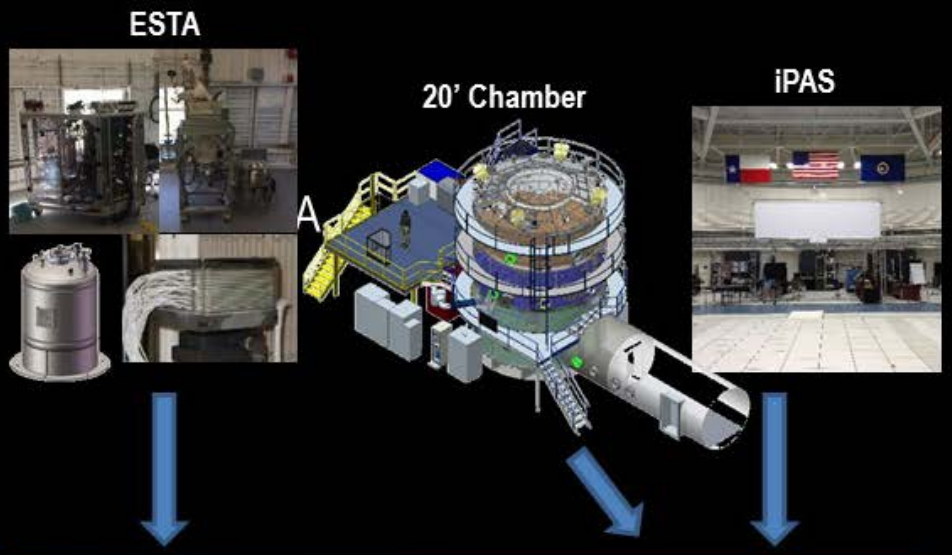
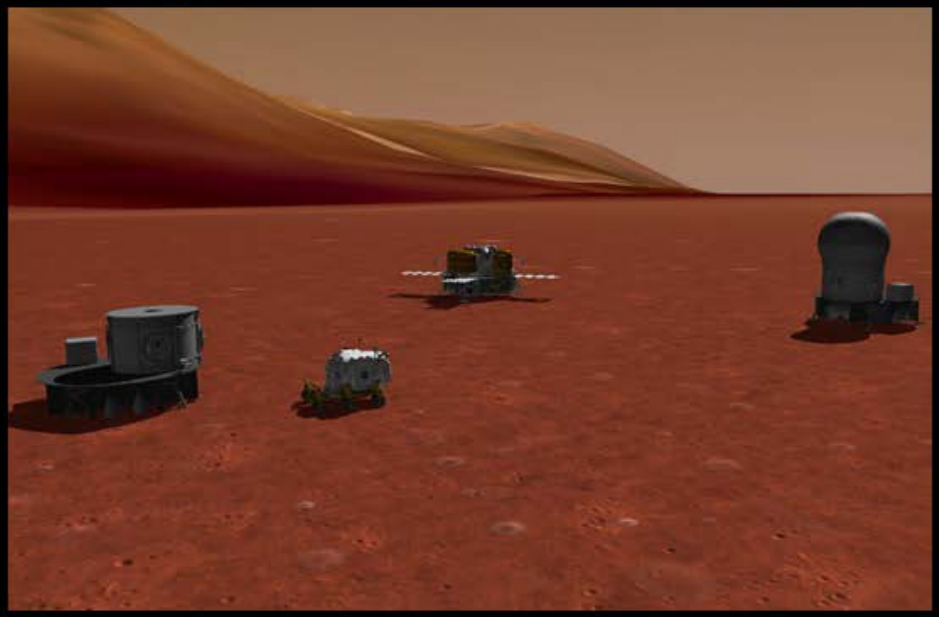
HUMAN
EXPLORATION
SPACECRAFT
TESTBED FOR
INTEGRATION AND
ADVANCEMENT



HESTIA Support of Future NASA Deep-Space Missions

Jose Marmolejo & Mike Ewert
NASA / Crew & Thermal Systems Division



AIAA Technical Symposium – NASA / JSC
06 May 2016

HESTIA Support of Future NASA Deep-Space Missions

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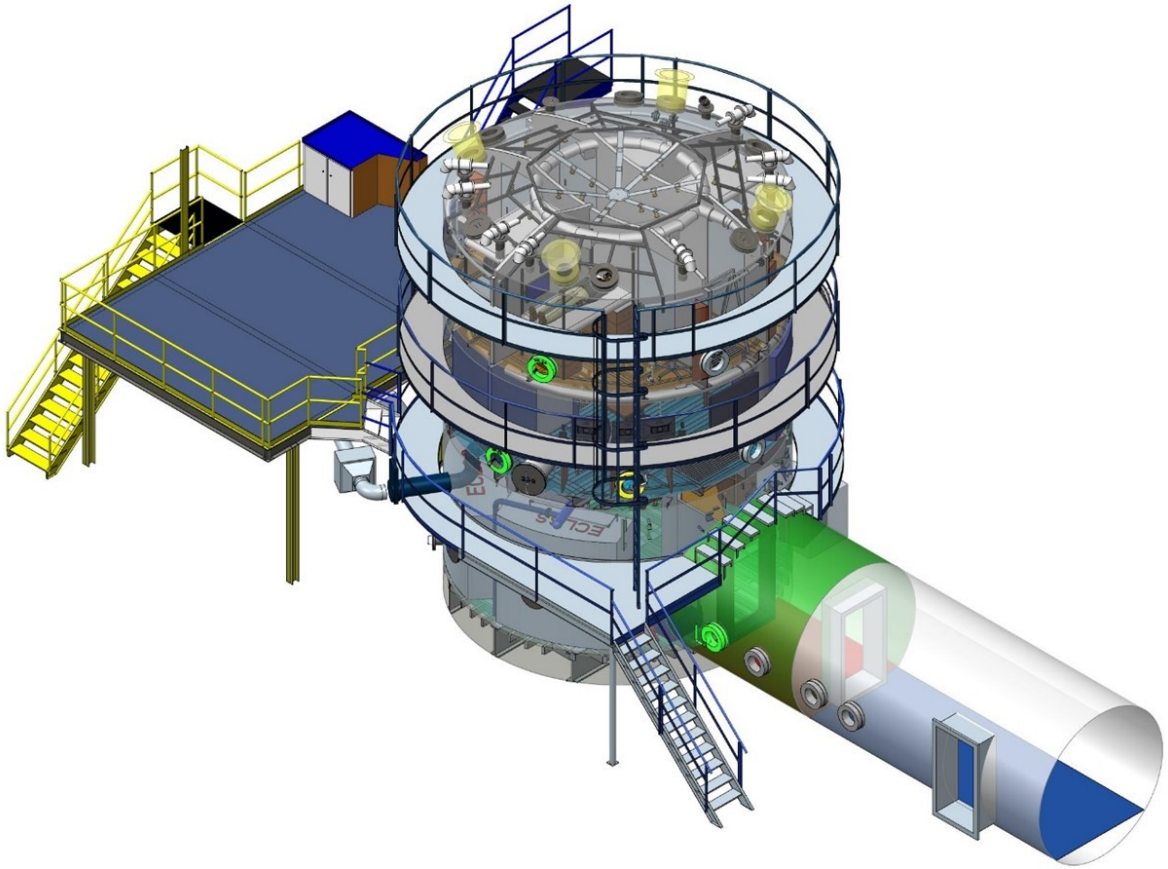

