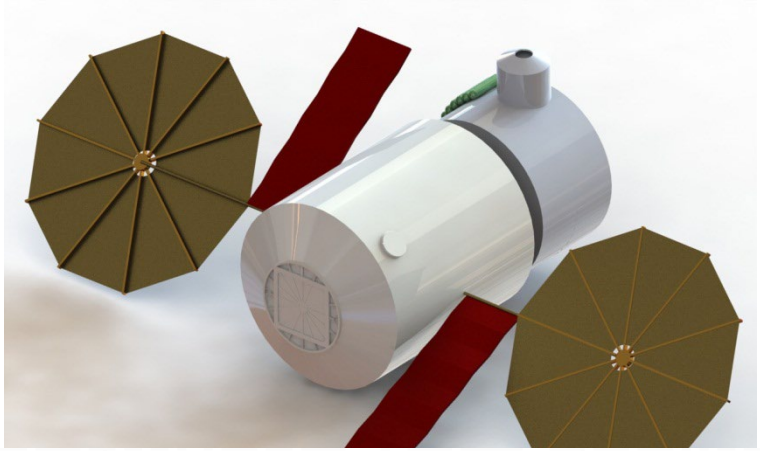
MPLM (Fall Design)

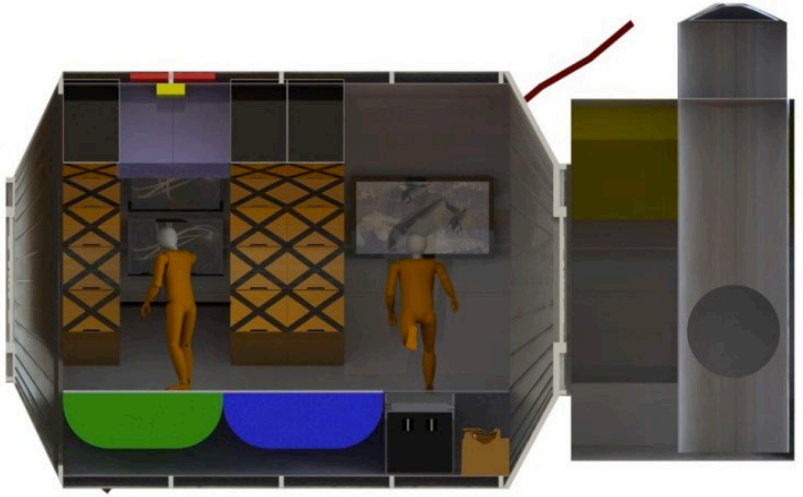
OSU XHab's MPLM



Module For Analog

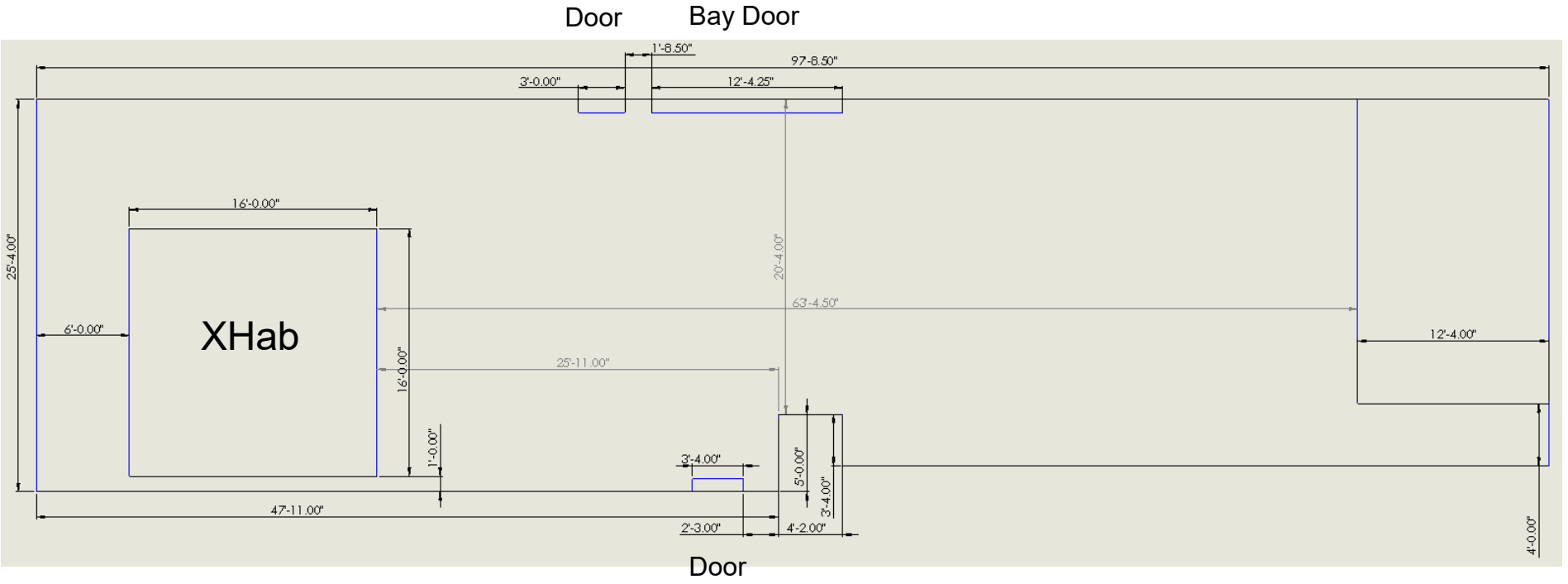
- MPLM
- Includes:
  - *Workout*
  - *Lab Stations*
    - *Computer Station, Aeroponics, Glove Box*
  - *Hygiene*
    - *Toilet, Shower*
  - *Storage*
    - *Small to Large Items*
  - *HVAC*
  - *Lighting*
  - *Interior Design Group Project*





