MARS ICE HOUSE

Alba Mons, Mars
2015

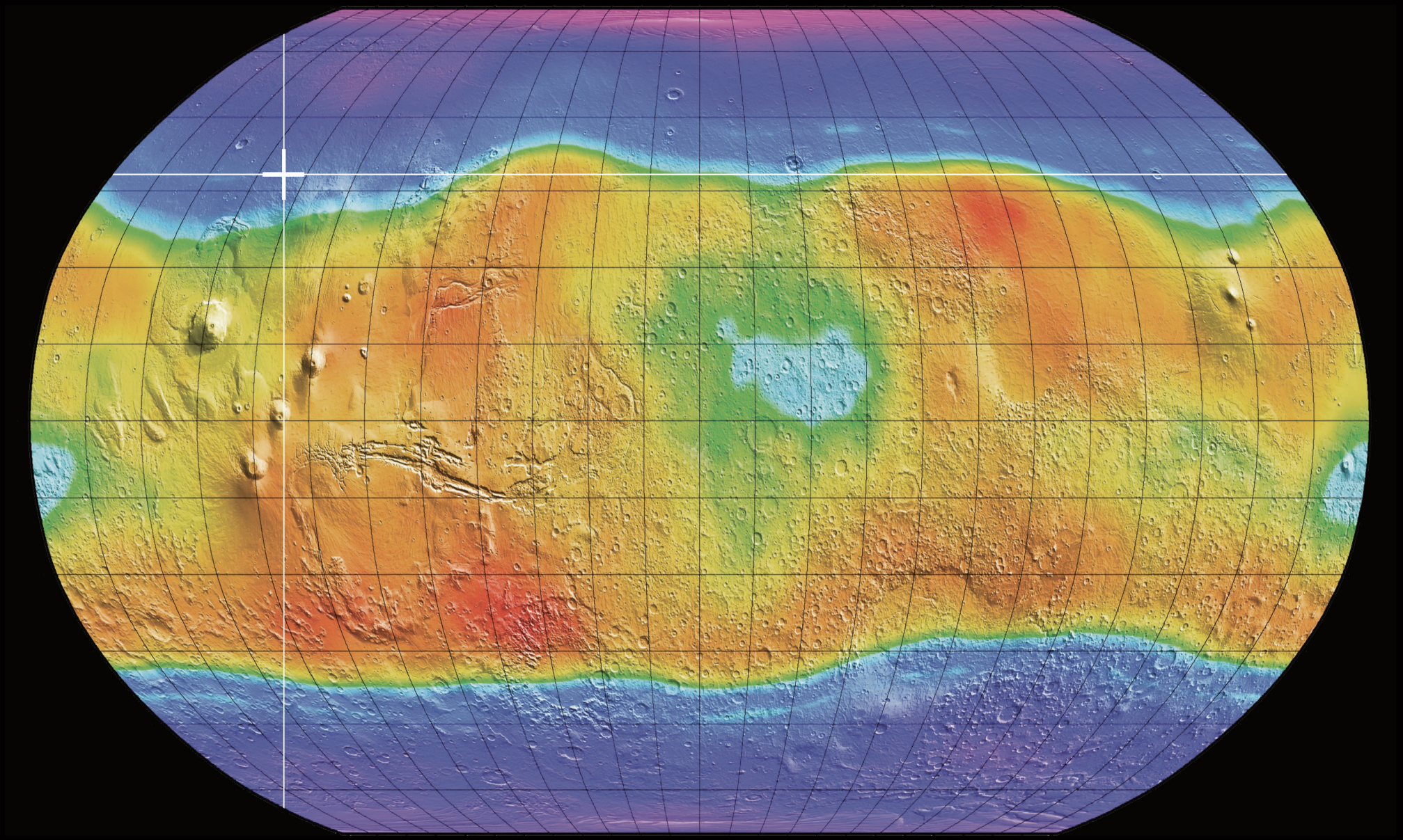
Water is essential for all known life. Scientific discoveries offer proof that planetary bodies within our solar system are awash with water - more than 5 million km3 of water ice exist on Mars. Ice is an excellent radiation shield, reducing transmission of ultraviolet solar and galactic gamma rays to safe levels. Mars Ice House takes advantage of waters abundance on Mars and life sustaining properties to robotically construct a habitat in advance of 4 astronauts who will first arrive to live on the planets surface.

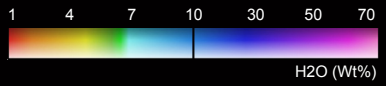
Located in the northern latitudes of Alba Mons, where an abundance of water ice is believed to be only 30cm beneath loose regolith, the project was designed in response to NASA's Centennial 3D Printed Challenge competition. It employs the physics of phase transition and energy efficient harvesting of Martian ice to be 3D printed as liquid water that freezes on contact at the sites constant -0°C temperatures.

Organized vertically about a lander module that houses mechanical and life support systems, multi-layered ice shells are printed within an inflated Dyneema reinforced membrane. The nested redundancy of the ice shells creates two pressurized zones that house a hydroponic garden and allow astronauts to experience semi-exterior space without the use of a suit: an inner insulated pressure and temperature regulated zone, and an intermediate pressure regulated zone requiring an oxygen mask. This ' yard' extends the boundaries of safely occupiable space and provides an overflow cavity for venting to prevent contamination.

The structurally engineered translucent ice shells maximize interior access to daylight, linking inhabitants to circadian rhythms essential to overall health. The shells are printed in a gradient of thicknesses with transparent gas filled apertures affording panoramic views to the landscape beyond.

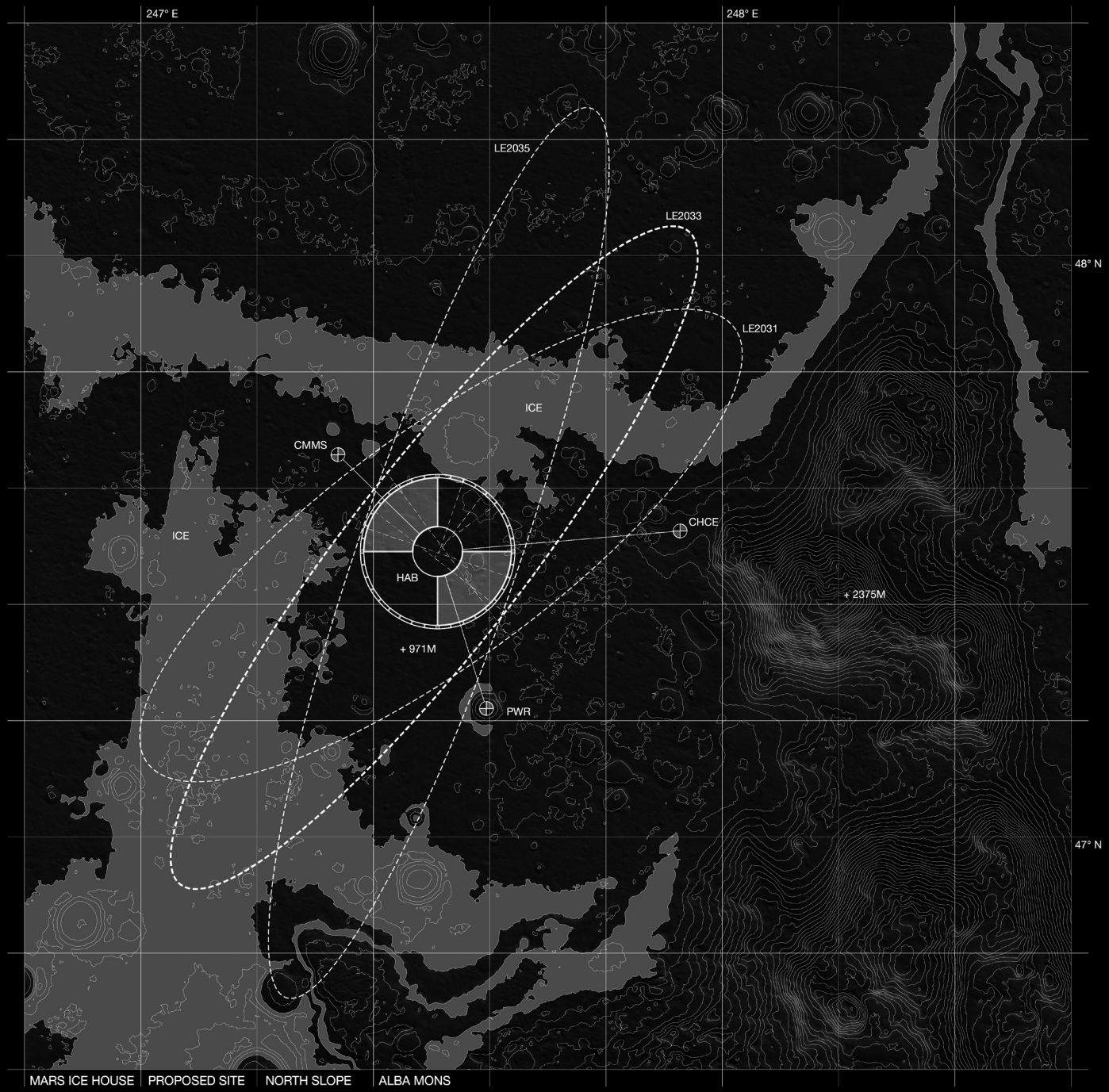
The luminous architecture of Mars Ice House celebrates mans first presence on Mars, while embodying spatial, material, and temporal dimensions paramount to the crews physical and psychological well being. Critical of imagined precedents that situate planetary explorers within dark caves and regolith covered spaces, Mars Ice House offers a paradigmatic shift in extraterrestrial habitat design through innovative 3D printed ice construction that reintroduce light and air to the living spaces.





