NASA
HABITAT DEMONSTRATION UNIT (HDU)
DEEP SPACE HABITAT ANALOG

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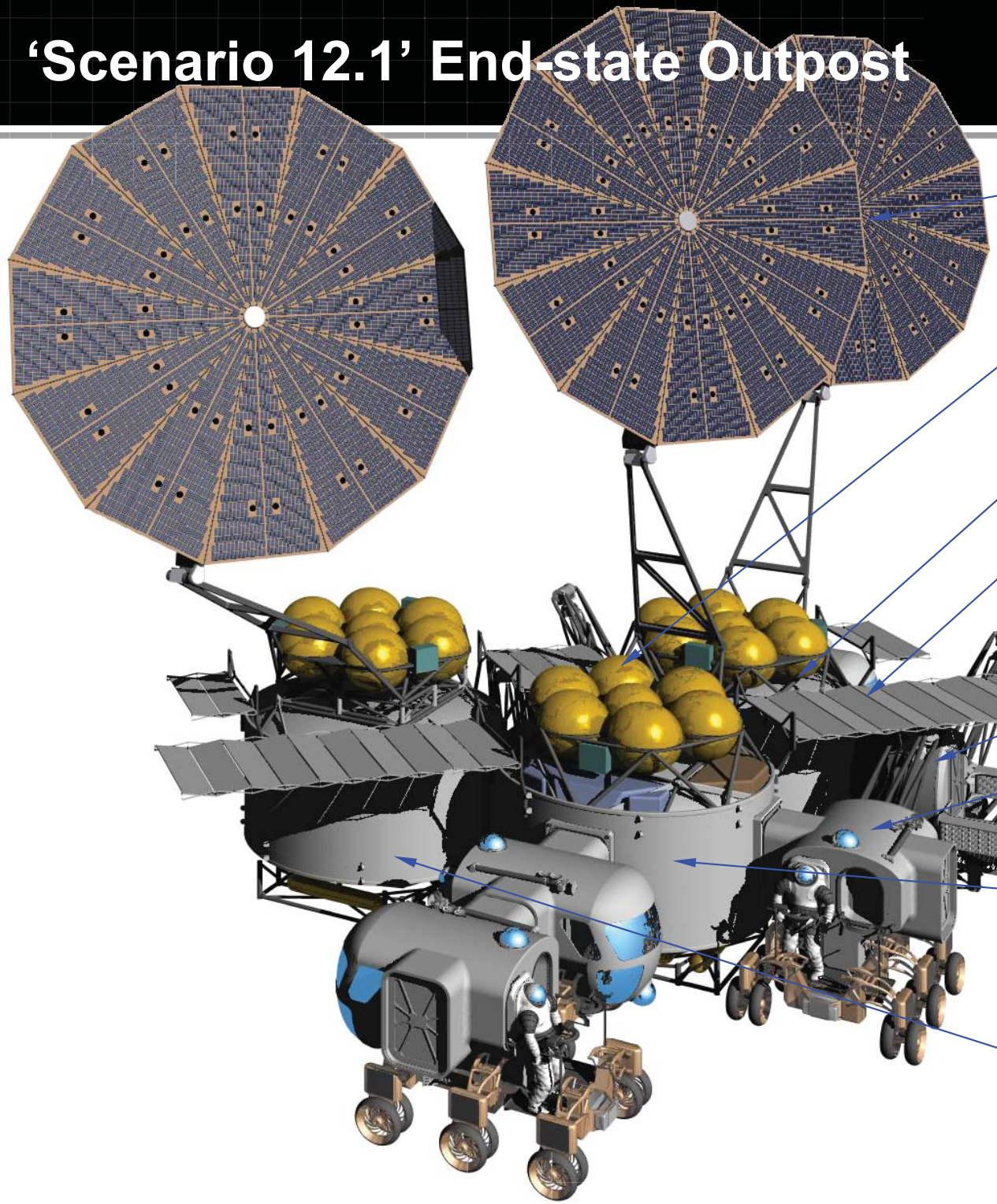
Habitat Demonstration Unit

- 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

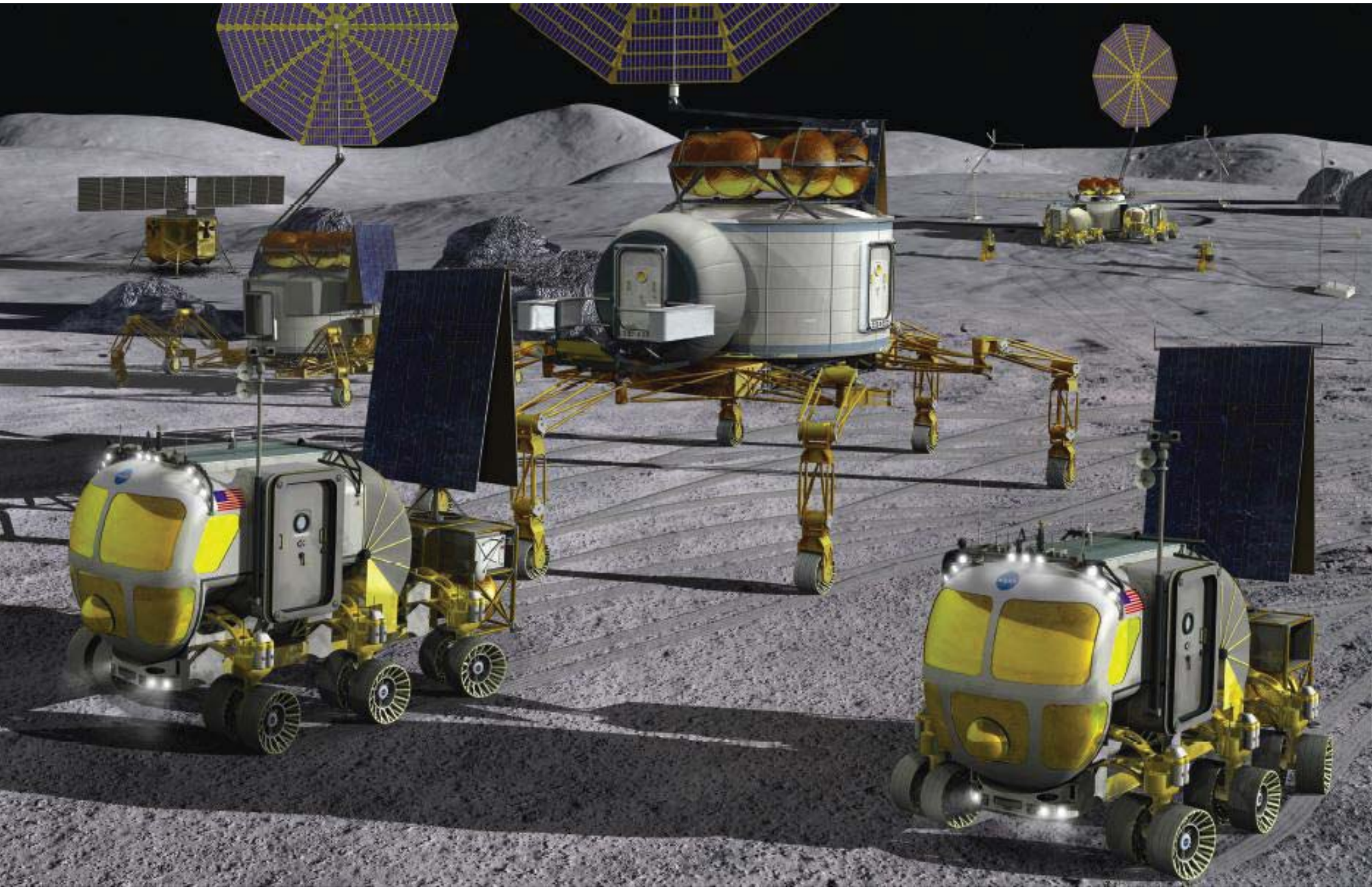
Remote Robotic Assembly

‘Scenario 12.1’ End-state Outpost

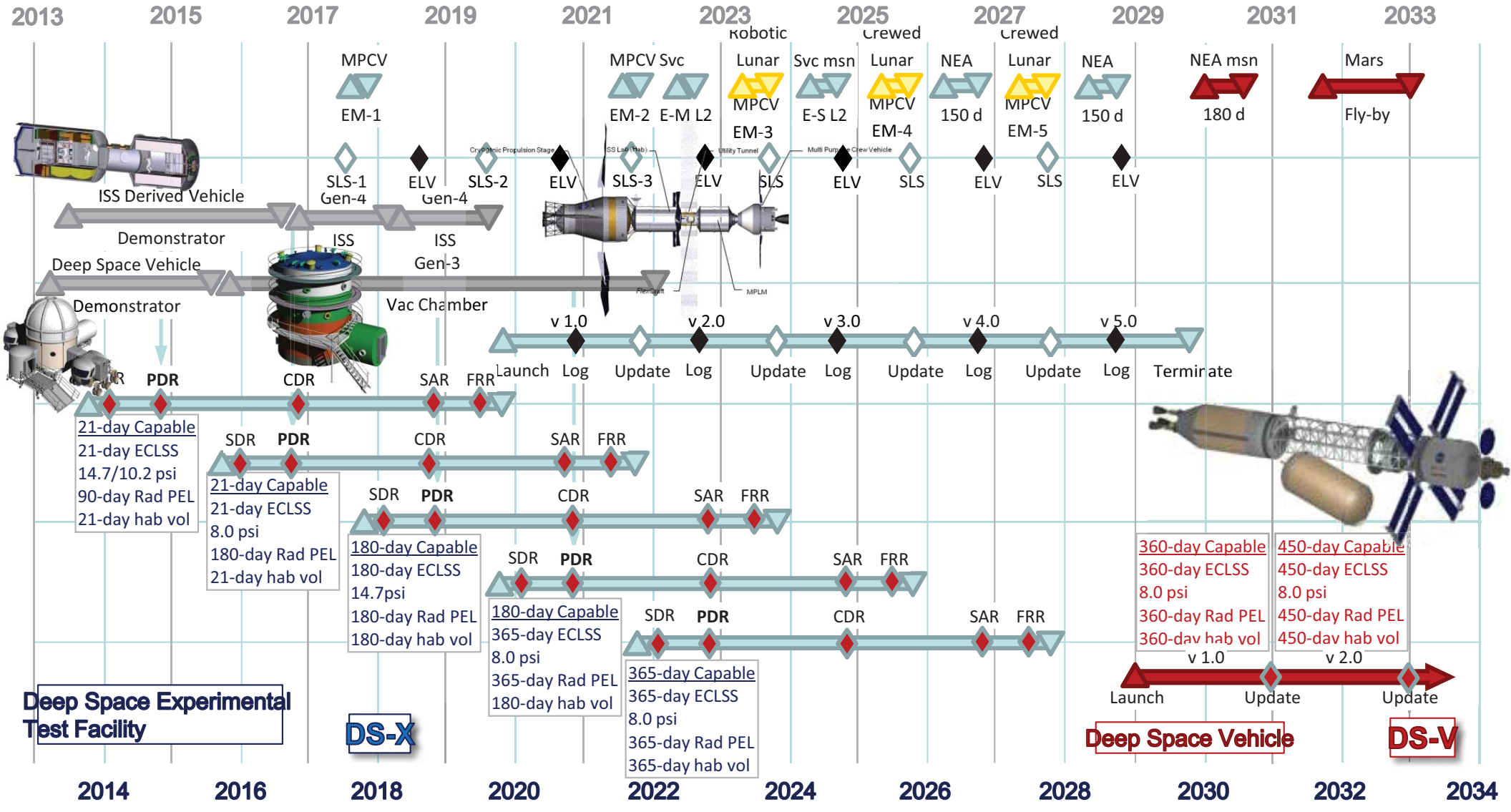


- Solar arrays
- Fuel cells and reactant tanks
- PEM excursion module
- Radiators:
  - PCM 24m^2
  - PEM 5m^2
  - PLM 5m^2
- Inflatable airlock
- LER (4 x)
- PCM core module
- PLM logistics module

