Mars Habitat Commonality: CPP-HAB

X-Hab Academic Innovation Challenge

Department of Architecture, Cal Poly Pomona

2017-18

Assessment and Evaluation (Spring 2018)


CR1
NASA

AGENDA

1. Project Goals and Objectives

2. Team Members and Additional Involvement Related to the Collaborative Work Environment

3. Organization and Project Planning (Milestones)

4. Organization and Project Planning (Phases and tasks)

5. Background Research and Survey

6. Design Problem

7. BIM and VR Approach

8. Tools to be used

9. Physical Mock-up

10. Budget

3. Overview Organization and Project Planning:

The proposal is organized into phases correlated to the deliverables.

Kickoff Telecon w/ NASA : Wed, 27 Sep, 2017

Phase 1: Background Research and Survey
Milestone 1: 11 Oct 2017 – Requirements and System Definition Review (SDR)

Phase 2: Requirements and Constraints Definition
Milestone 2: 01 Nov 2017 – Preliminary Design Review (PDR)

Phase 3: Develop Habitat Design Concepts with Commonality (ADDITIONAL REVIEW)
Milestone 3: 01 Dec 2017 – Critical Design Review (CDR)

Winter Kickoff Telecon w/ NASA
Wed, 3 Jan, 2018

Phase 3: Develop Habitat Design Concepts with Commonality
Milestone 3: 24 Jan 2018 – Critical Design Review (CDR)

Phase 4: Prototype Construction/ Testing
Milestone 4: 9 March 2018 – Progress Checkpoint Review

Phase 5: Assessment and Evaluation (Spring 2018)
Milestone 5: Wed, 9 May 2018 – Project Completion and Evaluation by NASA

1. Overview of Project Goals and Objectives

This proposal addresses the challenge 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.

Foster + Partners | Branch Technology of Chattanooga, Tennessee / NASA - 3d Printed Habitat Challenge Phase1

2. Overview of Team Members and Additional Involvement Related to the BIM / Collaborative Work Environment

(PI) Michael Fox
Professor, CPP, Department of Architecture
Project Lead

Mikhail Gershfeld
CPP, Department of Civil Engineering
Structural / Constraint Analysis

Co-Pi - Marc Schulitz
CPP, Department of Architecture
Design / Fabrication

Marc Cohen
Astrotecture
Systems Engineering / Design

German Aparicio
Director, Gehry Technologies
BIM / Design

Allyn Polancic
Design Technology / HNTB Architecture
Collaborative Work Environment / BIM

4. Organization and Project Planning Contd. (Fall)

The general stages of investigation were divided into five Phases:

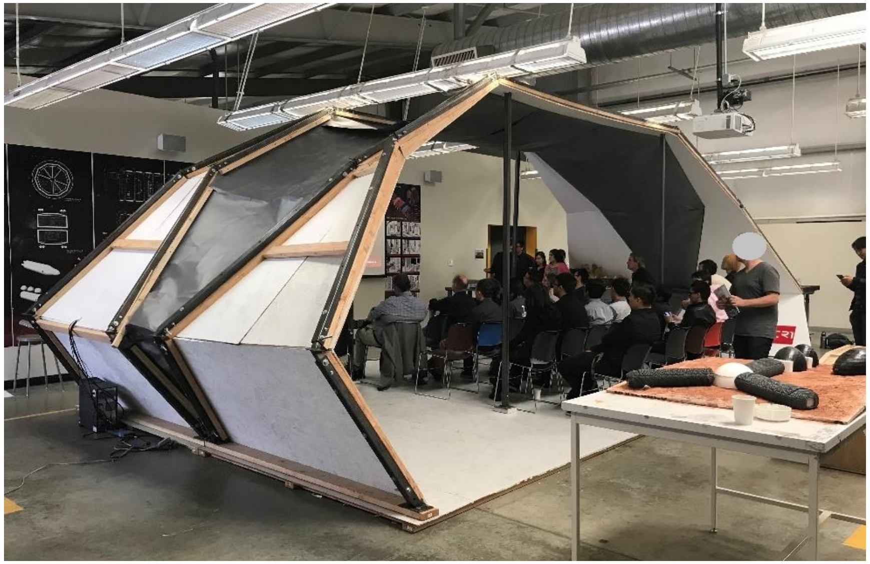
- Background Research and Survey
- Requirements and Constraints Definition
- Develop Layout Design Concepts
- Single Final Design Concept Development
- Documentation and Dissemination

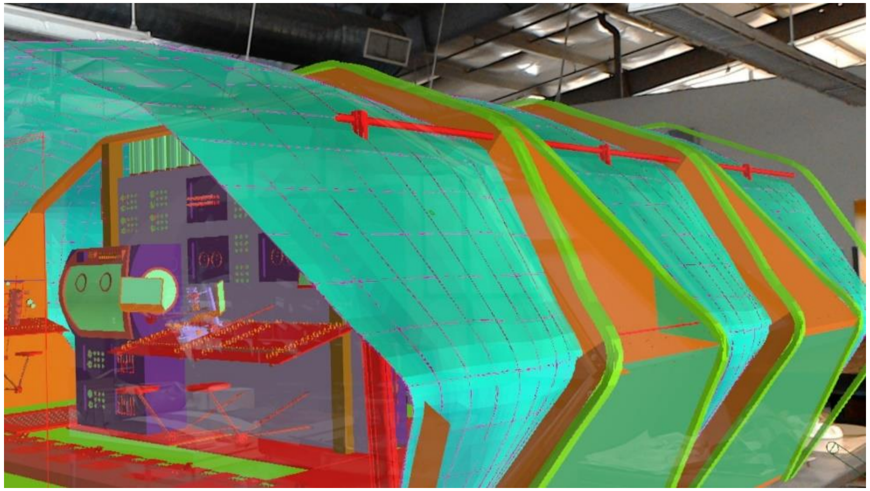
This presentation covers the final development work since the last review as well as documentation and dissemination

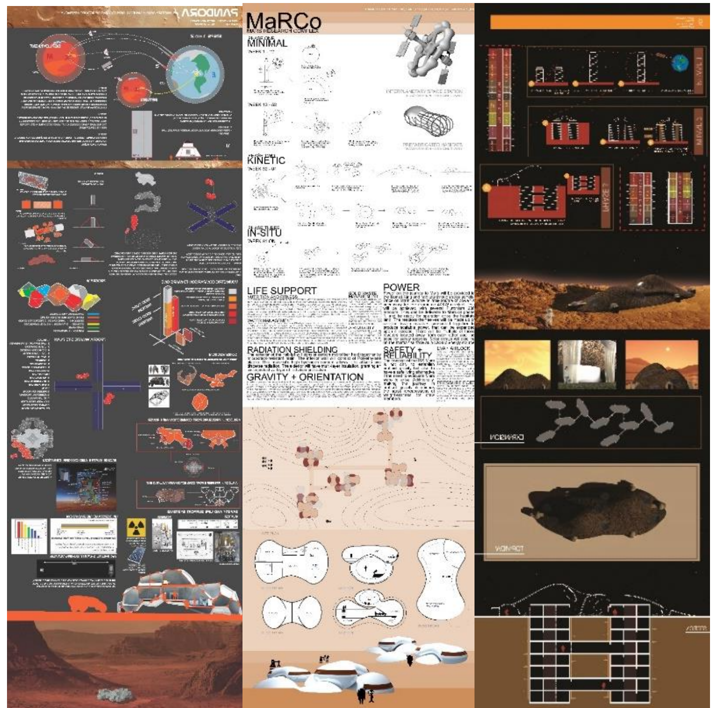
8. Tools used

Organization:
Gnatt Project
Onedrive
Slack

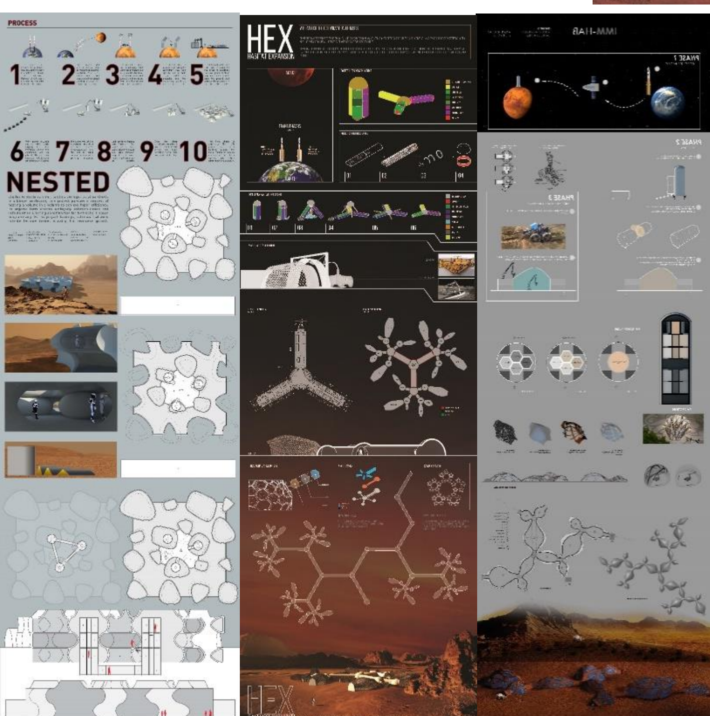
Design:
Rhino, Sketch-up
Oculus Rift (VR)
Mocrosoft Hololens (AR
Development:
REVIT
Grasshopper
Excel
Digital Fabrication:
3-d Print
CNC
Direct Manual Assembly
Robotics:
Arduino







MaRCo
MINIMAL
KINETIC
IN-SITU
LIFE SUPPORT
POWER
RADIATION SHIELDING
SAFETY + RELIABILITY
GRAVITY + ORIENTATION



PROCESS
1
2
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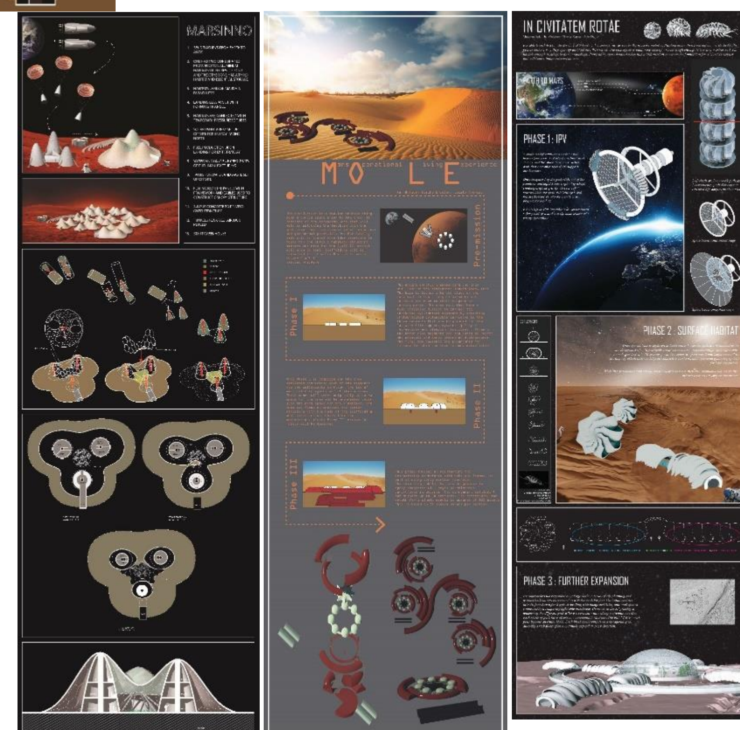
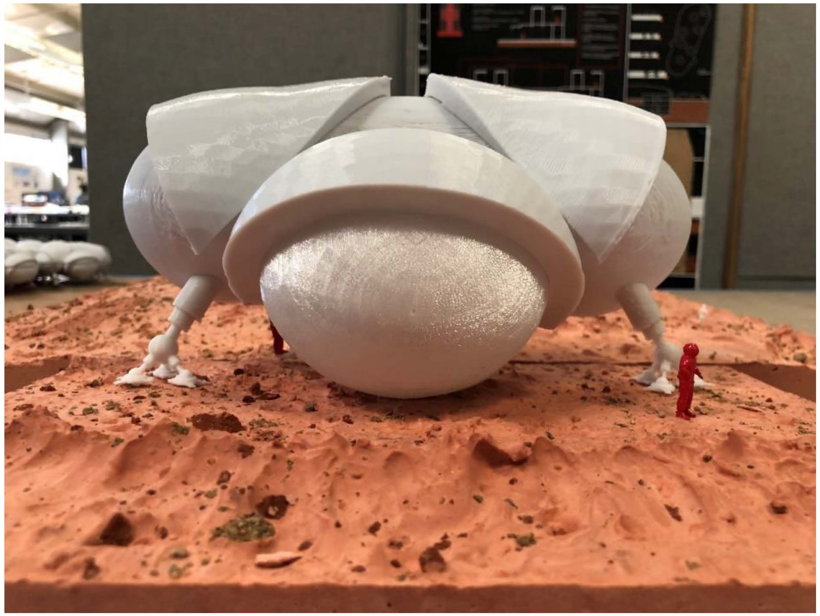
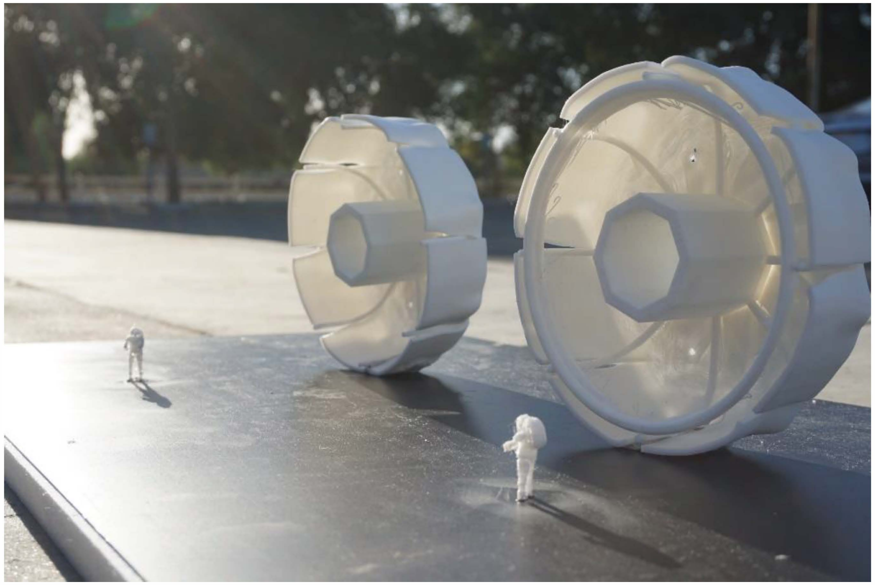
10
NESTED
HEX



MARSINNO
MO LE
Phase I
Phase II
Phase III
IN CIVITATEM ROTAE
PHASE 1: IPV
PHASE 2 : SURFACE HABITAT
PHASE 3 : FURTHER EXPANSION






We initially compared alternatives and evaluated the relative merits of the designs against a set of criteria that provided the framework for evaluating potential design and engineering options.

