

# NASA HABITAT DEMONSTRATION UNIT (HDU) DEEP SPACE HABITAT ANALOG



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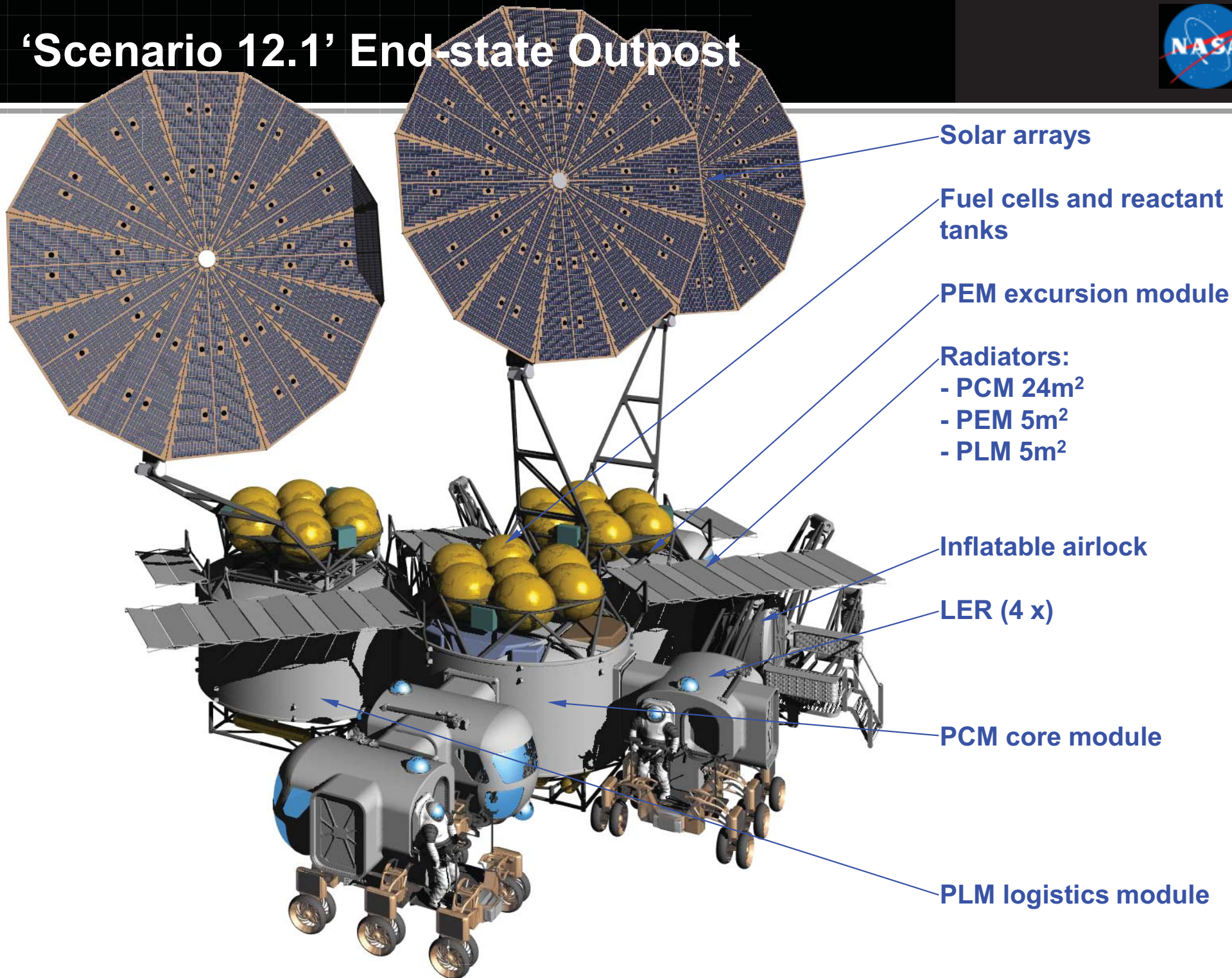


- HDU Background Concept:
  - Constellation Lunar Architecture studies
  - Remote robotic assembly
  - Surface optimized pressure vessel
  - Horizontal expandability
  - Vertical expandability
- Rapid Prototyping Development:
  - Analogs and testing
  - If you build it they will come (technology integration)
- Selected Technologies and Subsystems
- Lessons Learned

