Deep Space Habitats

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Humans to Mars Summit 2015

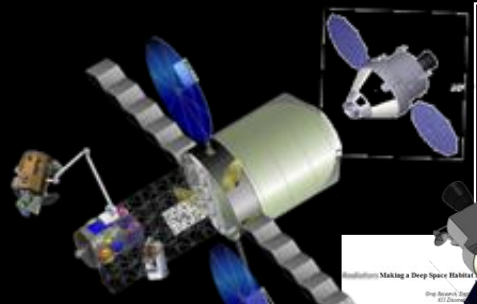
Stepping Stones (II): ISS and Beyond

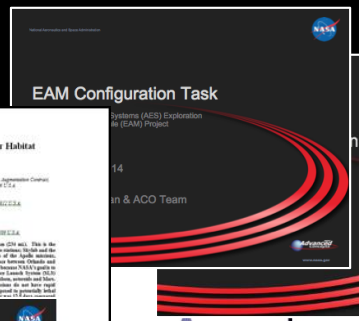
Deep Space Habitat Studies

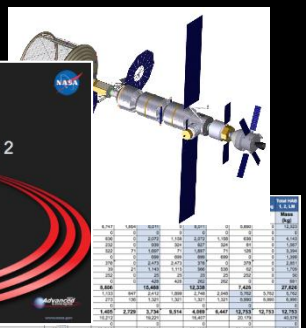
Advanced Explorations Systems Program

Studies – Technical Papers – Concept Demonstrators

2011	2012	2013	2014	2015
ISS Derived Configurations	Launch Vehicle Derived Configurations	Integrated Propulsion Configurations	ELV & SLS Launched Systems	Asteroid & Mars Mission Configurations