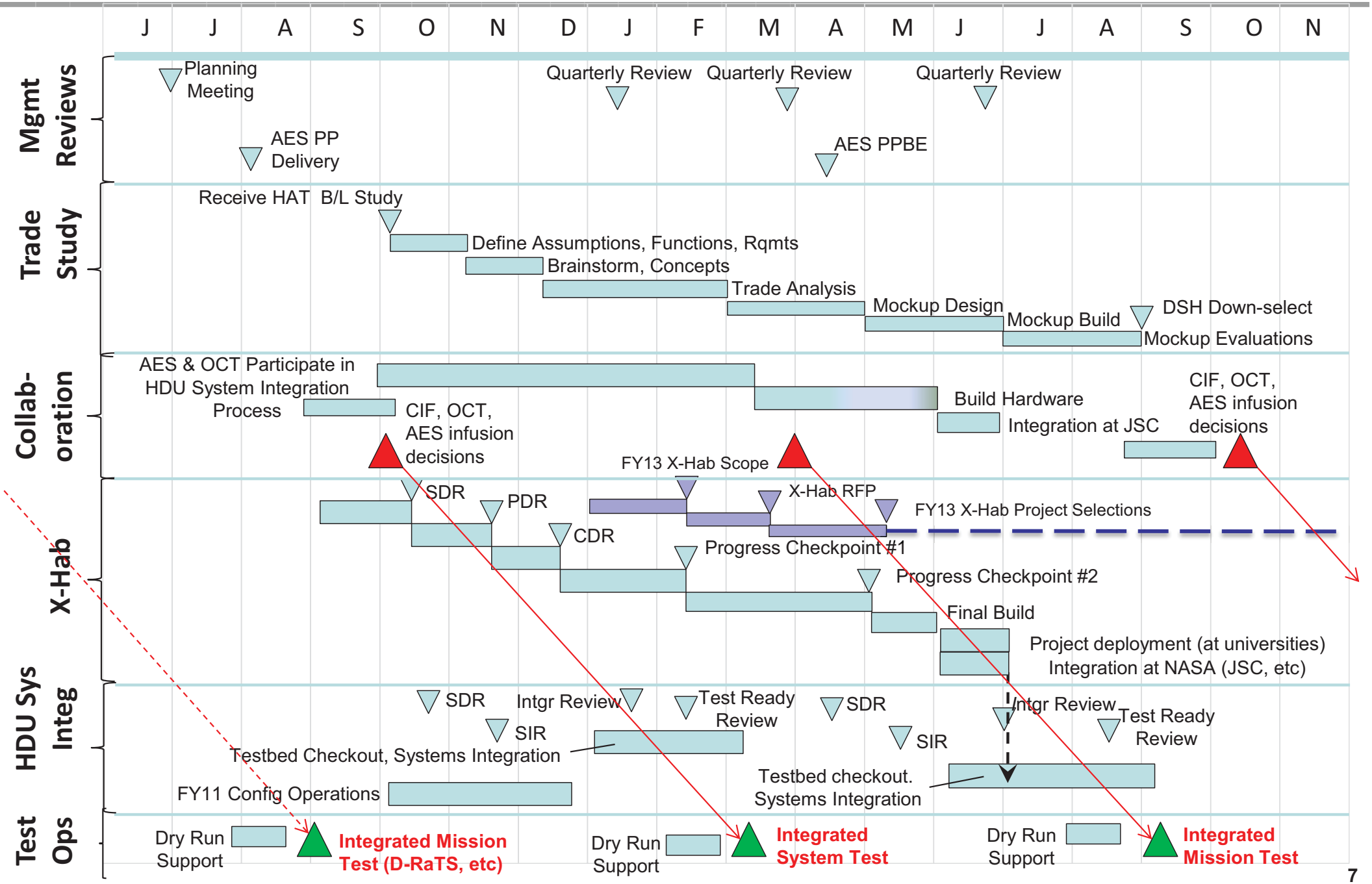
‘Scenario 12.1’ Highly Mobile Outpost



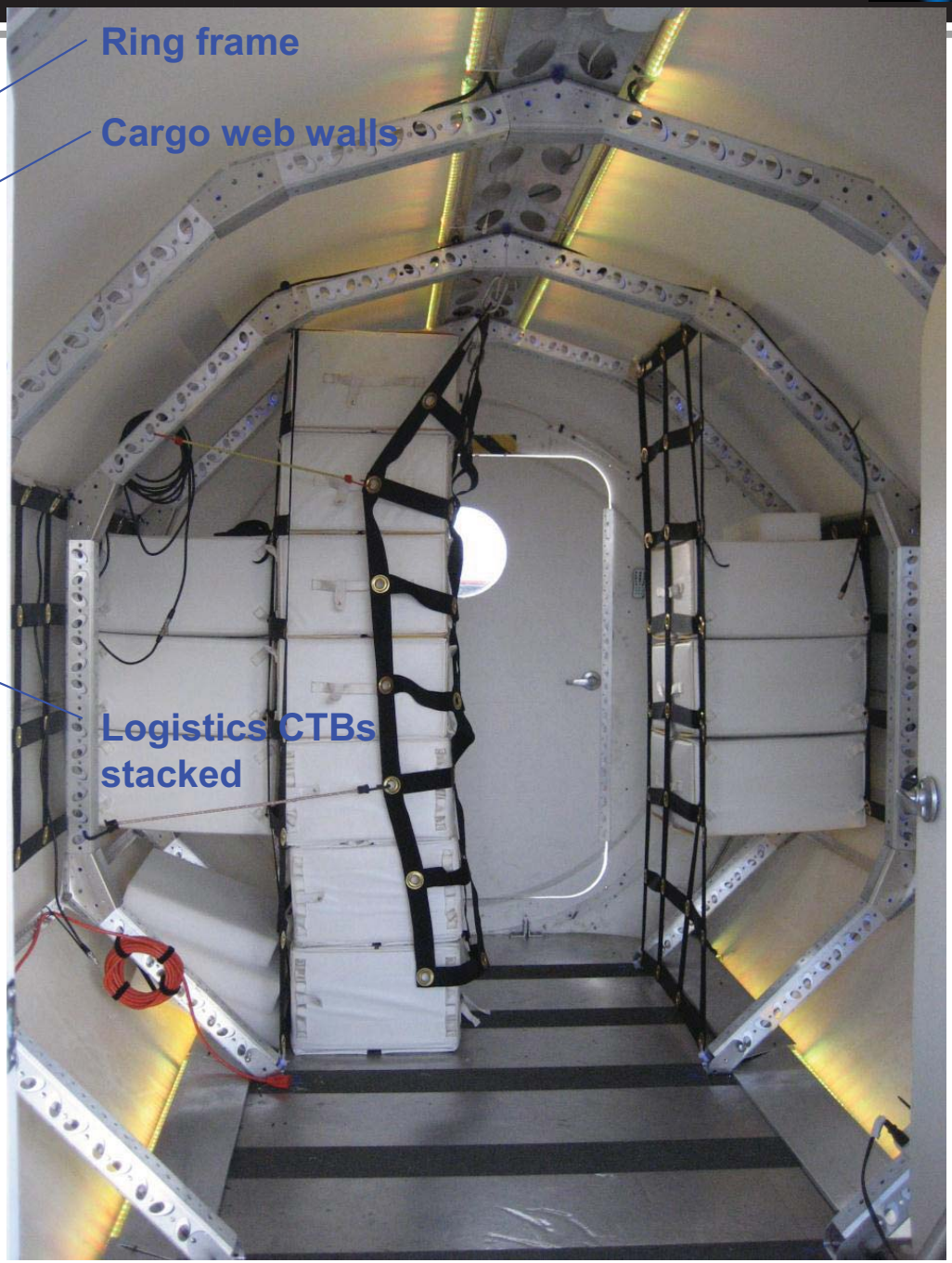
AES DSH Multi-Year Multi-Gen Strategy



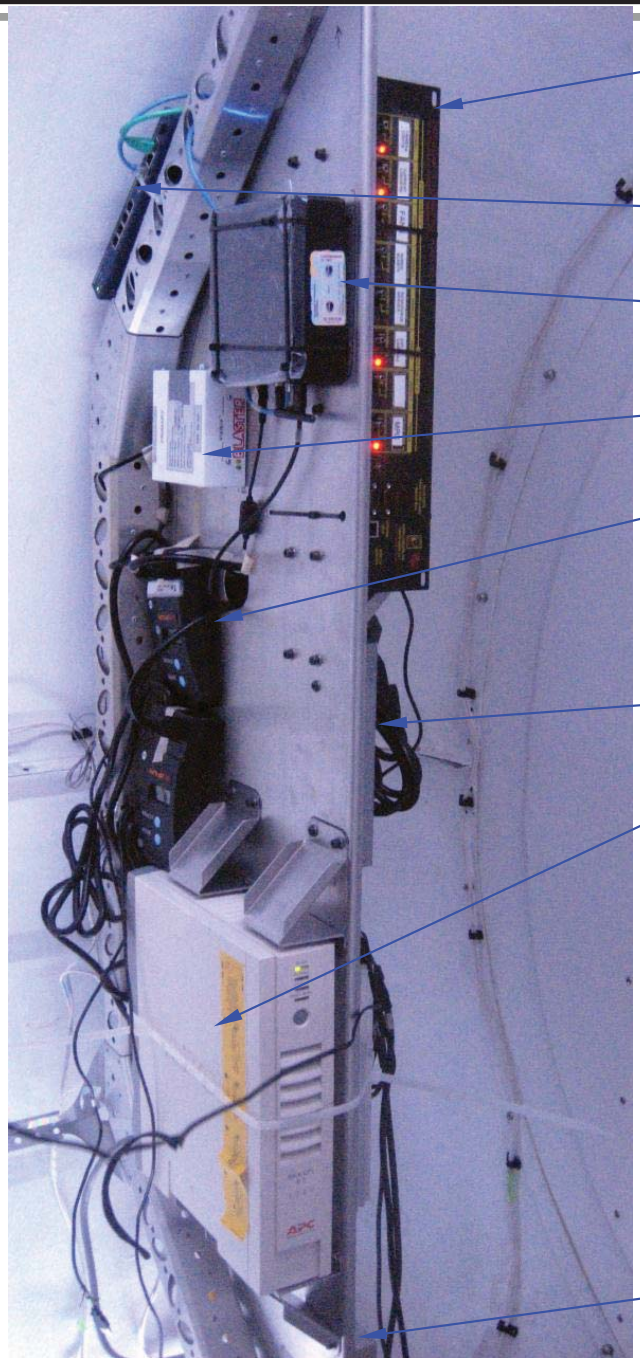
Yearly Schedule: Semi-annual Integration



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_2 / humidity monitor

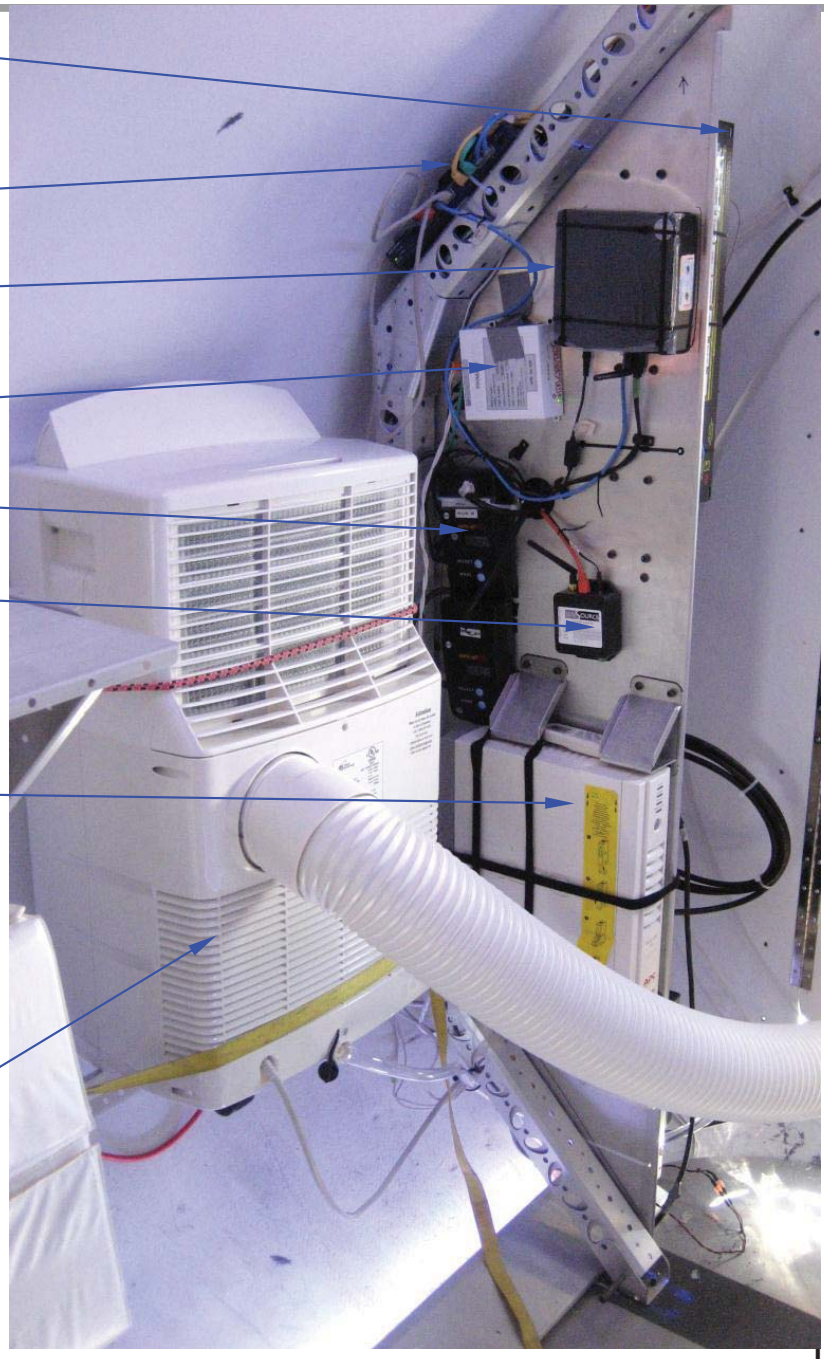
Light controller (behind)