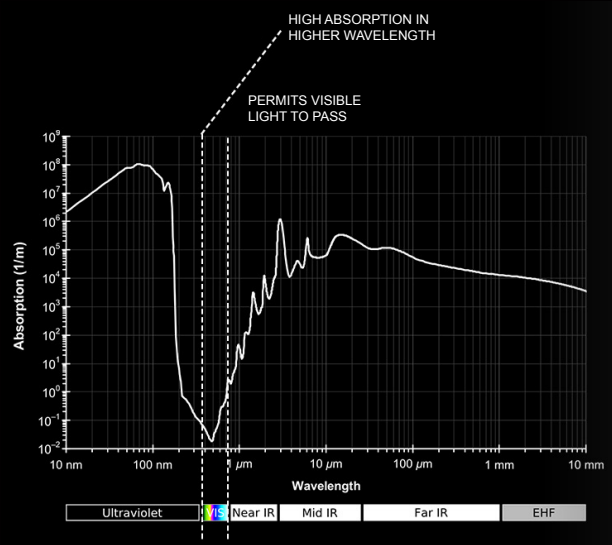
SITE LOCATION REGISTERED ON WATER MAP

SITE: ALBA MONS, MARS: 45N-50N LATITUDE / 230E-270E LONGITUDE

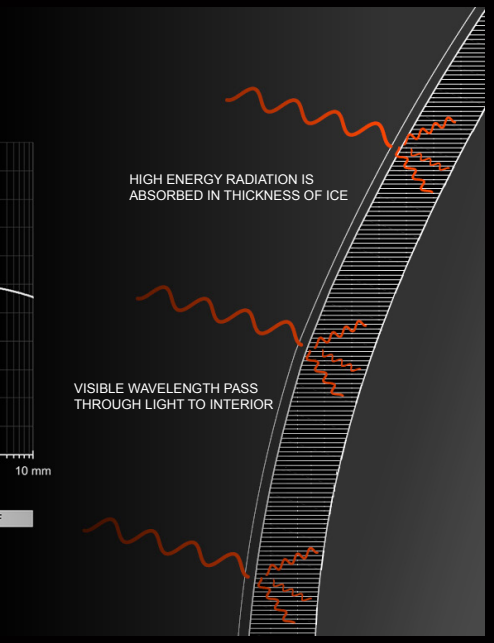


SITE PLAN WITH LANDING LOCATION TOLERANCE

CONCEPT IMAGE OF HABITATION WITH NATURAL LIGHT AND EXPANSIVE VIEW OF MARTIAN LANDSCAPE



ELECTROMAGNETIC ABSORPTION BY WATER

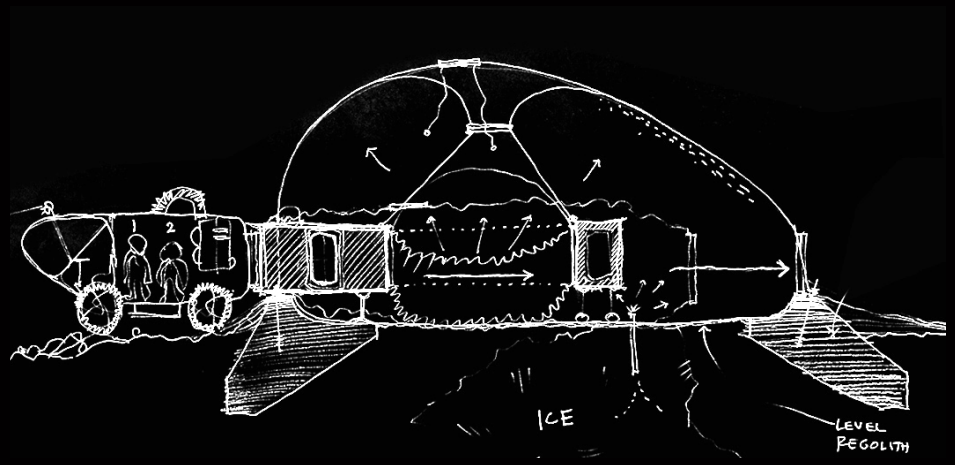


RADIATION SHIELDING USING ICE SHELL

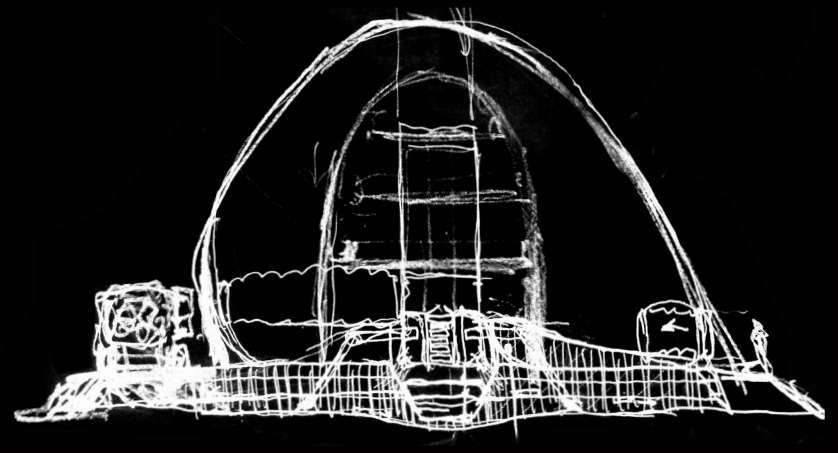
ICE AS SOURCE OF LIFE AND ARCHITECTURE

- INDIGENOUS TO MARS
- ESSENTIAL FOR LIFE
- EXCEPTIONAL RADIATION SHIELD
- TRANSPARENCY FOR VIEW
- NATURAL LIGHT
- MARS AVERAGE TEMPERATURE -43°C
- ENERGY EFFICIENT FABRICATION
- NATURAL AESTHETICS

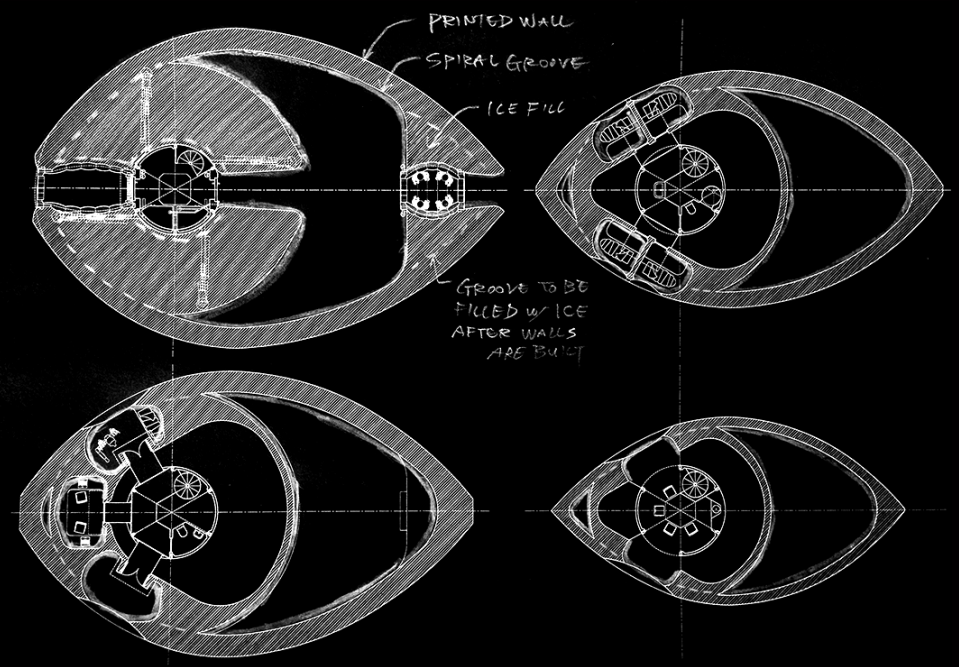
CONCEPT: TRANSPARENCY AND RADIATION PROTECTION USING ICE



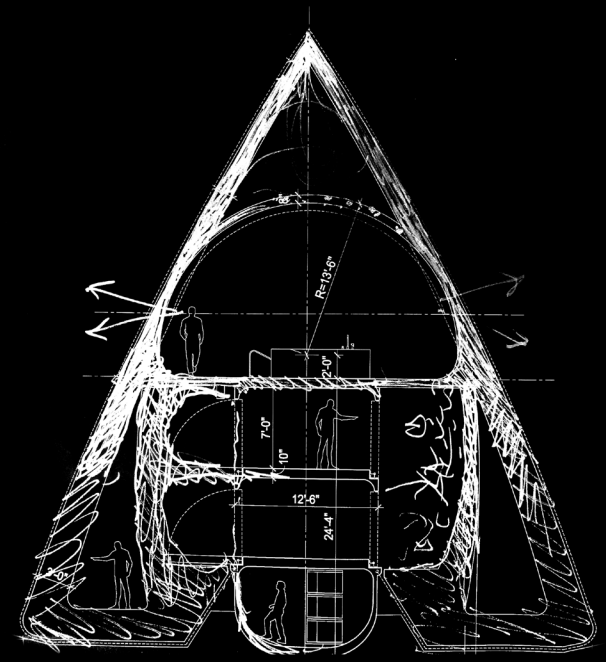
CONCEPTUAL LONGITUDINAL SECTION ILLUSTRATING LAYERED INTERMEDIATE SPACES



DEVELOPMENT ILLUSTRATING THREE PROTECTIVE LAYERS: DOUBLE ICE SHELL AND LANDING VEHICLE

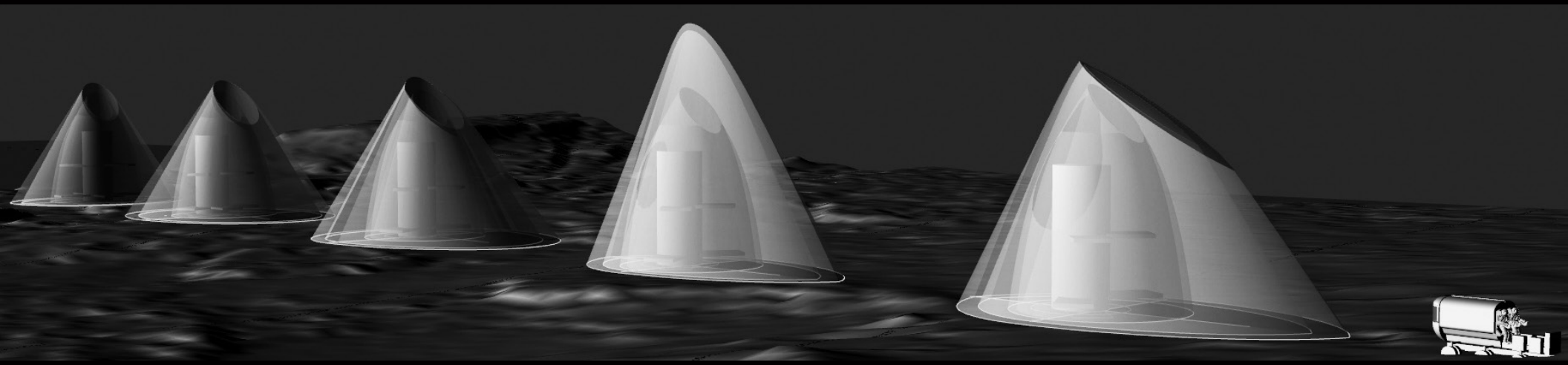


PROGRESS PLAN ILLUSTRATING PROGRAM LAYOUT AND ICE 3D PRINTING TRACKS

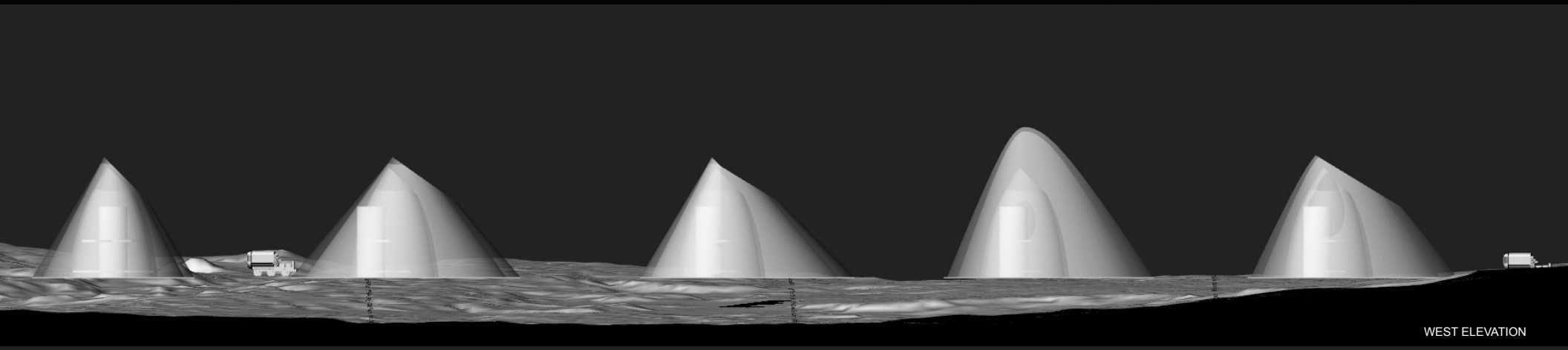


SHORT SECTION ILLUSTRATING WINDOW AREAS WHERE ICE SHELLS CONVERGE

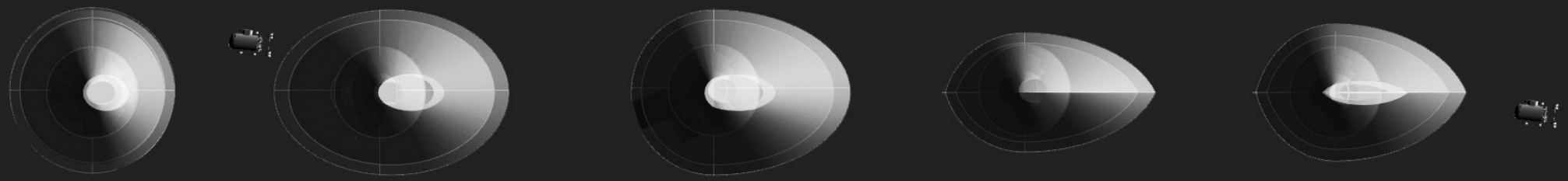
ARCHITECTURAL DEVELOPMENT: LAYERED PROTECTIVE SHELLS WITH GRADATIONAL BUFFER ZONES