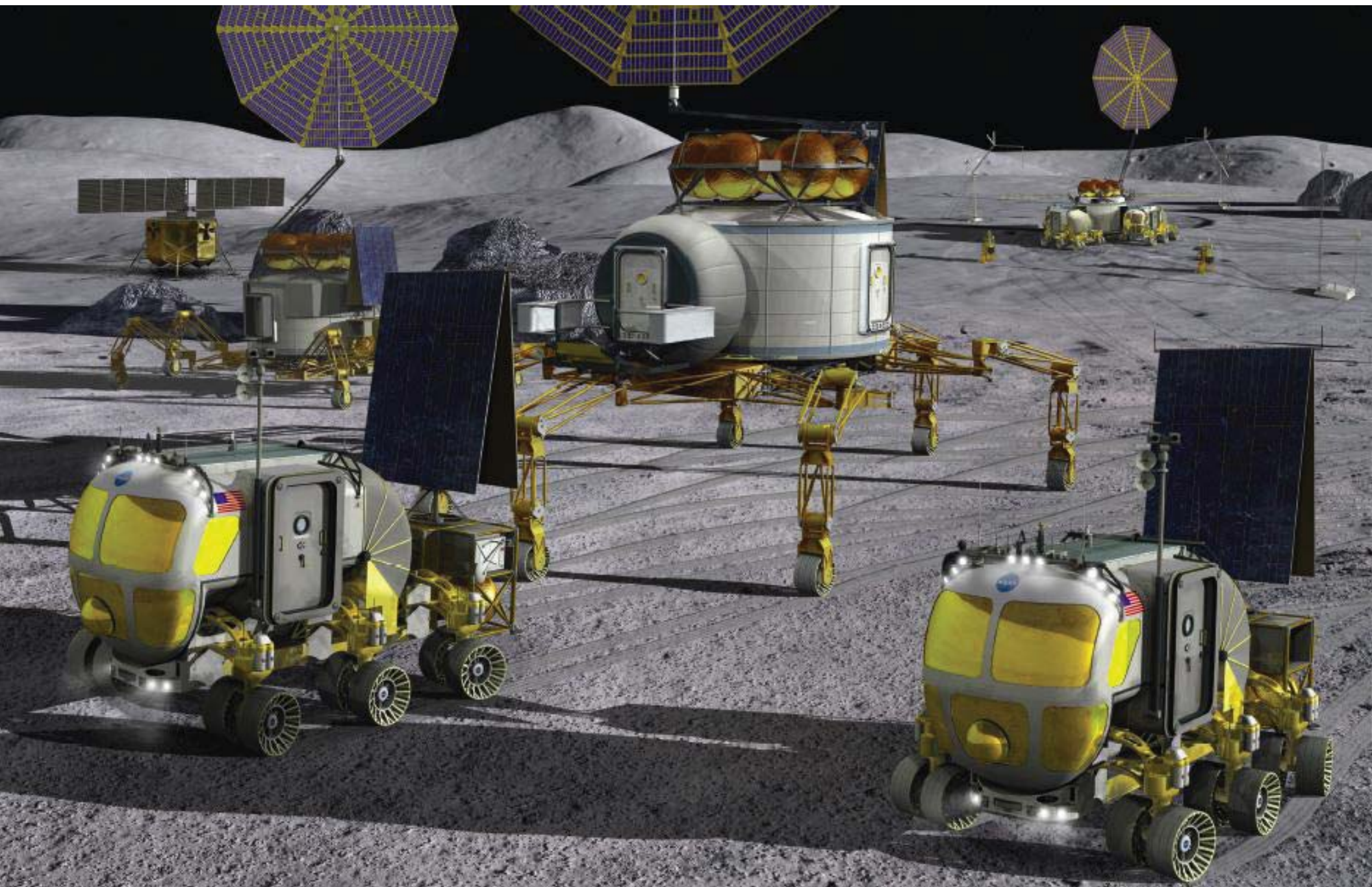
# Remote Robotic Assembly



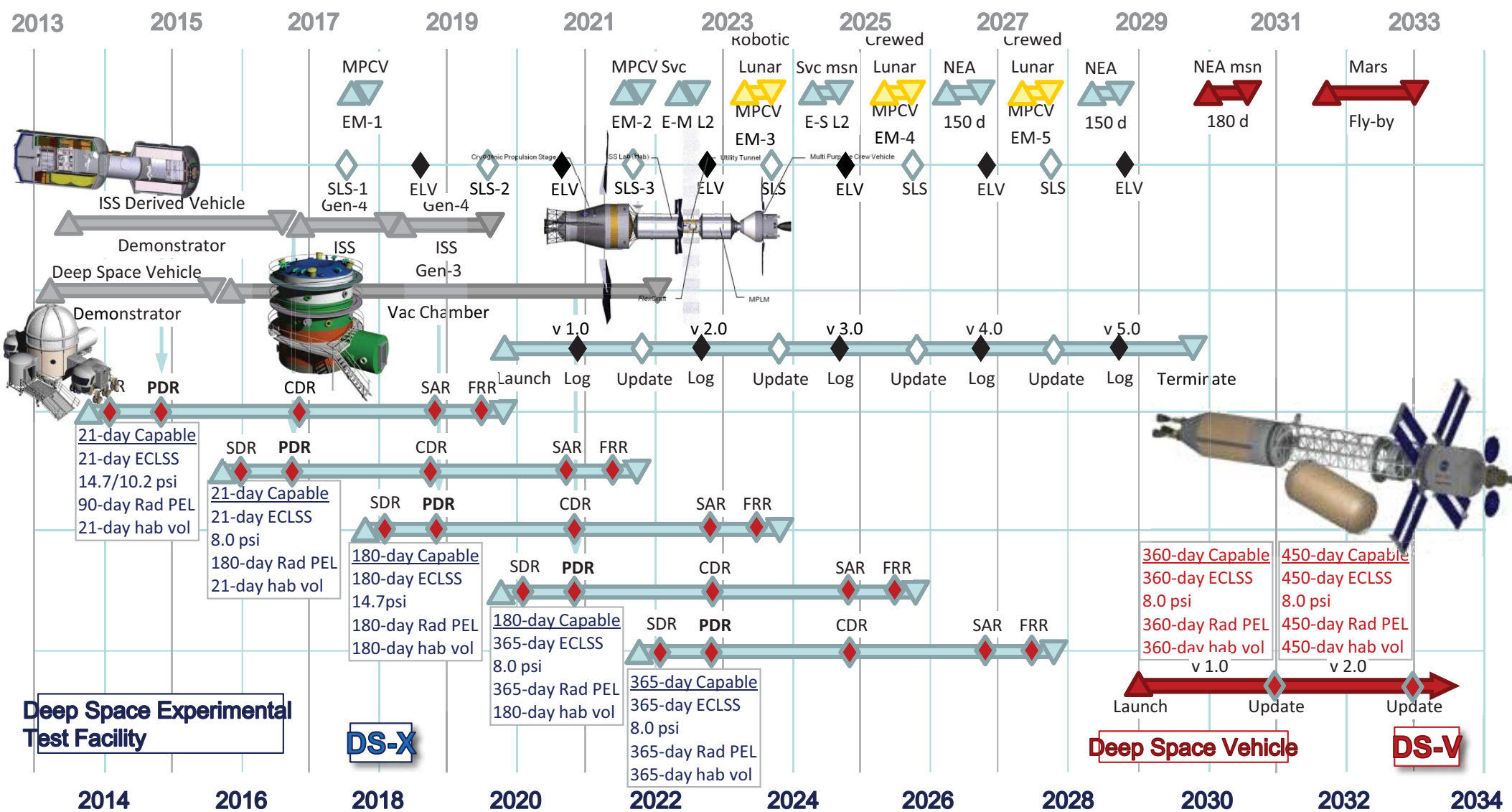
# 'Scenario 12.1' End-state Outpost



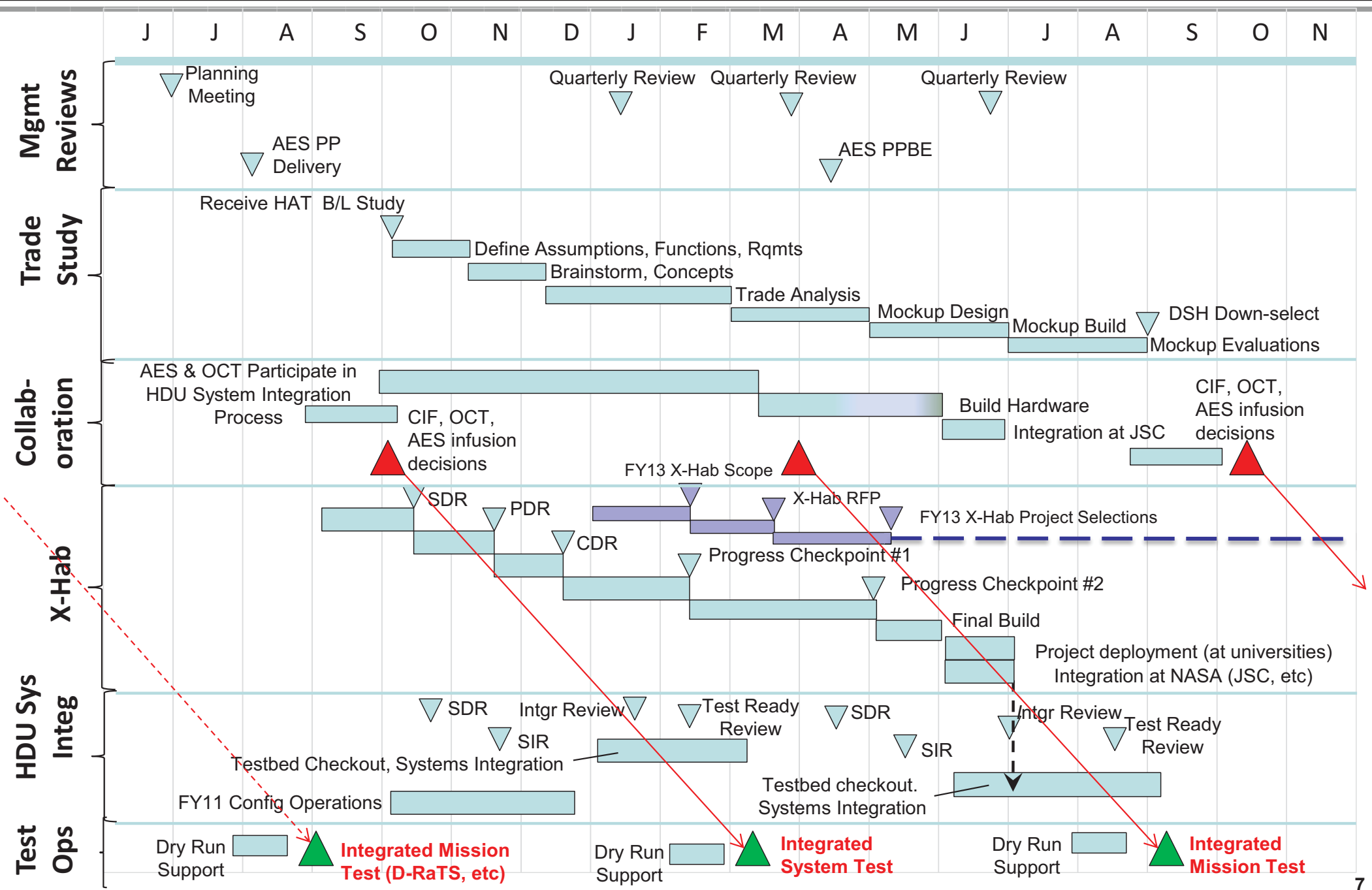
# 'Scenario 12.1' Highly Mobile Outpost



# AES DSH Multi-Year Multi-Gen Strategy



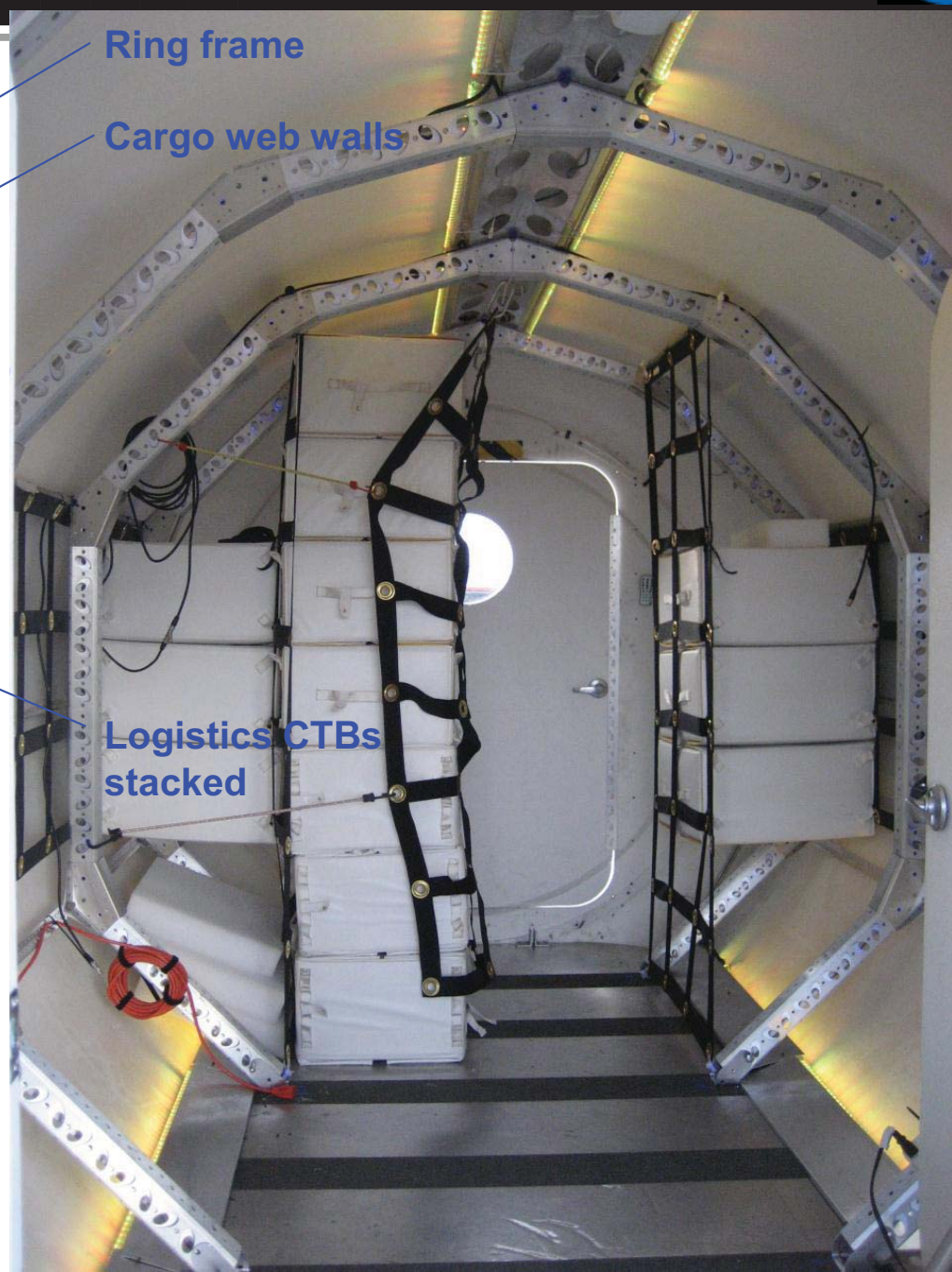
# Yearly Schedule: Semi-annual Integration



# Microhab ISHM Analog D-RATS 2009





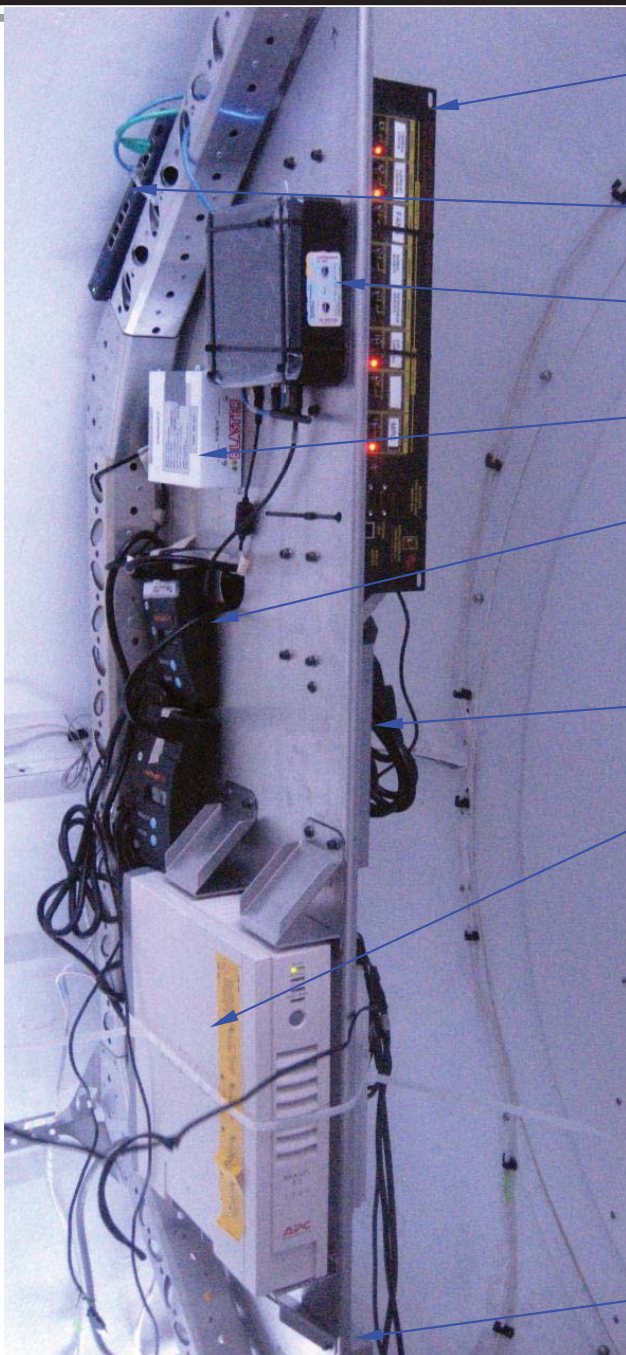


Ring frame

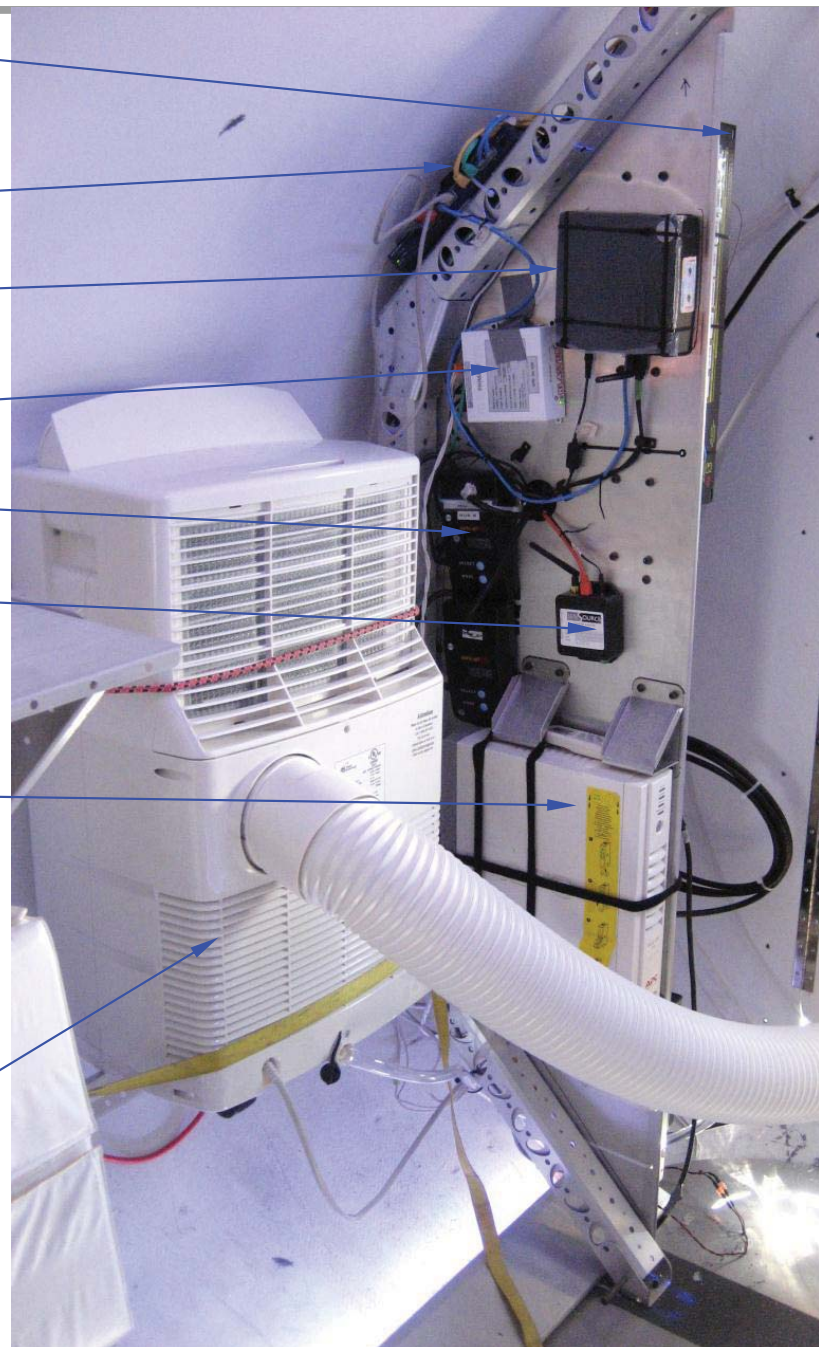
Cargo web walls

Logistics CTBs stacked

# Microhab Instrument Bulkhead



- Ethernet Remote control power switcher
- Ethernet hub
- Mini PC
- Temperature monitors
- Voltage sensors
- CO<sub>2</sub> / humidity monitor
- Light controller (behind)
- Power Supply Unit (PSU) rechargeable battery pack
- Tropos modem (behind)
- Package air conditioner (analog for ECLSS)
- LED light power supply