Richmond Facility Layout

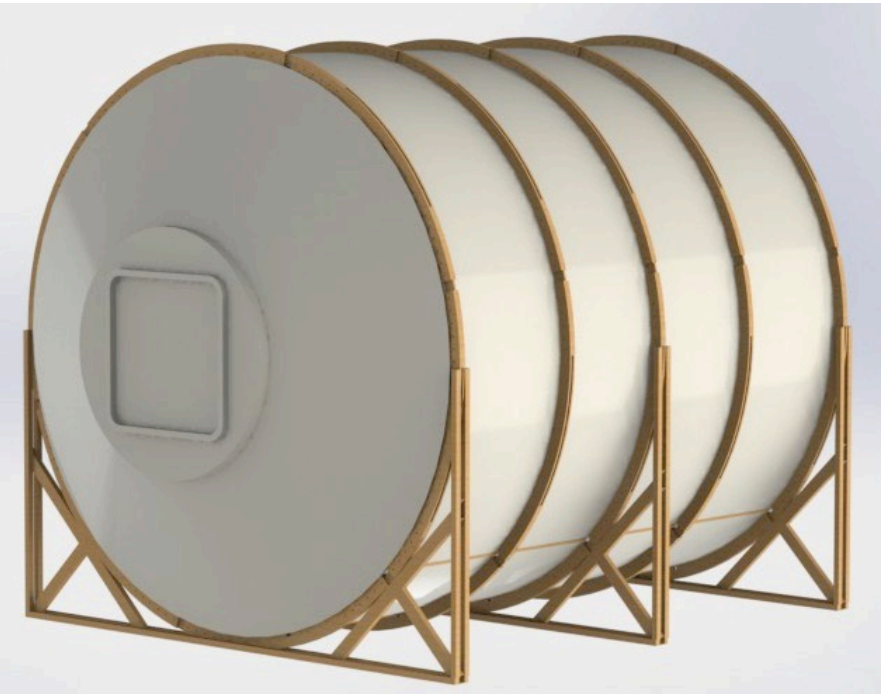
- Large Open High Bay Area, Large Bay Door For Unloading Larger Items

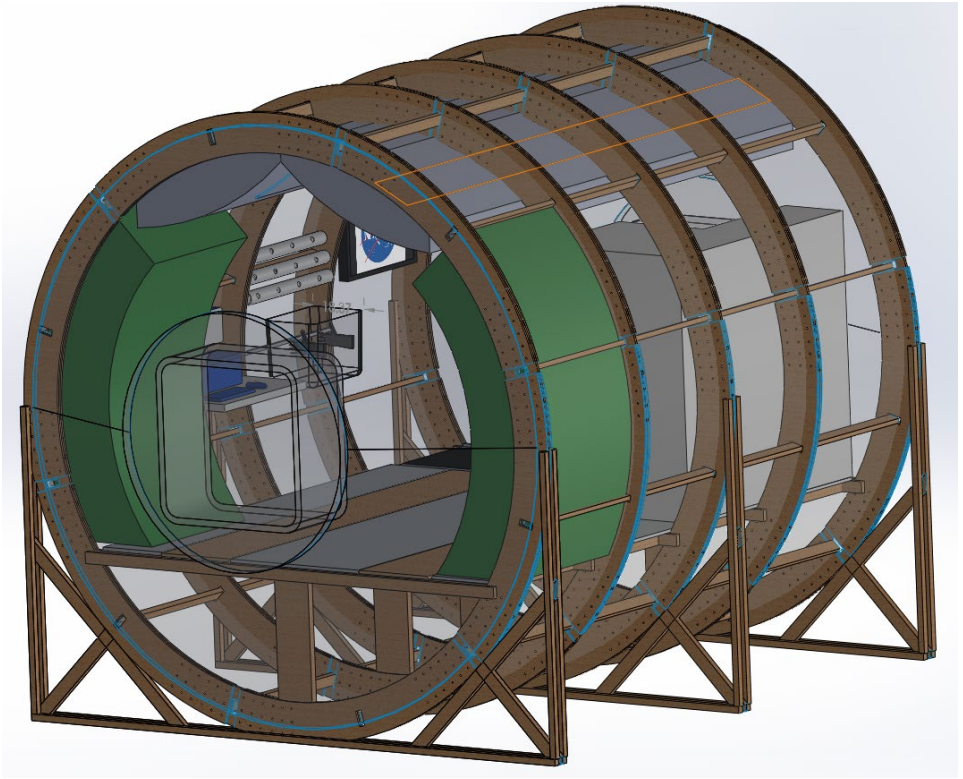


- Plenty Of Space To Expand If Desired (60ft of open space in front of analog)

Earth Analog Concept

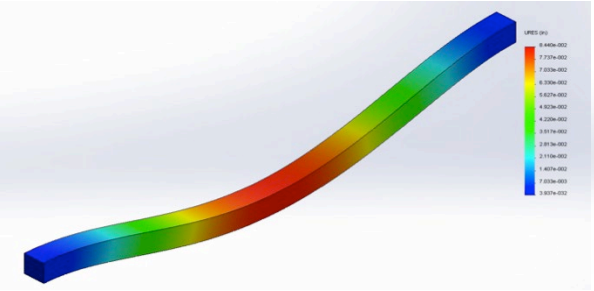
- Earth Analog of Garriot (MPLM)
  - *Main structure is wooden: 5 ring frames with 12 evenly spaced stringers; floor substructure wood with wood and metal panels*
  - *Skin is foam core and foam insulation*