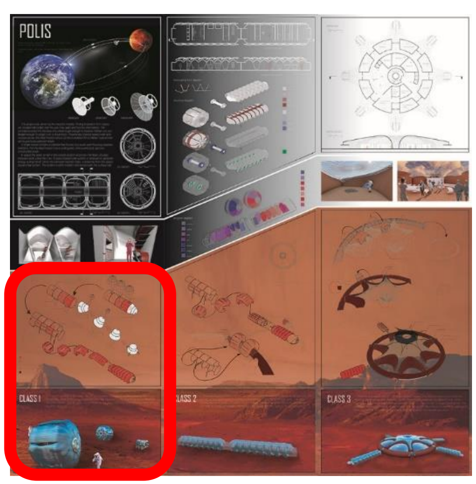
The designs were then downselected to three final concepts to be further developed.

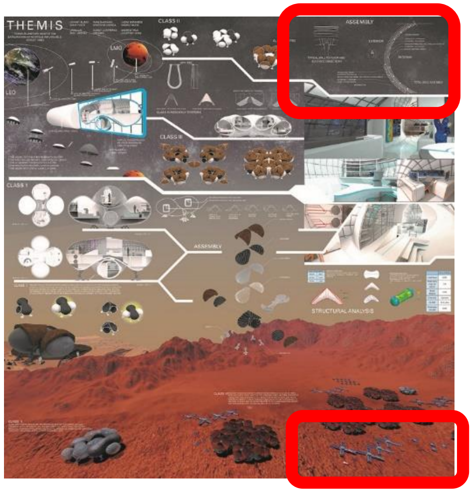
CODEX: COnstraints Definition Evaluation Checklist

Team:
Project:

		-100	-50 sometimes	0 balances	50 sometimes	100	
	seen it before						clearly innovative
	program missing						Program inclusive
	inneficient use of space						efficient use of volume
	organization unclear to user						clear organization
	ugly						aesthetically pleasing
Overall Approach	Unclear strategy for payloads						clear strategy for payloads
	Impossible strategy for ascent						Good ascent strategy
	Unclear Surface Mobility						Clear strategy for surface mobility
	Performance Expectations unclear						Well defined preformance expectations
	Design Criteria Unclear						Well defined design criteria
	P1: Unclear Minimal Functioning Habitat						P1: Clear Minimal Functioning Habitat
	P2: Unclear Advanced/Enhanced Habitat						P2: Clear Advanced/Enhanced Habitat
	P3: Unclear Strategy for Permanent Habitat						P3: Clear strategy for surface Phase1 (MFH)
Constraints	not related to IPV						clearly related to IPV
	Clear Strategy for Growth / Expansion						Clear Strategy for Growth / Expansion
	Poor radiation sheilding						Good radiation sheilding
	Unclear Pressure Port strategy						Clear Pressure Port strategy
	Poor EVA system / airlock						Good EVA system / airlock
	Poor Weightlessness Response						Clear Weightlessness Response
	Poor Gravity Orientation						Clear Gravity Orientation
	Poor Life Support System						Clear Life Support System
	Poor Safety and Reliability						Good Safety and Reliability
Constraints	not related to IPV						clearly related to IPV
	Unrealistic Strategy for Growth / Expansion						Realistic Strategy for Growth / Expansion
	Poor radiation sheilding						Good radiation sheilding
	Unclear Pressure Port strategy						Clear Pressure Port strategy
	Poor EVA system / airlock						Good EVA system / airlock
	Poor Weightlessness Response						GoodWeightlessness Response
	Poor Gravity Orientation						Clear Gravity Orientation
	Poor Life Support System						Clear Life Support System
	Poor Safety and Reliability						Good Safety and Reliability
materials/fabrication	seen it before						clearly innovative
	Unclear Phasing						Clear Phasing
	Power gerneration not clear						Clear startegy for Power
	Clear Response to Physics						Unclear Response to Physics
	Much human involvement						Minimal Human involvement
	Unclear Structural Systems						Well defined Structural systems

-2400 min.	2400 max.





VR group

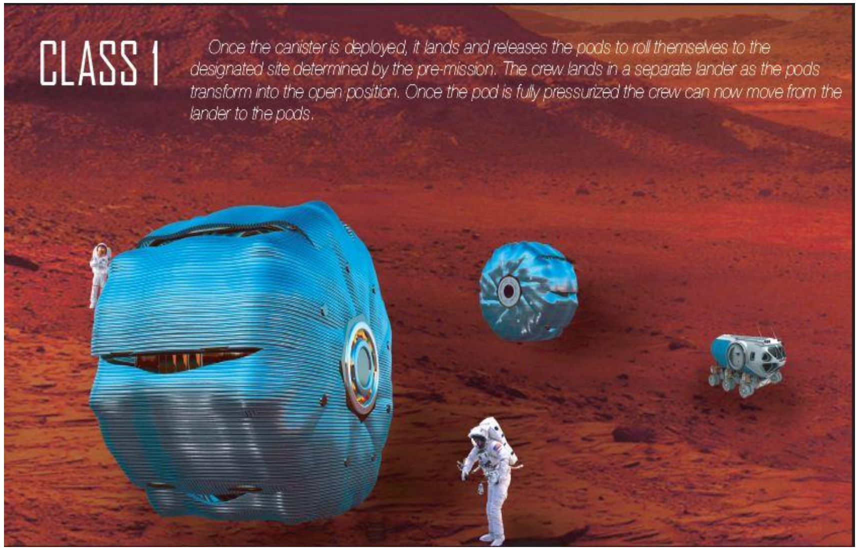
Chingmei Lee
Skyler Maroste
Eduardo Martinez
Liliana Perez
Marc Rudy
Sanhloc LeHuynh

Mock-up group

Sonny Contreras
Daniel Sanchez
Jocelyn Hernandez
Qiting Huang
Giancarlo Manglicmot
Franco Mellone
Nick Ramirez

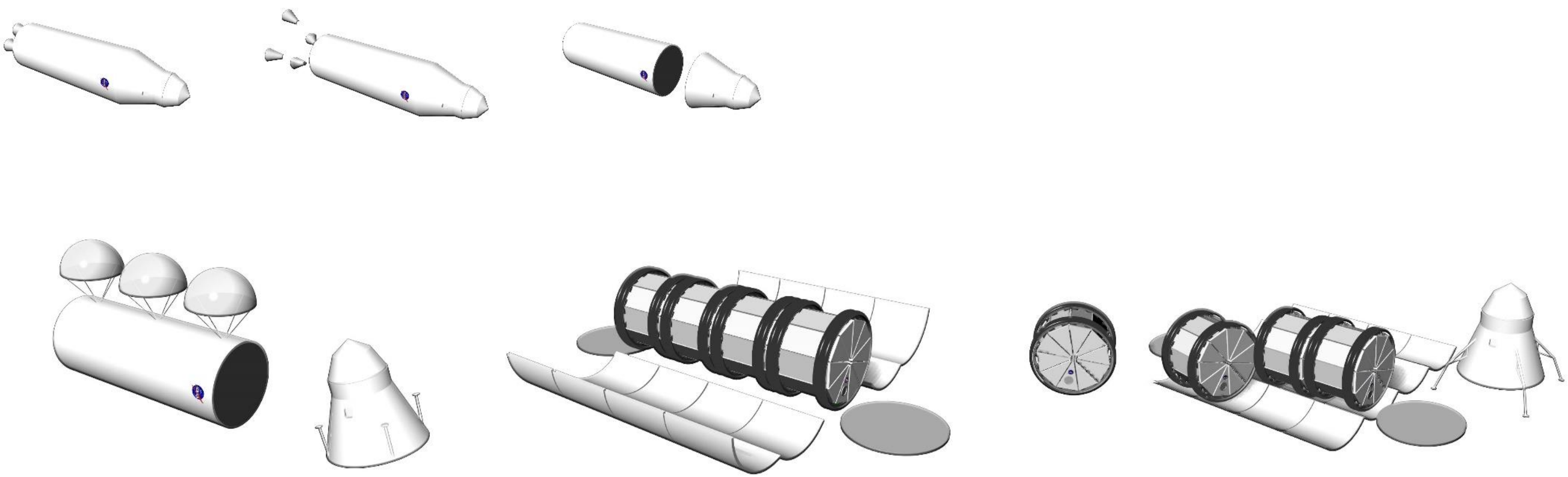
Roly group

Chiao Lin ,
Larry Phong,
Gemme t. Ng ,
Samuel Cruz Prado ,
Roger Yu



The concepts were developed were subsequently developed and again the point based checklist was used to arrive at down-selecting to a single final concept.

In addition, the final concept was selected in part because it developed a unique strategy for mobility and transformation of the surface habitat prior to its Class II configuration.



9. Final Prototype Design – CR-1

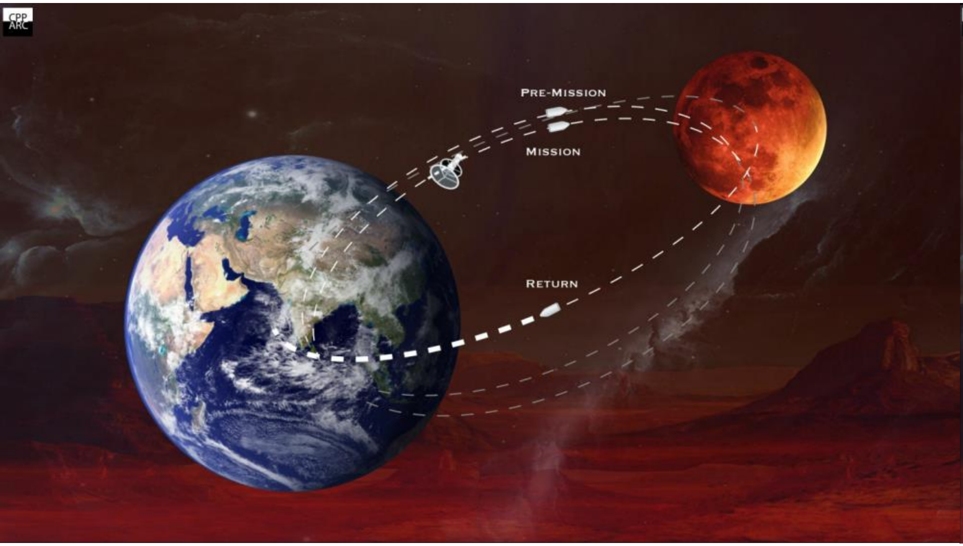
The most important aspects that needed resolution were:

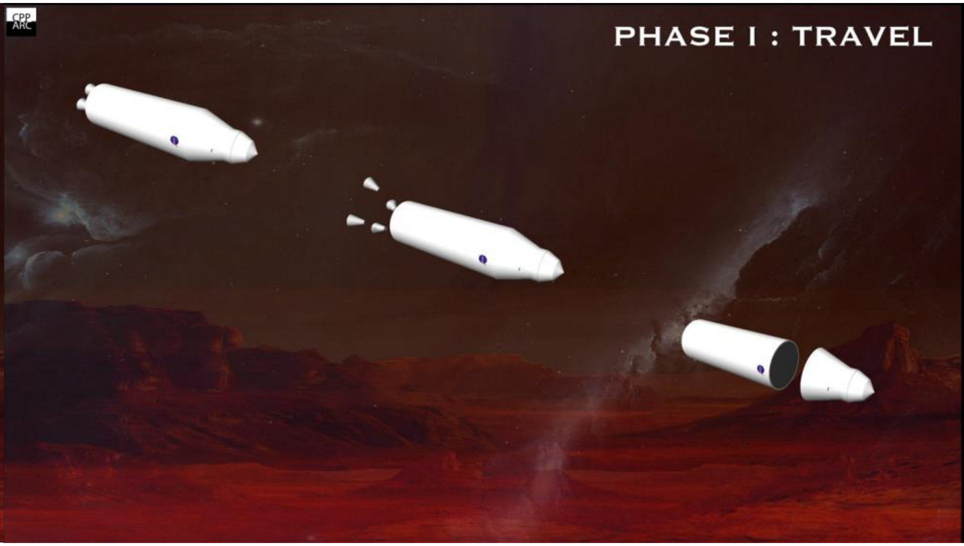
- The CR-1's transformation mechanism that would allow the IPV to function on 0g and in the Martian gravitational environment and its structural integrity.
- The program layout had to be designed allowing all components to be preinstalled with full functionality before and after the transformation
- Allowing a limited mobility on the mars surface

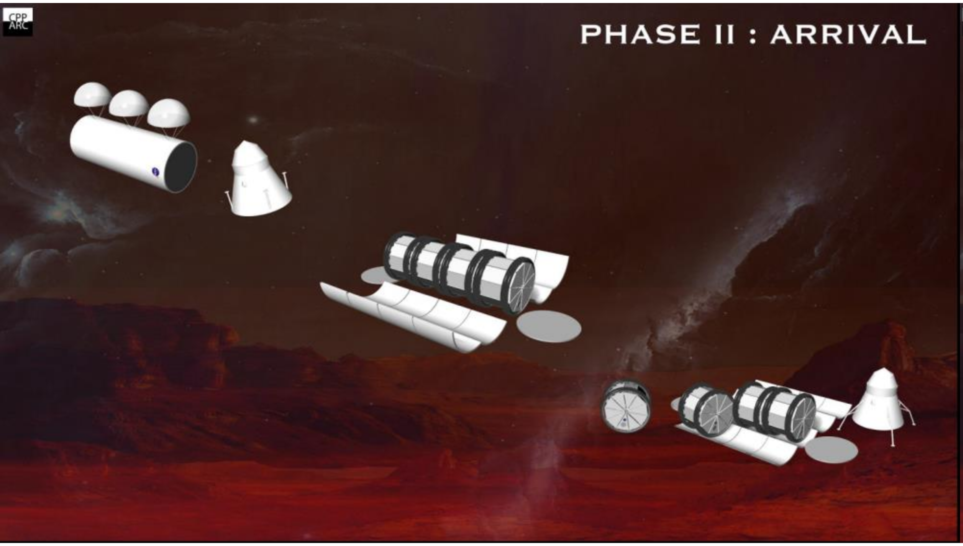
9. Final Prototype Design – CR-1Final Prototype Design – CR-1