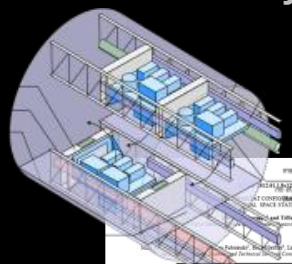


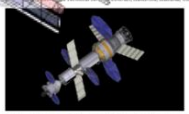


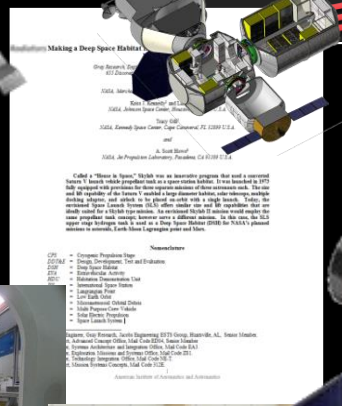


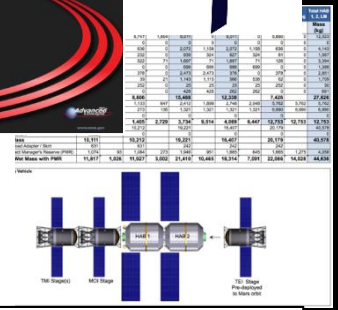
Floor & Ceiling Subsystem Pallets

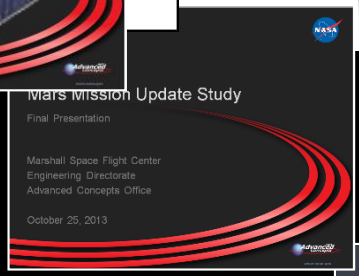
Skylab II

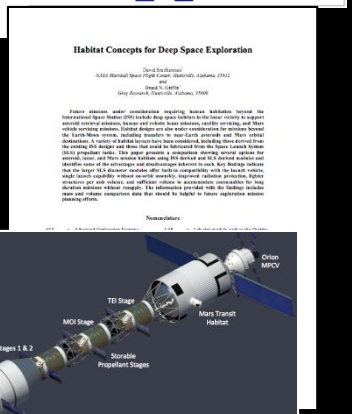










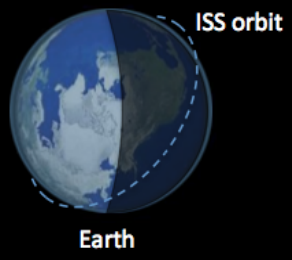


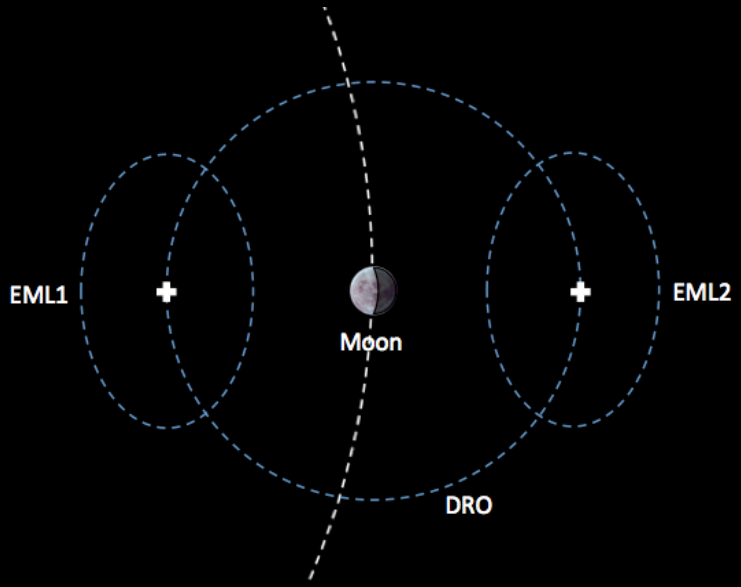
Pallet Mockups

SLS Class Configurations
4 & 6 Crew / 1000 Days

Habitation Missions

Moving from Low Earth Orbit to Deep Space



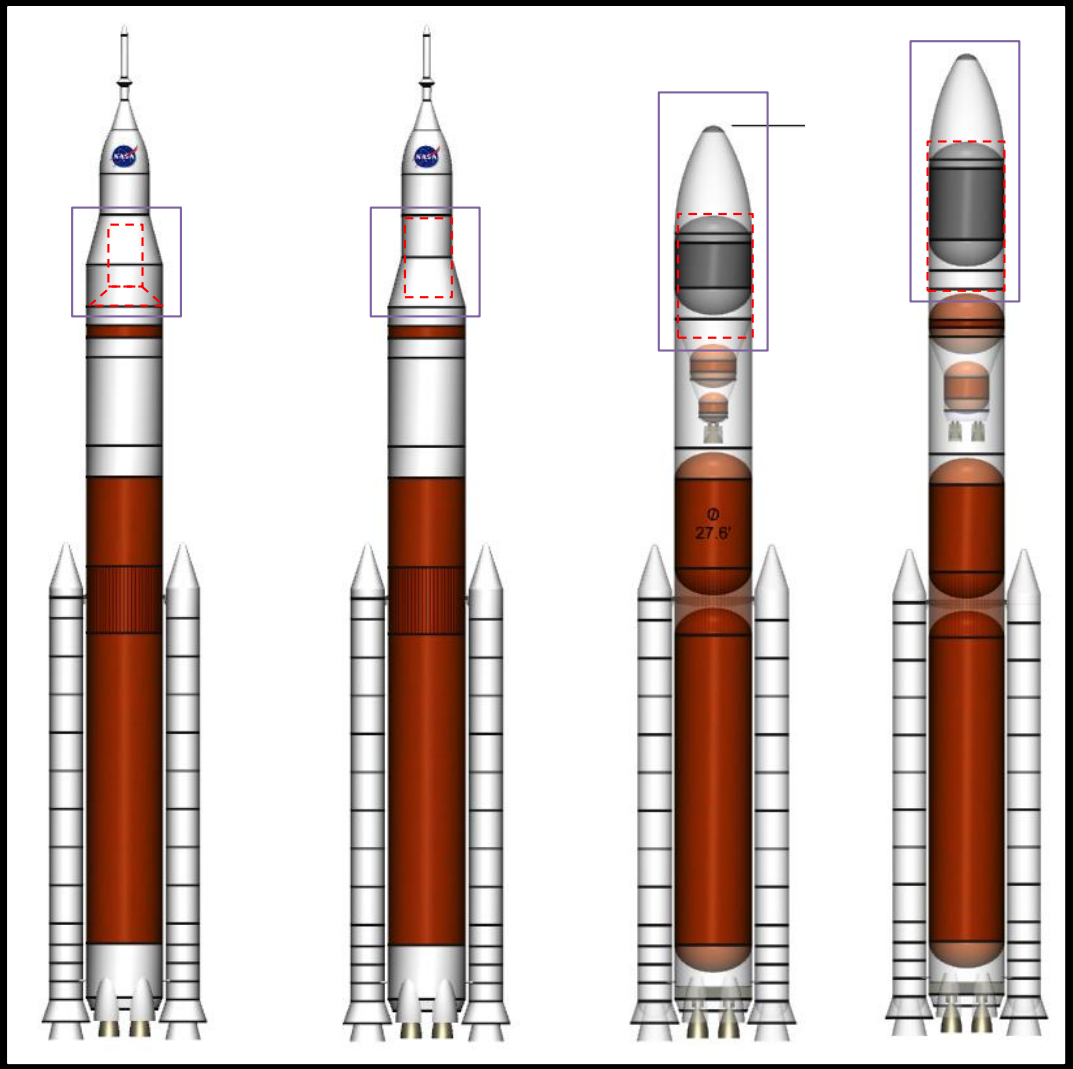


- Habitation testing concepts at ISS
  - Human research & technology demonstrations
- Deep Space Habitats in the Lunar Vicinity
  - Asteroid Retrieval Mission support
  - Mars vehicle assembly & habitat servicing support
  - International & commercial interest including lunar mission support
- Mars transfer habitat concepts
  - Launch vehicle payload integration analysis
  - Mass & volume studies
  - Interior configurations, outfitting, and human factors studies