Power Supply Unit (PSU) rechargeable battery pack

Tropos modem (behind)

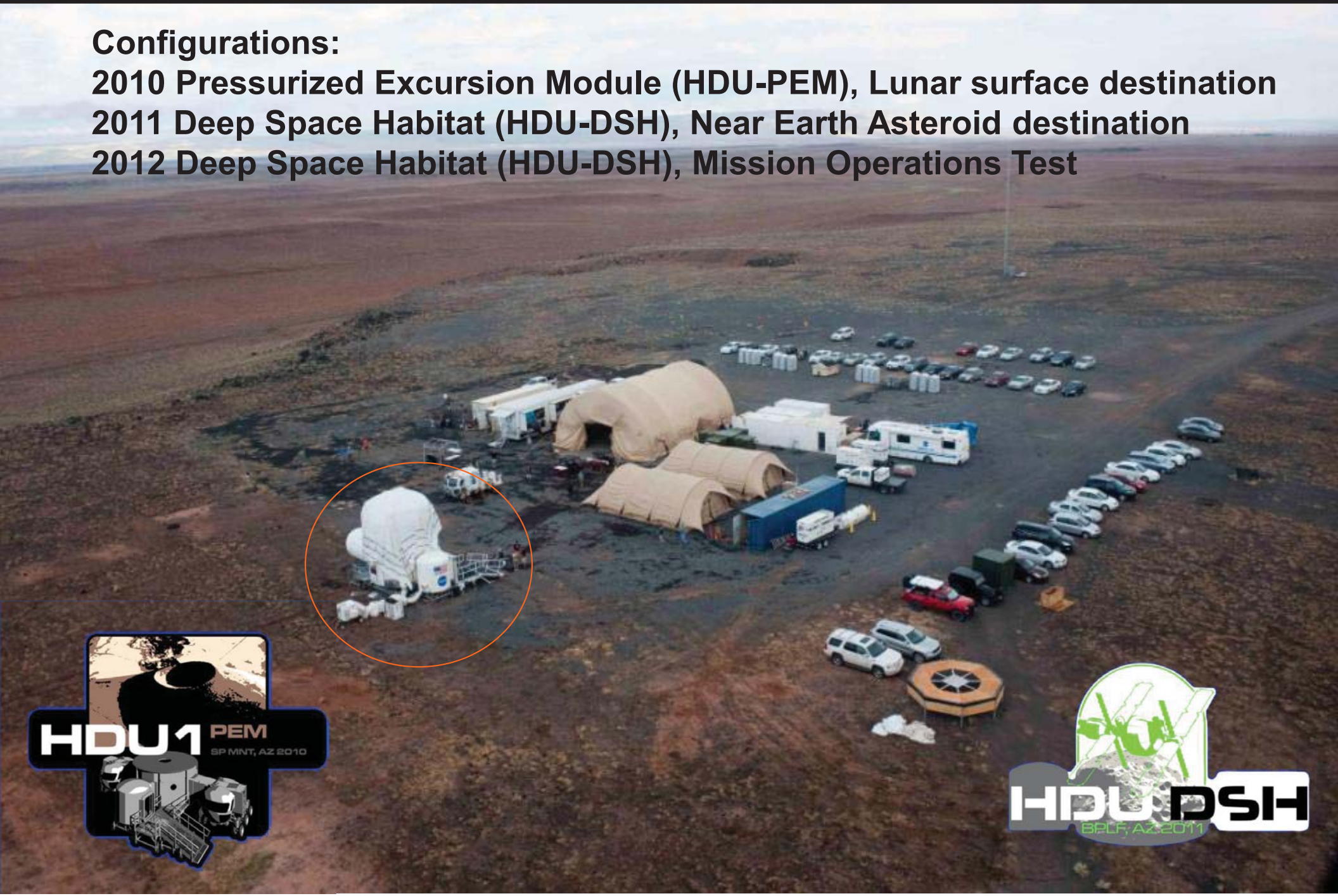
Package air conditioner (analog for ECLSS)

LED light power supply



D-RATS 2011 Base Camp

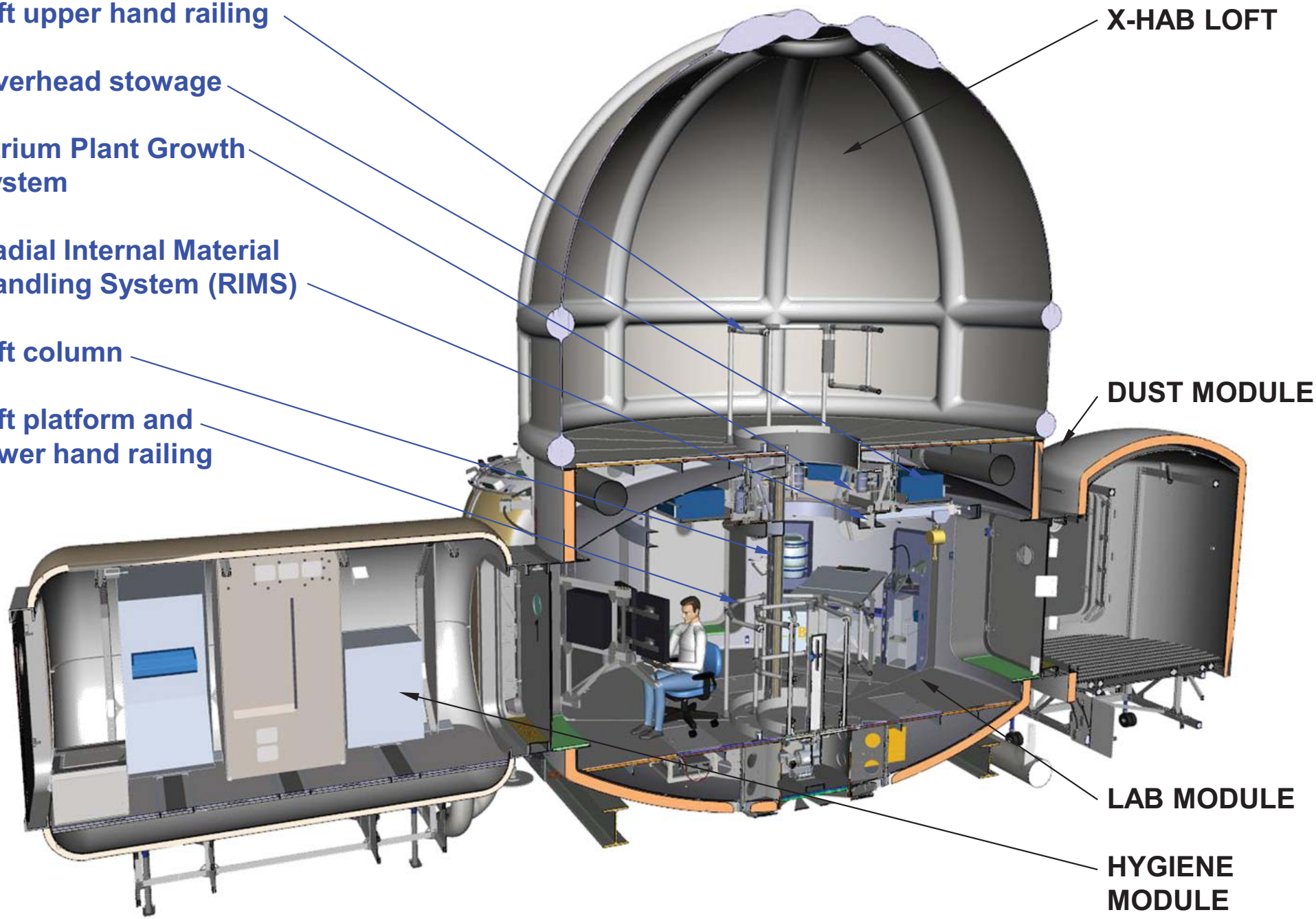
Configurations:
2010 Pressurized Excursion Module (HDU-PEM), Lunar surface destination
2011 Deep Space Habitat (HDU-DSH), Near Earth Asteroid destination
2012 Deep Space Habitat (HDU-DSH), Mission Operations Test



