



Argo Dual Purpose Habitat
Final Presentation May 7, 2018

Team Structure

Overview

- Project Overview
- Sponsors
- Design Process
- Concept of Operations
- Habitat Overview
- Future

Project Recap: Vision, Mission, and Objective

Vision and Mission Statement

Commonality of design between a space transit habitat and Mars surface habitat has the potential to reduce mission cost and risk by reducing crew training and increasing efficiency on arrival. Using the diverse array of talent and expertise available at the University of Michigan, BLiSS will explore the concept of commonality on every level of the design.

System Definition

We will design a habitation system that will house a human crew on either the Martian surface or a deep space transit. The system will be designed with a high degree of commonality between the two configurations. The team will validate the design through analysis and the construction of full scale mockups.

Level 1 Requirements Review

Level 1 Requirements				
Level	Requirement	Traceability	Rationale/Details	Type of Requirement
L1_01	The Habitation Systems shall be capable of being configured into either a Transit Configuration or a Surface Configuration	X-HAB RFP	Need to create a habitation system that has commonality in both the in-space and surface habitat designs so the crew will be familiar with the layout, function, and location of everything in the surface habitat when they arrive on Mars.	Constraint
L1_02	The Habitation System shall accommodate a crew of 4 people	X-HAB RFP	Capacity of Orion MPCV	Functional
L1_03	The Habitation System shall include an airlock sized for at least 2 people	X-HAB RFP	Lets two people perform EVAs, and allows efficient ingress/egress	Functional
L1_04	Habitation System shall be capable of being reused on multiple missions	X-HAB RFP	Reuse will lower the cost of successive missions.	Functional
L1_05	Habitation System shall be compatible with all EMC mission architecture	X-HAB RFP	Compatibility with vehicles and mission architecture as designated by X-HAB RFP	Constraint
L1_06	Habitation System shall enable productive science in space and on Mars.	MEPAG	Science is the primary objective of all space exploration. MEPAG outlines the overarching science goals for Mars.	Operational

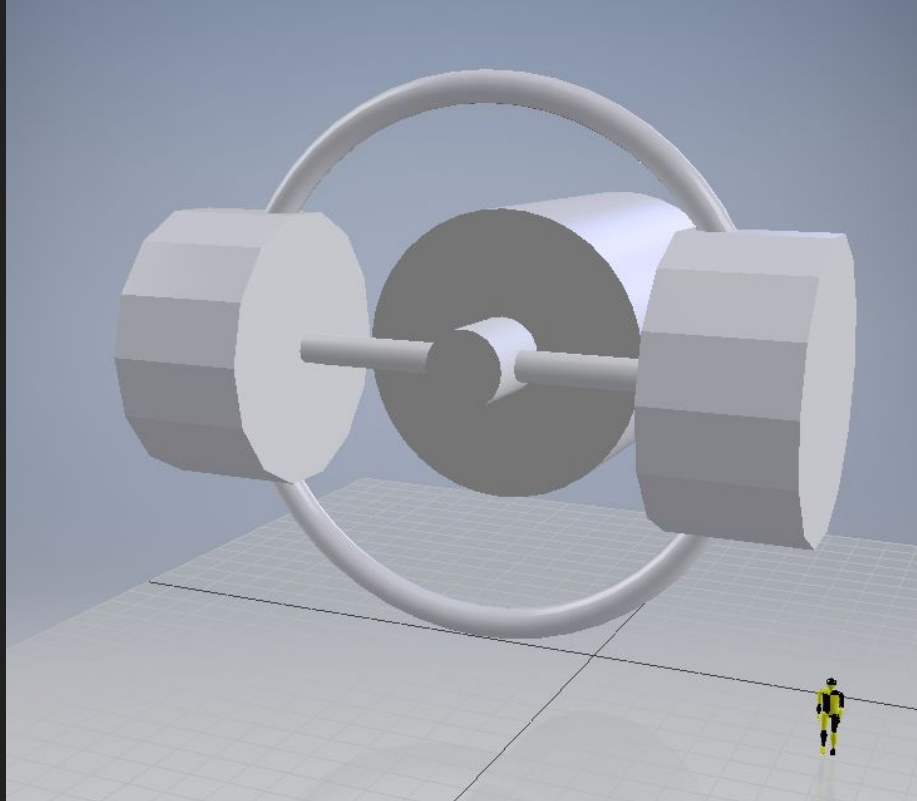
Level 2 Requirements Review

Level 2 Requirements				
Level	Requirement	Traceability	Rationale/Details	Type
L2_01	Habitation System shall include utilities, including ECLSS	L1_02	Mission to Mars will last years, and a life support system is necessary to keep the crew alive and well for the duration of the mission without assistance from Earth	Functional
L2_02	Transfer Configuration shall provide redundant habitable volumes	L1_02, X-HAB RFP	Redundant volumes can act as a safe haven from the other in the event of smoke, fire, or pressure loss in one of the pressure vessels	Functional
L2_03	Design of the Habitation System shall adhere to NASA NPG: 8705.2 Human Rating Requirements and Guidelines for Space-Flight Systems	L1_02, X-HAB RFP	As a crewed vehicle the Habitat must adhere to NASA safety and habitability standards	Functional
L2_04	Transfer Configuration shall provide 1000 days of logistics per crew member	L1_05, X-HAB RFP	EMC gives 1000 days as a reference for transfer to and from Mars	Functional
L2_05	Surface Configuration shall provide 500 days of logistics per crew member	L1_05, X-HAB RFP	EMC gives 500 days as a reference for a prolonged surface stay on Mars	Functional
L2_06	The largest element of the Surface Configuration shall fit on one of NASA's baselined landers.	L1_05, X-HAB RFP	Lander dimensions and payload will severely constrain habitation elements	Constraint
L2_07	Surface Configuration shall provide connectivity to logistics resupply	L1_05, X-HAB RFP	EMC envisions a gradual buildup of equipment and supplies at a single exploration site on Mars	Functional
L2_08	Surface Configuration shall provide connectivity of two pressurized rovers	L1_05, X-HAB RFP	Mobility is key for enabling human exploration of the Martian surface	Functional
L2_09	Surface Configuration shall provide access to crew descent and ascent vehicles	L1_05, X-HAB RFP	Crew may arrive and depart from Mars in dedicated vehicles	Operational
L2_10	Transfer Configuration shall be sized to fit within a 10-m diameter SLS fairing during launch	L1_05, X-HAB RFP	10 meters is the largest SLS fairing size	Constraint
L2_11	Surface Configuration shall include options for base growth	L1_05, X-HAB RFP	Compatibility with vehicles and mission architecture as designated by X-HAB RFP	Functional
L2_12	The design and operation of the Surface Configuration shall adhere to current planetary protection protocol	L1_06	Planetary Protection is crucial for meeting the MEPAG objectives. Protocols are also there to protect life on Earth	Functional, Operational

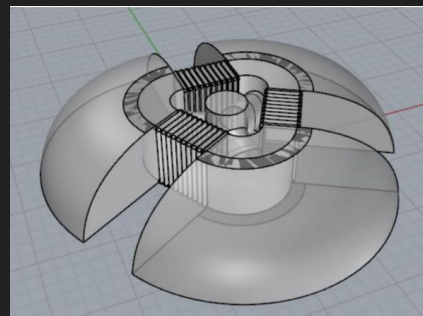
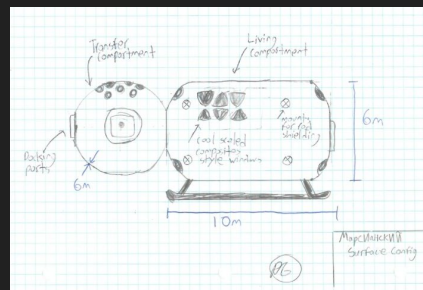
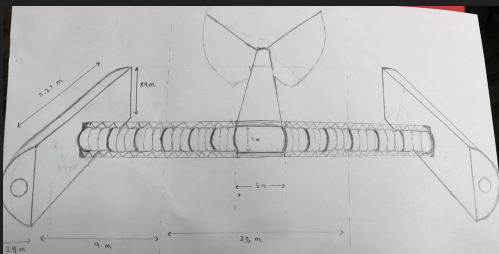
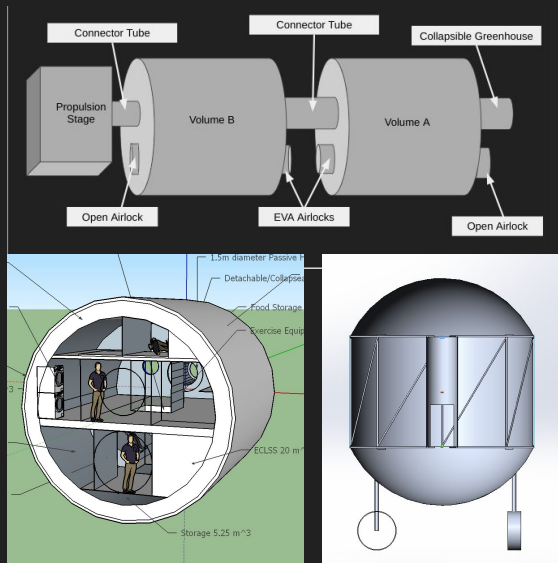
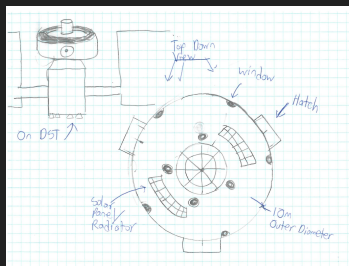
Project Recap: Sponsors



Project Recap: DAC-1/2

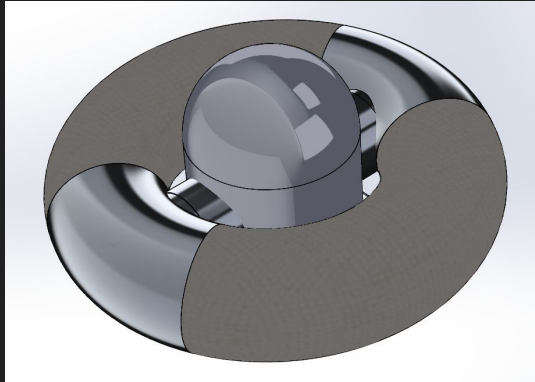


Project Recap: DAC-3

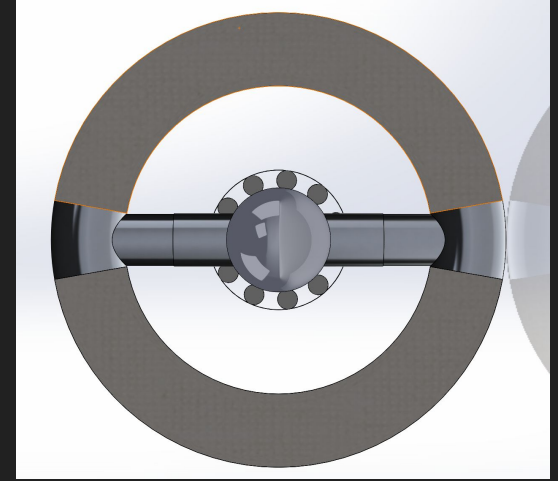
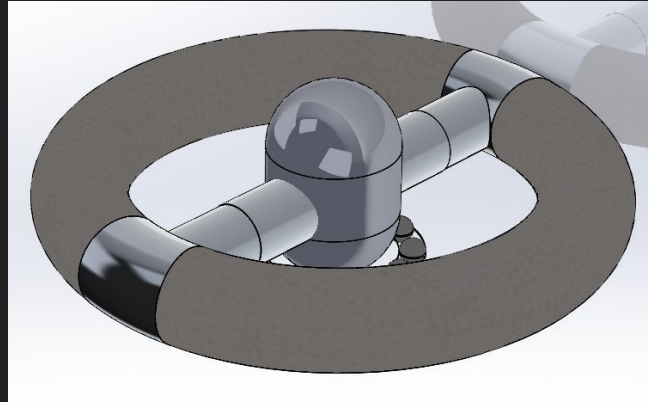