The development used a variety of scales and strategies

- **BIM Model**
  - To understand all aspects of the project and to carry out the other aspects
- **Full-Scale Prototype (AR)**
  - To understand ergonomics and human scale
- **Fully detailed Virtual Reality Prototype (rolled and Unrolled (VR))**
  - To understand ergonomics and human scale
- **Small Scale Robotics**
  - To understand ergonomics and human scale
- **1:10 Physical Prototype**
  - Mechanics and connections

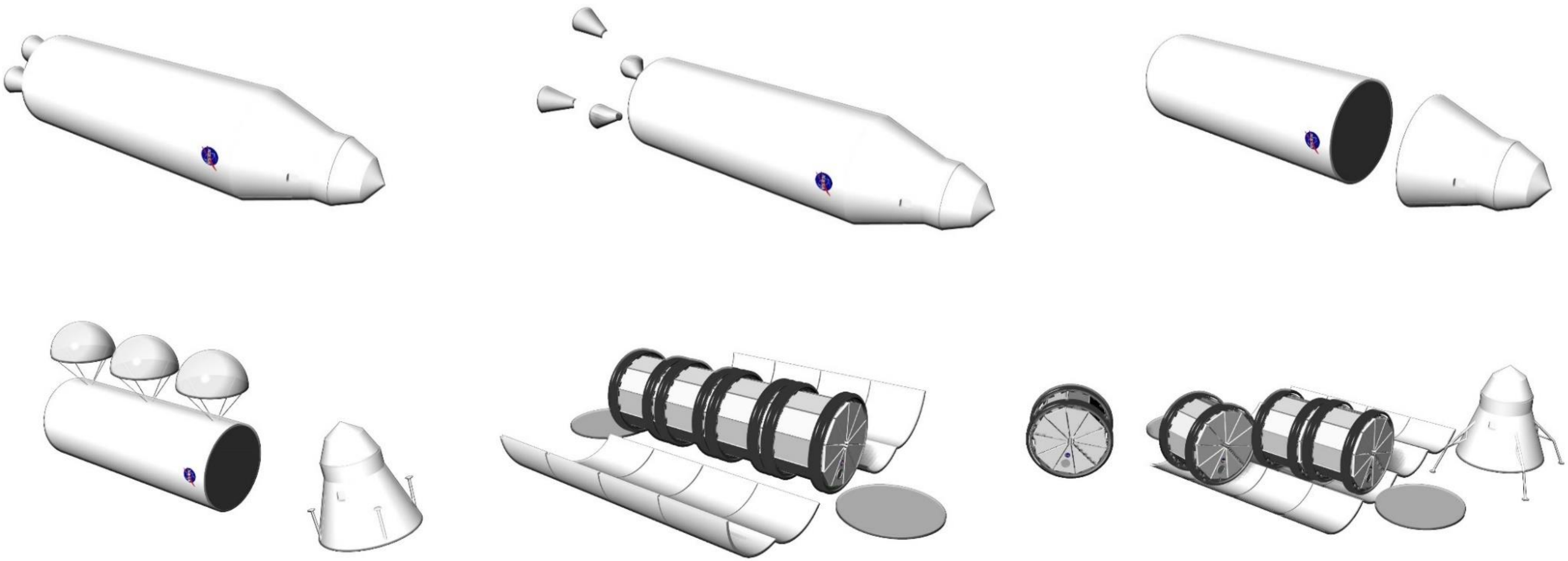

CPP ARC
Pre-Mission
Mission
Return


CPP ARC
PHASE I : TRAVEL

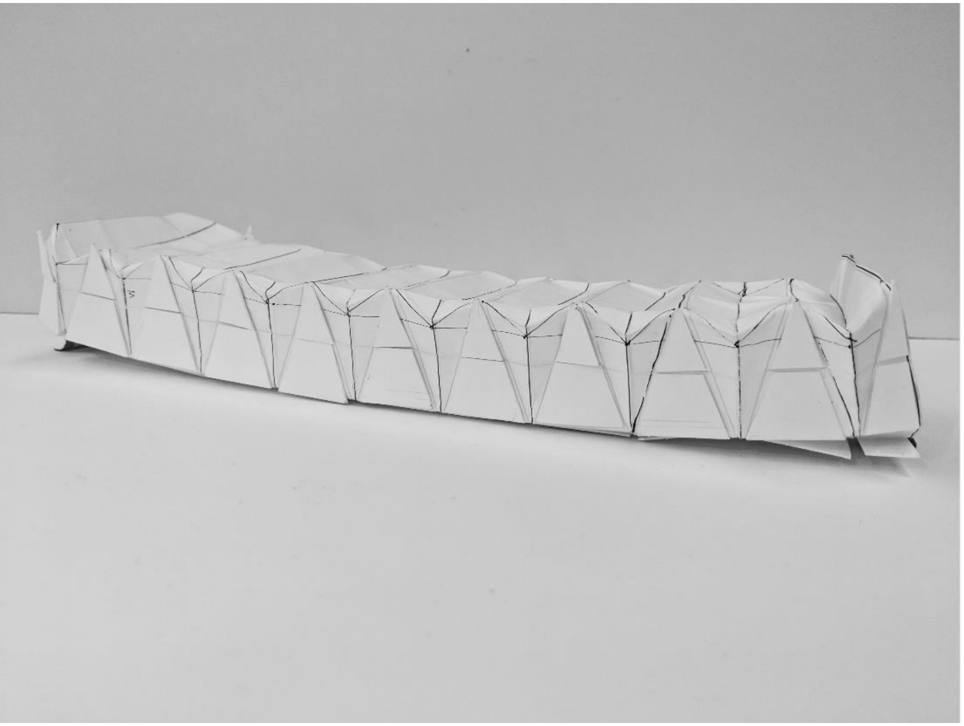

CPP ARC
PHASE II : ARRIVAL

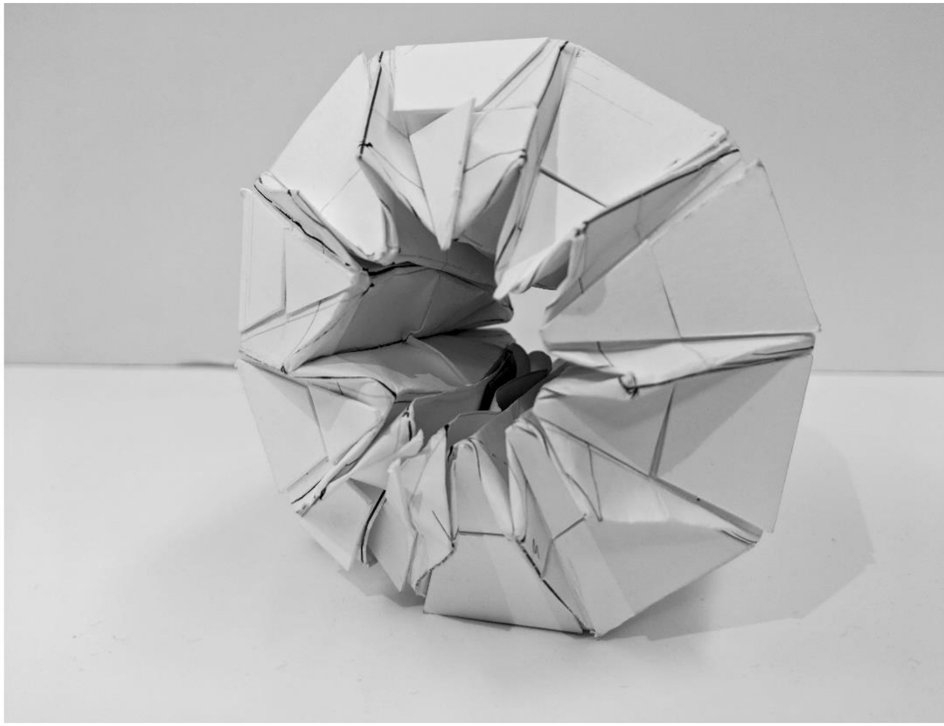

CPP ARC
PHASE III : UNROLLING-DEPLOYMENT PROCESS
1. The rotating frame will wheel the stationary frame to the desired location
2. The rotating frame then detaches from the stationary frame
3. The detachable wheels are then taken off the stationary frame

