AstroPod

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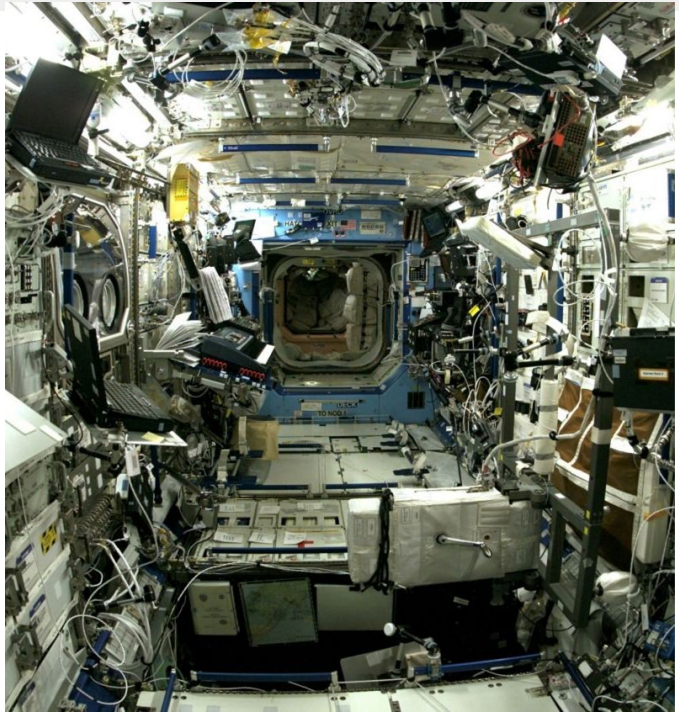
Contents -

- Problem
- Solution
- Design
- Testing
- Material
- Applications
- Milestones

Psychological problems

1. Lack of communication/ isolation
2. Acrophobia / vertigo
3. Stress from internal conflicts
4. Feeling of sustained tumbling / inversion
5. Navigation - push -off force
6. Unpredictability of dynamic reaction of vehicle
7. Eye-hand coordination
8. Inaccurate perception of spatial orientation
9. Post -flight disorientation problems



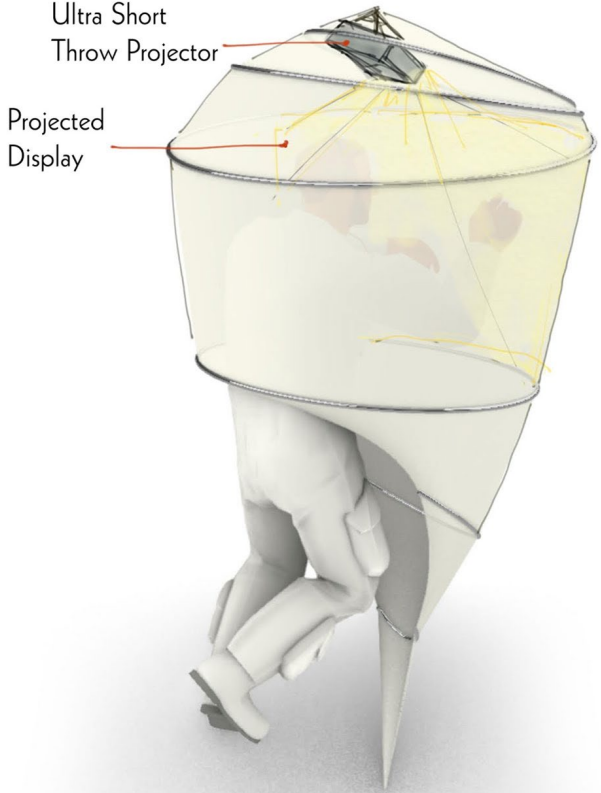
Problem

Psychological Problems In Deep Space Missions

Present Provisions Unavailable

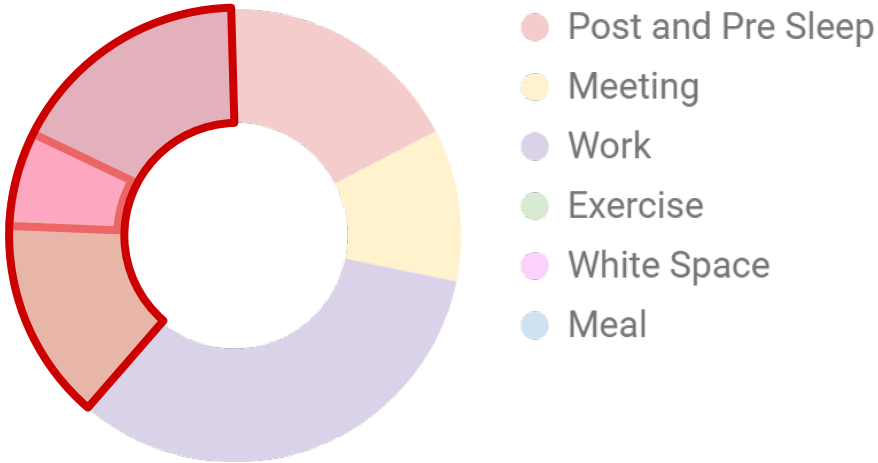
Limitations of VR headsets

Solution



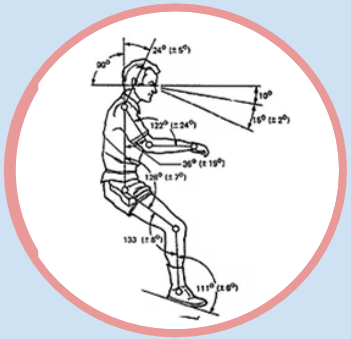
Scope of Functions

	7:00 AM	7:30 AM	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:00 AM	10:30 AM	11:00 AM	11:30 AM	12:00 PM	12:30 PM	1:00 PM	1:30 PM	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM	5:00 PM	5:30 PM	6:00 PM	6:30 PM	7:00 PM	7:30 PM	8:00 PM	8:30 PM	9:00 PM	9:30 PM	10:00 PM	10:30 PM
Post and Pre Sleep																																
Meeting																																
Work																																
Exercise																																
White Space																																
Meal																																



Design

1



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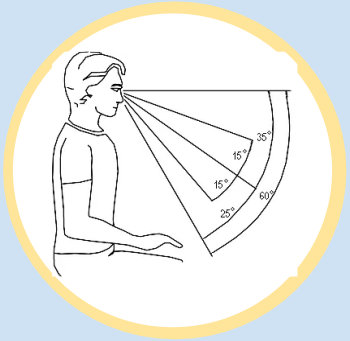

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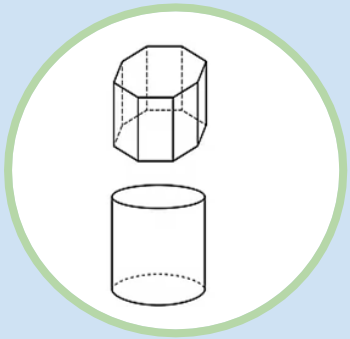

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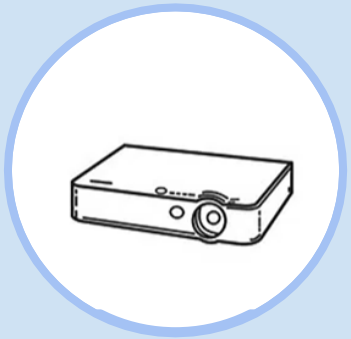