Project Recap: DAC-4

Stored

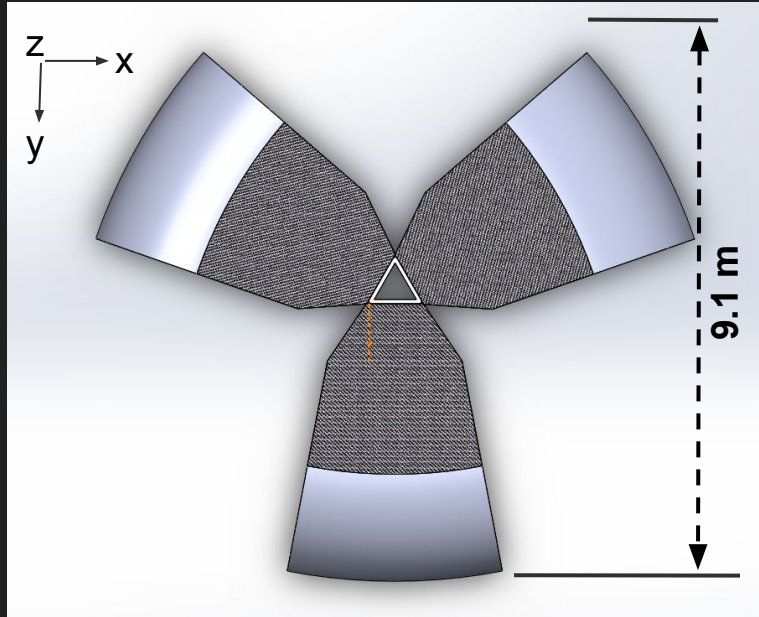


Deployed

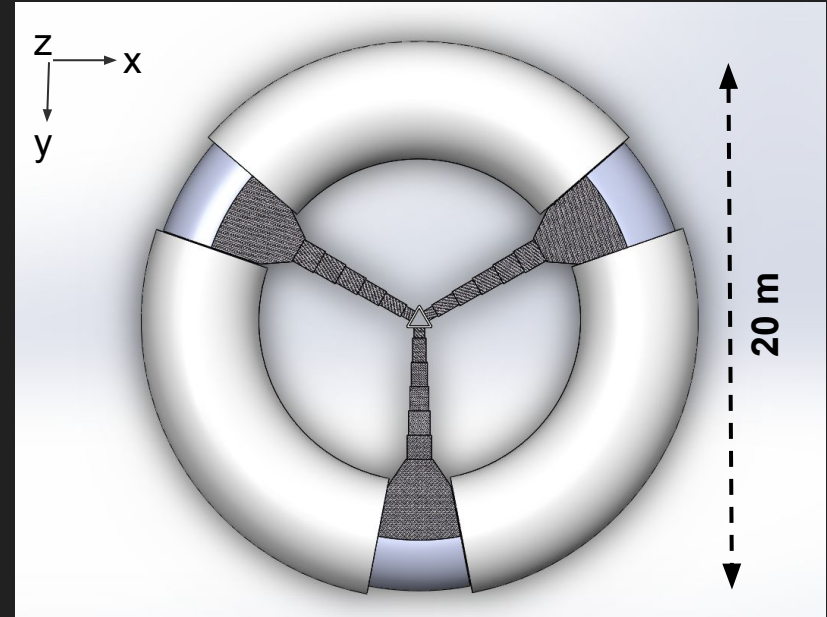


Final Configuration (DAC-5)

Launch Configuration

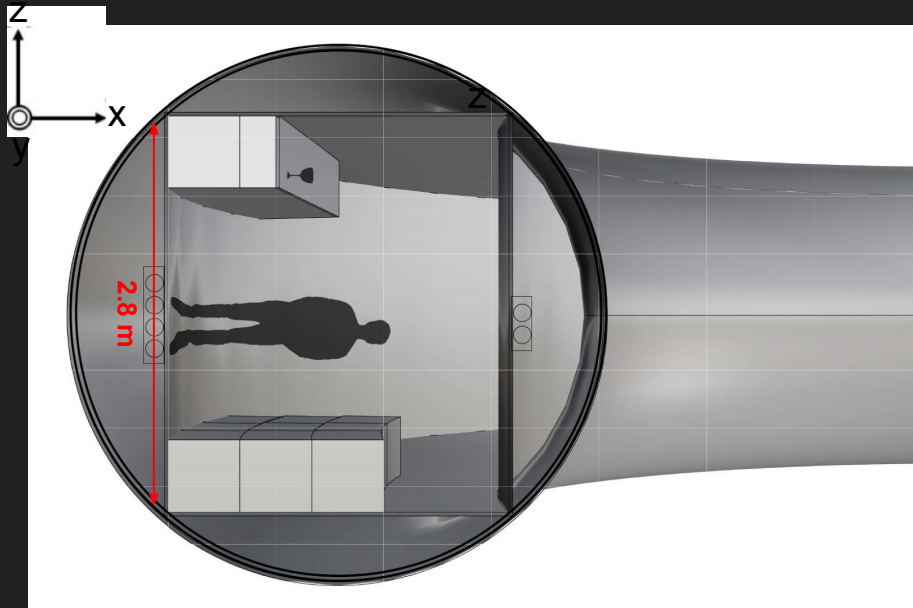


Deployed Configuration

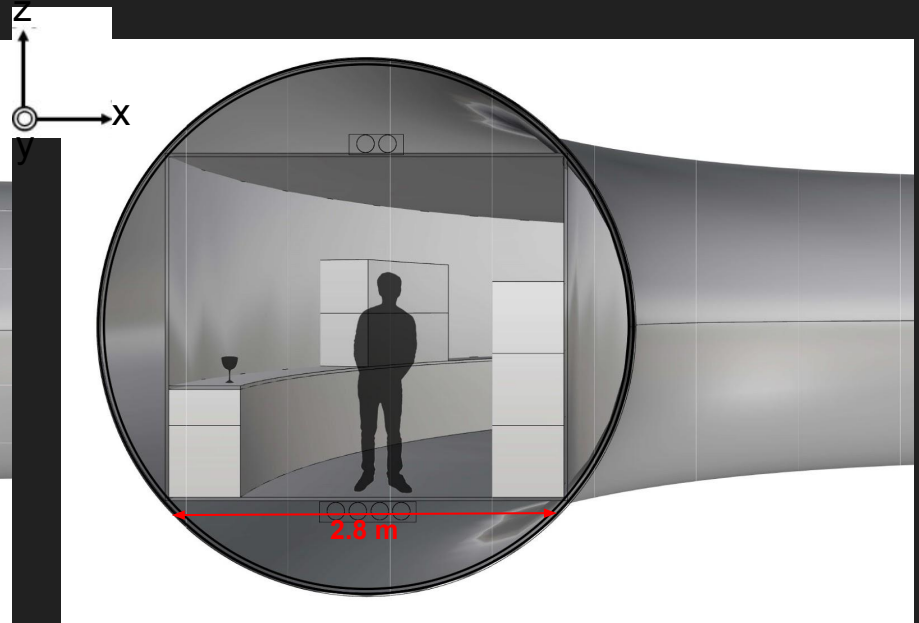


Cross-Section

Transit Configuration

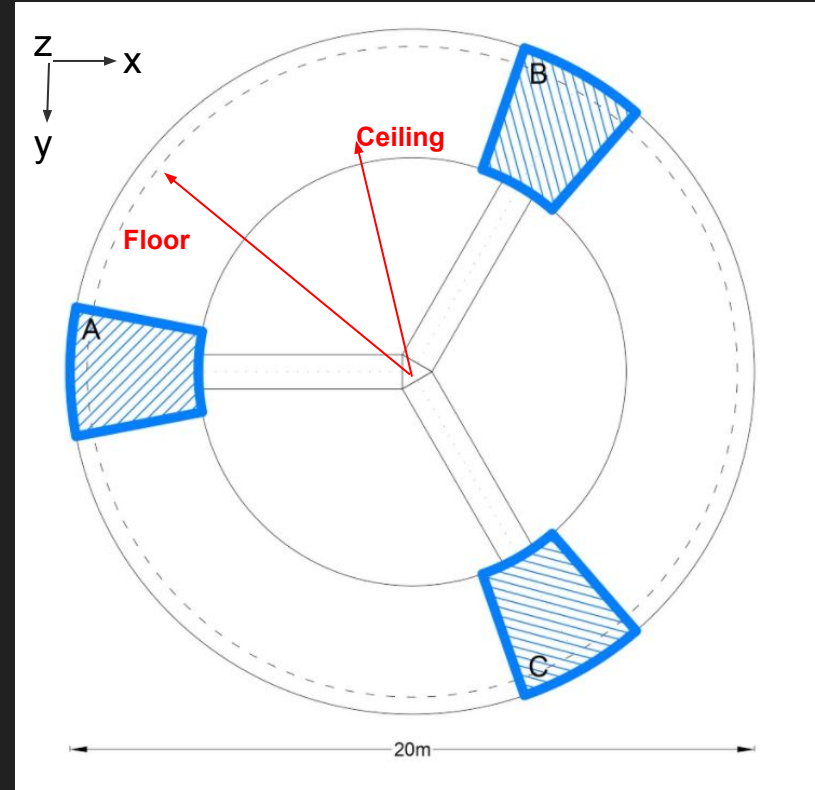


Surface Configuration

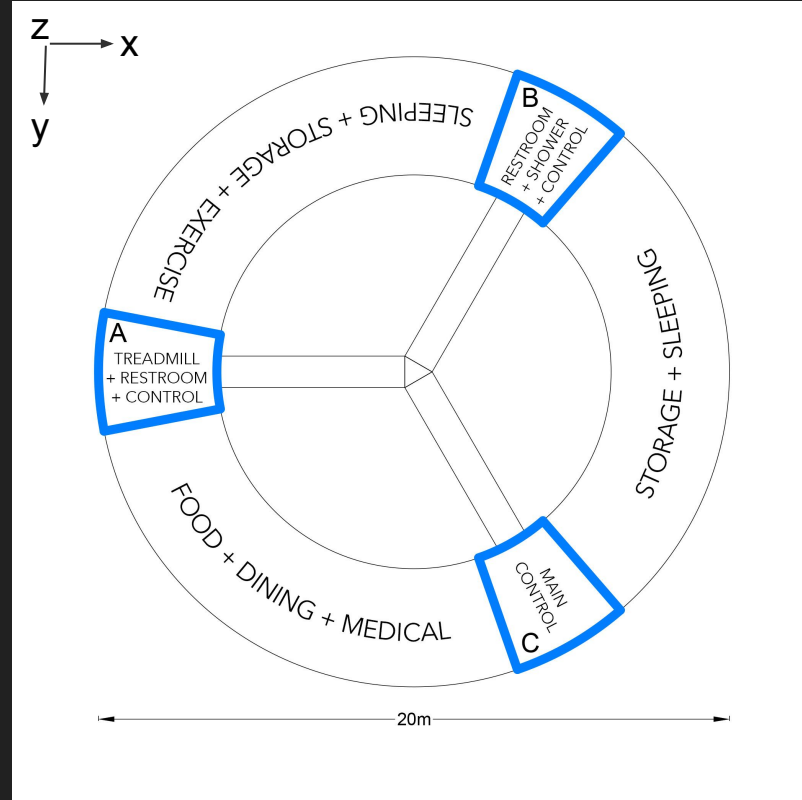


Habitat Parameters

	At Floor	At Ceiling
Radius	9.5 m	7.0 m
Angular Velocity	6.0 rpm	6.0 rpm
Tangential Velocity	6.0 m/s	4.4 m/s
Centripetal Acceleration	0.38 g	0.28 g
Habitable volume	293 m ³	