Development Drawings

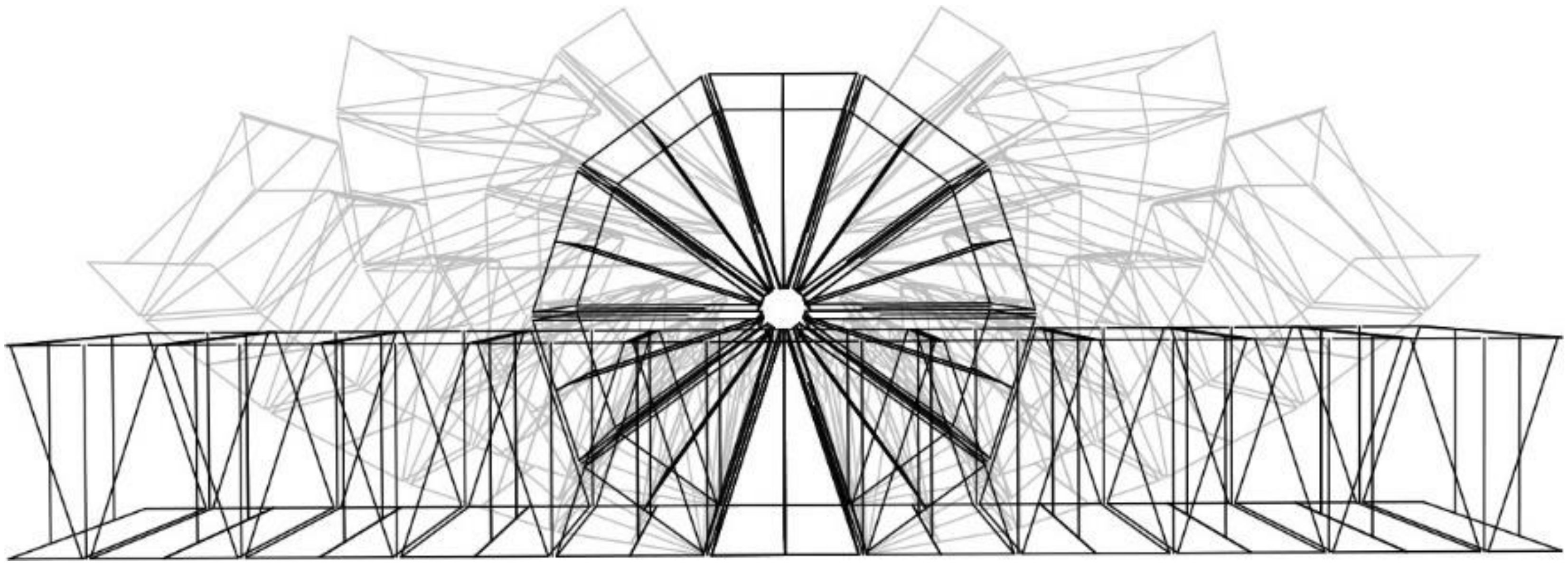


Development Drawings

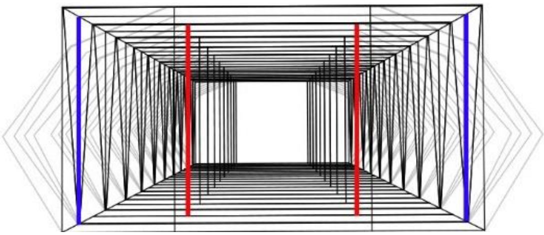


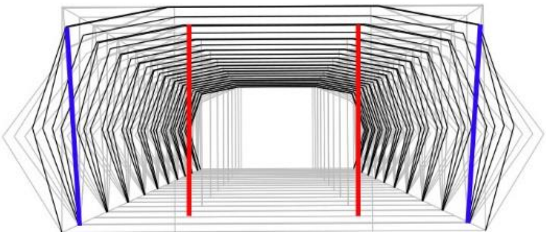


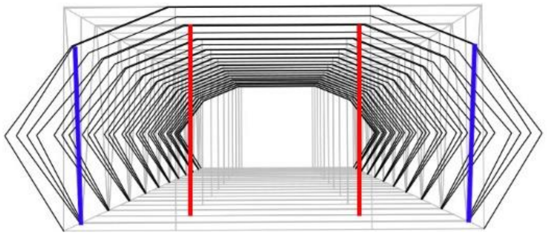
Development Drawings

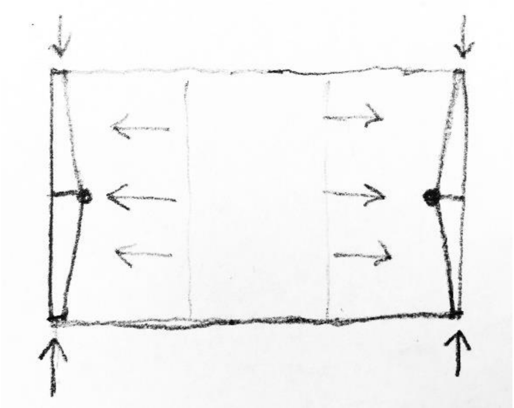


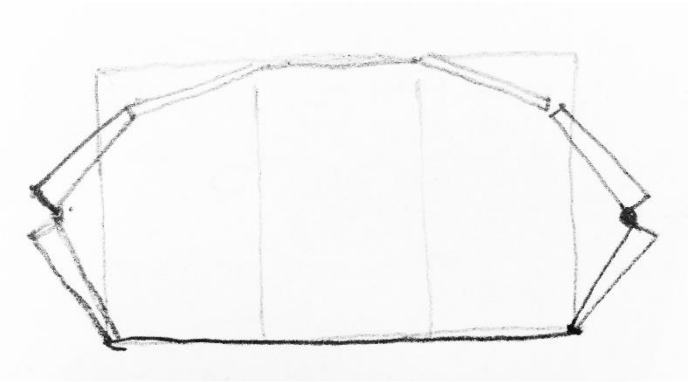
Development Drawings



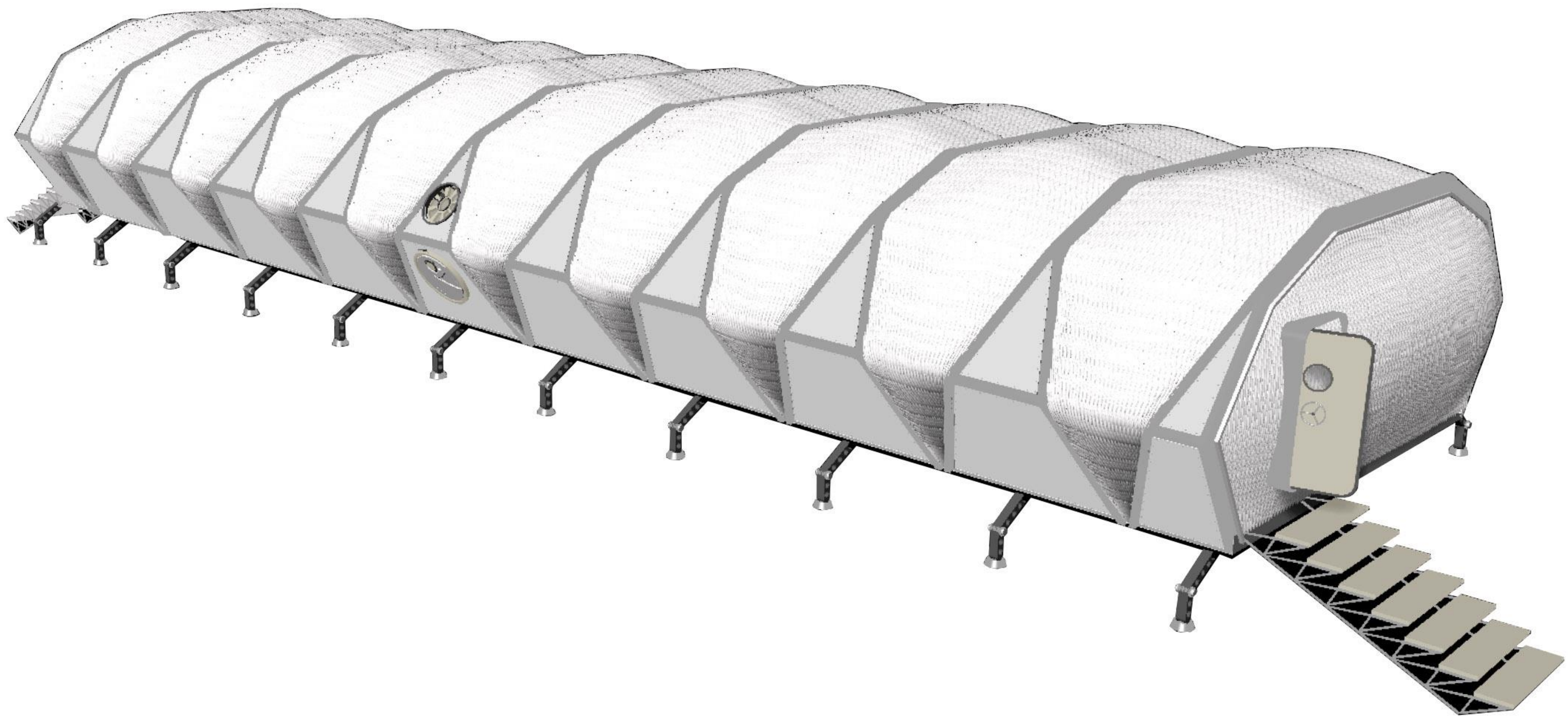




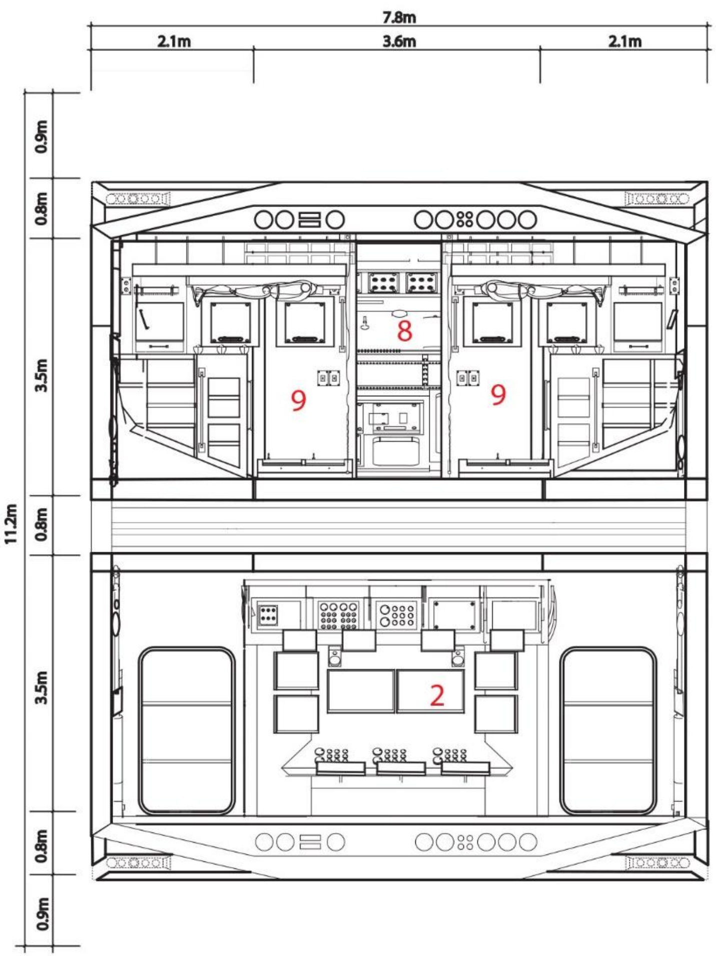


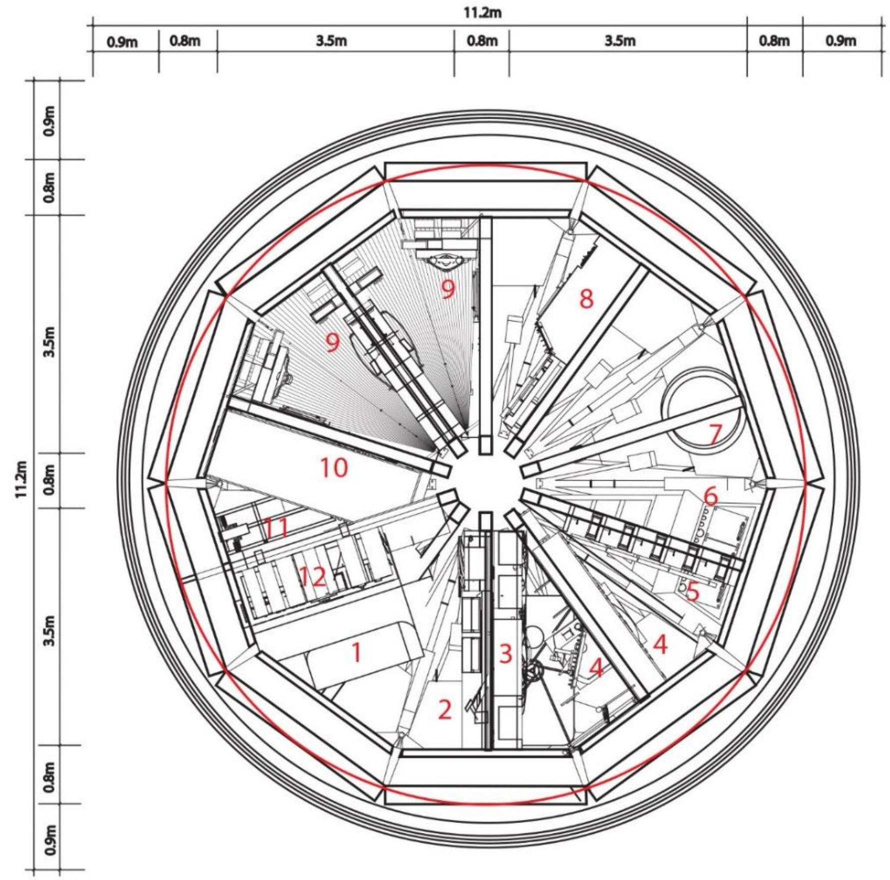


Development Drawings

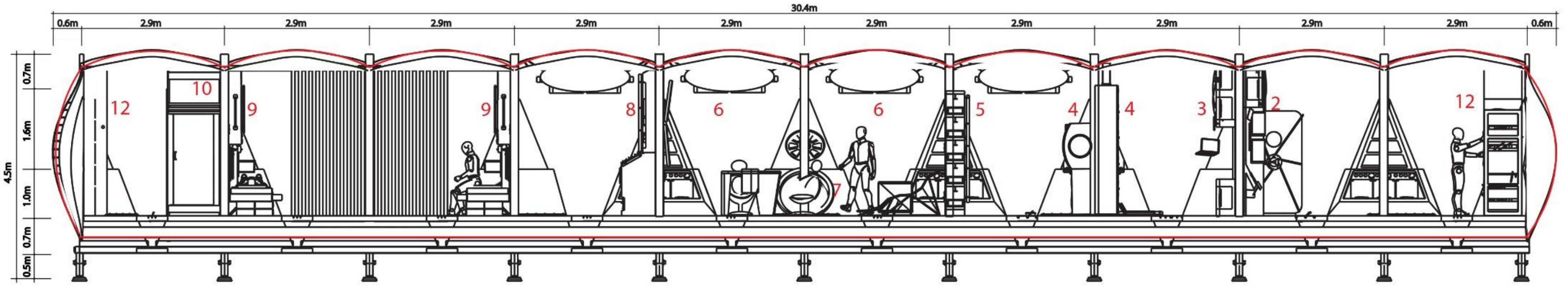


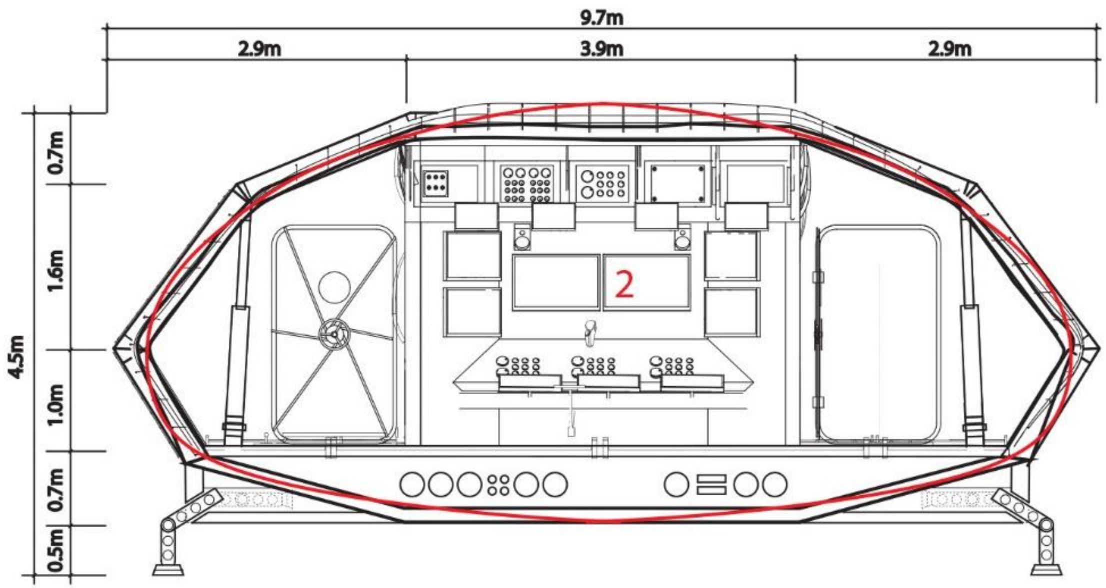
Development Drawings





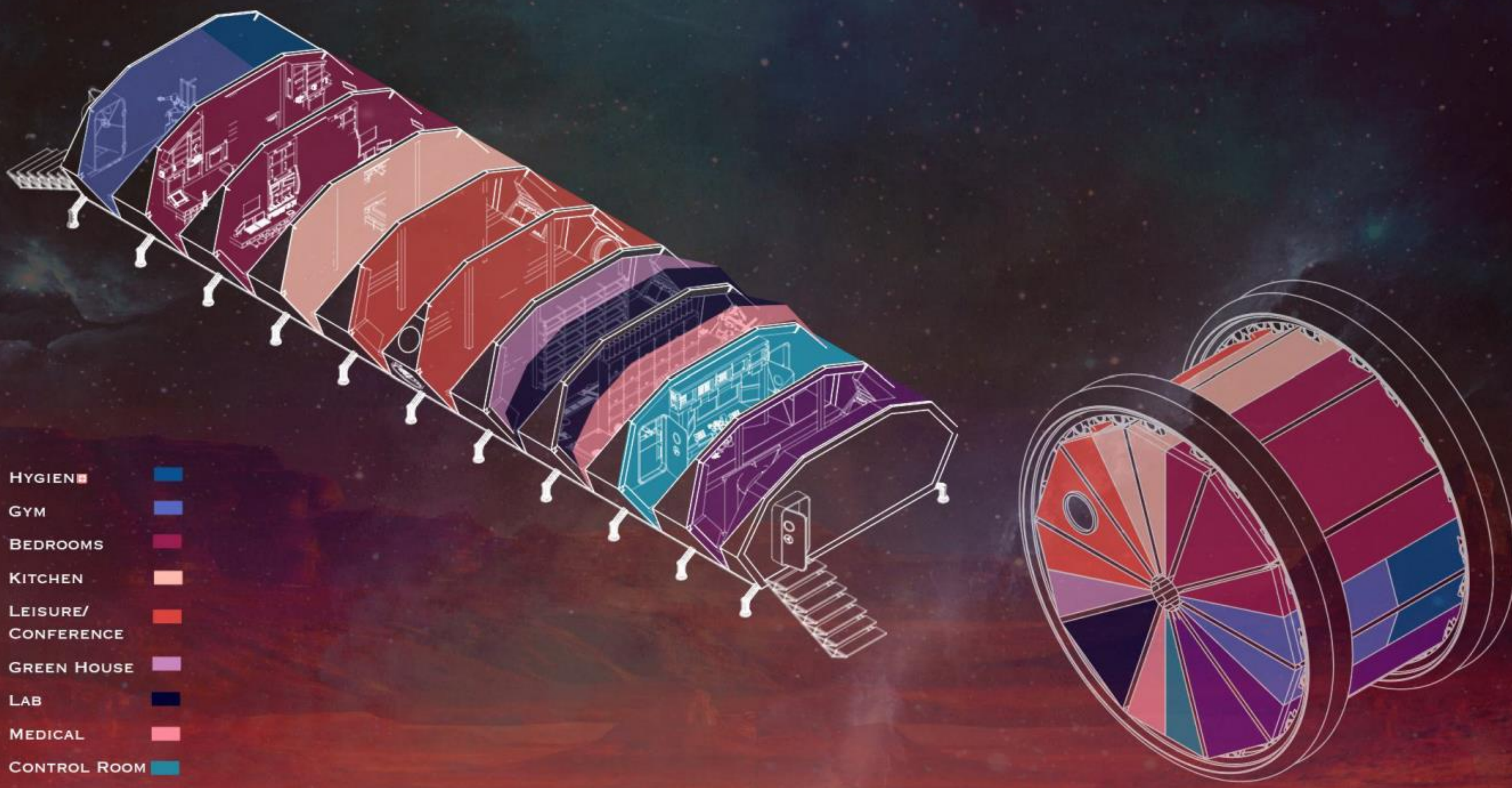
Development Drawings