SLS Integration

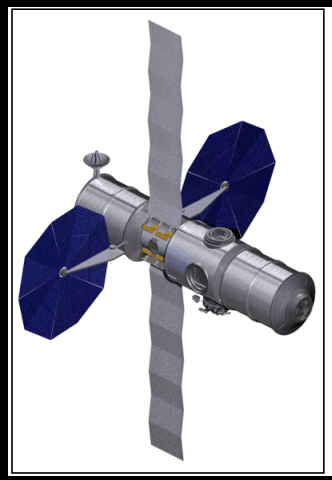
Co-manifested & Primary Payload Configurations

- Co-manifested payload configurations
  - 4.5m ISS diameter
    - 5 rack-bay length
    - Outfitting flights required
  - 5.5m diameter
    - 2 deck level layout
    - Outfitting flights required
- Primary payload configurations
  - 8.4m SLS diameter
    - Standard barrel section lengths
    - 3 deck level layout



ISS & SLS Derived Concepts

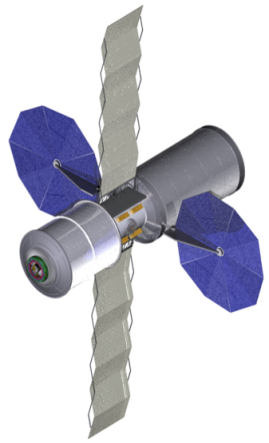
Deep Space Habitats for the Lunar Vicinity



Design Constraints/Parameters	
Pressurized Volume	~281 m^3
Habitable Volume	~108.3 m^3
Atmospheric Pressure	101.3 kPa
Crew Capacity	4
Crewed Mission Duration	500 d
EOL Solar power generation	34 kW
Power load during battery operation	20 kW
Average TRL	8.1
TRL 9 / Heritage	65%
ECLSS Closure - Water	Closed Loop
ECLSS Closure - Air	Closed Loop
Habitat Structure	Rigid Cylinder
Habitat Length	20 m
Habitat Diameter	4.5 m
Mass Growth Allocation	8.35%
Project Manager's Reserve	10%

Category	Mass (kg)
Structures	19,955
Propulsion	0
Power	924
Avionics	1,383
Thermal	2,744
Environment Protection	4,603
ECLSS	4,607
Crew Systems	964
EVA	272
Science	0
Dry Mass	**35,452**
Stowed Provisions	3,416
Consumable Fluids	5,973
Non-Propellant Fluids	229
Inert Mass	**9,618**
Total Less Propellants	45,070
Propellant	0
Wet Mass	**45,070**
Project Mgrs Reserve (10%)	4,507
Total	**49,578**

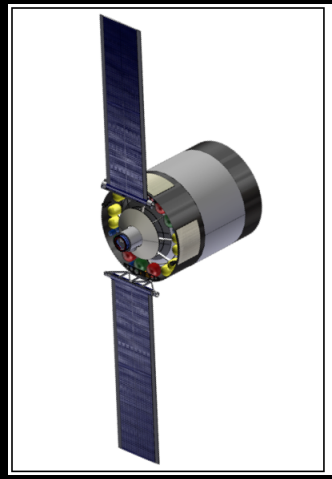
ISS Node & MPLM's*



Design Constraints/Parameters	
Pressurized Volume	~193 m^3
Habitable Volume	~90 m^3
Cabin Pressure	70.3 kPa
Crew Capacity	4
Crewed Mission Duration	500 d
EOL Solar power generation	34 kW
Power load during battery operation	20 kW
Average TRL	7.7
TRL 9 / Heritage	47%
ECLSS Closure - Water	Closed Loop
ECLSS Closure - Air	Closed Loop
Habitat Structure	Rigid Cylinder
Habitat Length	18 m
Habitat Diameter	4.5 m
Mass Growth Allocation	13.62%
Project Manager's Reserve	10%