VIEW FROM SOUTHWEST



WEST ELEVATION



A: CIRCLE
(TOP CHAMFER)

B: ELLIPSE
(TOP CHAMFER)

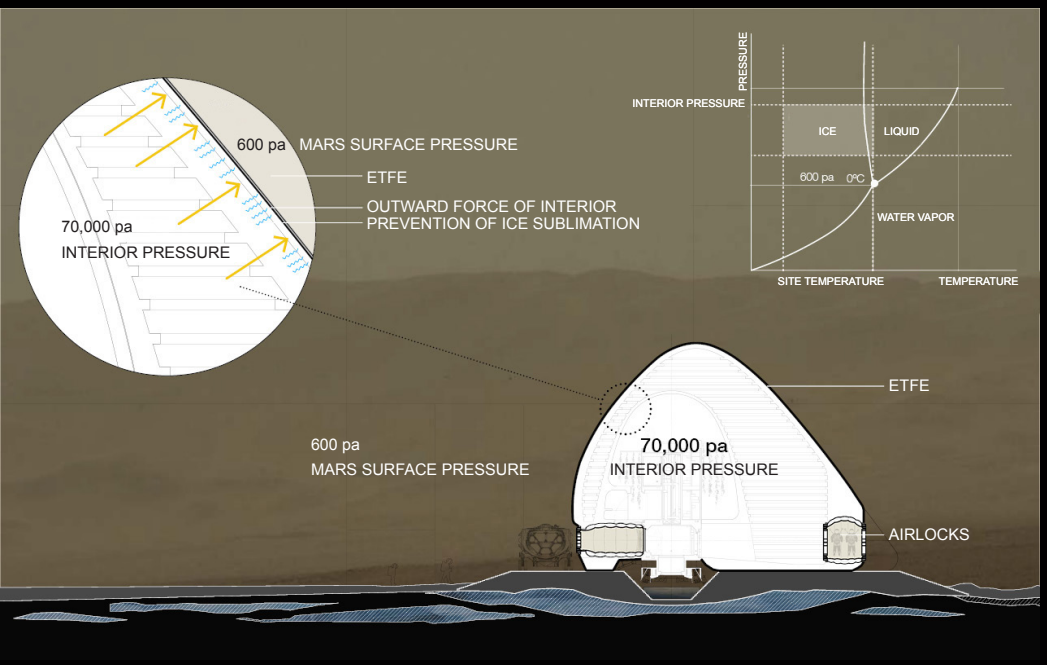
C: CIRCLE + ELLIPSE
(TOP CHAMFER)

D: COMPOSITE CONE
(CREASED/NO CHAMFER)

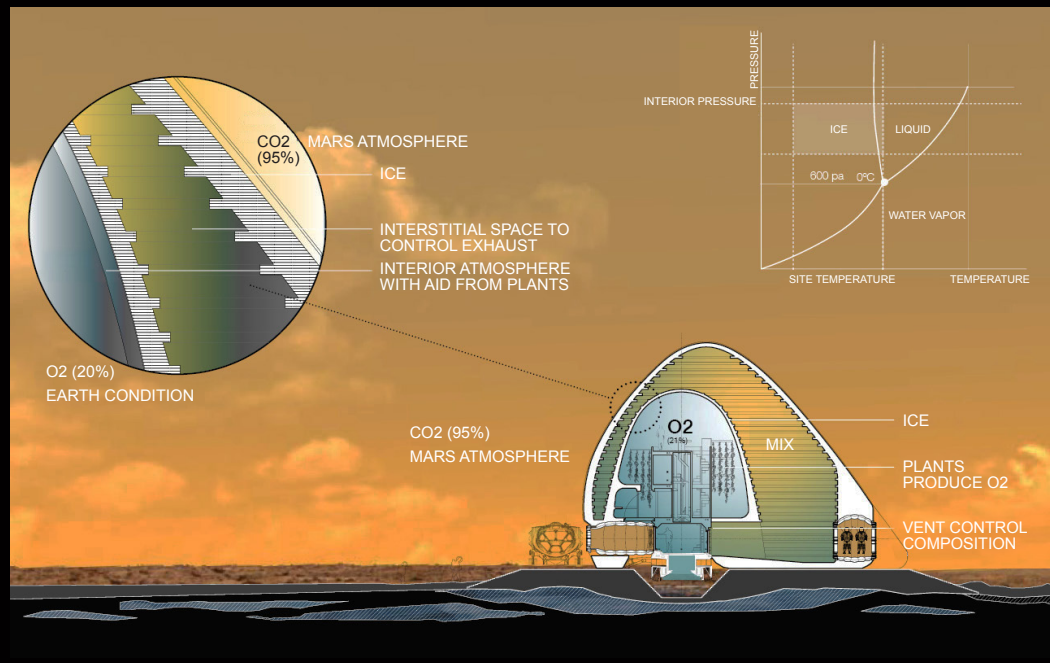
E: COMPOSITE CONE
(CREASED/TOP CHAMFER)