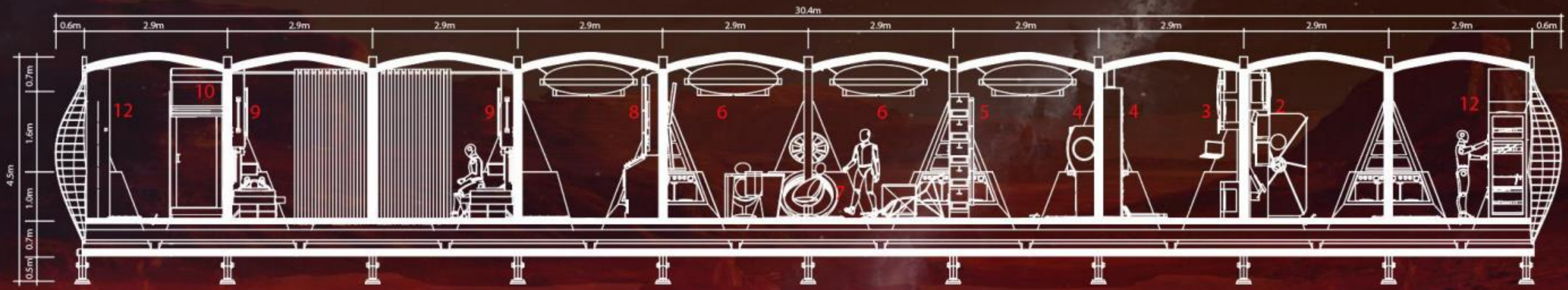


CPP
ARC

Programming

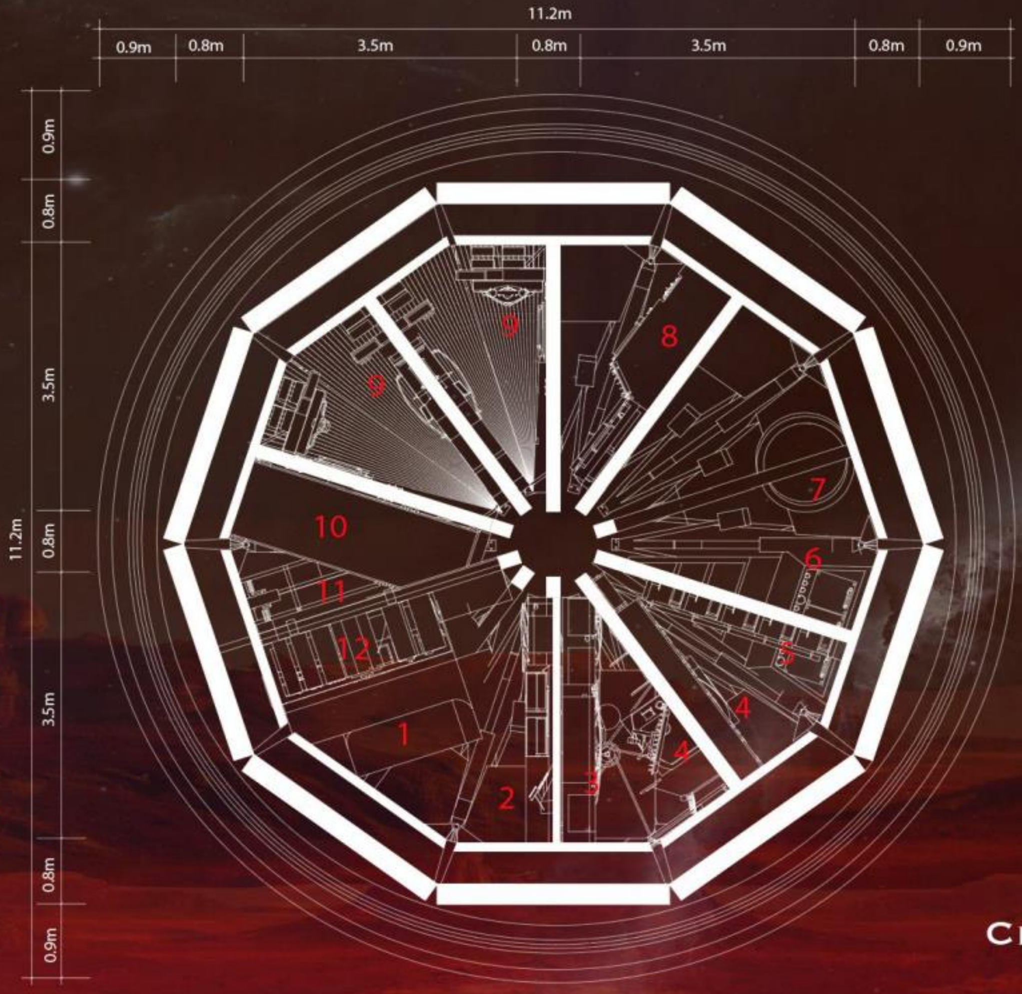


- Hygiene
- Gym
- Bedrooms
- Kitchen
- Leisure/ Conference
- Green House
- Lab
- Medical
- Control Room
- Life Support



EXPANDED SECTION

ARC



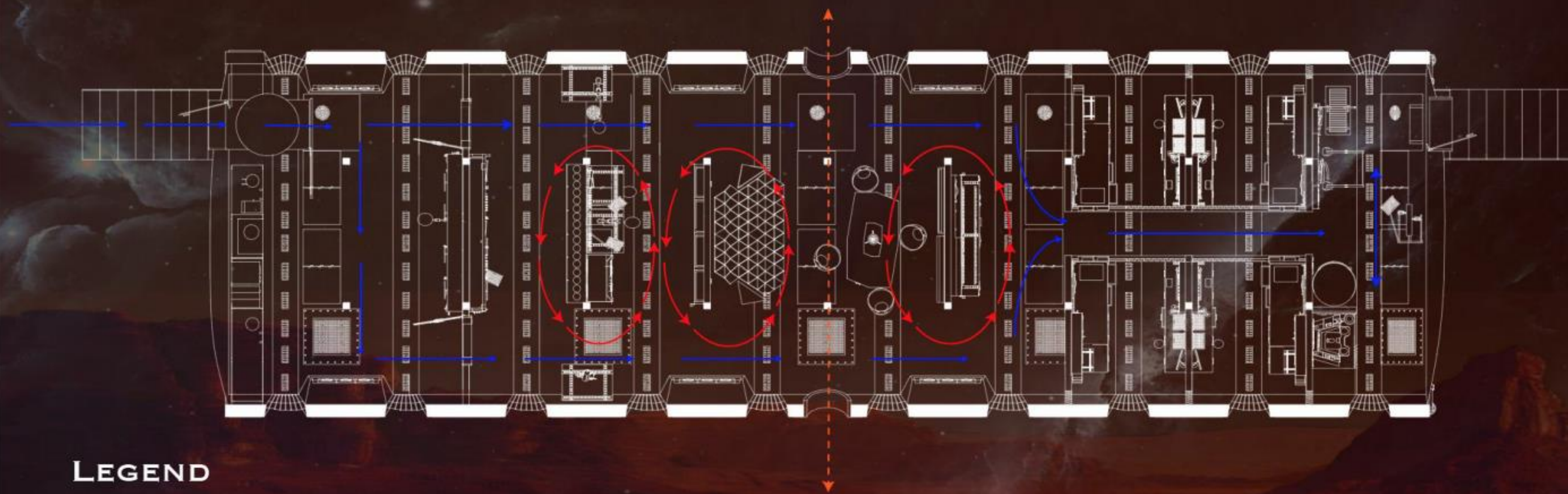
KEY

1 - AIRLOCK
2 - MISSION CONTROL
3 - MEDICAL RACK
4 - RESEARCH LAB
5 - GREEN HOUSE
6 - LEISURE / CONFERENCE
7 - SIDE HATCH
8 - KITCHEN
9 - SLEEP
10 - HYGIENE
11 - GYM
12 - LIFE SUPPORT

CLOSED SECTION A

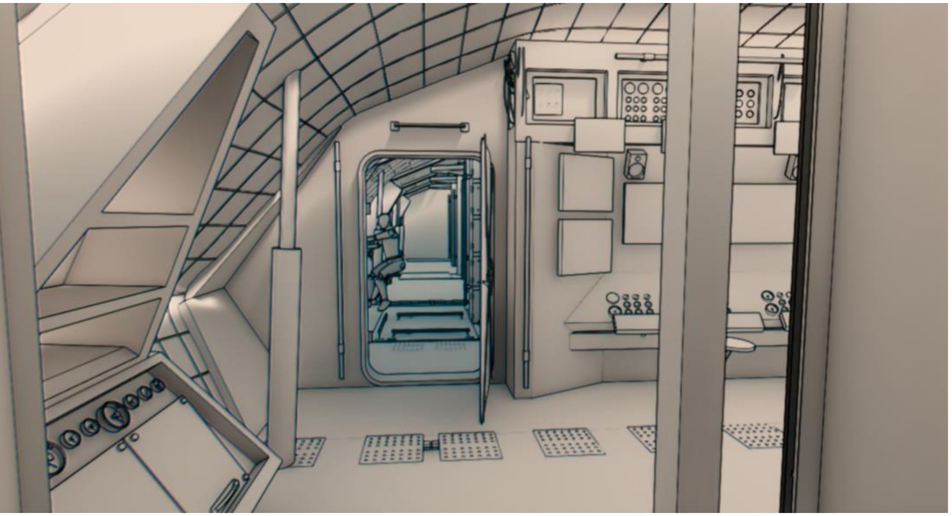
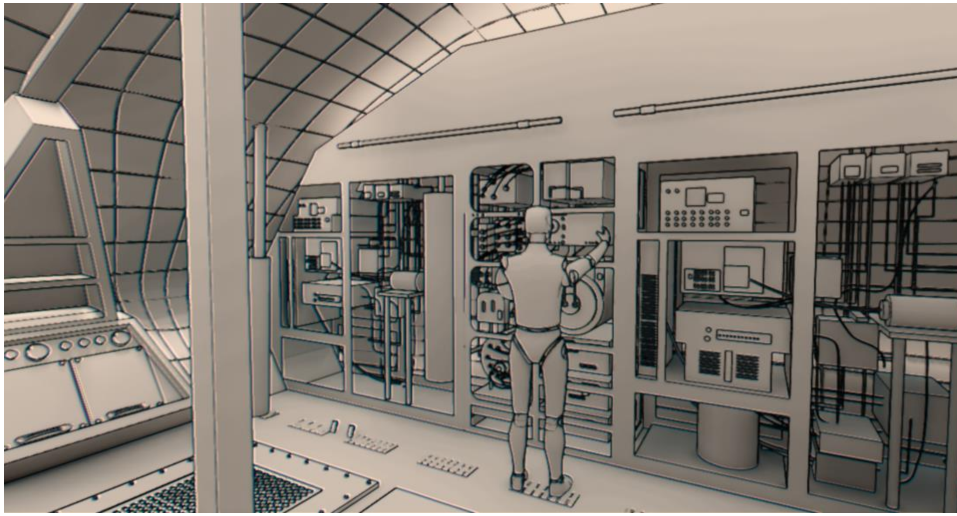
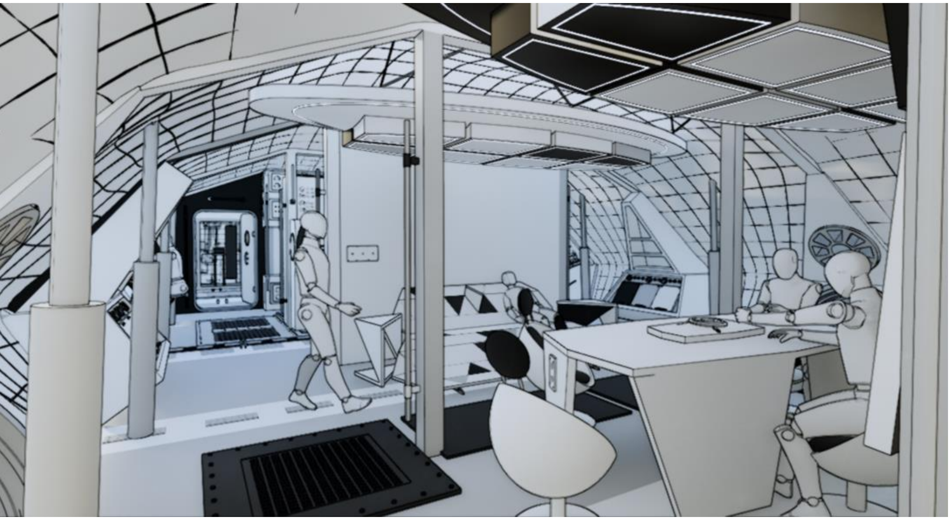
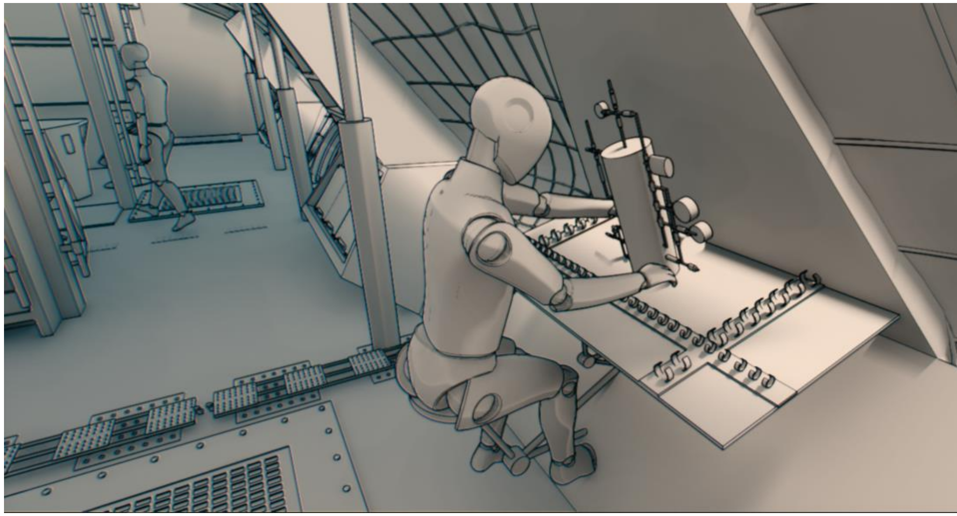
CPP ARC