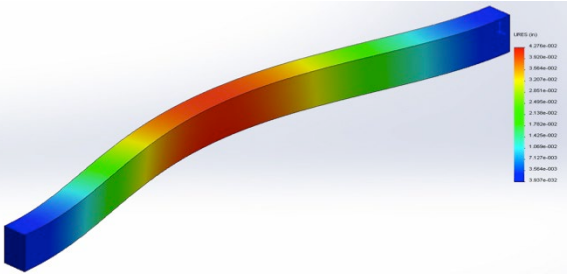


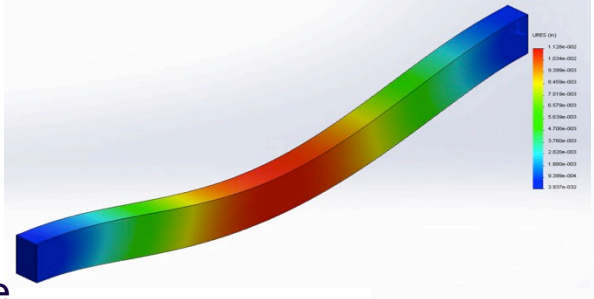


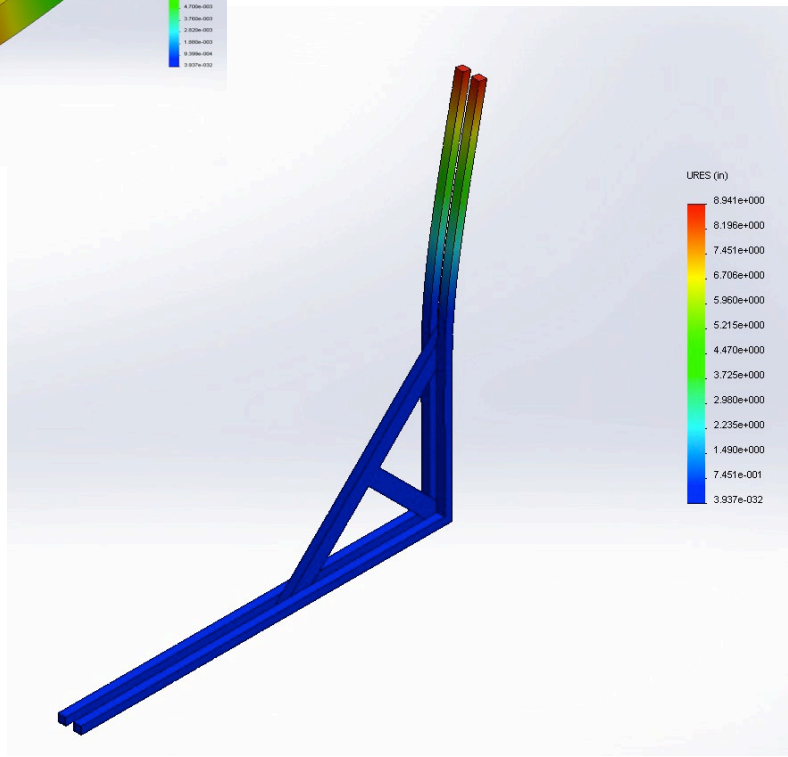
Structural Analysis

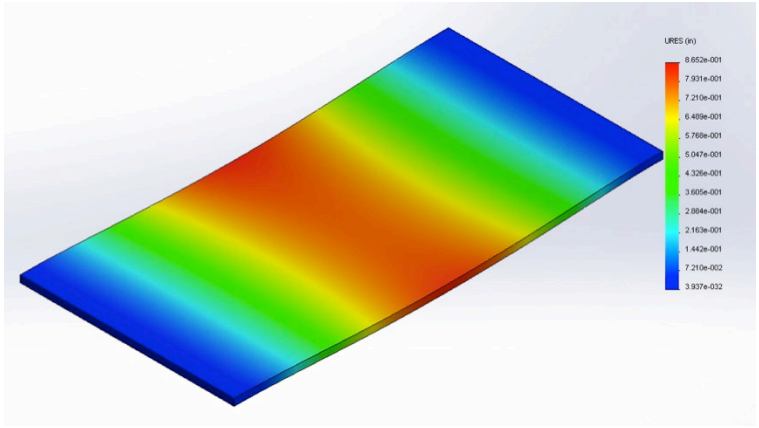
- FEA On 2”x2”, 2”x4”, Floor Panels and Supporting Structure
- Obtained/Estimated Pine and Plywood material characteristics (Matweb)
- 500 lbf point loads at worst case loading positions
- Minimal deflections, well within limits of safety
- Floor panel and support structure had largest deflections (support used 1000 lbf) but still did not fail





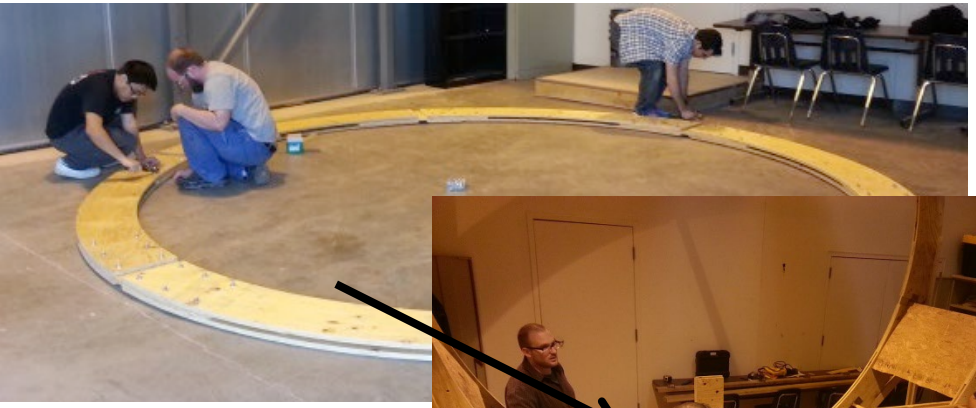






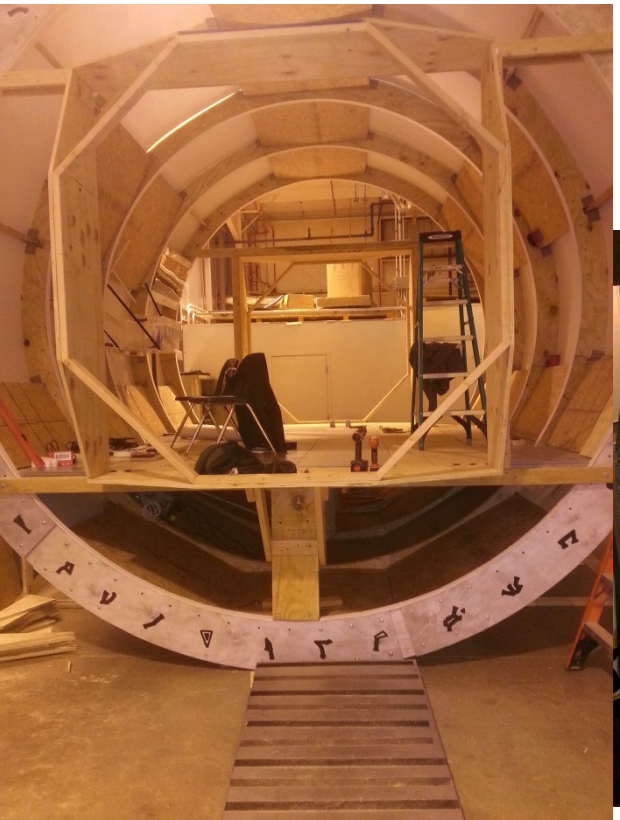
Fabrication

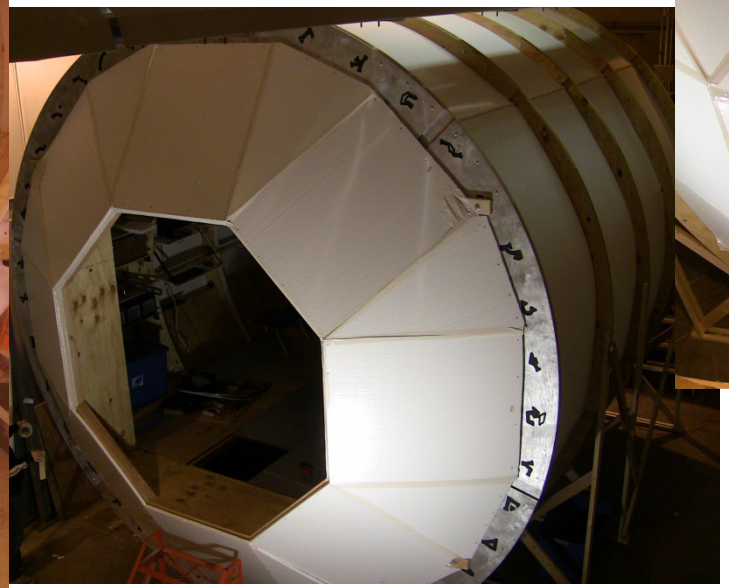
- Used CNC router for cutting circular frame out of plywood.
  - *Assembled rings horizontally and then rotated them to be vertical*
  - *Used 2x4s and metal brackets to brace the rings together*
- Used 2x4s for construction of the floor
  - *Aluminum covered wood plates along with plywood for floor covering*