Placements

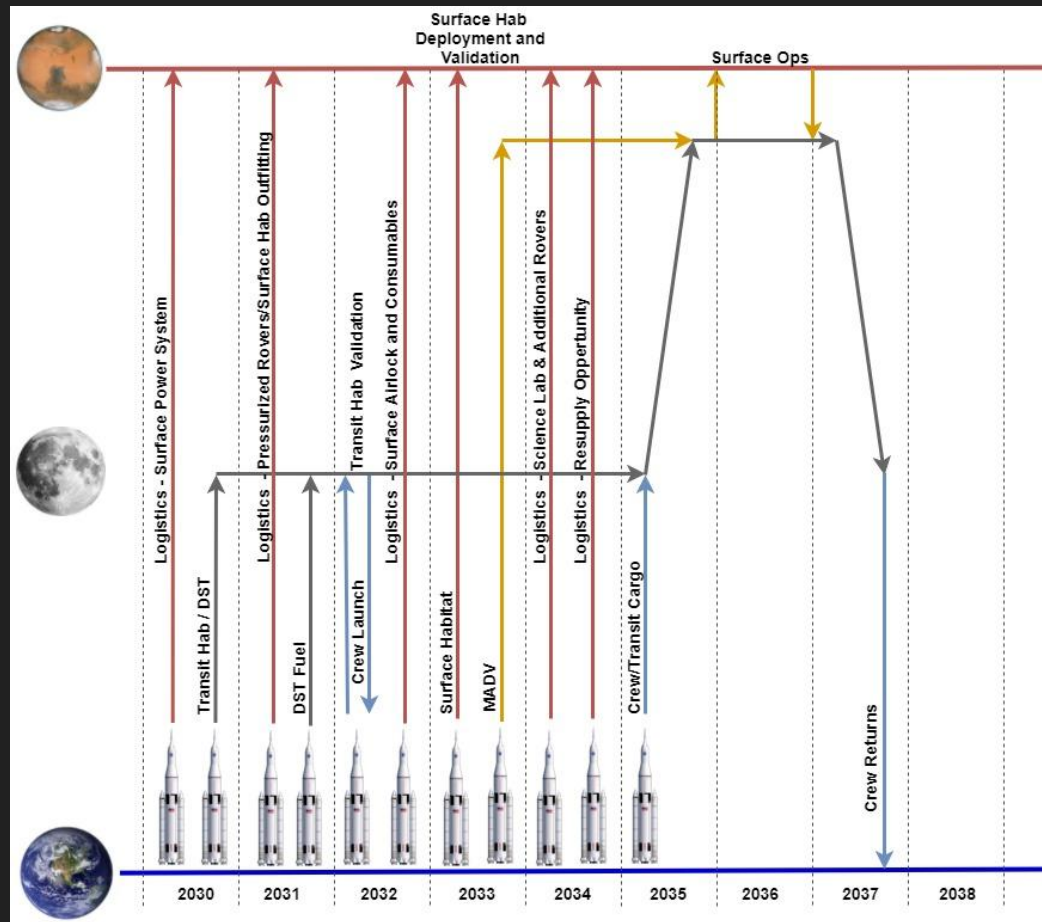


Concept of Operations

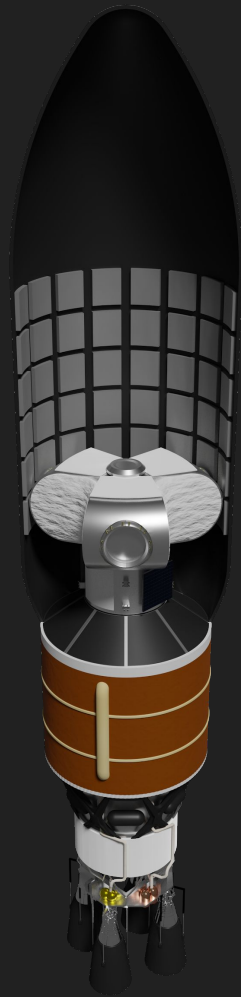
Mission Overview

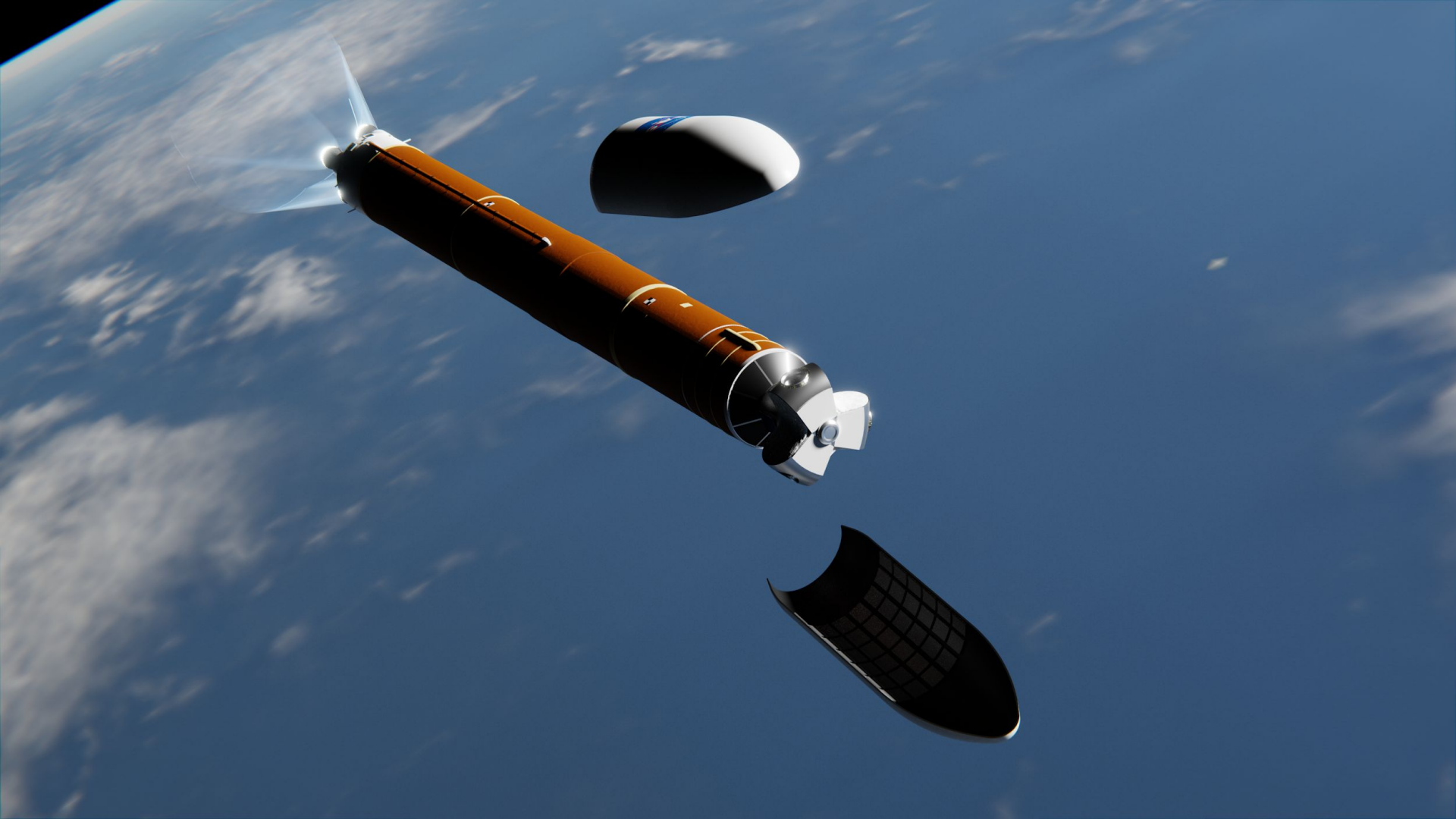
Assumptions:

- Max of 2 SLS Launches per year
- 20mT Lander capability
- Transit Times to Mars
 - Landers - 2.5 years (EP)
 - MADV - 0.75 years*
 - DST - 0.75 years*