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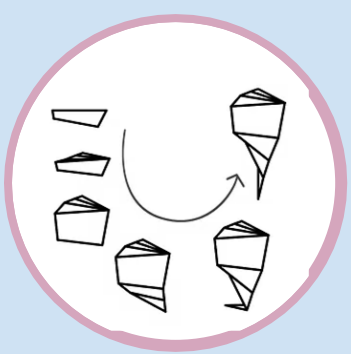
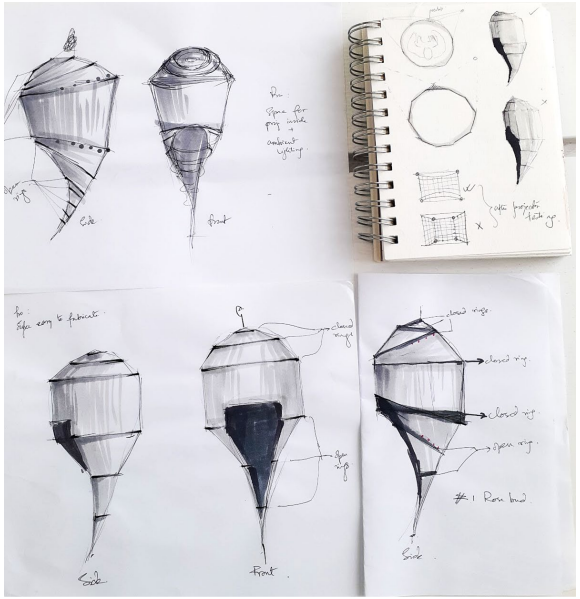
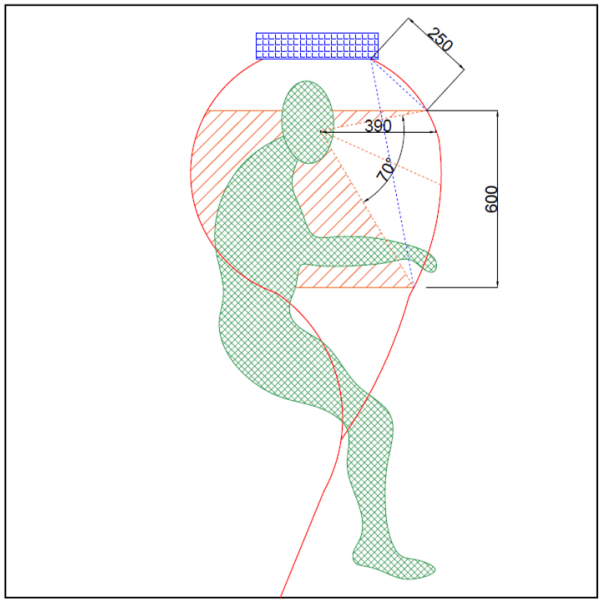
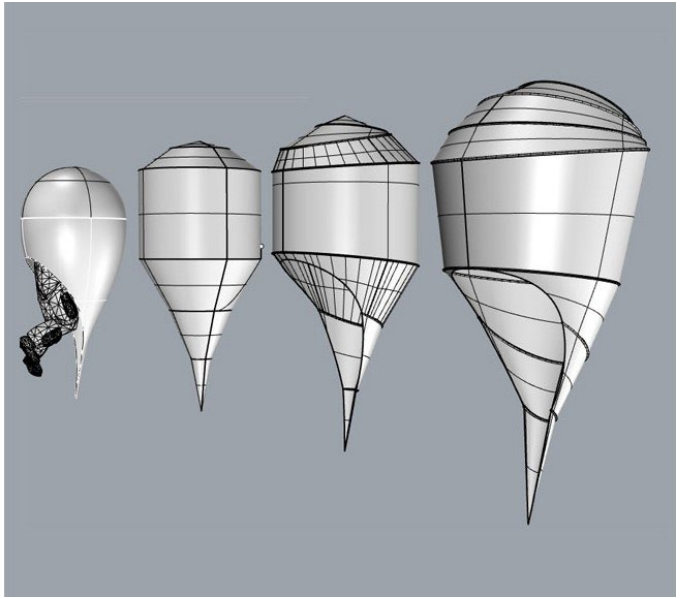