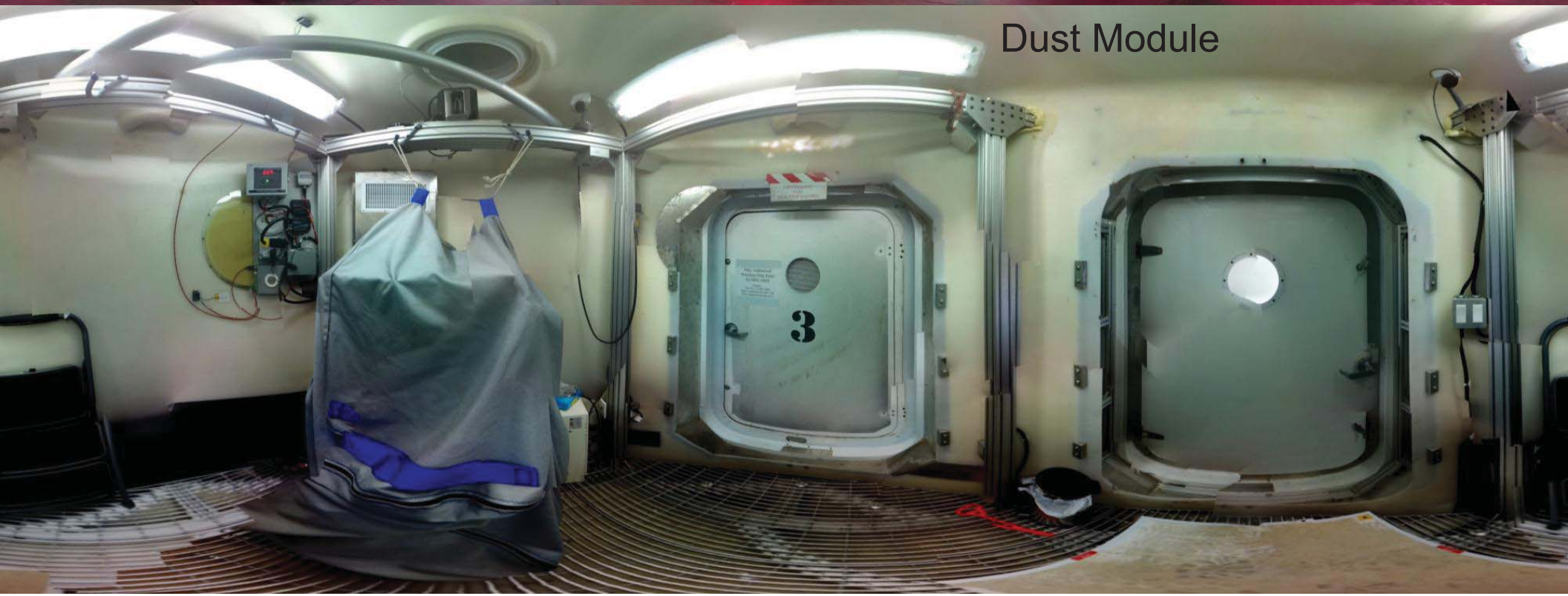
HDU-DSH Configuration

HDU-DSH Configuration

DRaTS HDU-DSH Configuration



HDU Lab deck



Dust Module

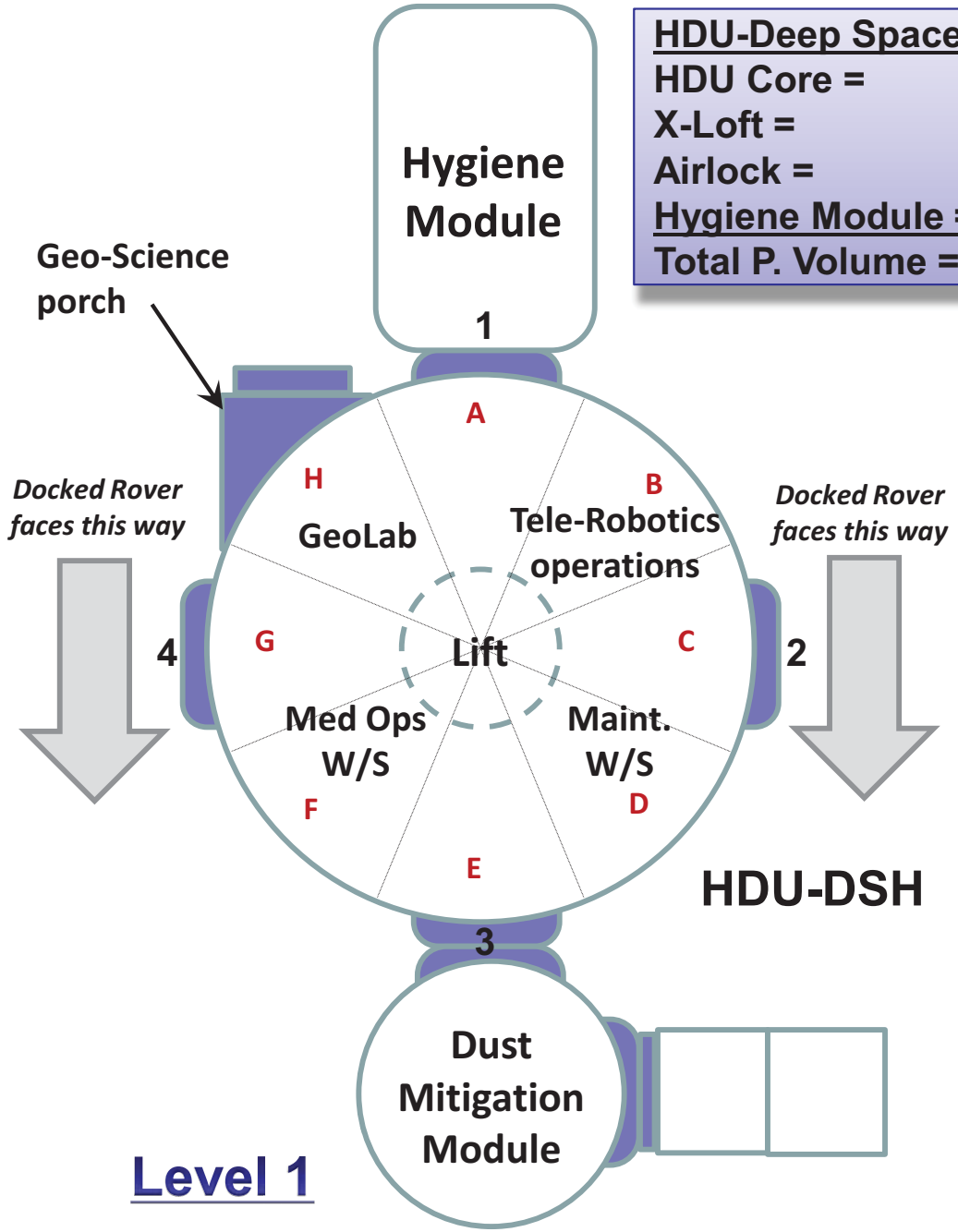

X-Hab Inflatable Loft


Hygiene Module

HDU-DSH Technology & Innovations Demonstrations

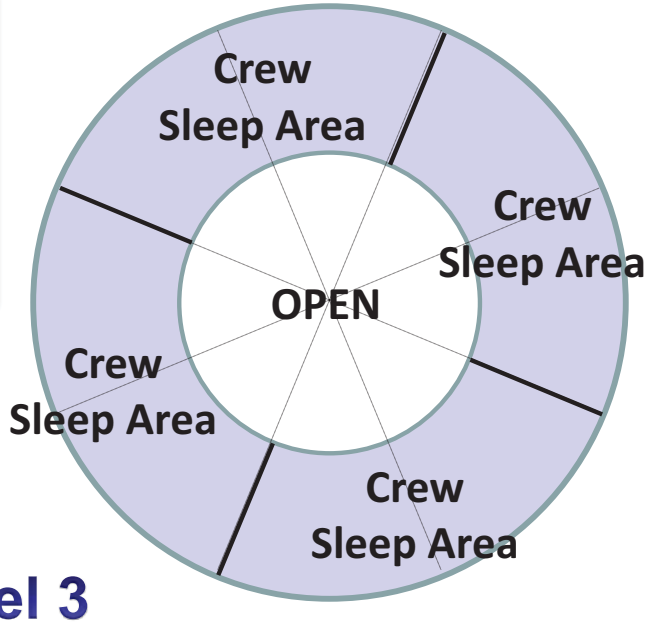
1. Inflatable Loft (X-Hab 2011)
2. Logistics-to-Living
3. Autonomous Ops:
   - A. "Intelligent" Habitat System Management Software
   - B. SHIELD & ACAWS
4. iHab Digital Double (D^2)
5. Power Generation & PM&D Systems
6. Environmental Protection Technologies
   - A. Dust Mitigation Technologies
     - 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

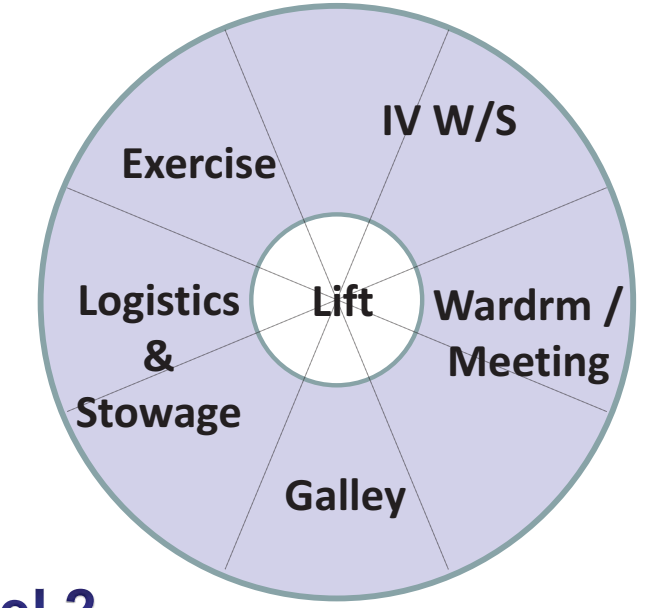
HDU-DSH Plan Views



HDU-Deep Space Hab:

HDU Core =	56.0 m^3
X-Loft =	69.9 m^3
Airlock =	8.6 m^3
Hygiene Module =	14.1 m^3
Total P. Volume =	148.1 m^3





