VIABILITY OF COMMON HABITAT AREAS FOR PARTIAL GRAVITY & MICROGRAVITY

PAOLA GONZALEZ MARQUEZ
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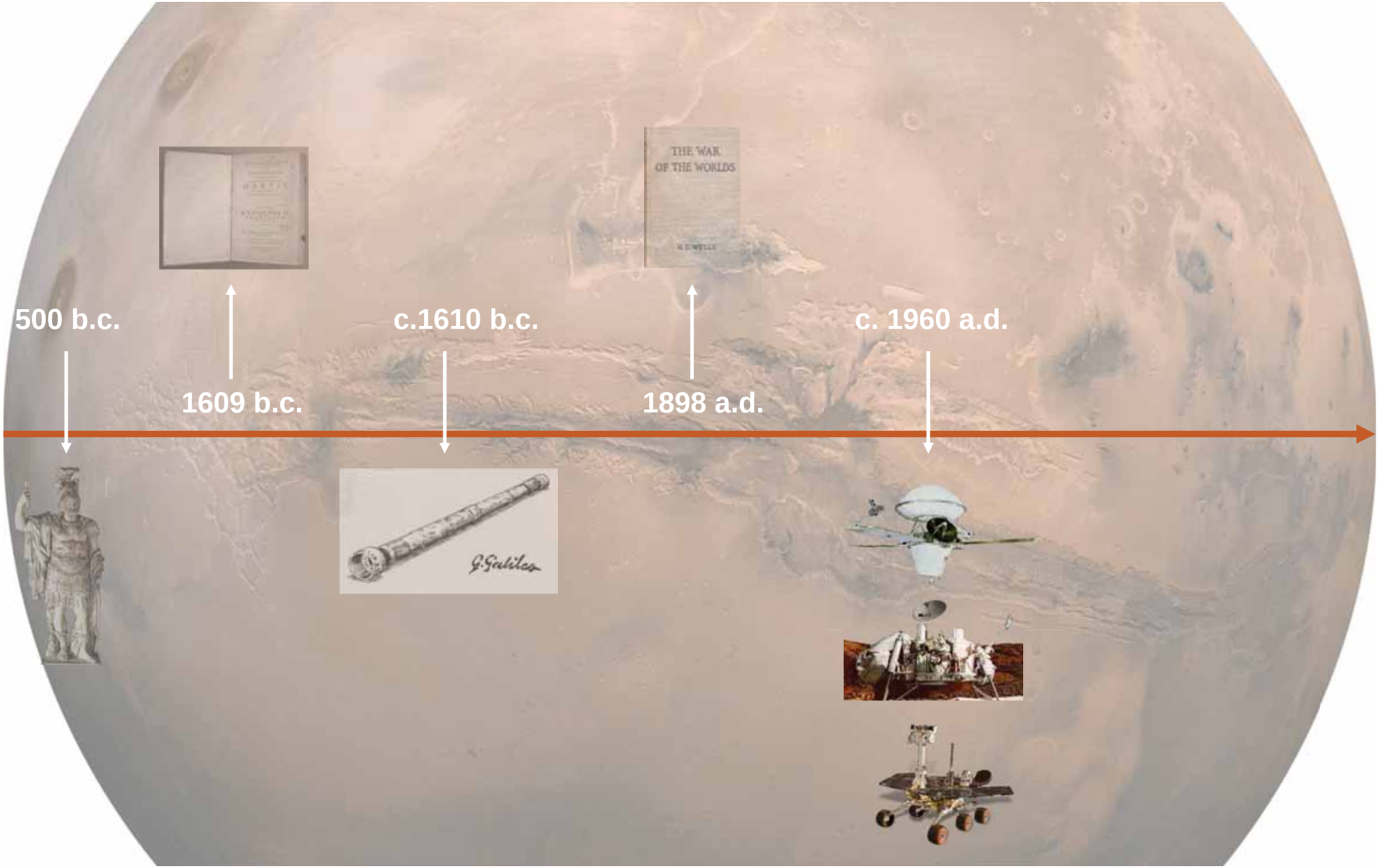
Sasakawa International Center for Space Architecture


THE WAR
OF THE WORLDS
500 b.c.
1609 b.c.
c.1610 b.c.
1898 a.d.
c. 1960 a.d.
G.Galilei

“Will man ever go to Mars?

I am sure he will, but it will be a century or more before he’s ready...”

–Dr. Wernher, 1954

“Will man ever go to Mars?

I am sure he will, but it will be a century or more before he's ready. In that time scientists and engineers will learn more about the physical and mental rigors of interplanetary flight and about the unknown dangers [illegible] another planet. Some of that information may become available within the next 25 years or so, through the erection of a space station above the Earth... and through the subsequent exploration of the Moon.”

-Dr. Wernher, 1954

In 100 years, 2054

In 28 years, 1982

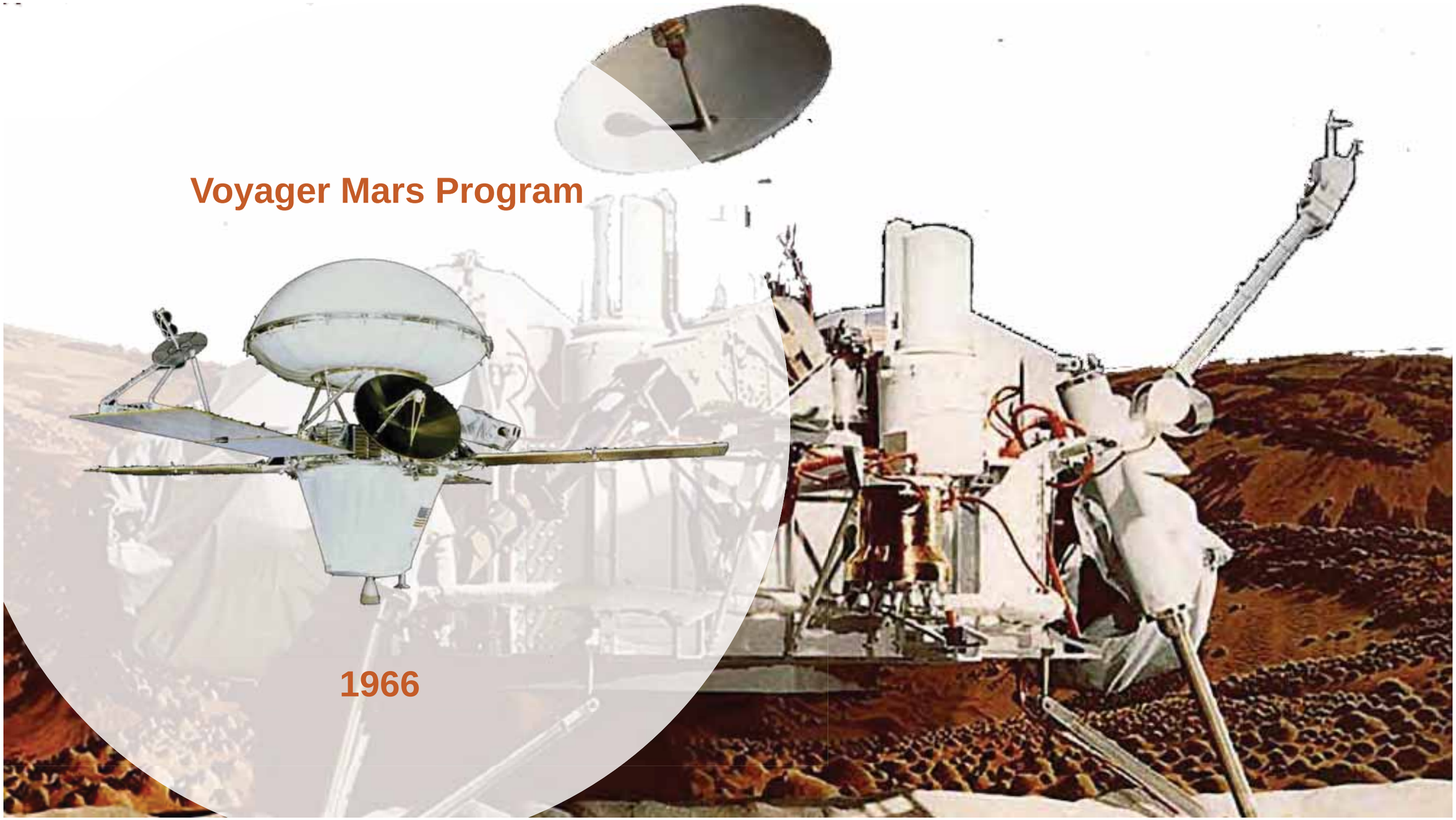

9 billion
per year for 5 years


Mars
Curiosity Rover
Low Earth Orbit,
International Space Station

2024

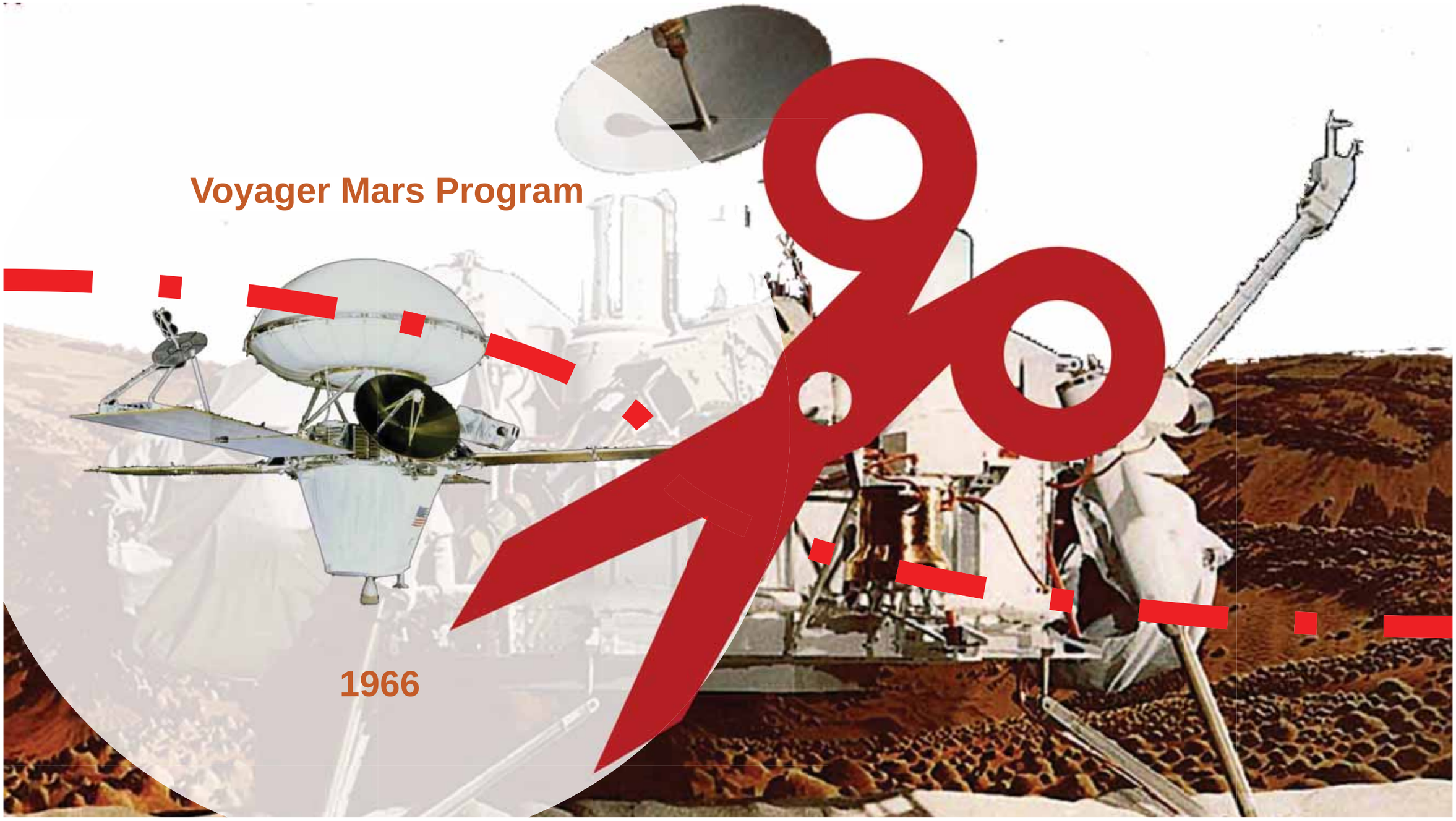
2033

Voyager Mars Program



1966

Voyager Mars Program



1966

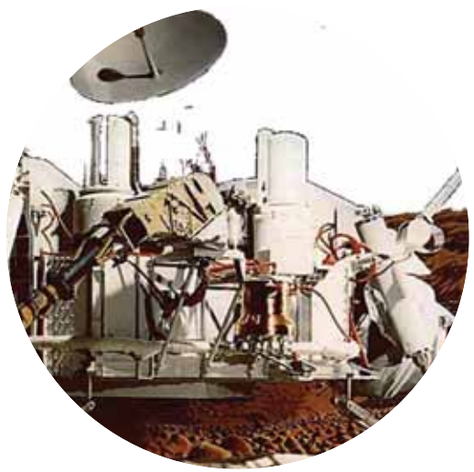
Mariner 8

Mariner 9

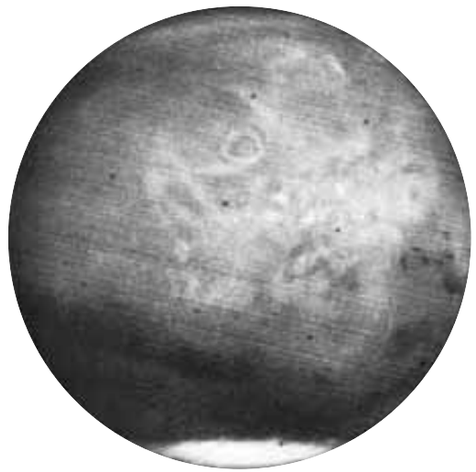
Titan III- E/Centaur

FIRST EVER COLORFUL IMAGE OF MARS

Viking 1 Orbitor



Viking 1 Lander



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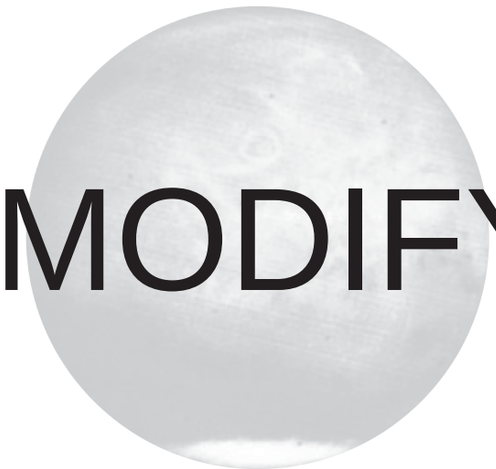
Viking 1 Orbitor

Viking 1 Lander



COPY & MODIFY

Do you own a build-to-order car?

Probably not.

Custom Orders

GMC

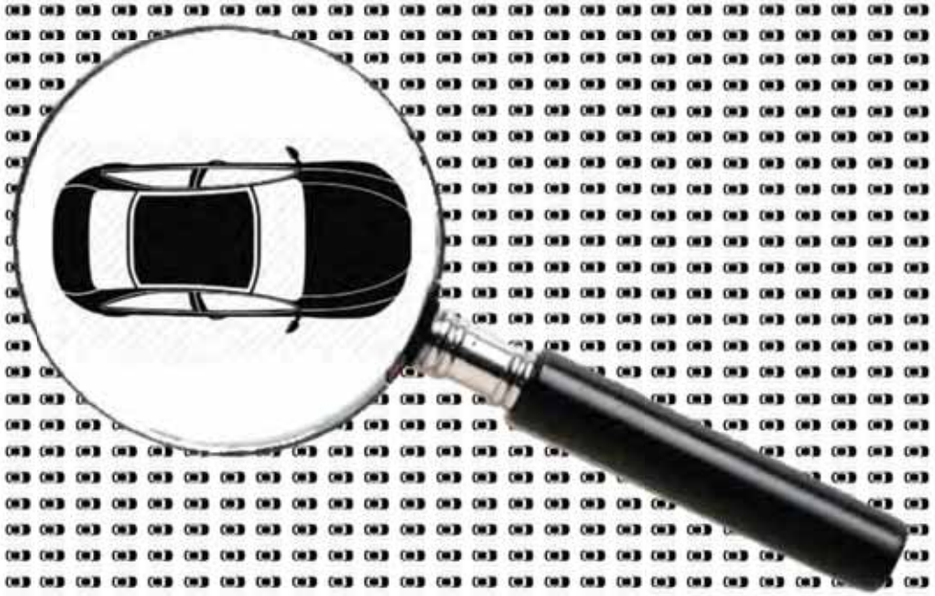
28-42 days

TESLA

21 to 42 days

42-70 days

7,000 cars In 7 days




Common ≠ Identical
Common = Sharing Features


Decrease DDT&E Phase Cost
Decrease Crew Training Cost
Decrease Crew Training Time
Increase Crew Adaptability

CONTRARY PHILOSOPHY

"...

that the **interplanetary and surface capabilities are fundamentally so different that it is not possible to optimize** them within a single set of habitation elements. Rather, design optimization demands separate interplanetary and surface habitats."