Form Finding

Sketch | AutoCAD | Rhino







Prototyping + Fabrication

Paper models

concept test

geometry test

Fabric Models

geometry test

1:10 scale

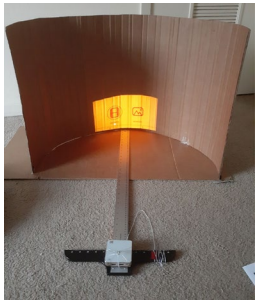
1:4 scale

1:1 scale

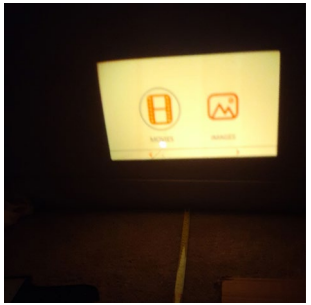
Full -scale

Projector Testing

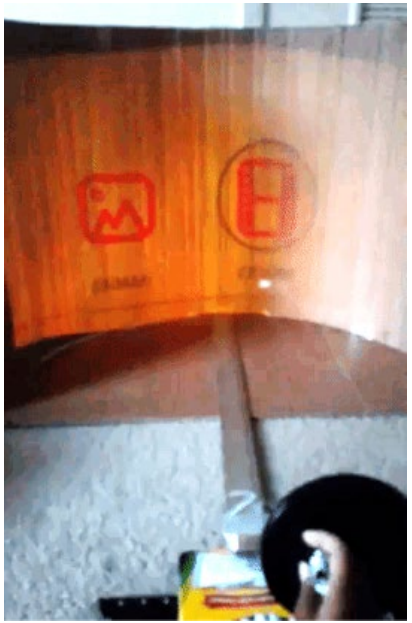
Macro lens

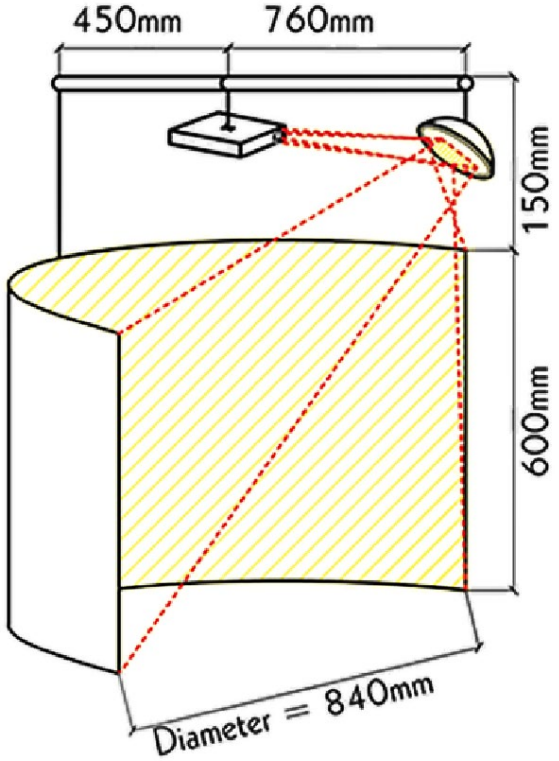


Screen curvatures



Convex mirror



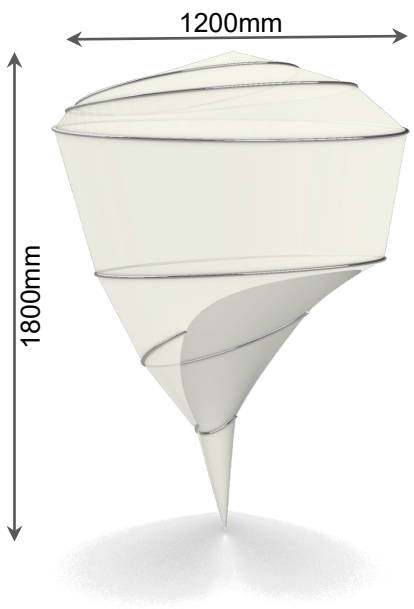


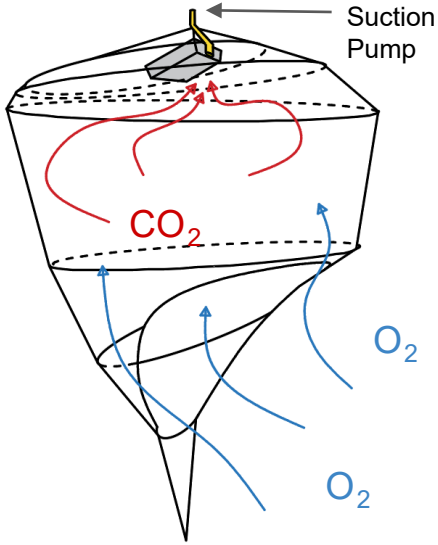
Redesign

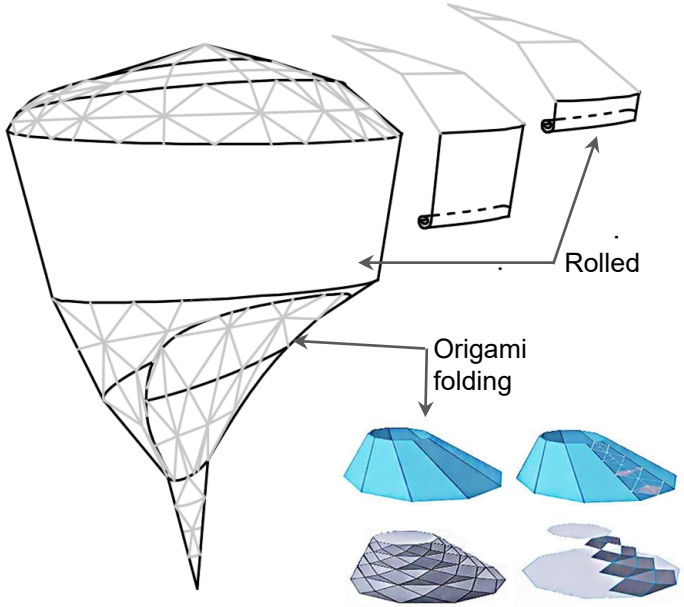
Size

Air Circulation

Deployment





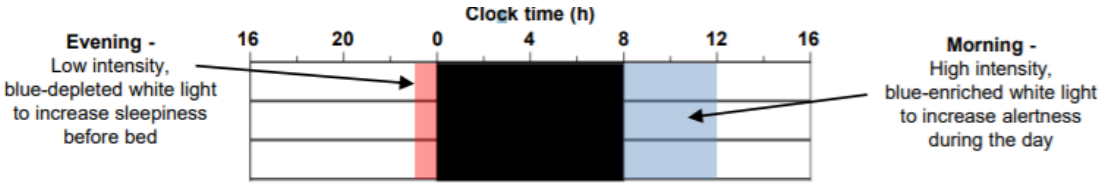


Material

	Visual quality	Flammability	health hazards and toxicity
Durette	creases possible	good	space -rated
Fiberglass	lacks opacity	best	Very toxic
Cotton	Creases possible	not good	none
PBI	no risk yet	good	inhalation, skin contact
Teflon	no risk yet	very good	none
Nomex webbing	weaving can be risk	not good	low off gassing
Kevlar	weaving can be risk	not good	low off gassing
Carbon	black color	good	none

Lighting Guidelines

- Circadian rhythm
- Orientation
- Illumination levels of functions
- Effect of exterior light
- Emergency lighting and protocol
- Provision for dimming
- Glare prevention
- Total amount of light falling on crews' eyes
    - Direction of light sources
    - viewing angle
    - graphics design of display

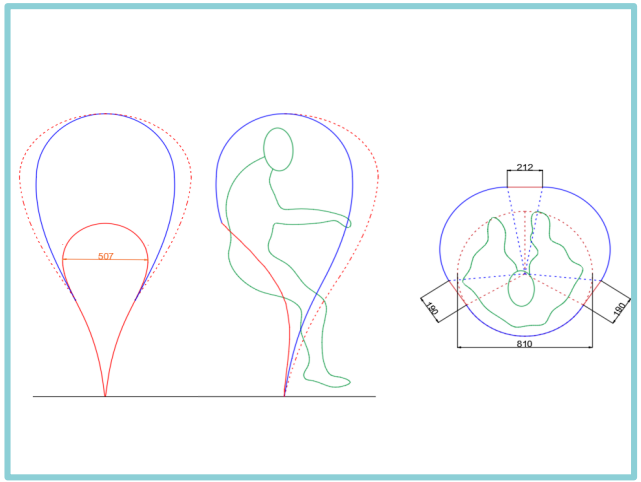


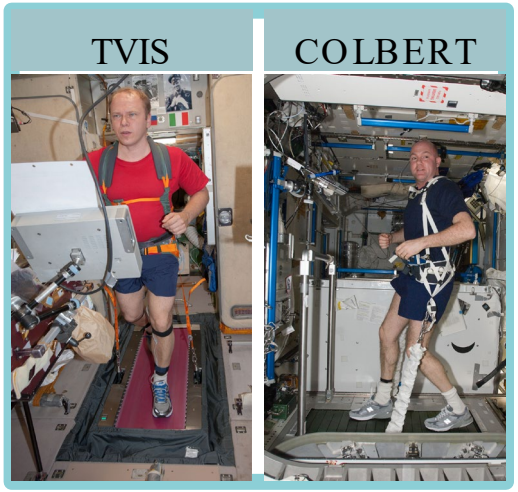
Multi -sensory Applications

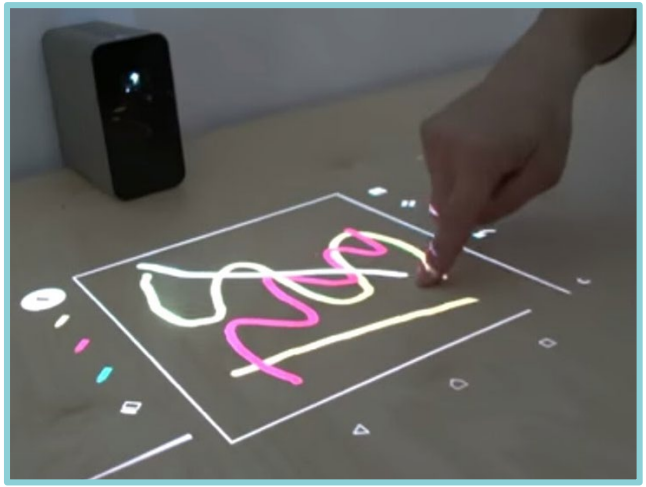
Spatial

Tactile

Kinesthetic







Terrestrial Applications

- Hospitals
- Crowded communal living solutions
- Wheelchair users' recreation
- Hotels and luxury resorts
- Test in an analog mission

Considerations for ISS Integration

- Airflow systems integration
- Power usage
- Specific constraints with each location on the ISS
- Synchronization with ambient lighting
- Waist restraint for gravity