# D-RATS 2011 Base Camp



## Configurations:

2010 Pressurized Excursion Module (HDU-PEM), Lunar surface destination

2011 Deep Space Habitat (HDU-DSH), Near Earth Asteroid destination

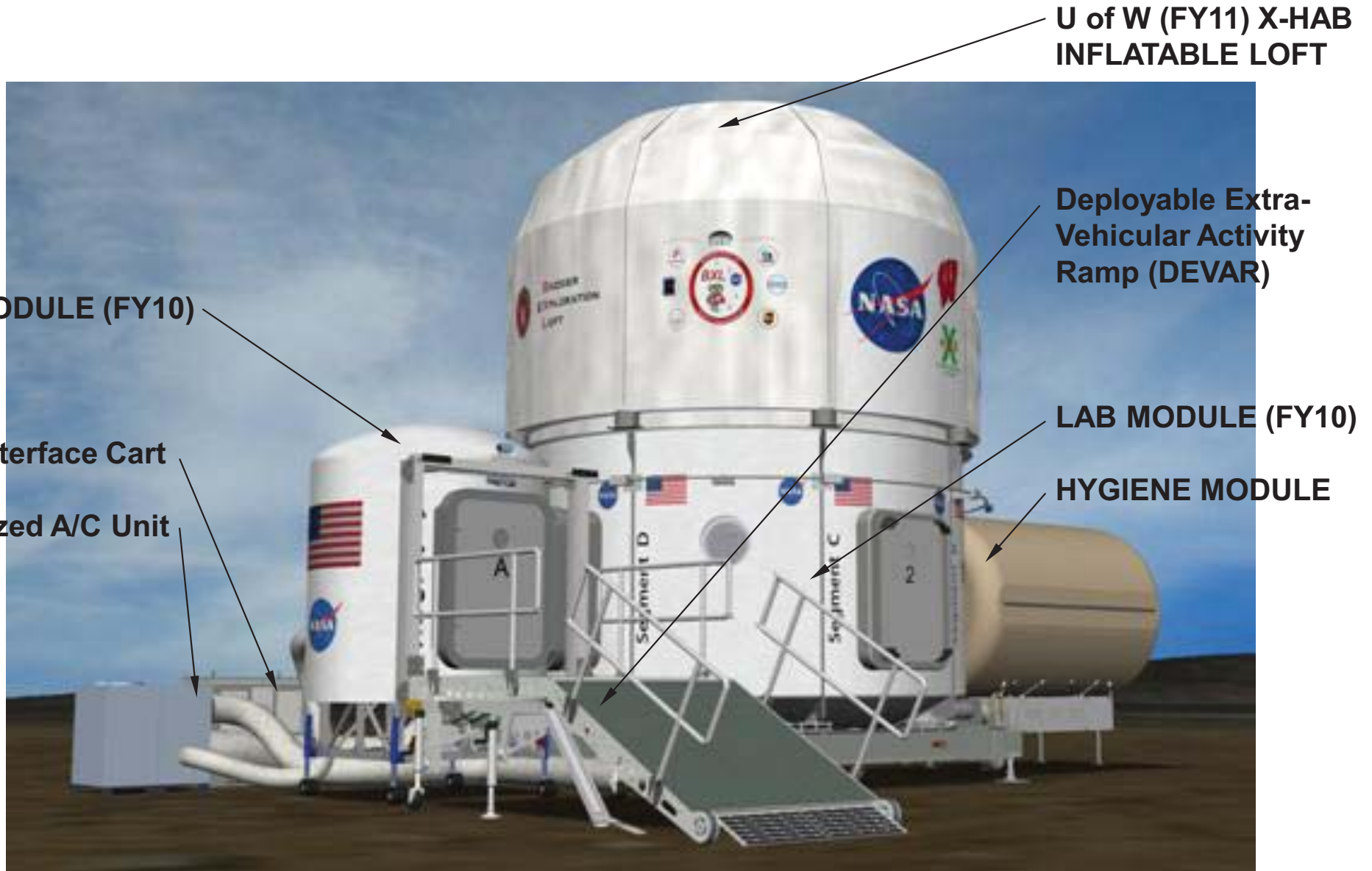
2012 Deep Space Habitat (HDU-DSH), Mission Operations Test