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CONTRARY PHILOSOPHY

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BIASED STANDPOINT

Regardless of the divergence of opinion in the human spaceflight community concerning commonality, the following work will show the **study on the viability biased of either inclination**. Further on results demonstrate habitat components common to two gravitation conditions or exclusive to either one.

VISION

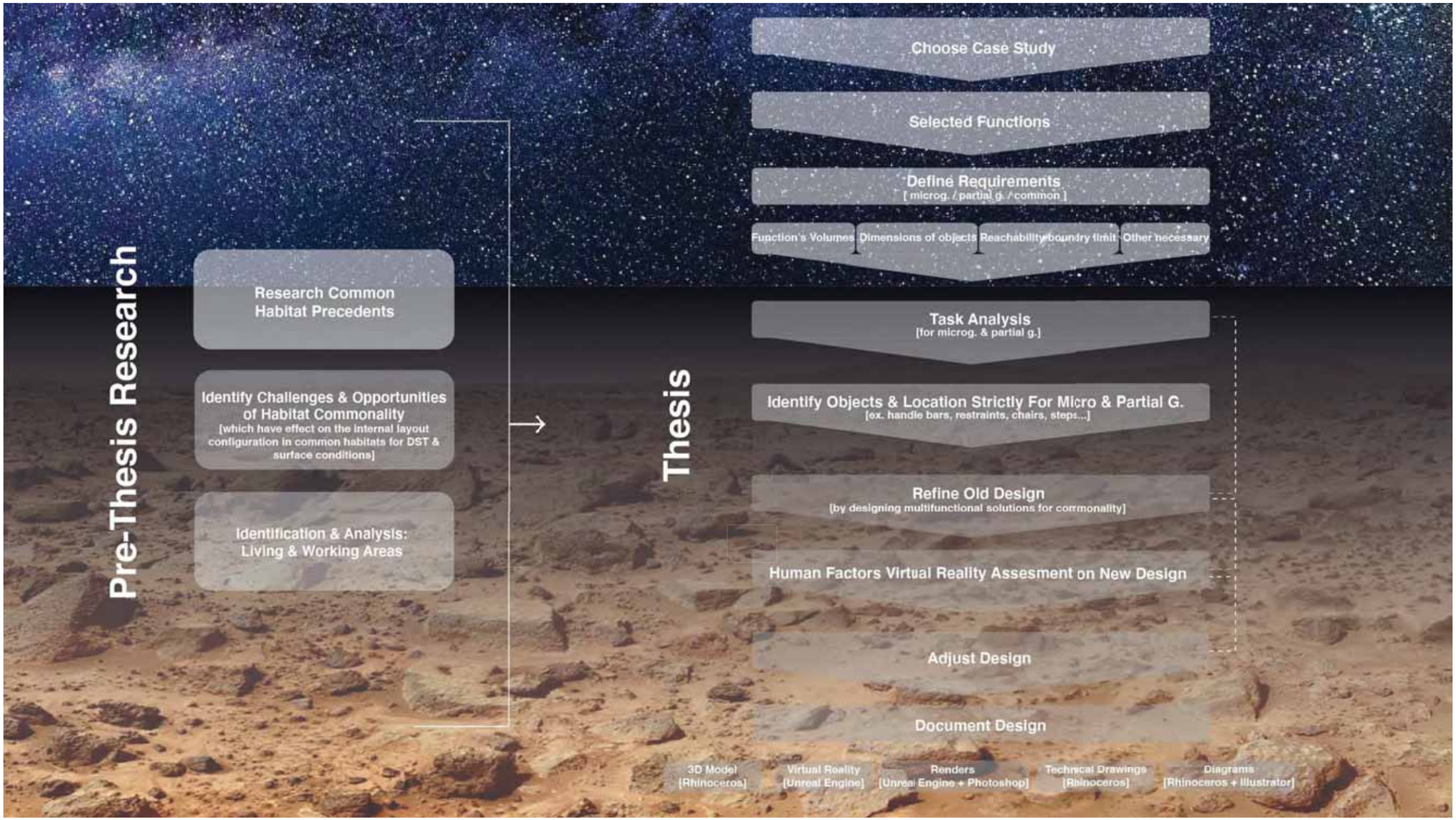
Develop cost effective human habitats for missions held in different gravity environments in a **quick span** of time, meanwhile reducing crew training of habitat usability.

MISSION

Explore the **viability of commonality** in specific living and working areas.

GOAL

Provide **design requirements of common habitats** for microgravity and partial gravity **to future designers.**


Pre-Thesis Research
Research Common Habitat Precedents
Identify Challenges & Opportunities of Habitat Commonality
[which have effect on the internal layout configuration in common habitats for DST & surface conditions]
Identification & Analysis: Living & Working Areas
Thesis
Choose Case Study
Selected Functions
Define Requirements
[microg. / partial g. / common]
Function's Volumes
Dimensions of objects
Reachability boundry limit
Other necessary
Task Analysis
[for microg. & partial g.]
Identify Objects & Location Strictly For Micro & Partial G.
[ex. handle bars, restraints, chairs, steps...]
Refine Old Design
[by designing multifunctional solutions for commonality]
Human Factors Virtual Reality Assesment on New Design
Adjust Design
Document Design
3D Model
[Rhinoceros]
Virtual Reality
[Unreal Engine]
Renders
[Unreal Engine + Photoshop]
Technical Drawings
[Rhinoceros]
Diagrams
[Rhinoceros + illustrator]

CASE STUDY:

NASA MSFC ACO
Common Habitat for Microgravity, Partial Gravity & Artificial Gravity in a Safe Haven Configuration

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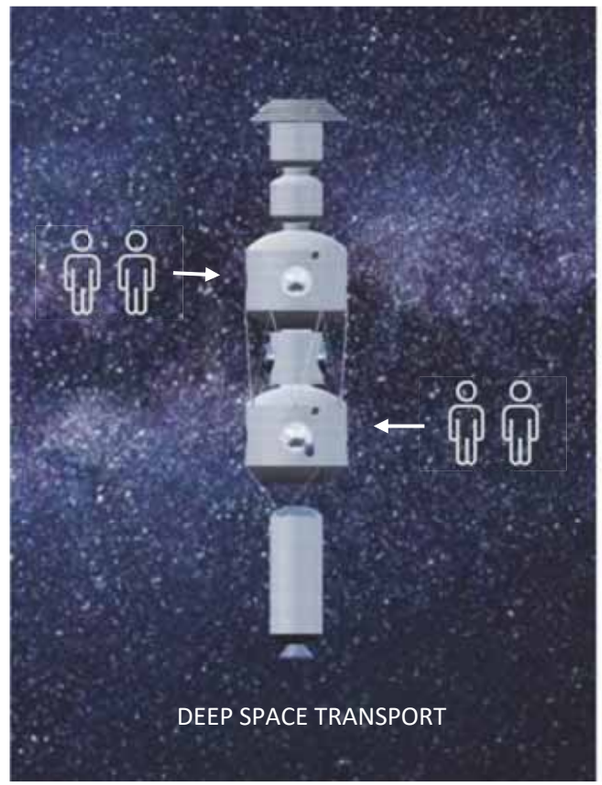
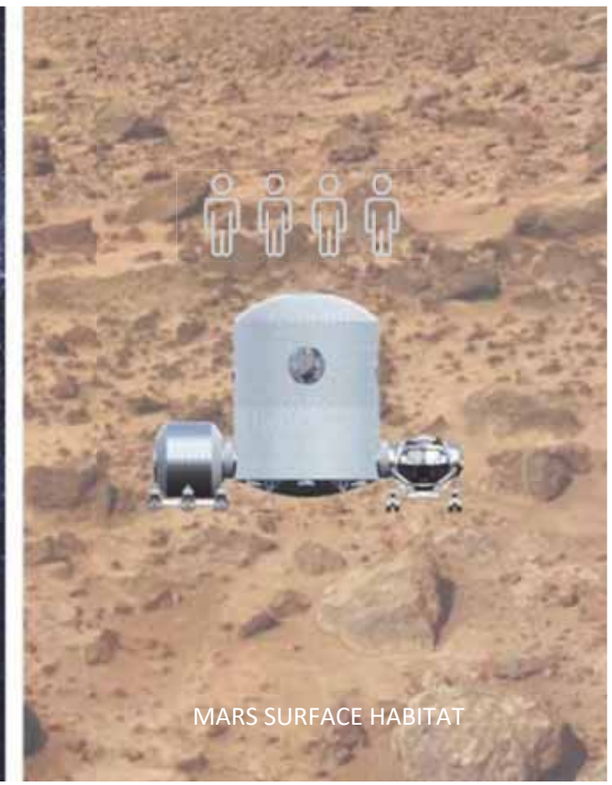
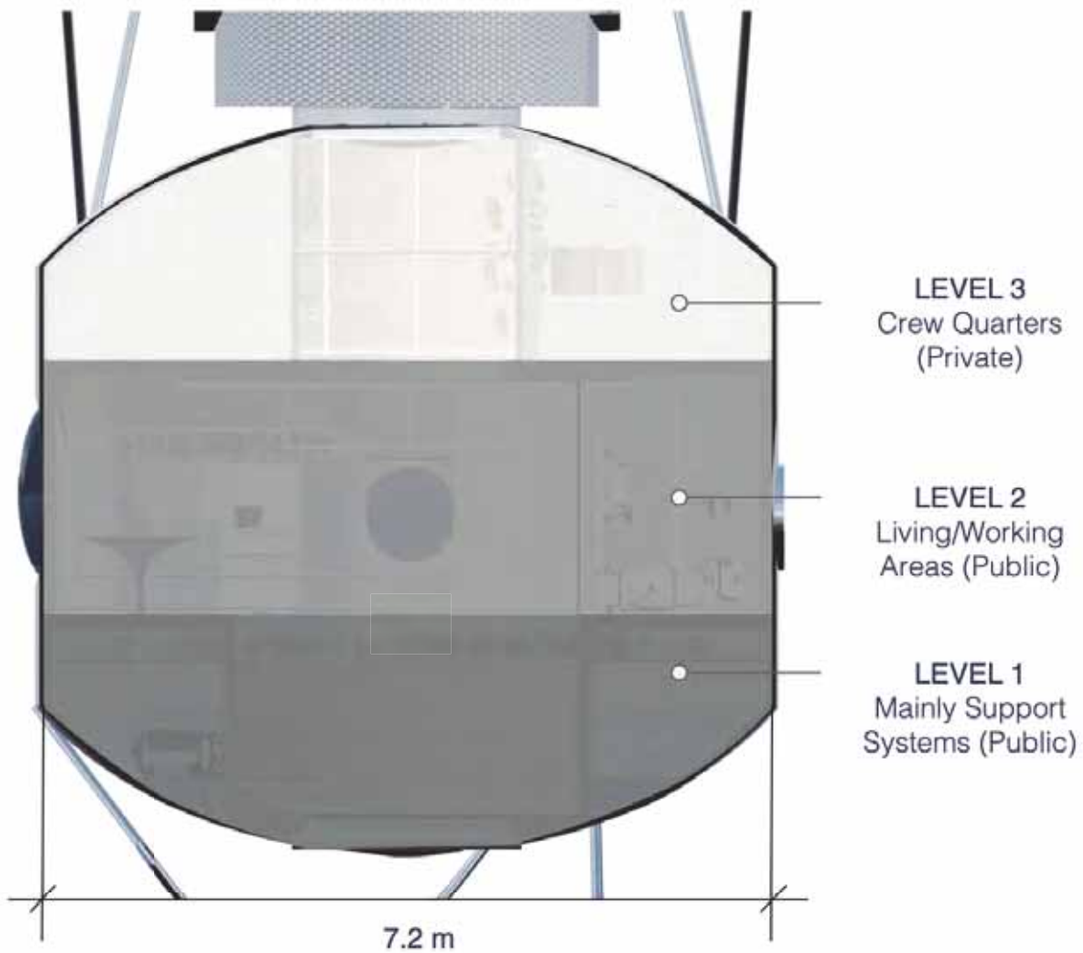
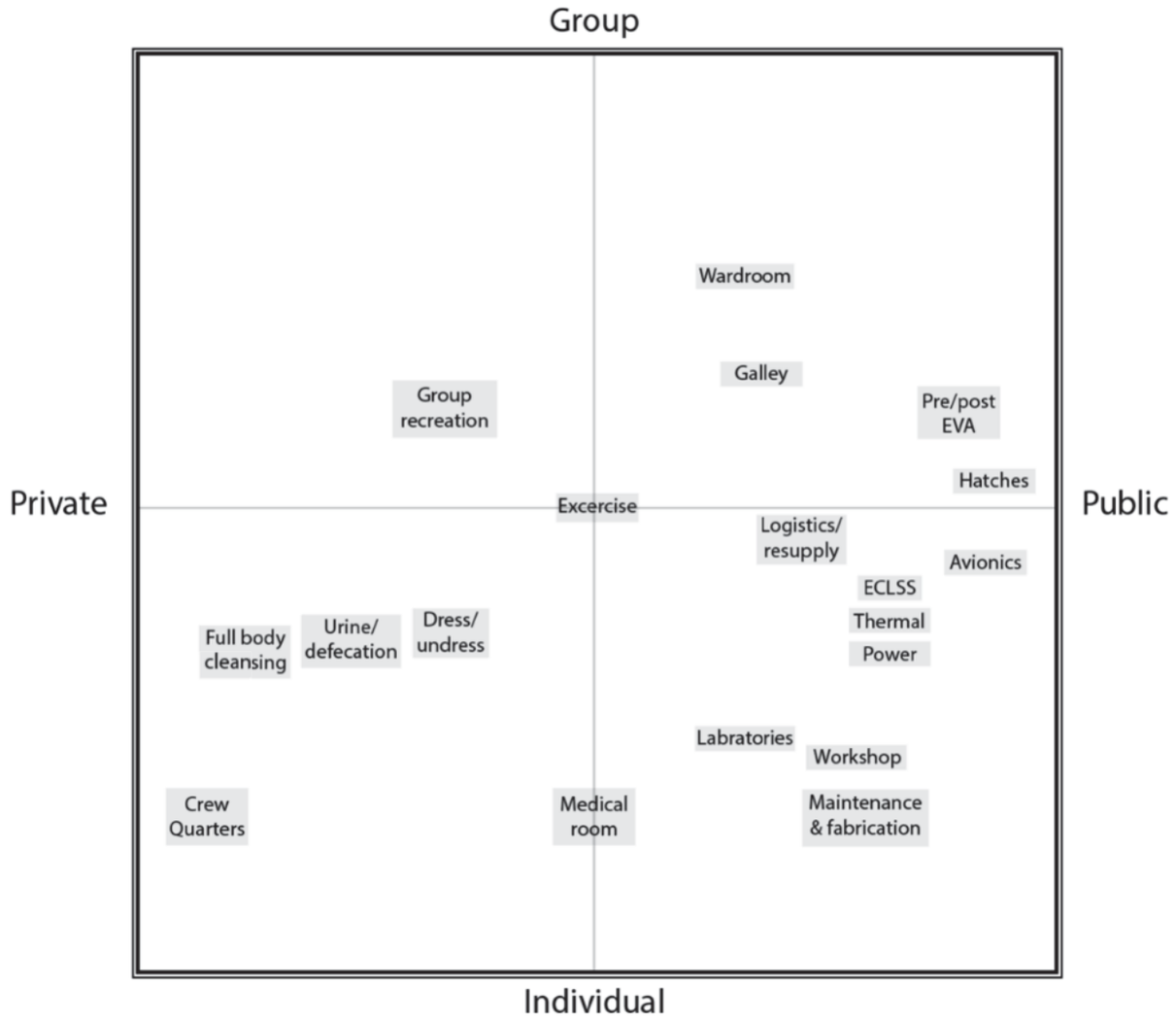




COMMON HAB GENERAL DISTRIBUTION



ADJACENCY OF FUNCTIONS



HUMAN ANTHROPOMETRICS

BIOPHILIA


Node A level 2 in microgravity condition.
Material variation for psychological purposes.