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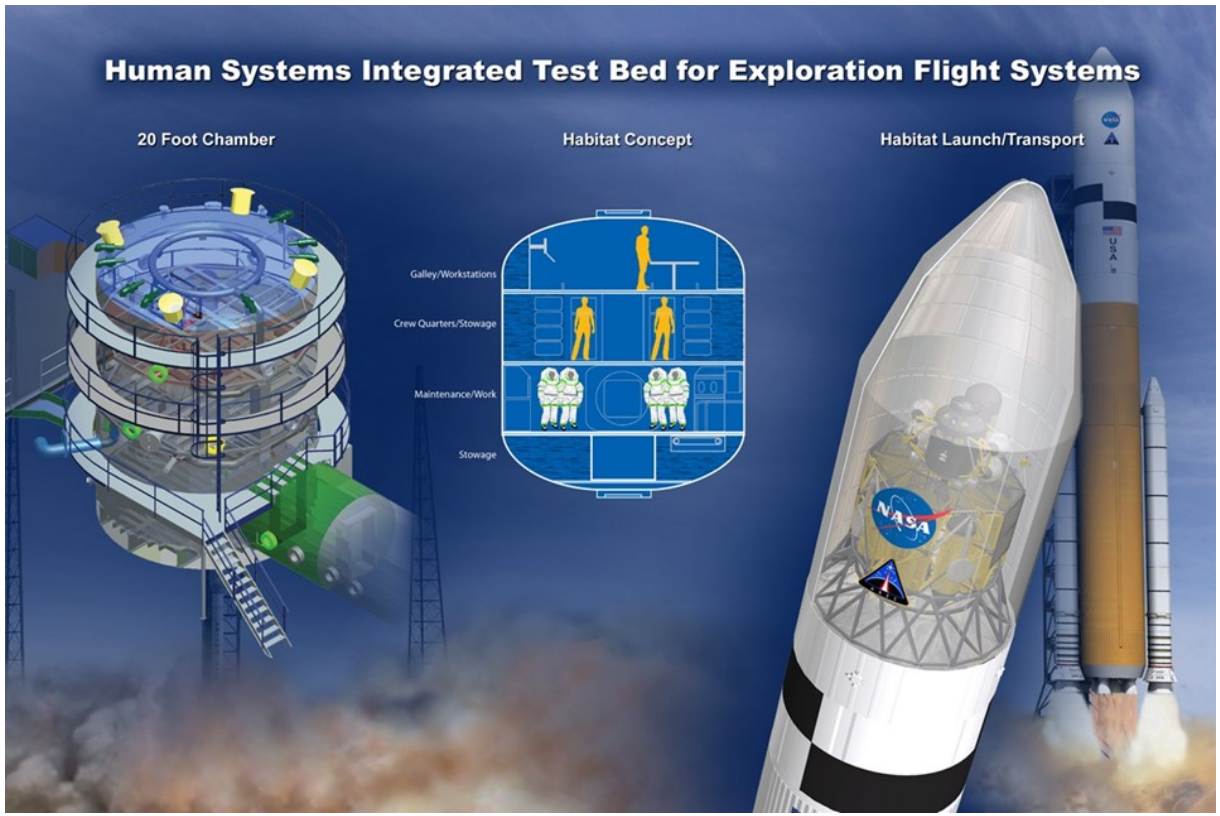

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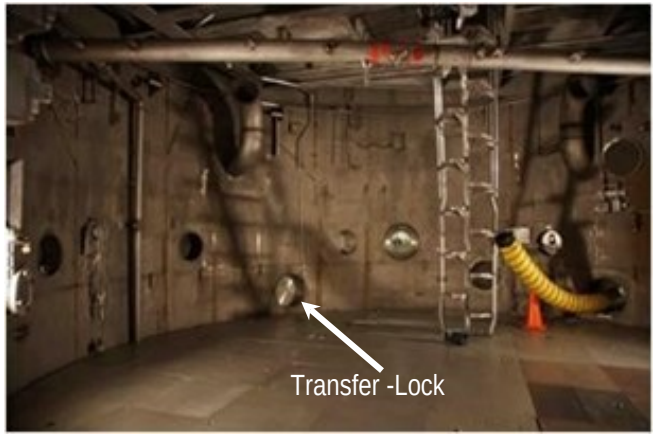
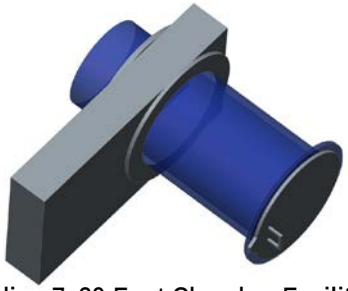
NASA / JSC Building 7, 20-Foot Chamber Facility – Man-Lock



NASA / JSC Building 7, 20-Foot Chamber Facility – Transfer -Lock



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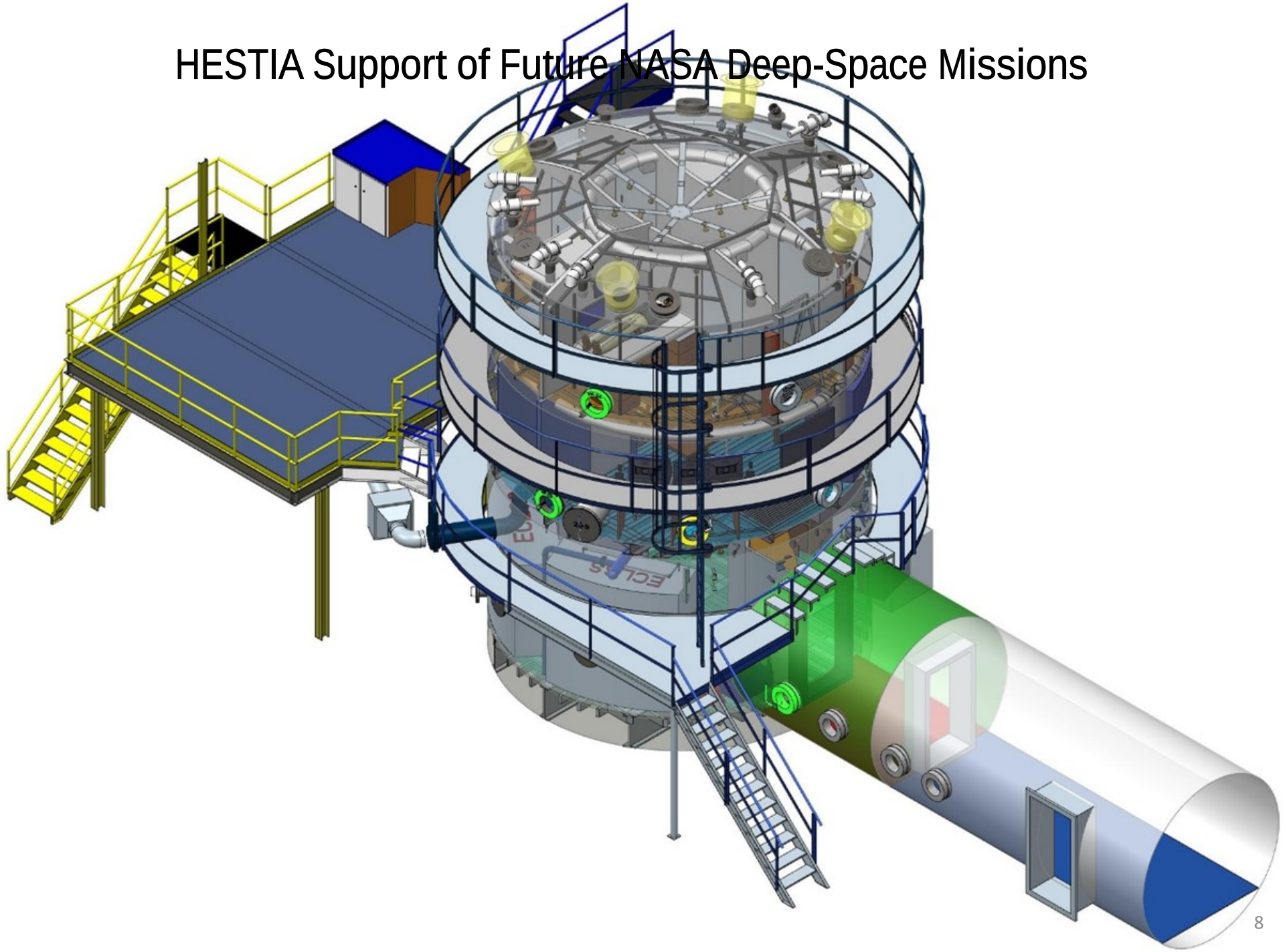