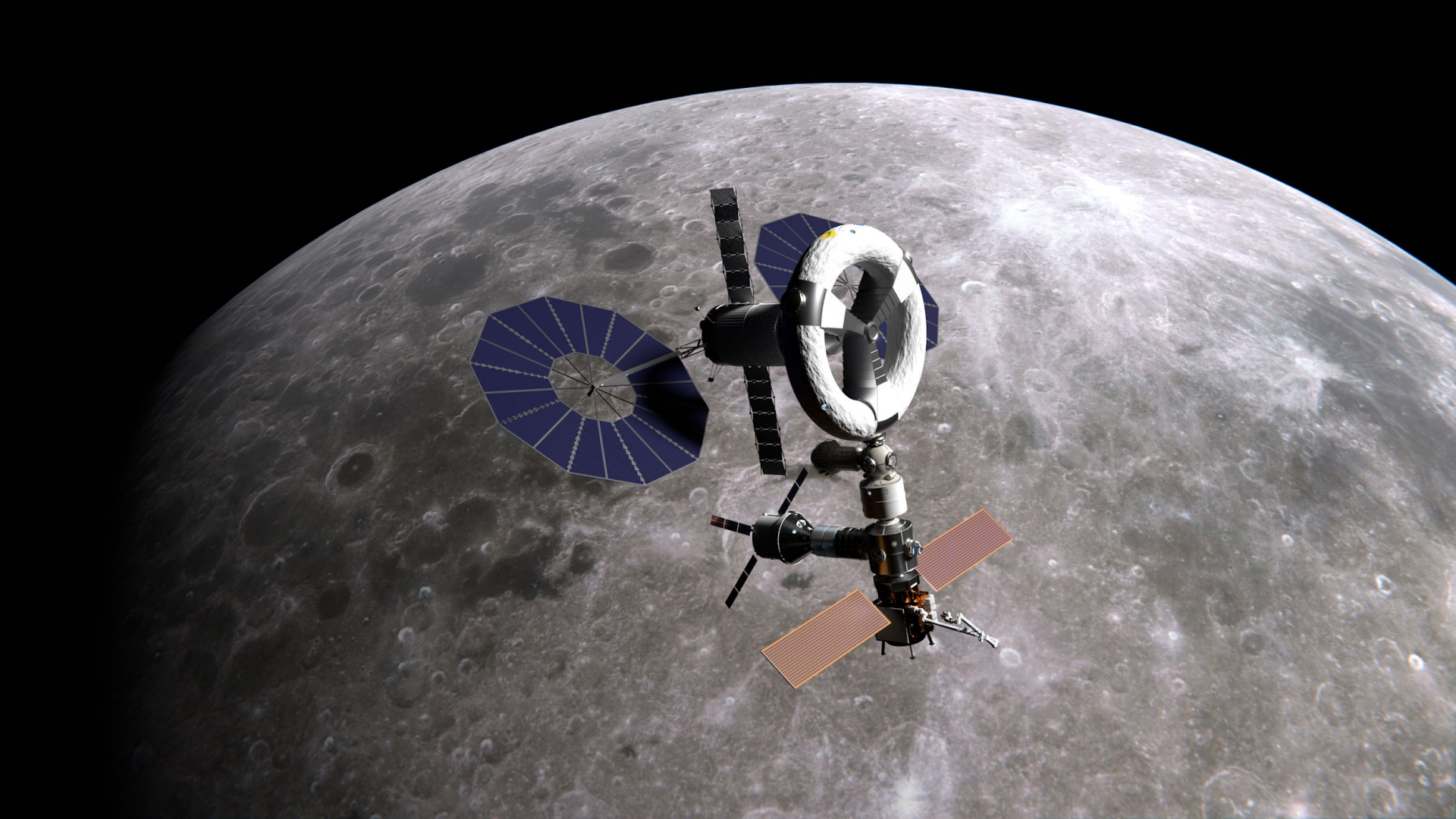


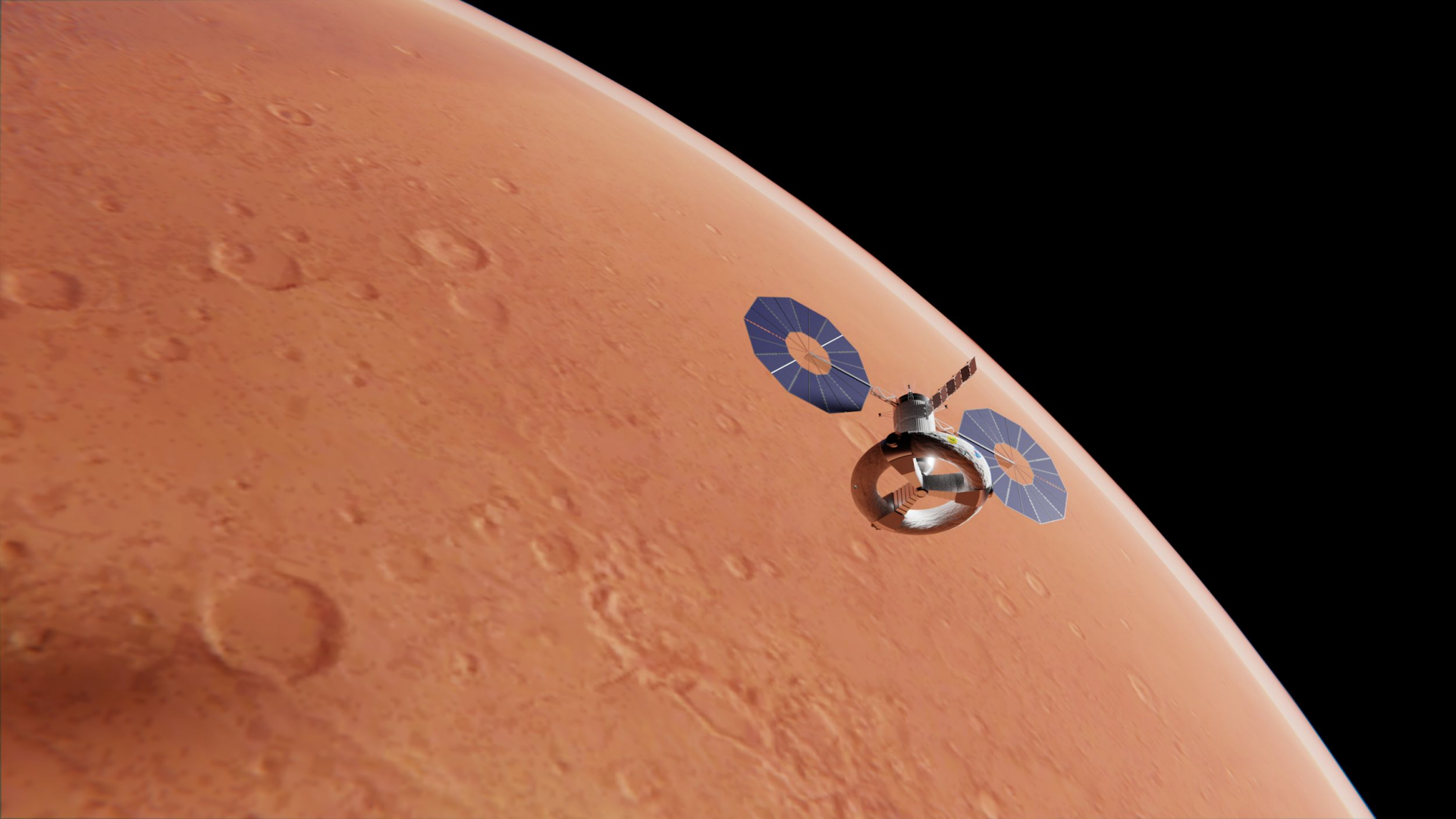
*Assuming Hohmann Transfer Window













Mass Budget

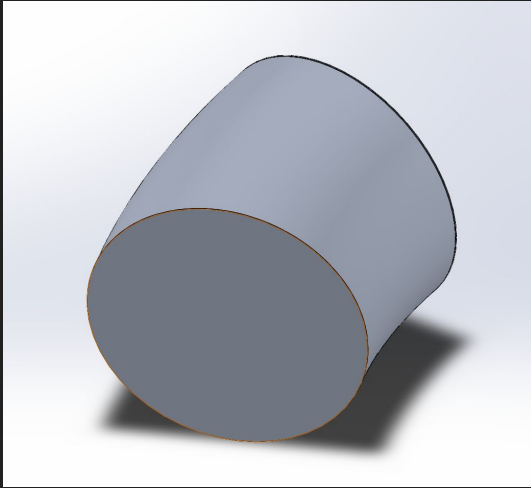
Element	Mass (kg)	Allowable Mass (kg)	Margin
Surface Habitat (dry)	15000	20,000	25%
Transit Habitat (dry)	23500	25,000	6%
Transit Habitat Logistics	18800	15,000	-25%

Habitat Overview

Structures

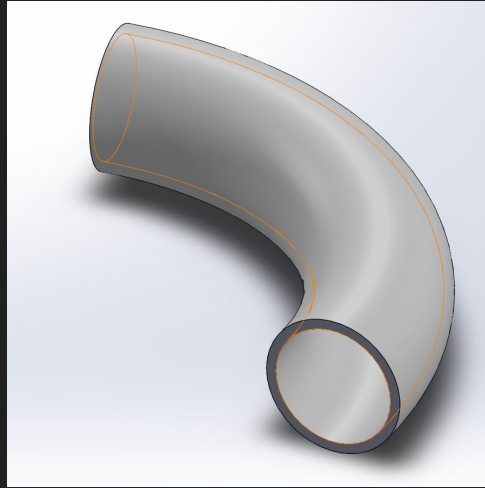
Node

Pressure shell,
MMOD, Insulation



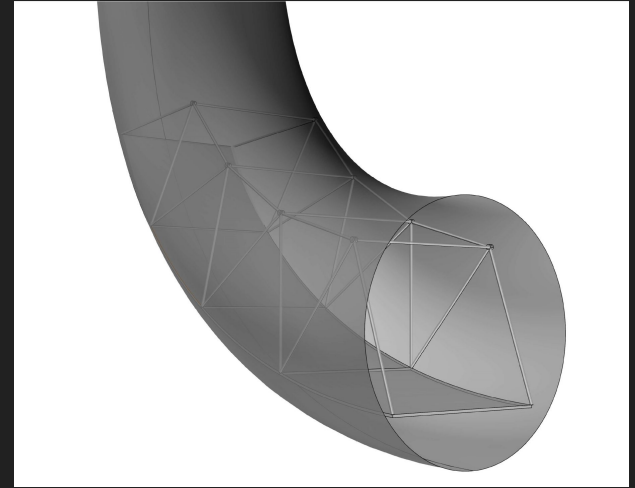
Corridor

Inflatable shell,
MMOD, Insulation



Transit Floor and Wall

Cross supports, Ceiling
beams, Floor panels



Power - Distribution System



Power Zones A, B, C: Power in the Nodes, each node contains circuit breaker

Power Zones AB, BC, AC: Power in the Connectors, powered through adjacent circuit breakers

Power Zone 0: Powers all the essential units that should not be turned off during the mission, powered through all circuit breakers

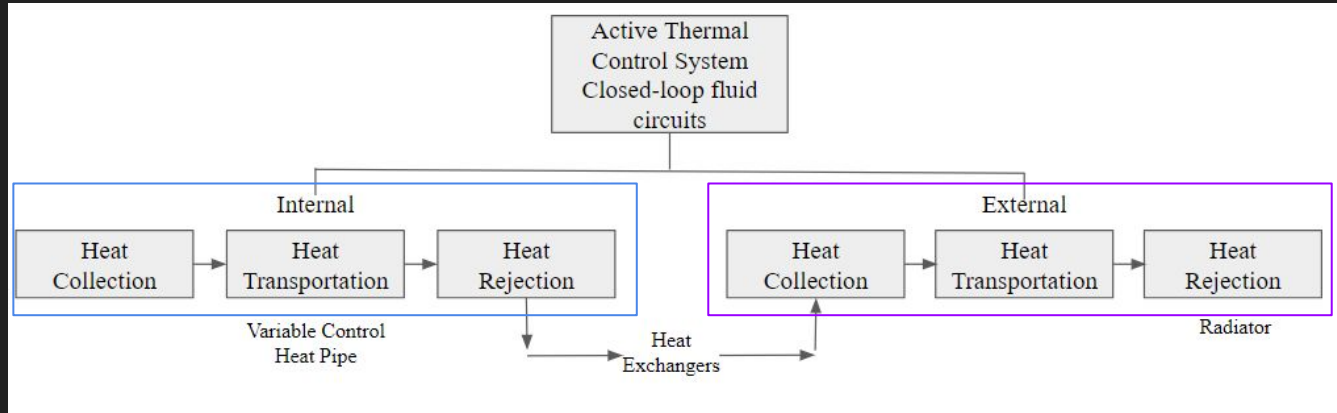
Power - Surface Power Budget

System	Subsystem	Power used (W)
Comms	To Mars Orbiting Satellite	56
	To EVA	150
Crew Systems	Air Revitalization	2,545
	Waste	863.7
	Water	2,491
	Food	4,076
Human Factors	Washer/Dryer	60
Power	Lights	4,725
Other	Exercise Area, Kitchen, Med Bay, Rovers, etc.	15,000
Total (w/ 5% Margin)		31,500

Power - Transit Power Budget

System	Subsystem	Power used (W)
Comms	To Earth	1,450
	To EVA	150
Crew Systems	Air Revitalization	2,540
	Waste	862.6
	Water	2,489
	Food	4,076
	Washer/Dryer	60
Power	Lights	4,725
ADCS	Reaction Wheels	14,076
Other	Kitchen, Med bay, Living Area, etc.	13,000
Total (w/ 5% Margin)		45,600

Thermal - Management System



Communications

Communications will be separated into 3 distinct phases:

Cruise/Orbit

- Ka-Band HGA
- Long distance direct to Earth
- Modeled off of MRO Ka-Band Suite

Surface Operations

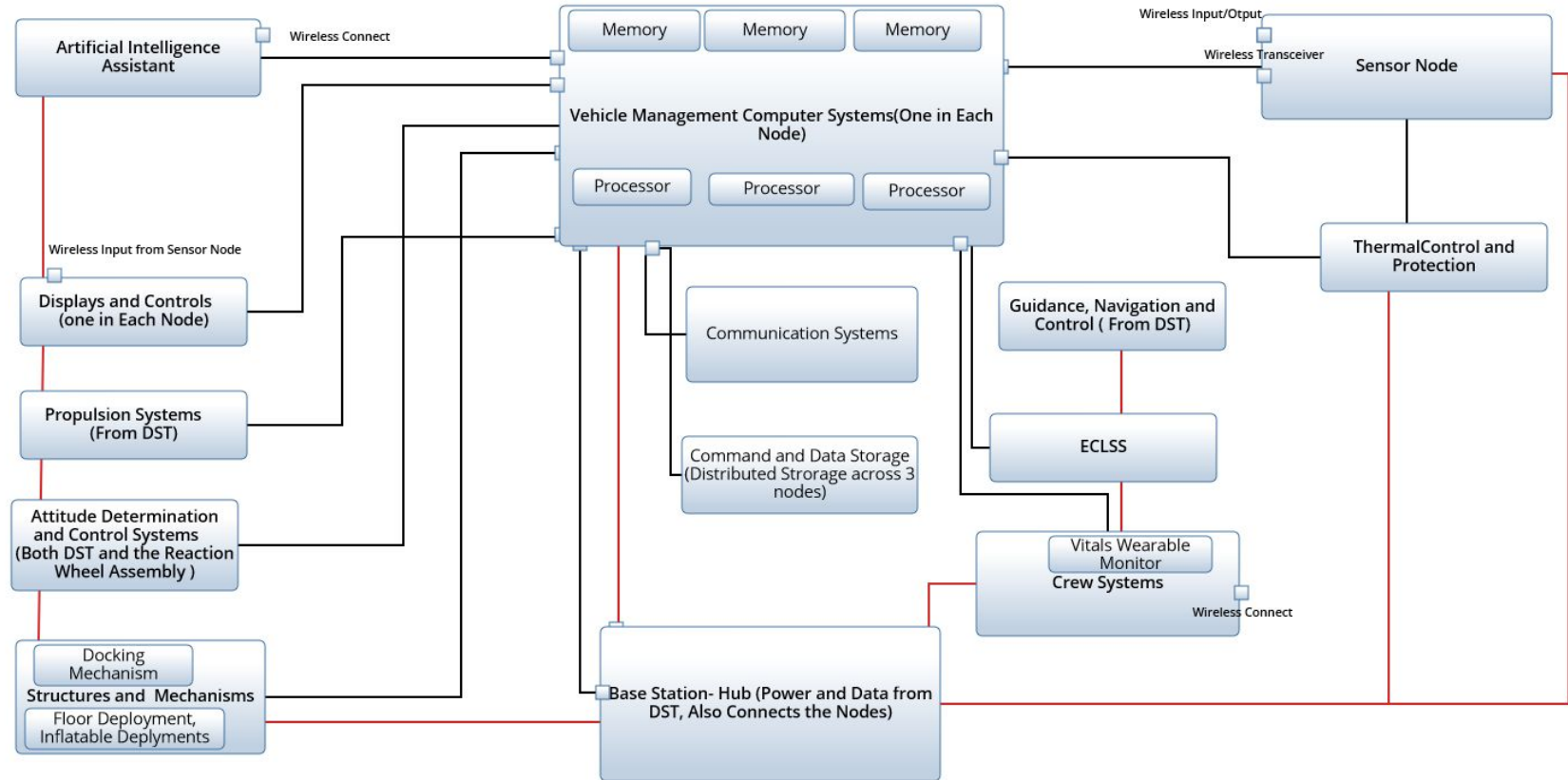
- Surface to Orbit
- Ka-Band MGA to relay satellites