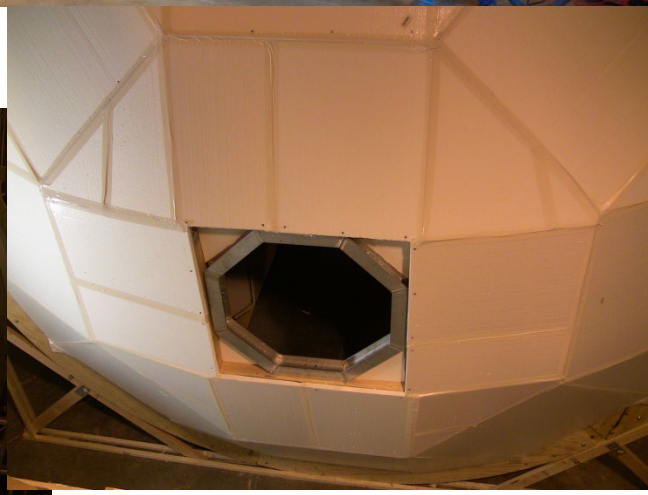


Fabrication

- Foam board for exterior skin
- 2x4s for frames of end caps
  - *Star foam sheets for covering*

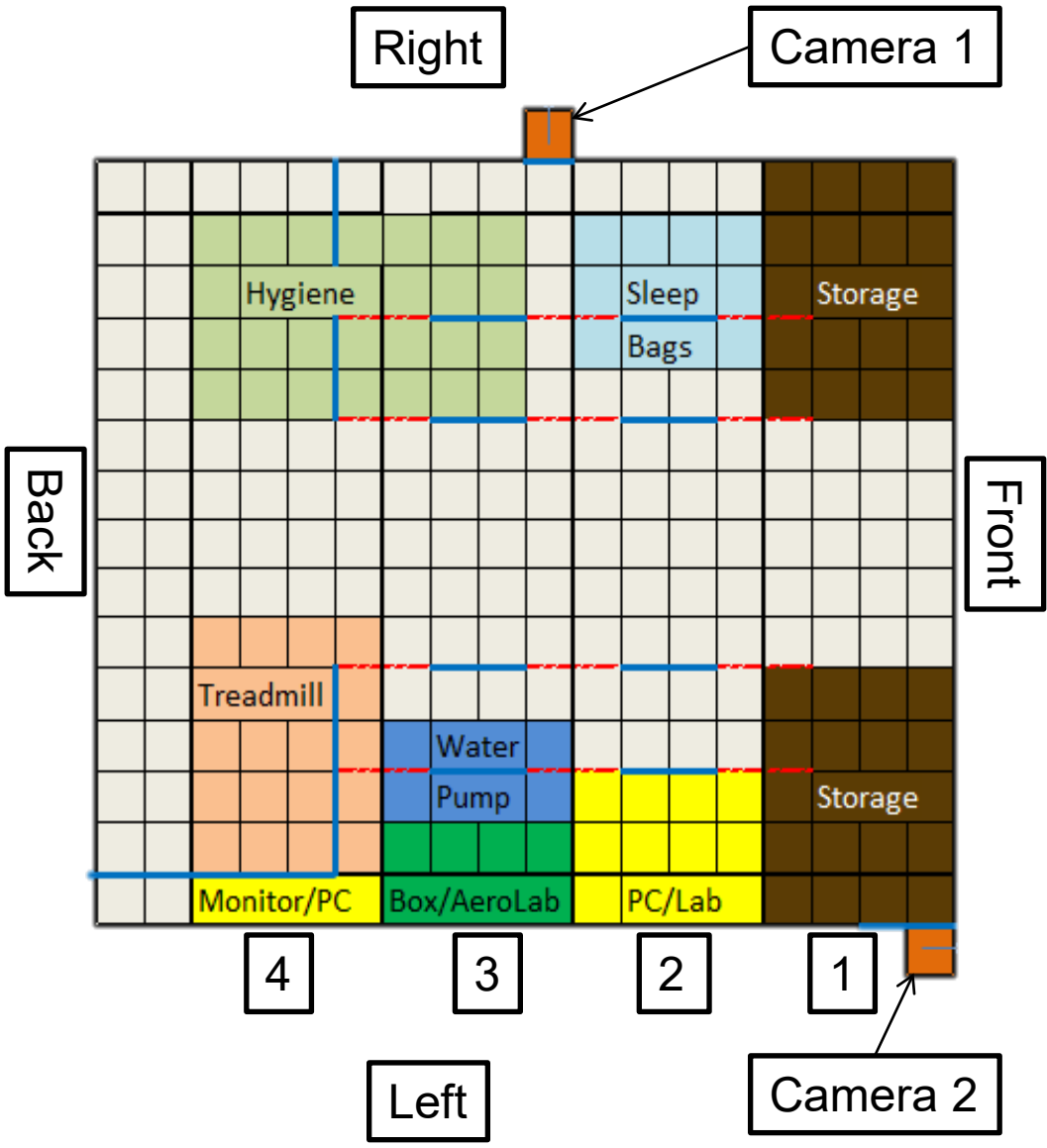




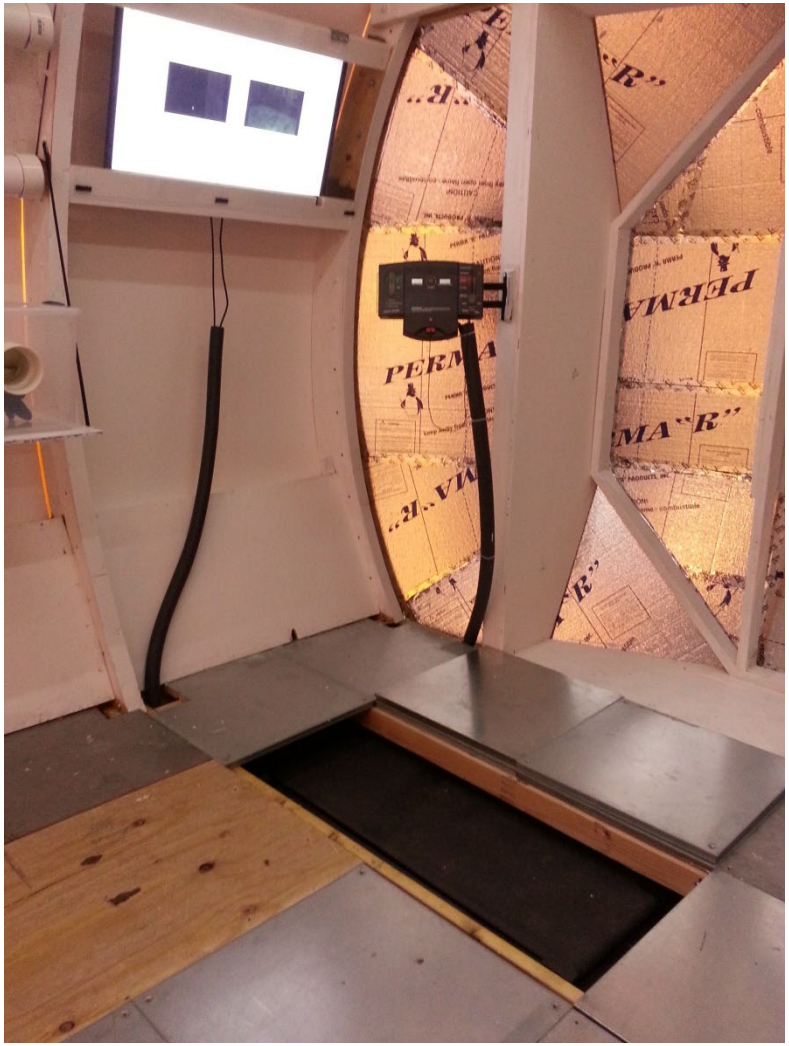


Interior Planning

- Ring 1
  - *Small storage and large storage(under the floor)*
- Ring 2
  - *PC and sleeping area*
- Ring 3
  - *Aeroponics (water pump under the floor) and glove box*
  - *Hygiene Module will be in both Ring 3 &4*
- Ring 4
  - *Treadmill and monitor for virtual window*



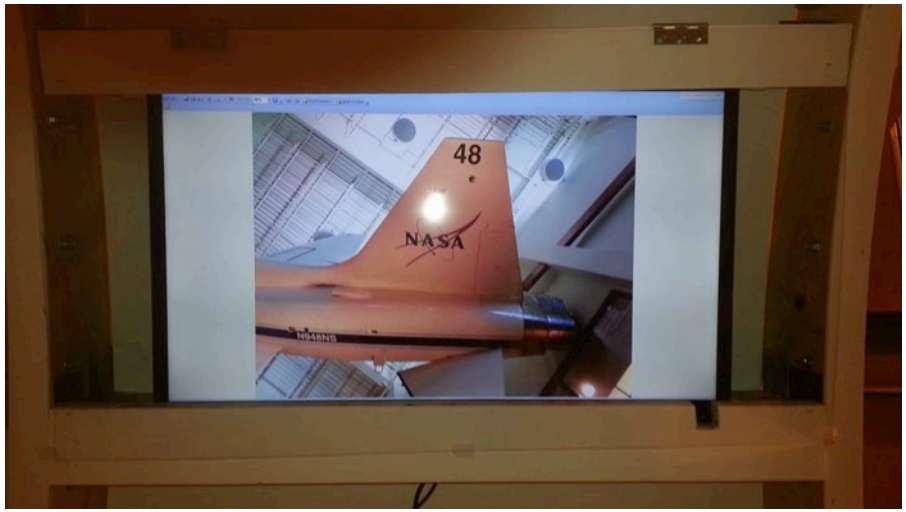
Exercise