Category	Mass (kg)
Structures	14,116
Propulsion	0
Power	924
Avionics	1,321
Thermal	2,868
Environment Protection	4,826
ECLSS	6,890
Crew Systems	807
EVA	272
Science	0
Dry Mass	**32,022**
Stowed Provisions	2,766
Consumable Fluids	6,187
Non-Propellant Fluids	457
Inert Mass	**9,409**
Total Less Propellant	**41,430**
Propellant	0
Wet Mass	**41,430**
Project Mgrs Reserve (10%)	4,143
Total	**45,573**

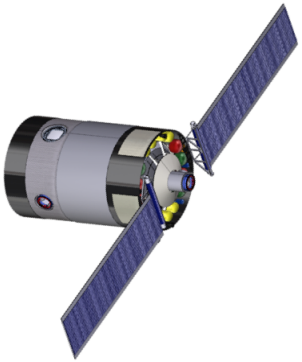
ISS HAB & MPLM*



Design Constraints/Parameters	
Pressurized Volume	~496 m^3
Habitable Volume	~353 m^3
Atmospheric Pressure	101.3 kPa
Crew Capacity	4
Crewed Mission Duration	180 d
EOL Solar power generation	22 kW
Power load during battery operation	3.3 kW
Average TRL	7.9
TRL 9 / Heritage	50%
ECLSS Closure - Water	Closed Loop
ECLSS Closure - Air	Closed Loop
Habitat Structure	Rigid Cylinder
Habitat Length	13.5 m
Habitat Diameter	8.4 m
Mass Growth Allocation	9.90%
Project Manager's Reserve	10%

Category	Mass (kg)
Structures	9,596
Propulsion	0
Power	1,364
Avionics	1,736
Thermal	1,007
Environment Protection	0
ECLSS	2,491
Crew Systems	599
EVA	488
Science	0
Dry Mass	**17,280**
Stowed Provisions	870
Consumables	1,566
Nonpropellant Fluids	91
Inert Mass	**2,527**
Total Less Propellant	**19,807**
Propellant	0
Wet Mass	**19,807**
Project Mgrs Reserve	1,981
Total	**21,788**

SLS-Class Minimum Capability Habitat*



Design Constraints/Parameters	
Pressurized Volume	~662 m^3
Habitable Volume	~519 m^3
Atmospheric Pressure	101.3 kPa
Crew Capacity	4
Crewed Mission Duration	180 d
EOL Solar power generation	22 kW
Power load during battery operation	3.3 kW
Average TRL	7.9
TRL 9 / Heritage	50%
ECLSS Closure - Water	Closed Loop
ECLSS Closure - Air	Closed Loop
Habitat Structure	Rigid Cylinder
Habitat Length	16.5 m
Habitat Diameter	8.4 m
Mass Growth Allocation	9.61%
Project Manager's Reserve	10%