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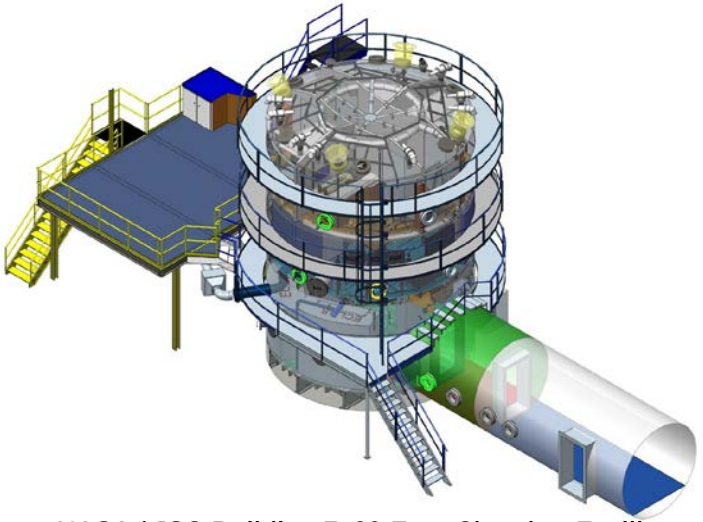
- External 2nd Floor platform allows flexibility for test and support hardware.



NASA / JSC Building 7, 20-Foot Chamber Facility – 2nd Floor Platform

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- Test operations follow stringent processes by a certified test team for both human and non-human testing.

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- Project management, analysis, design, acquisition, fabrication, assembly and test certification services are available for facility build-ups to support HESTIA research.

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- HESTIA offers close proximity to key stakeholders including astronauts, Human Research Program (HRP) [who direct space human research for the agency], Mission Operations, Safety & Mission Assurance, and the Engineering Directorate.

NASA / JSC Building 7, 20-Foot Chamber Facility

HESTIA Support of Future NASA Deep-Space Missions

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HESTIA 20-Foot Chamber Facility Project (FY '15)

- HESTIA was formed in FY '15
- FY '15 goal was to provide a demonstration of In-situ Resource Utilization (ISRU) and Environmental Control & Life Support System (ECLSS) cross-discipline technologies.
    - Test series conducted in September 2015. (Note: This will be further elaborated in the next presentation.)

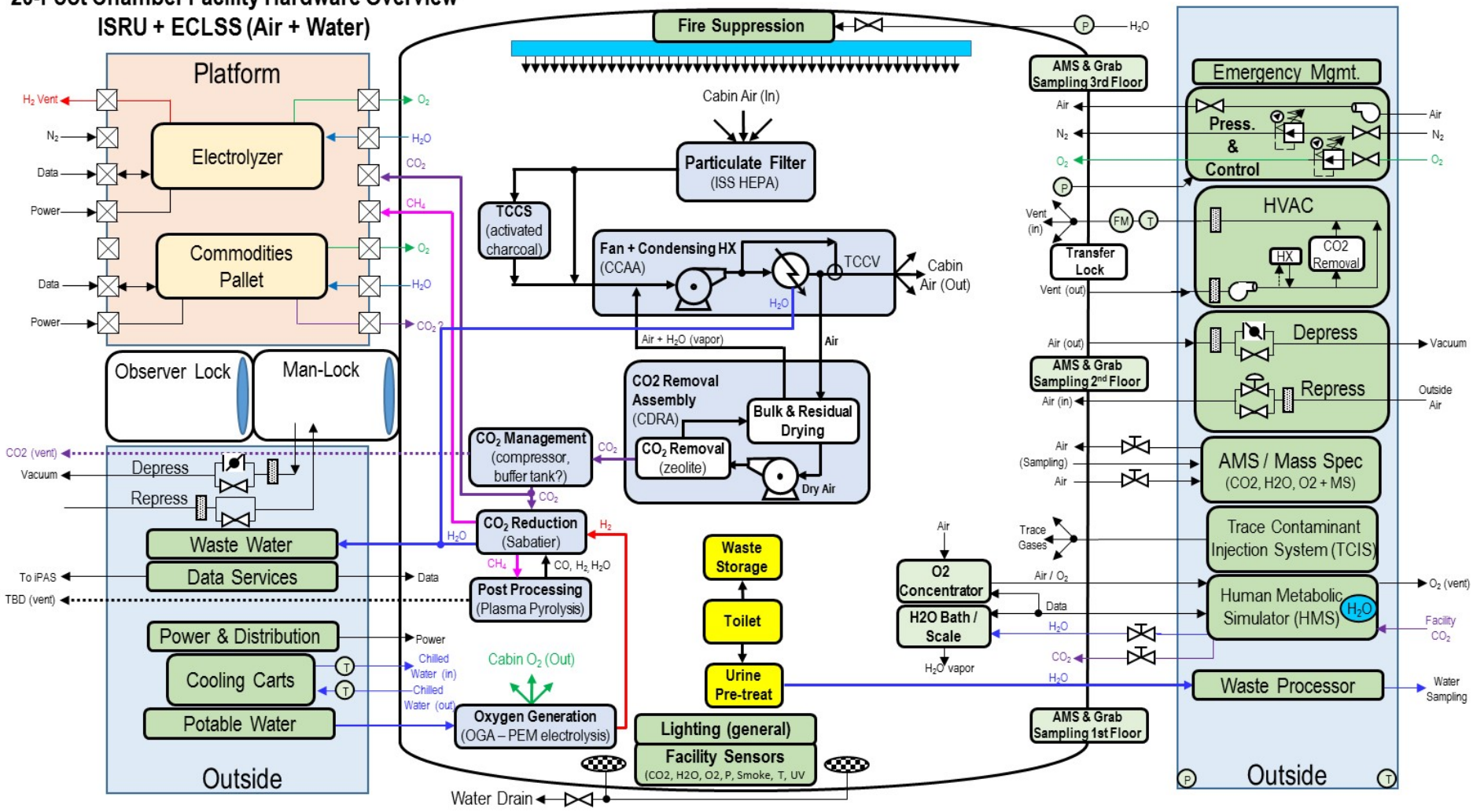
HESTIA Support of Future NASA Deep-Space Missions

HESTIA 20-Foot Chamber Facility Project (FY '16)

- FY '16 Goals
  - Begin to transform the 20-Foot Chamber Facility into a 4-person Mars Habitat analog capable of sub-atmospheric operation at elevated O2 concentrations
  - Work closely with ECLSS, Habitation, and HRP groups to plan and execute evaluations in the 20-foot chamber facility in support of deep-space research
  - Further build on the chamber facility capabilities of FY '15 in order to support more complex HESTIA and other customer evaluations. For example, the following are being integrated into the chamber:
    - Atmosphere Monitoring System (AMS) [integration & checkout]
    - Pressure Control System (PCS) [integration only; checkout to be performed in FY '17]
    - Trace Contamination Injection System (TCIS) [integration only; checkout to be performed in FY '17]
  - Participate in the HRP-sponsored Elevated CO2 Human Exposure Evaluation to study the effects of elevated CO2 on cognitive performance (April – June 2016)

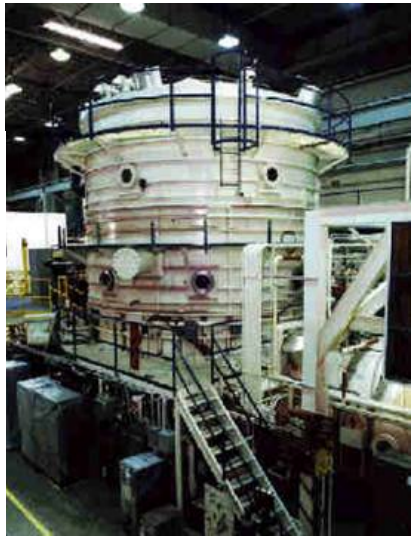
- FY '16 Products
  - Identify representative ECLSS System Schematic for 4-person Mars Habitat (use as 'road map')
  - Develop ECLSS System Schematic for 20-foot chamber build-up and support
  - Develop preliminary habitation outfitting plan to support both short & long-duration human evaluations
  - Develop Master Build Plan to aid in laying out future facility build-ups in the coming years
  - Provide additional test capability through select build-ups (e.g., meet depressurization & repressurization rates for upcoming FY '17 Exploration Atmosphere & EVA Prebreathe Protocol Validation)