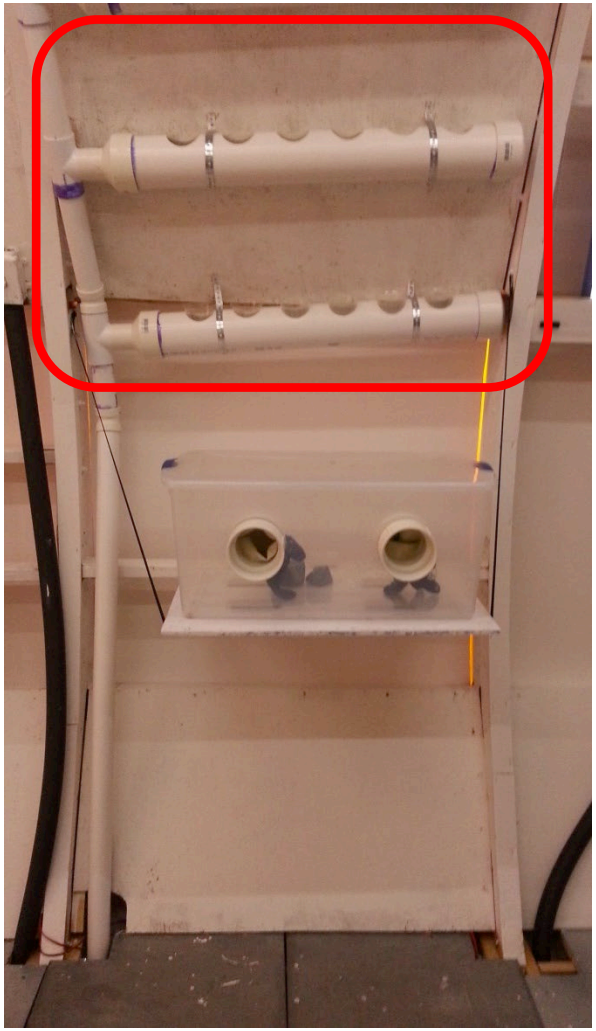
- Colbert Treadmill
  - *Designed to help reduce possible muscle atrophy in space*
  - *Mounted under the floor for easy access and to save space when not in use*
  - *Can be accessed via the floor access magnets*
  - *Control panel to the side to adjust speed*
  - *In zero gravity, straps will hold you down to allow you to run*

Viewing Screen

- Virtual Window
  - *39” television*
  - *2 webcams with fisheye lensed attachments*
  - *Controlled via net top computer*
  - *User interfaces via wireless keyboard and mouse*
  - *Window doubles as lighting diagnostic tool*