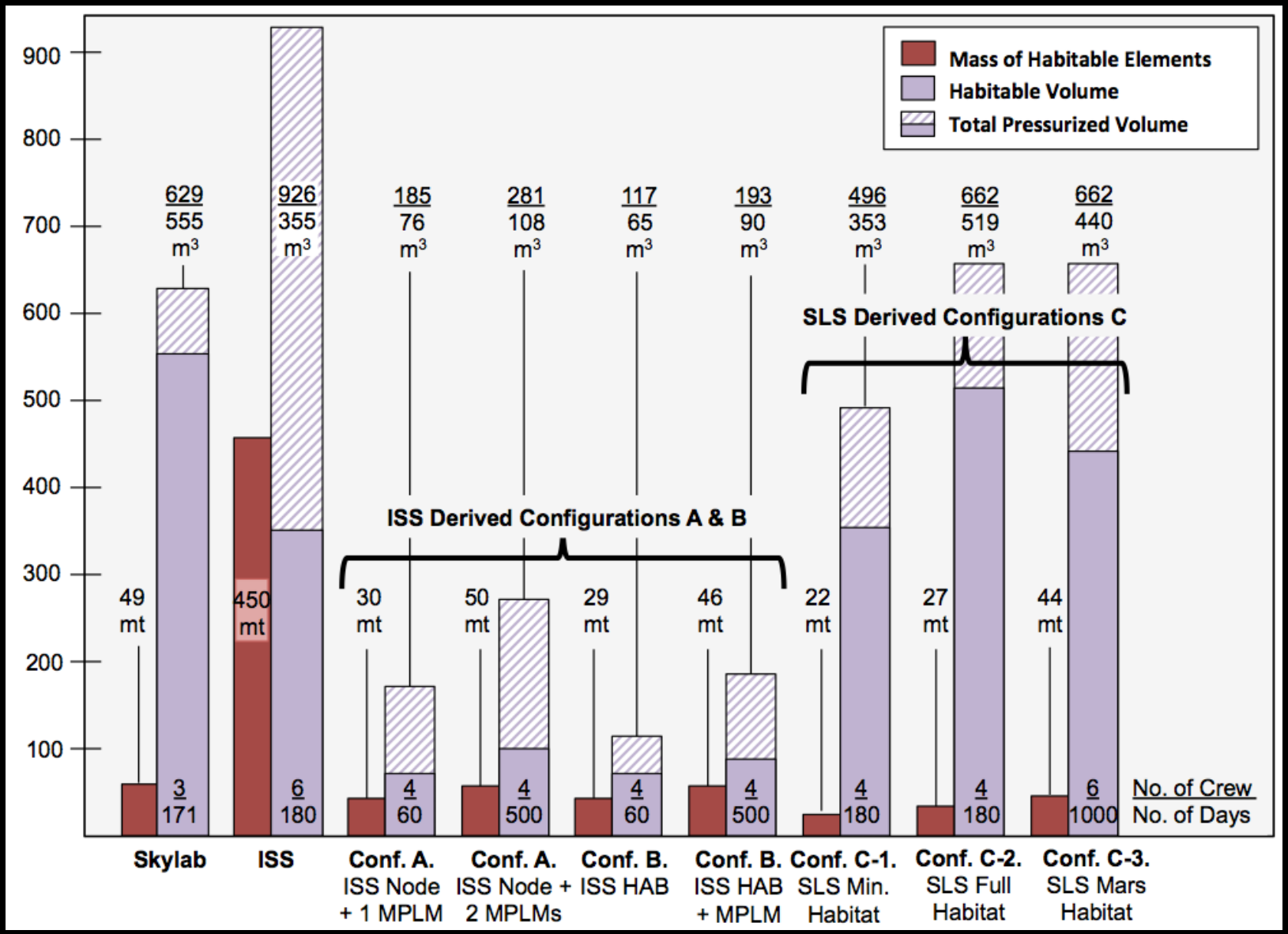
Category	Mass (kg)
Structures	13,902
Propulsion	0
Power	1,364
Avionics	2,154
Thermal	1,102
Environment Protection	0
ECLSS	2,572
Crew Systems	702
EVA	570
Science	0
Dry Mass	**22,366**
Stowed Provisions	870
Consumables	1,566
Nonpropellant Fluids	138
Inert Mass	**2,574**
Total Less Propellant	**24,940**
Propellant	0
Wet Mass	**24,940**
Project Mgrs Reserve	2,494
Total	**27,434**

SLS-Class Full Capability Habitat*

*Smitherman, D., B. Griffin, "Habitat Concepts for Deep Space Exploration," AIAA Space 2014, Paper No. 4477, San Diego, CA, August 2014.

Mass & Volume Comparison

Deep Space Habitats in the Lunar Vicinity



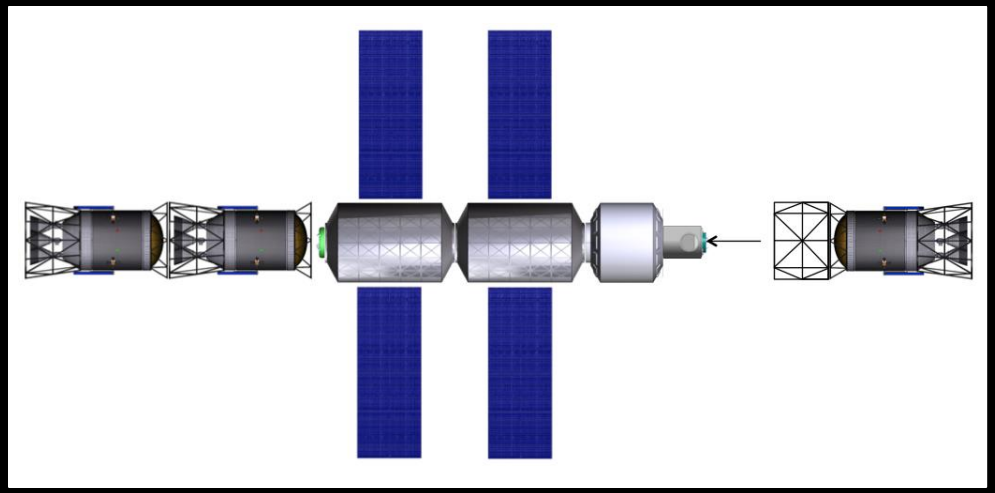
Mass & Volume Comparison*

*Smitherman, D., B. Griffin, "Habitat Concepts for Deep Space Exploration," AIAA Space 2014, Paper No. 4477, San Diego, CA, August 2014.