Possible Locations for ISS Integration

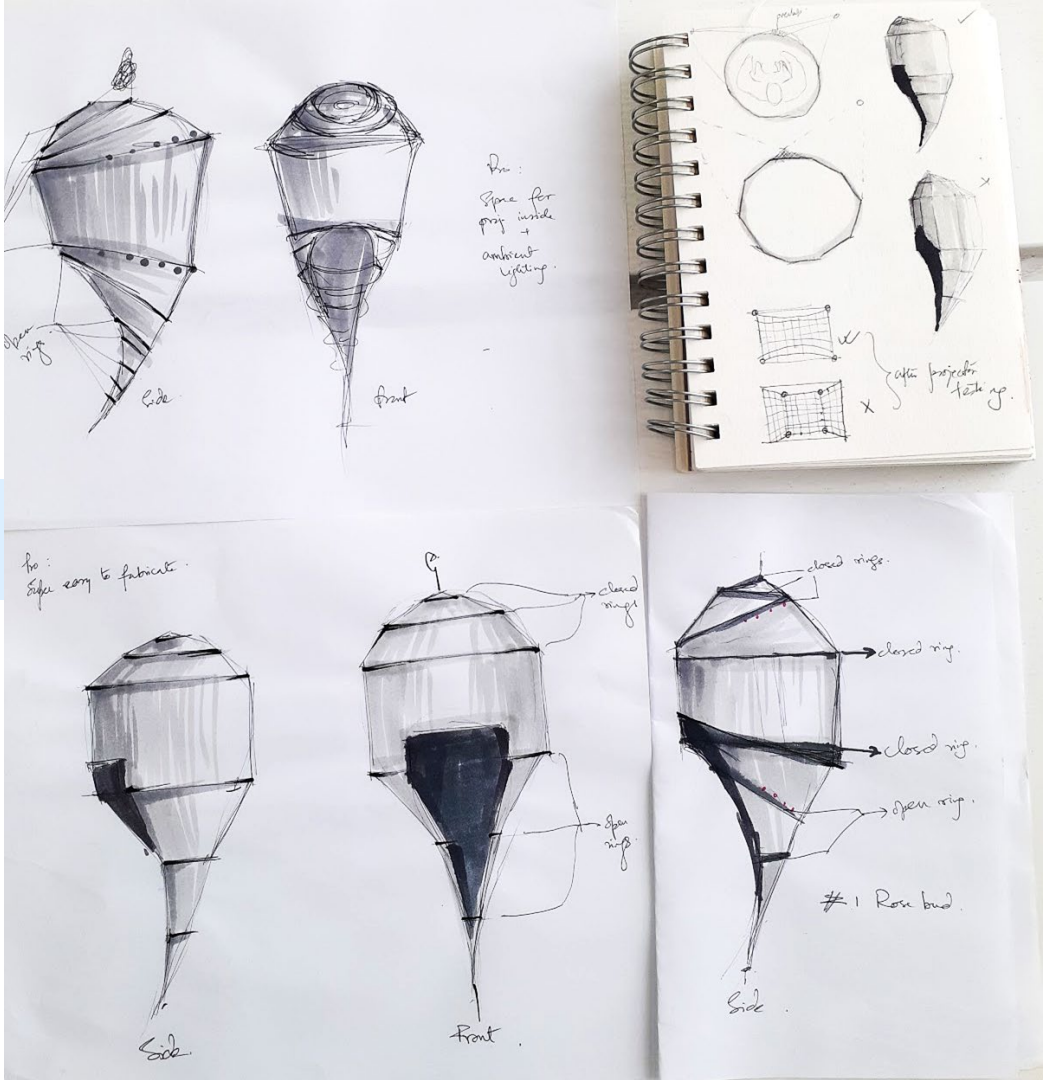
No.	Application	Module	Pros.	Cons.
1	Pre-post sleep	Harmony	• functions more predictable, easily controlled • **use of smell** maybe possible	• Can only be **individual** based • Tested for **short period** of day
2	Hygiene/ Exercise	Tranquility	• combining psychological health with **physical health** • **use of smell** maybe possible	• low scope of multi-purpose application
3	Workspace	Destiny	• has CEVIS fitness equipment, hence multi-use of vr	-
		Columbus	• has MARES fitness equipment, garden, metal alloy research	• mostly medical equipment, plus very crowded
		Kibo	• Multiplicity of functions	-
		Zvezda	• galley, workstation, space toilet	• crowded
4	Meal	Unity	• **social use** of virtual reality, entertainment centric • combination of **taste sensory** experience as well	• too socially active for psychological impact testing

Milestones

2019								2020		2021	2024	2026	2034
May	Jun	Jul	Aug	Sep	Oct	Nov	Dec						
Research	Design	Prototyping		Testing		Re-Design		Fabrication	Analog	Analog	ISS	Gateway	DST
TRL 1		TRL 2				TRL 3		TRL 4	TRL 5	TRL 6	TRL 7	TRL 8	TRL 9

Materials	1000$
Projector	2300$
Makerspace	600$

Questions?


Pro:
Space for proj inside + ambient lighting.
open rings
Side
Front
Pro:
Edges easy to fabricate
closed rings
open rings
Side
Front
closed rings
closed ring
closed ring
open ring
#1 Rose bud
Side

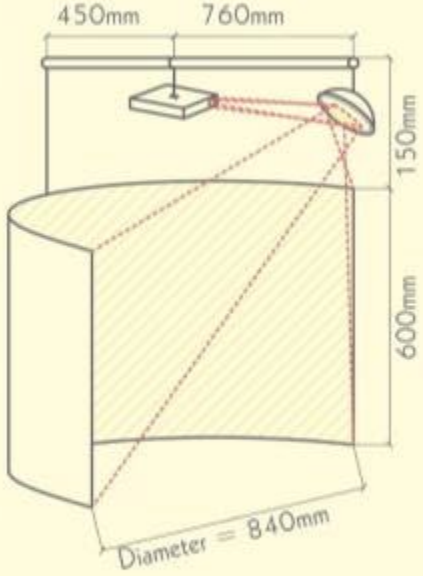
Backup Slides

Proof of Concept

Paper Models

Fabric Models

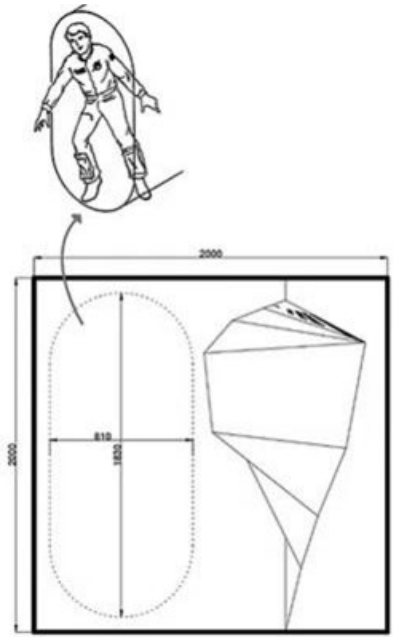
Full-scale Models



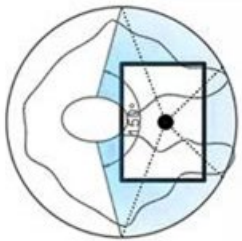
Projector Testing

Subsystems

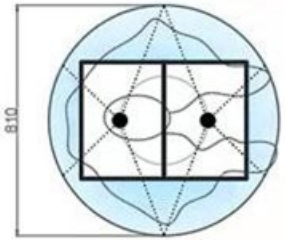
Emergency Egress



Energy Efficiency



150 degree



360 degree

Mediated Atmospheres in Space

COMPARISON OF OVERALL MIXED REALITY (MR) SYSTEMS

	CAVE					HMD					
	visbox	**Cornea**	**NexCAVE**	**StarCAVE**	**dVision**	**HoloLens**	**Oculus Rift**	**Occulus Go**	**Google Cardboard**	**Samsung VR Gear**	**Valve's Steam**
Heat Generated	CAVE VR needs intense air exchange every 15 mins					Passively cooled (no fans)	cooling fan	Poor ventilation	Poor ventilation	cooling fan	passively cooled
Subsystems involved	screens, elaborate projectors, mirrors and supporting structure	Elaborate Sound System, PC, Microphone, Transmitter, receiver	10 to 21 LCD panels, supporting frame, PC + graphics card	Screens, projectors, surround sound system	Screen, projectors, surround sound system	charger, cable, nose pads	joystick, no external sensor required	Joystick	none	Joystick	gaming controller
Resolution	~2-24 Mpixels per screen	16-Megapixel/screen , ~90-Megapixels/eye	10 LCD panels , 10,000 x 1,500 pixels per eye	~68 million pixels per user / ~34 million pixels per eye	from 1024 x 768 to over 4096 x 2048	1268 by 720 per eye	~1 Mpixel per eye	1280×1440 per eye	variable	2160 by 2160 pixels per eye	> 1080×1200 per eye
field of view	170 degrees	170 degrees	140 degree	360 degree	120 degree (H), 40 degree (V)	-	110 degrees	101 degree	-	101 degree	-
Spare cost	much higher than HMD					3,000$	low	200$	15$	129$	-
users	Multi-user	Multi-user	Single	Multi-user	Multi-user	single user	single user	single user	single user	single user	single user
Projectors	yes	yes	no	yes	yes	no	no	no	no	no	no