Commonality Refinement in Case-Study Habitat Areas

CHOSEN HABITAT AREAS

Crew Quarters

Galley

Wardroom

Vertical Circulation

Waste Collection

Medical Operations

Exercise

Hygiene

Labs

Crew Meetings

Maintenance

Robotics/teleoperations

EVA operations

Spacecraft monitoring and commanding

Mission Planning

Logistics Operations

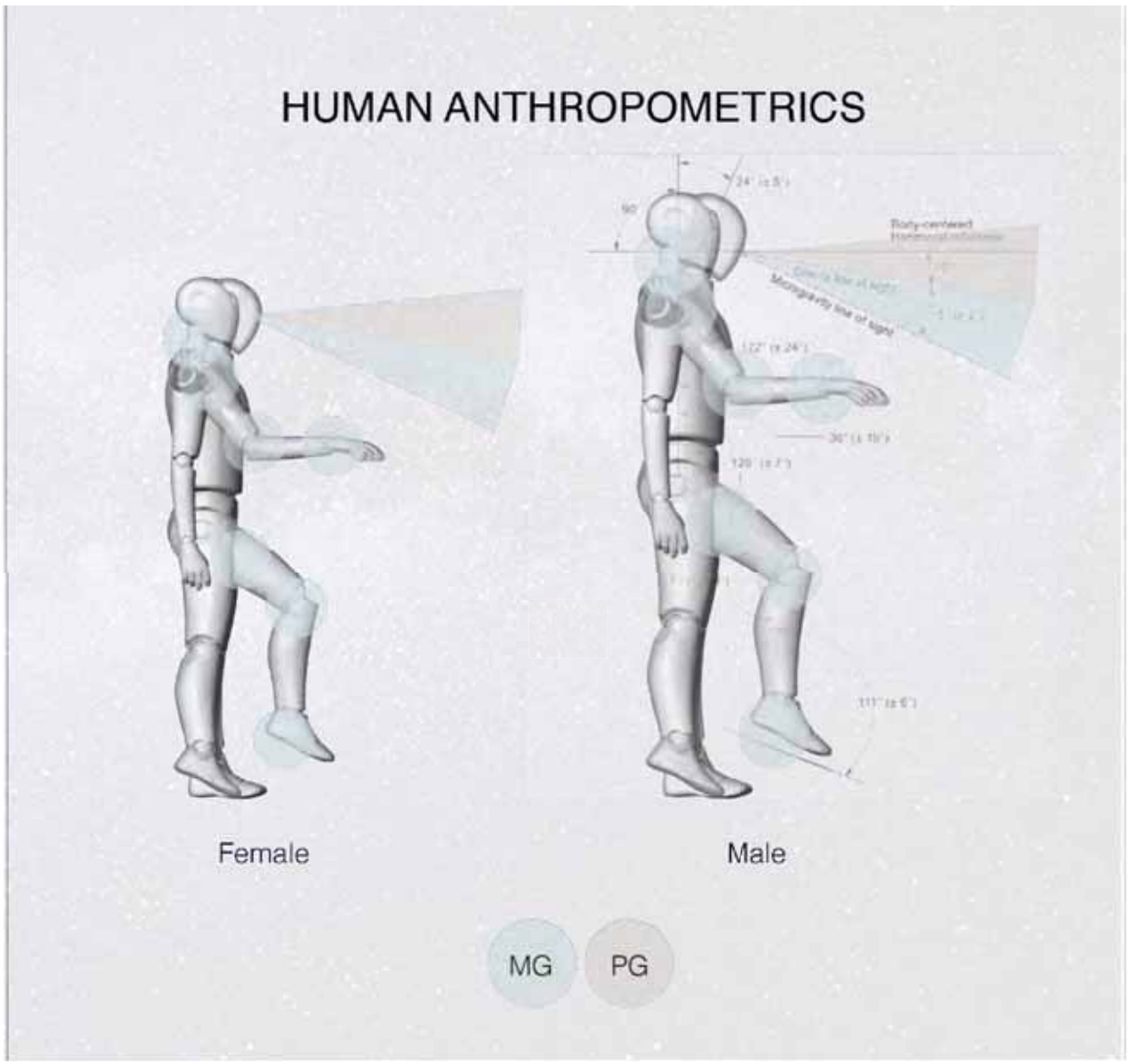
DESIGN CRITERIA

ORIENTATION

MicroGravity

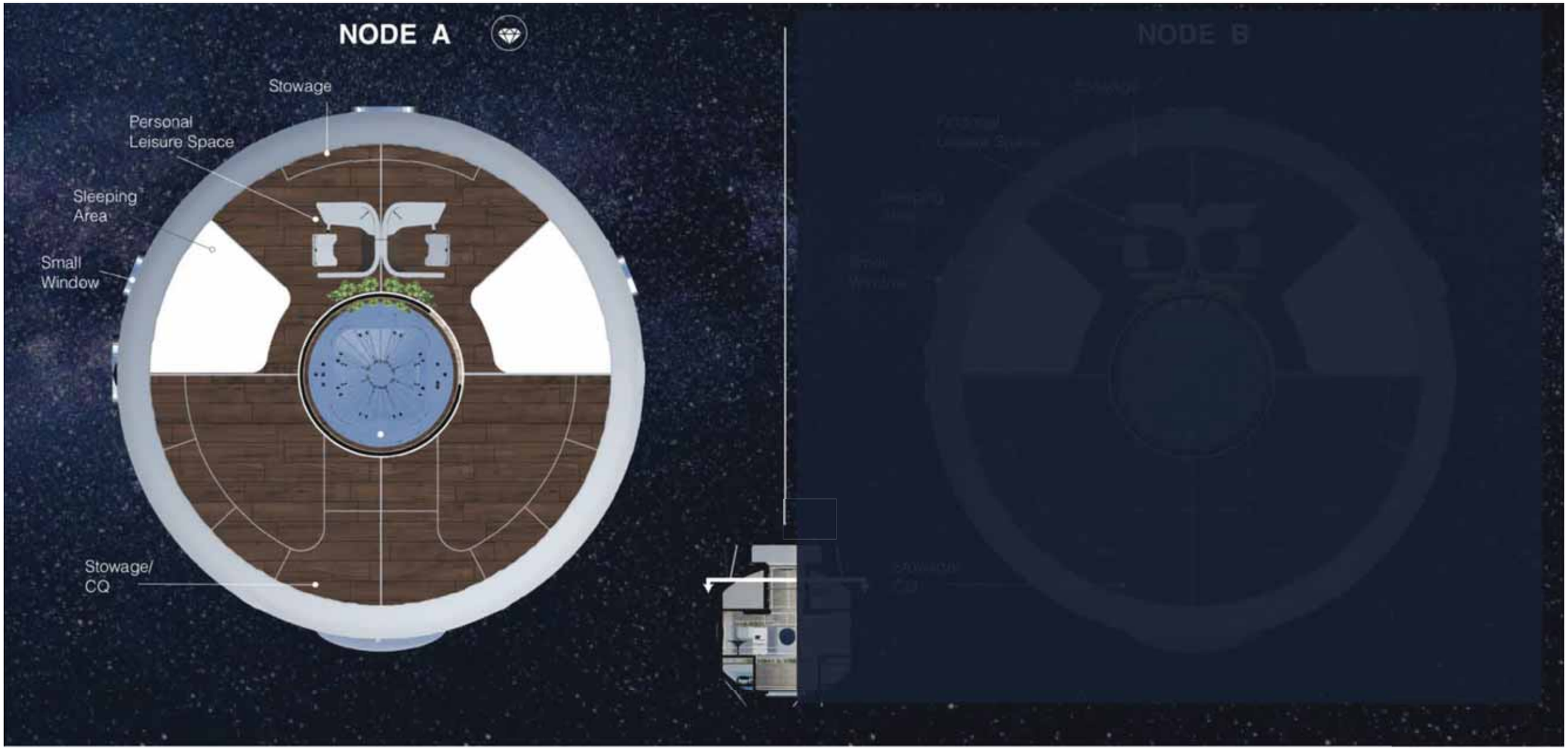
Partial Gravity

HUMAN ANTHROPOMETRICS



GEOMETRY/ VOLUME

Crew Quarters | Case-Study Refinement


NODE A
Stowage
Personal
Leisure Space
Sleeping
Area
Small
Window
Stowage/
CQ
NODE B

Crew Quarters Sub-Functions & Design Considerations

Sub-Functions	Design Considerations
Wake up	Alarm or annunciator
	Adequate lighting
Don and doff clothing	Adequate volume
	Privacy (i.e., door)
	Restraints for 0g
	Clothing and personal items storage
Groom	Adequate lighting
	Mirrors
	Stowage for grooming supplies
	Proximity to personal hygiene facility
Relax	Communications with friends or family
	Entertainment material: books, audio and video entertainment, games, etc.
	Adjustable lighting
	Window
	Ventilation and temperature control
	Restraints for 0g
	Radiation shielding
	Aesthetically pleasing environment
Prepare for sleep	Clothing storage
	Proximity to personal hygiene and body waste management facility
	Privacy
Sleep	Minimal noise
	Privacy
	Adjustable lighting
	Bedding
	Restraints
	Ventilation and temperature control
	Radiation shielding
	Minimal vibration
Respond to emergency	Alarm
	Two-way communications with other crewmembers or ground control
	Emergency lighting
	Properly configured door and path
Personal Projects	Privacy
	Work space

CREW QUARTERS

01 SUBJECT	02 MISSION REQ.	03 MG REQUIREMENT (~0 m/s²)	04 PG REQUIREMENT (3.711 m/s²)	05 COMMON REQ.	06 DONE ✓	07 CURRENT STATUS	08 RECOMMENDATIONS
Personal area							
Shared living area							
Shared work/study area							

CREW QUARTERS

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Private Sleeper							
Sleeping Bunk/Pod area							
Bed orientation							
Privacy							

CREW QUARTERS

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Bed & Sleep Systems							
Personal Storage							

CREW QUARTERS

01 SUBJECT	02 MISSION REQ.	03 MG REQUIREMENT (~0 m/s²)	04 PG REQUIREMENT (3.711 m/s²)	05 COMMON REQ.	06 DONE ✓	07 CURRENT STATUS	08 RECOMMENDATIONS
Sleep System		Private Crew Quarters for long duration (> 6 months) for Lunar/Mars outpost or flight to Mars (HIDH 638)					
Sleeping Volume / Bed size	1 sleeping surface per crew member	Sleeping dimensions: H 206cm x L 106cm x W 123cm Volume: 2.60m3 (HIDH 664) Restraints are needed. (HIDH 707)	Bed dimensions: H 47cm x L 225cm x W 100cm Volume: 1.05m3 (99th percentile) (K. Dvouletá, D. Káňová 88)	**Orientation:** shall be determined by PG, i.e. the sleeping surface shall be parallel to the surface determined to be the floor in PG. As MG sleeping system does not depend on orientation it is constrained by PG orientation. **Dimensions:** It is to be taken the largest dimensions from each axis between MG and PG dimensions, i.e. H 206cm x L 225cm x W 123cm (H from MG, L from PG and W from MG) **Volume:** 5.70m3 **Restraints:** needed in MG The ideal placement for a bed is with the head up against a windowless wall, to provide solid backing, and as far as possible from both windows and doors. If not, a headboard needs to be used. (Sporrle & Stich, 2010)	x		

CREW QUARTERS

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CREW QUARTERS

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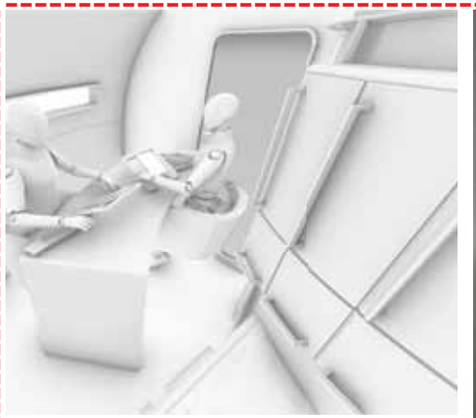
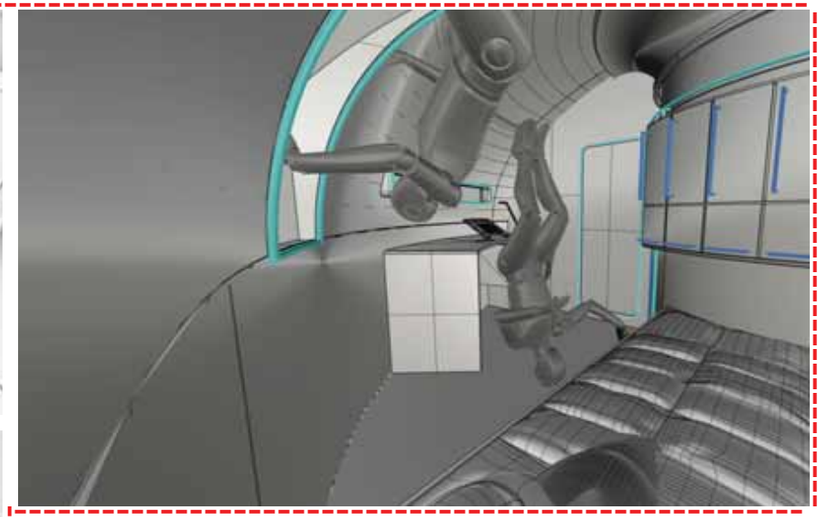
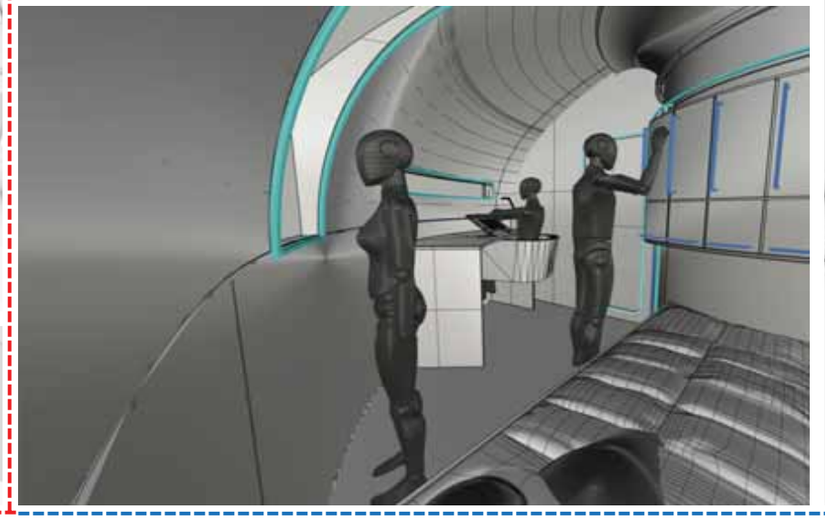
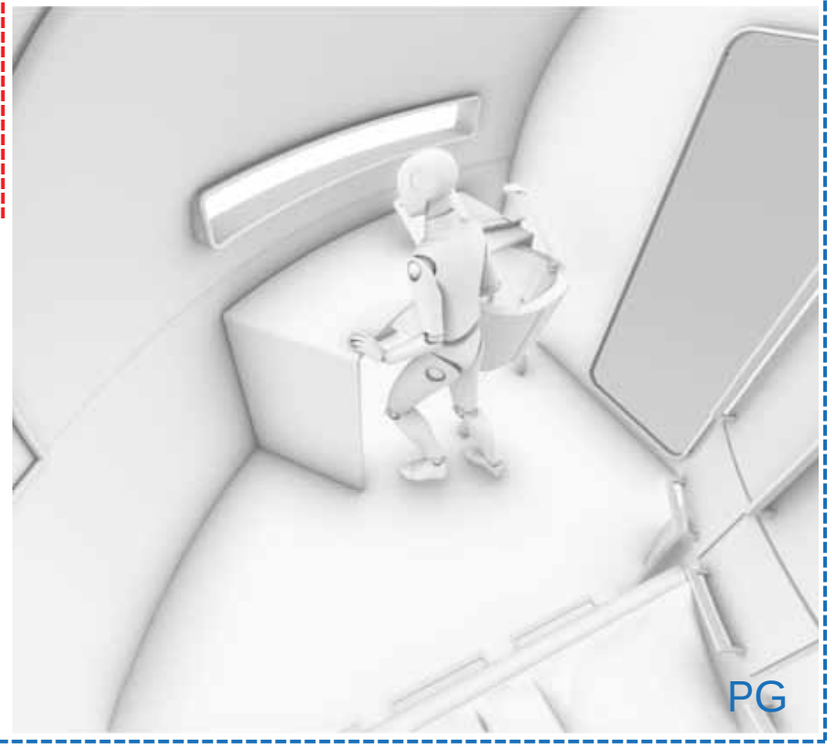
CREW QUARTERS ASSESSMENT