PLAN

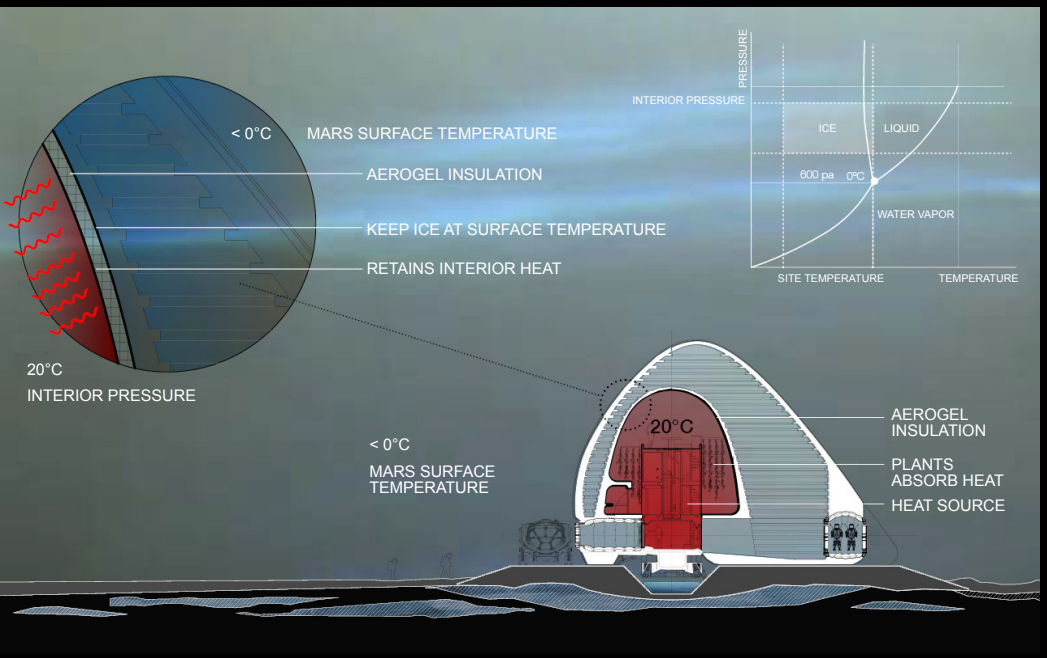
MASSING AND GEOMETRY STUDY



AIR PRESSURE DIAGRAM



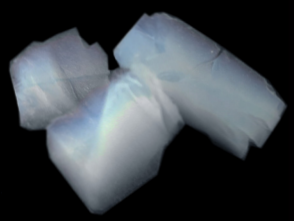
AIR COMPOSITION DIAGRAM



TEMPERATURE DIAGRAM

ETFE REINFORCEMENT:
DYNEEMA FIBER

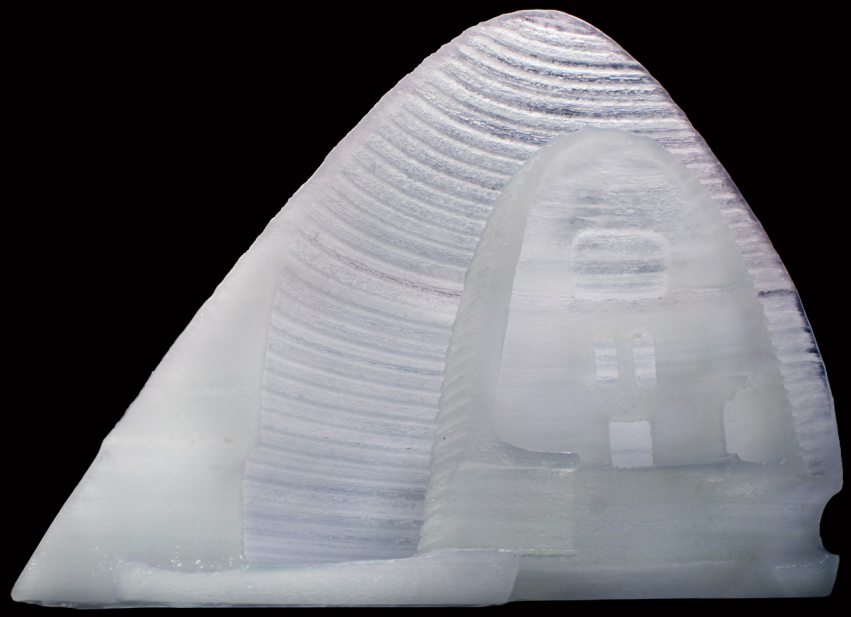
ICE REINFORCEMENT:
POLYMER FIBER



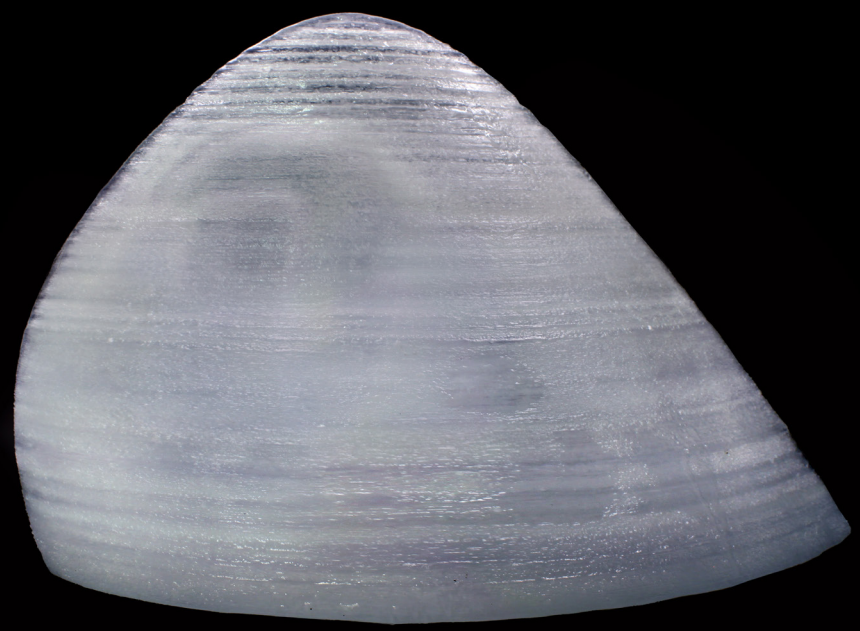
INSULATION:
AEROGEL

REINFORCEMENT AND INSULATION MATERIALS

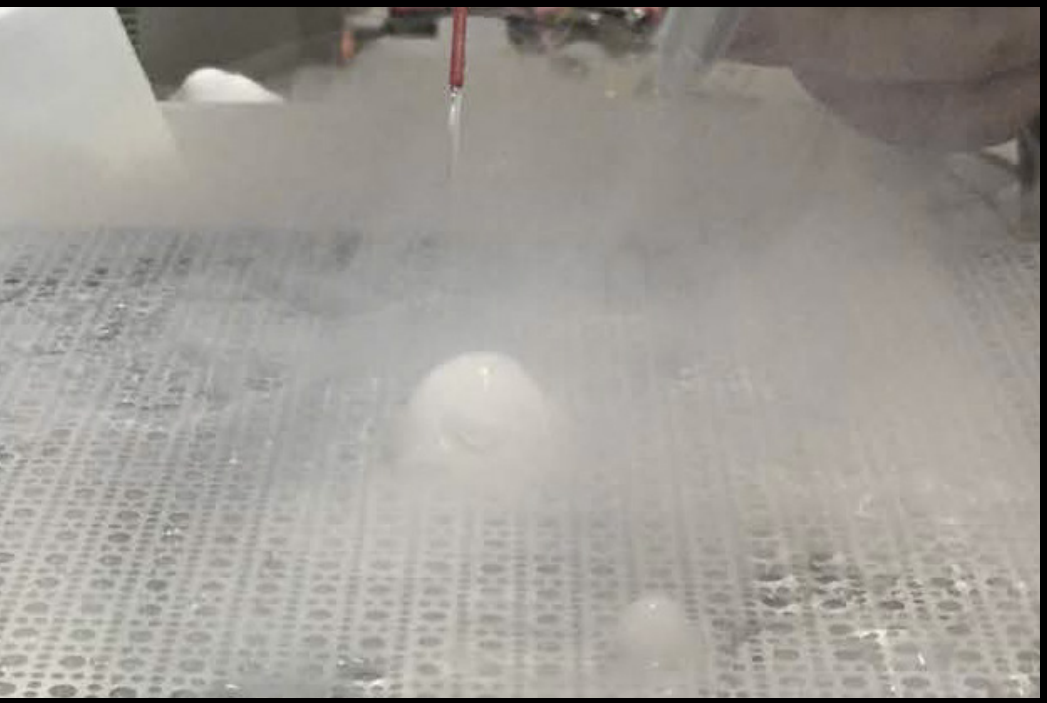
ENVIRONMENTAL / RADIATION SHIELDING DIAGRAM : GRADATIONAL BUFFER ZONES AND PROTECTION REDUNDANCY



ICE 3D PRINT SHELL TEST SAMPLE (INTERIOR)



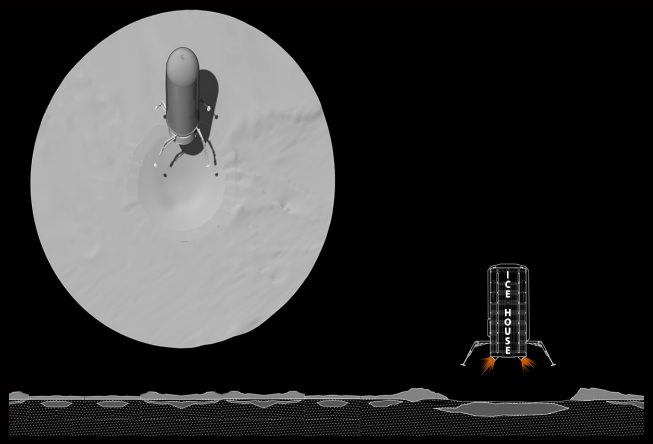
ICE 3D PRINT SHELL TEST SAMPLE (EXTERIOR)



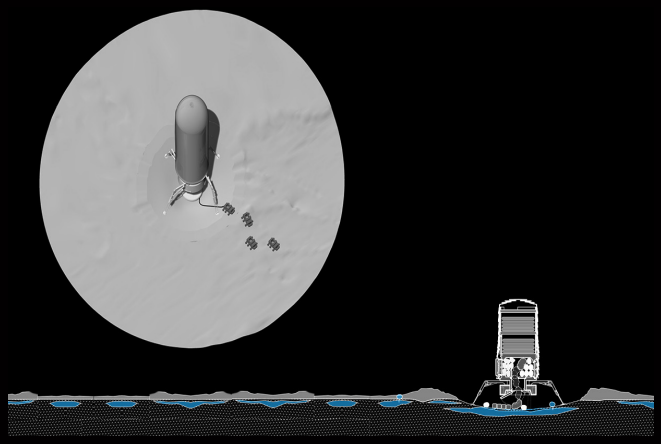
MATERIAL TESTING APPROXIMATING ATMOSPHERIC FREEZING CONDITIONS ON MARS

ICE 3D PRINT SHELL TEST (8 DEGREES FARENHEIT USING REMOVABLE SHORTENING SCAFFOLDING)

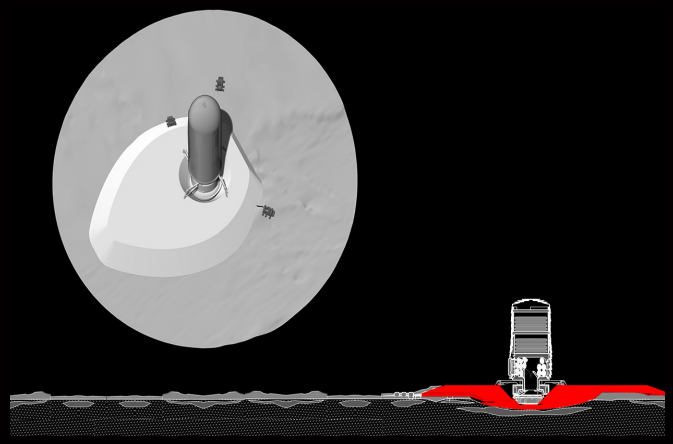
ICE 3D PRINT EXPERIMENT AND TEST SAMPLE



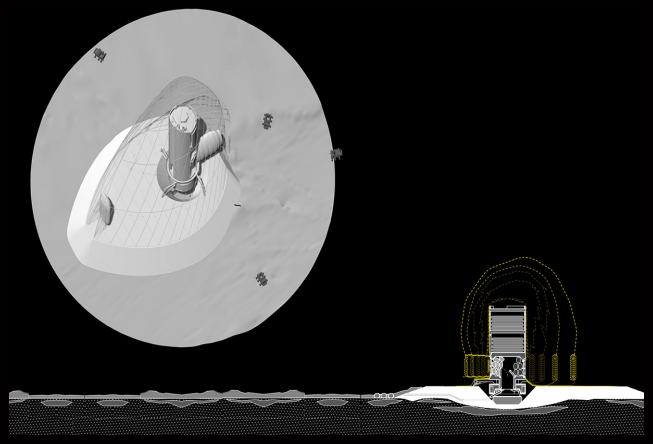
AUTONOMOUS LANDING VEHICLE LANDING



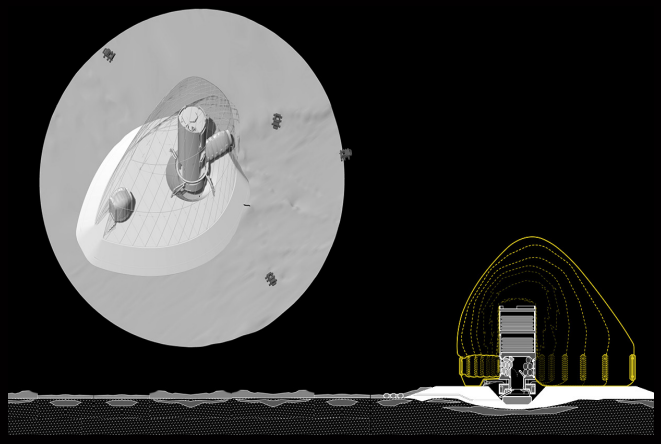
ICE MINING / SINTERING ROBOTS DEPLOYMENT