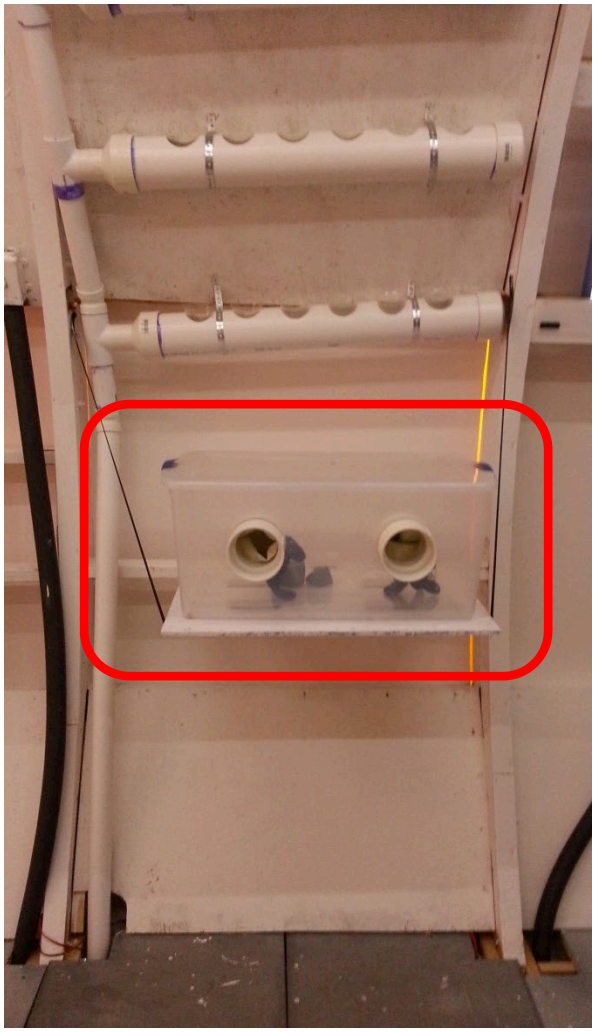
Aeroponics



- Design
  - *½" inner tube (pvc)*
  - *1/16" holes for mist*
  - *2" outer return tube (pvc)*
  - *3 racks of 6 plants*
  - *UV lighting to stimulate growth*
  - *Gravity based return system*
- Water supply
  - *1/6 hp pump*
  - *25 gallon tank filled with about 5 gallons*
  - *Stored under floor for convenience*

Lab Station

- Glove box
  - *Primary use as a clean environment work station capable of holding toxic test subjects as well*
  - *Removable via hook and loop tape and capable of being stored underneath the floor*
  - *Stand can then be used as a secondary work environment*
  - *Stand can also be stowed against the wall to enlarge the room*



Lab Work Station/Rovio

- Workstation
  - *Designed for working with lab statistics, rovio control, other needs*
  - *In the Earth analog, designed for comfortable standing position*
  - *Through the computer mounted beneath the floor the user can control Rovio and receive live video feed from outside the habitat*
  - *Keyboard table stores upward for increased space*

Hygiene Unit

- Planned design
  - *Lifted up from the floor and locked in place when in use and easily stores under the floor when not in use*
- Hygiene Module
  - *Used Hygiene Module to save time and resources*
  - *On loan from Stafford Museum in Weatherford*
  - *Contains a shower and bathroom station*
  - *Internal drawers in the bathroom for storage*

Small Storage

- Located along the circumference entering the habitat
  - *Contains small items such as flashlights, toothbrushes, etc.*
- Several removable bins (0.5 ft^3) to hold small items
- Larger bins to hold medium sized items (4.7 ft^3)

Additional Storage

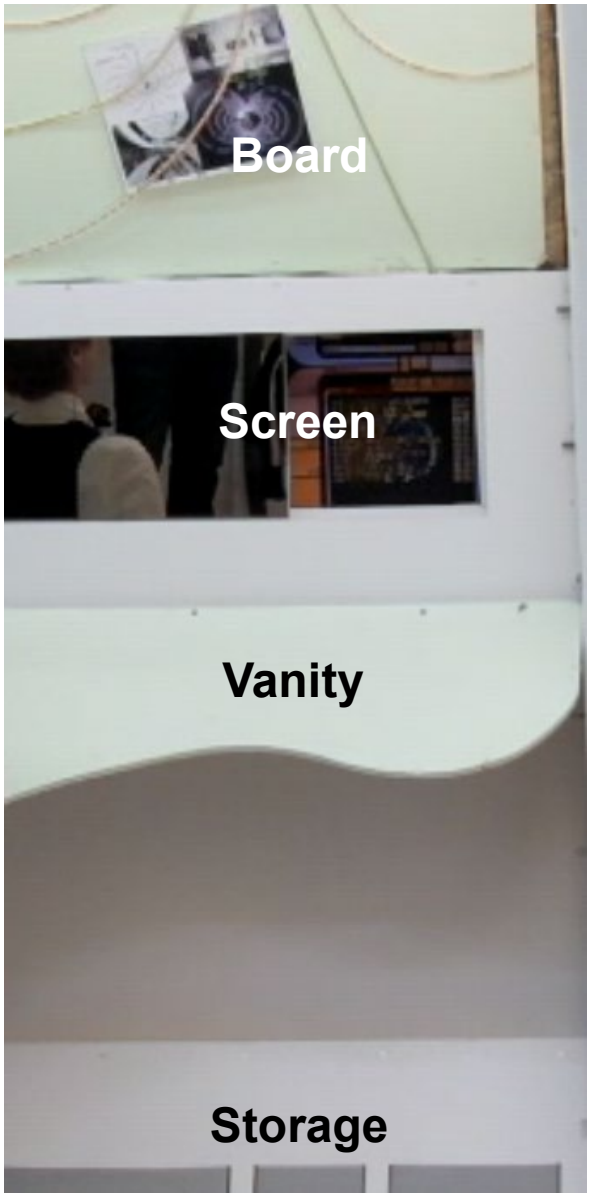
- Small-Moderate Storage
  - *Form fitting storage will be installed inside around the wall of the module*
- Design
  - *Use of lightweight (possibly fabric) materials with lightweight inserts color coded for the contents*
  - *Contents can range from clothing, repair tools, personal effects, lab equipment and many other possibilities*

Large Storage

- Large items are placed under removable floor panels
  - *Total volume is 184 ft^3*
  - *For everything from spacesuit storage and replacement parts for the habitat to large cargo items and stowaways*

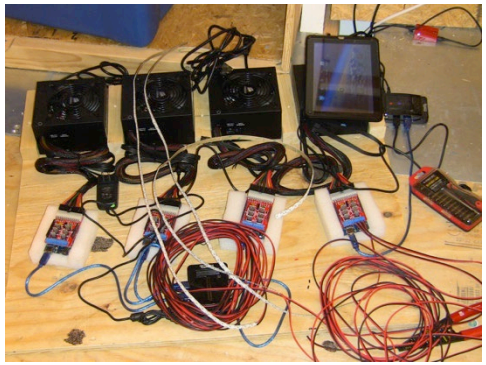
Personal Quarters

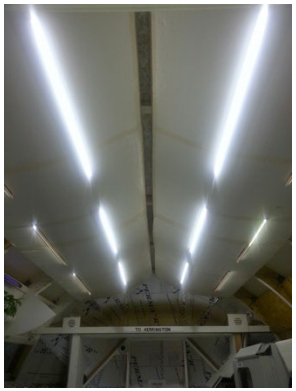
- Sleeping arrangements
  - *Mock up of one persons quarters*
  - *Board*
    - *Color*
      - *Based on aurora borealis*
      - *Provides a distraction from the typically sterile environment of the habitat*
    - *Doubles as a means to store personal items*
  - *Mirrors*
    - *For grooming; also act as viewing screen for skype, etc.*
  - *Sleeping bag mounted to extendible wall(not pictured)*