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

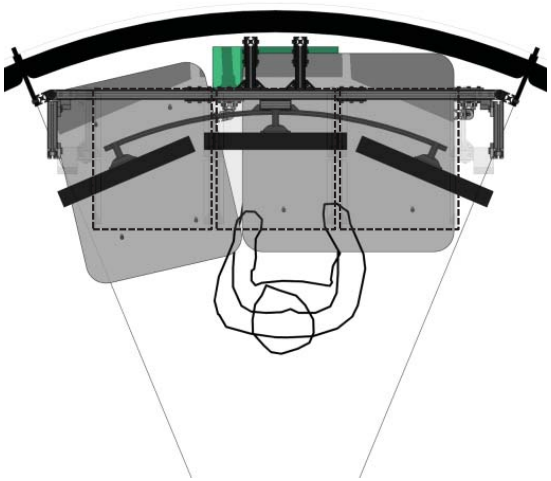
Control box

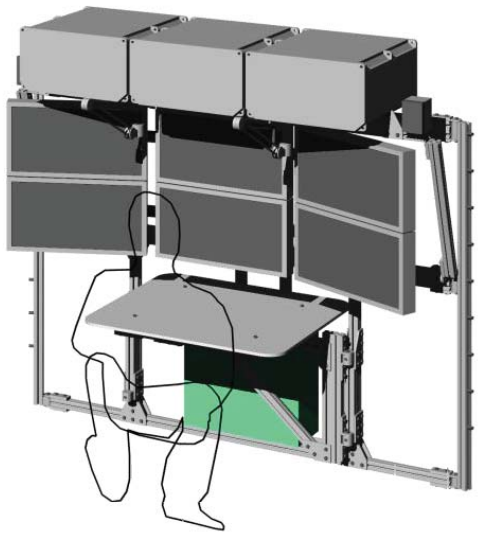
Geo-Lab Glovebox

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

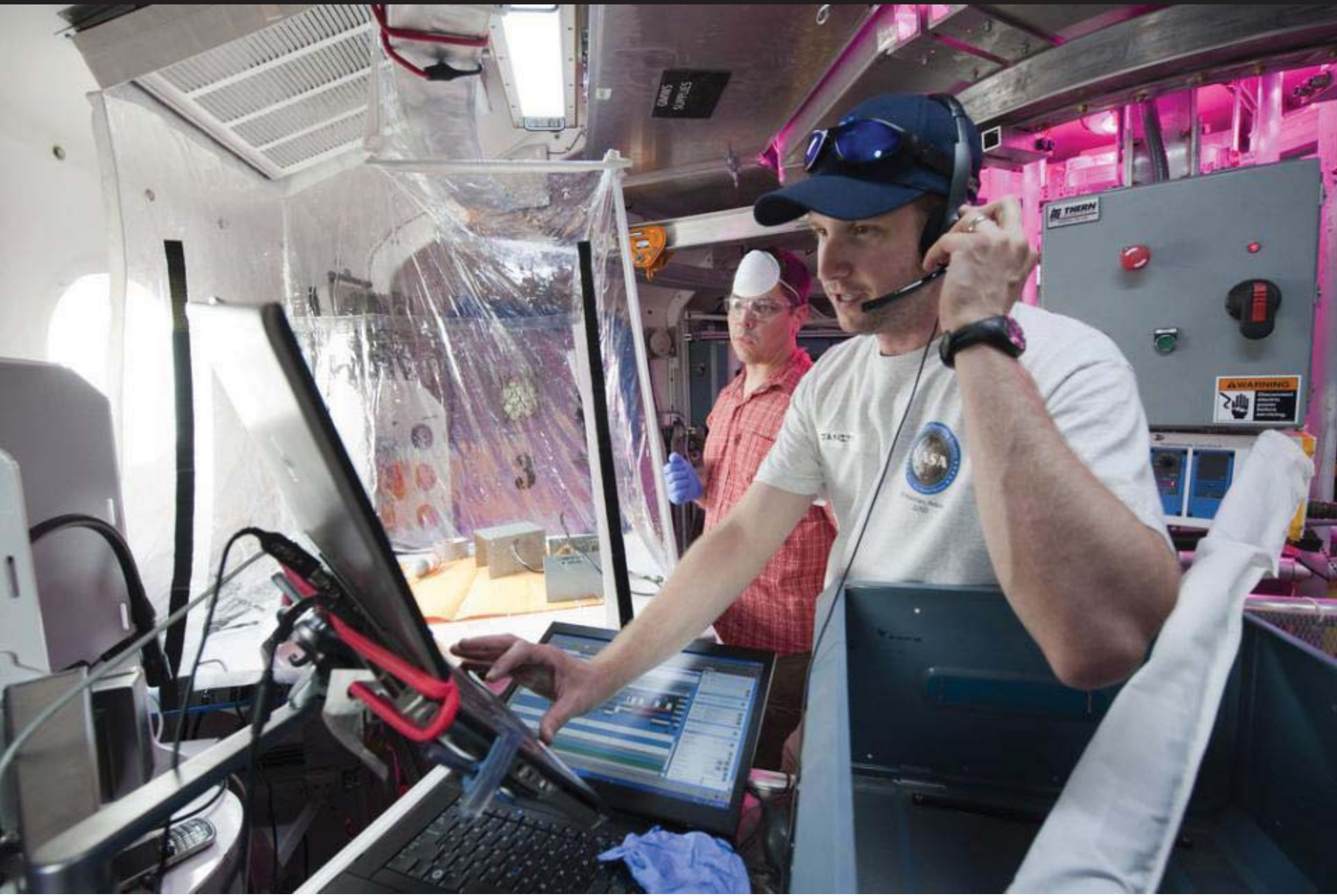
D-RATS 2010


D-RATS 2011

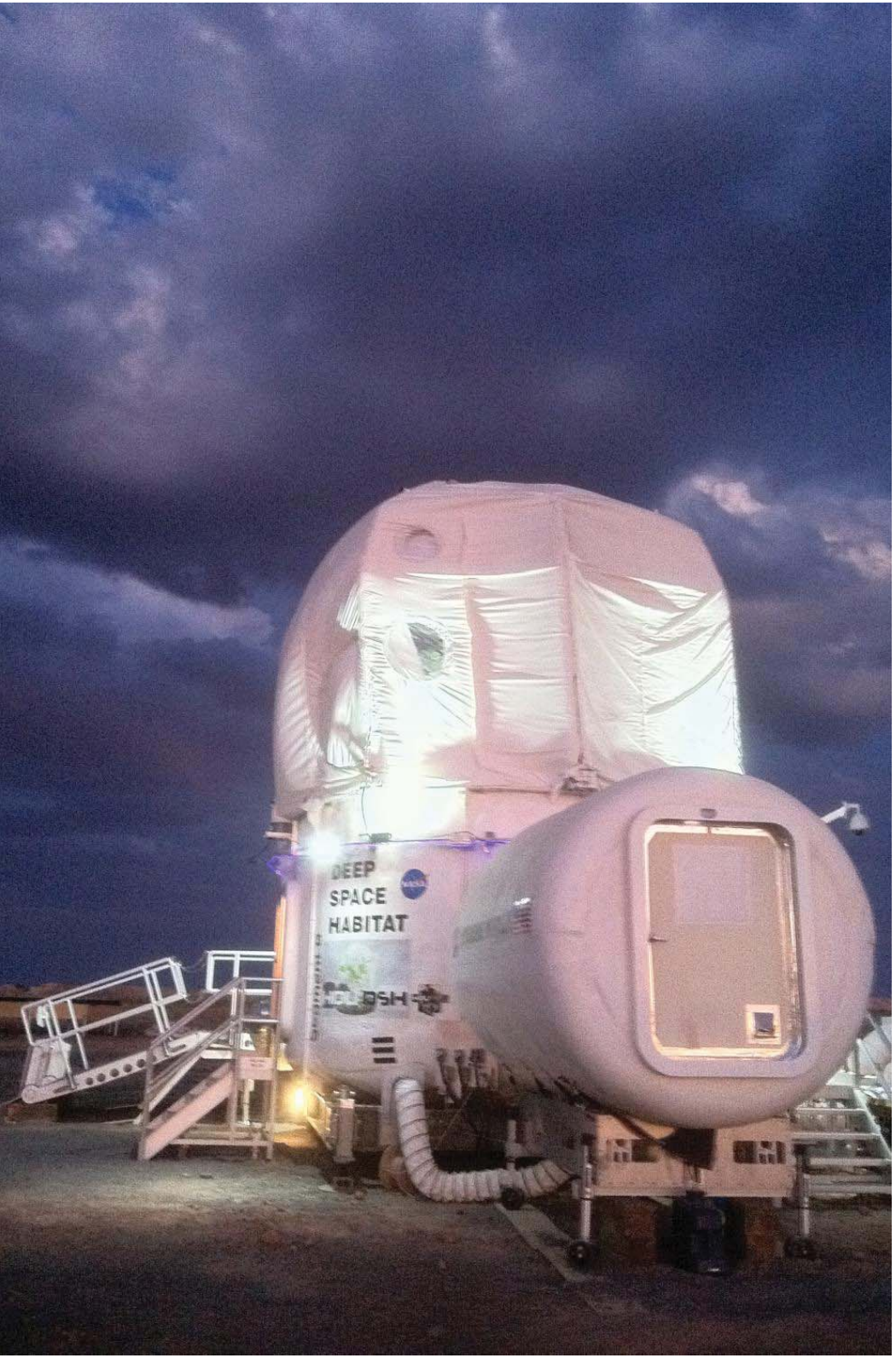

MOT 2012

Repair Work at Gen Maintenance W/S

Dust Containment at General Maintenance W/S

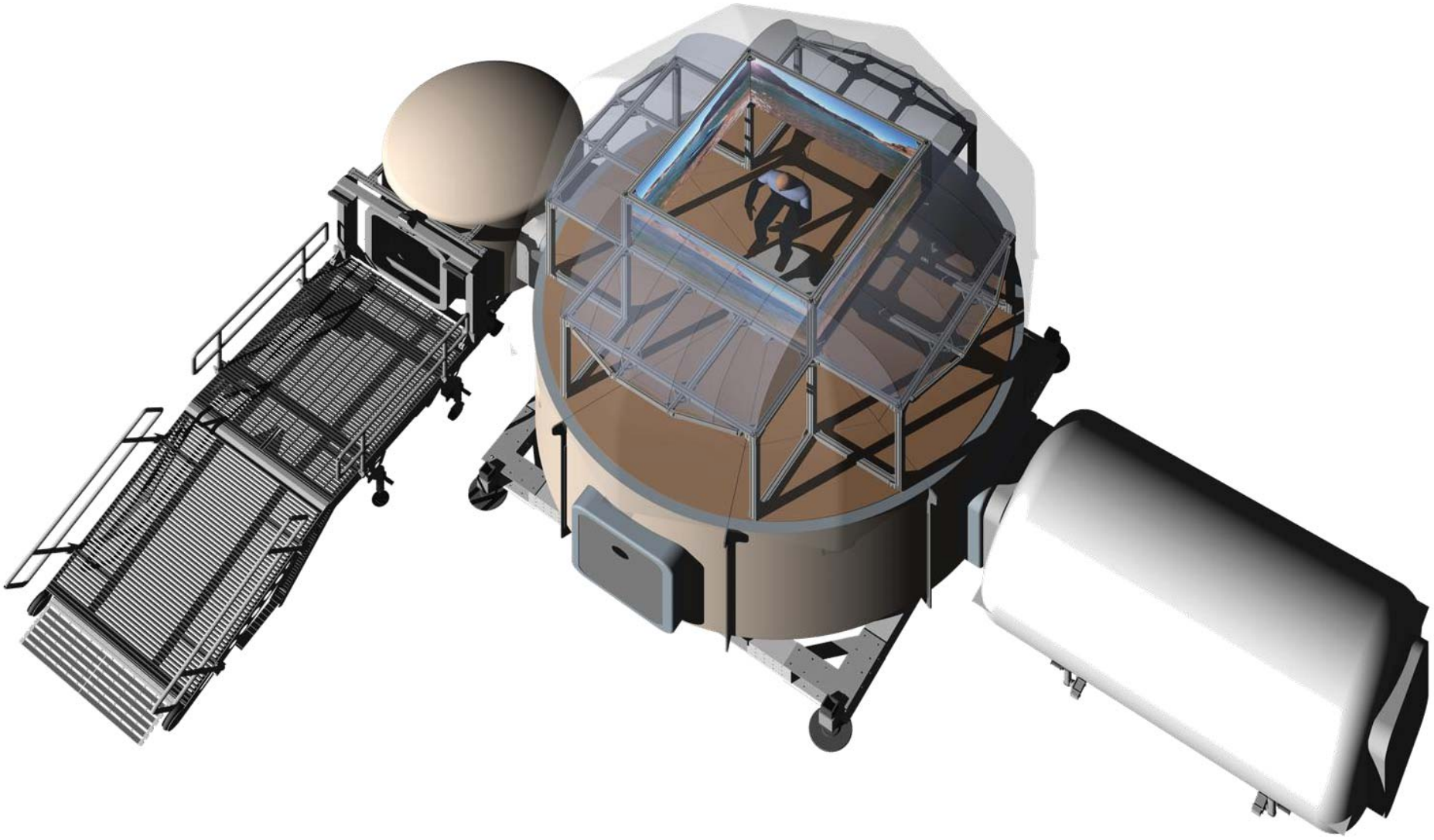


Waste and Hygiene Module


DEEP
SPACE
HABITAT


1

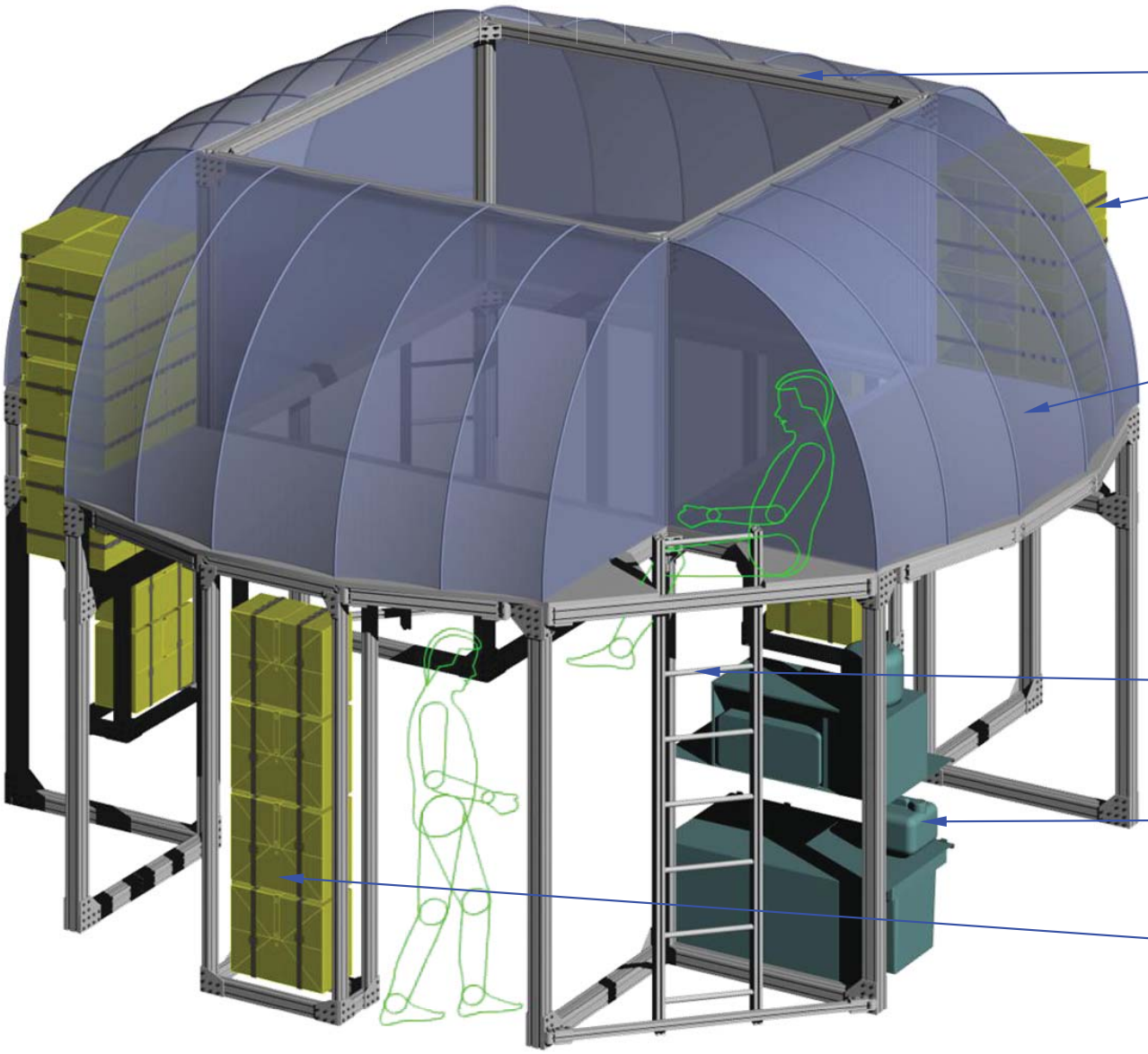
X-Loft Living Space



X-Hab Loft Early Designs

Photo: James W. Young

X-Loft Final Design



8020 frame

CTB stowage loft

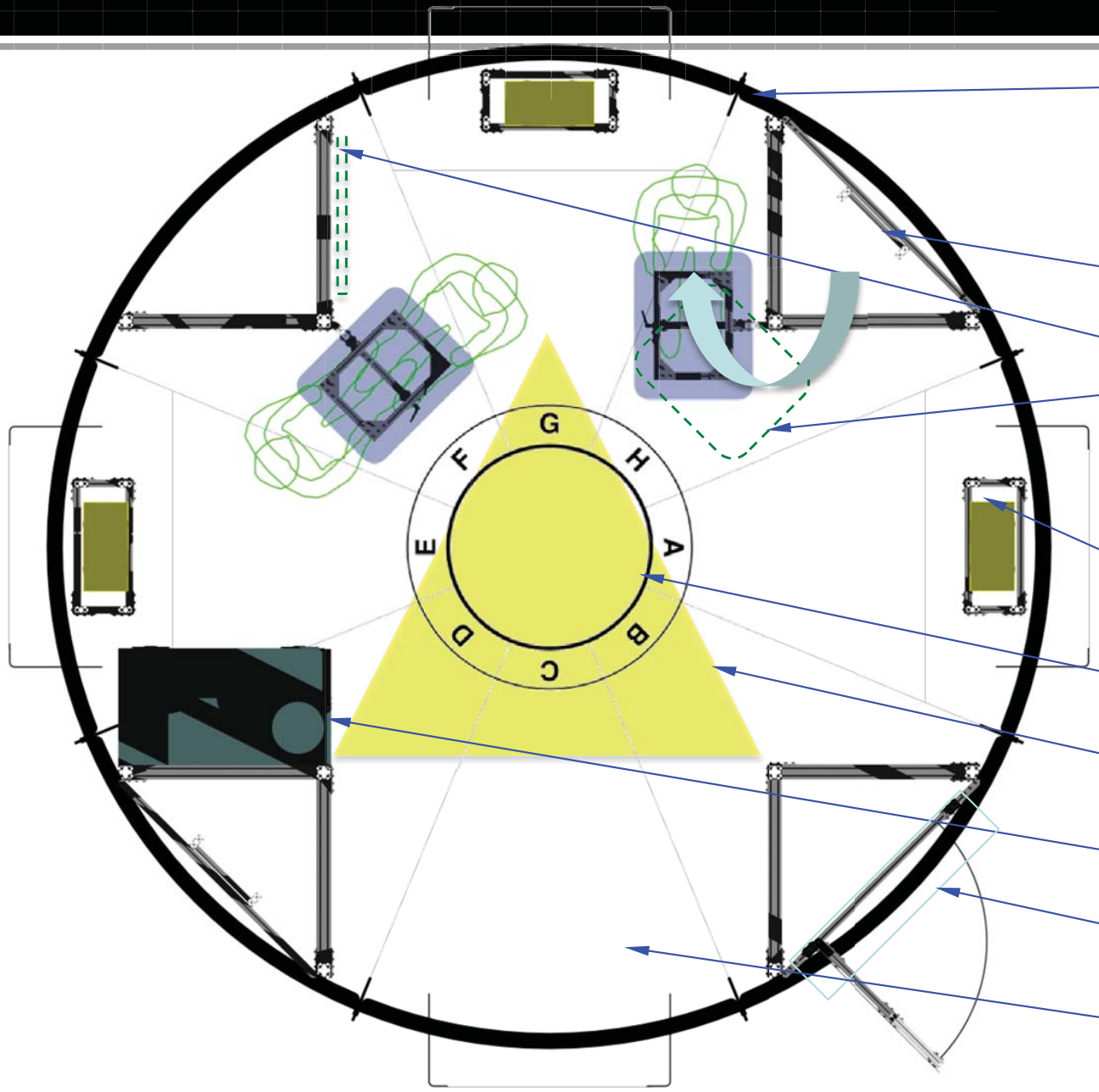
Crew quarters bowed out around perimeter (notional only – need to work out tension and compression poles)

Access ladder

Galley

CTB rack

X-Loft Plan View