Circulation Diagram



Legend

- Main Circulation
- Secondary Circulation
- IPV Circulation

Full-Scale Prototype (AR)

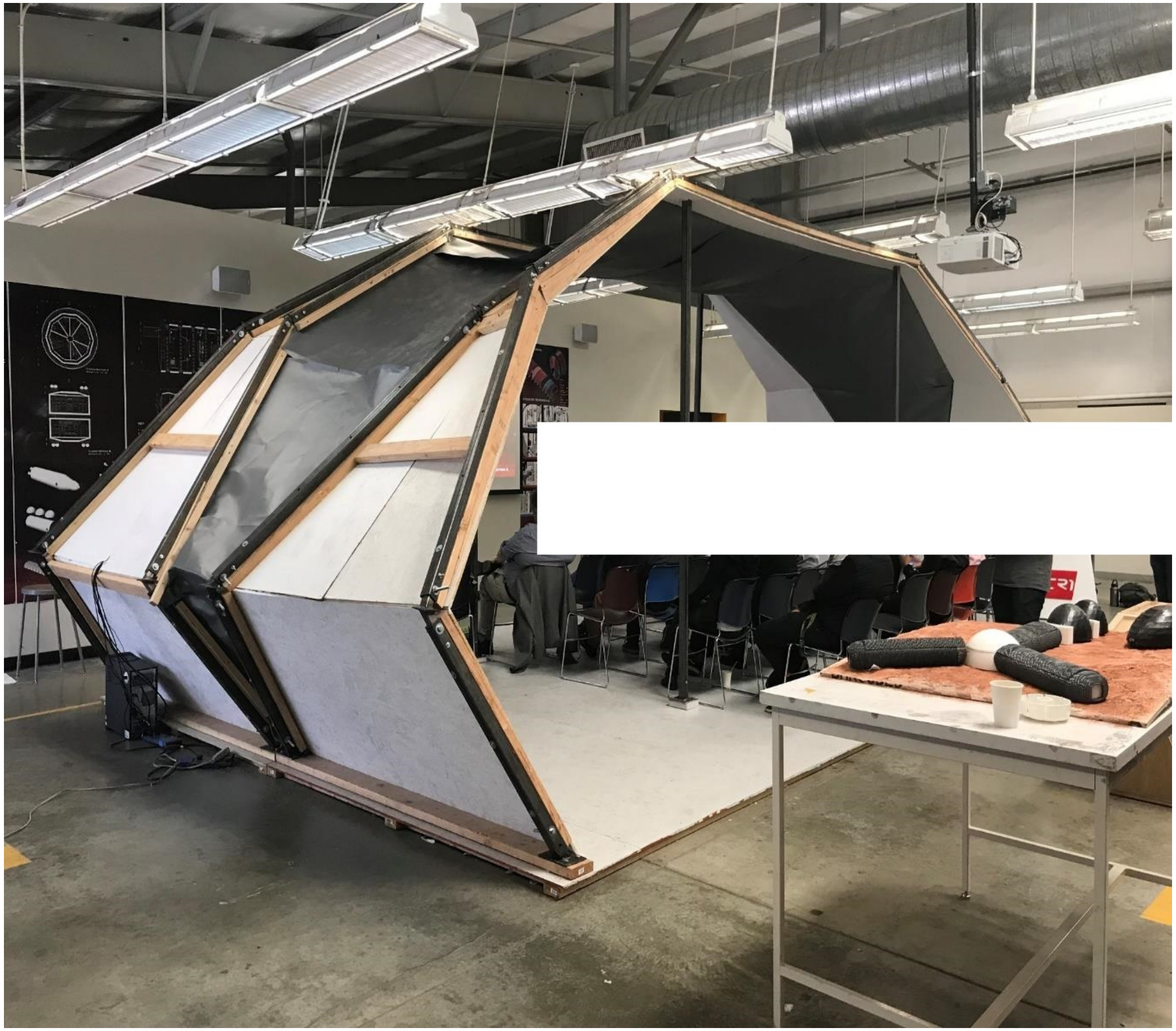
The Project was fully modelled in Rhino3D. The VR experience was generated with the Enscape plug-in for Rhino using 3D head sets . The VR model allowed to move through the model in IPV and the deployed mode.

The pavilion served multiple purposes:

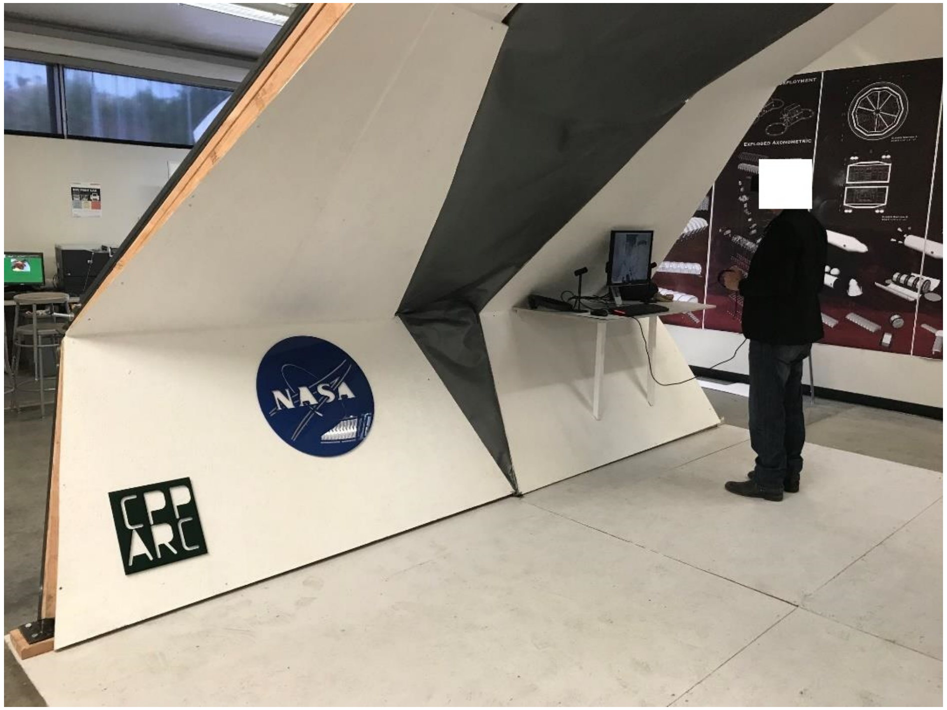
- The VR model was combined with the full-scale mock-up in an augmented reality environment using a MIcrosoft Hololens
- It illustrated the scale of the project and gave a sense of the designs space and proportions.
- This allowed us to verify the efficiency of the design's layout and the circulation concept.

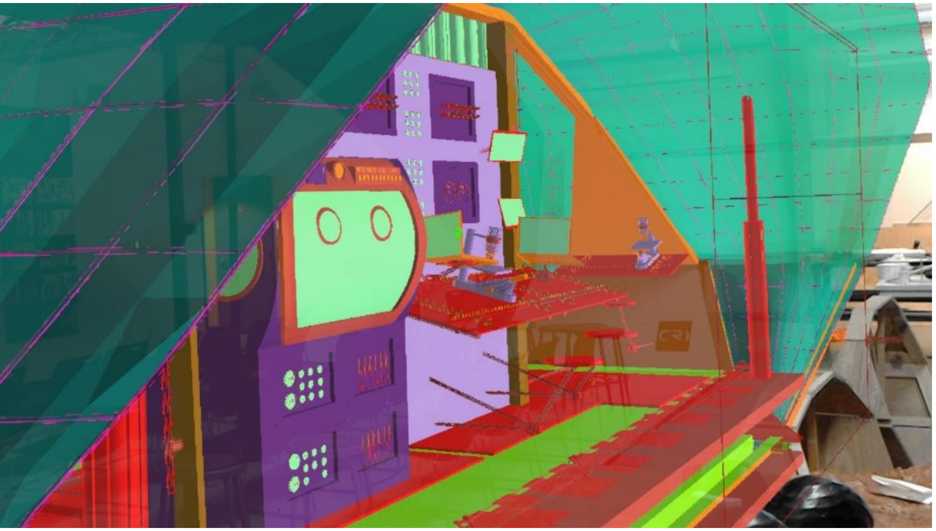
Full-Scale Prototype (AR)

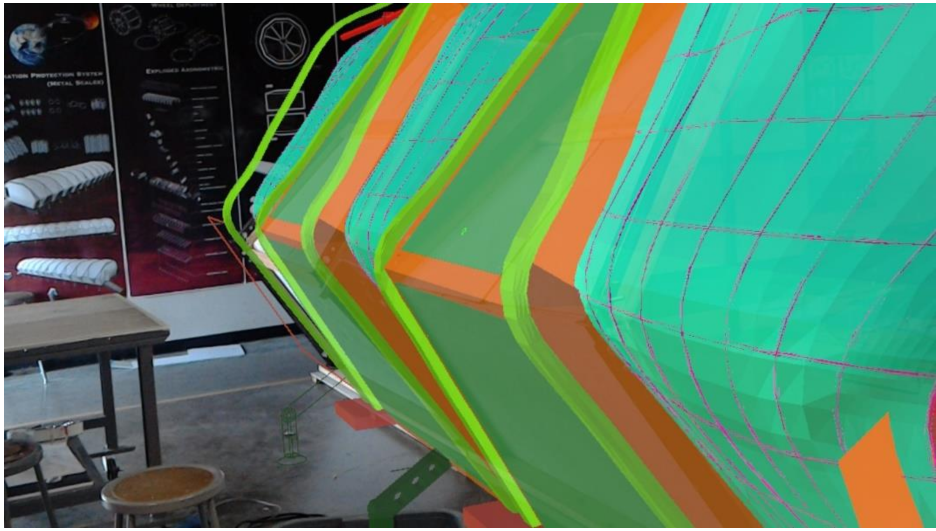
The full-scale mock-up was constructed using hollow section tubes, plywood sheathing and PTFE fabric. All 20 working drawings were computationally generated extracting the geometry from the VR Rhino model.



Full-Scale Prototype (AR)





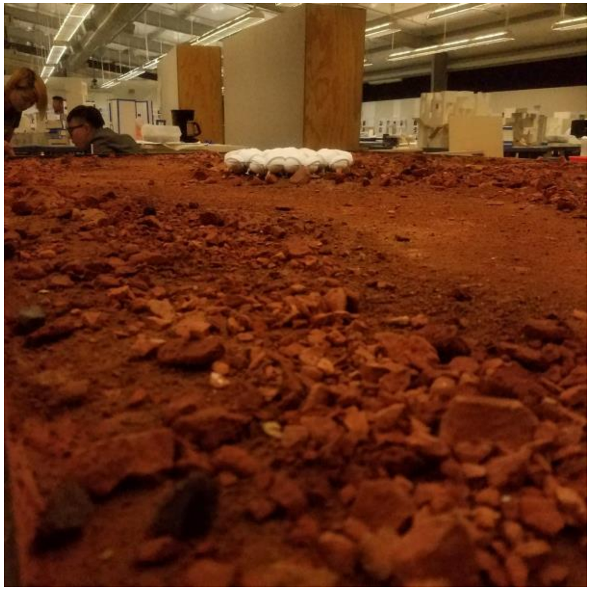

ATION PROTECTION SYSTEM
(METAL SCALES)
EXPLODED AXONOMETRIC

Fully detailed Virtual Reality Prototype (rolled and Unrolled (VR))

The Project was fully modelled in Rhino3D. The VR experience was generated with the Enscape plug-in for Rhino using 3D head sets (Occulus Rift)

Small Scale Robotics

Small Scale robotics was carried out with a “terrain” base and two models which explored both mobility and unrolling



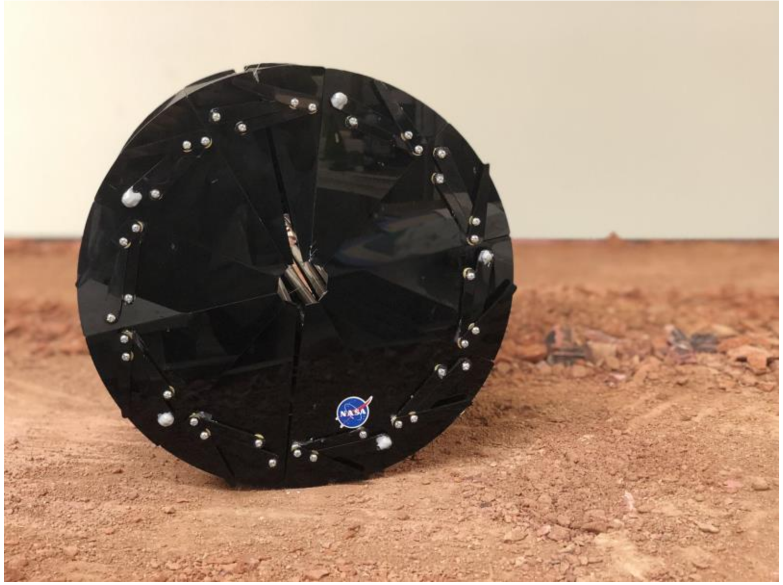
Base model measured at 5 feet wide by 8 feet long.