20-Foot Chamber Facility Hardware Overview
ISRU + ECLSS (Air + Water)

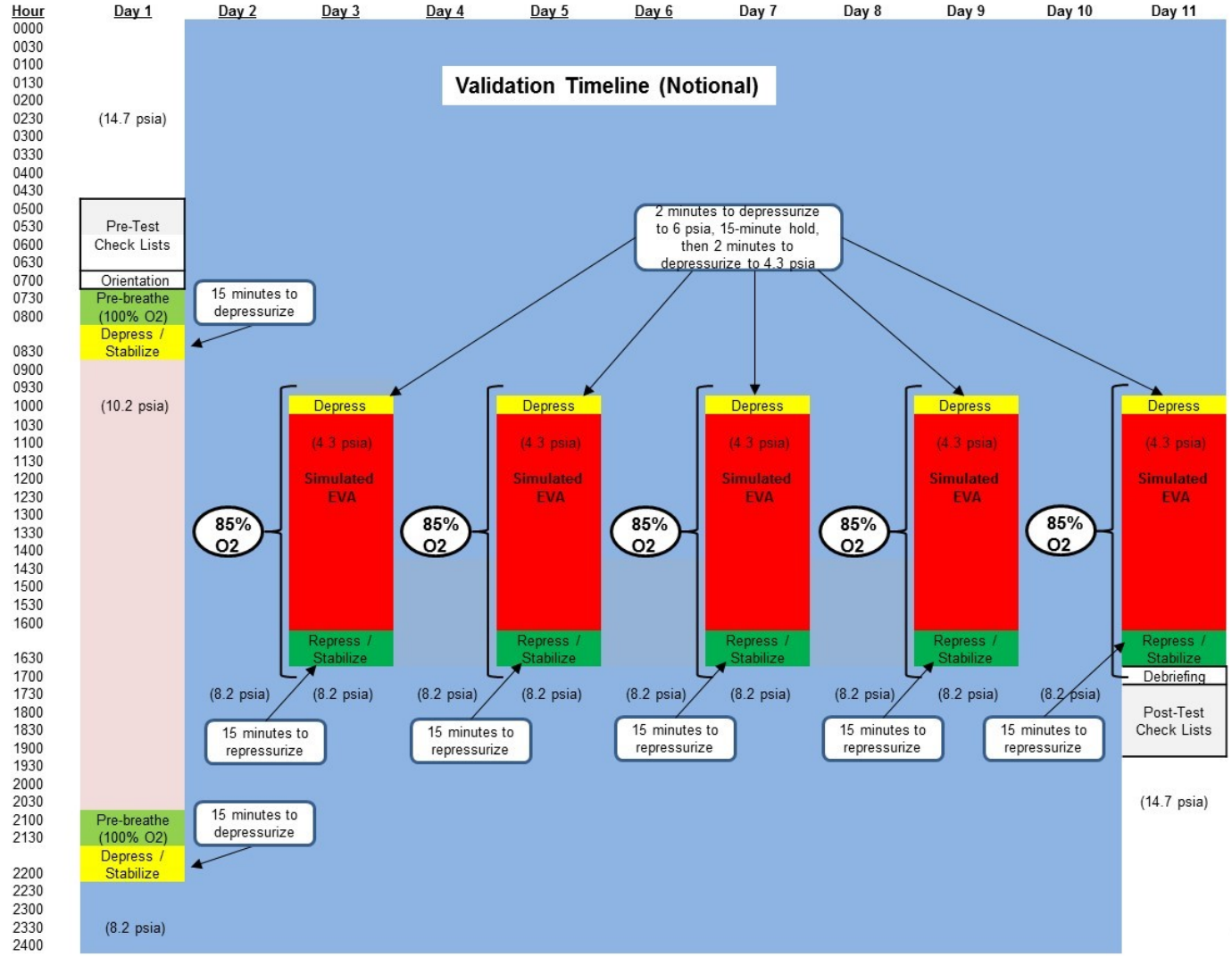


Ground Validation of 8.2 / 34 Exploration Atmosphere

- **Goal:** Ground Chamber Validation of Exploration Atmosphere & Prebreathe Protocols (with Shortened Purge, evaluation of Hypoxia & Other Physiological Effects) to support future space vehicles & habitats (e.g., Earth-Moon L1, Mars, NEA, etc.) and extravehicular activity (EVA) events
- **Approach:** Approximately 30 subjects (6 subjects per session) will conduct 5, 11-day saturation runs in order to validate



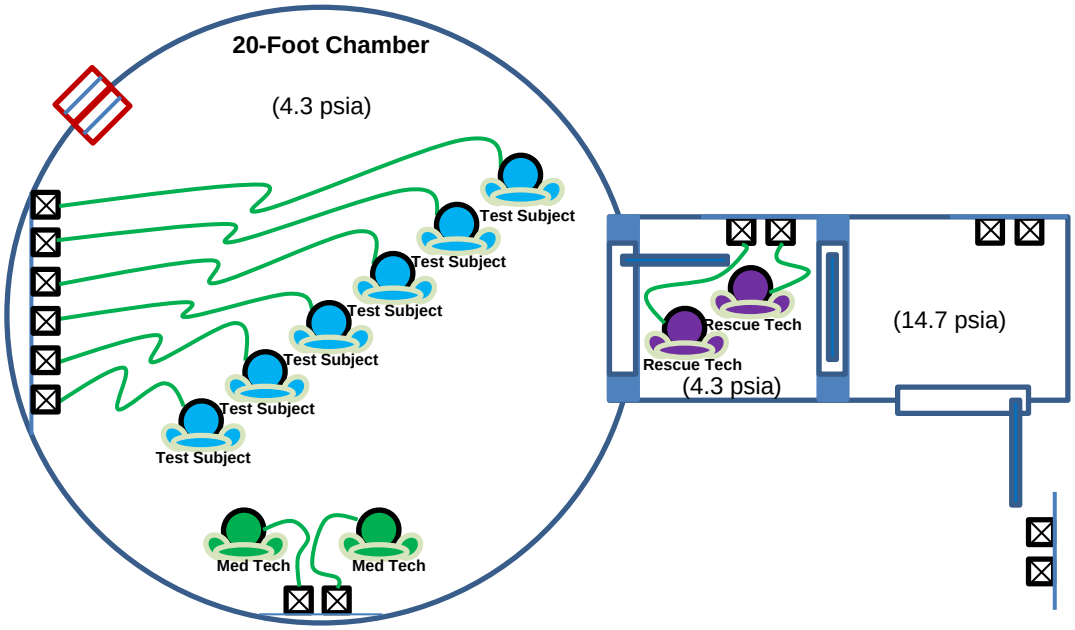
NASA/JSC 20-foot Chamber



Exploration Atmosphere & EVA Pre-breathe Protocol Validation

10f. Conduct EVA: EVA Operations
- Main Chamber
  - Hatch: Open
  - Techs: Masks On (100% O2)
  - Subjects: Masks On (85% O2)
- Man-lock
  - Hatch: Closed
  - Techs: Masks On (100% O2)
  - Subjects: N/A
- Exterior Hatch: Open

Time: Day 3
1019 - 1610 hours (Time EV: 00:09 – 06:00 hours)



Notes:
- 6-hour simulated EVA (max)
- Microgravity EVA or Surface EVA simulation

Assumptions:
- Rescue Techs (2) not swapped out during the simulated EVA. If this operation is necessary, the replacement Rescue Techs require a 4-hour prebreathe prior to chamber ingress.