- Direct to Earth
- Ka-Band HGA direct to Earth

Surface to Surface

- UHF LGA
- Short distance to Astronauts on EVA
- Set up Comms tower robotically on advance mission

Avionics Architecture



Crew Systems

Transit Config. System	Technology	Volume, m ³	Power, W
Air Revitalization	ISS	10.4	2,540
Waste Management	Warm Air Drying	18.6	863
Water Treatment	CDS	11.9	2,490
Food	Packaged/Crop	32.3	4,076
Total (w/ 5% Margin)		73.2	10,467

Surface Config. System	Technology	Volume, m ³	Power, W
Air Revitalization	ISS	7.9	2,545
Waste Management	Warm Air Drying	11.5	863.7
Water Treatment	CDS	10.7	2,491
Food	Packaged/Crop	22.0	4,076
Total (w/ 5% Margin)		52.1	10,474

Crew Systems

Transit Config. System	Base Mass, Kg	Supply Mass, Kg	Spare Mass, Kg	Total
Air Revitalization	1,865	2,043	1,061	4,969
Waste Management	627	895	204	1,726
Water Treatment	1,664	2,268	1,357	5,289
Food	2,490	6,034	73	8,597
Total (w/ 5% Margin)	6,573	13,220	2,695	21,544

Surface Config. System	Base Mass, Kg	Supply Mass, Kg	Spare Mass, Kg	Total
Air Revitalization	1,564	2,644	1,032	5,216
Waste Management	517	462	204	1,183
Water Treatment	1,526	1,640	1,077	4,243
Food	1,751	3,138	73	4,962
Total (w/ 5% Margin)	5,626	8,278	2,505	16,384

ECLSS Packaging

- ECLSS Modules will be packaged into NextSTEP Pallets
- 12 pallets required for redundant ECLSS
 - 4-Oxygen Generation System
 - 8-Water Recovery
- Additional pallets for:
 - Avionics (x3)
 - Heat Melt Trash Compactor (x1)
 - Food Rehydration (x1)
 - Washer/Dryer (x1)
 - Plant Growth Modules (TBD)

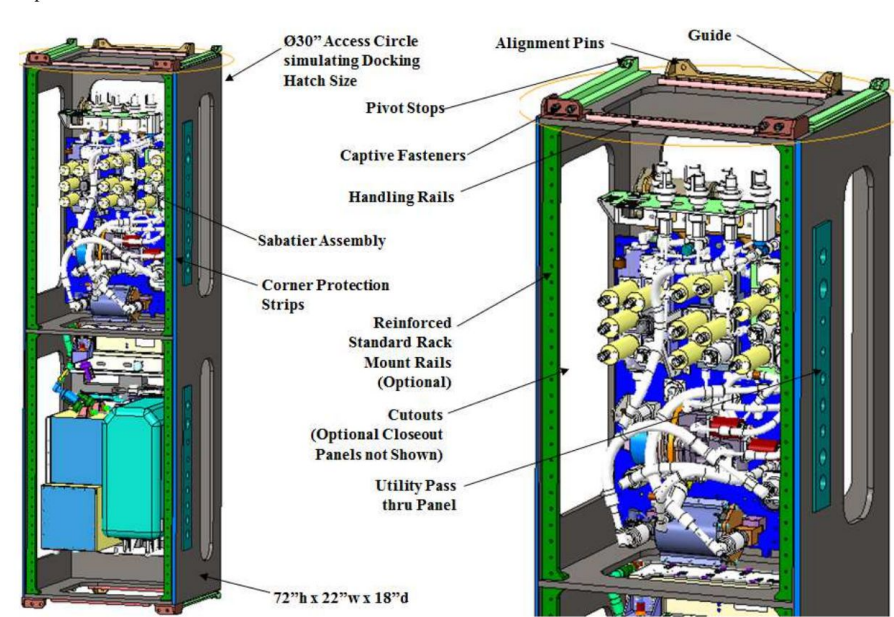


Figure 9: NextSTEP Pallet Design

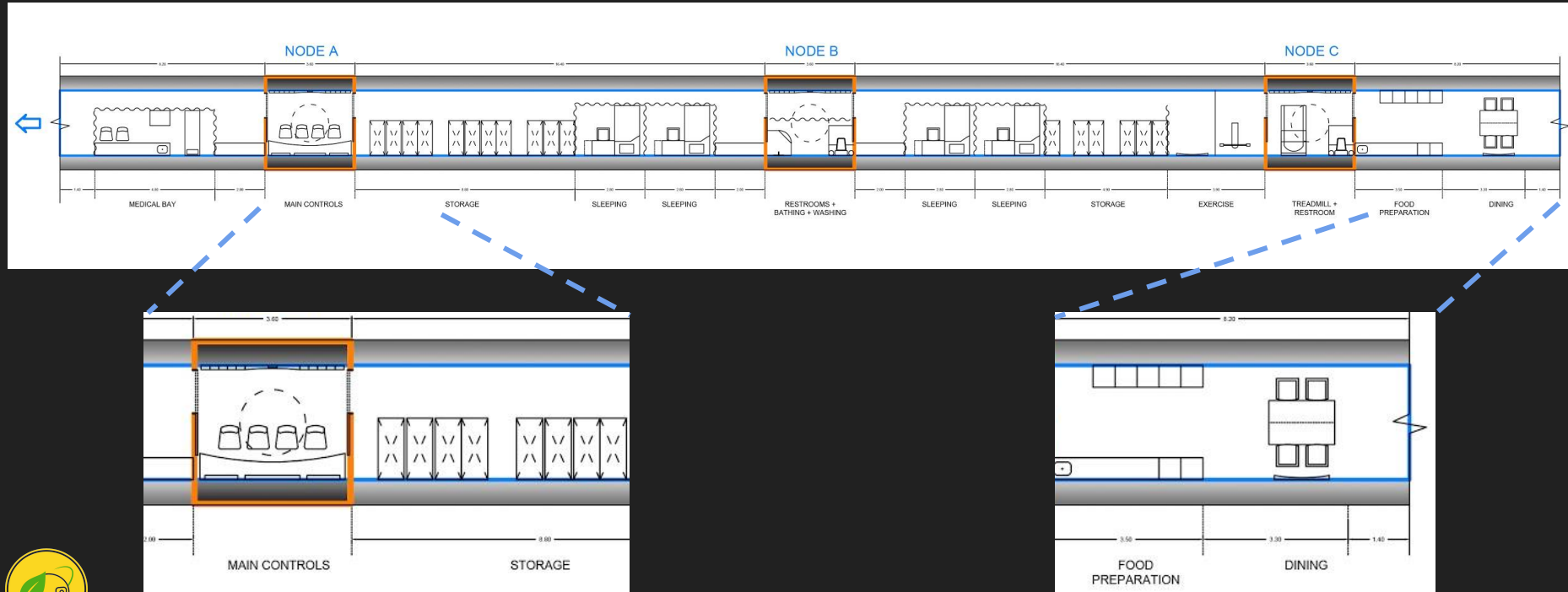
Artificial Gravity

- 6 RPM to generate 0.38g at crew's feet
- Driven by:
 - Crew rotation tolerance
 - Desire to train for surface EVA in transit
 - Retention of bone mass
- AG Systems
 - Rotary power coupling between Argo and DST
 - Drive motor
 - Large momentum wheel to cancel out habitat spin

Placements - Transit Configuration

UNROLLED LAYOUT

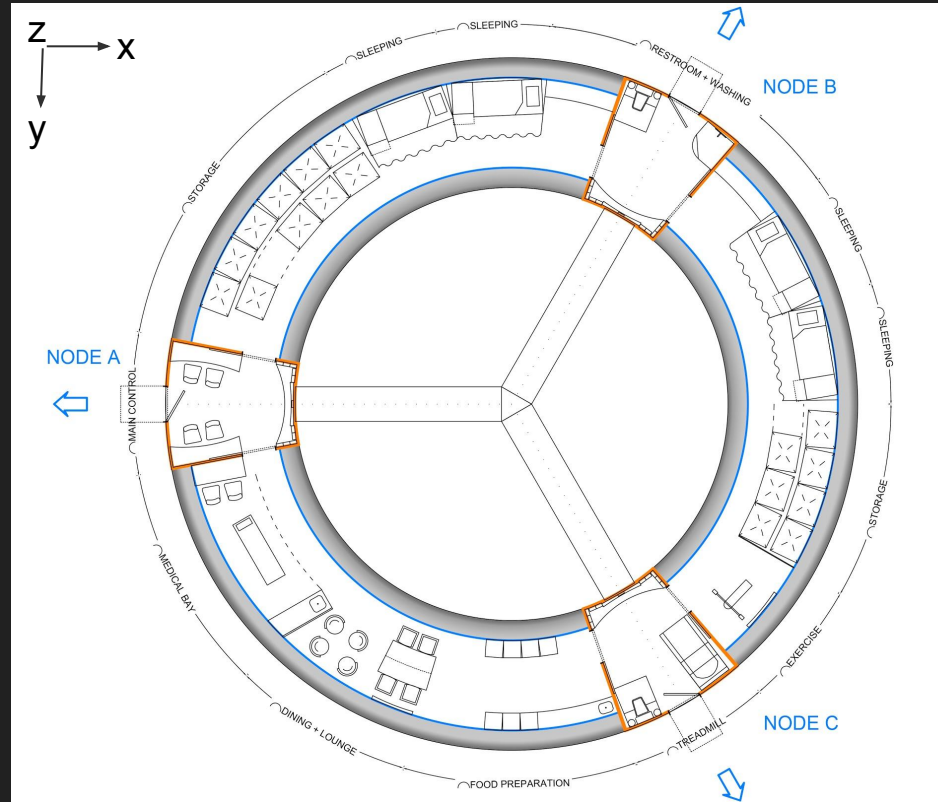
Floor area ~ 1680 sft



Placements - Surface Configuration

TOP VIEW OF LAYOUT

Floor area ~ 1430 sft



Node Mockup



Virtual Reality Mockup



EVA System Architecture: HERA Suit

Primary Components:

1. Base Layer
 - a. Maximum Absorbency Garment (MAG), Bra, Cup, Underpants, Socks
2. Sensor Layer
 - a. Moisture Wicking Sensor Garment (MWSG) - integrated
 - i. Sensors
3. Suit Layer
 - a. Mechanically Pressurized Suit (MPS) - integrated
 - i. Compressive Pressurization
 - ii. Liquid Cooling Ventilation Garment (LVCG)
 - b. AR Headset
4. Outer Layer
 - a. Protective Dust Cover (PDC) - integrated
 - i. Mylar layer
 - ii. Radiation Shielding (HBNNT)
 - iii. Kevlar patches
 - b. Helmet
 - c. Boots
 - d. Gloves