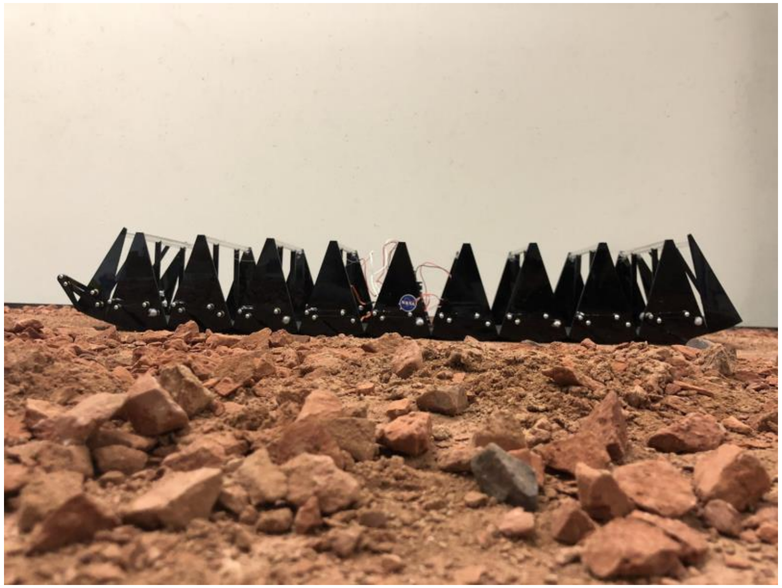
The next step was collecting certain sizes of brick aggregates and sands from local manufacturers to produce an average rocky terrain and texture of Mars. So what the team had done was to incorporate hydrocal for the main base which was mixed with red paint.

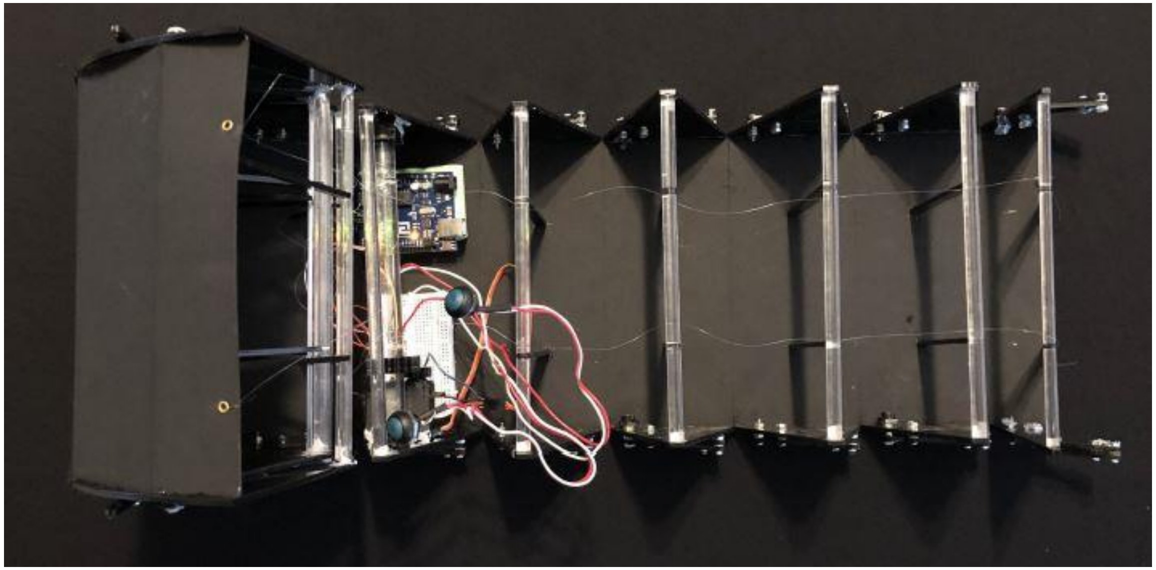
Afterwards, we spread chucks of rocks throughout the base for the finishing touches where the entire model became largely red.