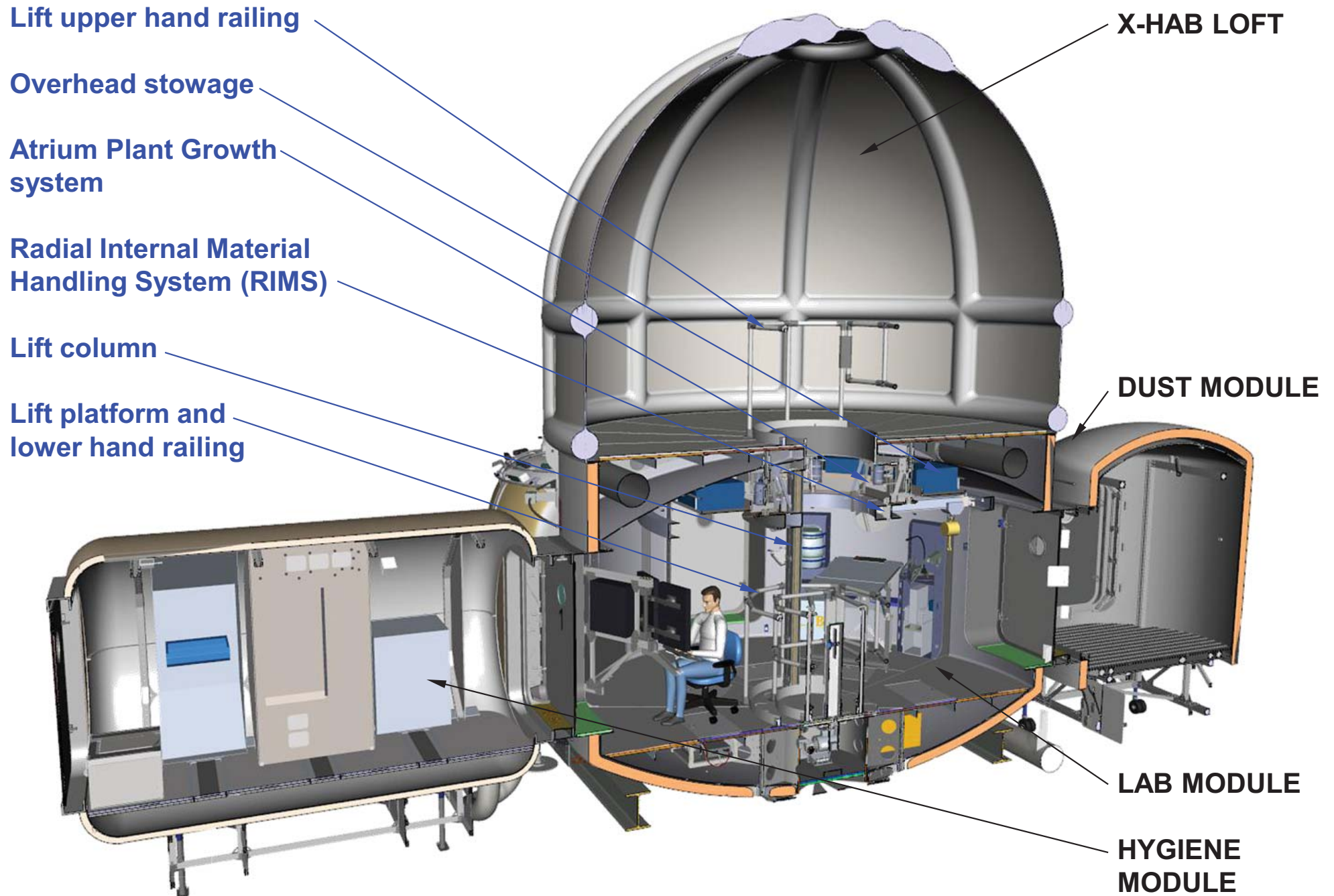
# HDU-DSH Configuration



# HDU-DSH Configuration

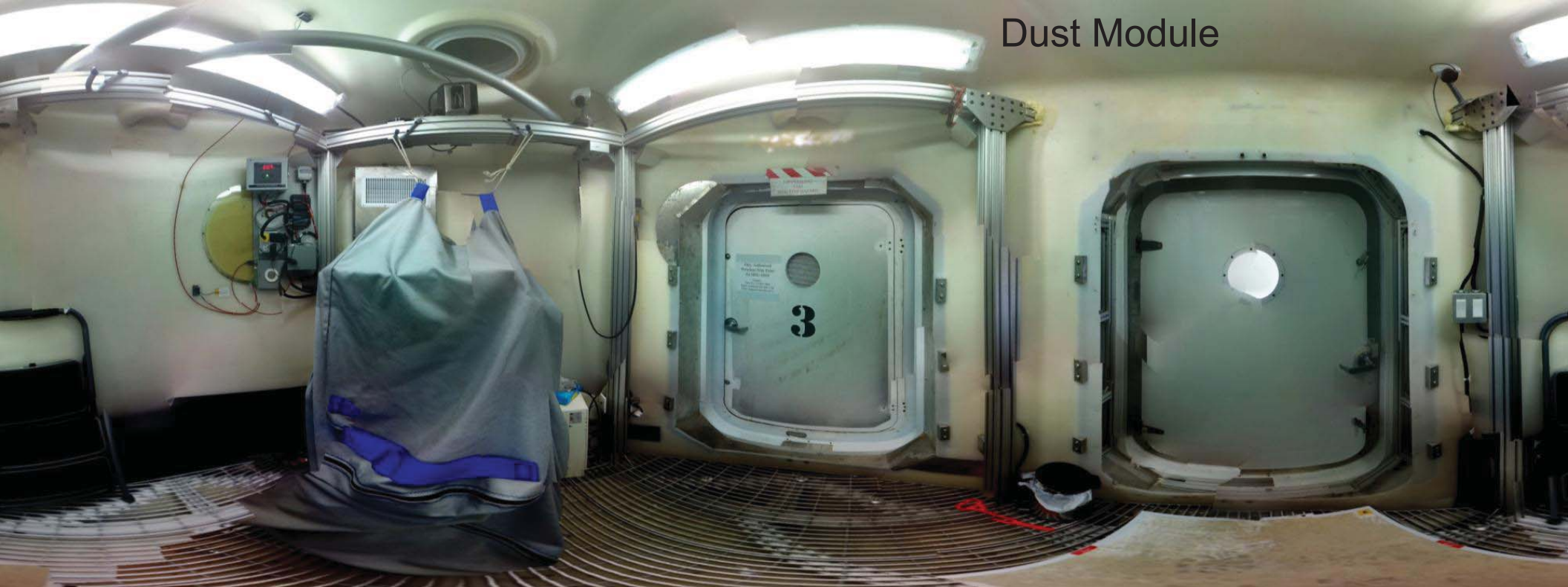


# DRaTS HDU-DSH Configuration





HDU Lab deck



Dust Module



X-Hab Inflatable Loft



Hygiene Module



# HDU-DSH Technology & Innovations Demonstrations

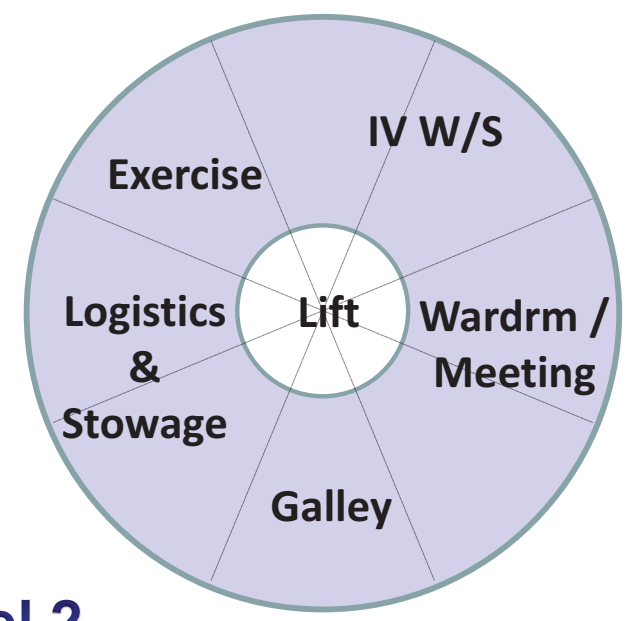
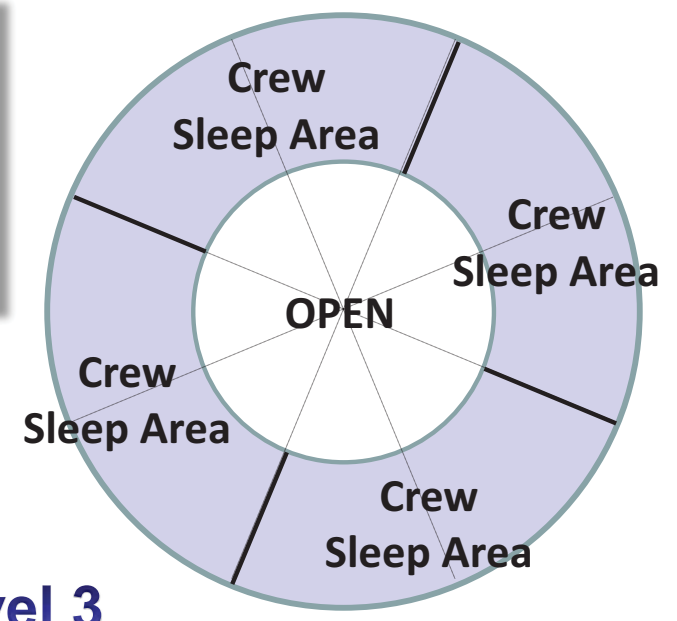
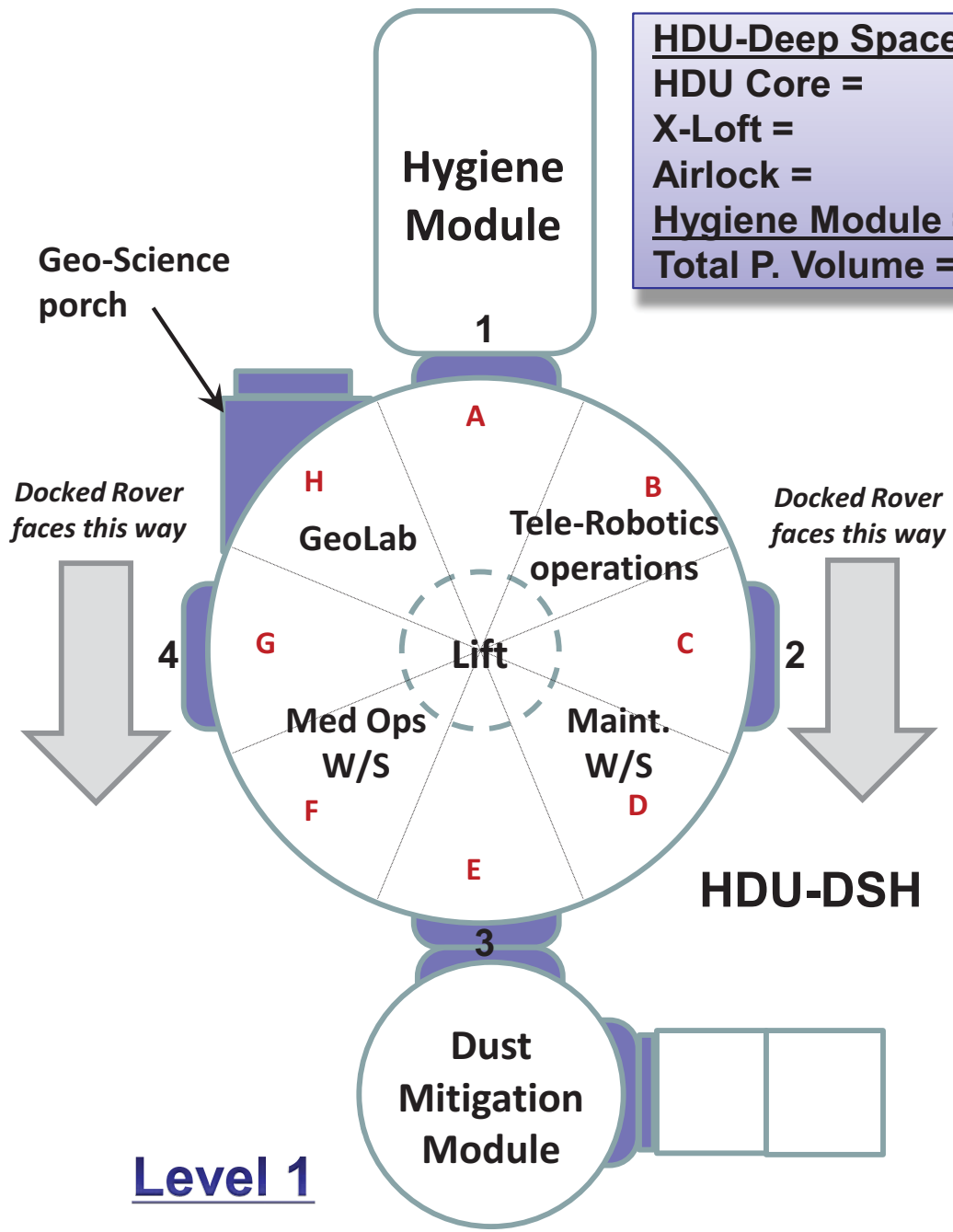


1. Inflatable Loft (X-Hab 2011)
2. Logistics-to-Living
3. Autonomous Ops:
  - A. "Intelligent" Habitat System Management Software
  - B. SHIELD & ACAWS
4. iHab Digital Double (D<sup>2</sup>)
5. Power Generation & PM&D Systems
6. Environmental Protection Technologies
  - A. Dust Mitigation Technologies
    - a. Electrodynamic Dust Screen to repel dust from surfaces
    - b. Lotus Coating
    - c. Vent Hood at the General Maintenance Workstation
    - d. Operational Concept for End-to-End Dust Contamination Management
    - e. Vacuum Cleaner
  - B. Micrometeoroid Mitigation Technologies
    - a. MMOD Hab Impact Monitoring System
    - b. Flat Surface Damage Detection system
  - C. Radiation
    - a. Operational Demonstration of Cargo Transfer Bags to deployable blankets for Radiation Protection and ECLS water purification demo
7. HDU Core Computing, Wireless Communication and RFID
8. Standards-based Modular Instrumentation System: Wireless Sensor Nodes
9. Geo-Science Lab Glovebox/Workstation
10. Telerobotic Workstation
11. General Maintenance/EVA Workstation
12. Medical Ops/Life Science Workstation
13. Partial-G Material Handling
14. Food Production: Atrium concept
15. LED Lighting
16. 3-D Layered Damage Detection System for Surfaces
17. Habitability / Habitation, Hygiene, Trash Management RFID

# HDU-DSH Plan Views



HDU-Deep Space Hab:	
HDU Core =	56.0 m <sup>3</sup>
X-Loft =	69.9 m <sup>3</sup>
Airlock =	8.6 m <sup>3</sup>
Hygiene Module =	14.1 m <sup>3</sup>
<b>Total P. Volume =</b>	<b>148.1 m<sup>3</sup></b>



# Geo-Lab Workstation



Overhead axis camera – remote controllable locally and from ground crew

Screen computers

Microscope

Cameras and other instruments through side ports

Glove box with three sample pass through airlocks to the exterior

Control box

# Geo-Lab Glovebox



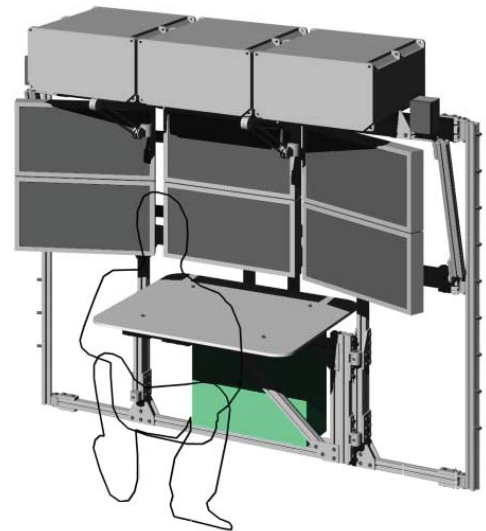
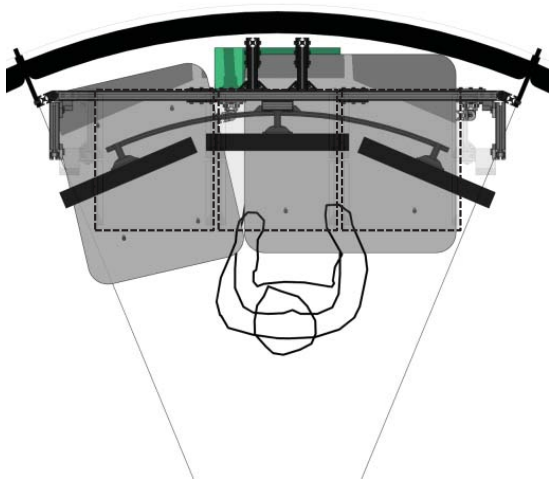
# Robotically-Assisted GeoScience Operations



# TeleRobotics Work Station Early Design



# Telerobotics Workstation Final Design



Shuttle middeck lockers

8020 frame

Monitors

Main table deployed (Extended Type)

CPU location (under construction)