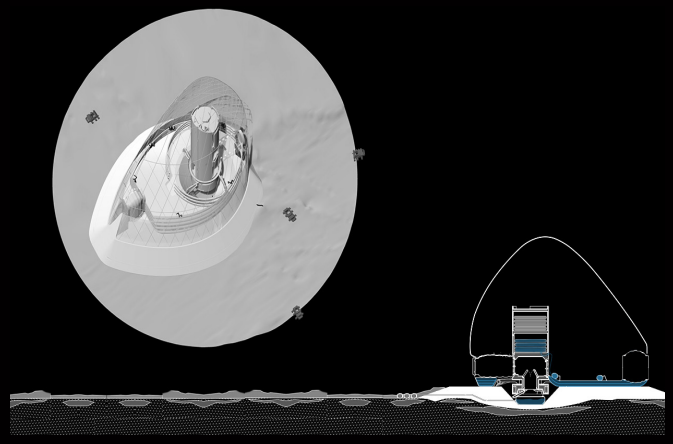
REGOLITH FOUNDATION SINTERING



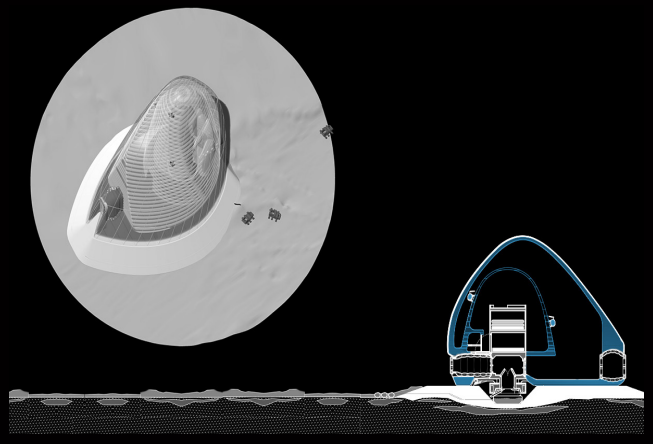
ETFE INFLATABLE MEMBRANE DEPLOYMENT



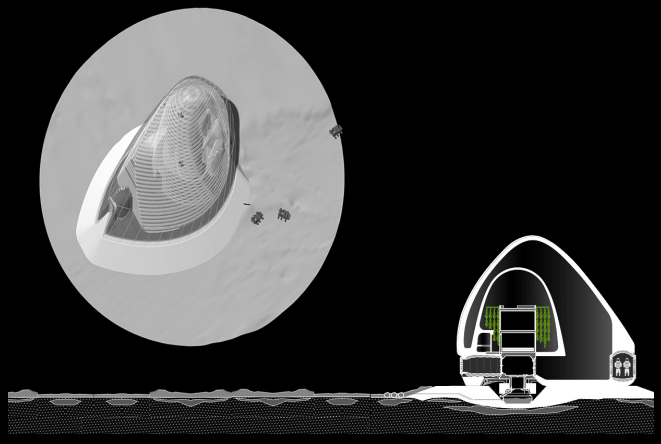
ETFE INFLATABLE MEMBRANE PRESSURIZATION



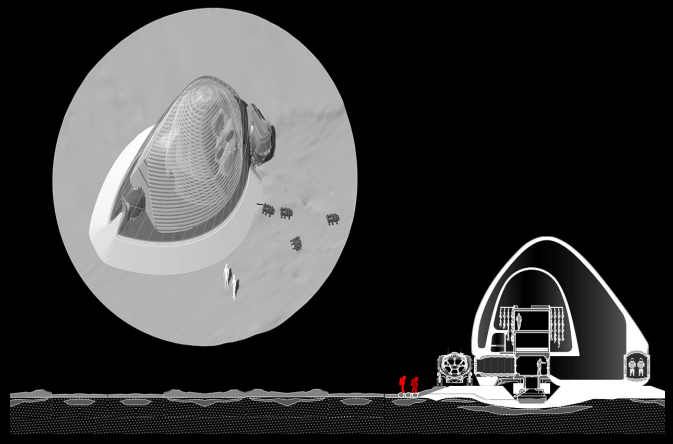
3D ICE PRINTING ROBOT DEPLOYMENT



3D ICE/INSULATION PRINTING COMPLETE

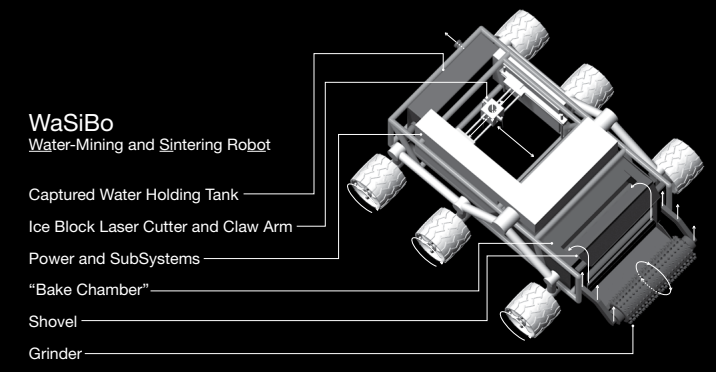


OXYGEN GENERATION / TEMPERATURE CONTROL

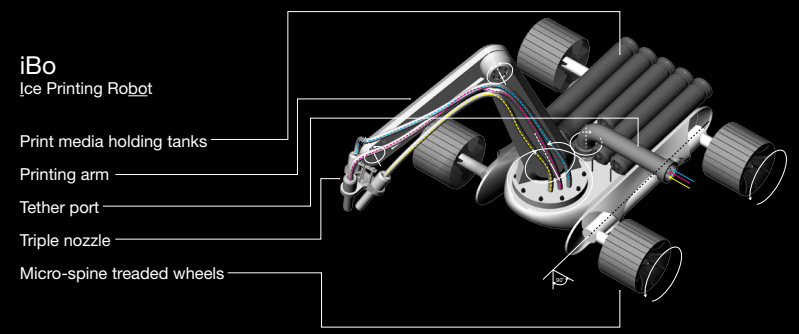


CREW ARRIVAL AFTER COMPLETION

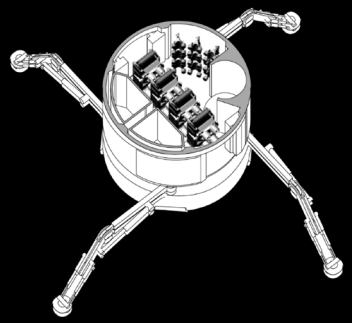
DEPLOYMENT AND FABRICATION SEQUENCE DIAGRAM



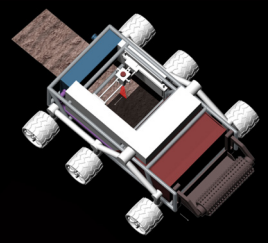
ICE MINING / REGOLITH SINTERING ROBOT ANATOMY



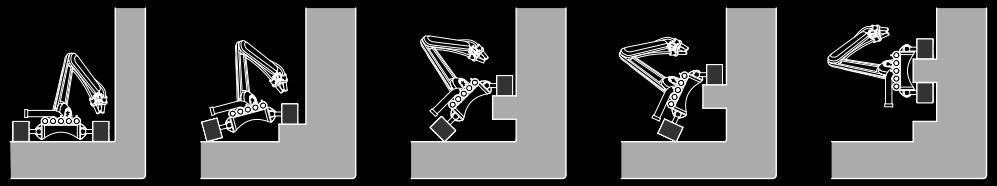
ICE 3D PRINTING ROBOT ANATOMY



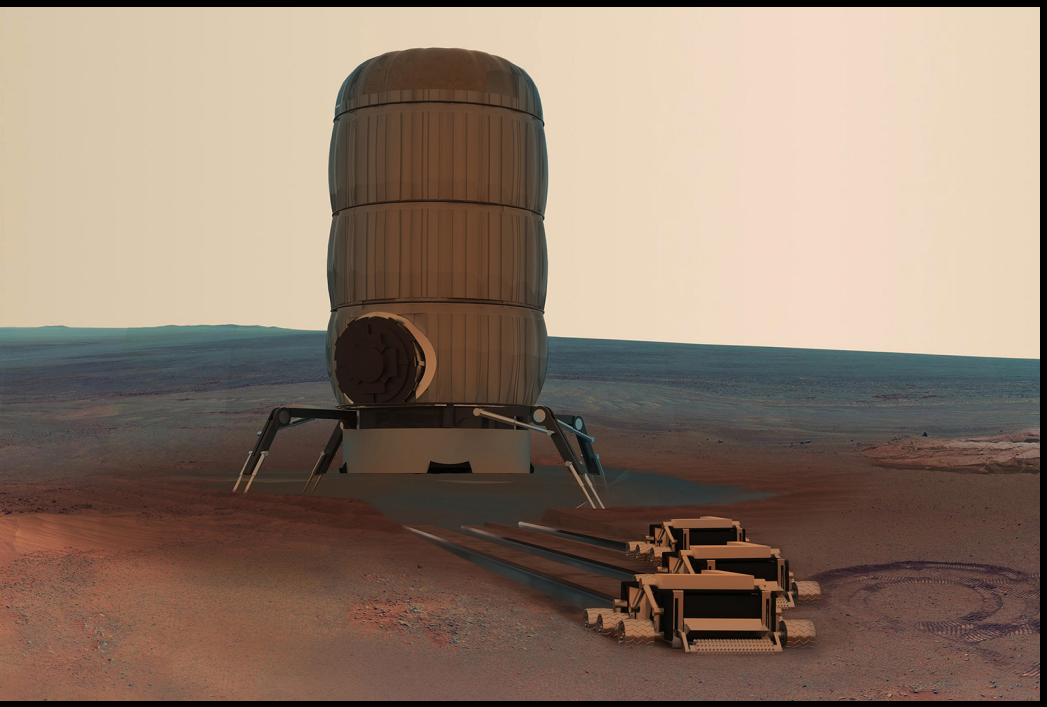
CONFIGURATION OF ROBOTS IN LANDING VEHICLE