Line of HDU below

Access ladder

Deployable table (folds up and out of the way) – space for all crew members to work/eat and watch projection

CTB rack

Access lift well

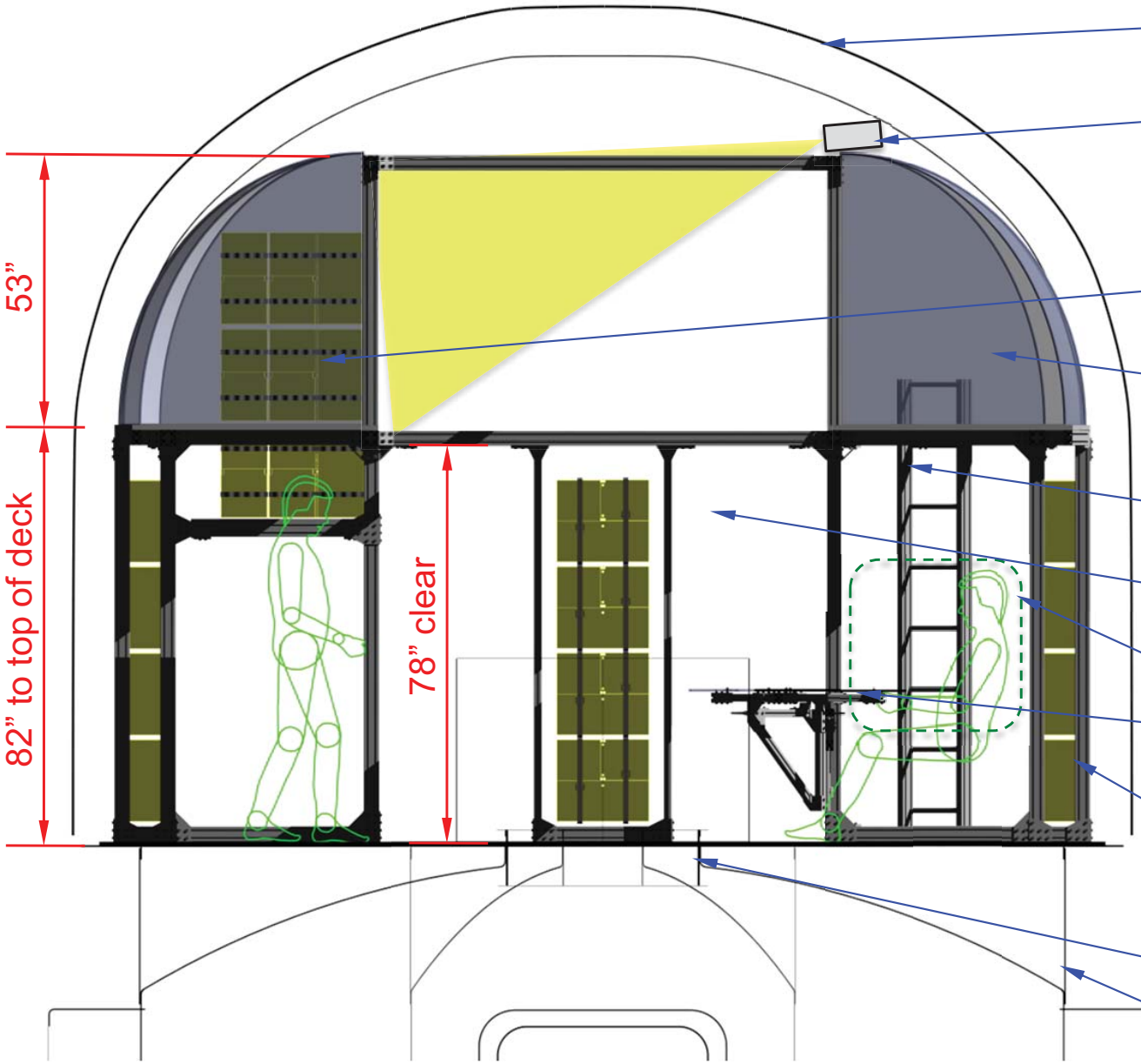
Projection area above

Galley

Emergency egress

Avionics section C floor clear access

X-Loft Section View Showing Projection Surface



Line of dome section

Digital projector (virtual window, possible 4 bays)

CTB stowage loft beyond

Crew quarters bowed out around perimeter

Access ladder

Projection area

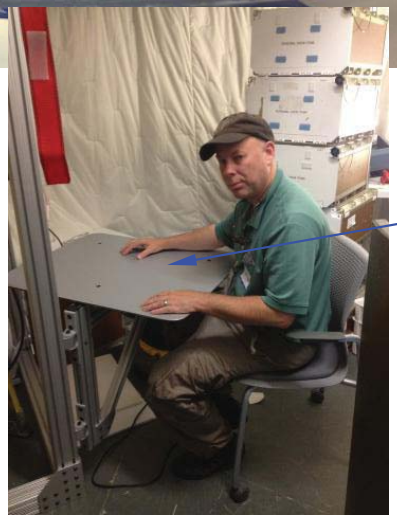
Deployable table folds up and out of the way

CTB rack

Lift access well

Line of HDU section

X-Loft Final Design (360 degree image)



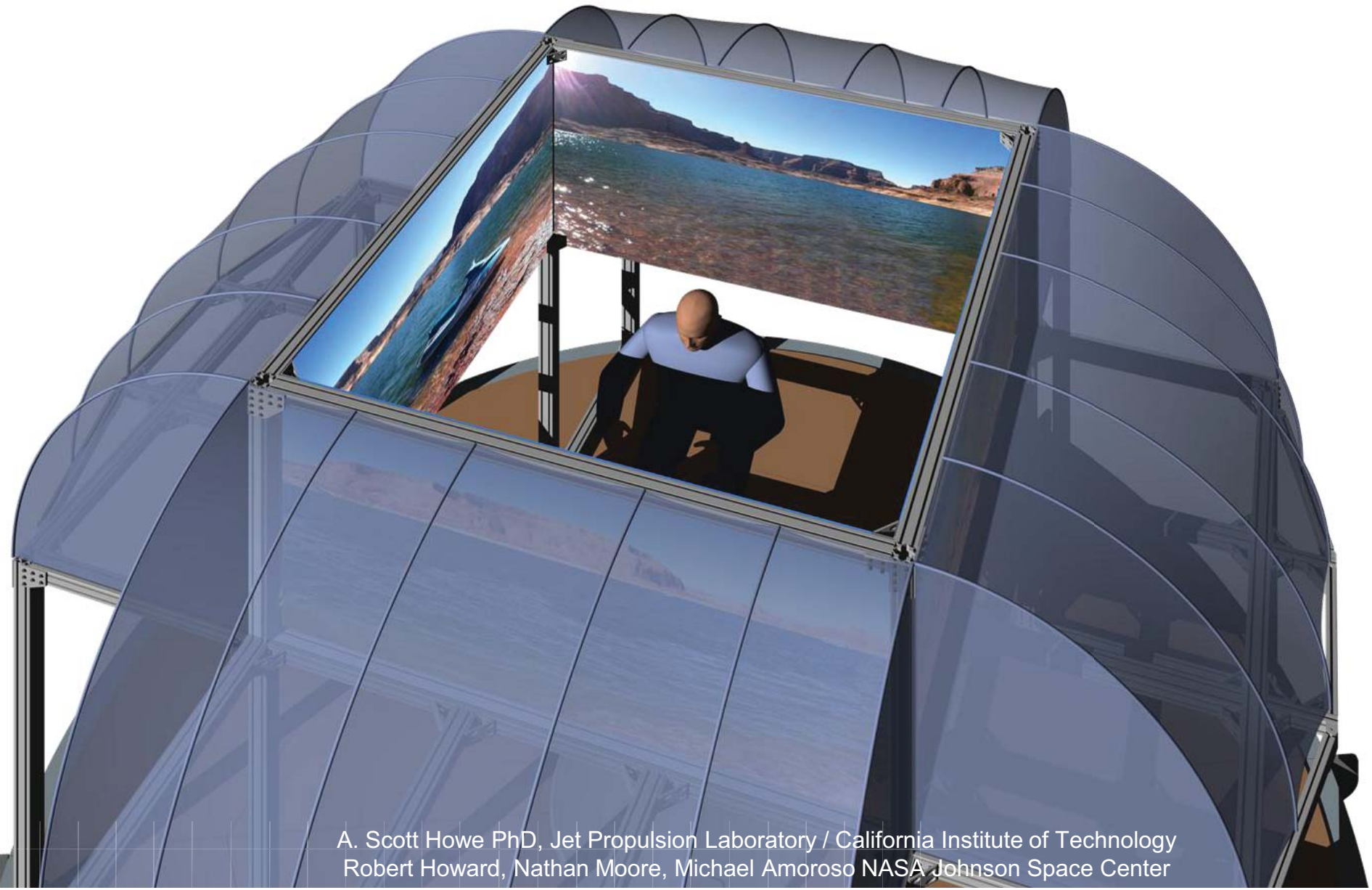
Deployable table deployed

Deployable table stowed

X-Loft Galley / Wardroom

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)