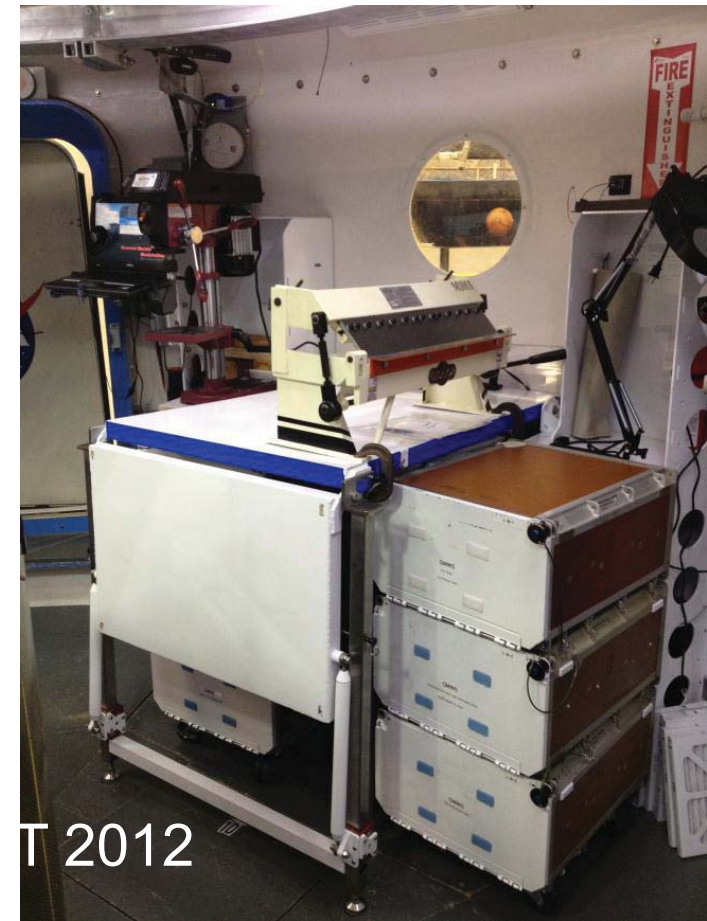
# General Maintenance Workstation



D-RATS 2010



D-RATS 2011



MGT 2012



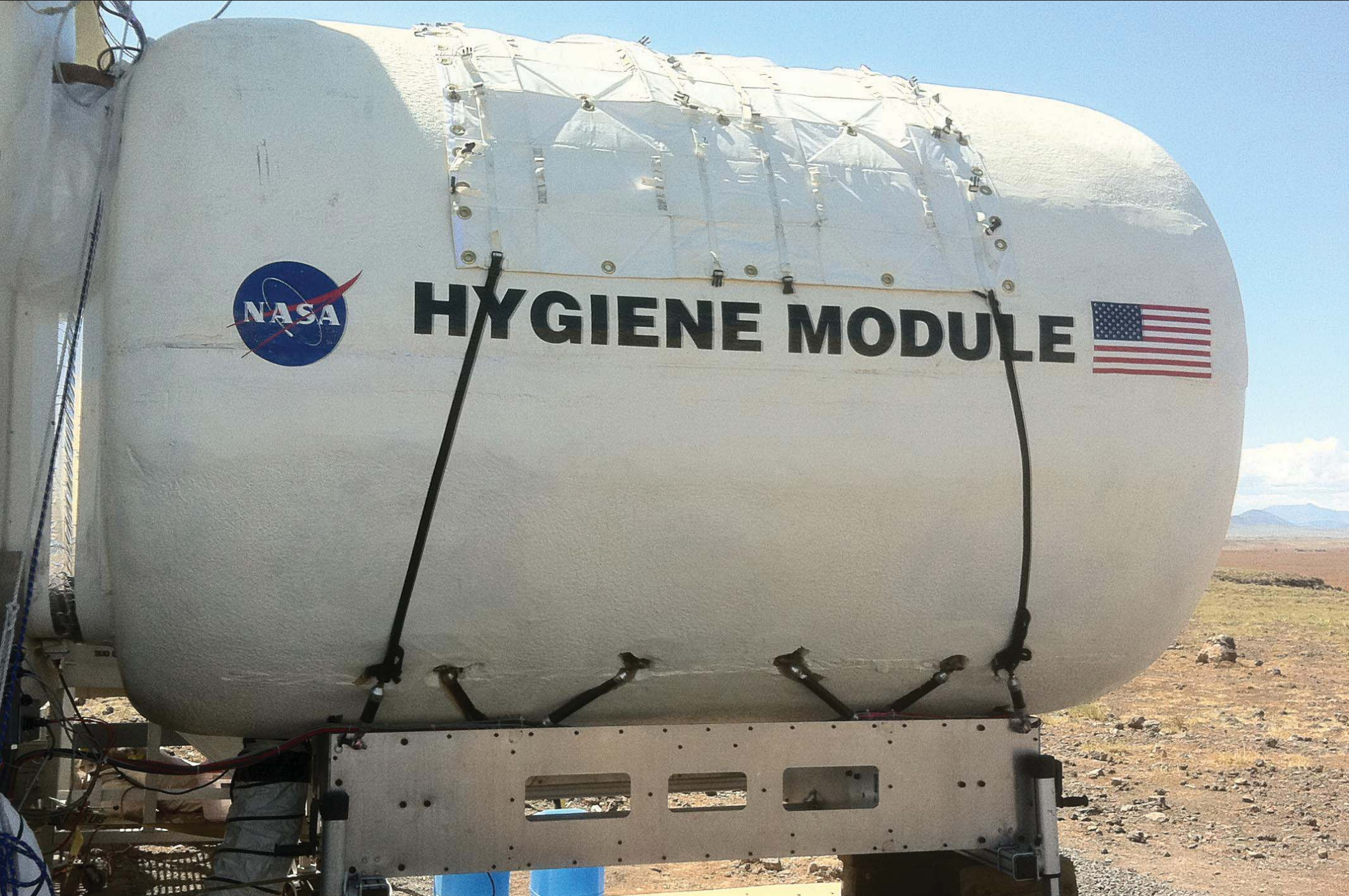
# Repair Work at Gen Maintenance W/S



# Dust Containment at General Maintenance W/S

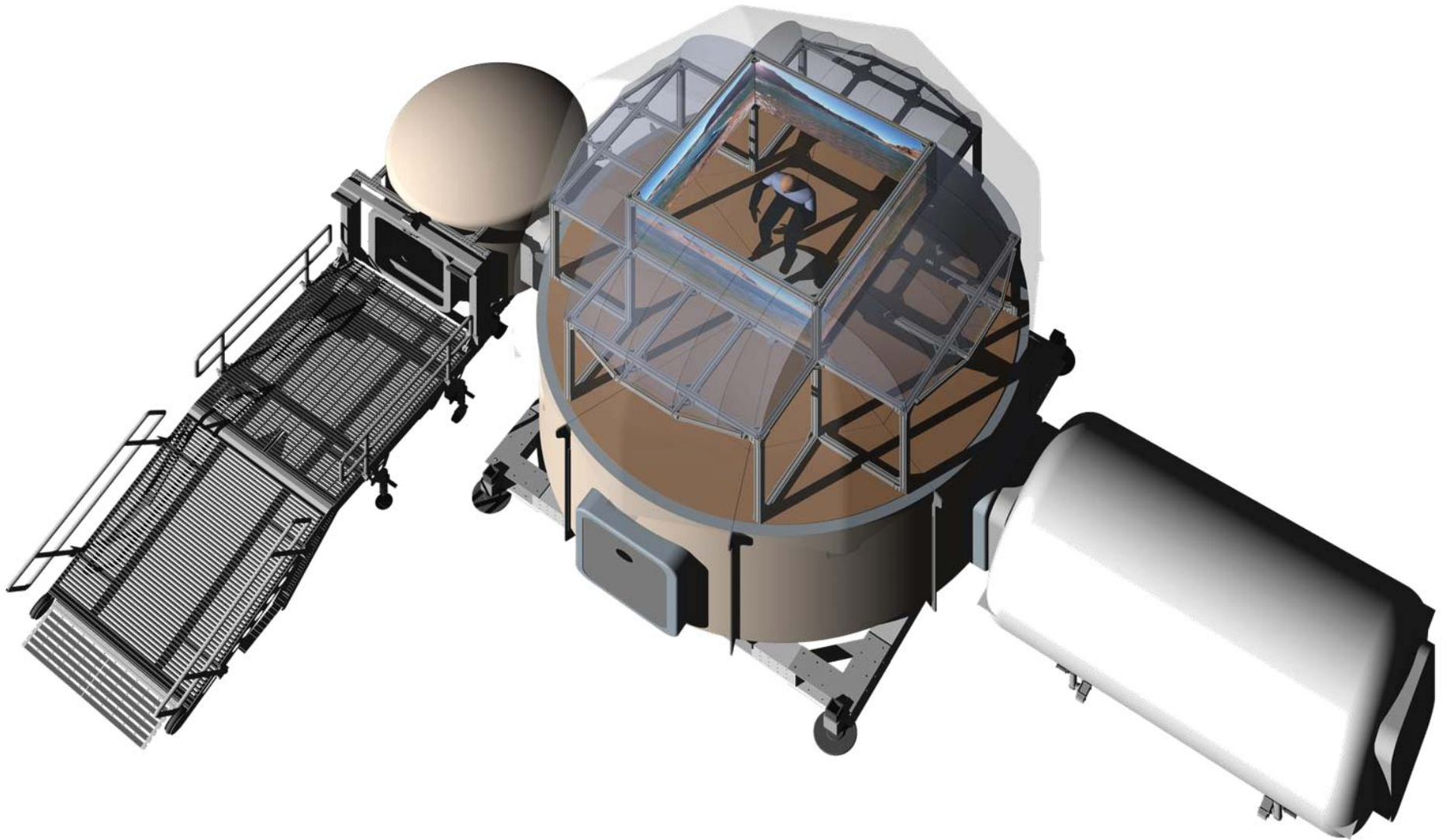


# Waste and Hygiene Module





# X-Loft Living Space

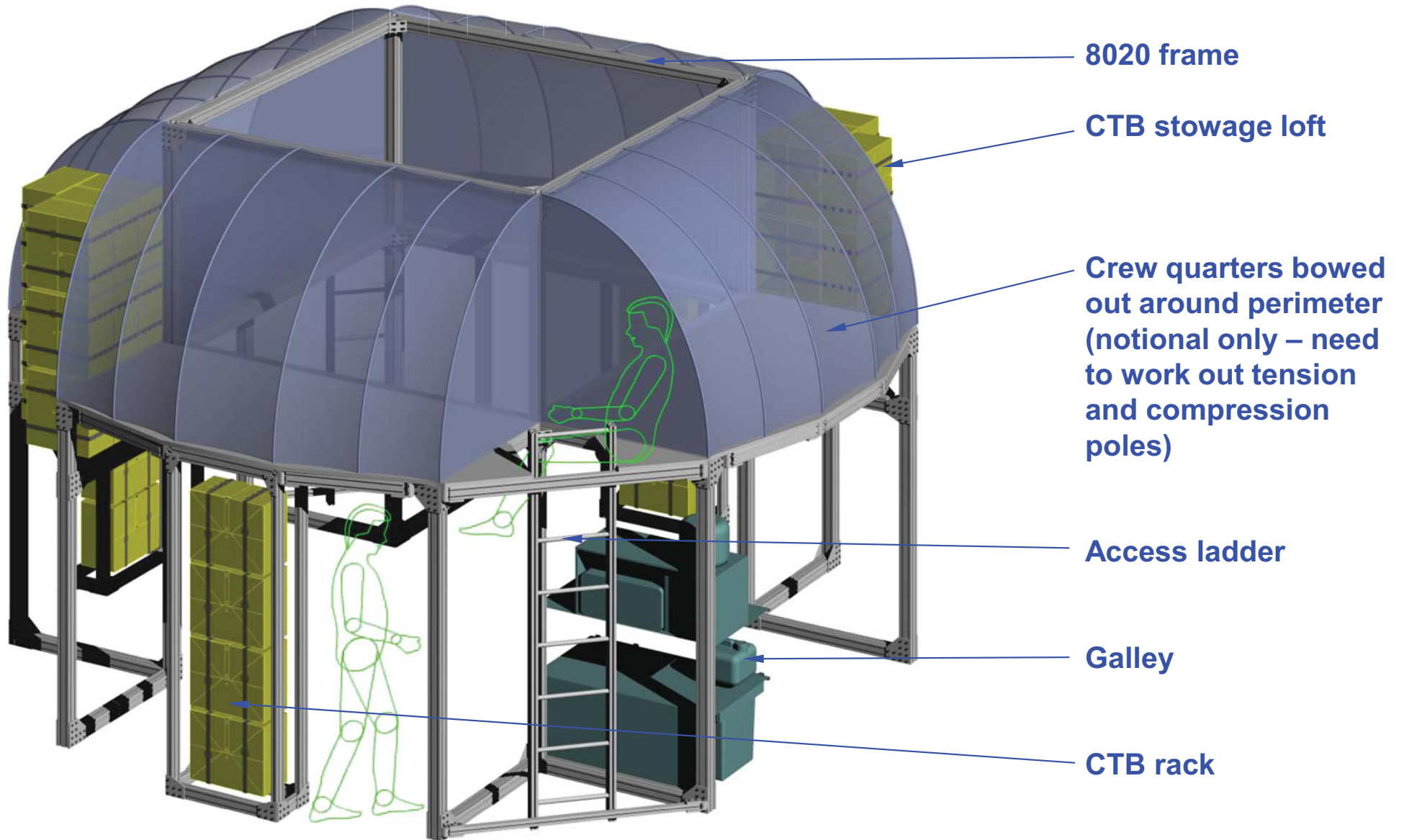


# X-Hab Loft Early Designs

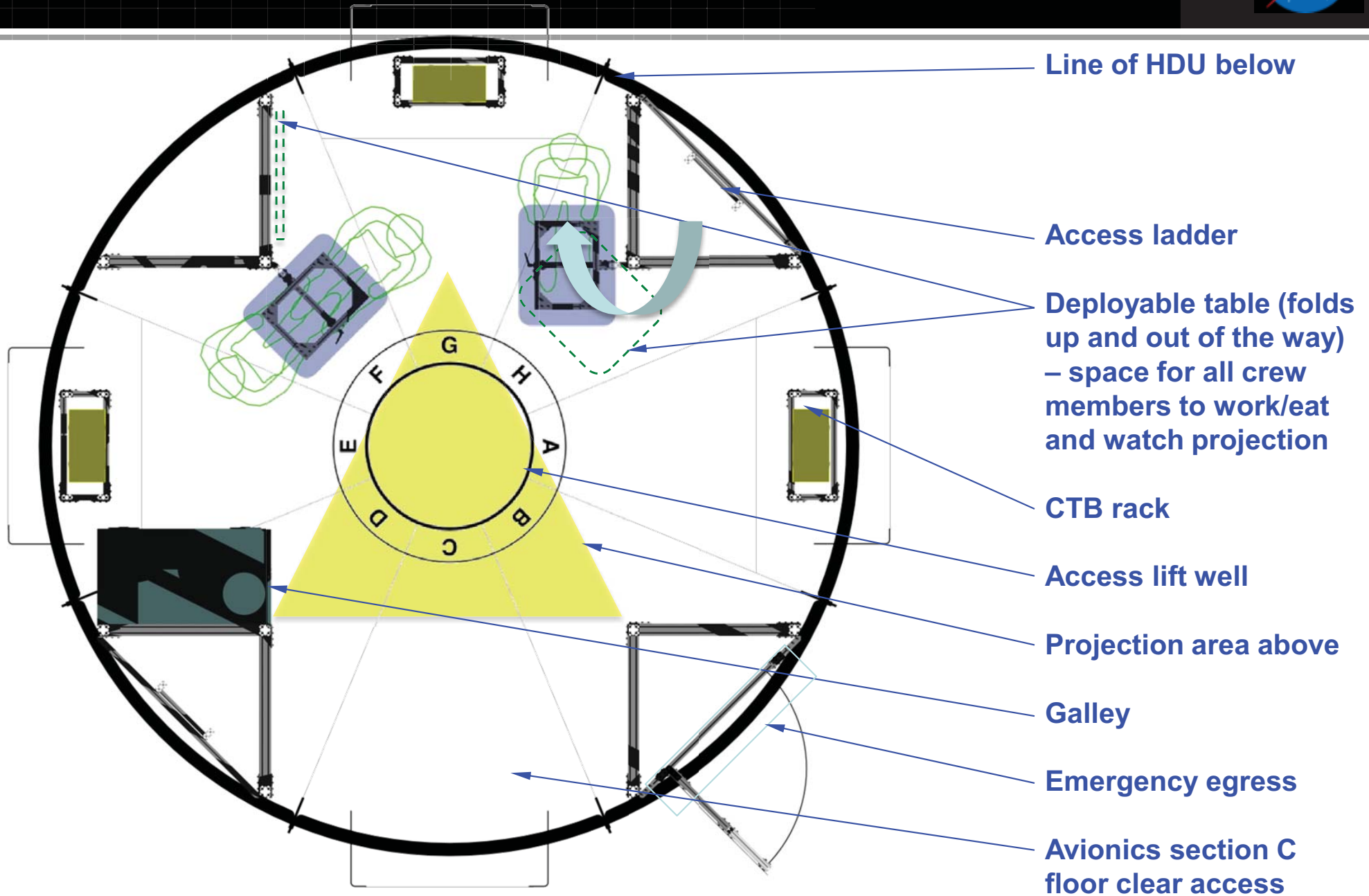


Photo: James W. Young

# X-Loft Final Design

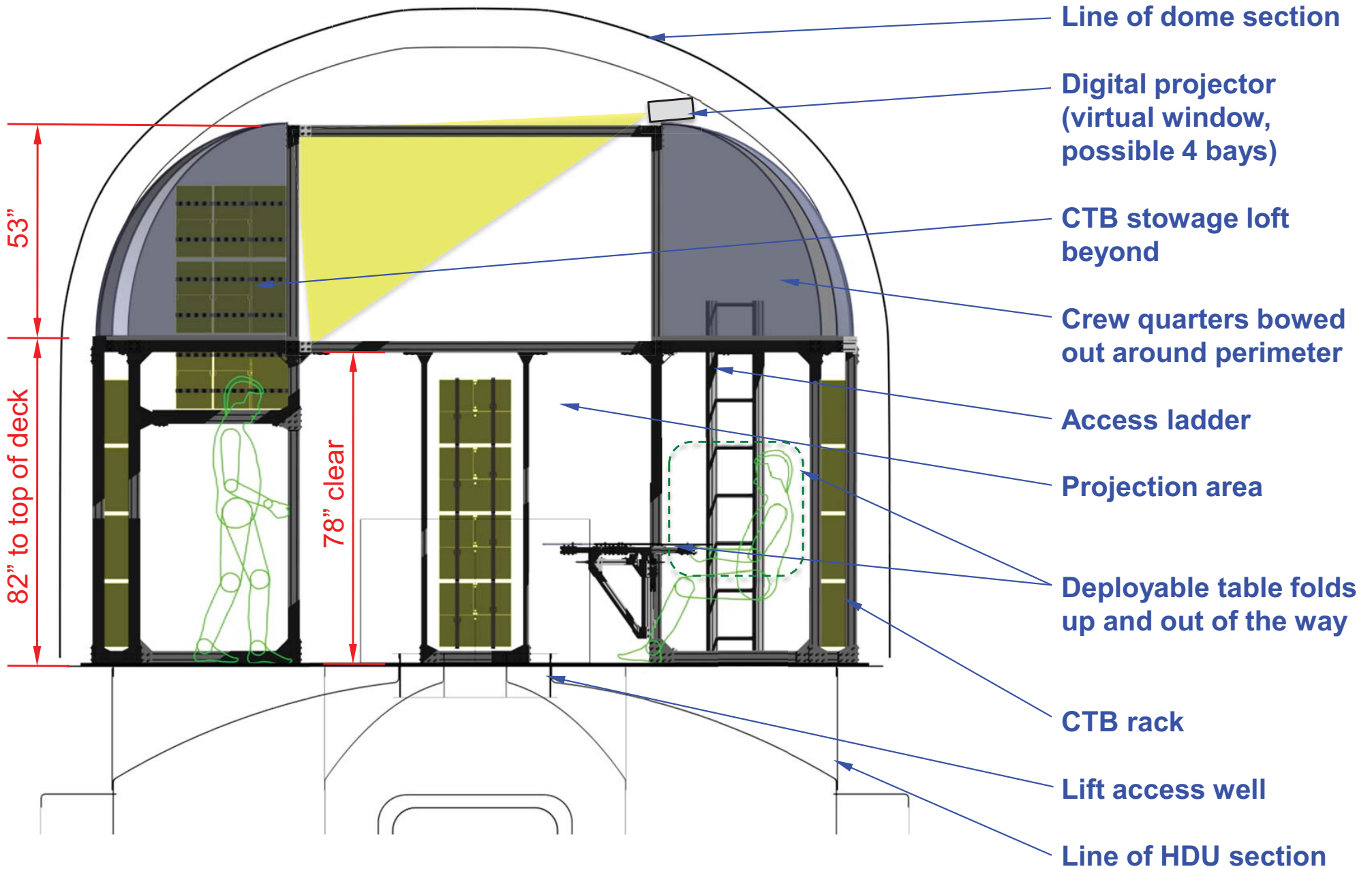


# X-Loft Plan View





# X-Loft Section View Showing Projection Surface



# X-Loft Final Design (360 degree image)



Dome above