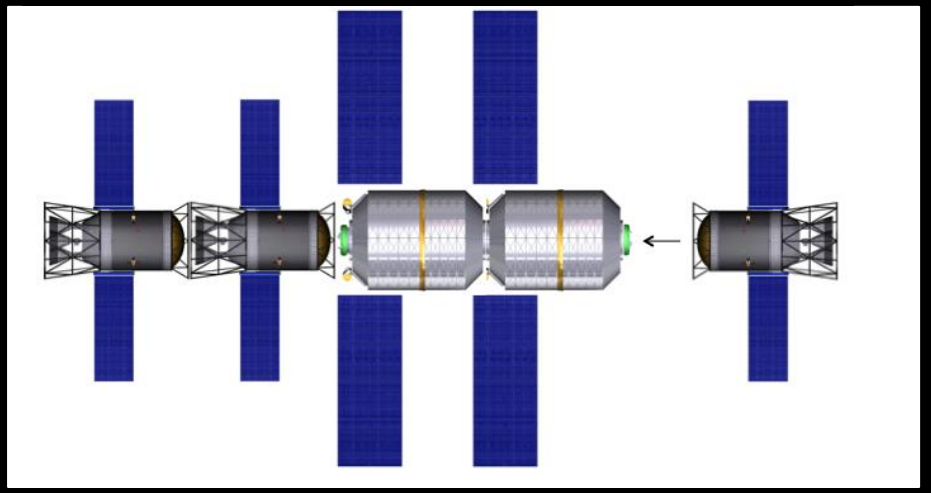
Mass & Volume Comparisons

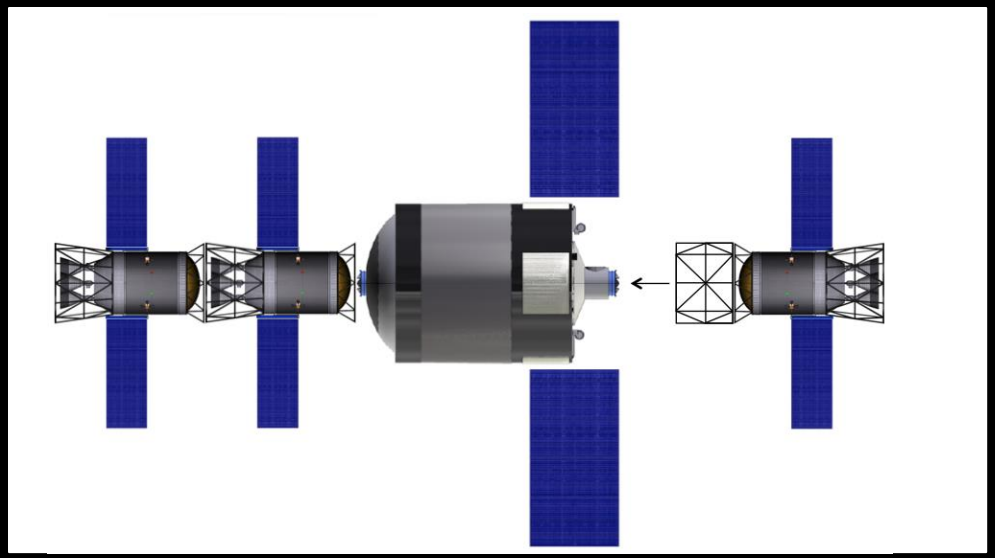
Deep Space Habitats for Mars Transit Vehicles