Pros

Cons

Pre-Design Research

- Psychological problems
- Why VR pod in ISS
- Lighting systems on ISS

Psychological problems

1. Lack of communication/ **isolation**
2. **Acrophobia** / vertigo
3. **Stress** from internal conflicts
4. Feeling of sustained tumbling / **inversion**
5. **Navigation** - push-off force
6. **Unpredictability** of dynamic reaction of vehicle
7. **Eye-hand coordination**
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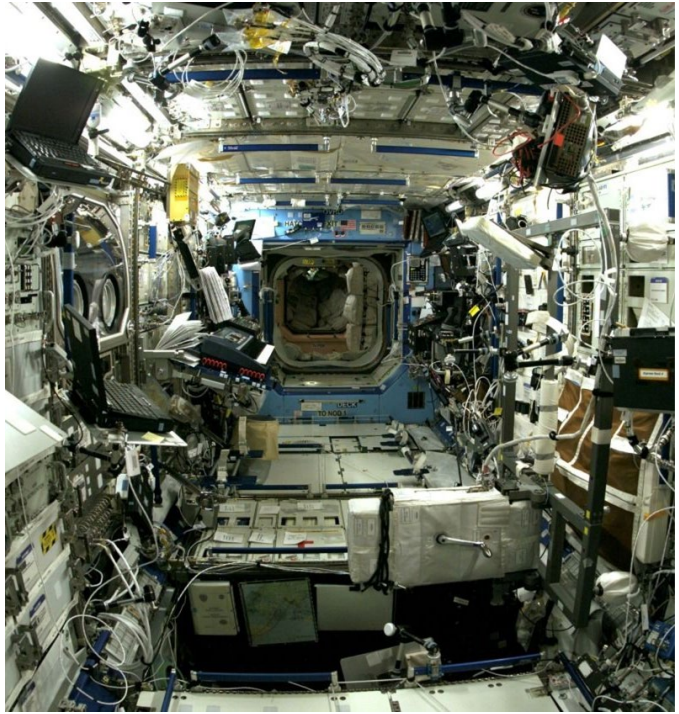


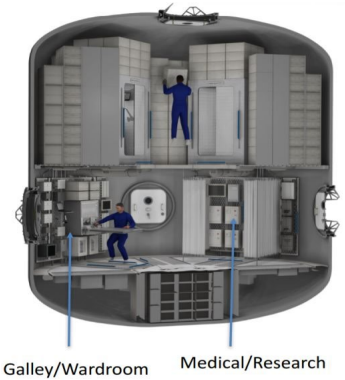
Why test VR Pod in ISS?

- Easy deployability
- Can be integrated with multiple functions
- Fully immersive with minimum intrusion
- Can be tested with more accuracy

Earth Analogs

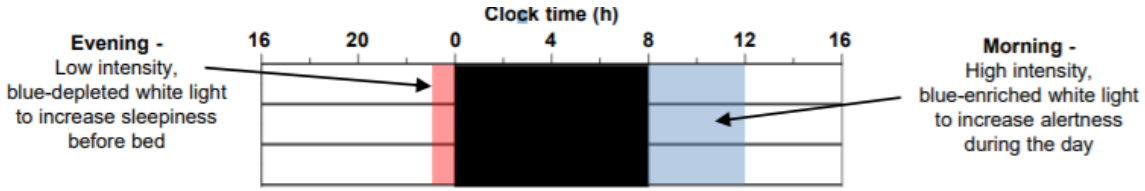
ISS

NASA DST



Design Guidelines for AstroPod Projections

- Circadian rhythm
- Holistic effect
- Lighting intensity and color
- Orientation
- Vibrations during acceleration
- Total amount of light falling on crews' eyes
  - Direction of light sources
  - viewing angle
  - graphics design of display
- Lighting schedule



Design Guidelines for AstroPod Projections

- Illumination levels of functions
- Effect of exterior light
- Emergency lighting and protocol
- Lighting controls
- Provision for dimming
- Glare prevention
- No mercury lamps
- Power usage
- Automation
- Brightness ratios

Possible Locations on ISS

No.	Application	Module	Pros.	Cons.
1	Pre-post sleep	Harmony	• functions more predictable, easily controlled • **use of smell** maybe possible	• Can only be **individual** based • Tested for **short period** of day
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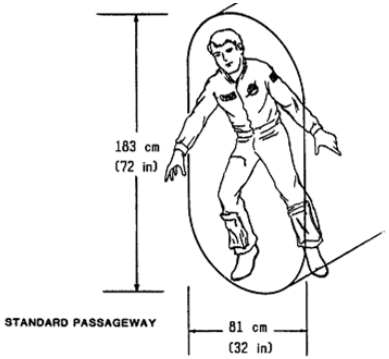
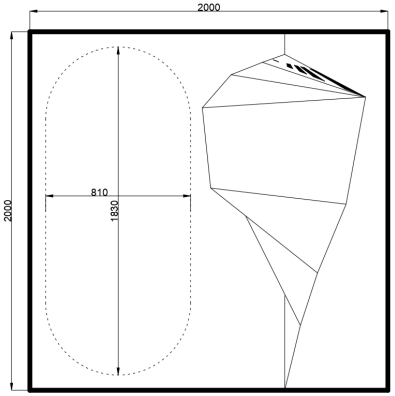
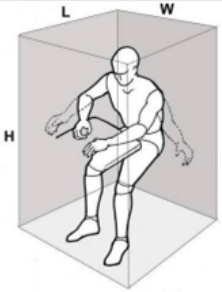
Considerations for integration with the ISS

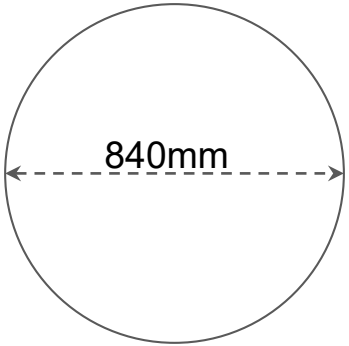
- Off-gassing of material
- Airflow systems
- Power usage
- Detailed mechanism for deployment
- Specific constraints with each location on the ISS
- Synchronization with ambient lighting
- Opaque pod
- Waist restraint for gravity
- Tactile senses
- Spatial senses

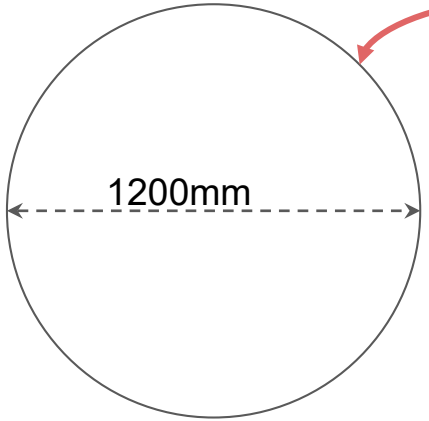
Size

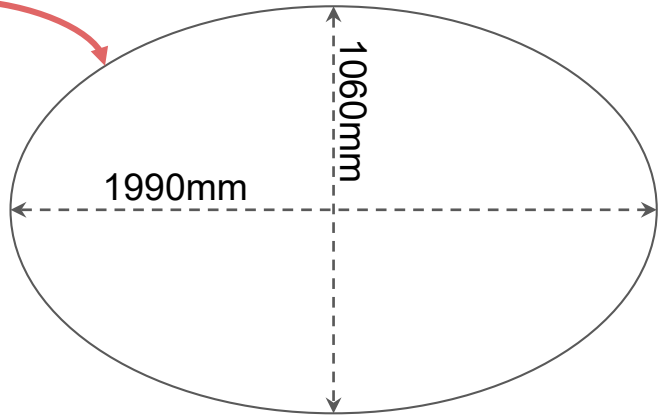




Figures of Human Body Postures and Volumes	Applicable Functions	Dimensions (m)		Volume (m^3)
	General workstations, food preparation, partial body cleaning, housekeeping	H	2.06	**4.34**
		L	1.06	
		W	1.99	