Crew Quarters level

Habitation level (under construction)



Deployable table deployed

Deployable table stowed

# X-Loft Galley / Wardroom



Wardroom

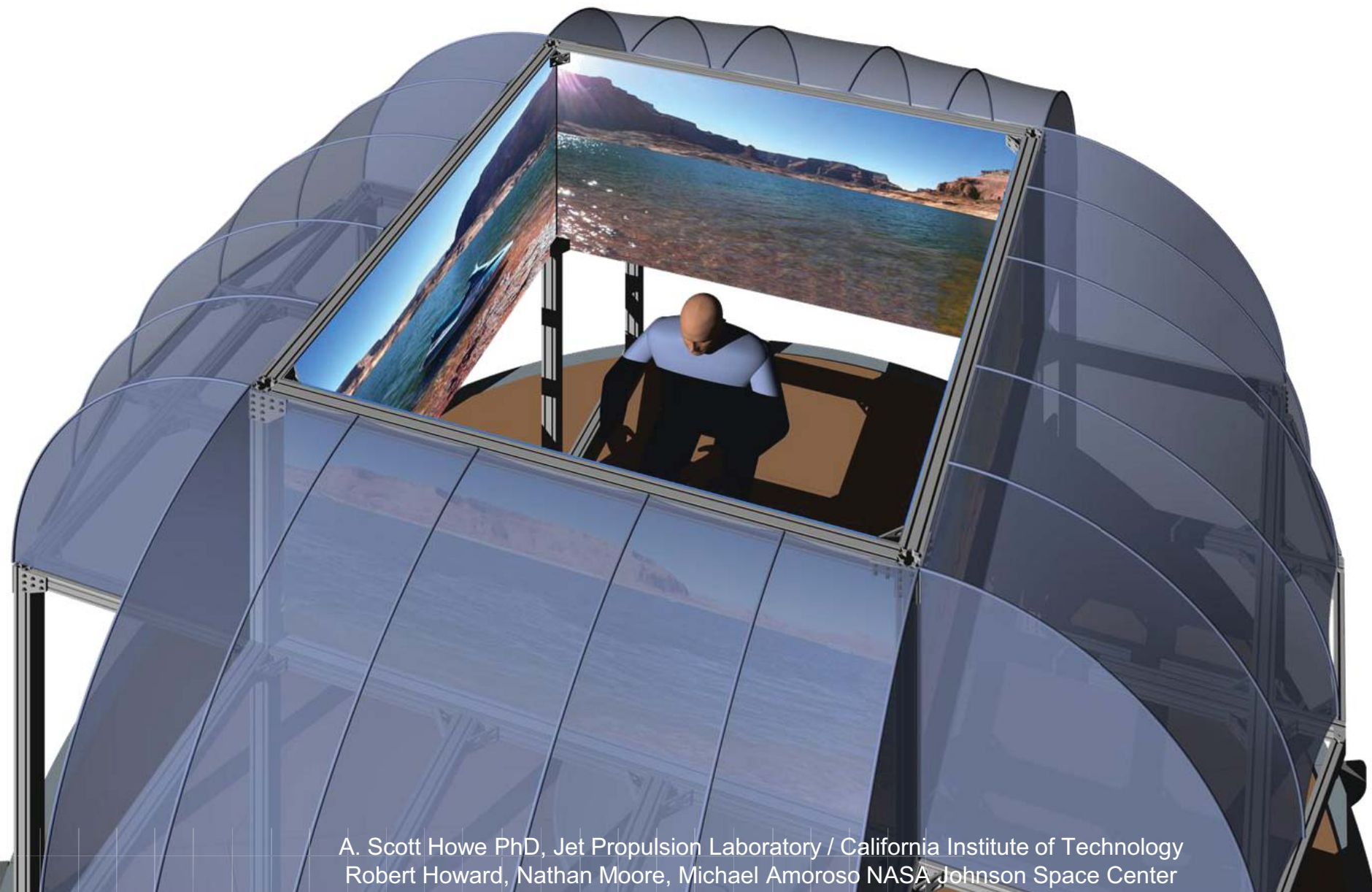


Galley

# X-Loft Crew Quarters



# Virtual Window Function: Remote Vehicle Piloting & Control



A. Scott Howe PhD, Jet Propulsion Laboratory / California Institute of Technology  
Robert Howard, Nathan Moore, Michael Amoroso NASA Johnson Space Center

# Virtual Window Crew Interaction



Dome above

Projection screens  
(back of crew quarters)

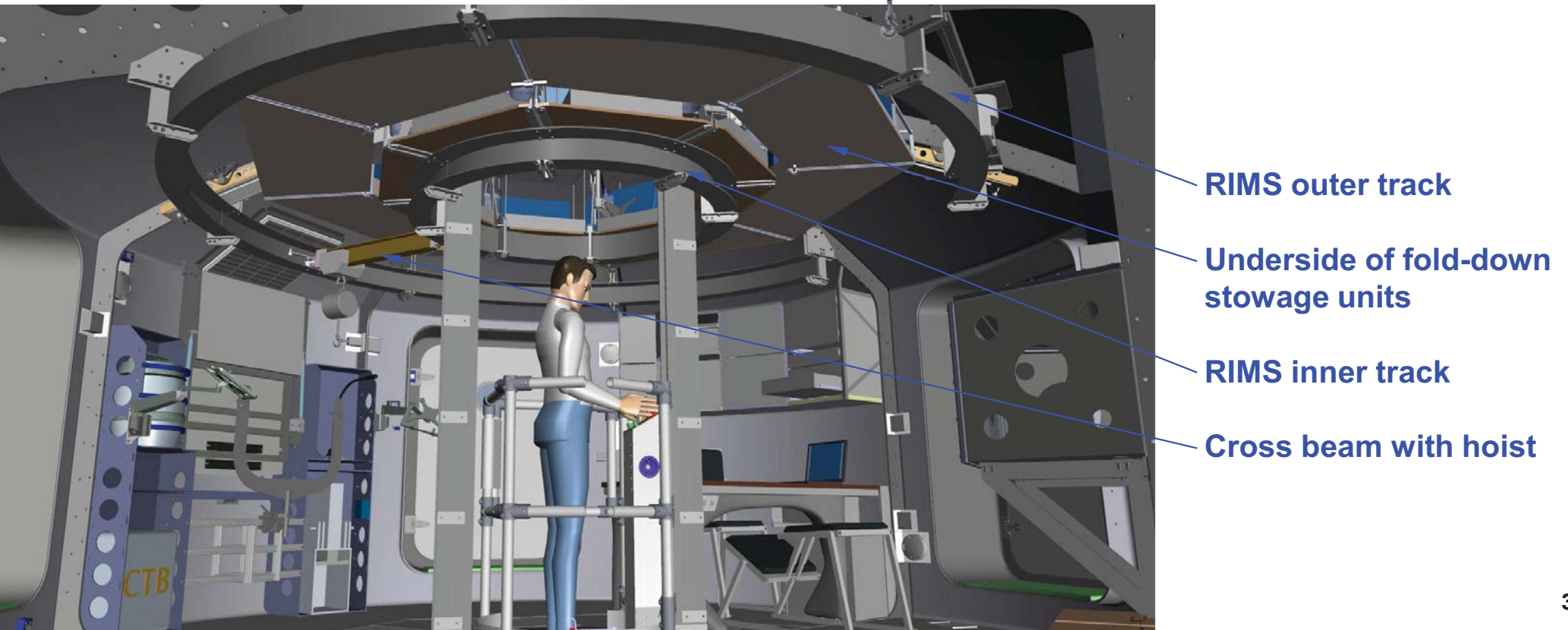
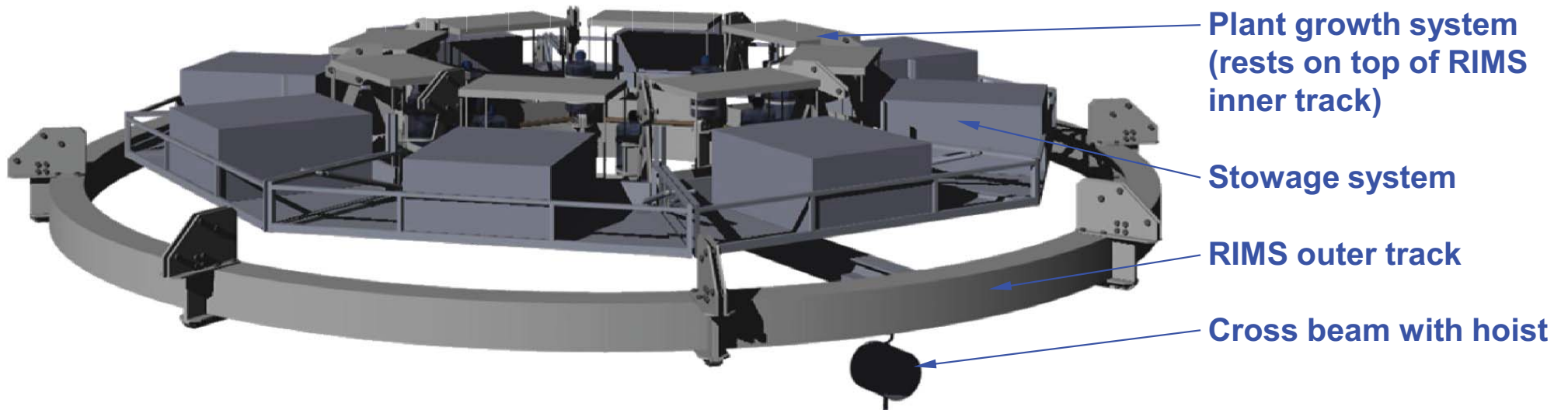
Digital projectors  
(mounted low in this case – could be mounted above)