HESTIA Support of Future NASA Deep-Space Missions

HESTIA 20-Foot Chamber Facility Project (FY '17)

- FY '17 Goals / Products
  - Perform facility build-ups in support of the HRP-sponsored Exploration Atmosphere & EVA Prebreathe Protocol Validation including the following:
    - Demonstrate pressure profiles & O2 control to achieve 10.2 psia / 26% O2 and 8.2 psia / 34% O2
    - Demonstrate simulated EVAs at 4.3 psia
    - Provide Habitation provisions (5, 11-day human evaluations)
      - Clothing
      - Exercise
      - Food & nourishment
      - Hygiene & waste control
      - Lighting
      - Privacy communications
      - Sleep quarters
    - Certify Emergency Management System (EMS) meets performance requirements. These provide for sensor response, fire / smoke detection, fire / smoke suppression, emergency repressurization, etc.
  - Based on Mars 4-person ECLSS schematic identified in FY '16, use SysML performance model to 'size' chamber for projected ECLSS hardware to be tested in future system-level evaluations.
  - Demonstrate capabilities of Trace Contamination Injection System (TCIS).
  - Continue to work closely with ECLSS, Habitation, and HRP groups in support of deep-space research.
  - Execute HRP-sponsored Exploration Atmosphere & EVA Prebreathe Protocol Validation in late FY '17 or early FY '18.

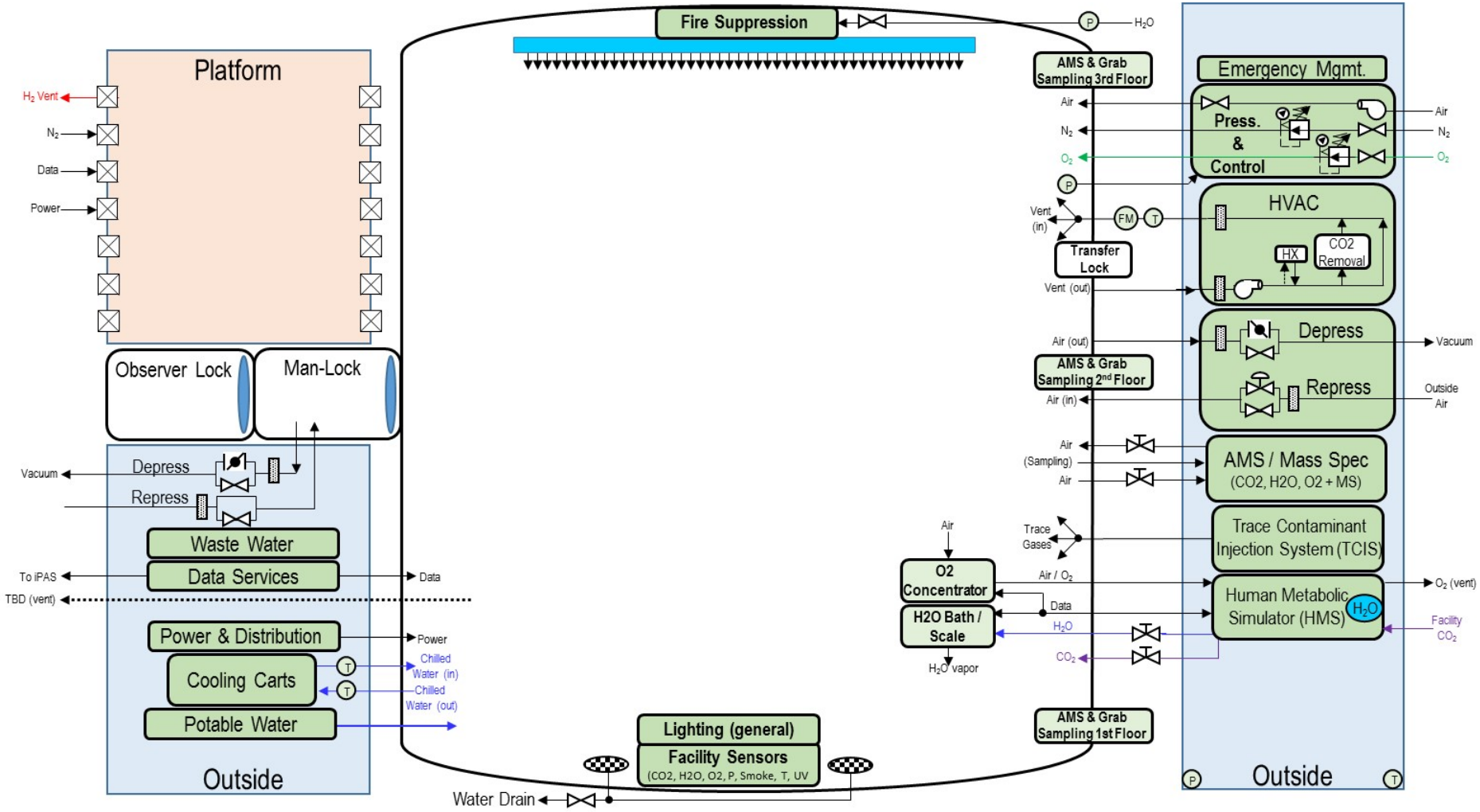
HESTIA Support of Future NASA Deep-Space Missions

HESTIA 20-Foot Chamber Facility Project (FY '18 & beyond)

- FY '18 and beyond Goals
  - Perform facility build-ups in support of ECLSS technology performance and Habitat outfitting research
    - Builds to power, data, thermal, physical (e.g., racks), potable water, waste water, etc.
    - Unique builds to support specific Habitation research (long-duration stays, e.g., months)
      - Command & Control
      - Clothing and support functions
      - Entertainment
      - Exercise
      - Food & nourishment, including food preparation (galley)
      - Hygiene & waste control
      - Lighting
      - Privacy communications
      - Secondary structure
      - Sleep quarters
  - Integrate technology candidates into the chamber and begin to conduct system-level ECLSS, Habitation, and HRP evaluations in support of deep-space research.
  - Continue to improve the SysML performance model for the 20-foot chamber ECLSS system based on available test data.
  - Work to expand our customer participation to include academia, industry, and international partners
- Product: In the end, the plan will be to perform long-duration (i.e., years) human, closed-loop research of key Deep-Space technologies and scenarios, including reduced pressure and elevated O2.

Backup Charts

20-FOOT CHAMBER FACILITY RESOURCES AVAILABLE



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HUMAN EXPLORATION SPACECRAFT TESTBED FOR INTEGRATION AND ADVANCEMENT