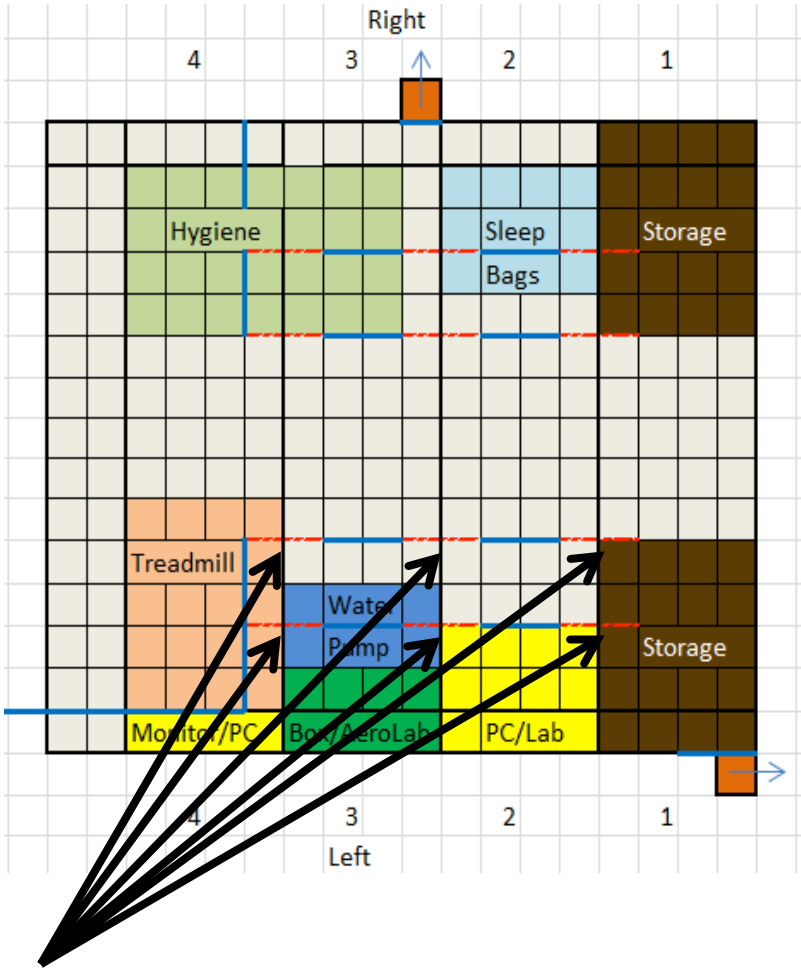


Lighting

- LED Strip lights
- 4 rows split into 3rds
- Controlled using a custom Android app
  - *Sends data over serial communication*
  - *Server then relays information to the Arduinos*
- 4 Arduinos(1 per row) with power shields
  - *Power shields allow amperage control along 12 volt rails*



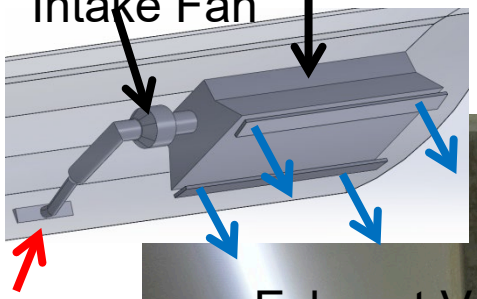




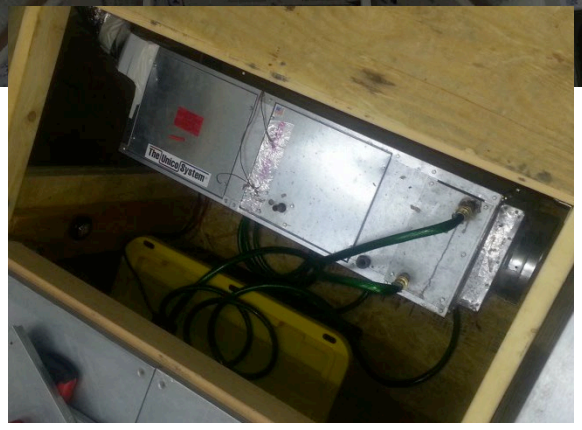
LED placement (red is LED, blue is wire) mirrored over the middle of the habitat

HVAC

- Use of Active Chilled Beams desired
  - *Outside ability to afford with budget*
  - *Volumetric mock up made*

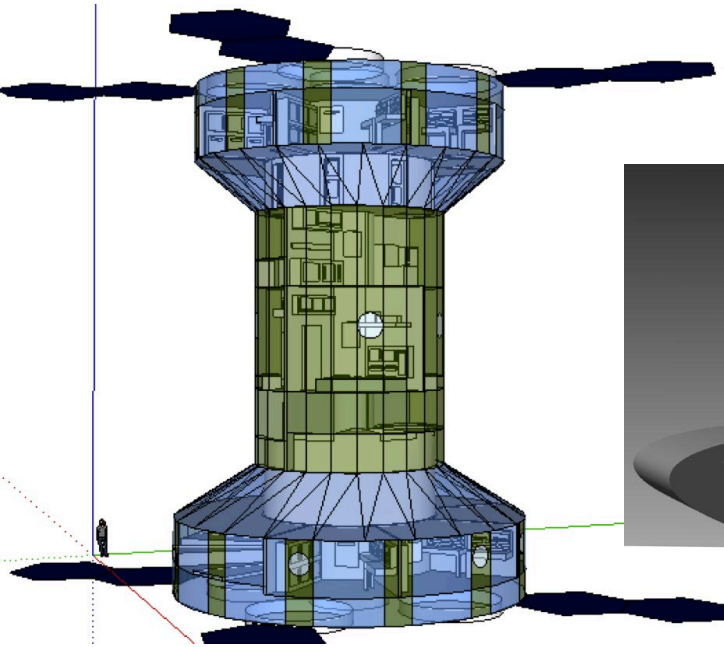


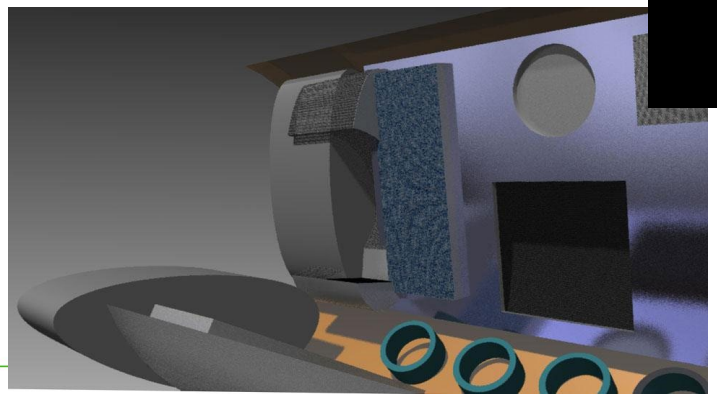
- Used spare AC unit for air circulation within module
  - *Added water tank with pump for cooling effect*
  - *Ice packs added to water for colder water circulation*