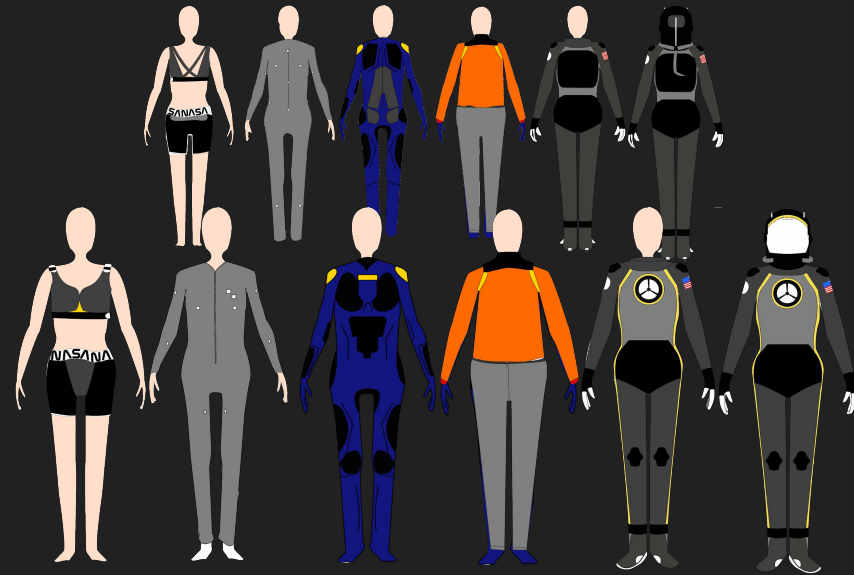
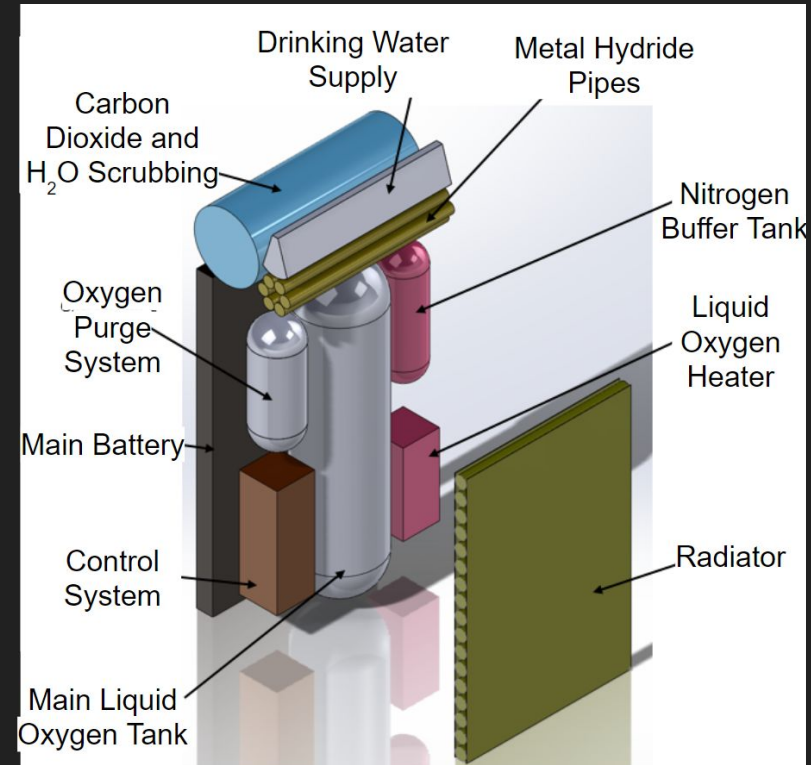


Diagram of the different stages of dress for the HERA suit

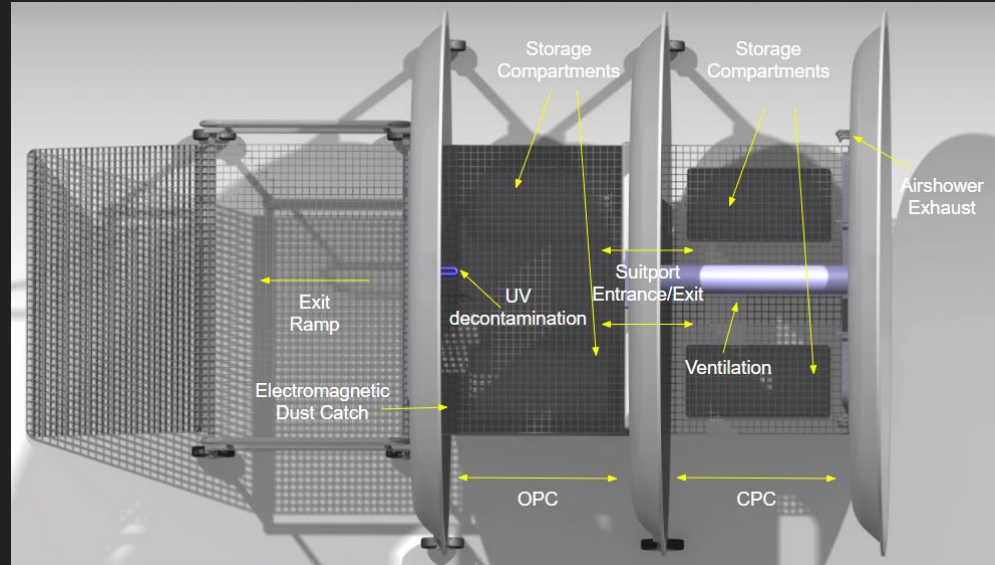
EVA System Architecture: PLSS

- Primary Components:
 - Insulated LOx storage with heaters
 - Secondary GOx tank for emergencies
 - Communication systems: 5 km range
 - CO₂ and H₂O removal: Pressure swing adsorption
 - Filters are fully reusable
 - Liquid cooling garment and Metal Hydride Heat Pump
 - Primary cooling is passive to Mars environment
 - Li ion batteries for 150 Watts for 8 hours
- Total Mass: 35 kg (feels like 13 kg in Mars gravity)
- Removable



EVA System Architecture - Airlock

- Airlock acts as transition between habitat and airlock system
- Main responsibilities:
 - Prepare Astronaut for EVAs
 - Avoid cross contamination between habitat and Mars environment
 - Provide integration access between astronaut, Suit and PLSS



Airlock Overhead View

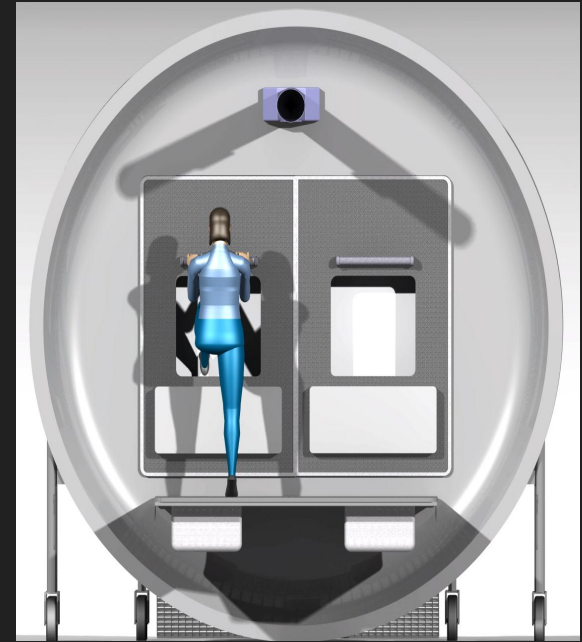
Suitport and PLSS Port

Suitport:

- Secure transition between compartments
- Airtight seal between compartments
- Maintains separation between human contaminants and Mars contaminants

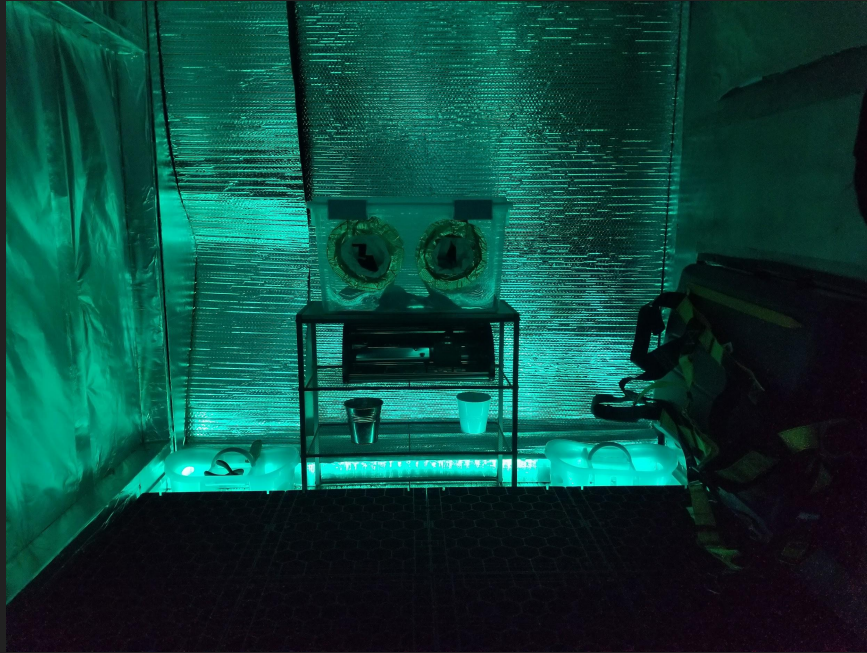
PLSS Port:

- Allows access to internal PLSS equipment
- Dual hatch closure to prevent cross contamination
- Allows for maintenance



Astronaut Using Suitport

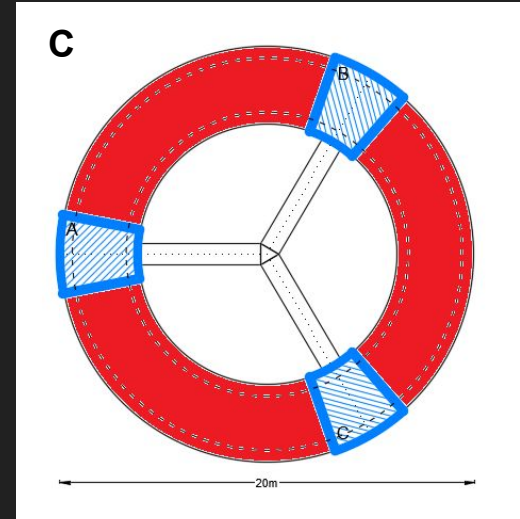
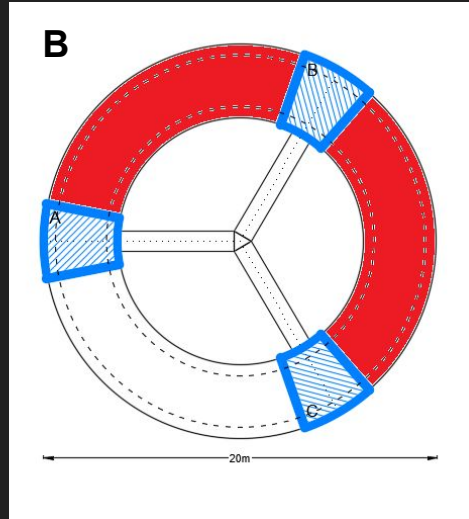
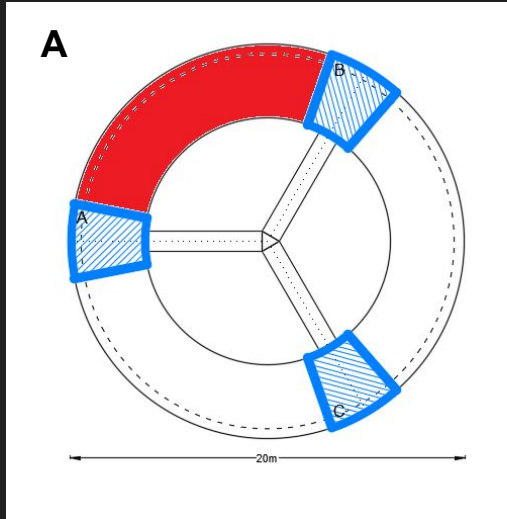
EVA Mockup