WaSiBo SINTER MODE



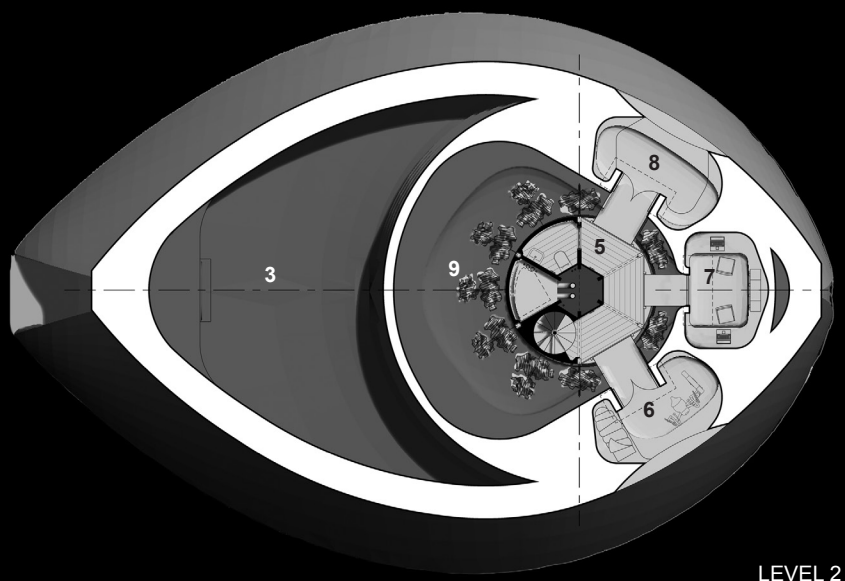
PROCESS OF PRINTING AND CLIMBING ICE WALL USING SPIRAL TRACK PROFILE



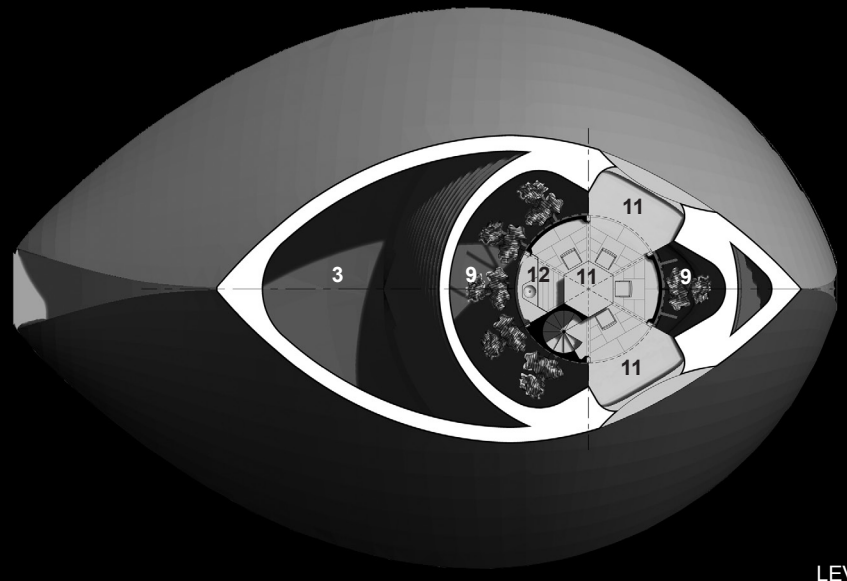
AUTONOMOUS LANDING VEHICLE AND ICE MINING / REGOLITH SINTERING ROBOT

ICE 3D PRINTING PROGRESS

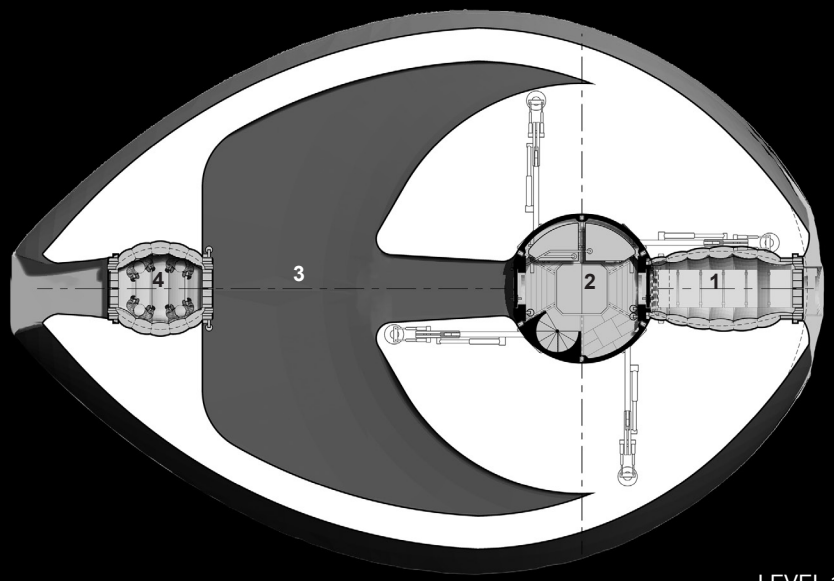
ICE MINING / 3D PRINTING ROBOTS



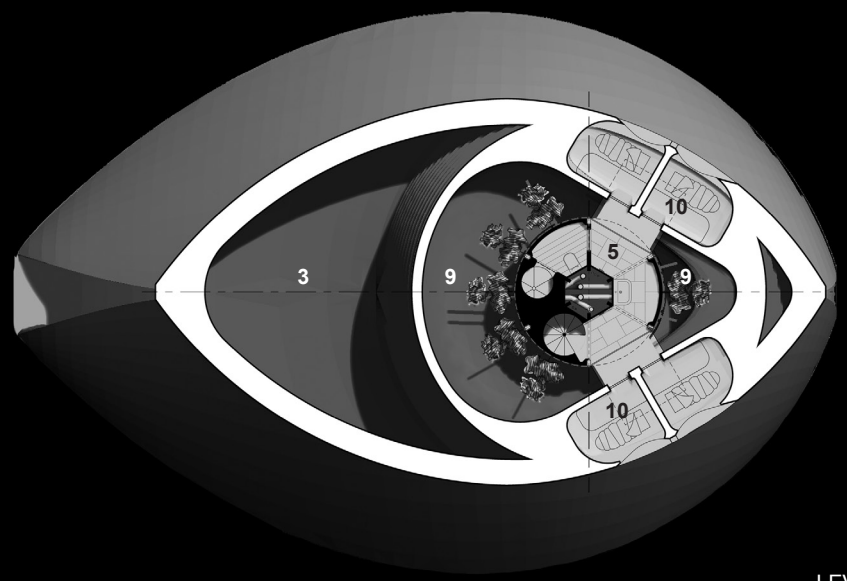
LEVEL 2



LEVEL 4



LEVEL 1

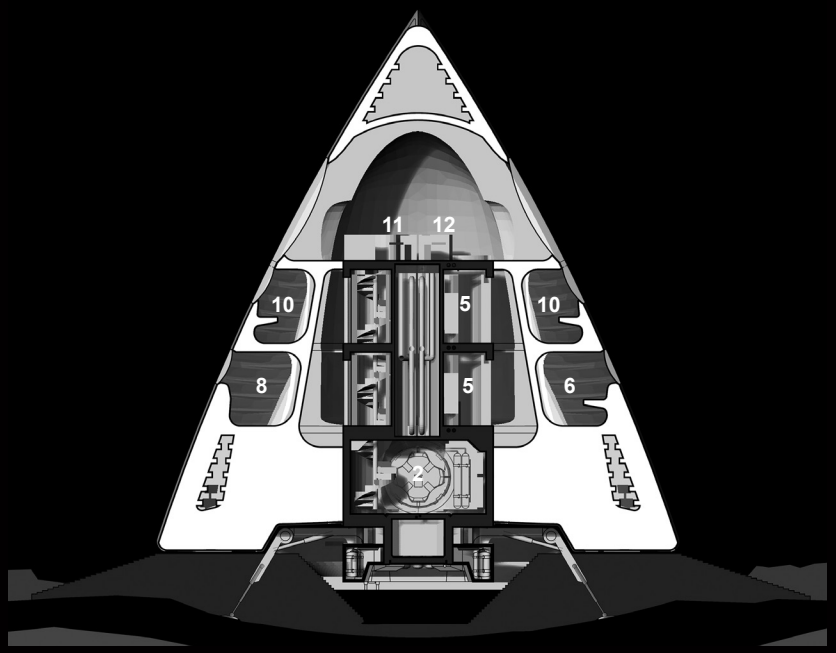


LEVEL 3

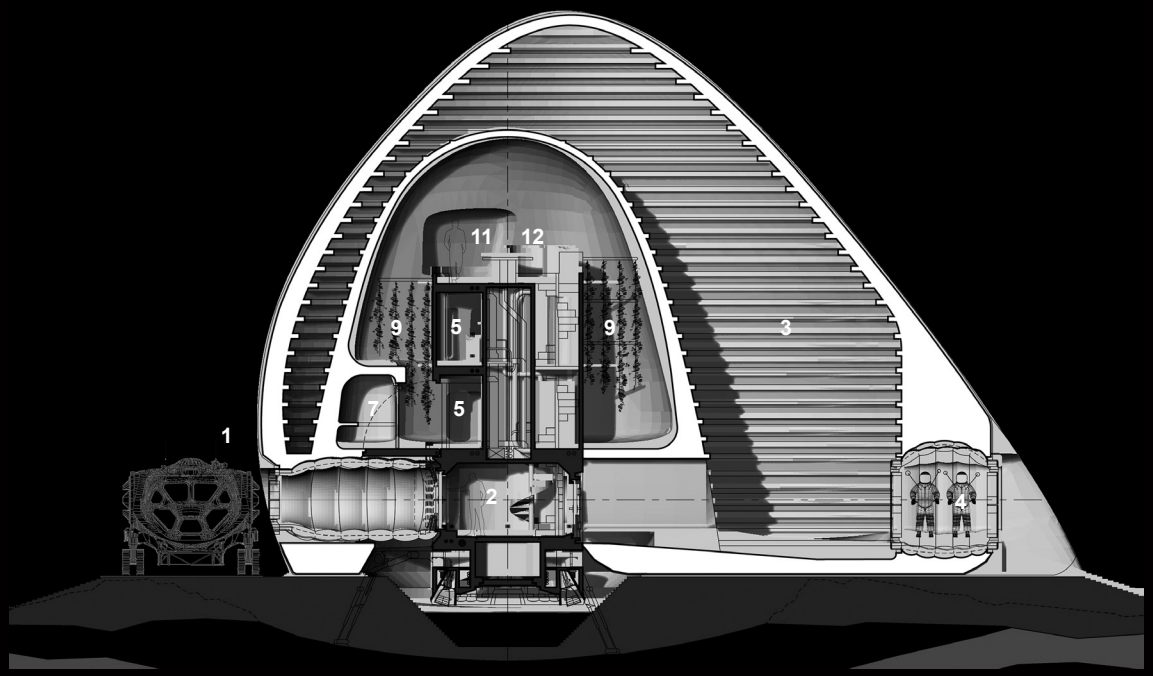
1. ROVER DOCK
2. ENTRY LEVEL / ECLSS
3. YARD (INTERMEDIATE CONTAINMENT ZONE)
4. EGRESS AIRLOCK
5. HYGIENE AREA / BATHROOMS
6. EXERCISE / MEDICAL
7. LABORATORY
8. LIBRARY / MEETING
9. VERTICAL HYDROPONIC GREENHOUSE
10. CREW QUARTER
11. WARDROOM / GALLERY
12. FOOD PREPARATION

0 10 20FT

PLAN



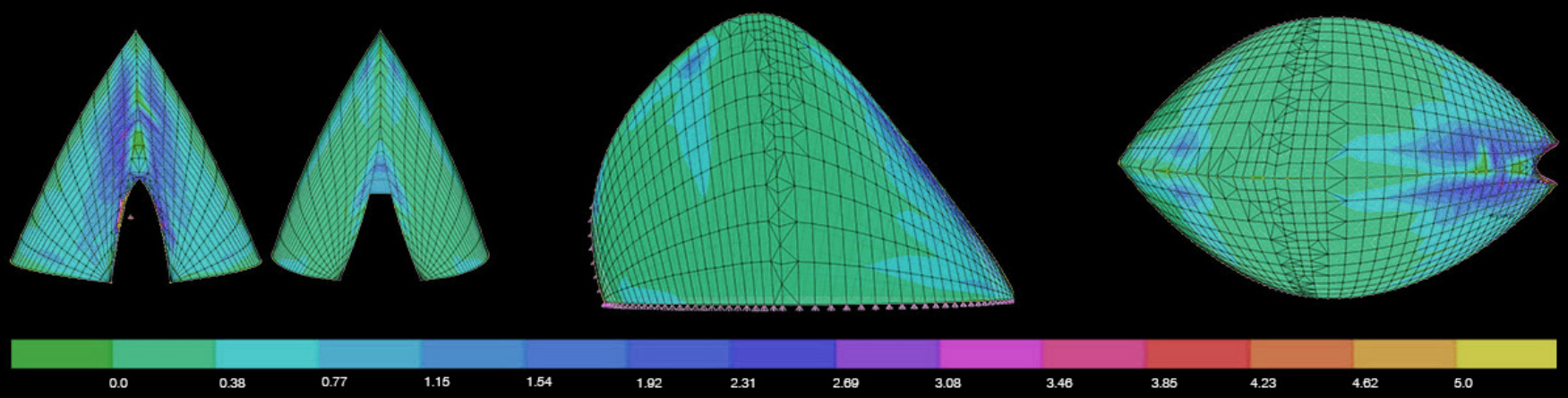
EAST-WEST SECTION



NORTH-SOUTH SECTION

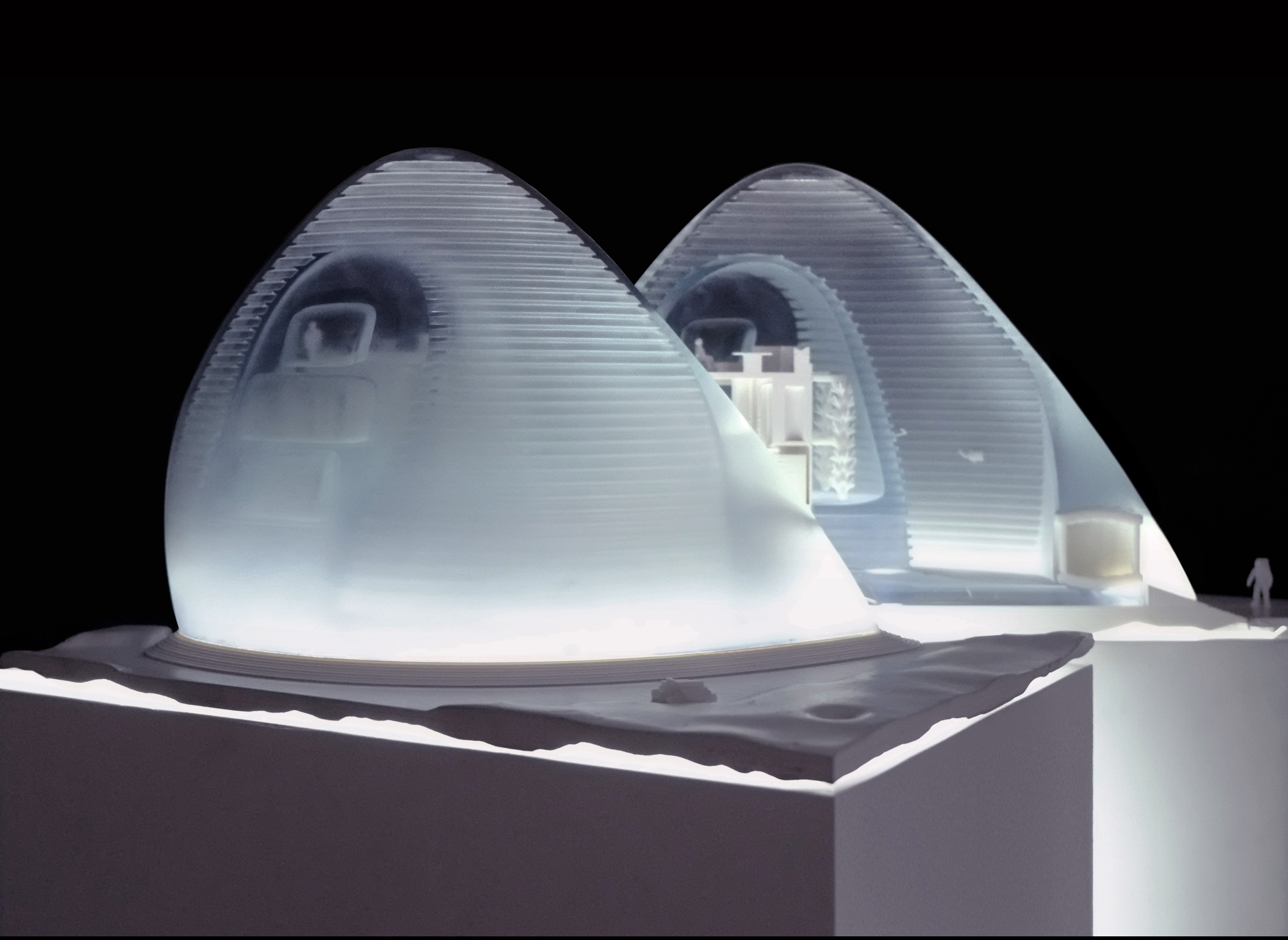
1. ROVER DOCK
2. ENTRY LEVEL / ECLSS
3. YARD (INTERMEDIATE CONTAINMENT ZONE)
4. EGRESS AIRLOCK
5. HYGIENE AREA / BATHROOMS
6. EXERCISE / MEDICAL
7. LABORATORY
8. LIBRARY / MEETING
9. VERTICAL HYDROPONIC GREENHOUSE
10. CREW QUARTER
11. WARDROOM / GALLERY
12. FOOD PREPARATION