3 Small ISS Diameter Modules

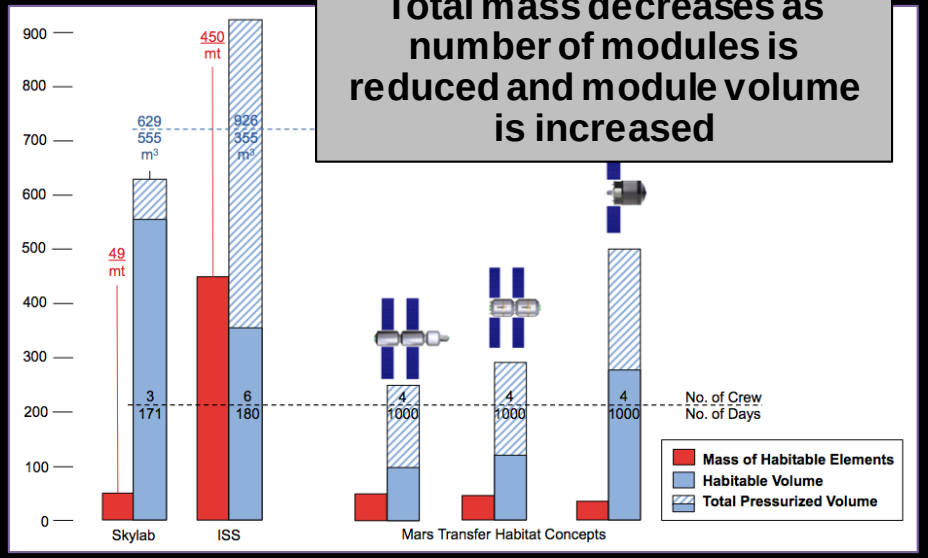


2 Medium Diameter Modules





1 Large Diameter Module

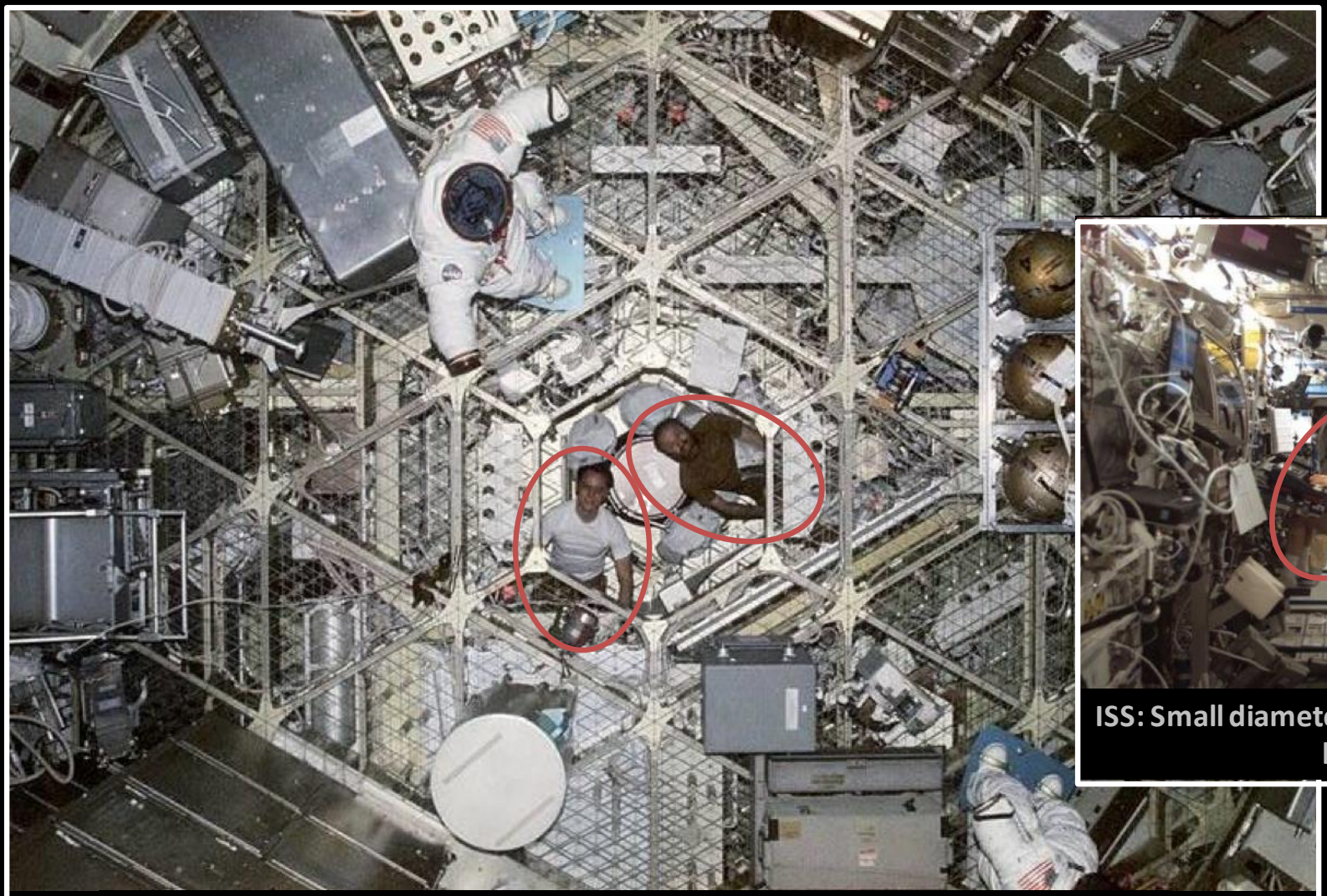


Mass & Volume Comparison**

**Data planned for publications at AIAA Space 2015

Interior Outfitting

Skylab & ISS



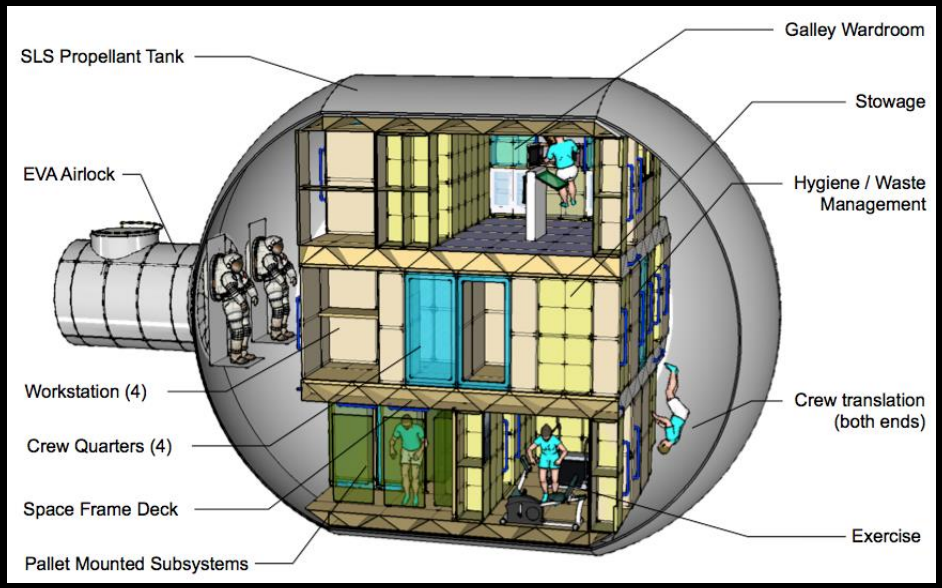
Skylab: Large diameter, vertically oriented layout.

ISS: Small diameter, horizontally oriented layout

Habitat Support Systems