Remote crew display

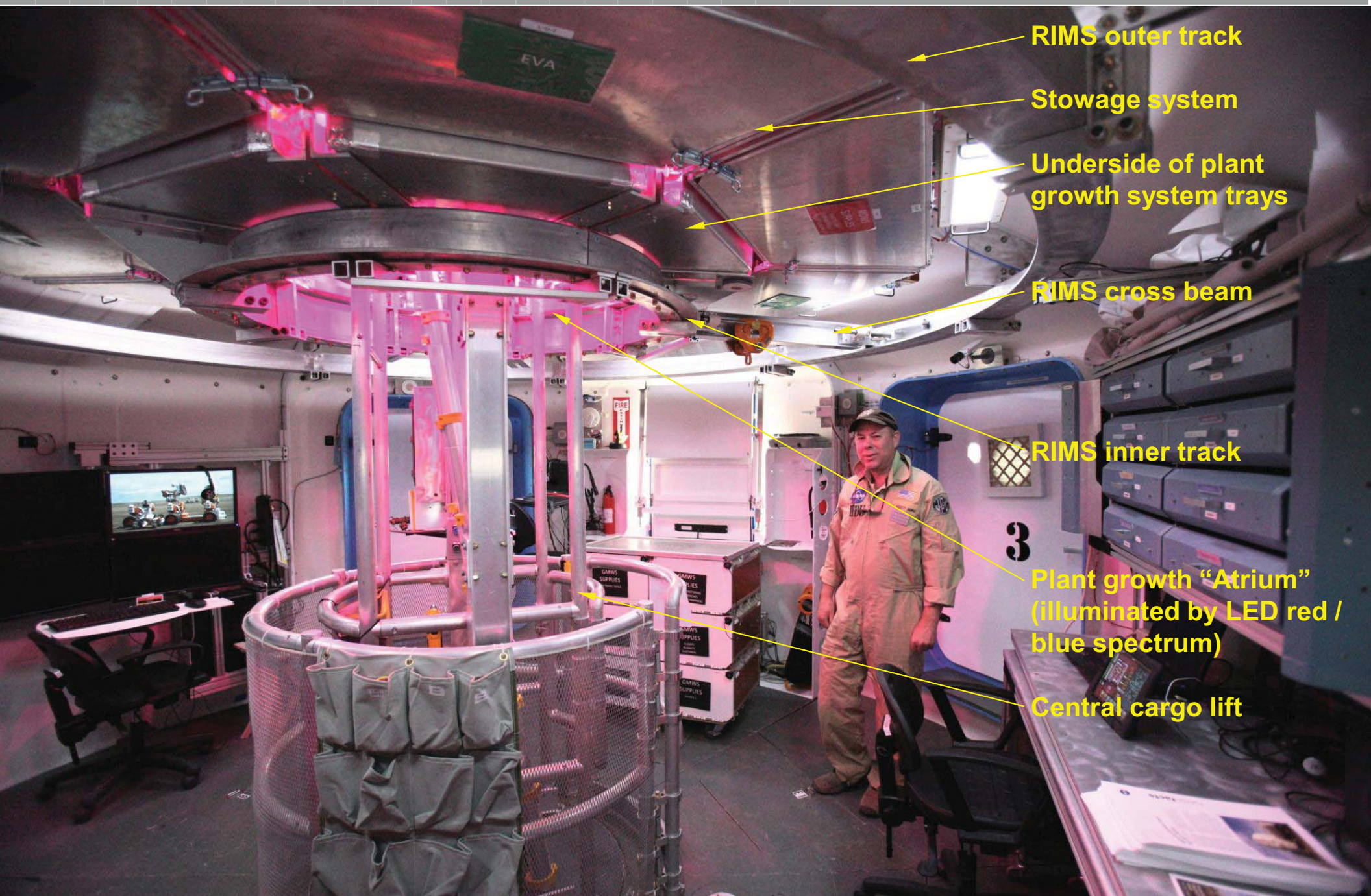
X-Loft deck below

Interactive crew member

# Radial Internal Material Handling System (RIMS)



# Radial Internal Material Handling System (RIMS)



RIMS outer track

Storage system

Underside of plant growth system trays

RIMS cross beam

RIMS inner track

Plant growth "Atrium"  
(illuminated by LED red / blue spectrum)