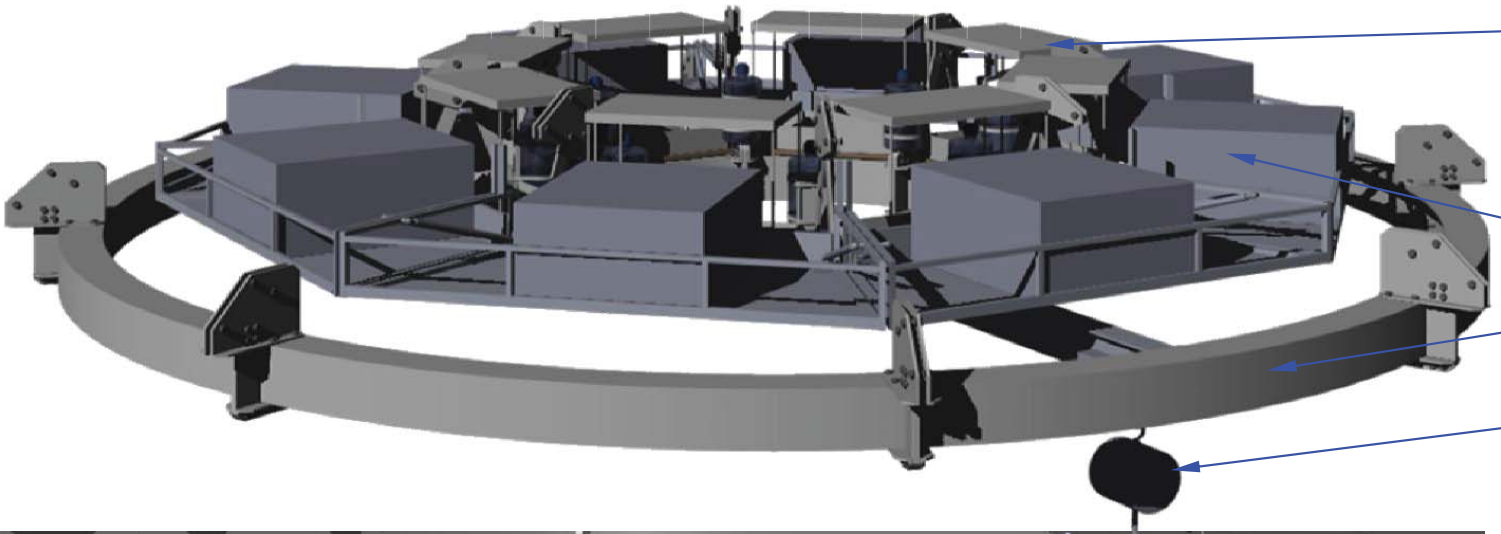
Digital projectors (mounted low in this case – could be mounted above)

Remote crew display

X-Loft deck below

Interactive crew member

Radial Internal Material Handling System (RIMS)

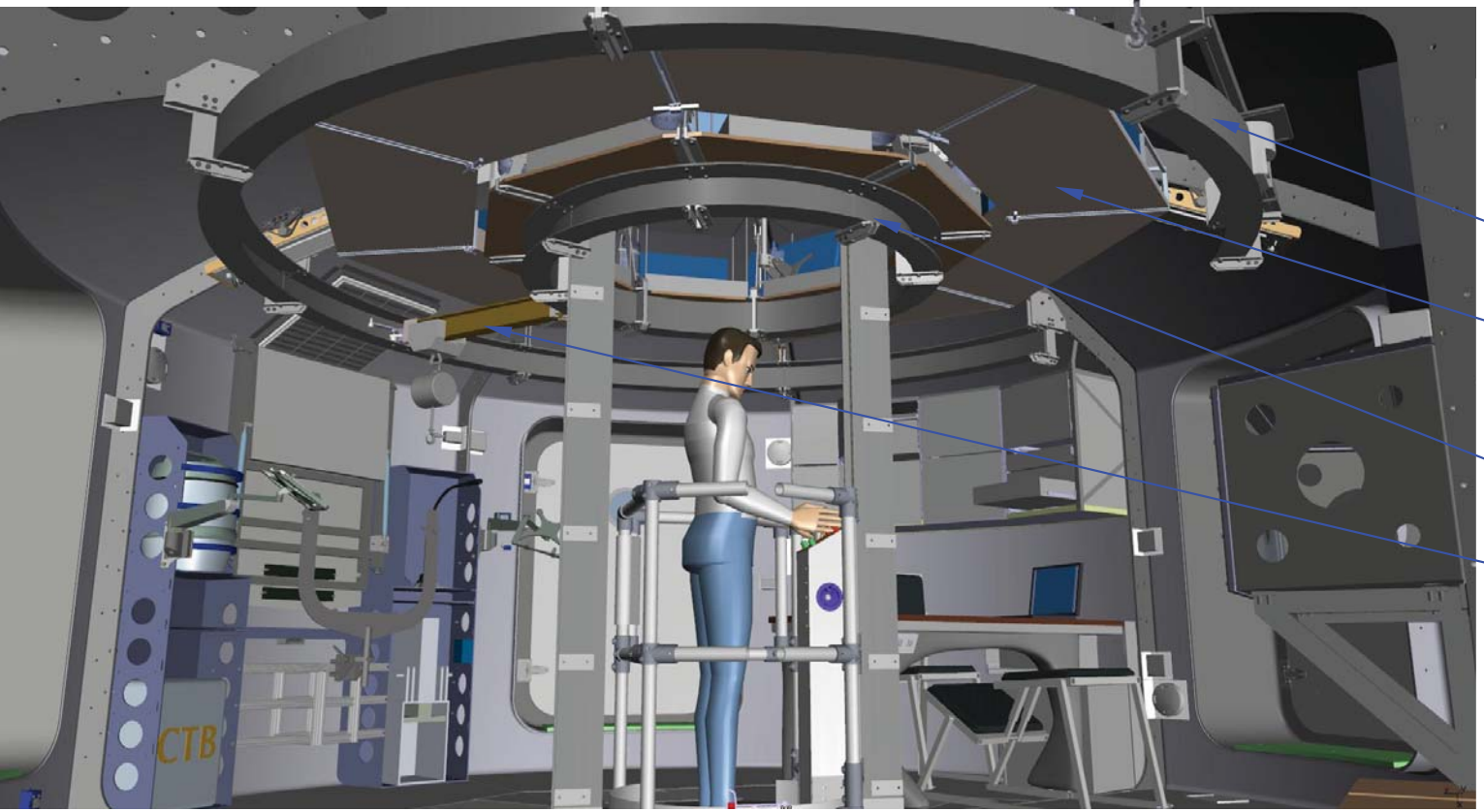


Plant growth system (rests on top of RIMS inner track)

Stowage system

RIMS outer track

Cross beam with hoist



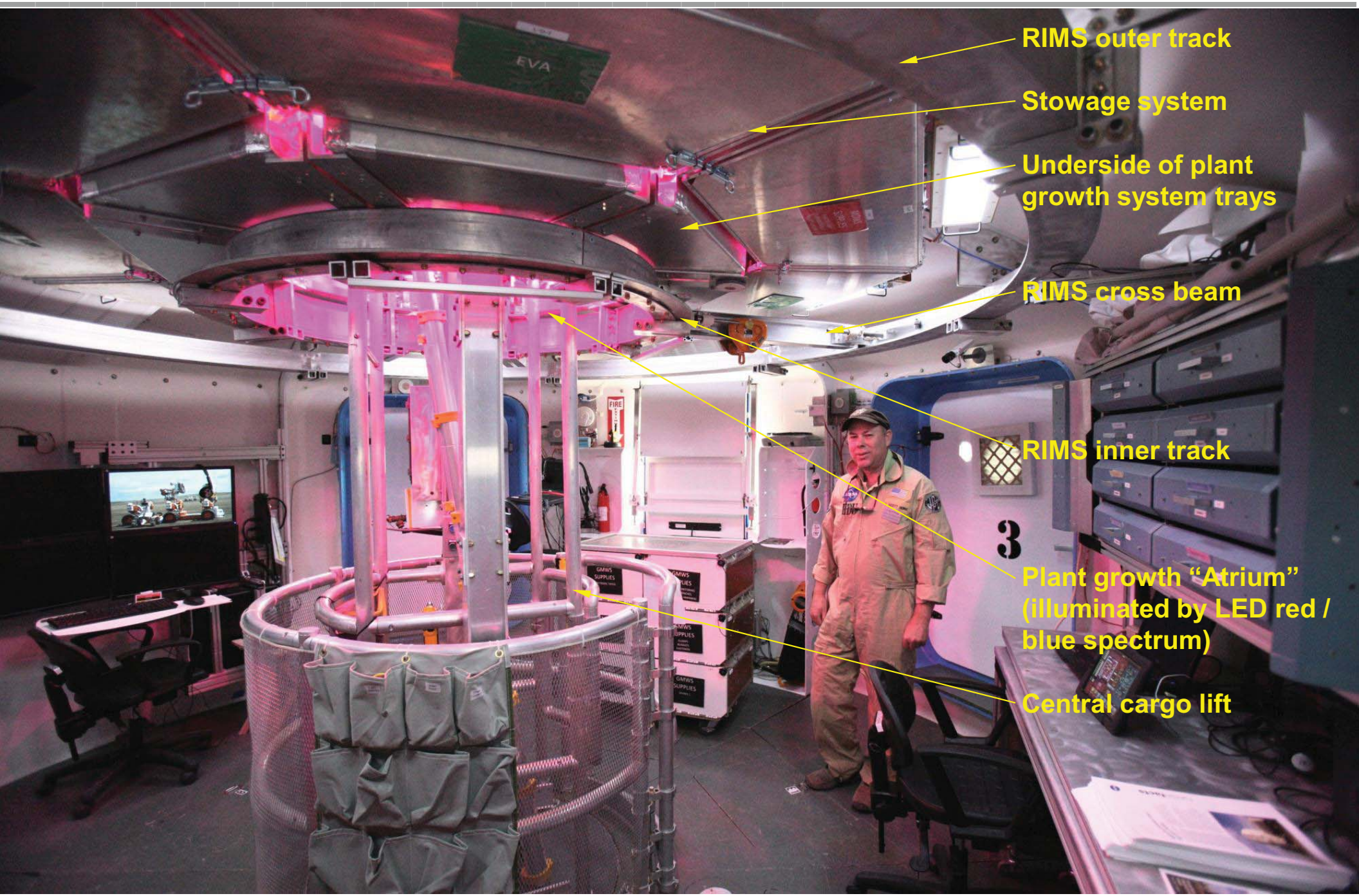
RIMS outer track

Underside of fold-down stowage units

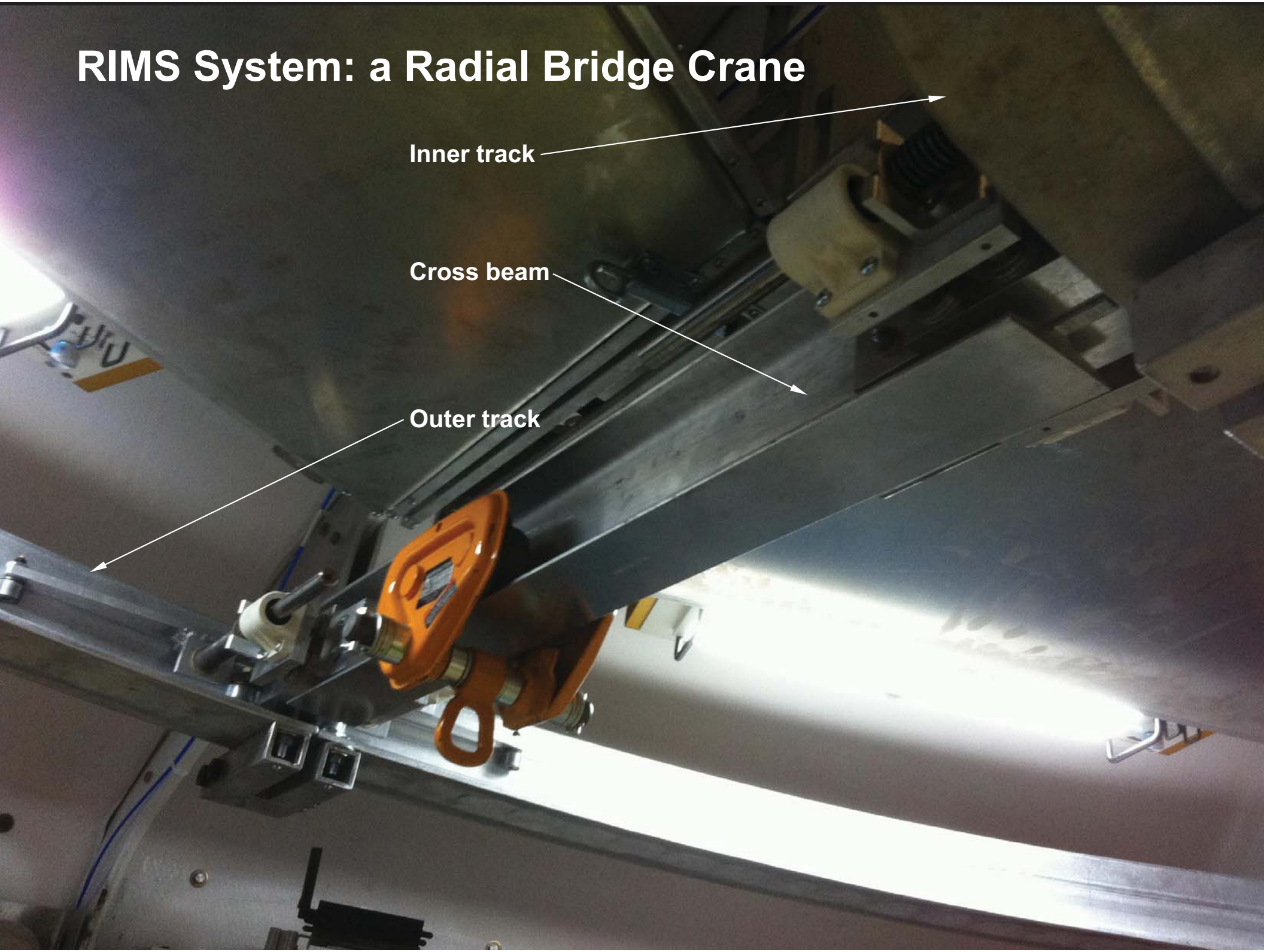
RIMS inner track

Cross beam with hoist

Radial Internal Material Handling System (RIMS)