Small Scale Robotics

Scale model exploring unrolling

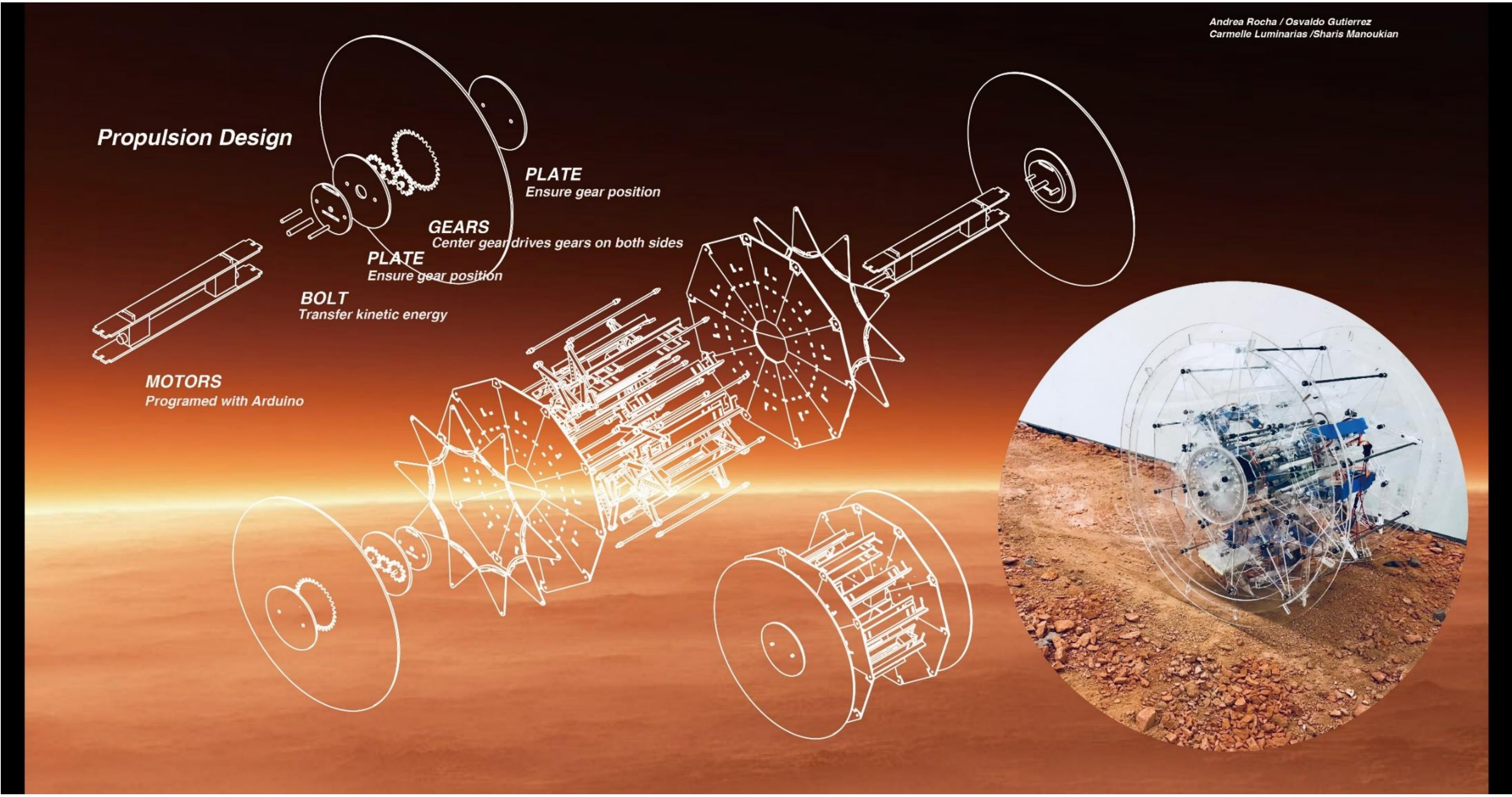




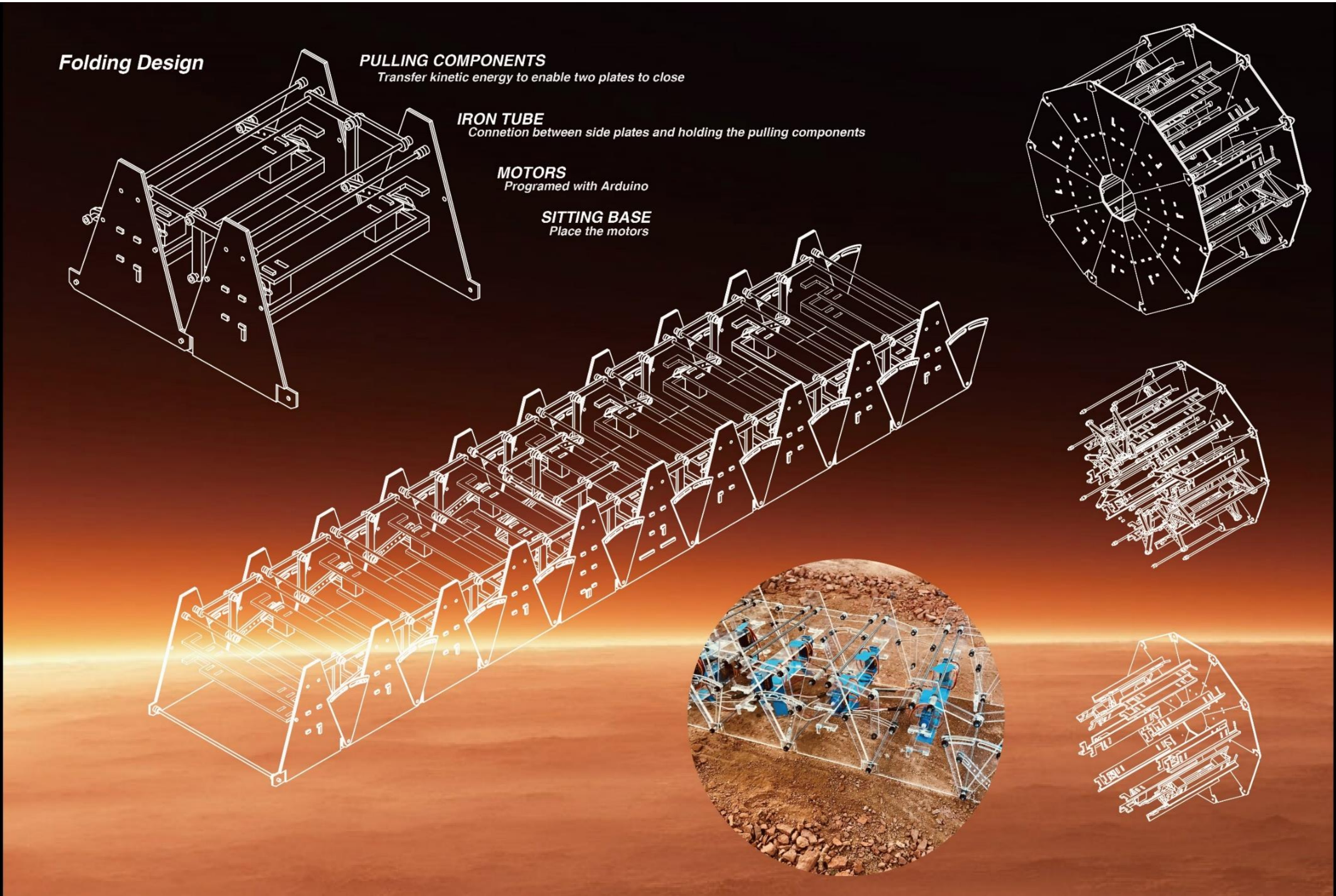


Small Scale Robotics

Scale model exploring mobility

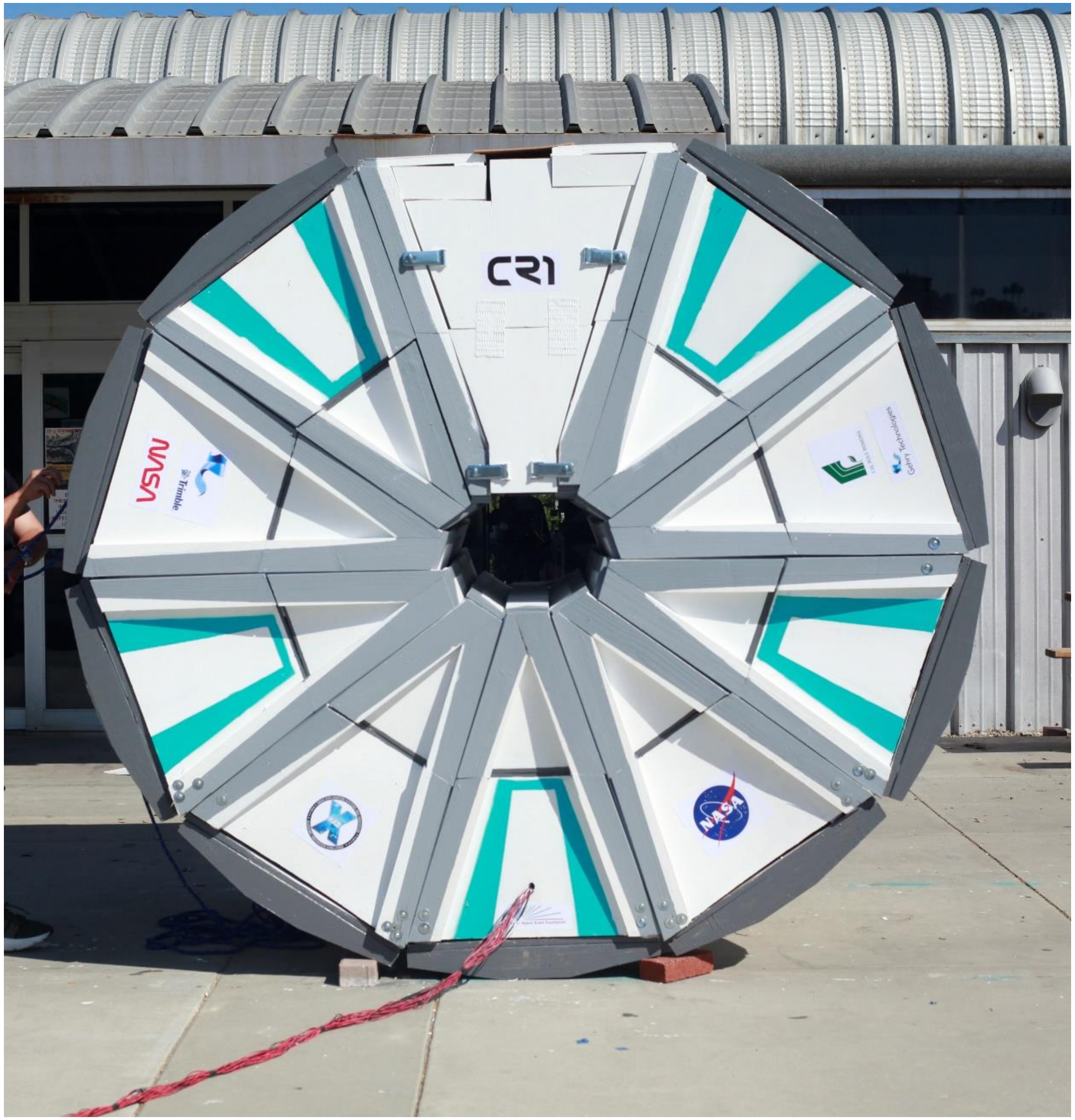


Small Scale Robotics



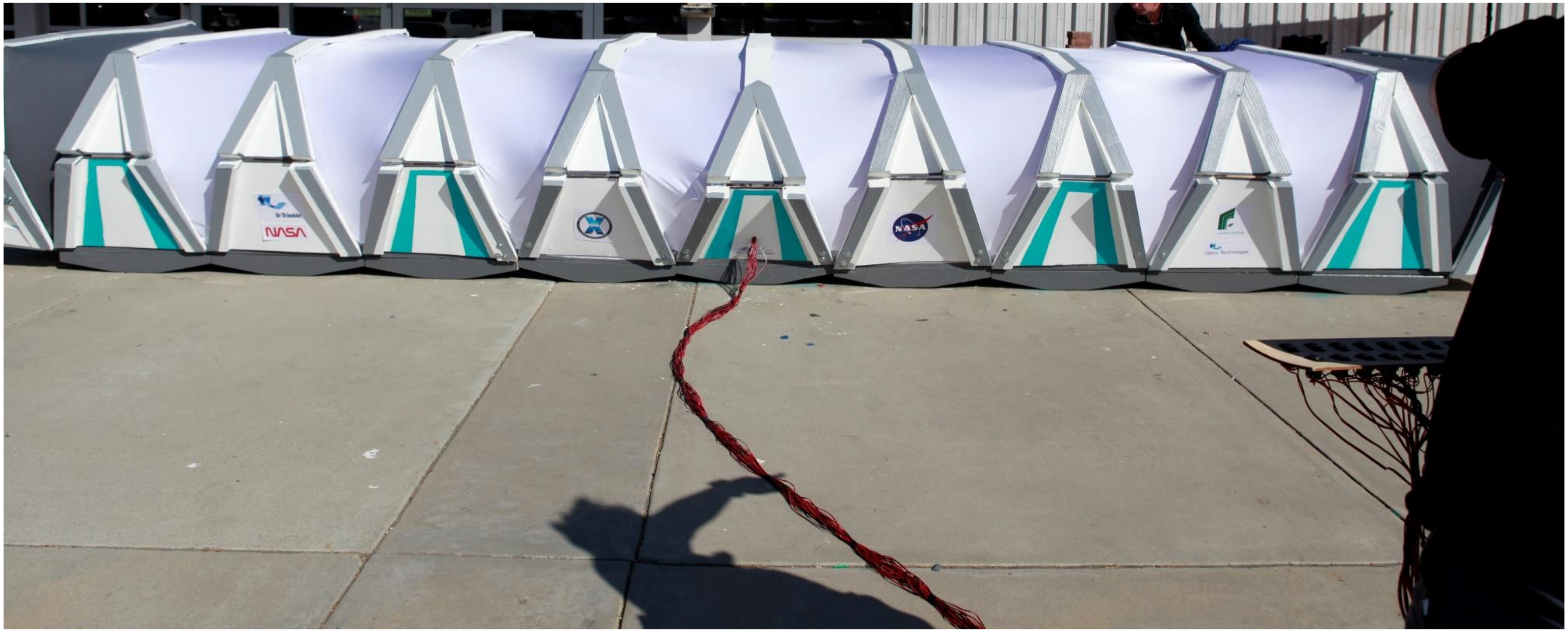
1:10 Physical Prototype

Used to explore kinematics, mechanics and connections



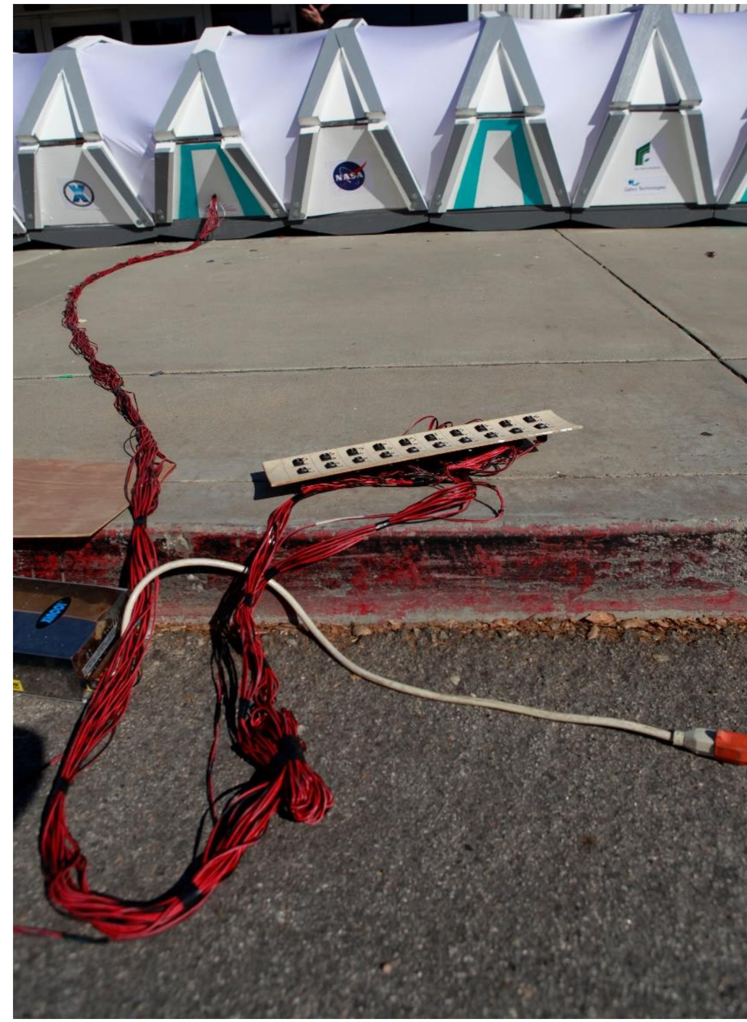
1:10 Physical Prototype

Used to explore kinematics, mechanics and connections



1:10 Physical Prototype

Used to explore kinematics, mechanics and connections




CR1
NASA


CRI


NASA
NASA


NASA
CAL POLY POMONA
Gehry Technologies

Dissemination

The project will be presented at 5 professional conferences with differing foci.

	Title/focus		
IASS 2018	Structure	MIT boston	16-20 July
2018 AIAA SPACE	Results of the Cal Poly Pomona NASA X-Hab Project	Orlando, FL	17 - 19 September
ICES2018- paper 202	Commonality of Mars IPV and Surface	Albuquerque, New Mexico	8-12 July
ICES 2018 paper 257	BIM	Albuquerque, New Mexico	8-12 July
NSS International Space Development Conference	General Overview	Los Angeles	May 23-27

Michael Fox, Professor Architecture
Marc Schulitz, Professor Architecture
Mikhail Gershfeld, Civil Engineering

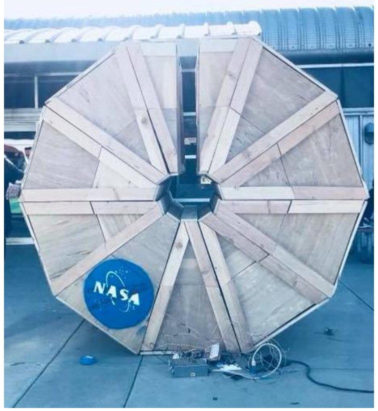
Consultants:

Marc Cohen
Astrotecture
Systems Engineering / Design

Allyn Polancic
Design Technology / HNTB Architecture
Collaborative Work Environment / BIM

German Aparicio
Director, Gehry Technologies
BIM / Design

Students:
Yu-chiao Lin, Teaching Assistant – Executive Project Coordinator



Laszlo Andrasi (Architecture)

Krystyna Howell (Architecture)

Lalo Espinoza (Architecture)

Johnny Busch (Architecture)

Yu-chiao Lin (Architecture)

Javier Correa (Architecture)

Madonna Sole (Architecture)

Edgar Sanchez (Architecture)

Sonny Contreras (Architecture)

Akemi Hidalgo (Civil Engineering)

Katherina Pishchik (Architecture)

Terry Xue(Architecture)

Ryan Dascanio (Architecture)

Dascha Wheeler (Architecture)

Andrew Tran (Civil Engineering)

Sorvito Areglado (Architecture)

Sin Gwon Baek (Architecture)

Tyler Thein (Architecture)

Jad Osseiran (Architecture)

Daniel Sanchez (Architecture)

Zheng Chen(Construction Engineering)

Ricardo Hernandez(Civil Engineering

Courtney Chan (Civil Engineering)

John Duguil (Civil Engineering)

Michelle Wangwa (Civil Engineering)

Miguel Magpantay (Civil Engineering)

Lucas Gabaldo Borghese (Civil Engineering)

Charles Kayser (Civil Engineering)

Anh Nghiem (Civil Engineering)

Andrea Nuno (Civil Engineering)

Billy Jimenez (Civil Engineering)

Victor Orozco (Civil Engineering)

Chingmei Lee (Architecture)

Skyler Maroste (Architecture)

Eduardo Martinez (Architecture)

Liliana Perez (Architecture)

Marc Rudy (Architecture)

Sanhloc LeHuynh (Architecture)

Sonny Contreras (Architecture)

Daniel Sanchez (Architecture)

Jocelyn Hernandez (Architecture)

Qiting Huang (Architecture)

Giancarlo Manglicmot (Architecture)

Franco Mellone (Architecture)

Nick Ramirez (Architecture)
Larry Phong (Architecture)

Gemme t. Ng (Architecture)

Samuel Cruz Prado (Architecture)

Roger Yu (Architecture)

Erick Cerano (Architecture)

Sonny Contreras (Architecture)

Evanna Diaz (Architecture)

Osvaldo Gutierrez Munoz (Architecture)

Jocelyn Hernandez (Architecture)

Carmelle Luminarias (Architecture)

Sharis Manoukian (Architecture)

Skyler Maroste (Architecture)

Gem Nguyen (Architecture)

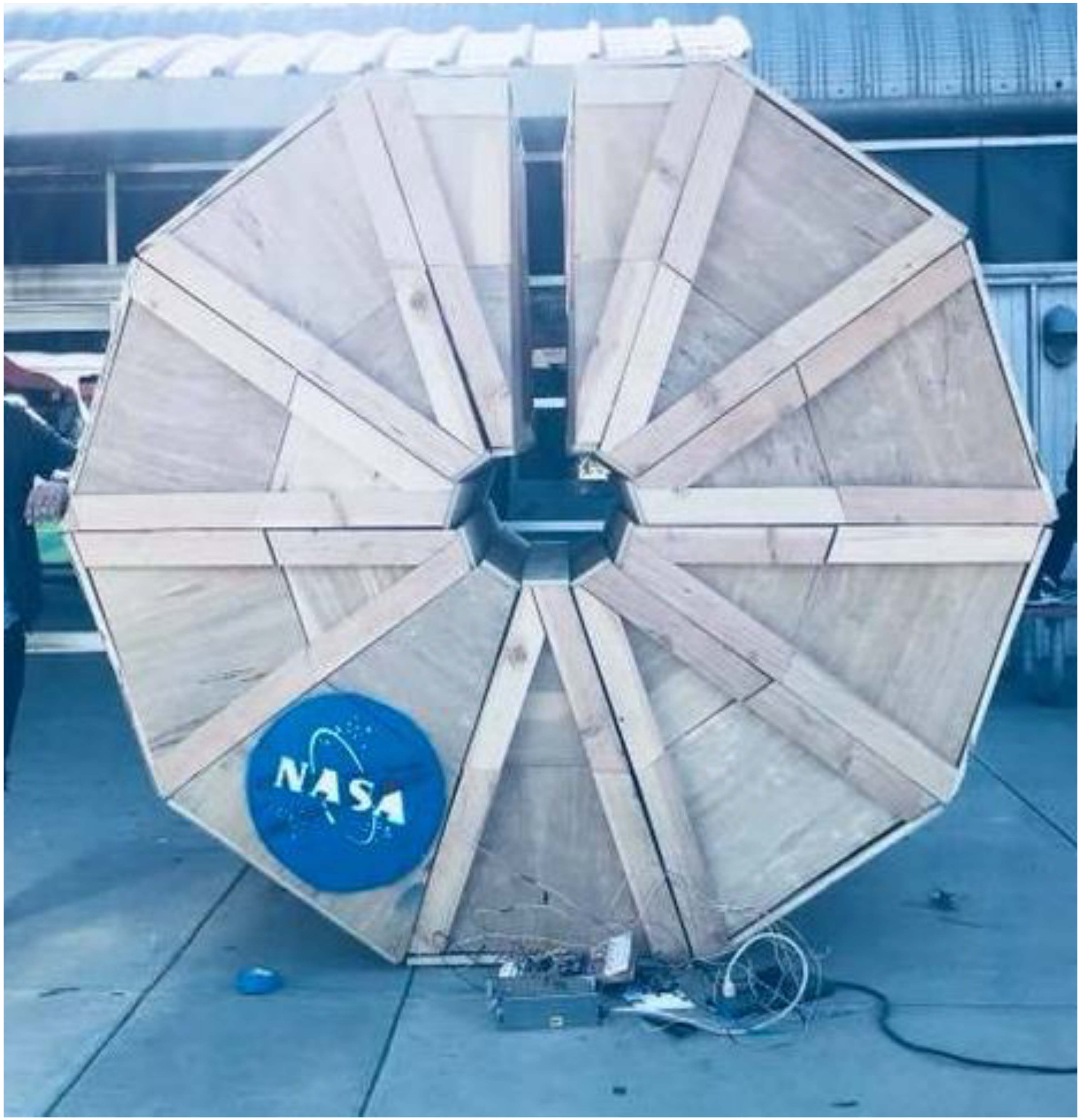
Nick Ramirez (Architecture)

Andrea Rocha (Architecture)

Eric Ton (Architecture)

Maryam Tork (Architecture)

Roger Yu (Architecture)


NASA