FUNCTION	TASK NUMBER	TASK		SUBTASK NUMBER	SUBTASK		POSITION/MOTION	
		Microgravity	Partial Gravity		Microgravity	Partial Gravity	Microgravity	Partial Gravity
SLEEP/REST	A.03	Control Lighting/Temperature/Ventilation		A.03.01	Float towards ipad	Walking towards ipad	Zero Gravity Neutral Position	Surface gravity neutral walking motion
				A.03.02	Detach ipad		1a. One hand grabbed onto the rail 1b. Other hand is extracting ipad from the velcro strip	One hand extracting ipad from velcro strip
				A.03.03	Take ipad to sleeping area		1a. One hand grabbed onto rail 1b. Pushing through space 1c. Holding onto ipad with other hand	Walking
				A.03.04	Place onto attachment near the sleeping bag/area		1a. One hand grabbed onto the rail 1b. Other hand is placing ipad to the velcro strip	Placing ipad onto velcro strip
				A.03.05	Change Lighting/Temperature from the ipad		Finger is placed and swiped	
	A.04	Get into sleeping suit/sac/bag		A.04.01	Float toward sleeping bag/hatch	Walk toward sleeping bag	Zero Gravity Neutral Position	Surface gravity neutral walking motion
				A.04.02	Unzip sleeping bag	(Not necessary)	Reach with arm and pull zipper down	
				A.04.03	Tuck into sleeping bag	Suck and blow	1a. One hand grabbed onto rail 1b. Push off rail 1c. Lower arms to the side (adduction)	Lower arms to the side (abduction)
				A.04.04	Insert both arms into arm holes	(Not necessary)	Lift arms out to the side (abduction)	(Not necessary)
				A.04.05	Zip sleeping bag	(Not necessary)	Bend elbow, Pinch, Pull zipper	(Not necessary)
	A.05	Fall asleep		A.05.01	Get into comfortable position		Neutral/prone position or prone/ fetmal position	
	A.06	Wake up		A.06.01		Same		Same
	A.07	Getting out of the sleeping bag		A.07.01	Unzip sleeping bag	(Not necessary)		(Not necessary)
				A.07.02	Take out arms from arm holes	(Not necessary)		(Not necessary)
				A.07.03	Float away from sleeping bag	Walk away from bed		Walking motion
	A.08	Turning off the alarm		A.08.01	Float towards the ipad	Walk towards ipad		Walking motion
PERSONAL ACTIVITIES	B.01	Bodycare		B.01.01	Float towards Storage compartment	Walk towards storage compartment		Walking motion
				B.01.02	Attach waist restraints	(Not necessary)		
				B.01.03	Open storage compartment			
				B.01.03	Grab objects			
				B.01.04	Attach object to velcro			
				B.01.05	Look in mirror			
	B.02	Undressing		B.02.01	Float towards storage compartment	Walk towards storage compartment	Zero Gravity Neutral Position	Surface gravity neutral walking motion
					Attach waist restraints	(Not necessary)	1a. Holding on to vertical railing with one hand 1b. Attaching a locking mechanism around the waist with the other hand	(Not necessary)
				B.02.03	Take off clothing		1a. Cross arms at the waist and pull shirt up up or grab the shirt from the back to pull it over the head (90° on z axis) 1b. Pull pants in downward motion 1c. Pull socks off	
				B.02.03	Grab clothing		Wrapping arms around clothes	
				B.02.04	Open storage compartment		reach and pull handle	
				B.02.05	Place clothes in storage compartment		Item over	
				B.02.06	Close storage compartment		Push storage door	
				B.02.07	Unlock restraints	(Not necessary)		(Not necessary)
	B.03	Placing on New Clothes		B.03.02	Attach waist restraints	(Not necessary)	1a. Holding on to vertical railing with one hand 1b. Attaching a locking mechanism around the waist with the other hand	(Not necessary)
				B.03.03	Take off clothing		1a. Cross arms at the waist and pull shirt up up or grab the shirt from the back to pull it over the head (90° on z axis) 1b. Pull pants in downward motion	
				B.03.04	Grab clothing		Wrapping arms around clothes	
				B.03.05	Open storage compartment		reach and pull handle	
				B.03.06	Place clothes in storage compartment		Item over	
				B.03.07	Close storage compartment		Push storage door	
				B.03.08	Unlock restraints	(Not necessary)		
	B.04	Reading/Writing		B.04.01	Restrained, Attached to the desk, floating around, in their bed	Sit in the desk, laying in bed, standing Same		
	B.05	Computer Usage (Email, Movies, and Messaging			Using computer or iPad			
	B.07	Snacking			Restrained, attached to the desk, floating around, in their bed	Sit in the desk, laying in bed, standing		
	B.08	Using Personal Objects			Placing Family Pictures Around the quarte			
	B.09	Socializing				Same		





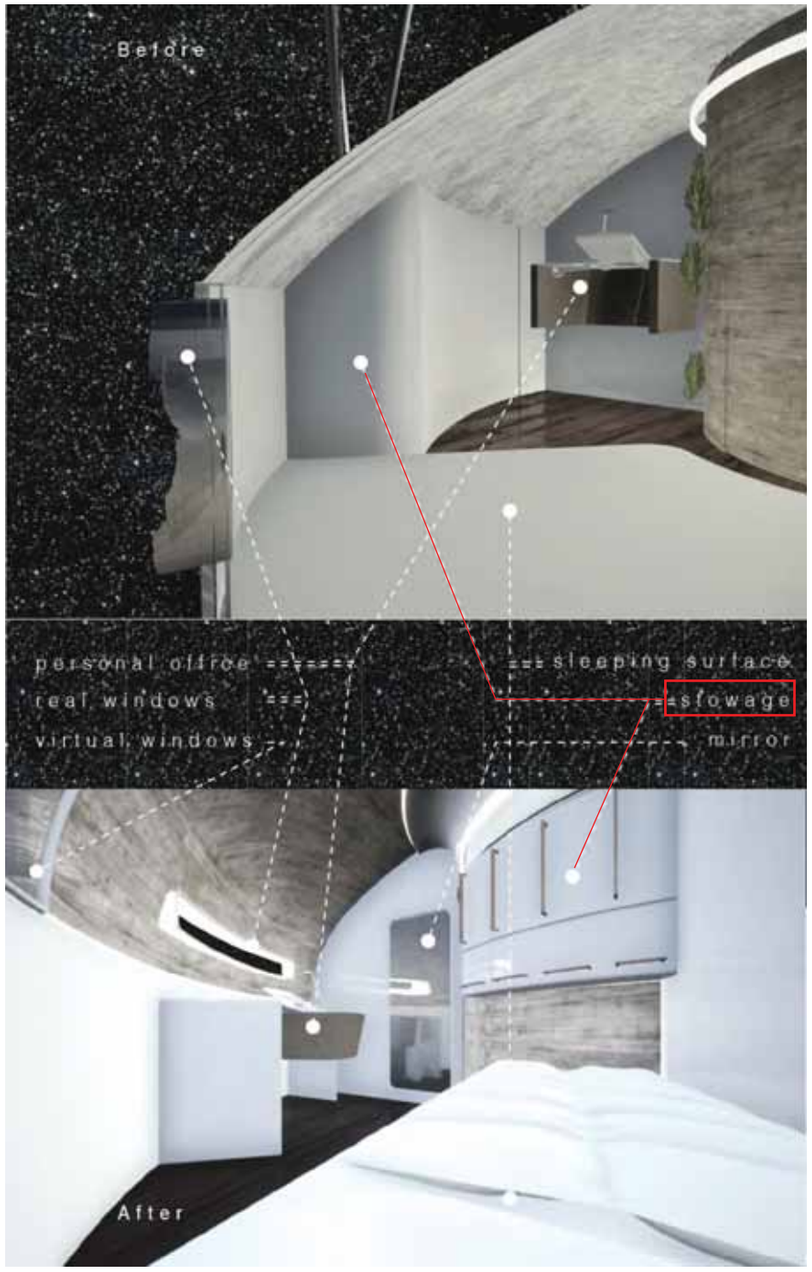




MG

PG

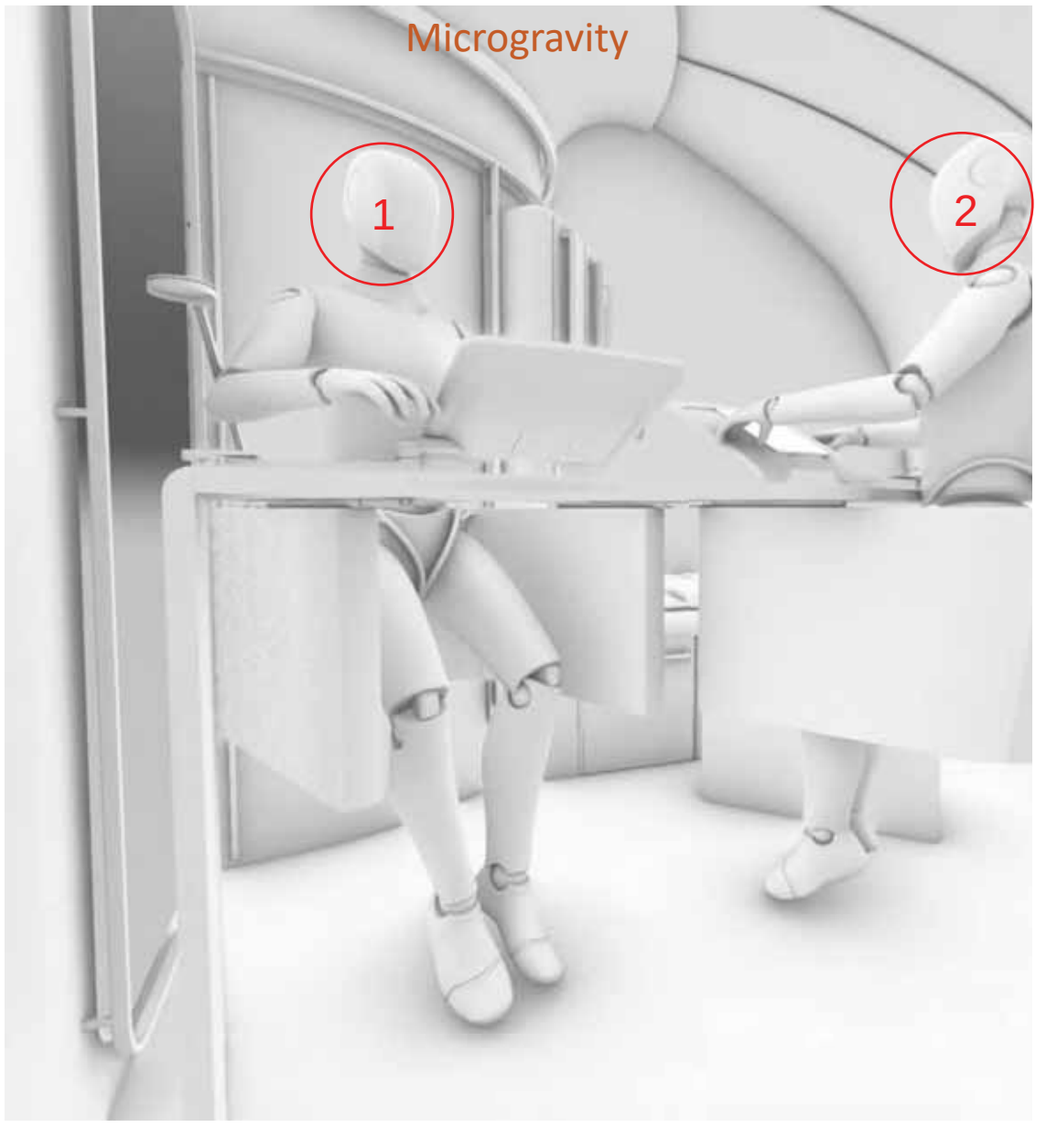
Before refinement



After refinement

Before refinement

After refinement



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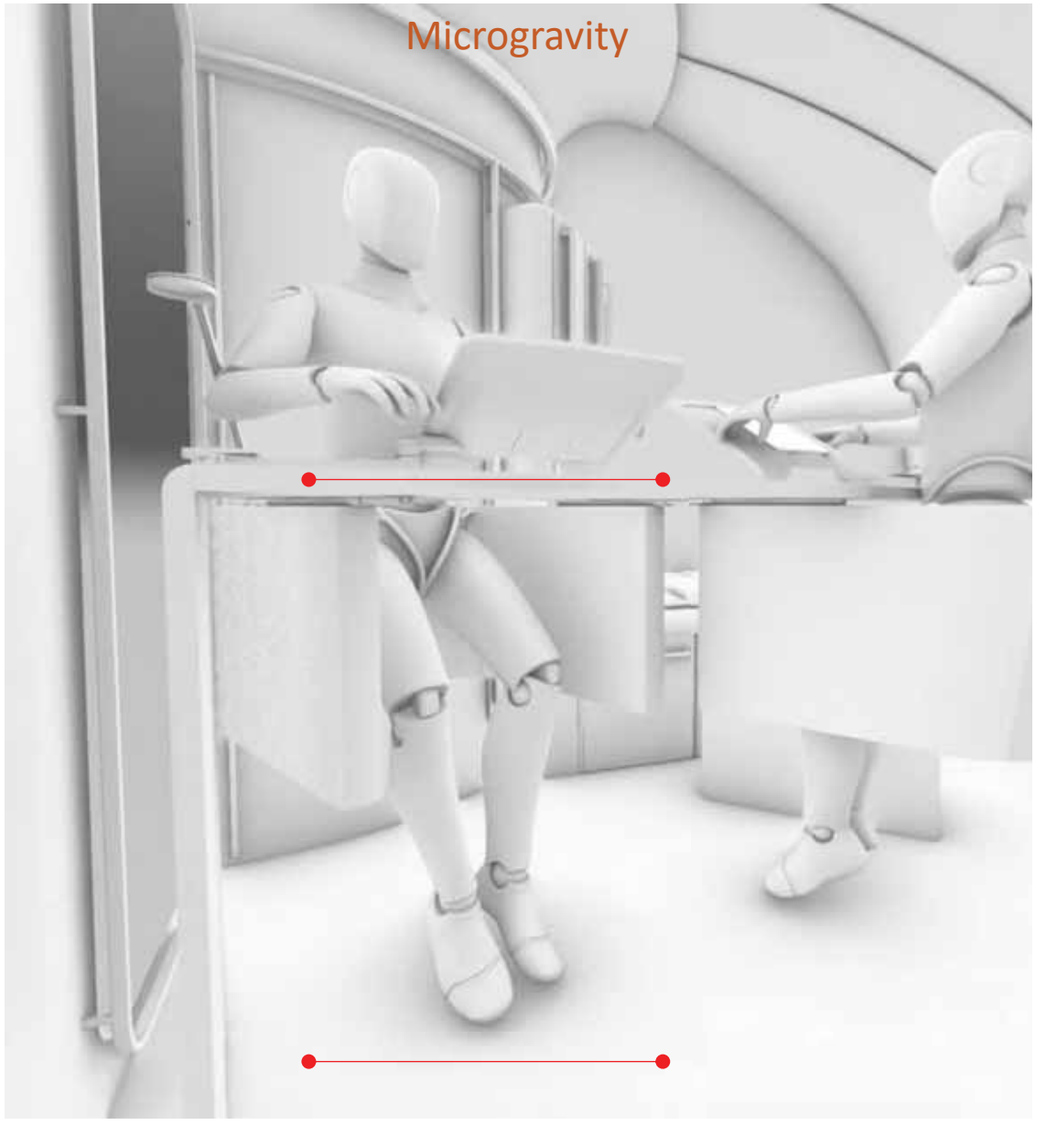
2 Person Meeting	Sufficient volume for two crew to sit, facing each other, with unobstructed line of sight, with physical work surface between them, with at least six inches separation between the nearest body parts of the two. (R. Howard, 23) **Restraints:** needed