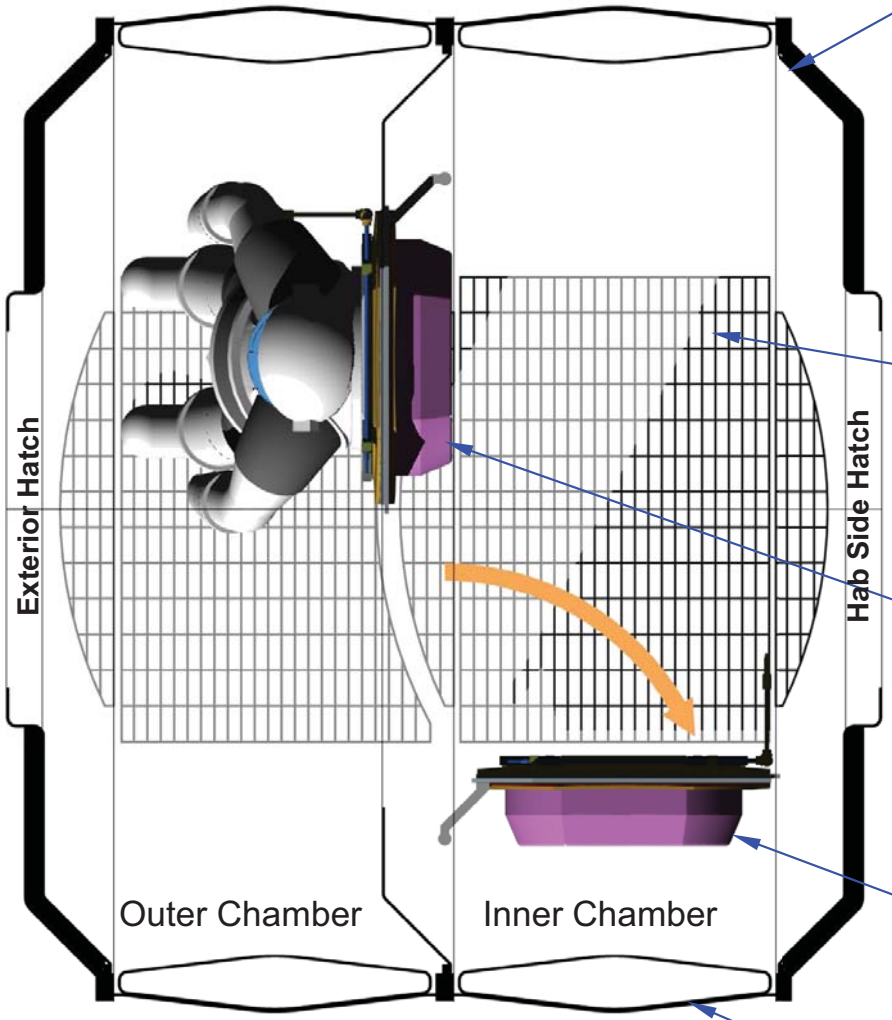


RIMS System: a Radial Bridge Crane



EVA Innovations

Suitlock: Conversion / Deployment



Folded membrane

End bulkhead

Middle bulkhead nested

Suitport system stowed

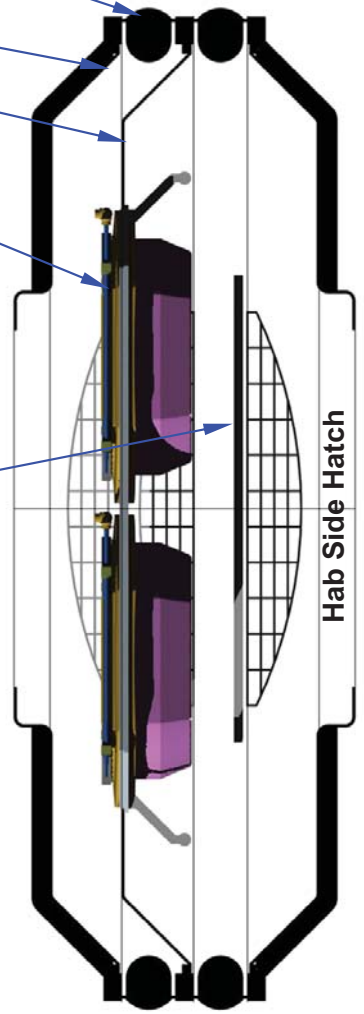
Mesh deck deployed

Mesh deck folded

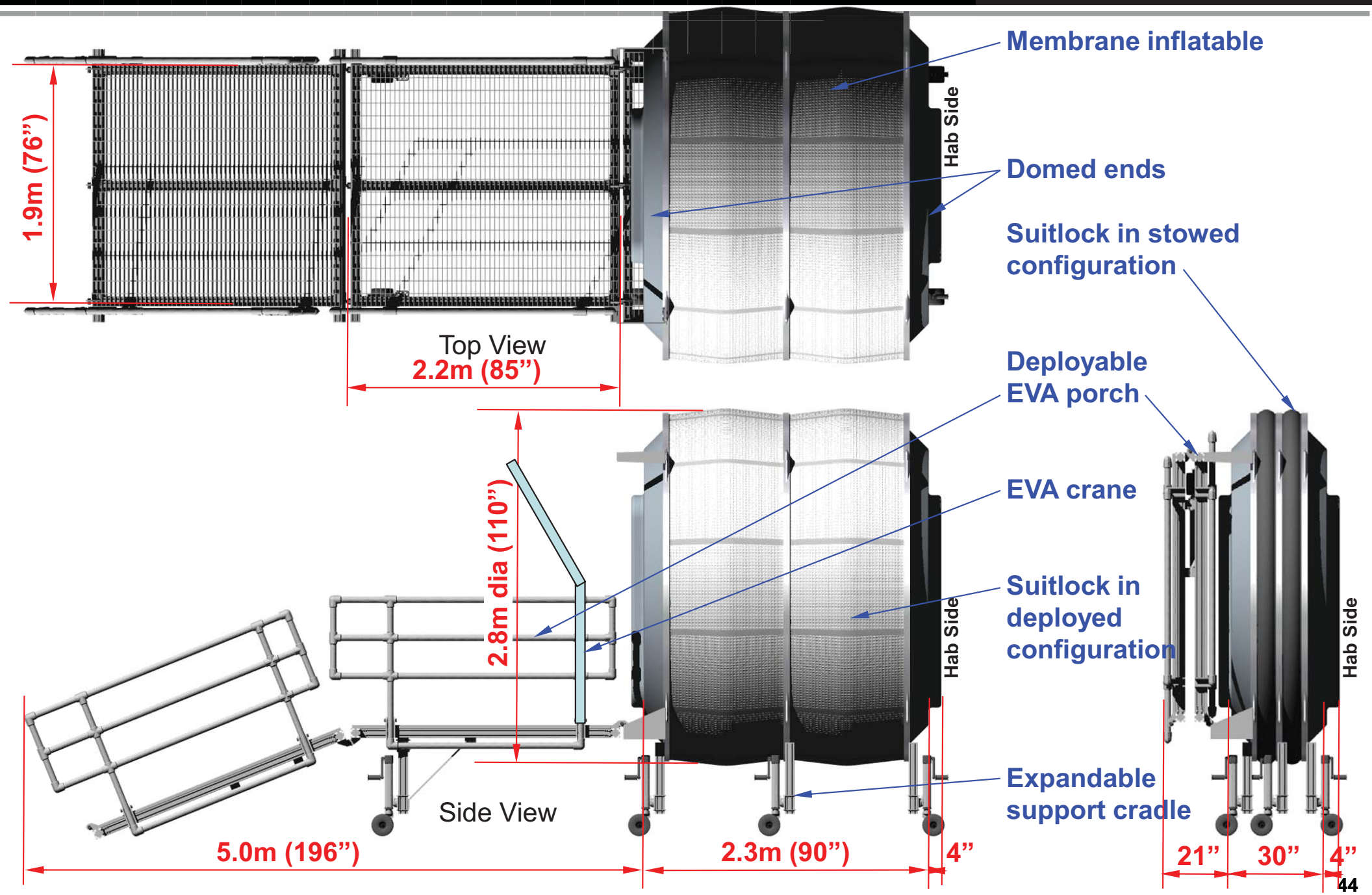
Suitport panel in "Suitlock Mode"

Suitport panel opens up in "Large Volume Airlock Mode"

Deployed membrane and pneumatic beams

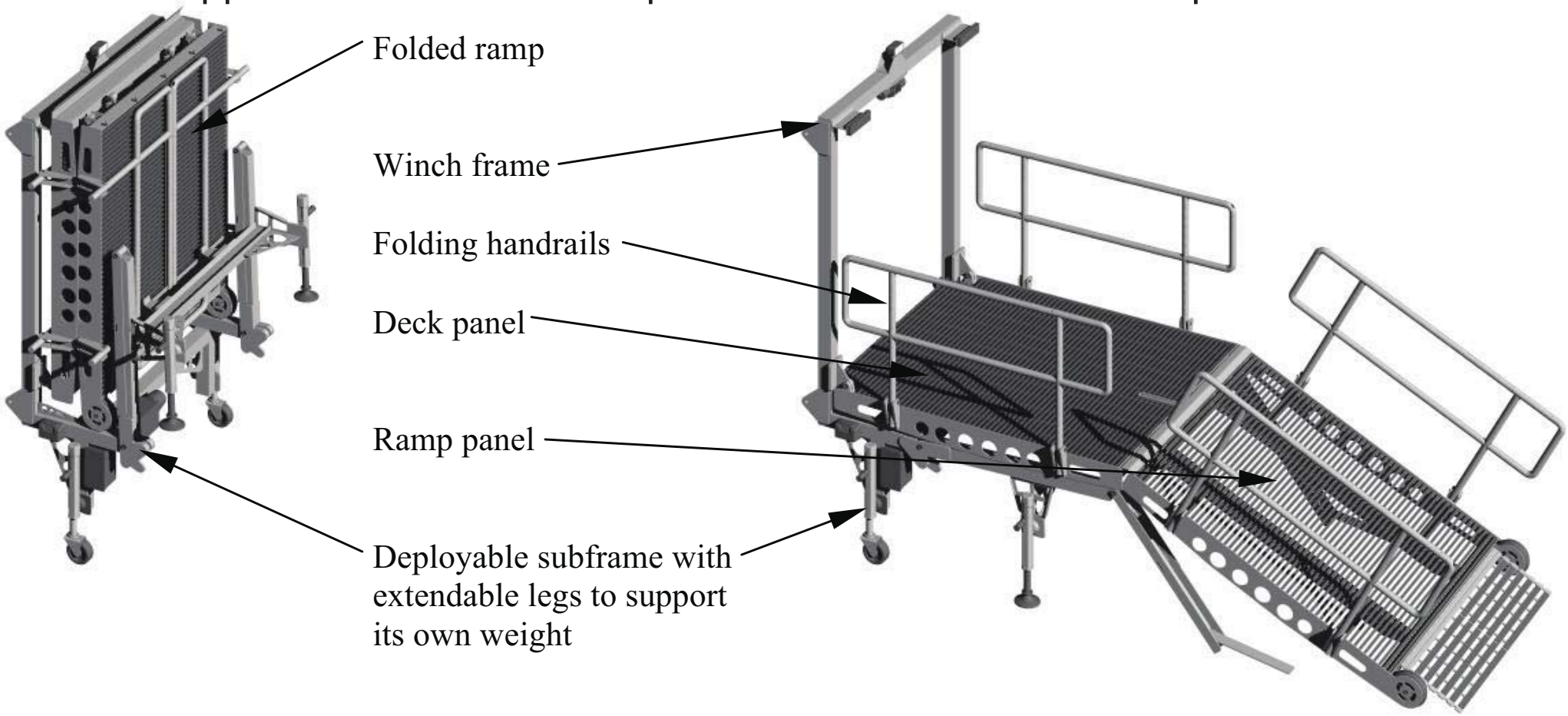


Suitlock: Overall Dimensions



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

Lessons Learned

- 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

Note: only part of team is shown

D-RATS 2010

Thank you