Safety: Radiation

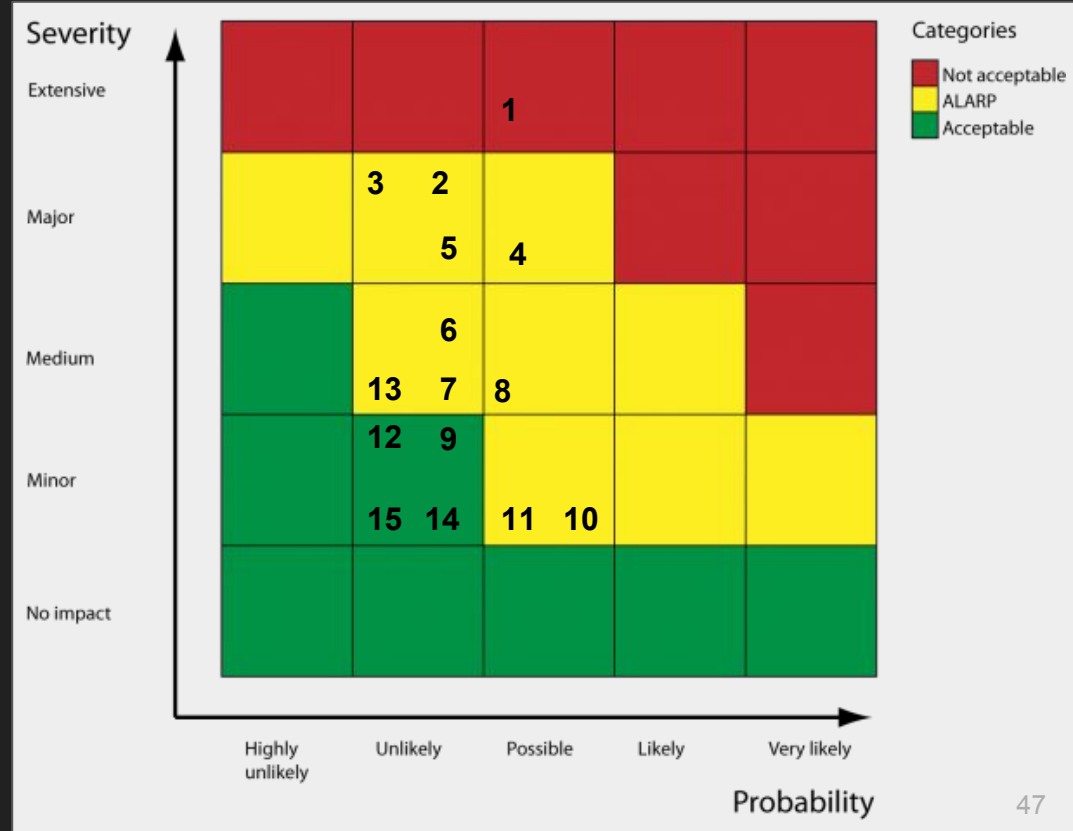
- Assumptions
 - 700 days in transit, 400 days on surface
 - Dose rates are equivalent to RAD data
 - 0.5 Sv annual limit
 - At least one previous trip to ISS or DSG
- Analysis conducted using OLTARIS
 - Transhab materials and thickness
- Results
 - Annual Max Dose: 0.431 Sv
 - Total Career Dose: 1.17 Sv
- SPE safe haven is provided via logistics as with Orion

Safety: Redundant Volumes



Safety: Risk Matrix

1. Explosive Decompression
2. Toxic Leaks
3. Power transmitter failure
4. Collision with Orbital Debris and other Spacecraft
5. EVA Airlock issues
6. Node failure
7. Stop spinning
8. Partial Pressure CO2
9. Partial Pressure O2 and N2
10. Cabin pressure issues
11. Inflatable tube failures
12. Fire
13. Air and water contamination
14. Waste Management problems
15. Wi-Fi failure



The Future

- Argo will be presented at ICES 2018
- Mockups will be used for future X-HAB projects
 - Node mockup will be our primary workspace for the Exploration Medical Project
 - Surface airlock mockup is the point of departure for our Gateway Mockup Project

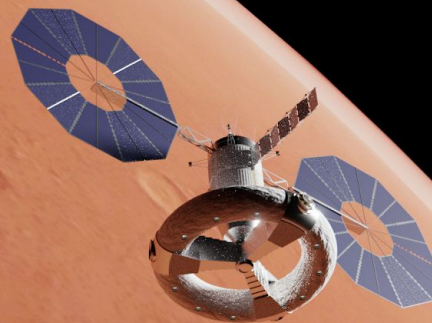


Concluding Remarks

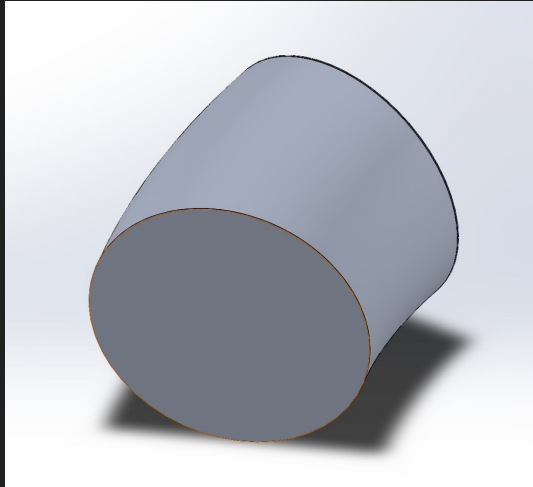
- Argo succeeded because of our multidisciplinary team.
- Argo grew BLiSS into one of the largest project teams on campus and captured the imagination of an entire generation of Michigan students.
- Argo is just one milestone towards BLiSS's ultimate goal of building flight hardware.



Domi Inter Astra!

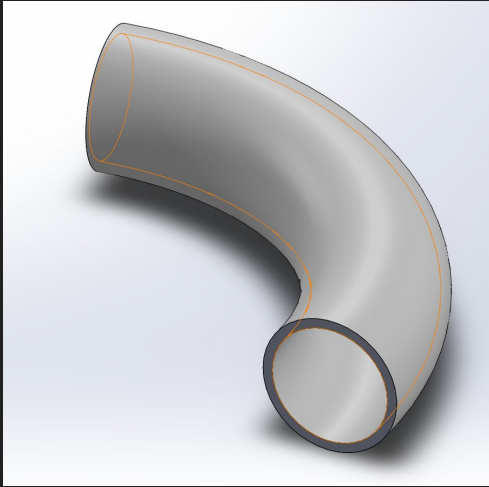


Structures - Node Design



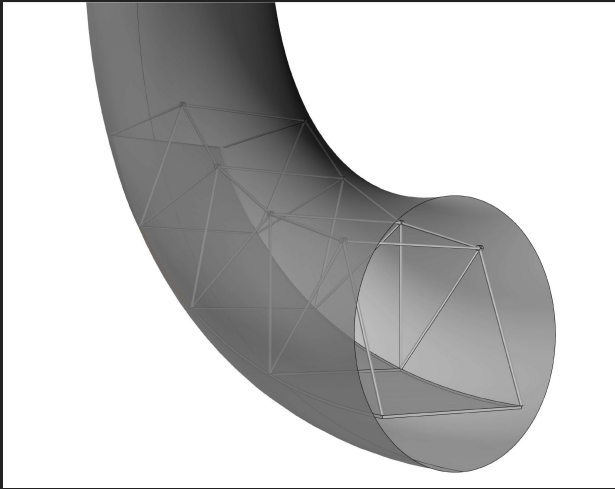
Component	Mass (kg)	Rationale
Pressure Shell	185.74	Al 7039-T61, FOS of 1.2
MMOD	312.55	<i>Columbus</i> MMOD shielding (7 kg/m ²)
Insulation	41.82	Advanced Life Support Baseline Values (9.4e-1 kg/m ²)
TOTAL: Transit	540.11	
TOTAL: Surface	227.56	Surface configuration does not receive MMOD shielding

Structures - Corridor Design



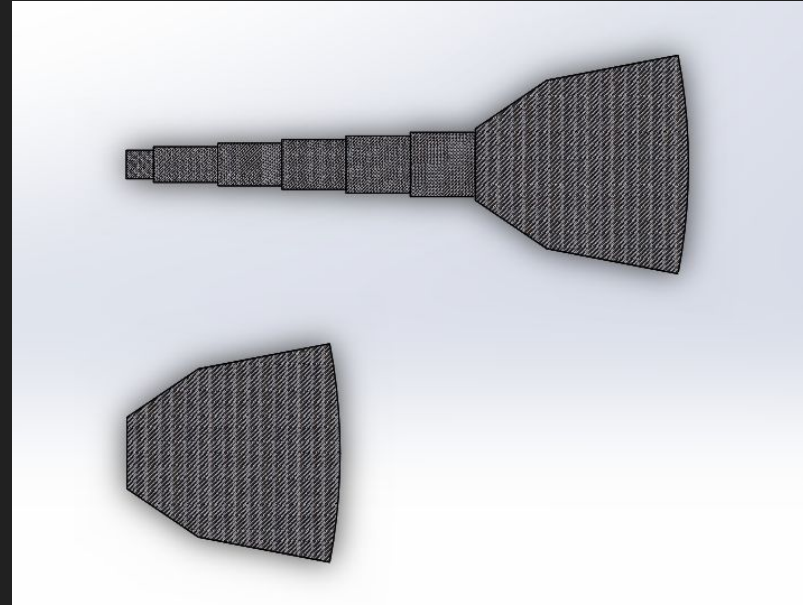
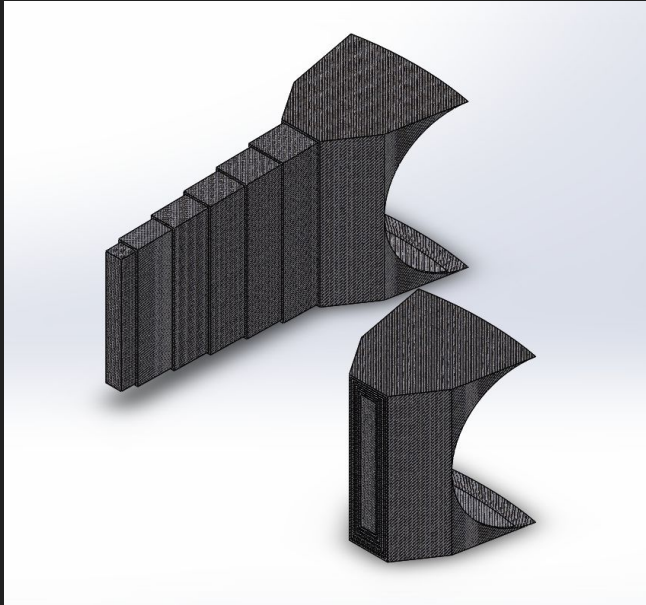
Component	Mass (kg)	Rationale
Inflatable Shell	43.17	Kevlar, FOS of 4
MMOD	2583.28	Advanced Life Support Baseline Value for TransHab (12.8 kg/m ²)
Insulation	189.23	Advanced Life Support Baseline Values (9.4e-1 kg/m ²)
TOTAL: Transit	2815.68	
TOTAL: Surface	232.4	Surface configuration does not receive MMOD shielding

Structures - Transit Floor and Wall Structure



Component	Mass (kg)	Rationale
Cross Supports (x87)	2.76e-2	PLA FOS of 1.2
Ceiling Beams (x36)	1.25	PLA FOS of 1.2
Floor Panels (x18)	81.65	Al-Honeycomb 1.14 kPa floor load
TOTAL:	1972.23	