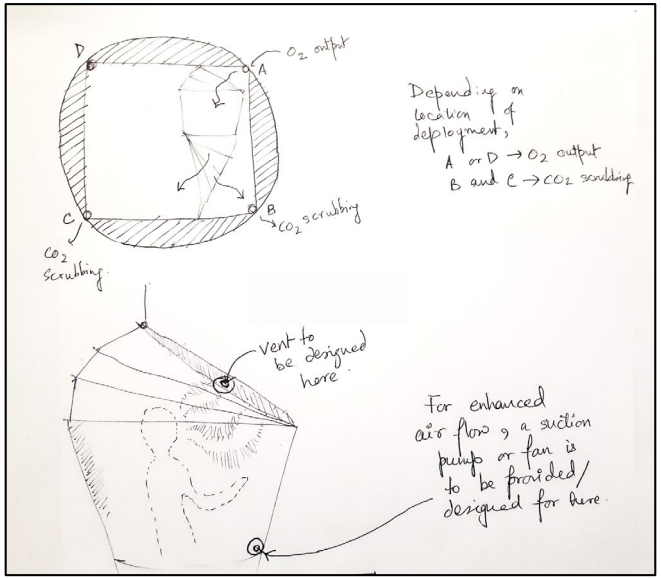






dampening

Air circulation system



Coping with vibrations

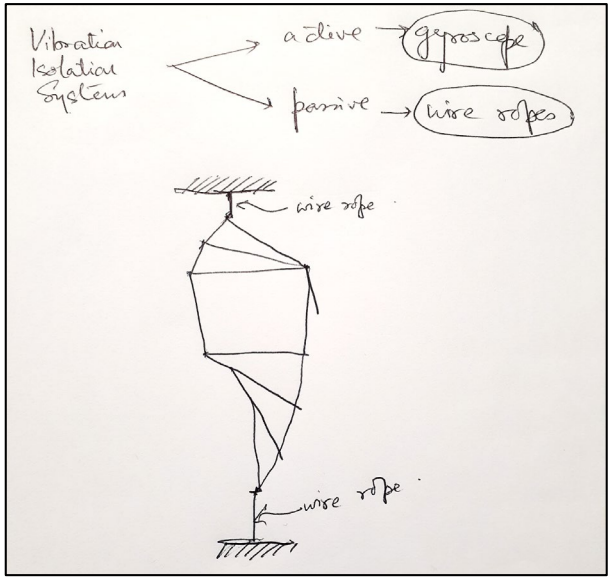


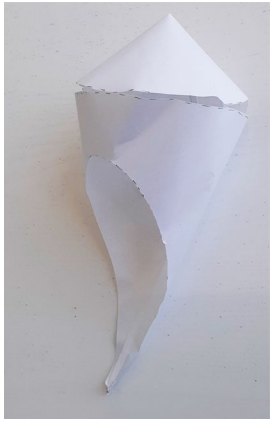
Figure 18. TVIS Gyroscope Wire Ropes

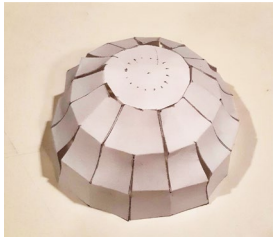
Figure 20. TVIS Stabilizer Corner Bracket Assembly Including Wire Ropes

Figure 15. CEVIS Isolators on ISS

Method of construction

Paper models

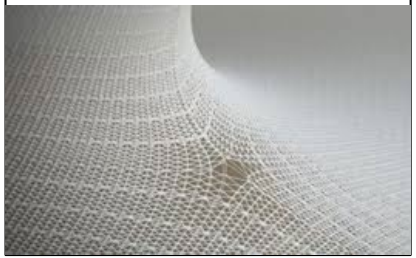




Fabric models

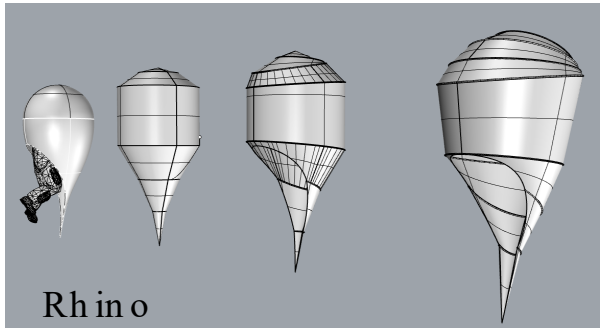
Most Important Learning

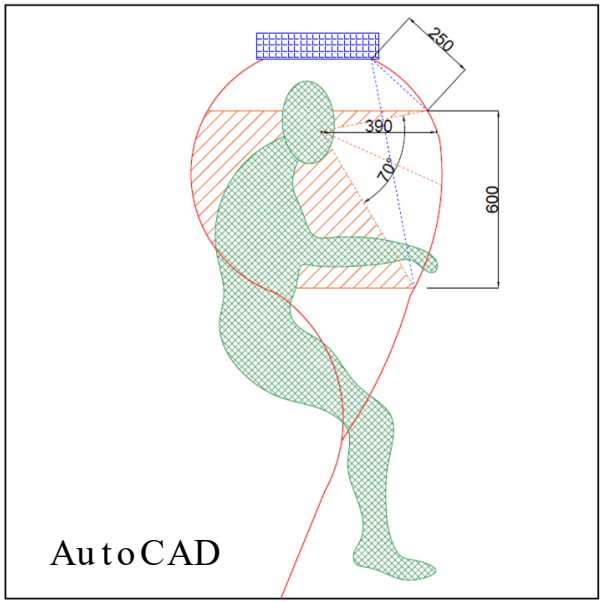
Spherical or Doubly curved surface causes seams, which is not suitable for rear / dual projection, Only exception being CNC weaving fabric.



Form Finding

Sketching

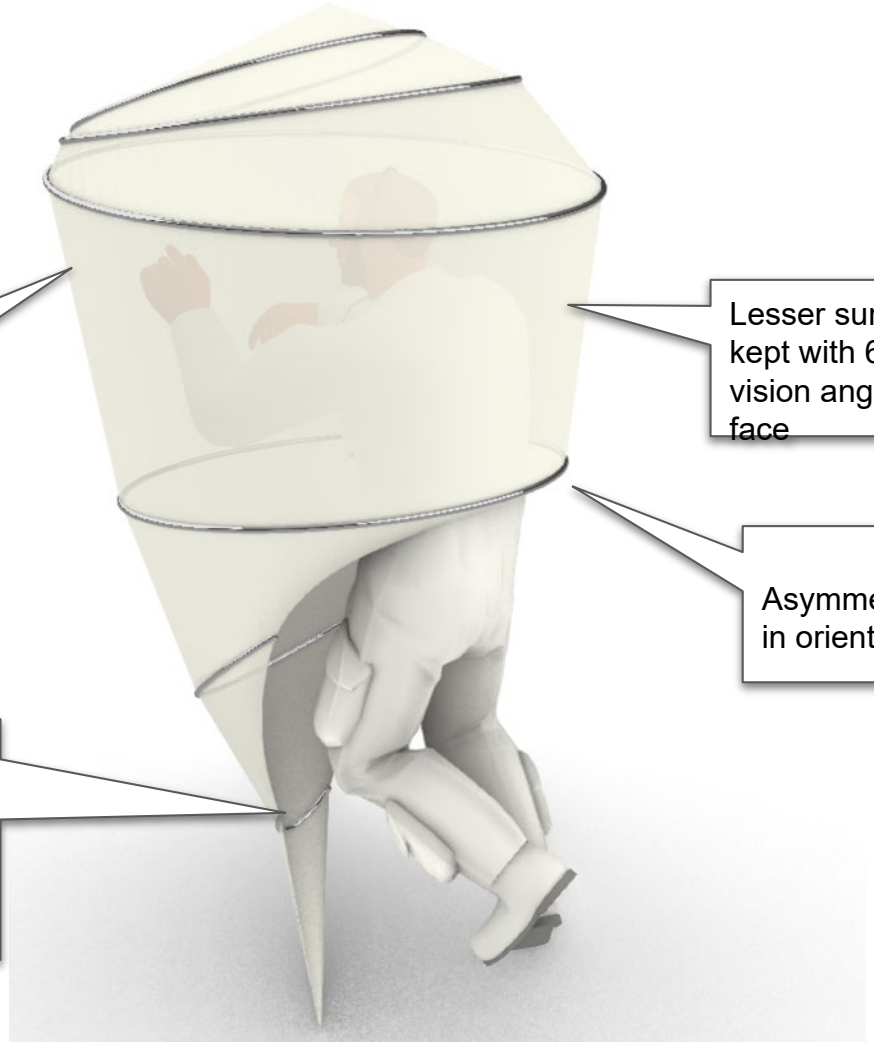




Learnings -

- Horizontal faceted geometry cause less **visual obstruction** than vertically faceted wireframe
- Vision angle and throw of projector decides **diameter of pod**
- Teardrop shape allows **leg movement** , hence allowing future provision for waist restraints for **gravity simulation**
- **Type of projector** decides airflow systems, position of projector, shadow formation, energy used, strain on eye