Microgravity



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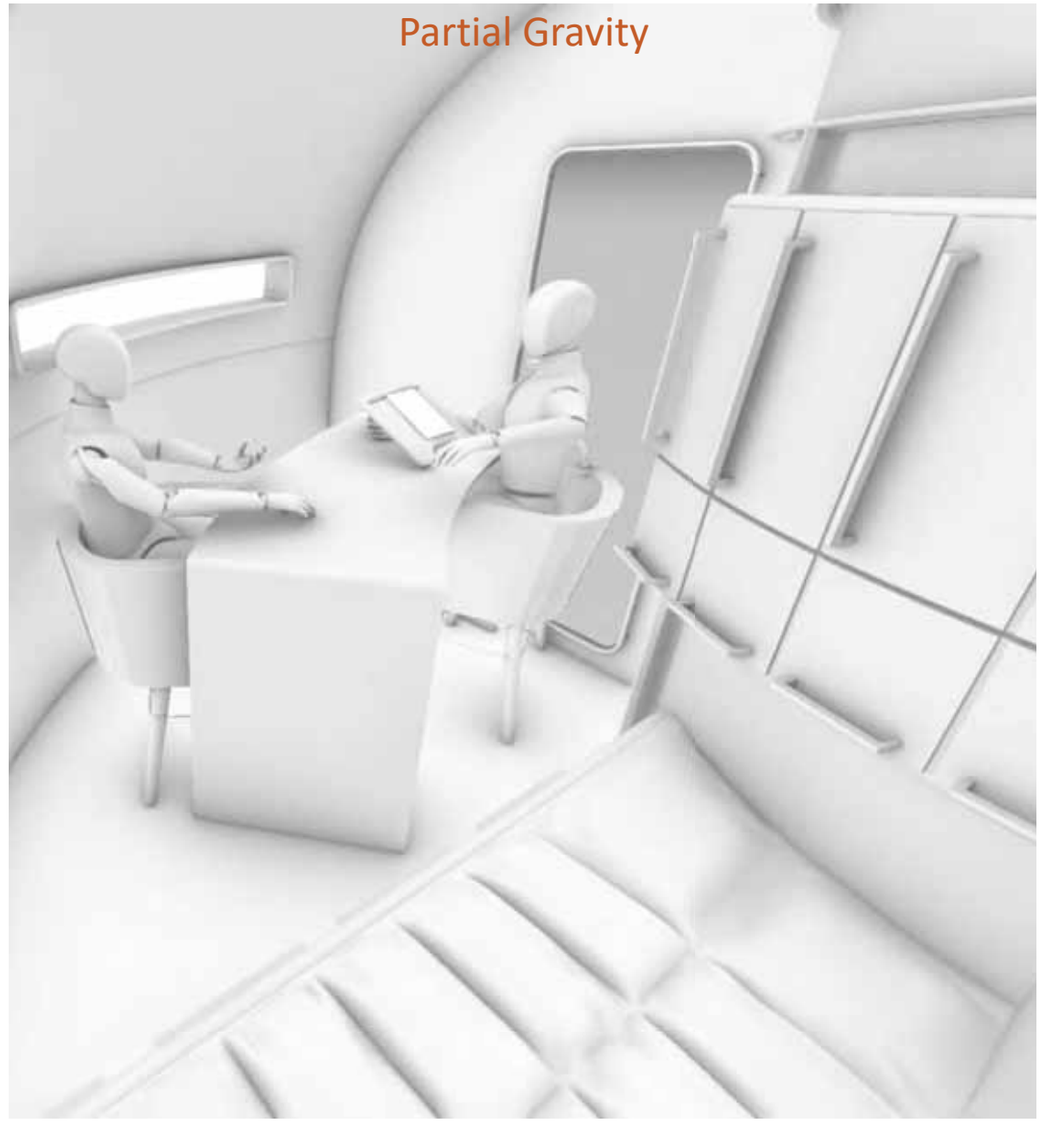

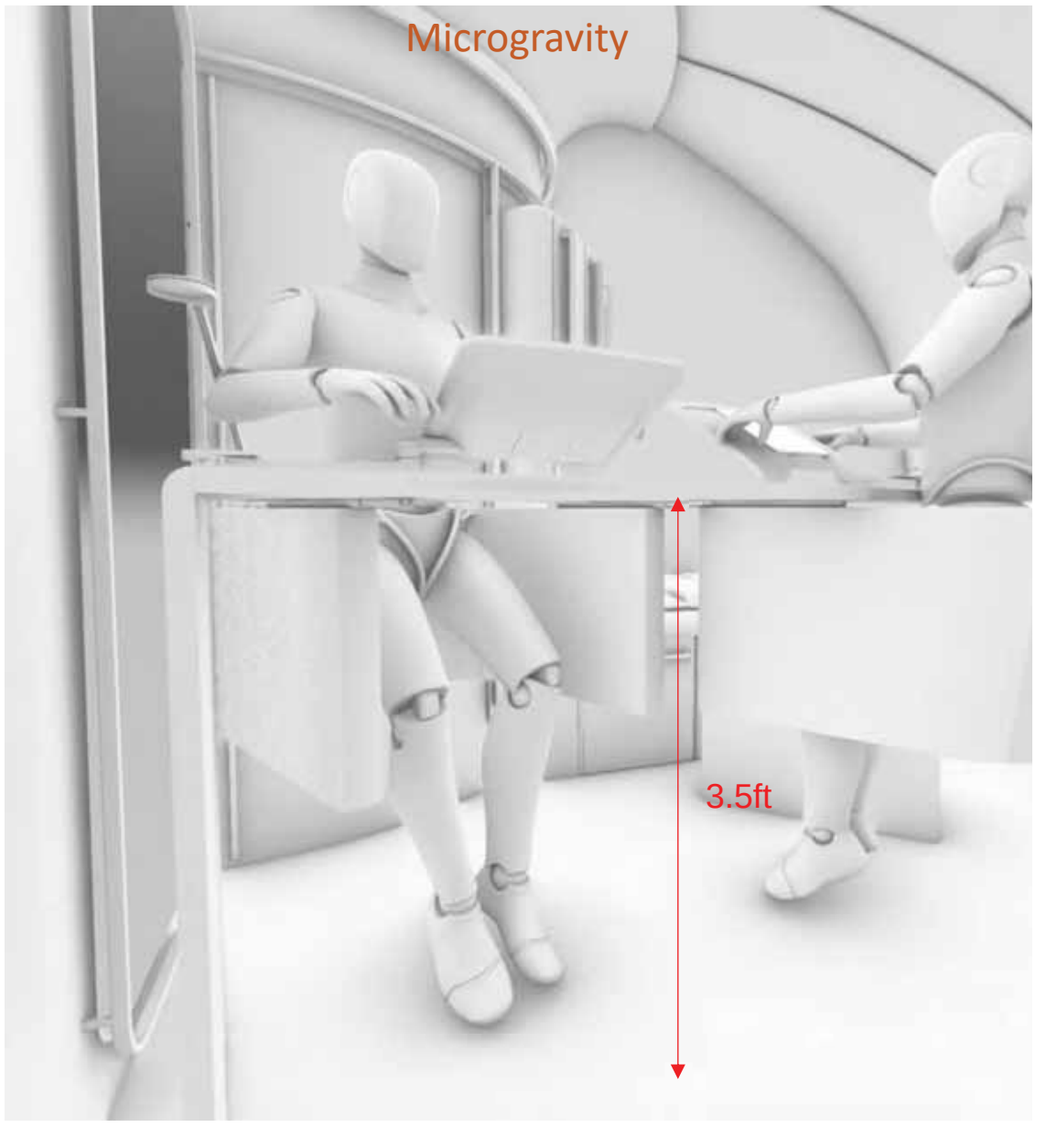

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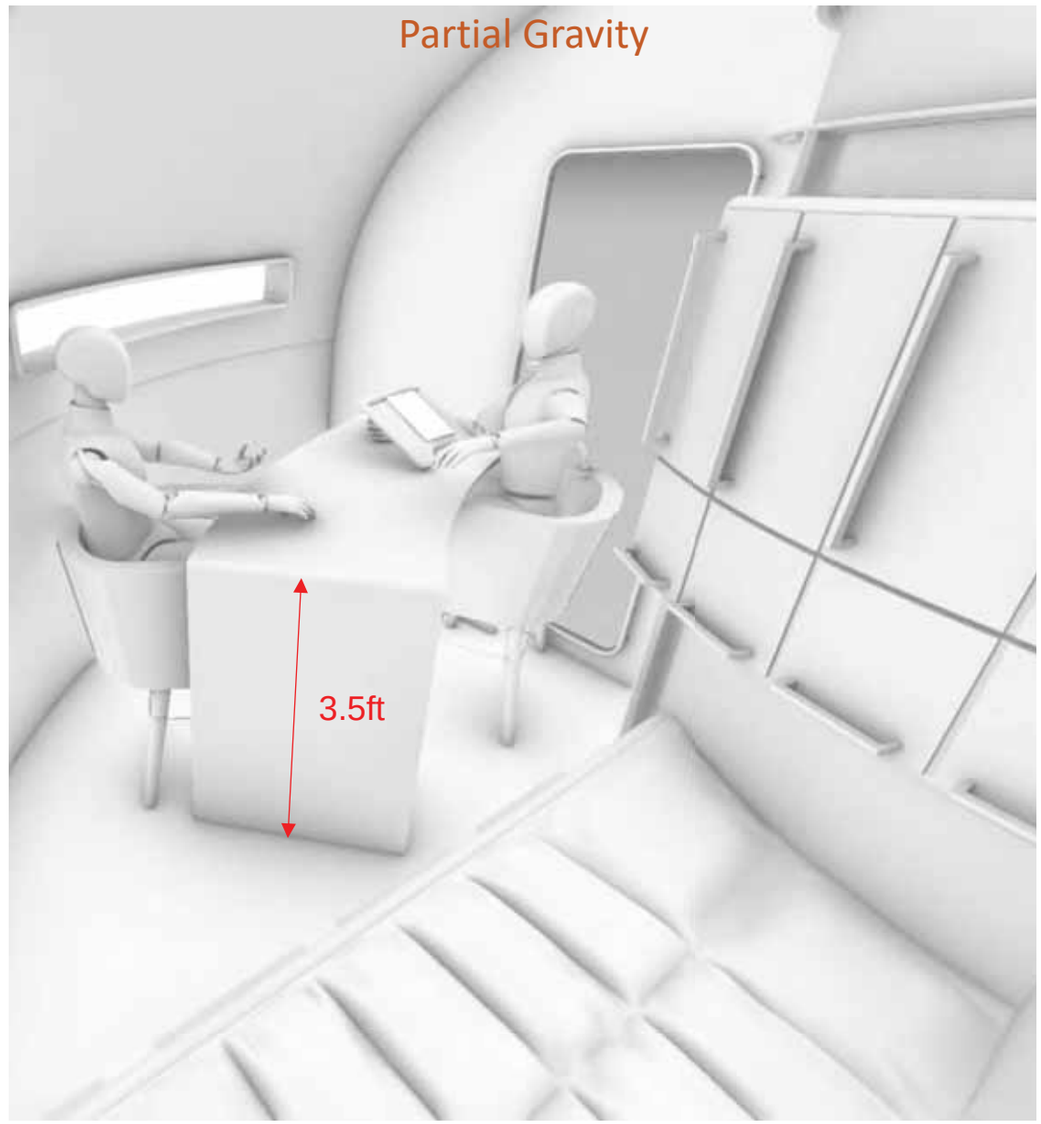
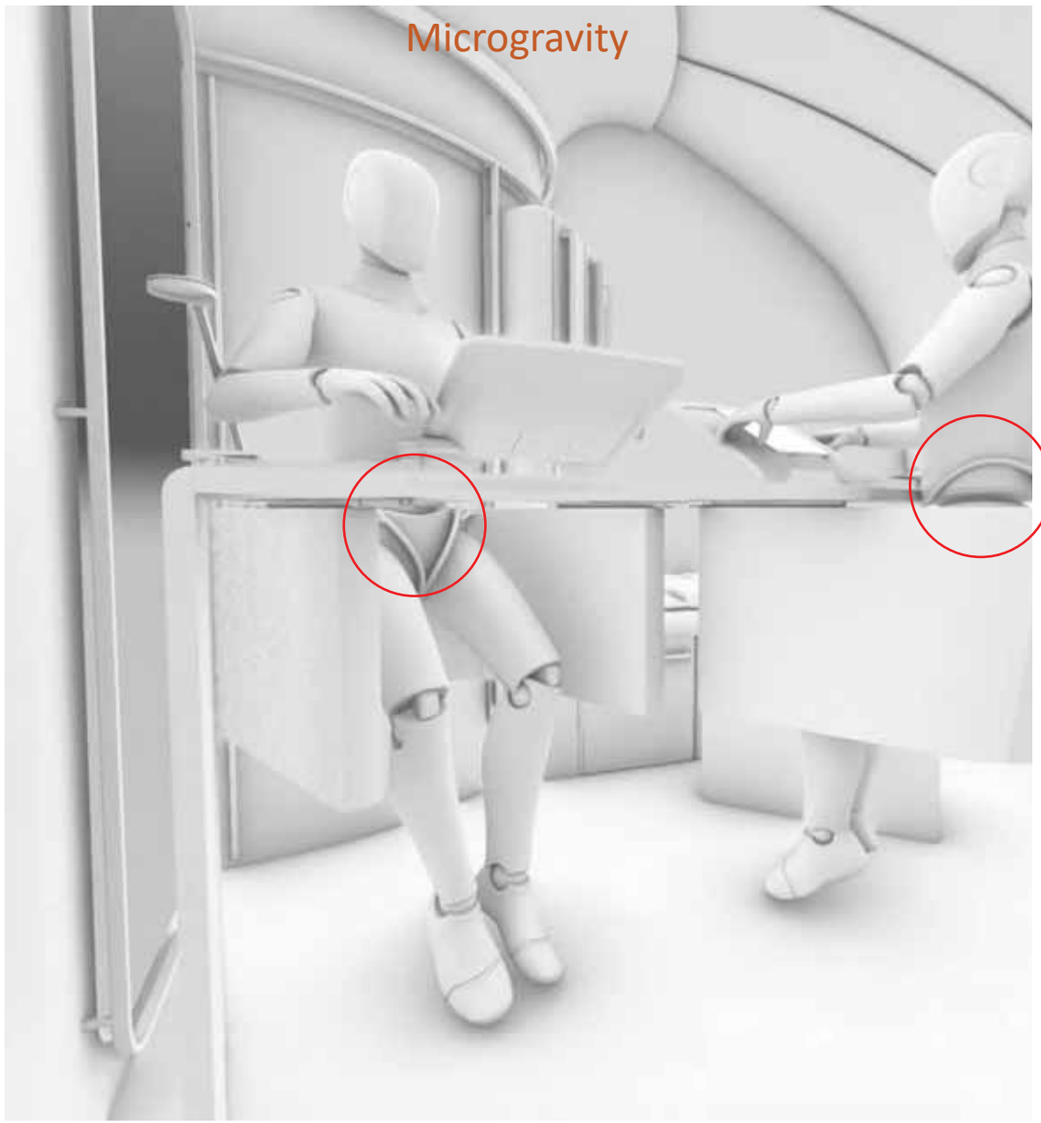


