Image courtesy of NASA

FABRICS IN SPACE ARCHITECTURE

History and examples of textile architecture for advance space habitats

2012 USC – School of Architecture

USC Façade Tectonics Workshop - September 2012, Los Angeles, CA

Raul Polit-Casillas

Image courtesy of NASA

FABRICS IN SPACE ARCHITECTURE

Textile architecture for advance space habitats

"Space Architecture is the theory and practice of designing and building inhabited environments in outer space"

Millenium Charter, Tx USA, 2002

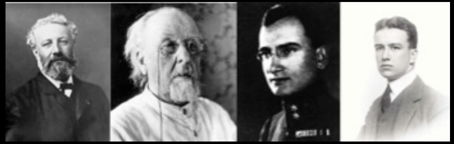
CONTENT

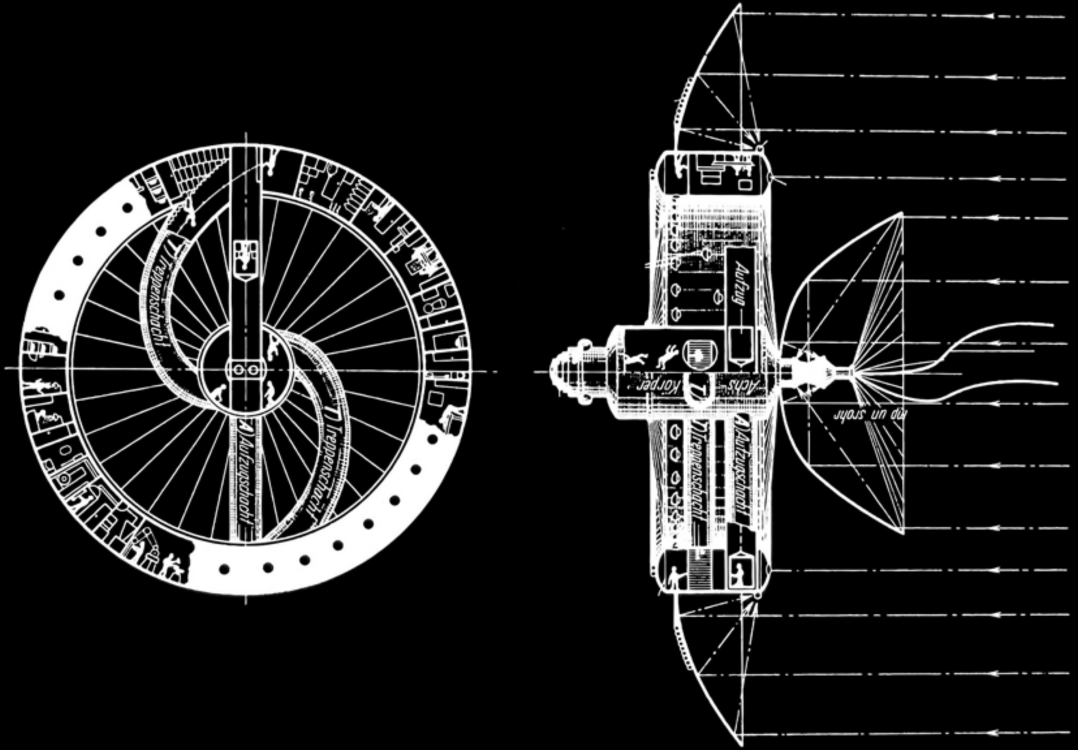
Mechanikoi, a constructive degree (Eastern Roman Empire):

- They mastered both construction science and technology as well mathematics and astronomy
- Key architects: Isidore of Miletus (H.Sofia), Heron of Alexandria (Robotics)
- *HAGIA SOFIA (Holy Wisdom, Istanbul, 537 A.C.)*: Mathematics and science to study the cosmos allowed a better and impressive structural design… (Earthquakes)

FABRICS IN SPACE ARCHITECTURE

Textile architecture for advance space habitats

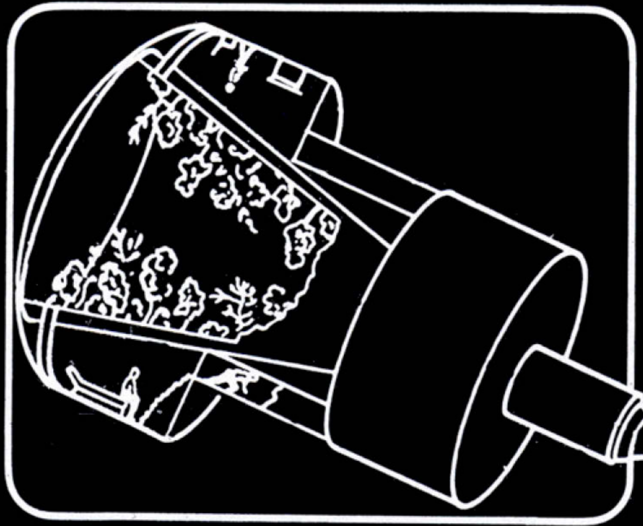




Herman Potočnik Concept, 1929

Credit: Public Domain

Konstantin Tsiolkovsky, Concepts (1897)