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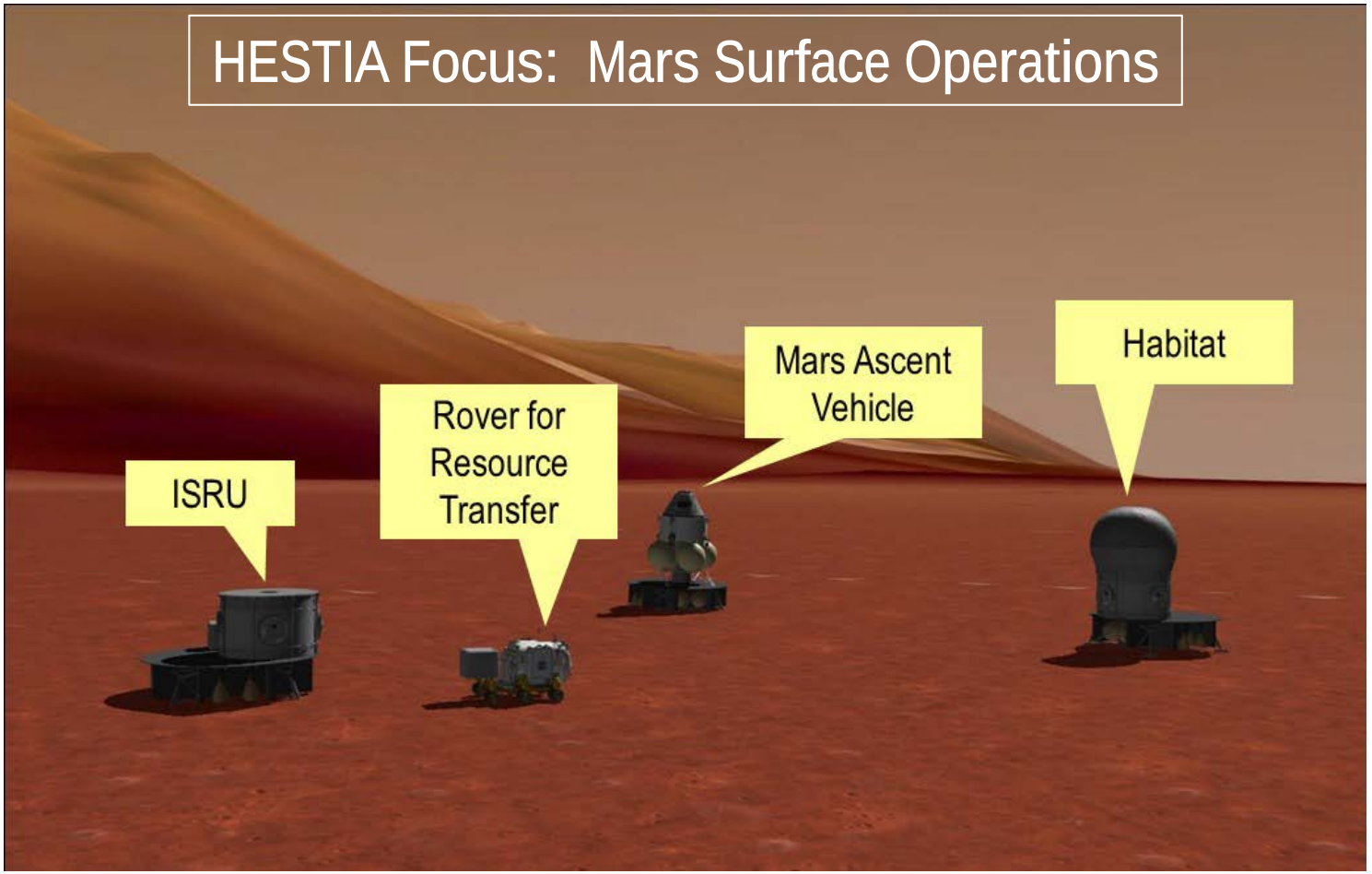
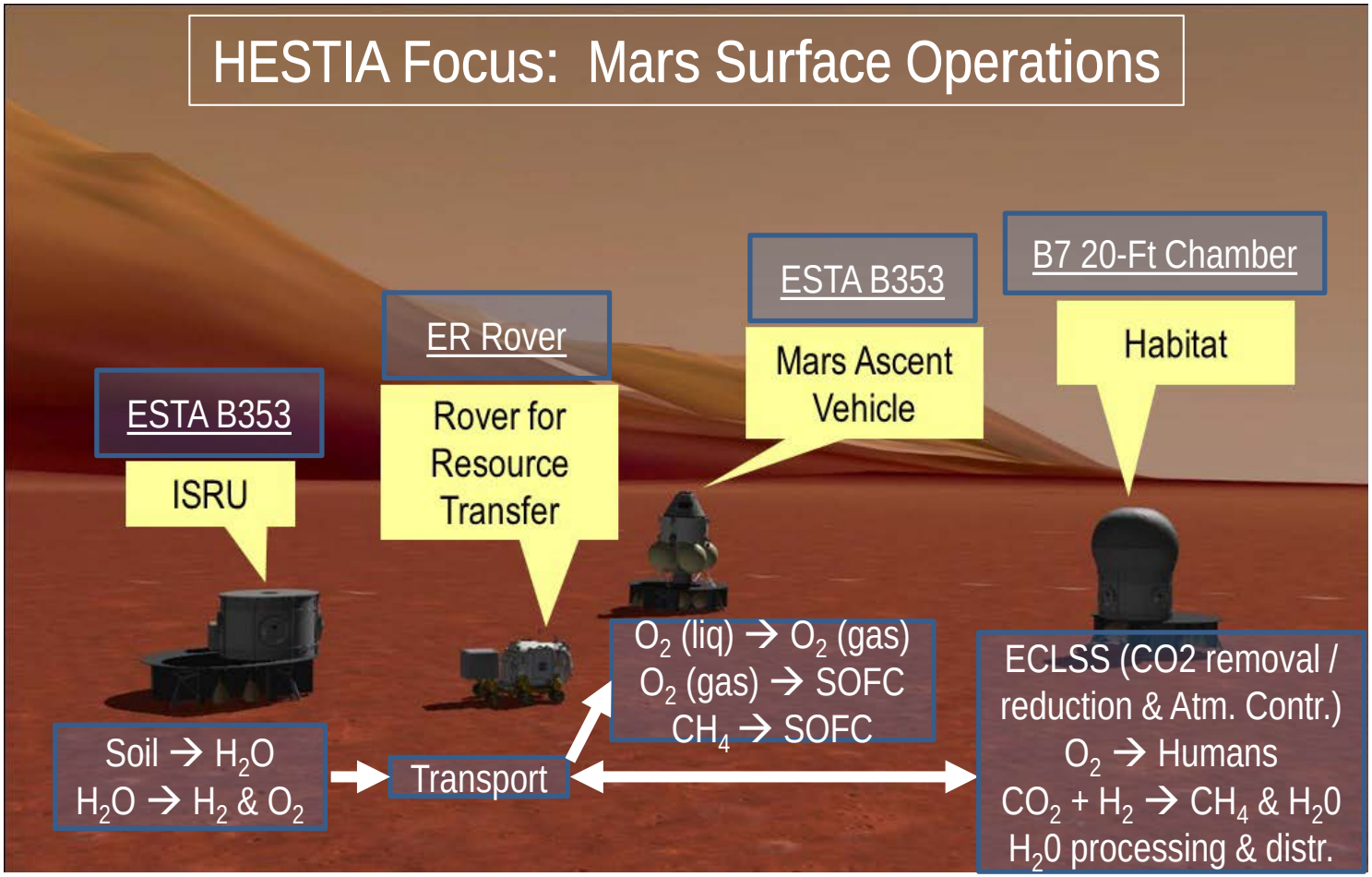
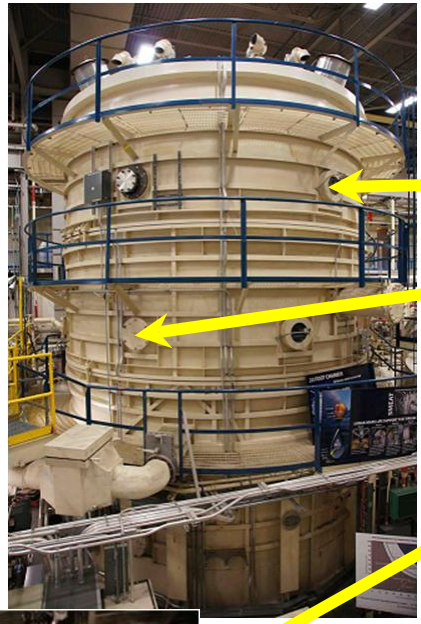