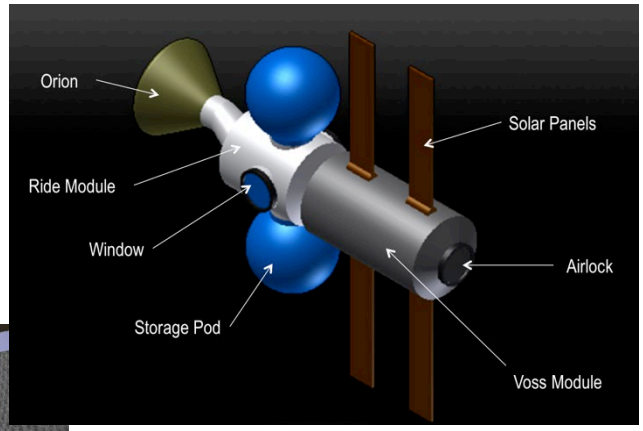


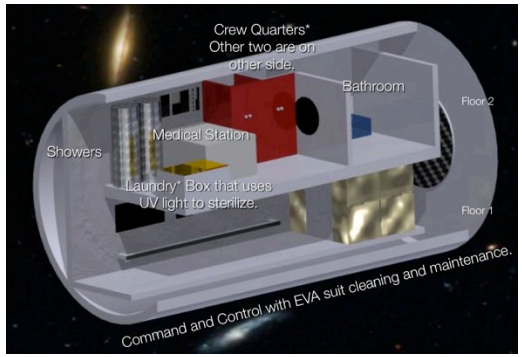
Outreach

- High School Space Habitat Innovation Challenge
- 25 groups involved (~125 students) from NASA INSPIRE and Explorer Schools
- 7 teams submitted proposals; down selected to top 3 – winners travel to MSFC in June



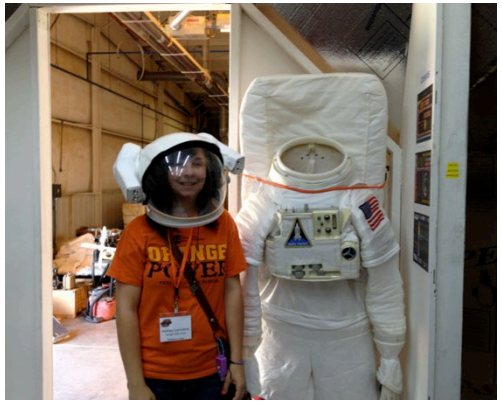






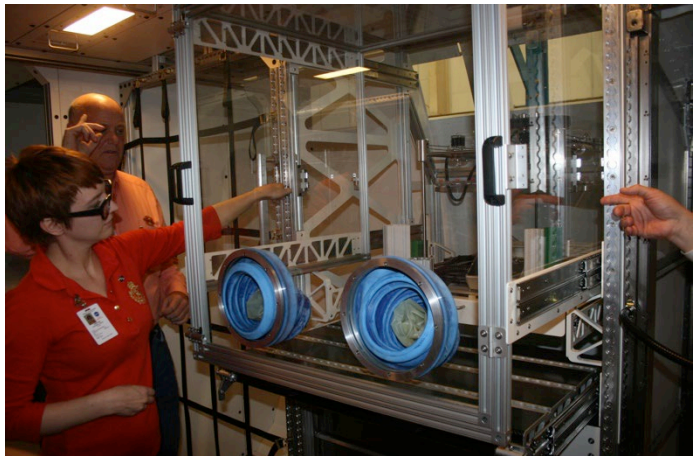
- https://www.youtube.com/watch?v=HHiAezyBI-k

Testing and Demonstration

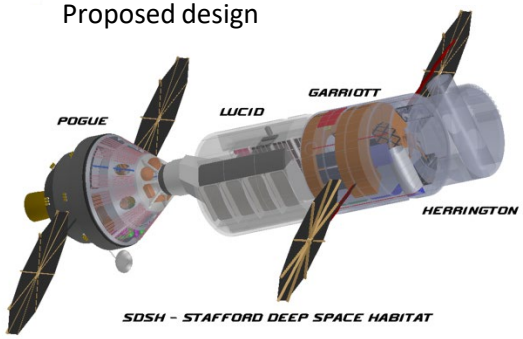


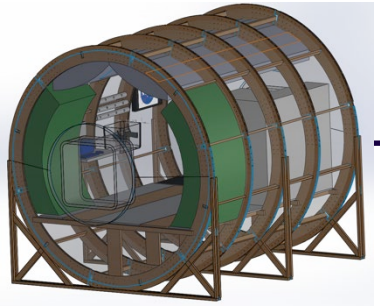
Trips

- Visits to NASA MSFC, Cosmosphere, and Stafford Museum



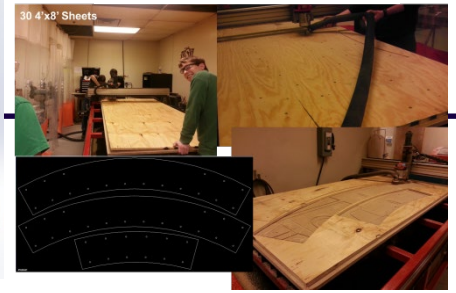
Proposed design





Earth analog

Manufacturing

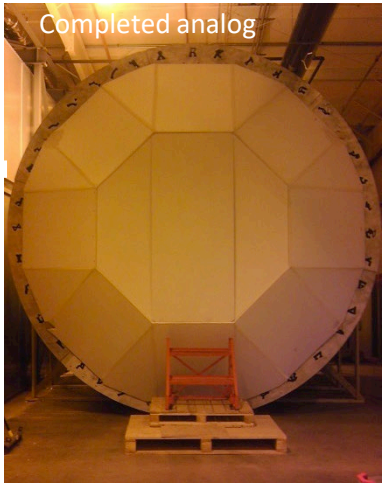


Construction

Grow station
& Glove box

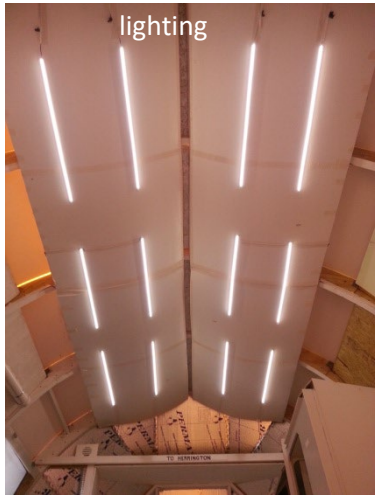
Exercise unit

Exploration habitat
Development of an
Earth analog for
Horizontal habitability
Layout studies of a
deep space habitat



Completed analog

Control station



lighting

storage

Hygiene unit

2013 design team

Video Tour

http://youtu.be/FI_Y1o9TRDU

Thank You