0 10 20FT

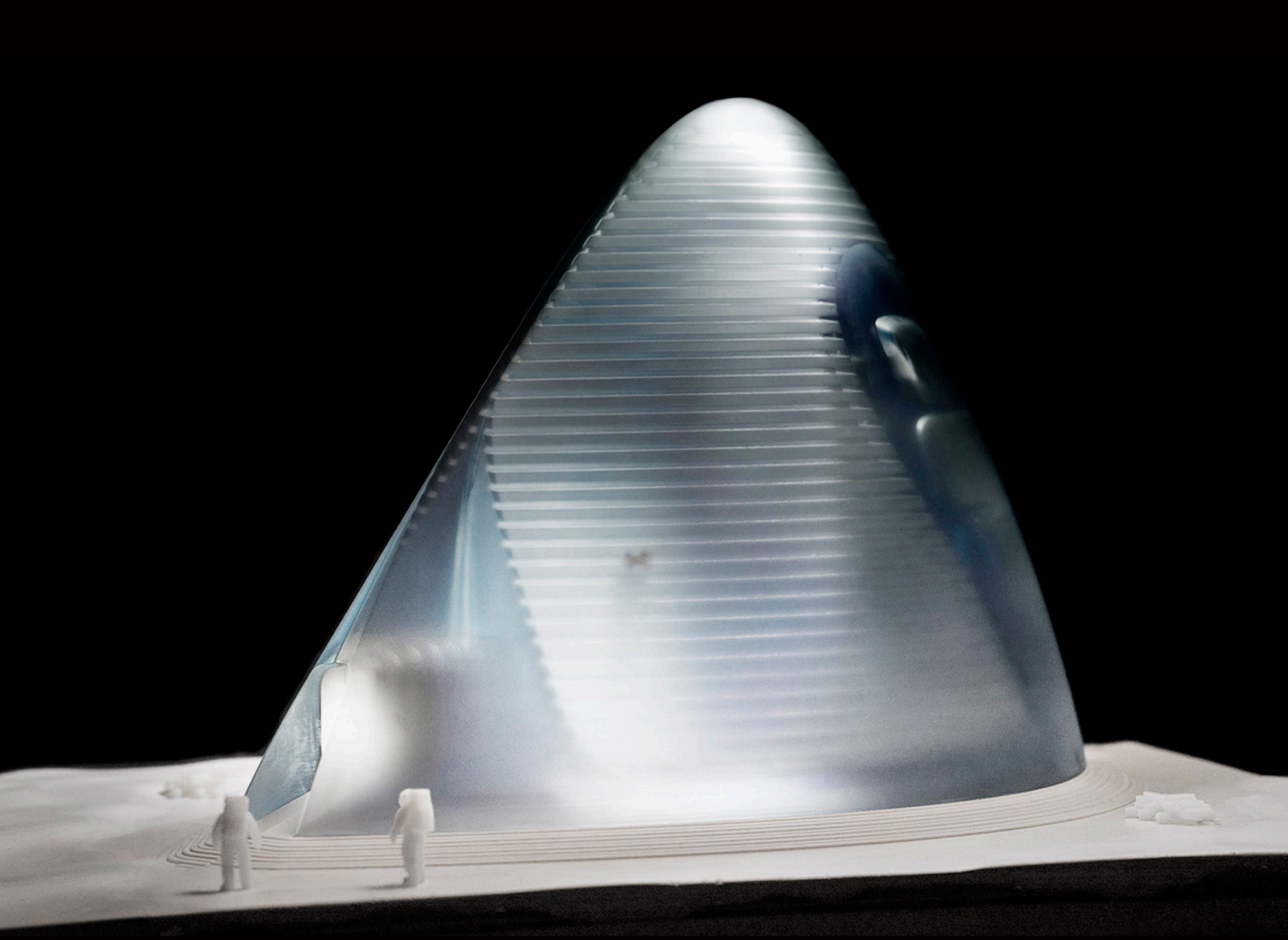


FINITE ELEMENT MODEL OF MAXIMUM STRESS IN DYNEEMA MEMBRANE UNDER 70 KPA INTERNAL PRESSURE

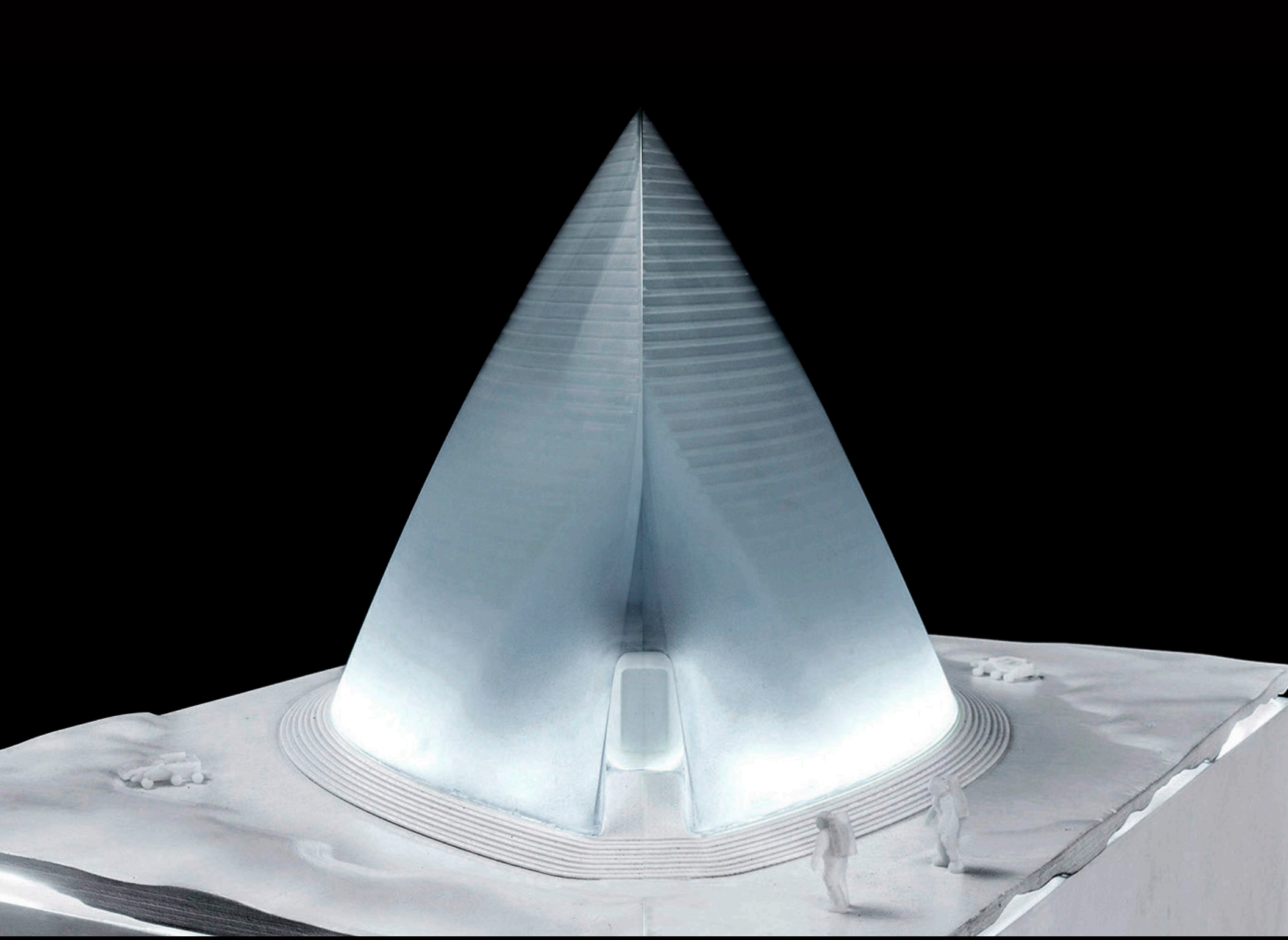
SECTION AND STRUCTURAL ANALYSIS



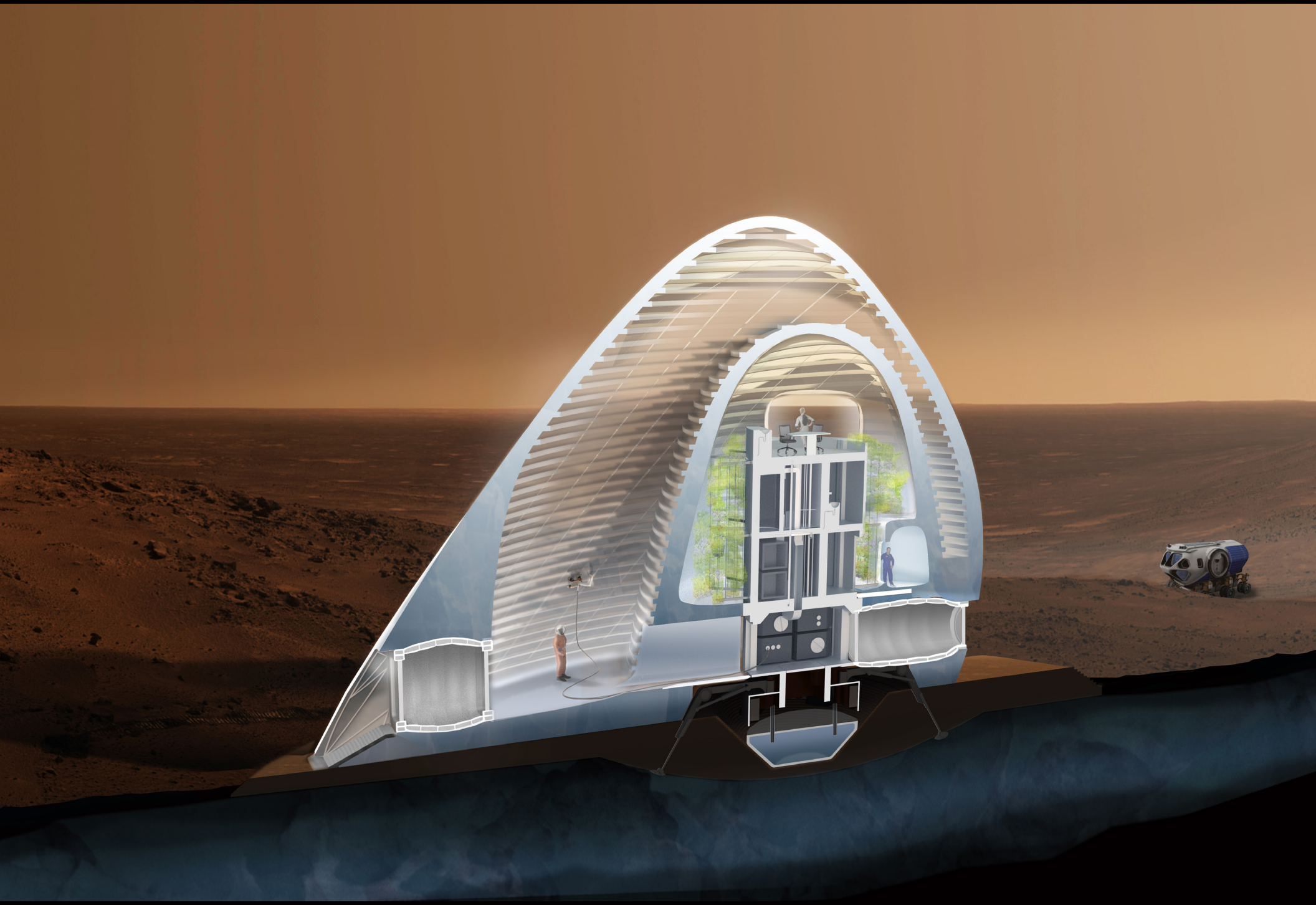
3D PRINTED SLA MODEL: LONGITUDINAL SECTION