OUR FOCUS IS CROSS DISCIPLINE SYSTEMS ENGINEERING …

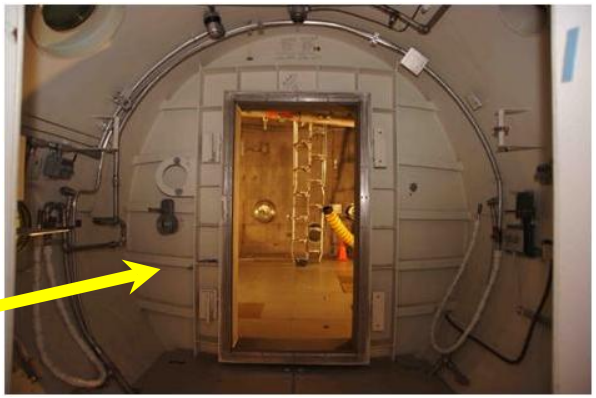


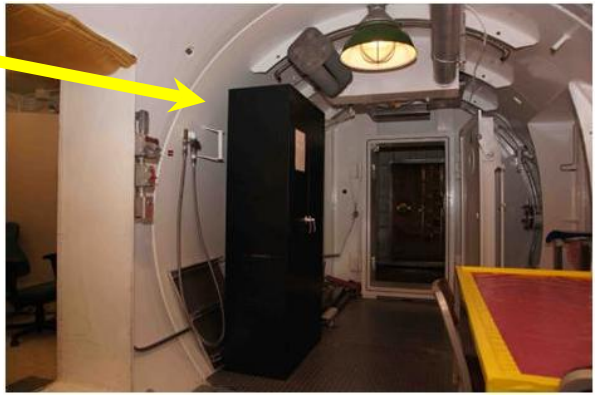
Some Key Facility Features

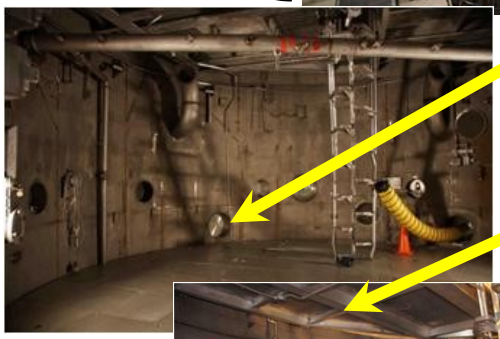
- 3 stories
- 27.5’ x 20’ dia.
- 8,090 ft^3 total volume



- Chamber Cylinder
  - View Ports
  - Pass Throughs
- Man-Lock
- Observer Lock
- Transfer Lock
- Interior
  - Floor / Ceiling Support
  - Ladders
  - Floor Plates
- 2nd Floor Platform

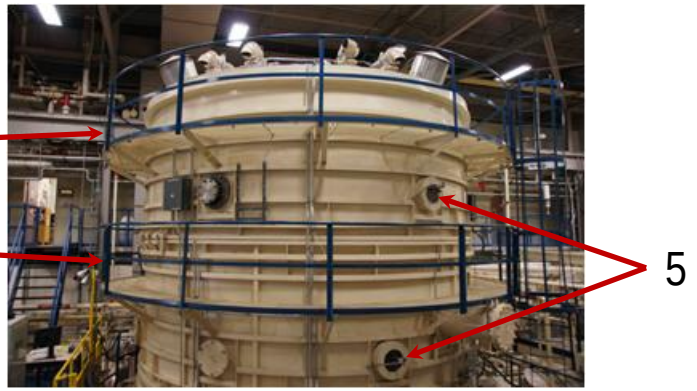






Various Facility Features

- Exterior Hardware
  1. 2nd Floor Platforms and Stairs
  2. 2nd Floor Walkway
  3. 3rd Floor Walkway
  4. Exterior Electrical Boxes (Breaker & Outlets)
  5. Camera Locations
  6. Vacuum Lines, Coolant Lines, etc.
  7. Top of Chamber (Relief Valves, etc.)



Exterior Photos

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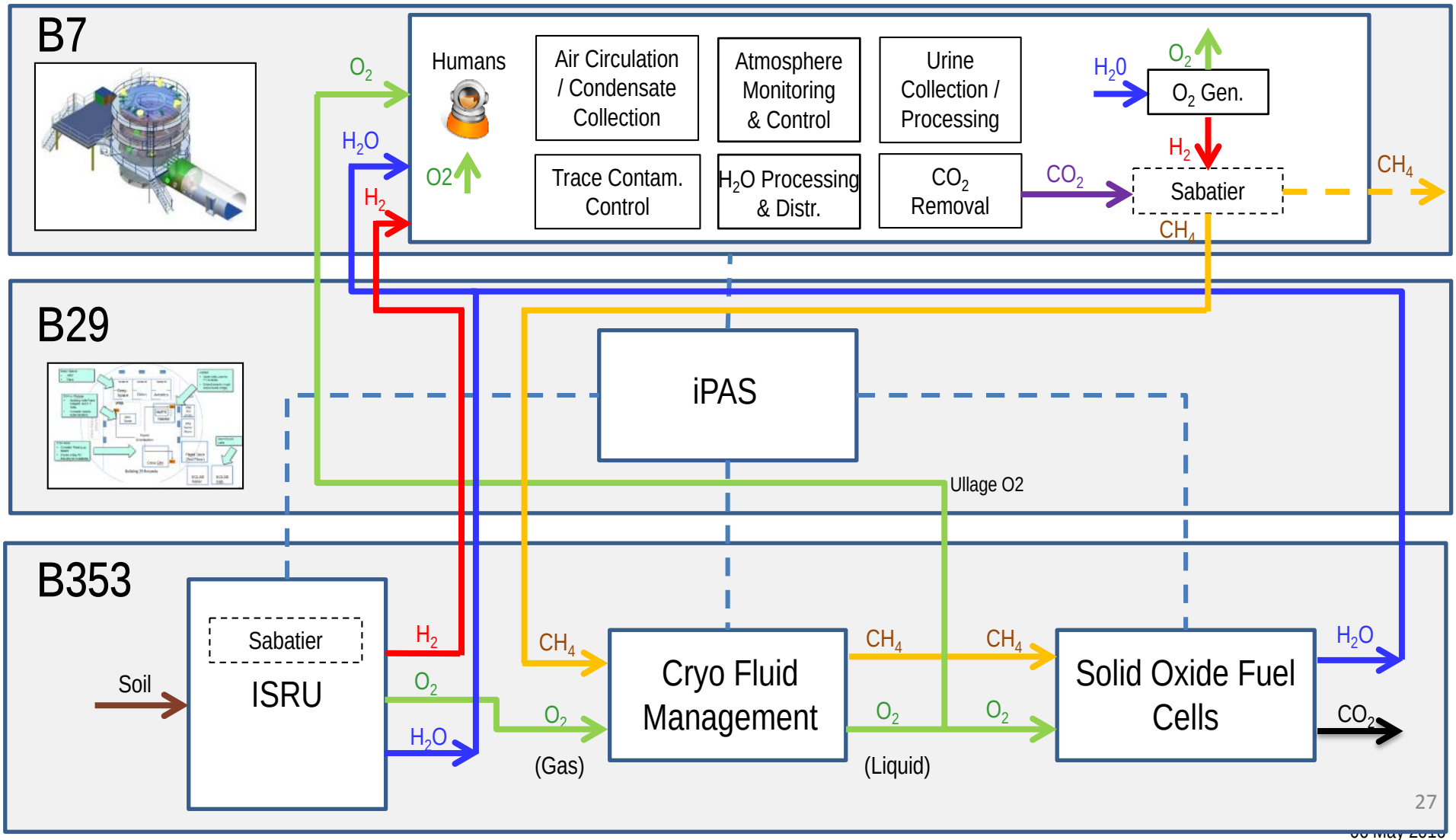