Microgravity



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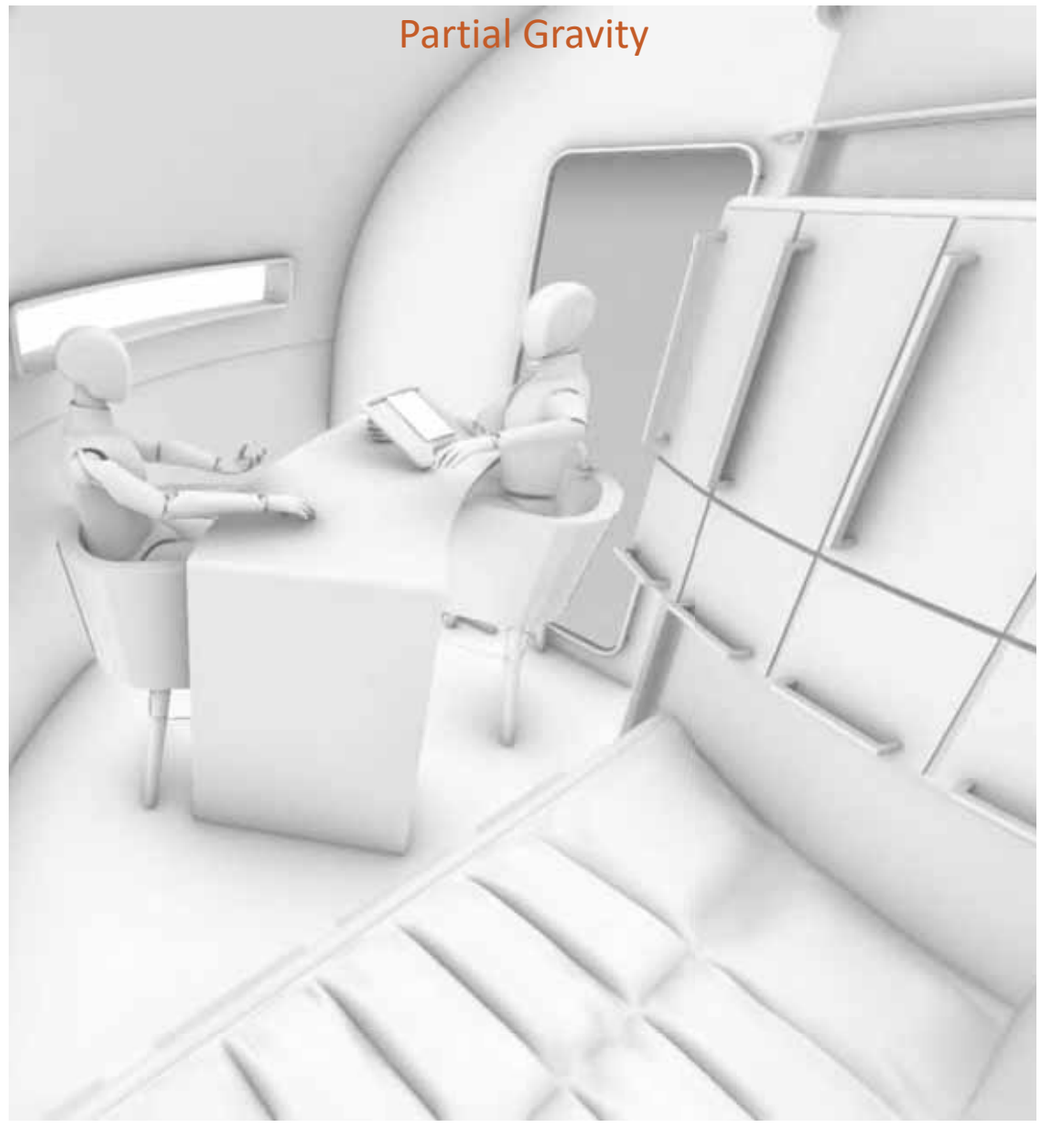

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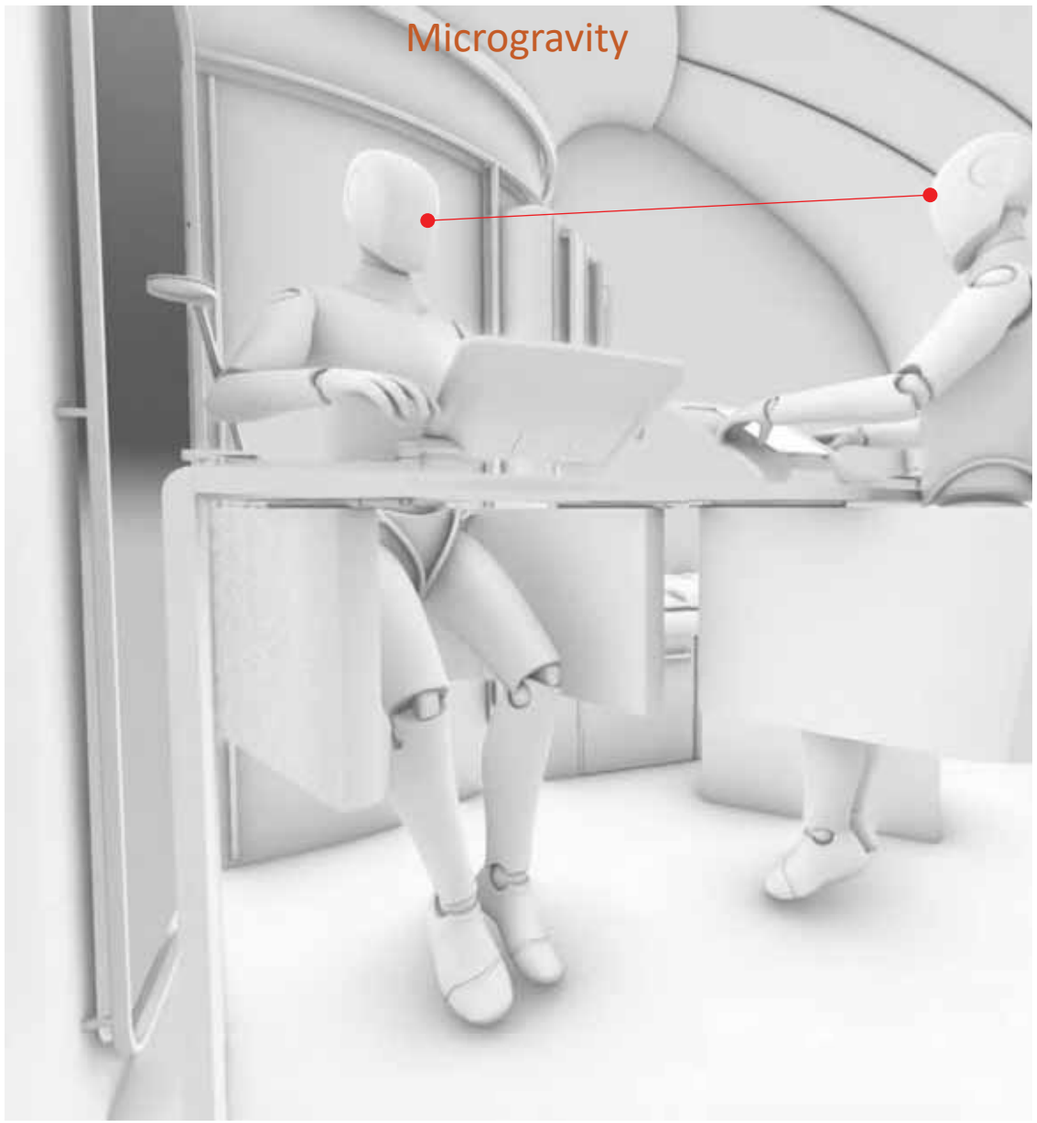

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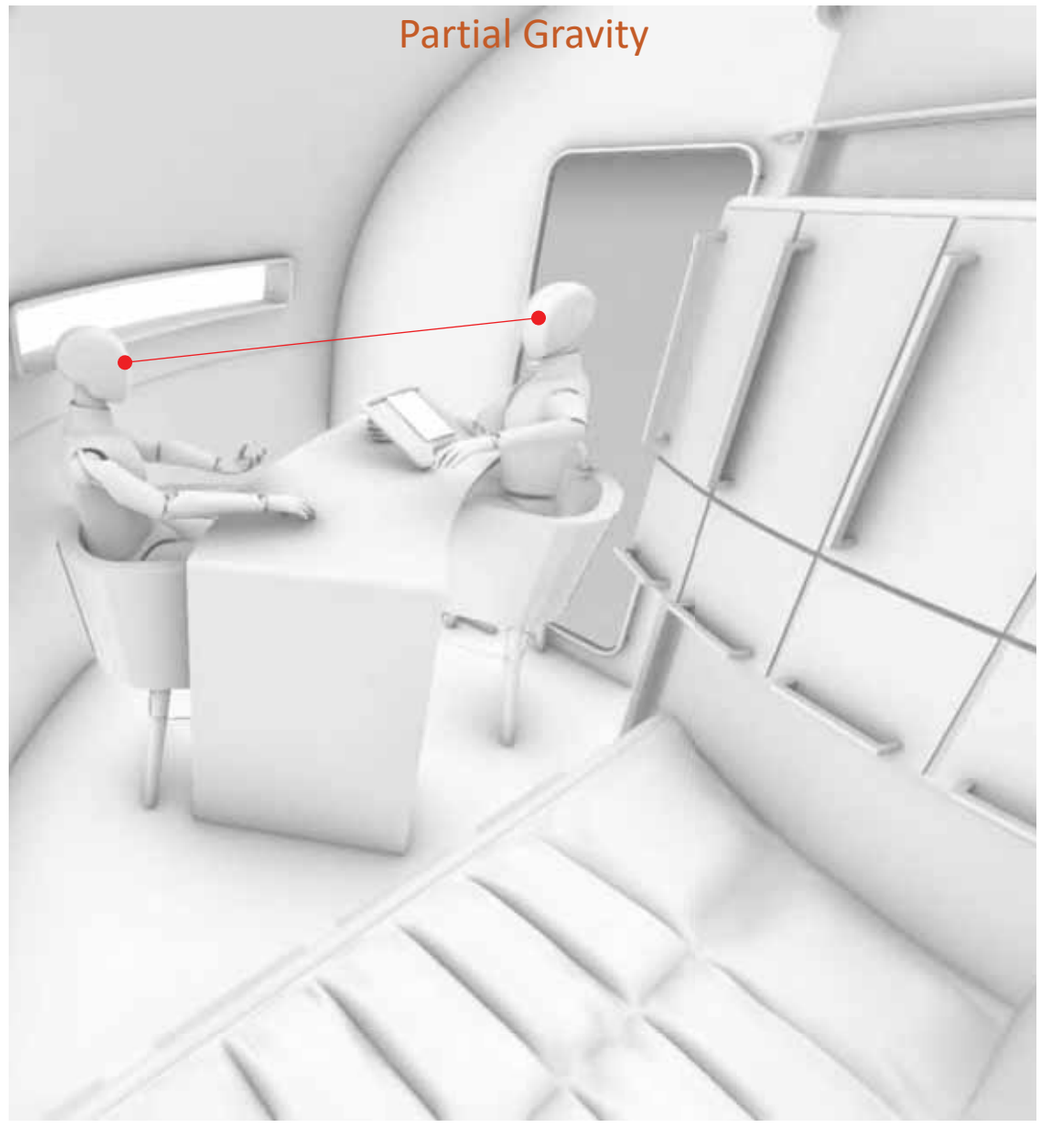