Final Design



Side is tilted keeping perpendicular to line of sight in neutral body posture

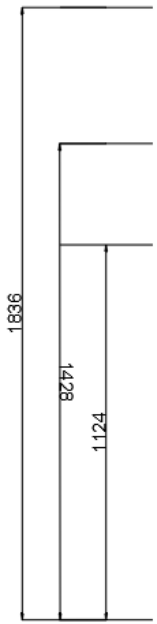
Lesser surface area kept with 60 degree vision angle for back face

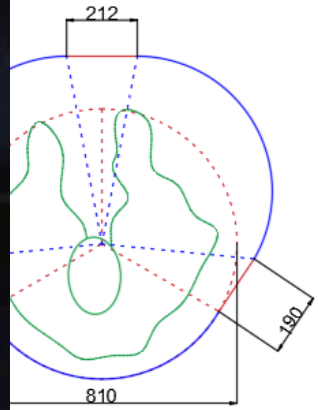
Asymmetry helps in orientation

Cutout does not have rigid edge for flexibility

Next Steps

- Expansive/Contractive pod (connecting spatial sensory output)





Next Steps

- Integration with various exercise equipment on the ISS

COLBERT

CEVIS

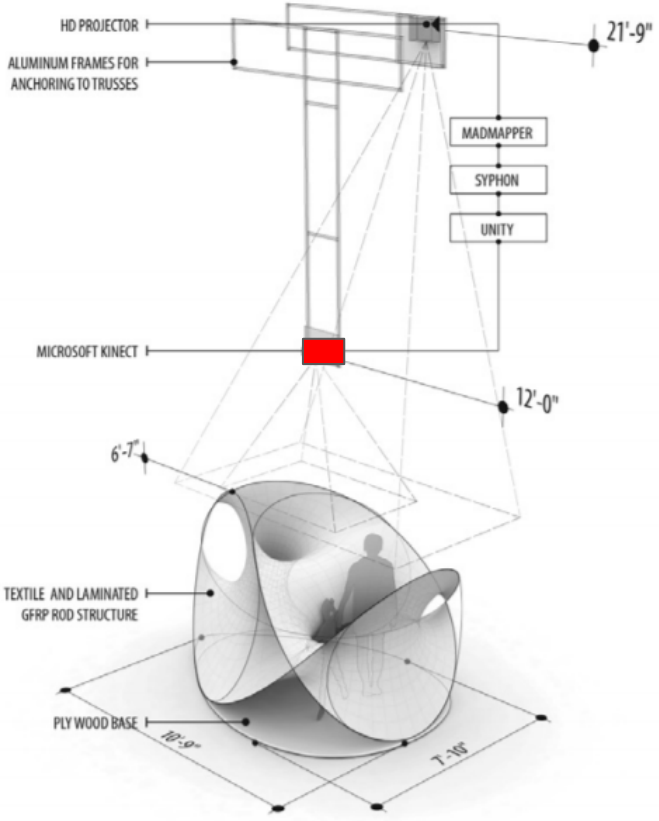
MARES

TVIS

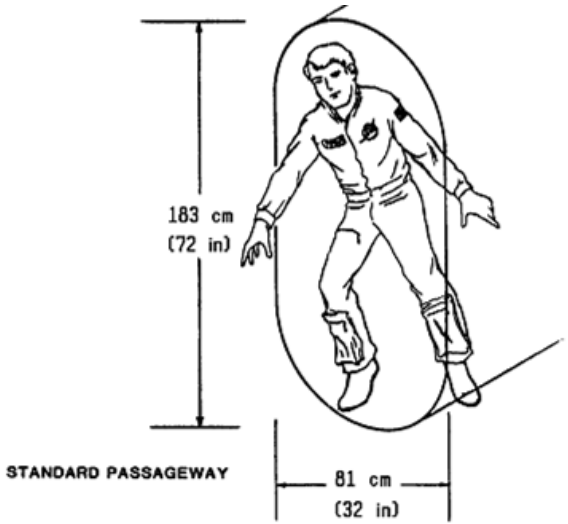
ARED

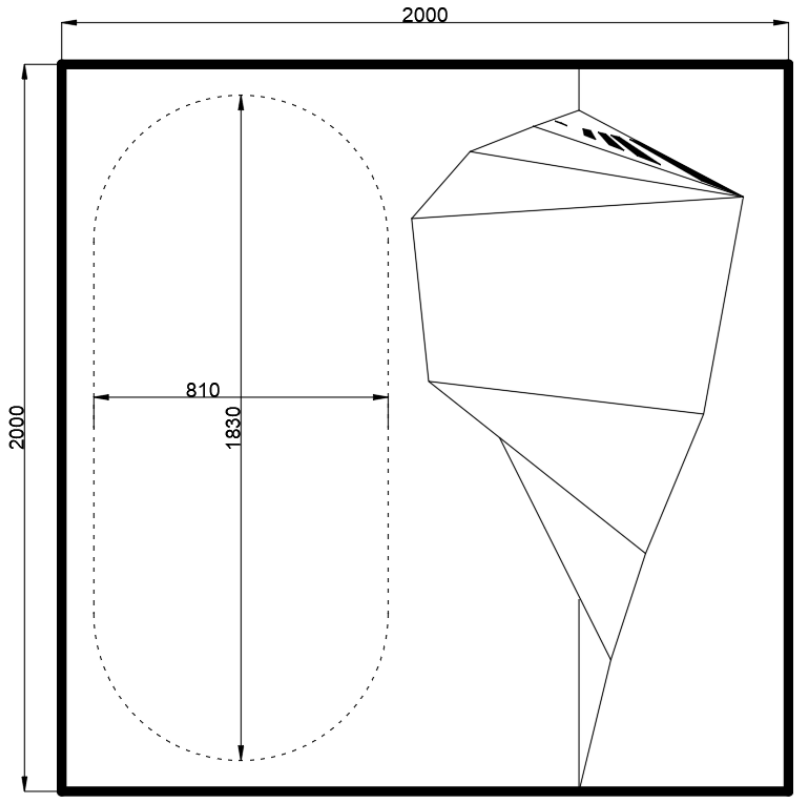
Next Steps

- Integration of projection-based touch input



Emergency Egress





Material choice

	Visual quality	Flammability	health hazards and toxicity	
Durette	creases possible	good		https://apps.dtic.mil/dtic/tr/fulltext/u2/779886.pdf
Fiberglass	lacks opacity	best		
Cotton	Creases possible	not good		
PBI	no risk yet	good	inhalation, skin contact	https://www.auburnmfg.com/uploads/msds114.pdf
Teflon	no risk yet	very good		
Nomex webbing	weaving can be risk	not good	low off gassing	http://www.nakedwhiz.com/gasketsafety/nomextechnicalguide.pdf
Kevlar	weaving can be risk	not good	low off gassing	
Carbon	black color = more energy	good		

Mass calculation

material	kg
Aluminium pipe	2.45
Projector	0.01814
teflon-min	0.5
total mass	2.96814

material	kg
Aluminium pipe	2.45
Projector	0.01814
durette	1
total mass	3.46814

material	kg
Aluminium pipe	2.45
Projector	0.01814
teflon-max	2.6
total mass	5.06814