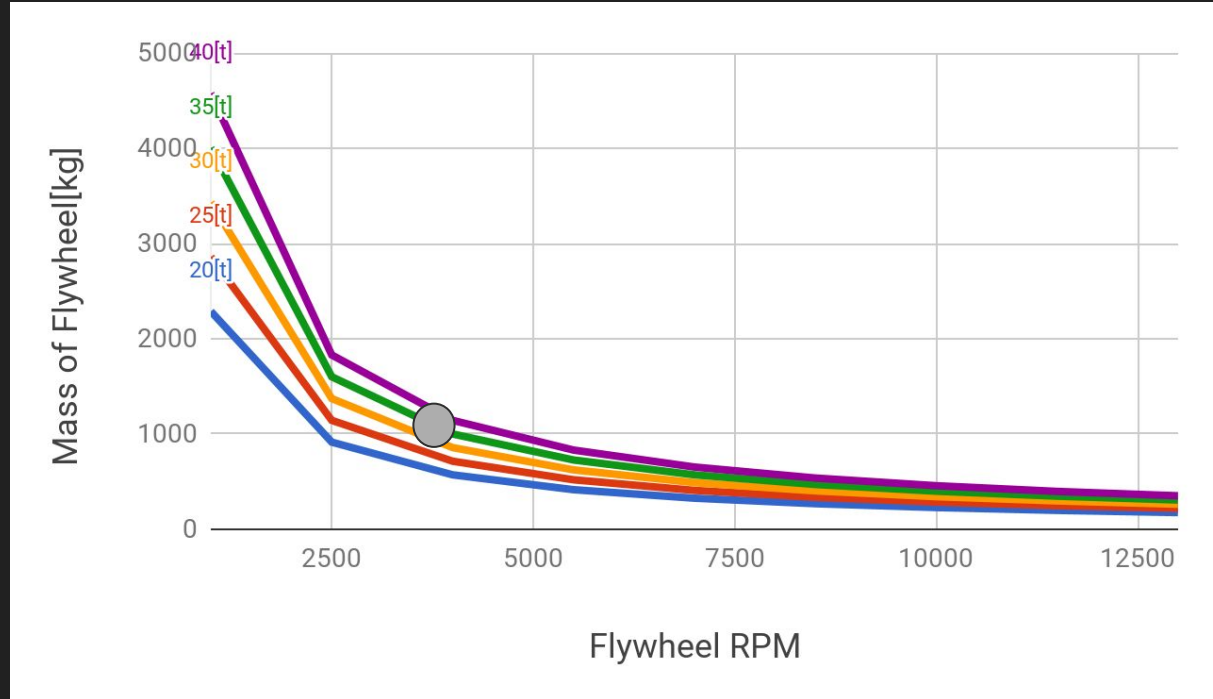
Structures - Radial Arms



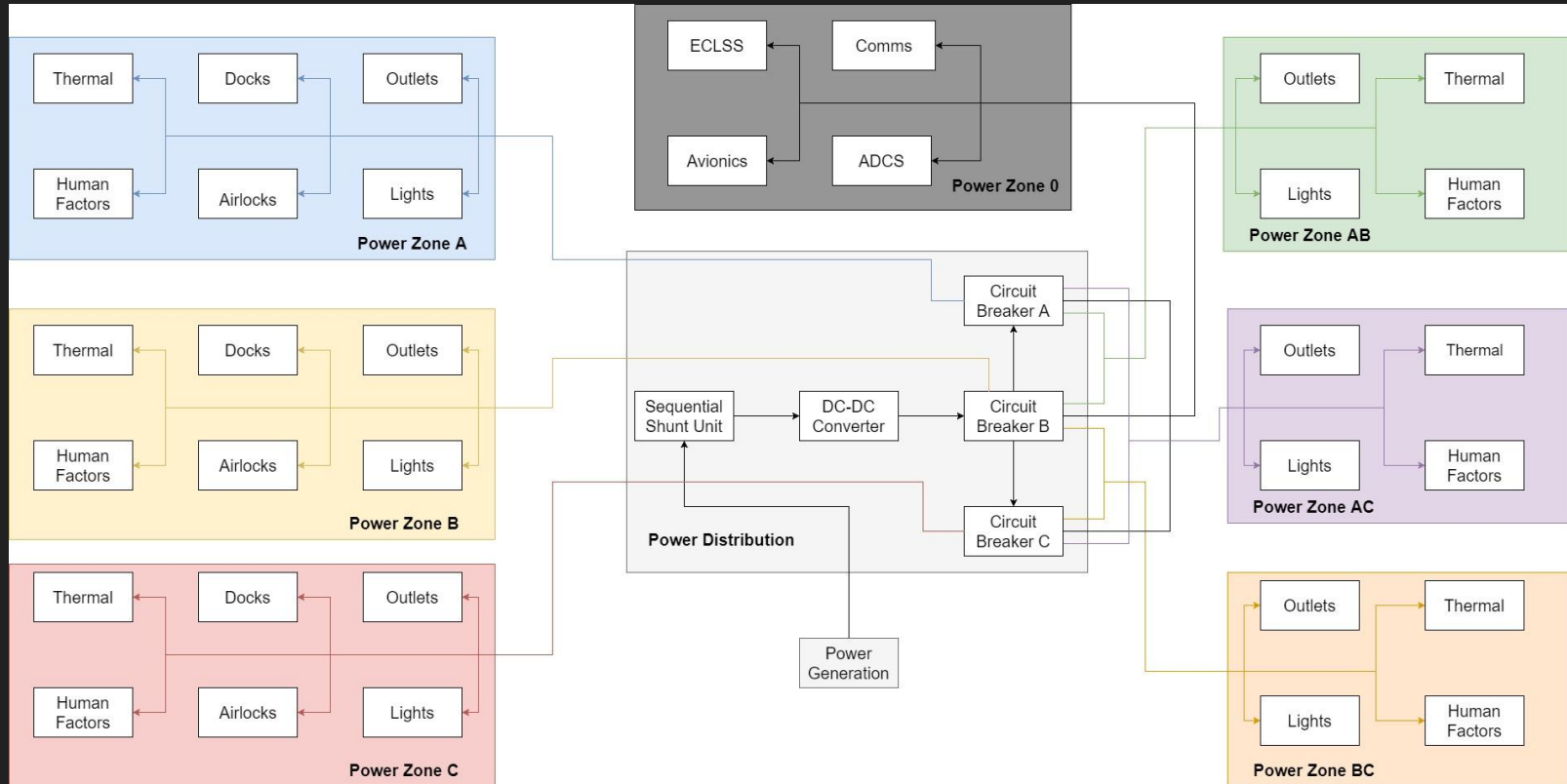
- Extend 1m to 7.84m
 - Composed of 7 pieces

Mechanisms-Reaction Wheel

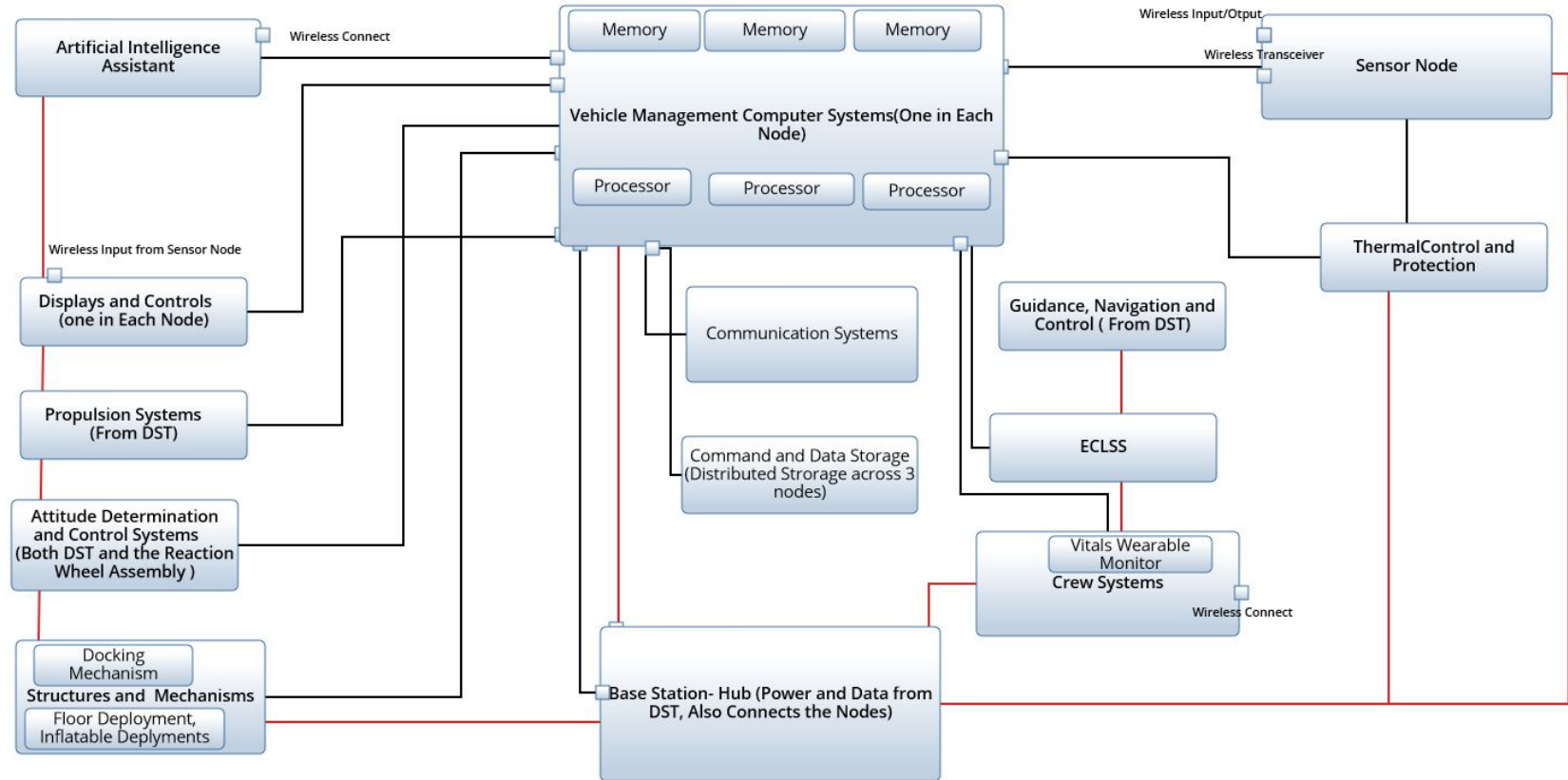
- Diameter 3[m]
- RPM-6600[rpm],
- Mass-653[kg]



Power - Distribution System

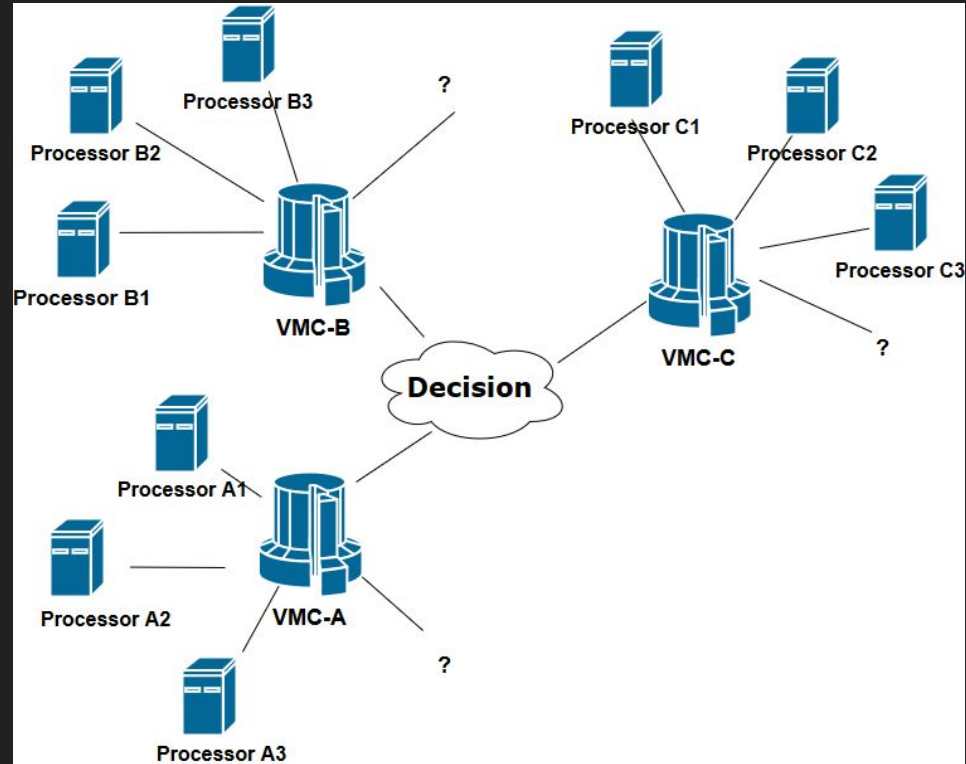


Avionics: Computer Architecture Contd



Avionics: Computer Architecture- Decision Making

- Each Processor in the VMC makes its own decision.
- Each VMC Selects the decision from the processor's decision by the process of selective decision making.
- The decision from the VMCs will be again selected on the majority rule.
- The Mission critical decisions are determined following this process.
- The Decision making layers are controllable , such that non critical decisions can be controlled at the Node level.
- This Architecture is scalable(in the order of Odd numbers to arrive at a decision)



Avionics: Wireless Sensor Network Architecture