ISS vs. other approaches

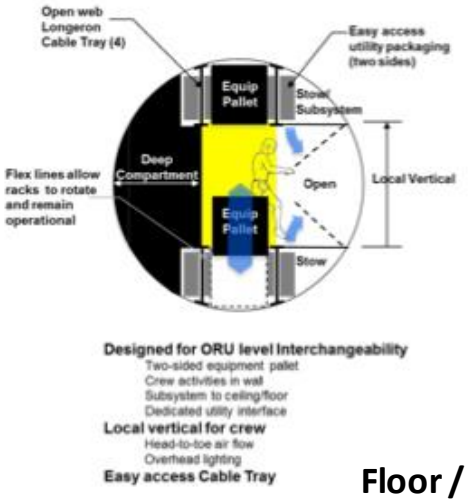
- Deep Space Habitats
  - Lunar vicinity
    - Crew tended operations
    - Limited resupply
    - Multi-mission support
  - Mars missions
    - Crew maintenance & repair
    - No resupply
    - Refurbishment

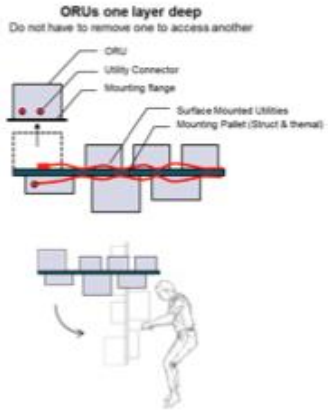


Large Diameter Modules

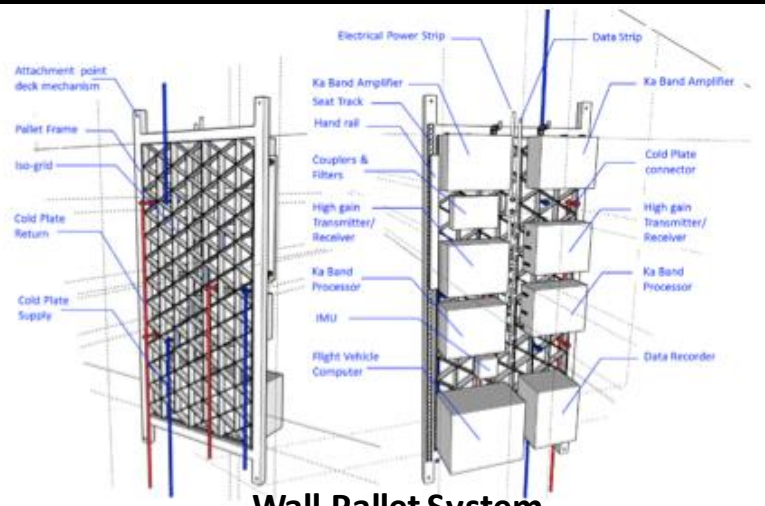
ISS Diameter Modules

ISS Rack System





Floor / Ceiling Pallet System



Wall Pallet System