Central cargo lift

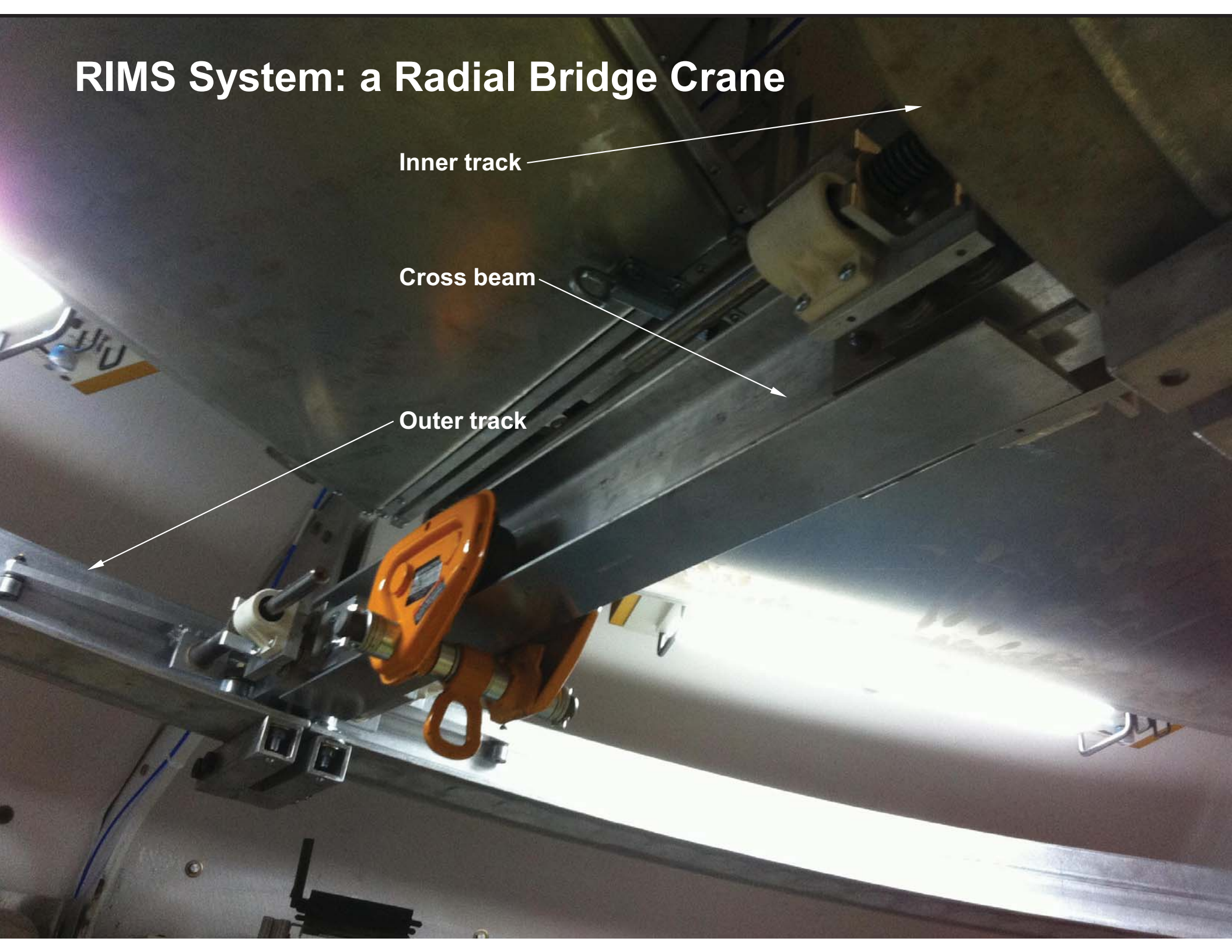


# RIMS System: a Radial Bridge Crane

Inner track

Cross beam

Outer track



# EVA Innovations



Work frame

HDU interior hatch

Suit stand

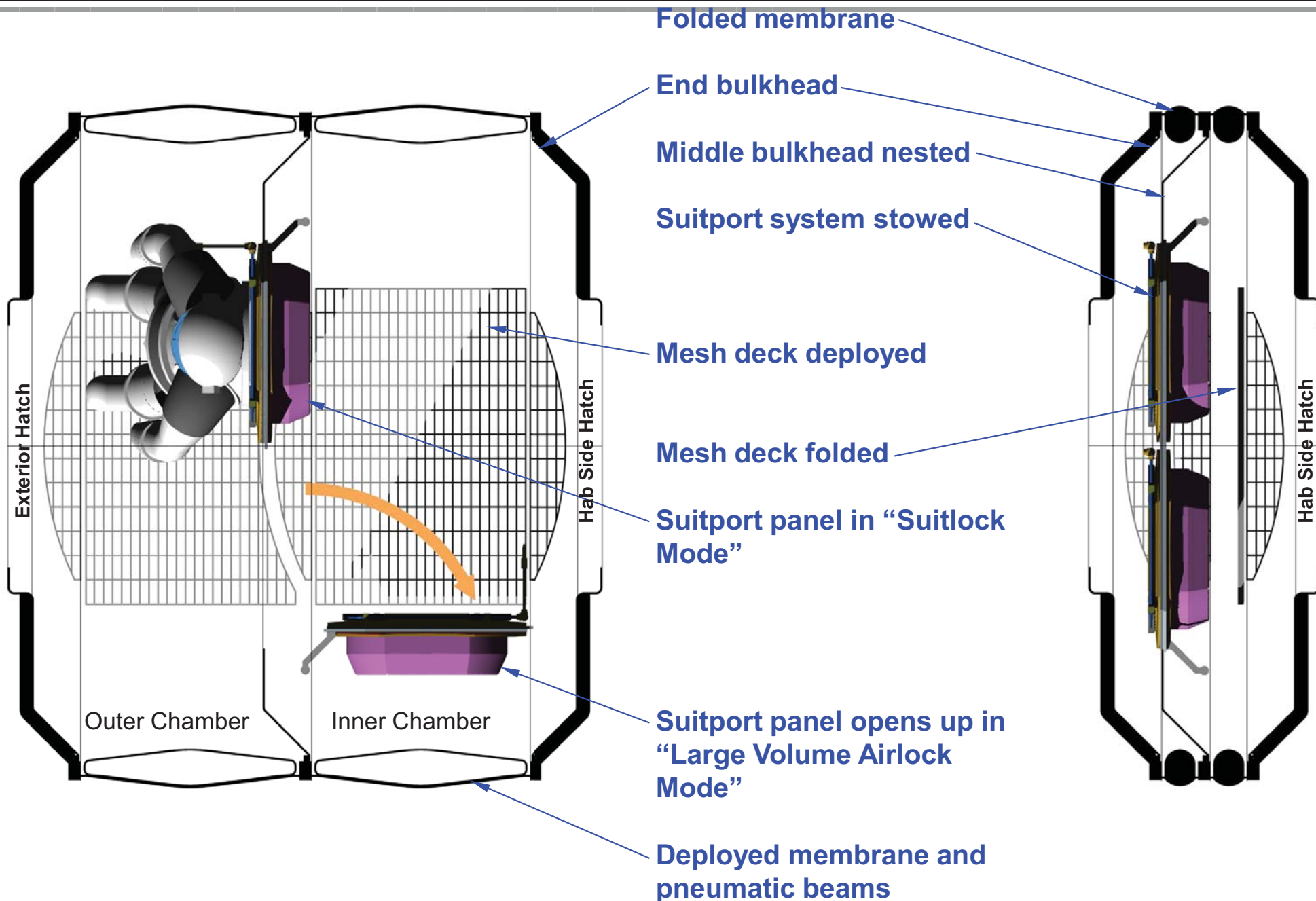
Pressure suit

Dust control

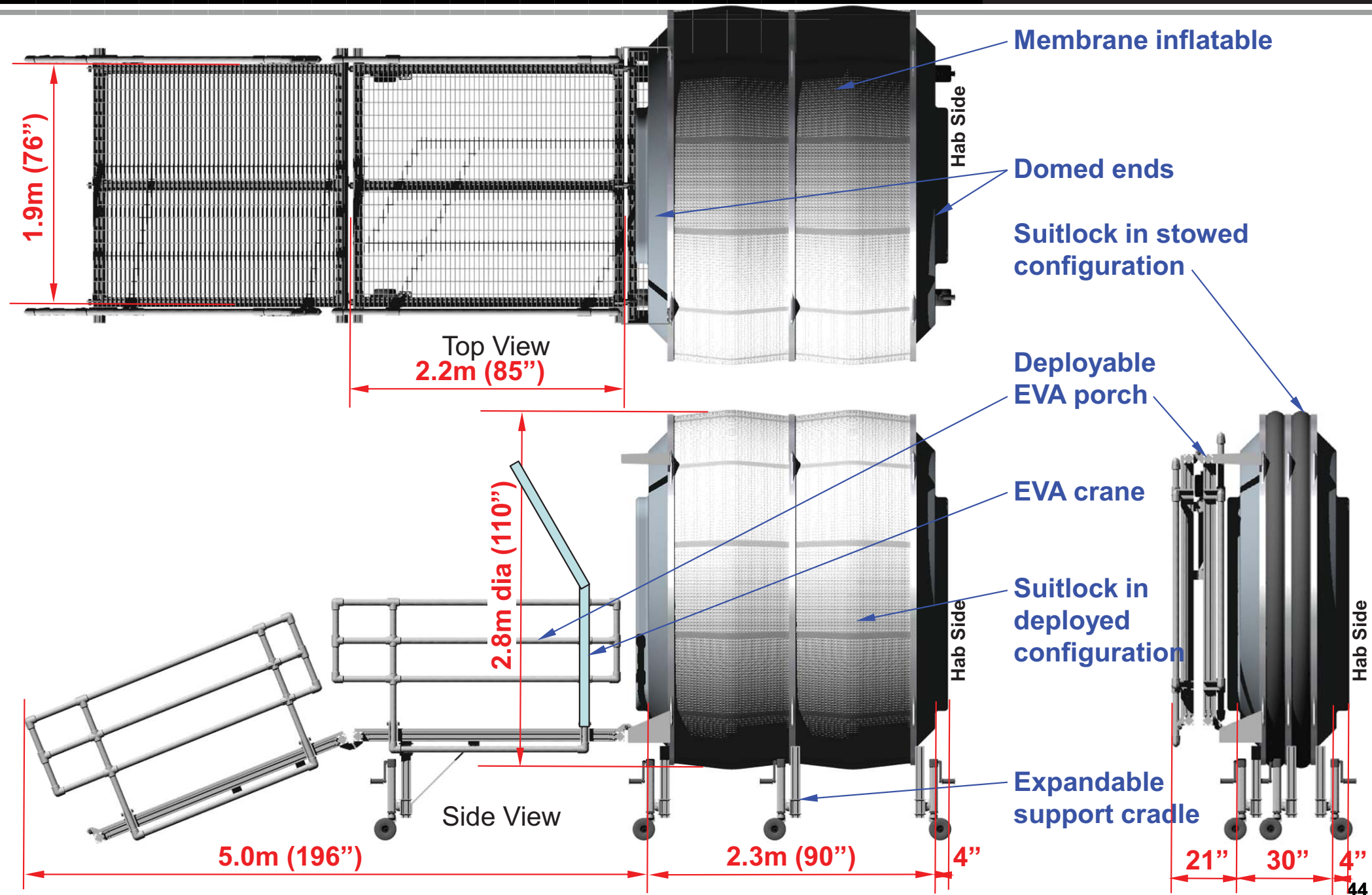
Egress hatch

EVA equipment stowage

# Suitlock: Conversion / Deployment



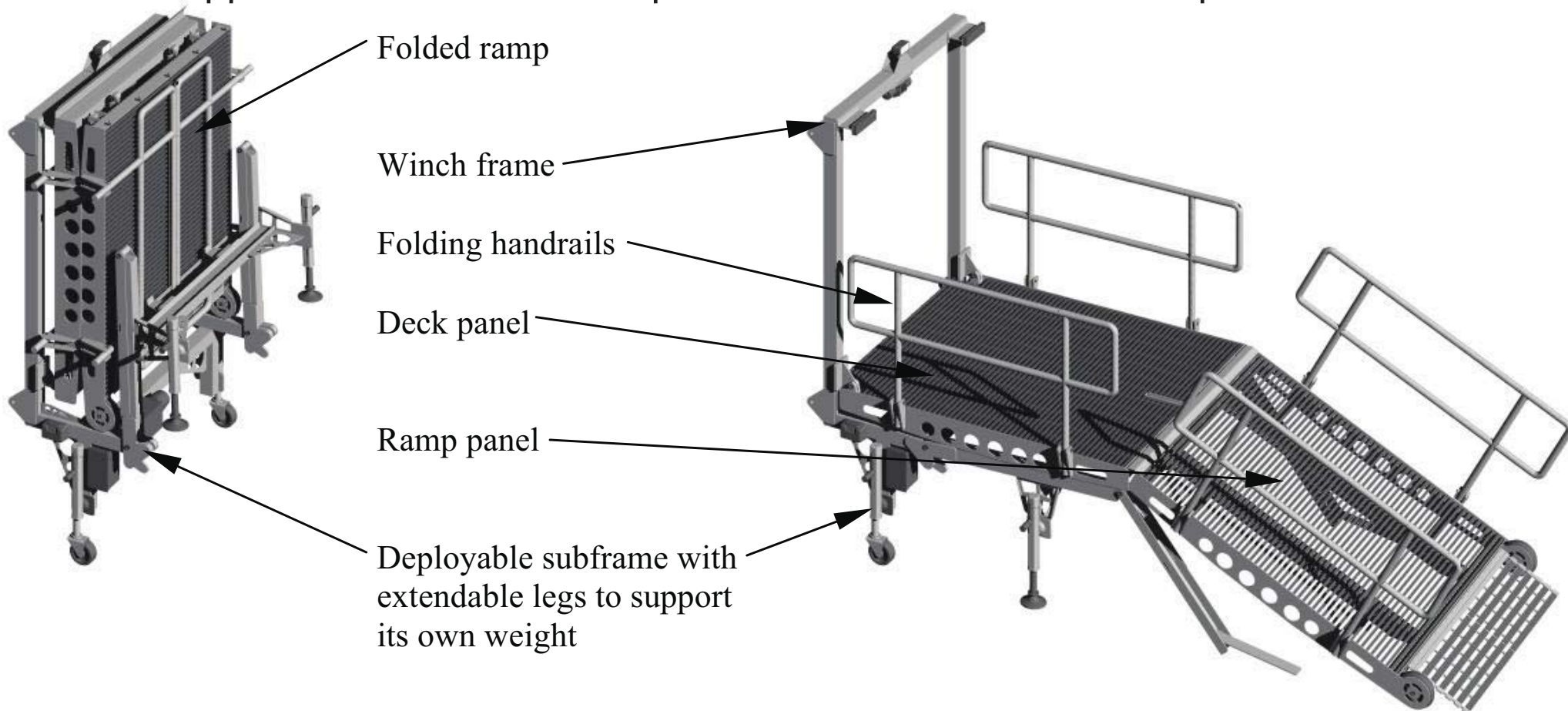
# Suitlock: Overall Dimensions



# DEVAP Requirements



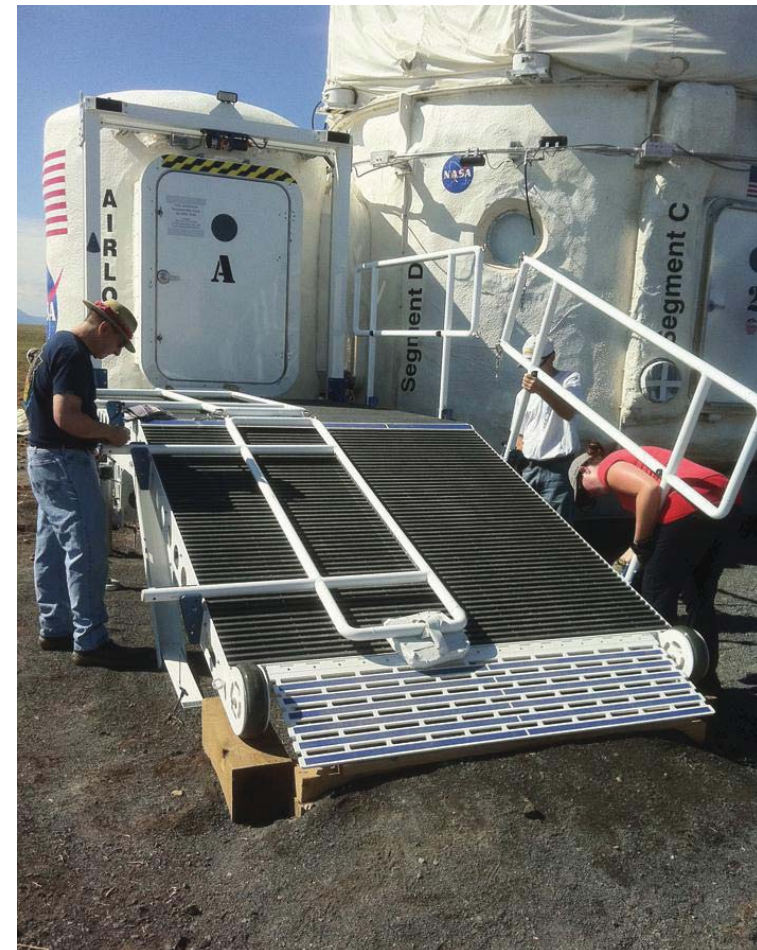
- Interface with suitlock bulkhead structure
- Manually deployable / stowable by two persons
- Can be latched or unlatched by a person from ground level
- Have lugs to permit lifting by crane by itself, or in tandem with suitlock
- Gratings on deck to permit dust to fall freely to the ground beneath
- Support a load of 100 lbs/sq ft on the Main Deck and Ramp



# DEVAP Operational Prototype



- DEVAP shown with augmented dirt mount with wood blocks at base (left), and handrails partially deployed (right)



# DEVAP Operational Prototype



- DEVAP shown during deployment / stow sequence



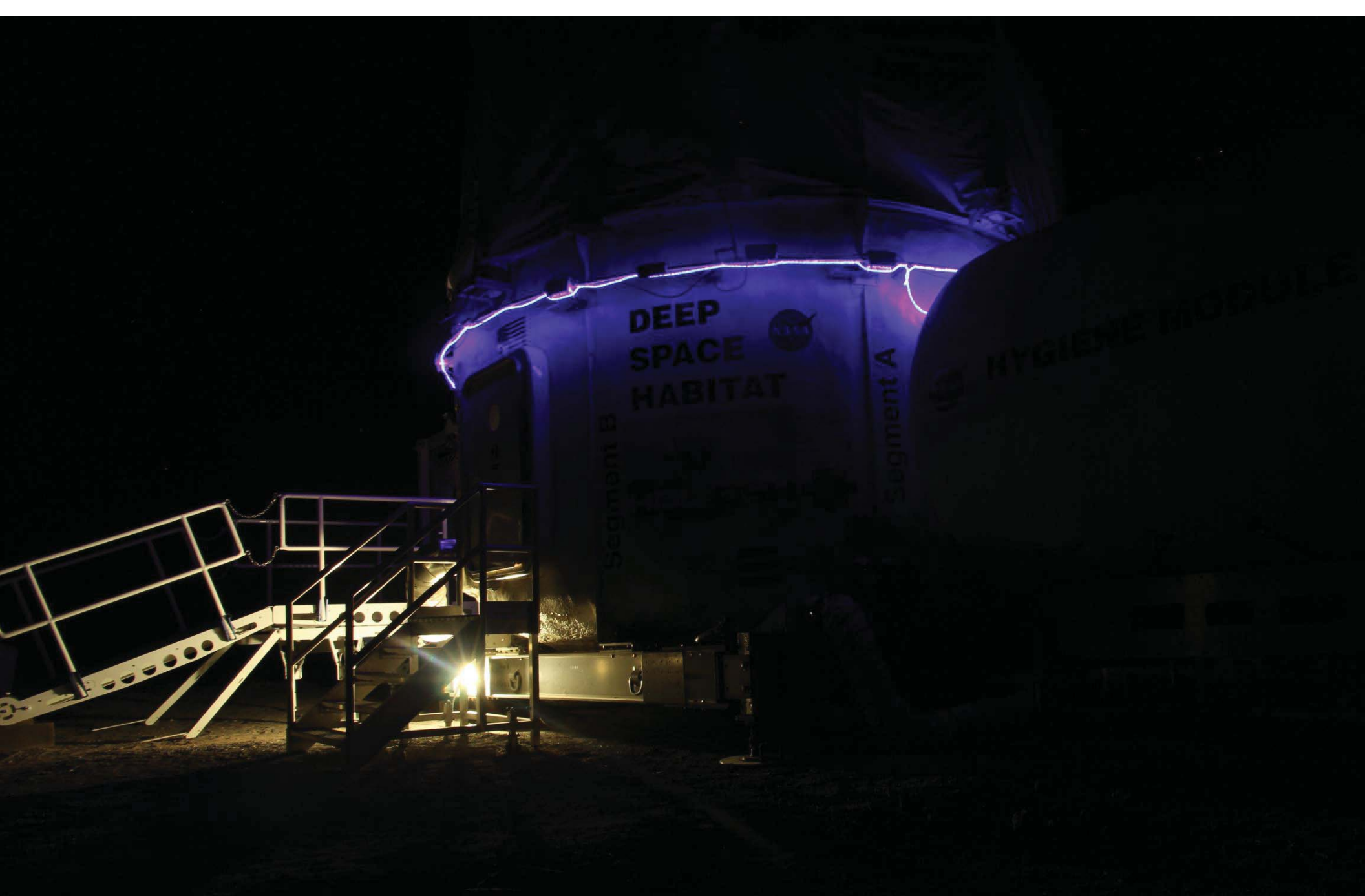


- Design is a cycle that includes build, integrate, test, evaluate, repeat
- Build many versions
- Six month cycle works very well to keep team excited and motivated
- Keep things functional, but not expensive during design cycles (Home Depot effect)
- Design to a mission, but consider multifunction for other scenarios as well
- NASA is not a jobs program
- Powerpoint engineering will get you nowhere
- Never list requirements before you build !!!!
- Build and test to find out what the requirements are
- Put student interns in the critical path – they stretch to meet expectations
- Don't rush to flight – take time to get it right using many prototypes



# The Team





**T h a n k y o u**