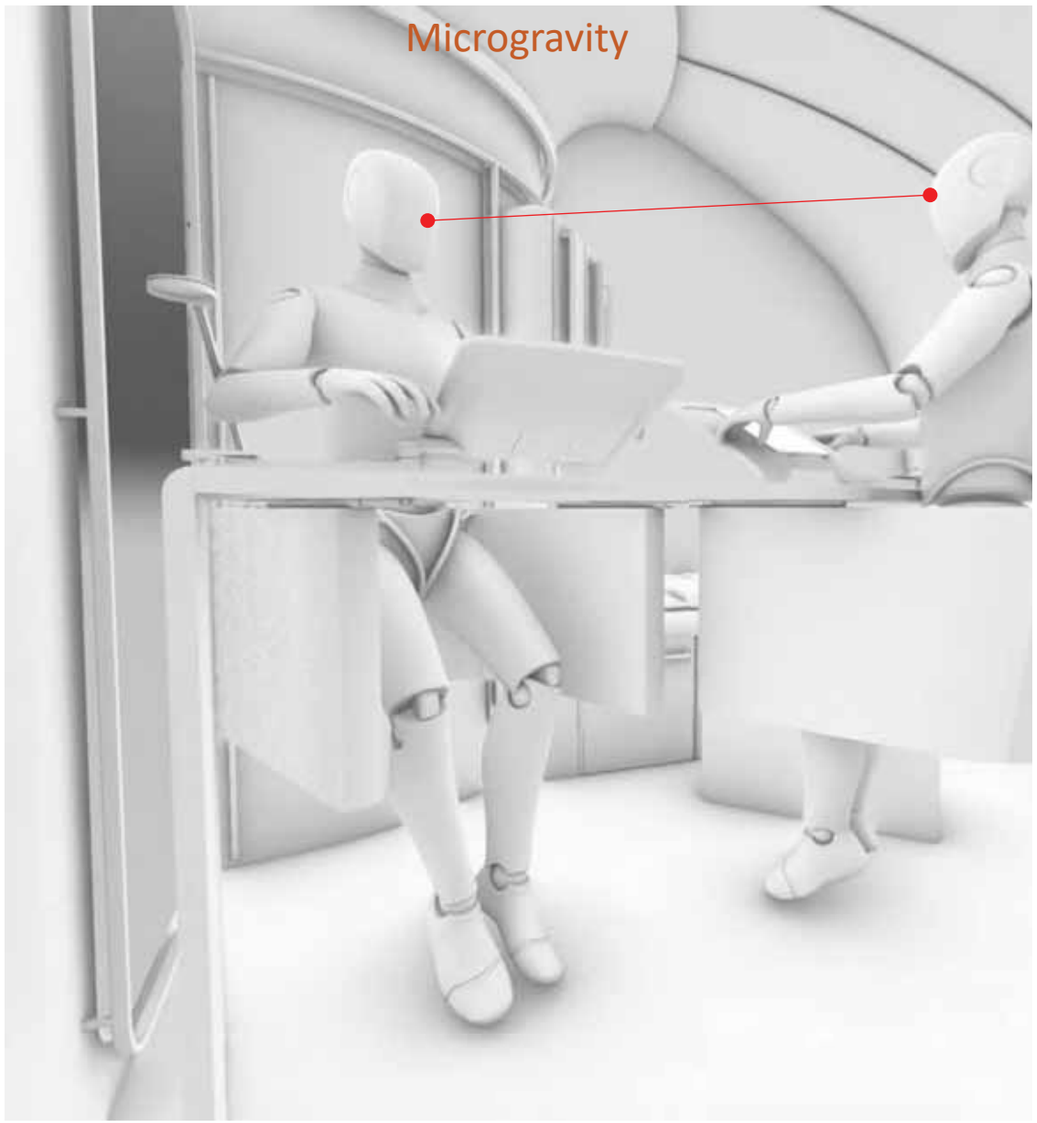

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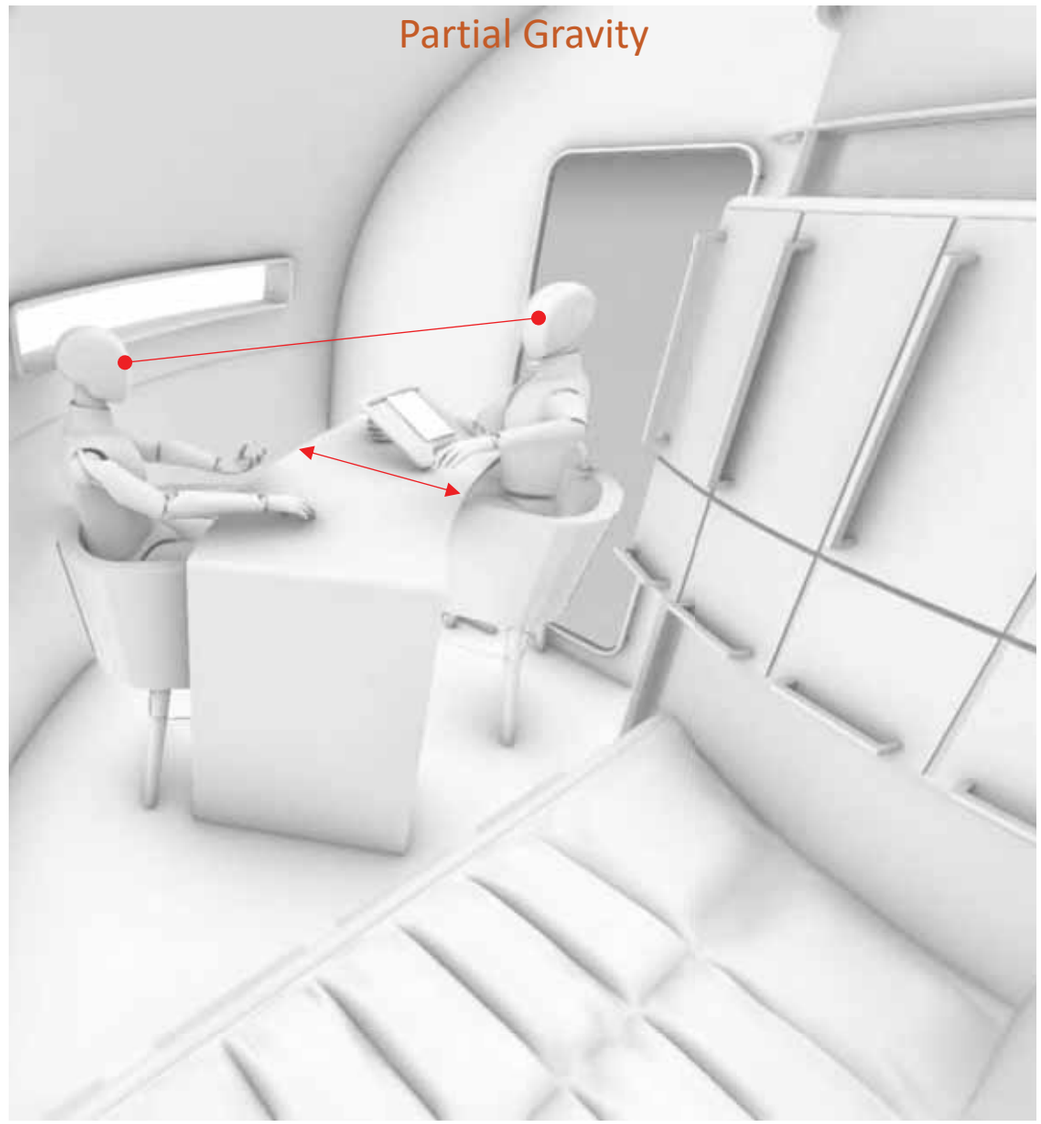
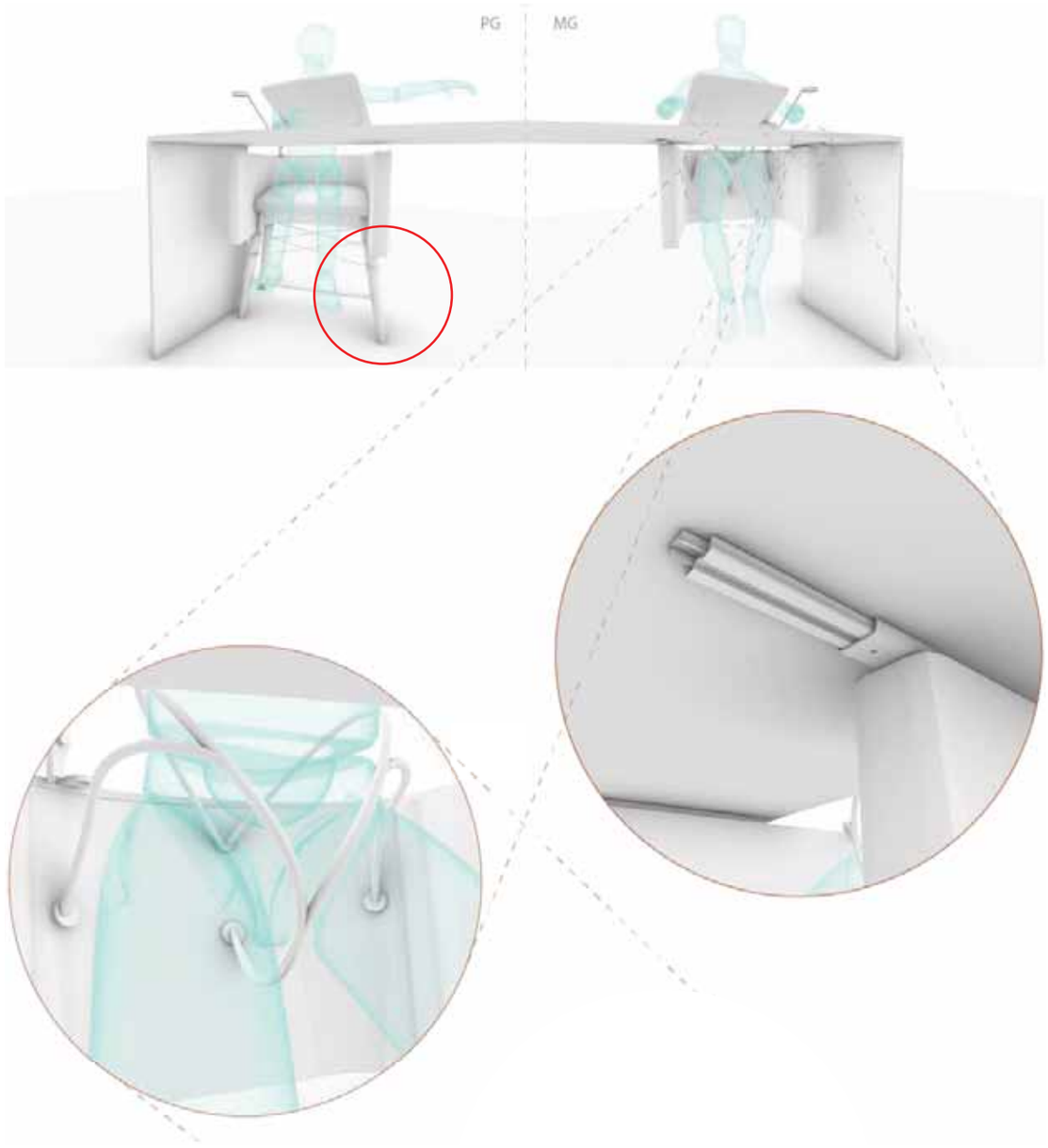
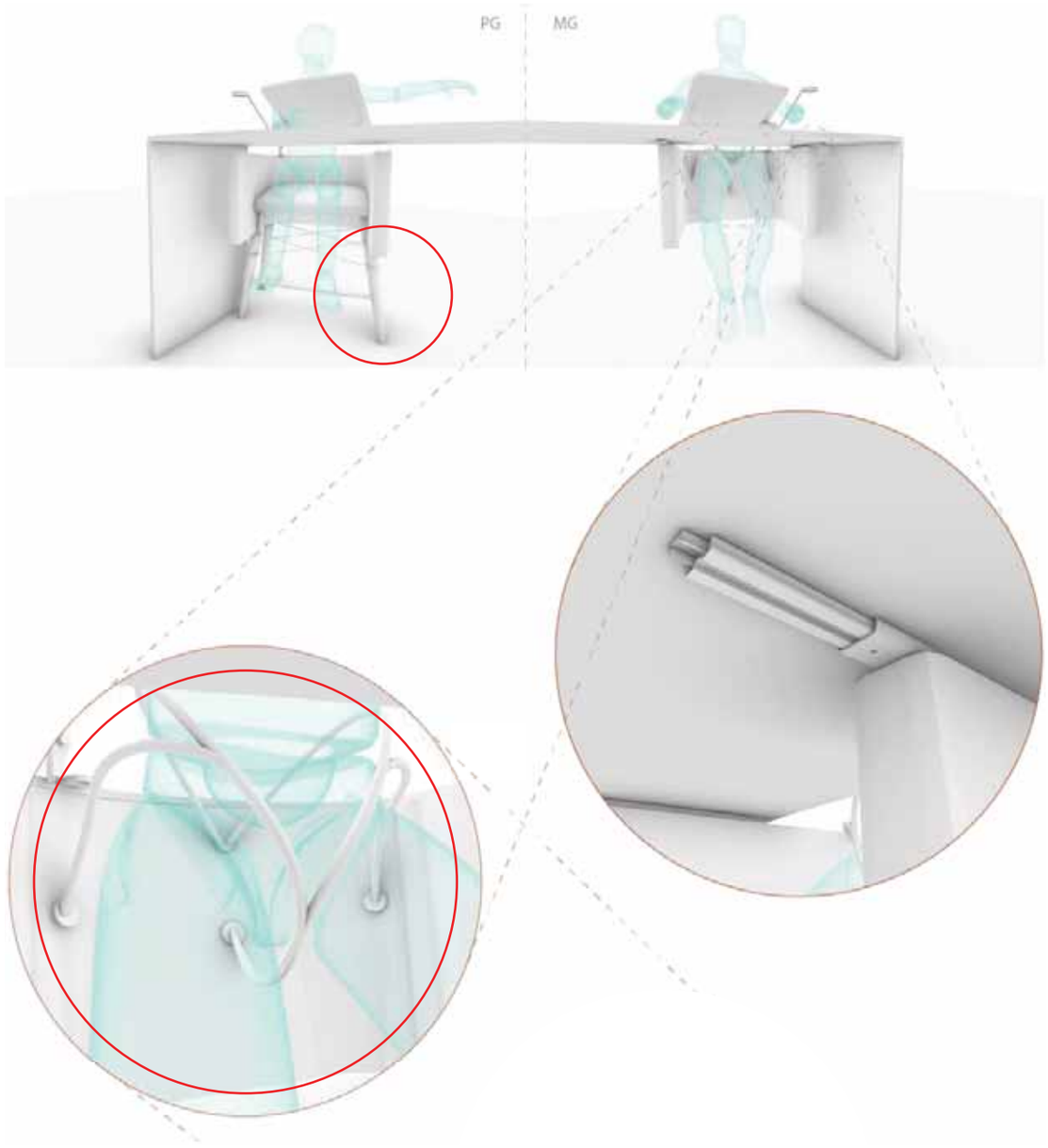
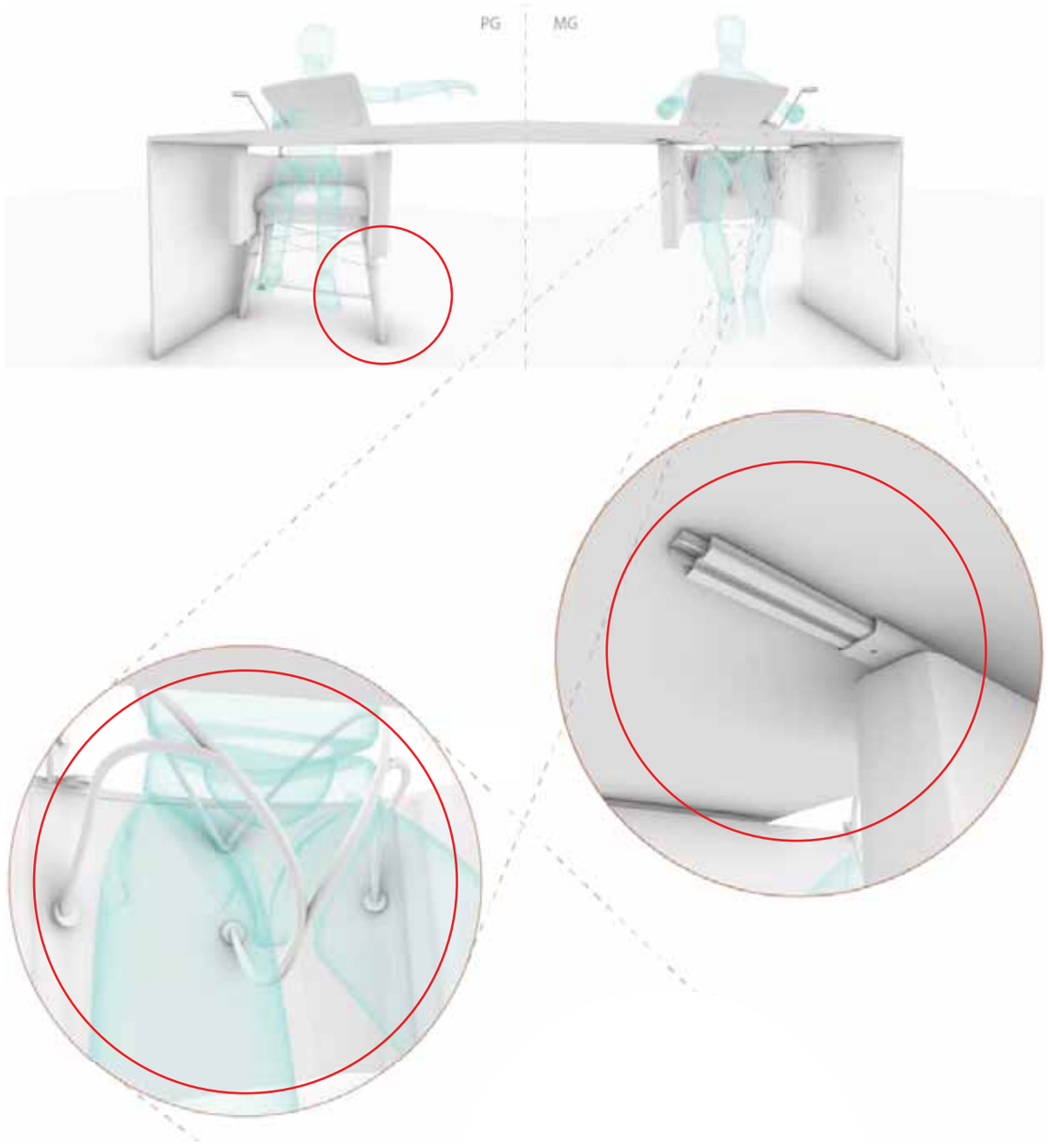
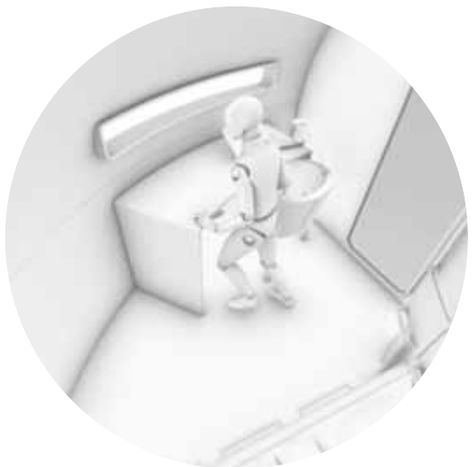


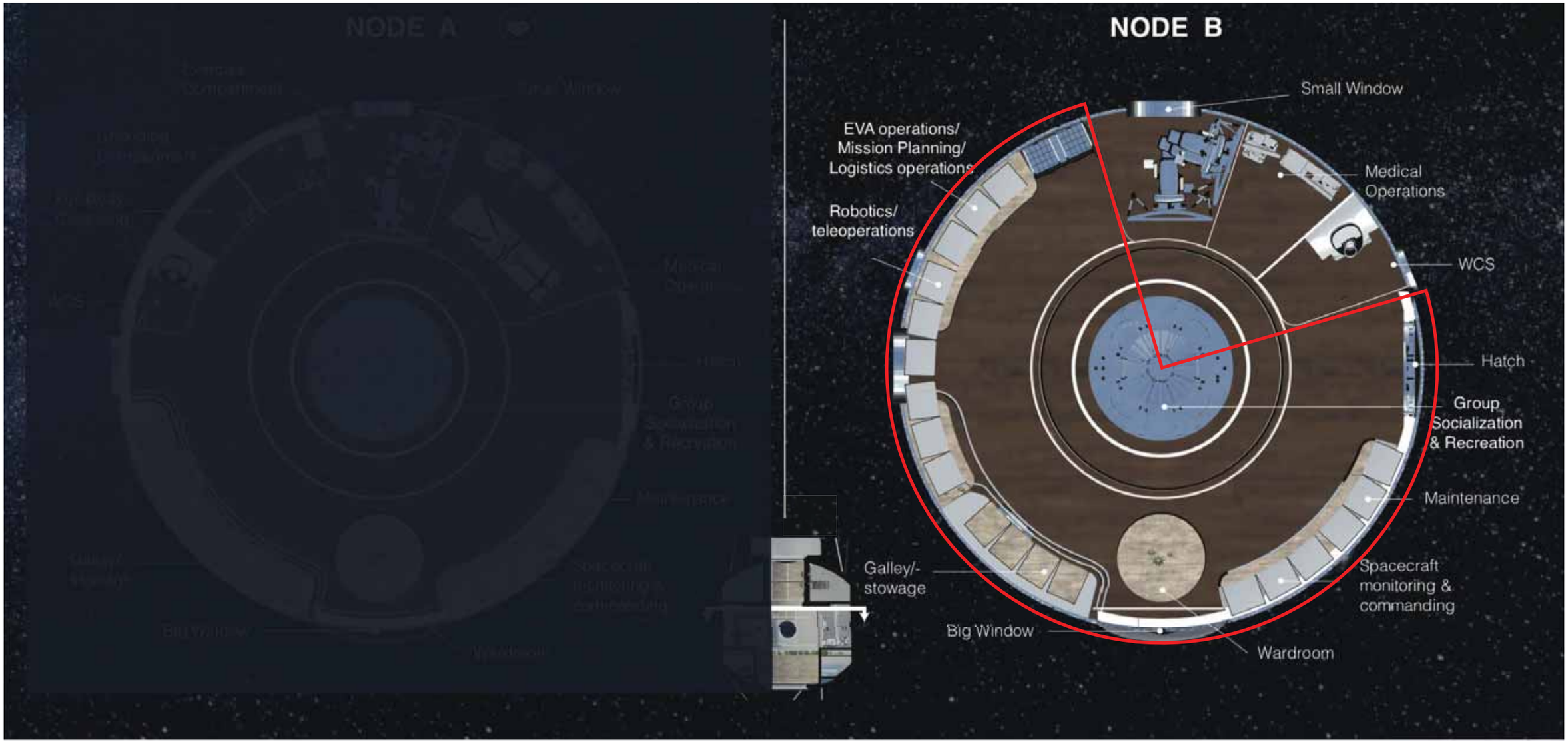

PG
MG


PG
MG


PG
MG




Case-Study Refinement: Galley, Wardroom, Work Areas


NODE B
Small Window
EVA operations/
Mission Planning/
Logistics operations
Medical
Operations
Robotics/
teleoperations
WCS
Hatch
Group
Socialization
& Recreation
Maintenance
Galley/-
stowage
Spacecraft
monitoring &
commanding
Big Window
Wardroom