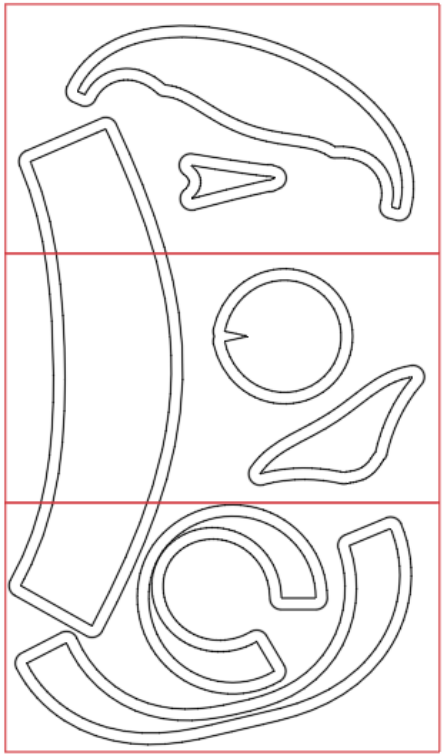
Depending upon material choice, 3 - 5kg or 6.6 - 11lbs

Mass calculation

	diameter of hoop {inch}	circumference(inch)	circumference(ft)	outside cross section (inch)	thickness of metal (1/16")	hollow cross section dia (inch)	solid volume (cubic inch)	void volume (cubic inch)	net volume (cubic inch)	volume (cubic cm)	mass (g)
Aluminium pipe 2.7g/cc	20	62.83	5.23	0.20	0.063	0.07	12.37	4.45	7.92	129.73	350.28
	24	75.40	6.28	0.20	0.063	0.07	14.84	5.34	9.50	155.68	420.34
	30	94.25	7.85	0.20	0.063	0.07	18.55	6.68	11.88	194.60	525.42
	30	94.25	7.85	0.20	0.063	0.07	18.55	6.68	11.88	194.60	525.42
	36	113.10	9.42	0.20	0.063	0.07	22.26	8.01	14.25	233.52	630.51
										total mass	2451.97

Cost breakdown

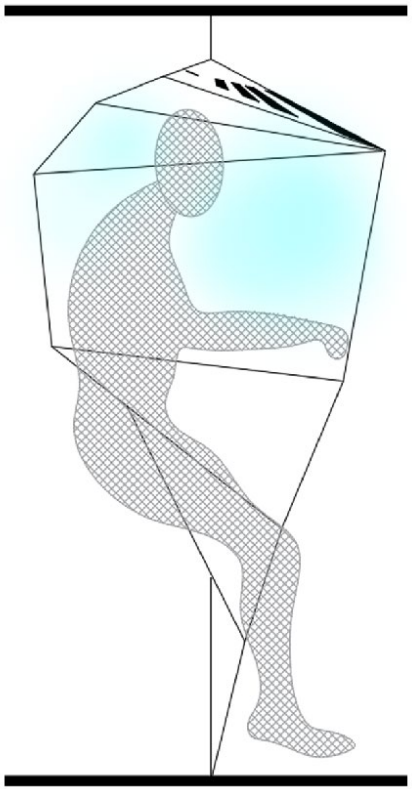
	size	Qt.	Price	Sub-total
durette	54"x94"	3	272$	817$
projector	-	1	2,300$	2,300$
aluminium pipe	varies	4	varies	126$
Makerspace	-	-	-	600$
			Total	3,843$



Cost breakdown

	diameter of hoop {inch}	Qt.	circumference (ft)	cost
Aluminium pipe	20	1	5.23	17.04
2.7g/cc	24	1	6.28	27.24
	30	2	7.85	54.48
	36	1	9.42	27.24
			total	126.00

Air flow system



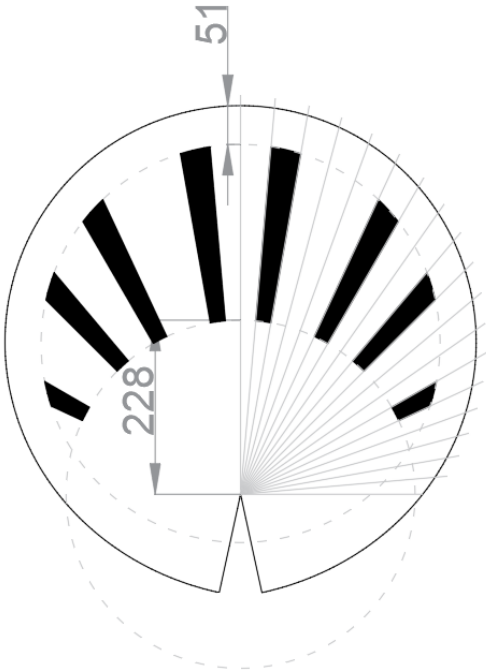
quired based on -

e differences

specific projector

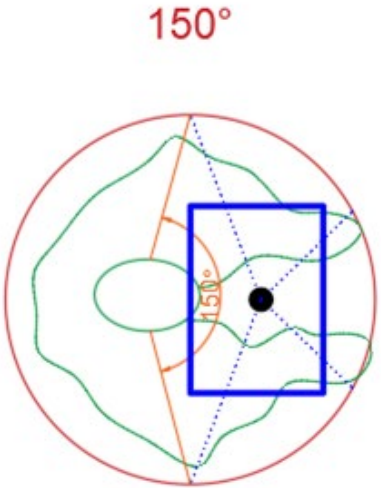
cations on ISS

Existing Vent Plan

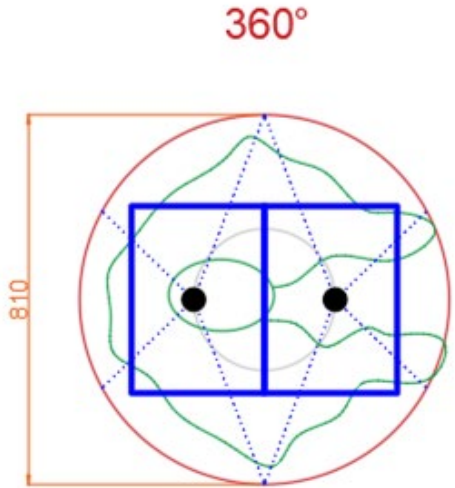


Energy requirements

Energy Saving Mode

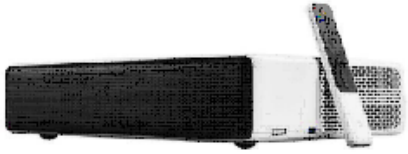


Full performance



Choosing a projector

- Ultra-short throw
- Physical size of projector
- HD visual quality
- Weight
- Cost
- Reliability / Customer review



Xiaomi Mi Projector
1920x1080 DLP,
5,000 ANSI lumens,
3,000:1 contrast, 15.4 lbs

Avg $2,294 See More Prices

+ Add to Compare List

Lens Standard Lens
Throw Ratio: 0.23

Aspect Ratio 16:9

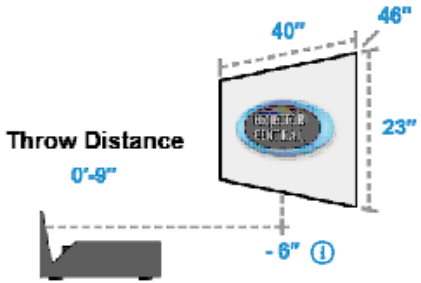
Units

Throw Distance 0'-9"

0'-9" 2'-6"

Image Size 46" Diagonal

0" 46" 150"



Earth Applications of AstroPod

- Hospitals
- Crowded communal living solutions
- Amputated / wheelchair users' recreation
- Hotels and luxury resorts
- Test in an analog mission

Inspiration

Inspired by the myth that you can hear the sea through the conch shell, AstroPod aims to connect astronauts to their home planet, Earth through immersive virtual reality experiences.


Activate Windo

Analog


ANALOG DURATIONS
HERA
30-45
DAYS
HI-SEAS
1
YEAR
PARABOLIC FLIGHT
40
PARABOLAS PER FLIGHT
NEK
1
YEAR
NSRL
7
MINUTE TESTS
CONCORDIA
4-6
MONTHS
ANTARTICA STATIONS
4-6
MONTHS
HESTIA
120
DAYS
DESERT RATS
14
DAYS
HAUGHTON MARS PROJECT
90
DAYS
ENVIHAB
60-90
DAYS
NEEMO
16
DAYS
PAVILION LAKE
14
DAYS
ALTITUDE CHAMBER
56-91
DAYS
IN-SITU RESOURCE
1
MONTH
MISSION TO MARS
180-240 DAYS