3D PRINTED SLA MODEL: VIEW FROM SOUTHEAST

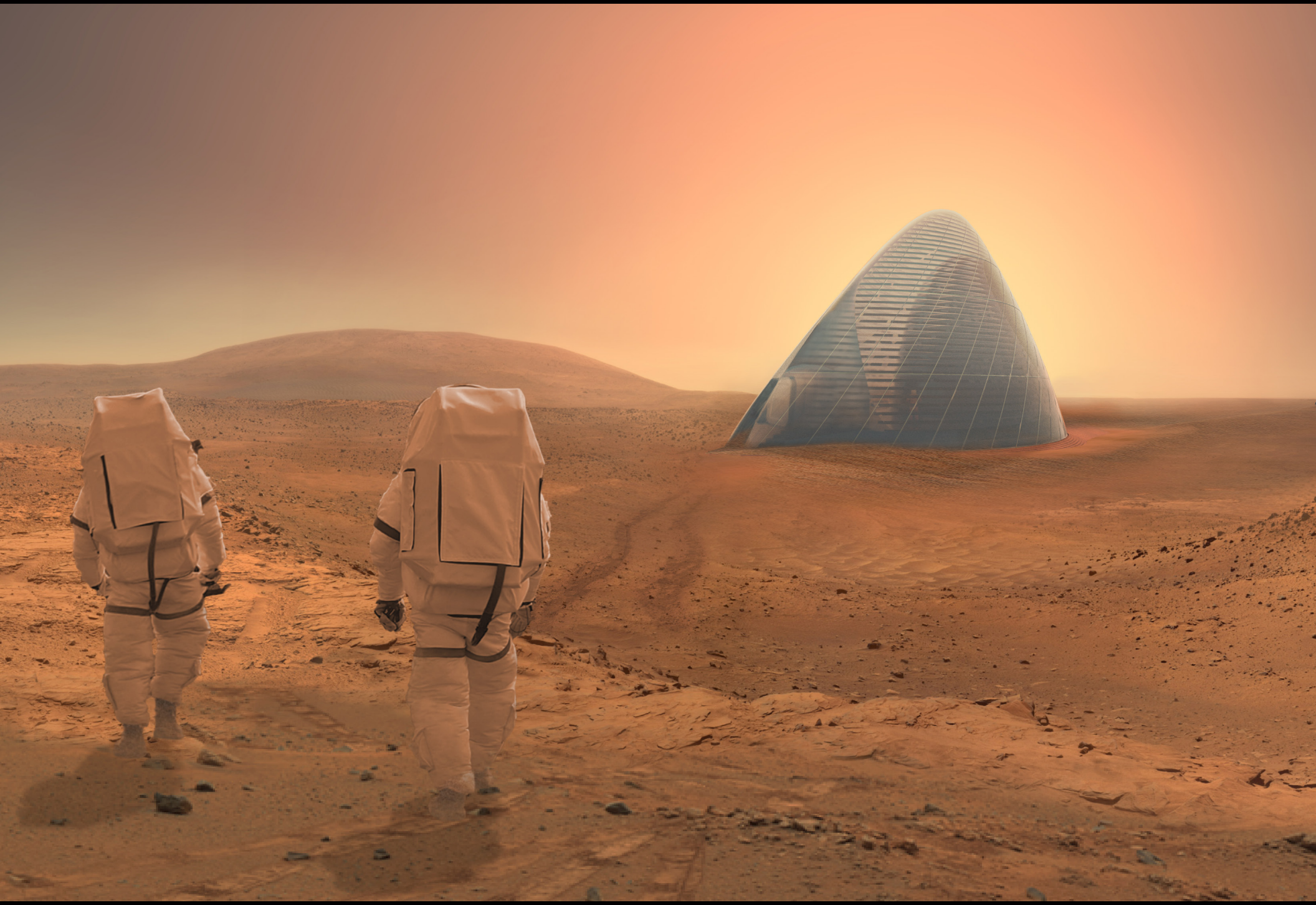


3D PRINTED SLA MODEL: VIEW FROM SOUTH



SECTION PERSPECTIVE

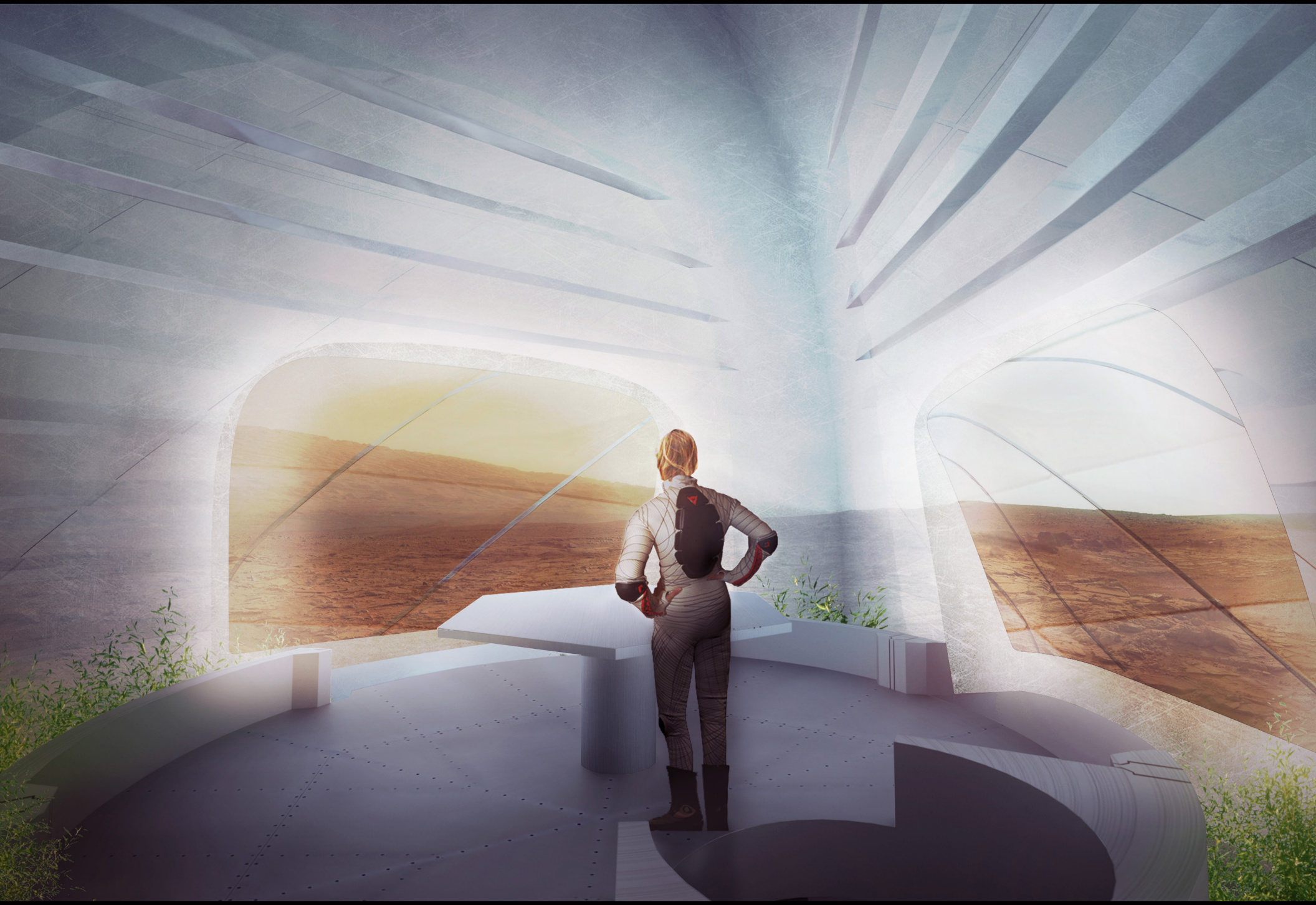
APPROACH FROM WEST



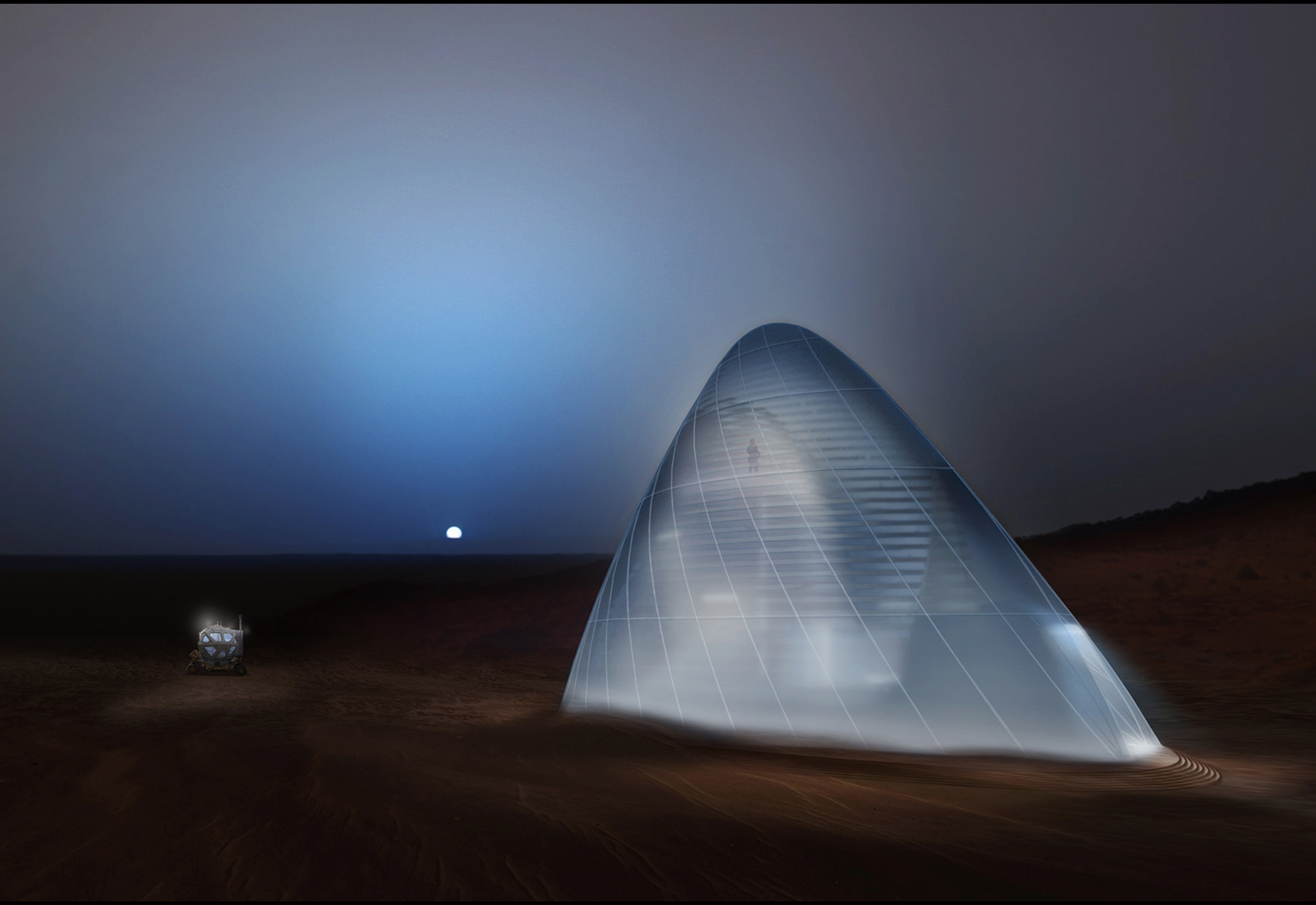
APPROACH FROM EAST

INTERMEDIATE YARD SPACE

CREW QUARTERS FROM CENTRAL CORE (LANDING VEHICLE)



WARDROOM



VIEW FROM SOUTHWEST AT DUSK