Galley, Wardroom, Working Area

01 SUBJECT	02 MISSION REQ.	03 WS REQUIREMENT	04 PS REQUIREMENT	05 COMMON REQ.	06 DONE ✓	07 CURRENT STATUS	08 RECOMMENDATIONS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Galley, Wardroom, Working Area

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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible] 	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Galley, Wardroom, Working Area

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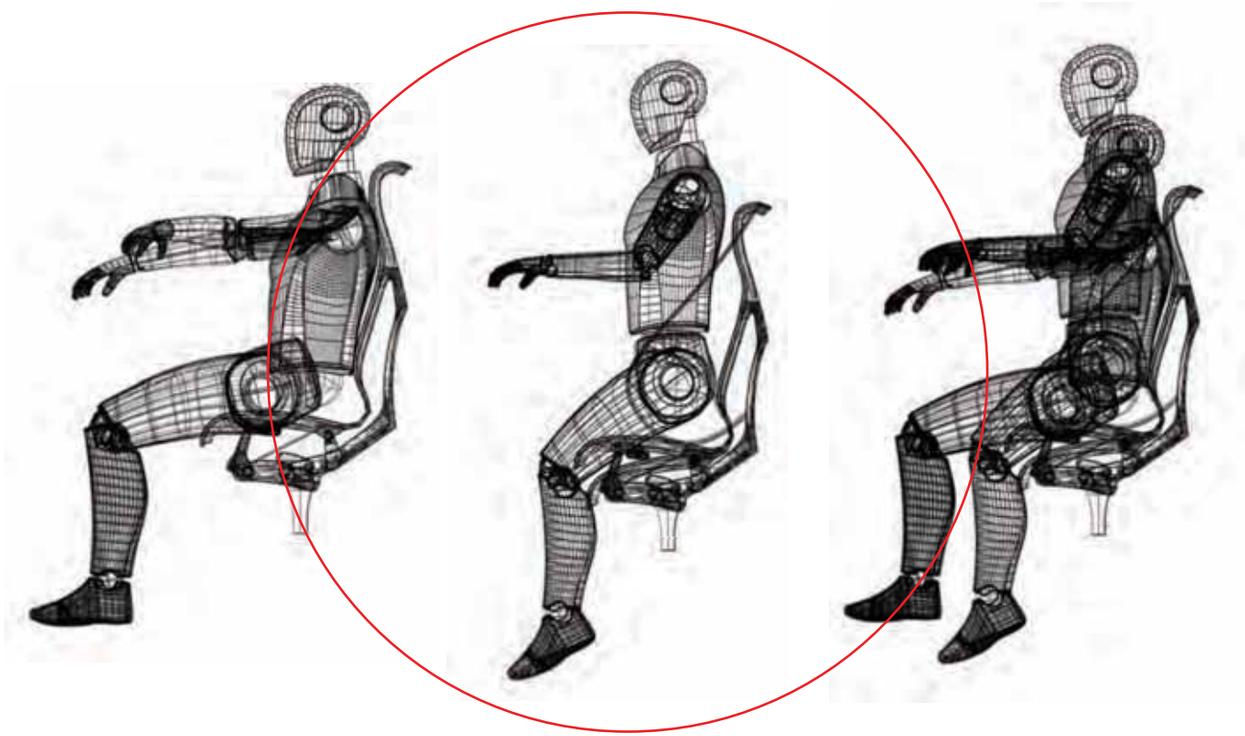
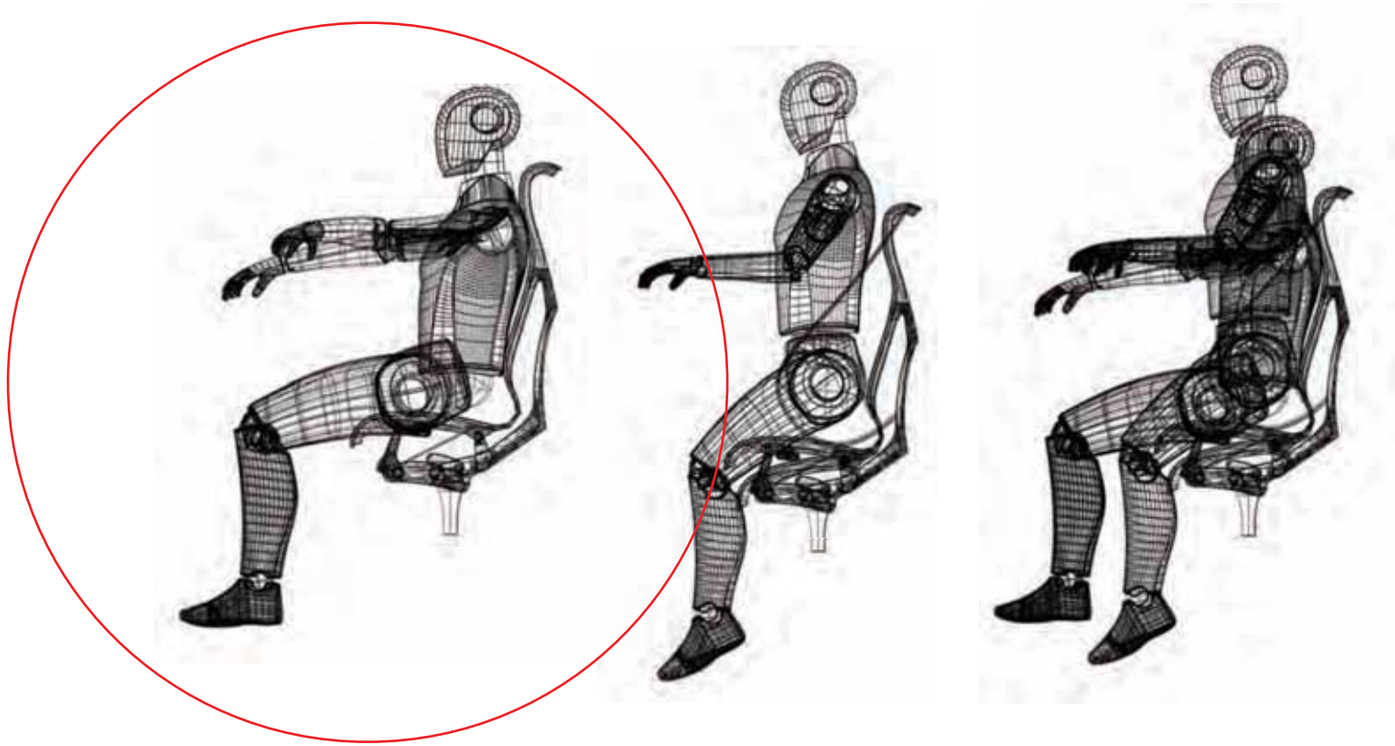
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

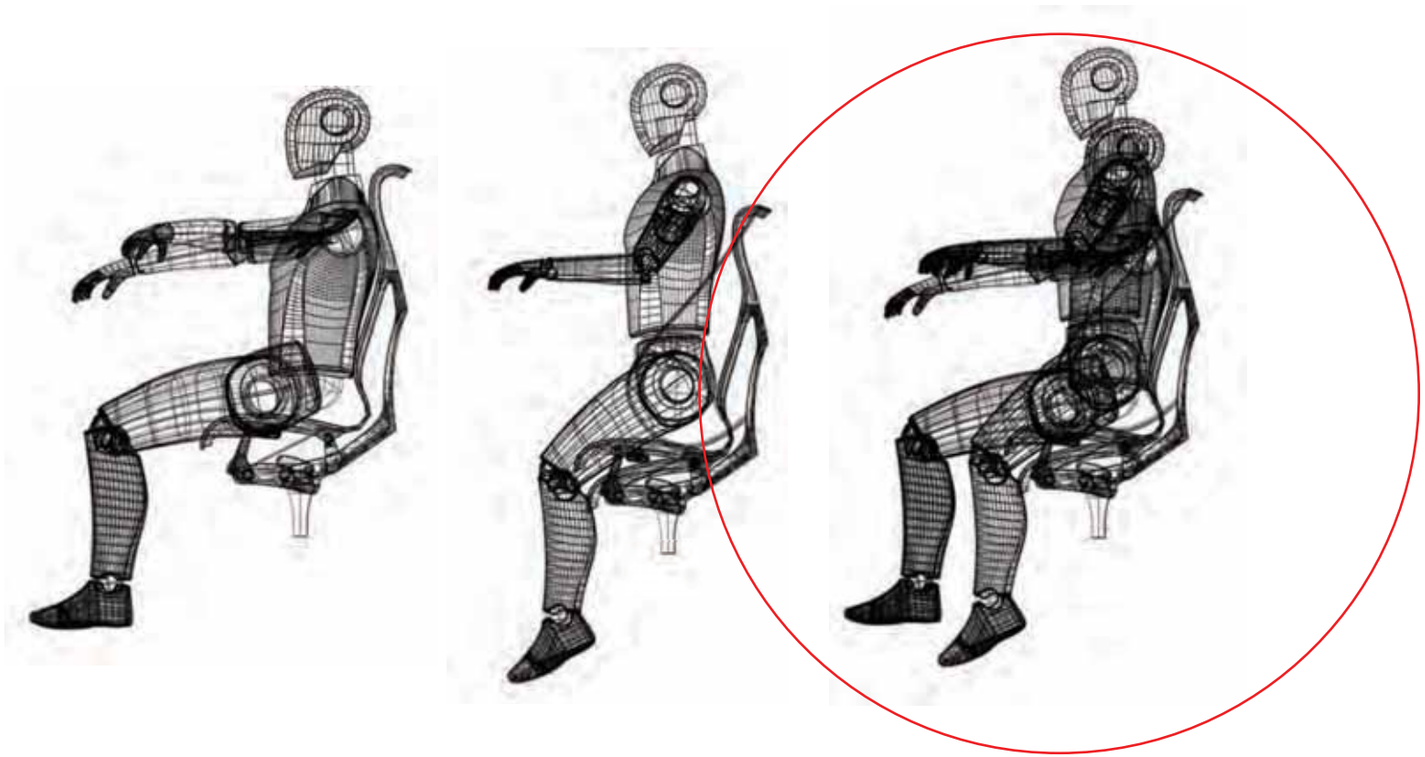
Before

After

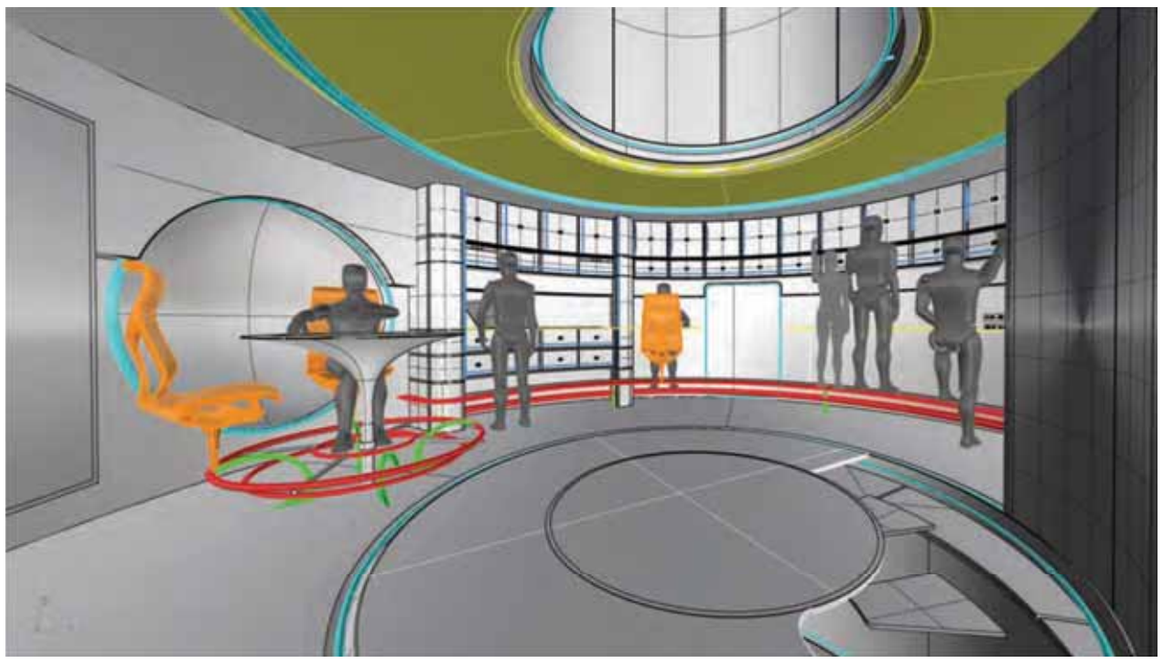

Partial gravity:
Seating and
stowage access
through step
Microgravity:
Body restraint



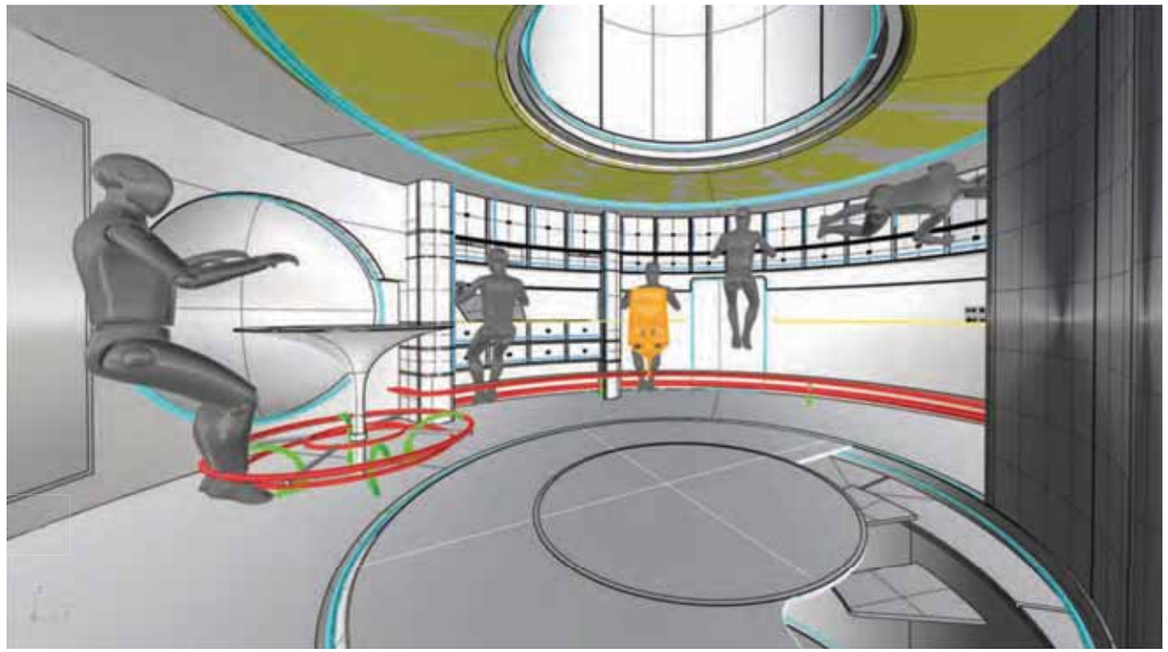




PG



MG



Design

Verification

Testing

Thesis Committee:

NASA:
David Smitherman
[Senior Space Architect - Advanced Concepts Office MSFC]

Dr.Robert Howard
[Habitability Domain Lead, Co-Lead Center for Design & Space Architecture JSC]

University of Houston:
Dr.Olga Bannova, SICSA Director
Larry Bell, SICSA Founder


ADVANCED
CONCEPTS
NASA
THANK YOU.
UNIVERSITY OF HOUSTON
FOUNDED 1927
SICSA