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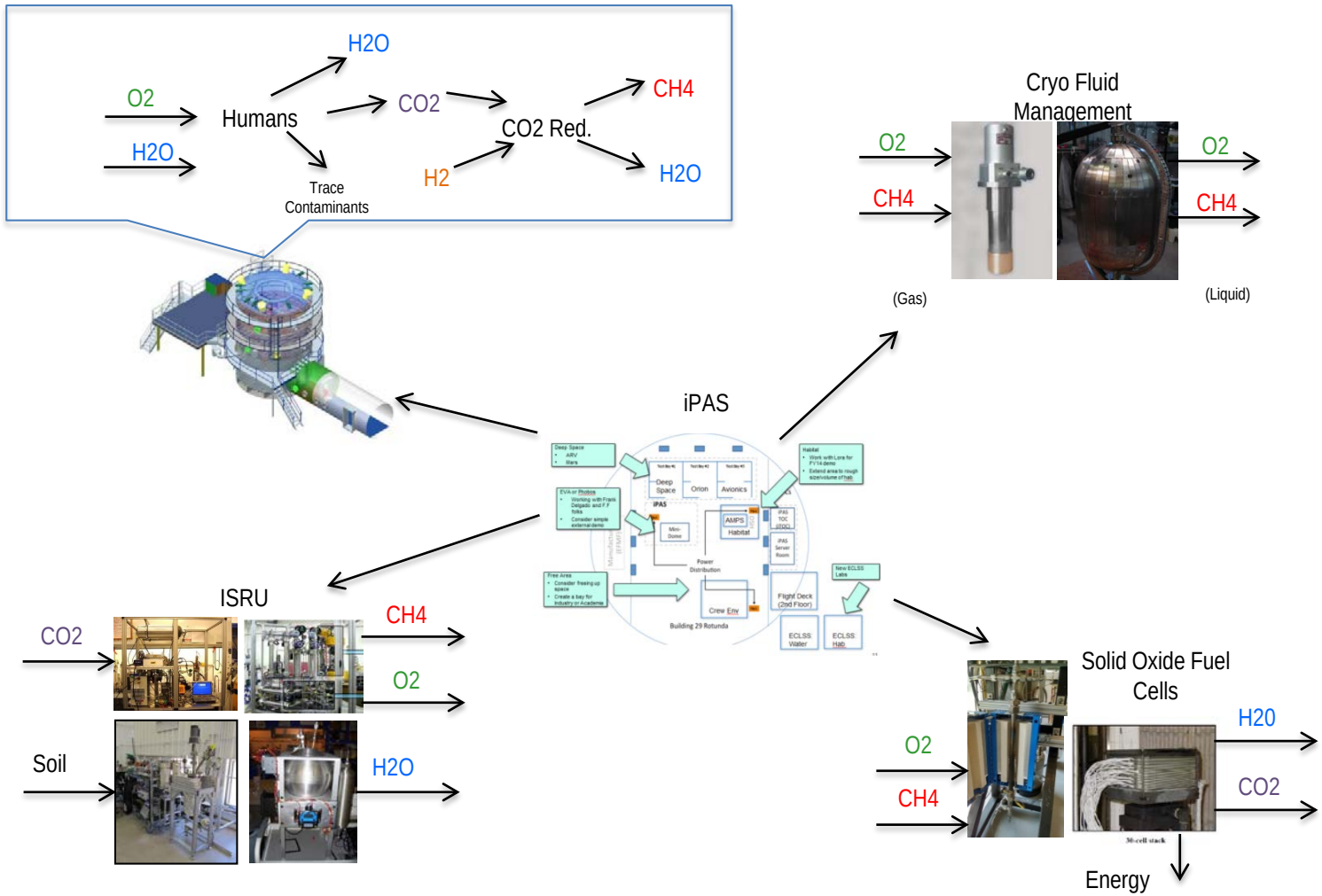
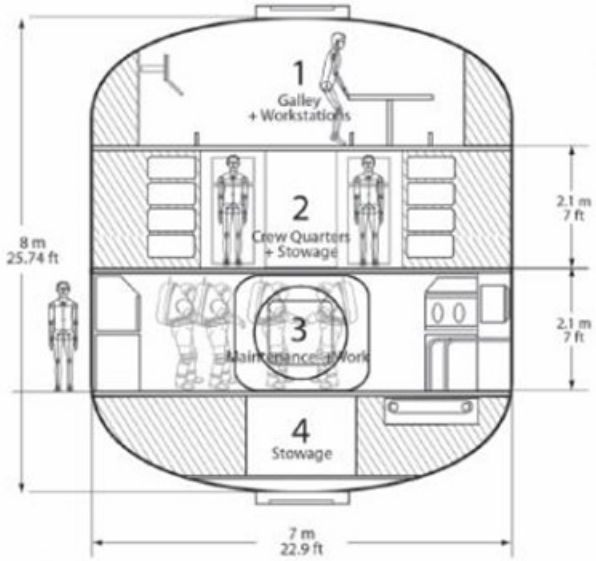
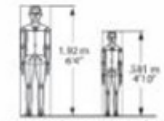


06 May 2016

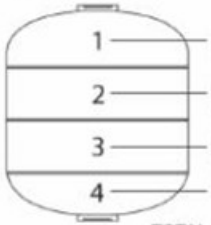
Deep Space Habitat
Vertical Orientation Floor Plan



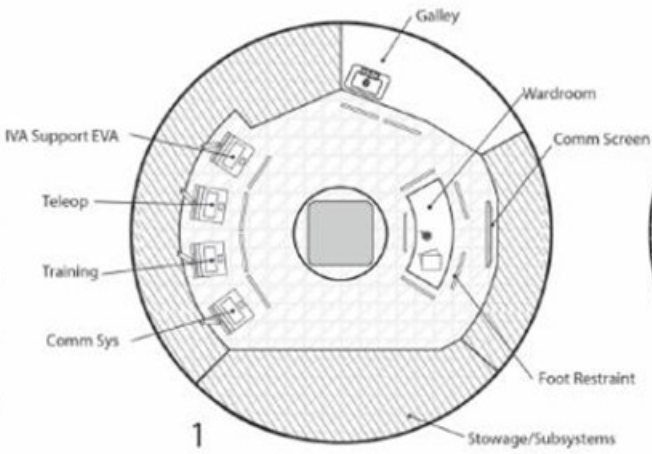


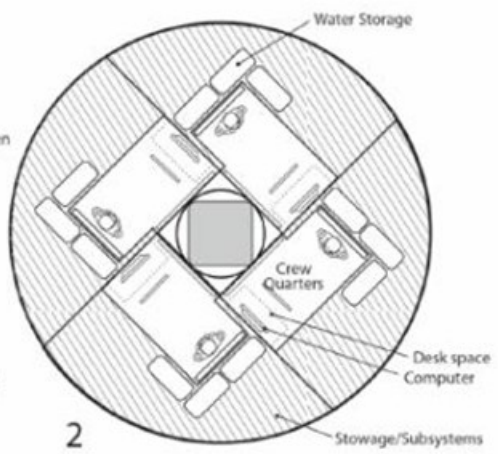
99% Male 1% Female

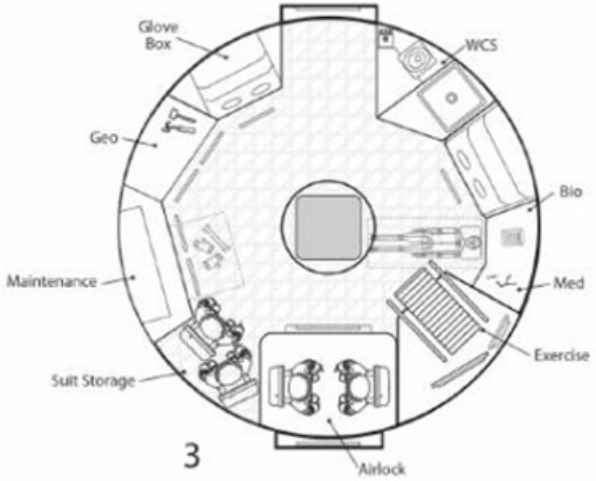
VOLUME

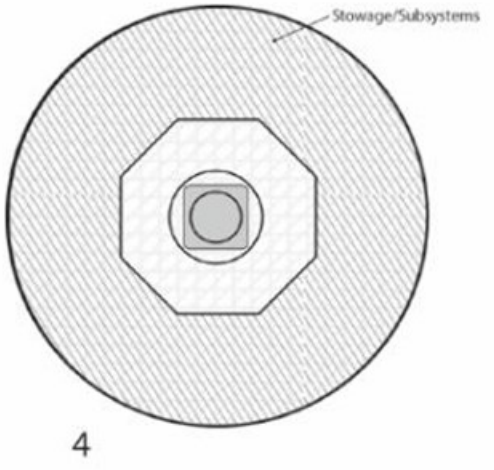


1	67.9m3/ 2399.7ft3
2	80.8m3/ 2854ft3
3	80.8m3/ 2854ft3
4	45.3m3/ 1600.6ft3
TOTAL	274.9m3/ 9708.5ft3









HABITABILITY DESIGN CENTER

TITLE	PROJECT	DATE	NAME
DSH Vertical Layout 7.3M x 8M	Deep Space Habitat (DSH)	09.28.11	Human Factors Design Team