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Textile architecture for advance space habitats

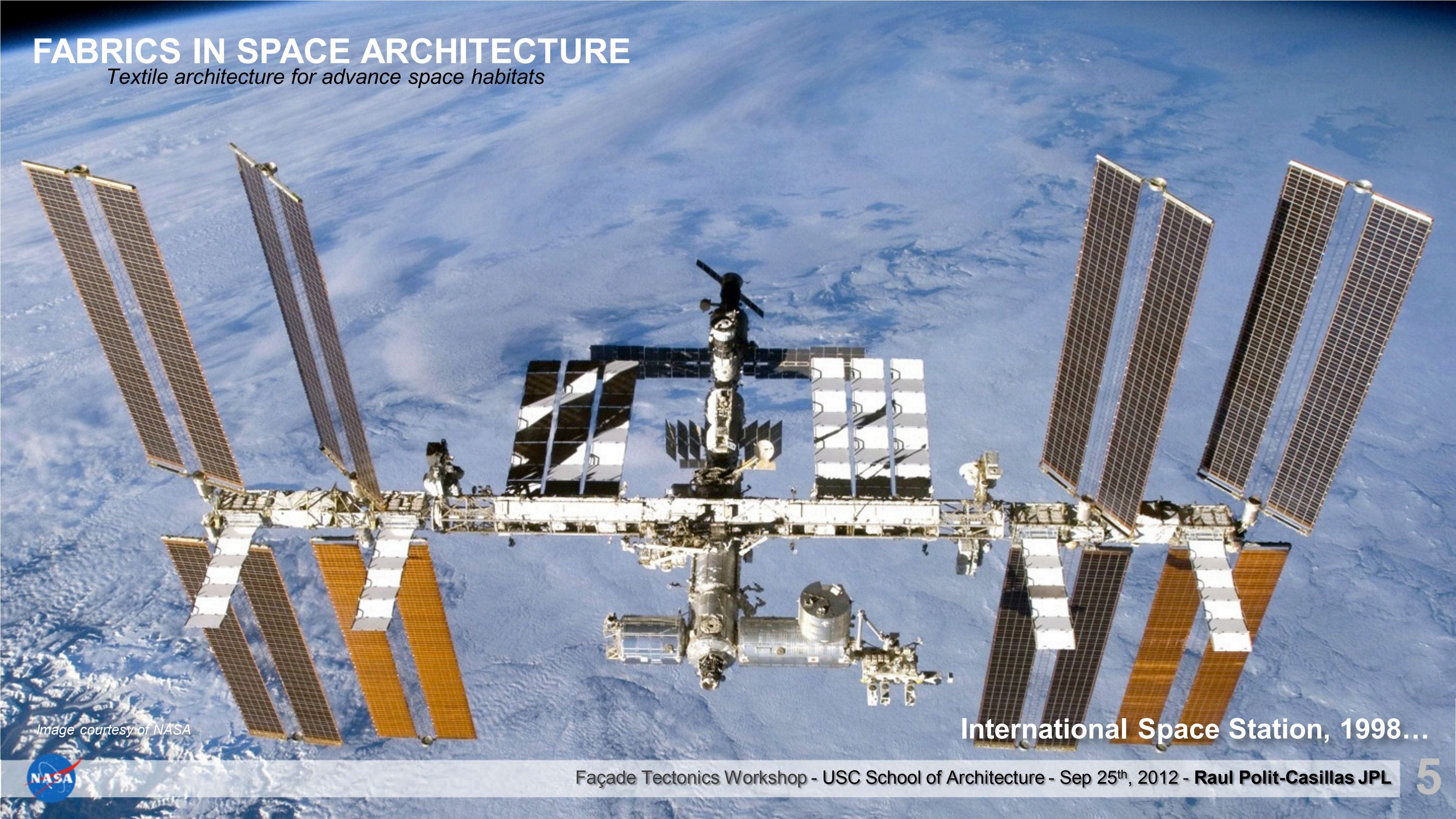


Image courtesy of NASA

International Space Station, 1998…

FABRICS IN SPACE ARCHITECTURE

Textile architecture for advance space habitats

Image courtesy of NASA

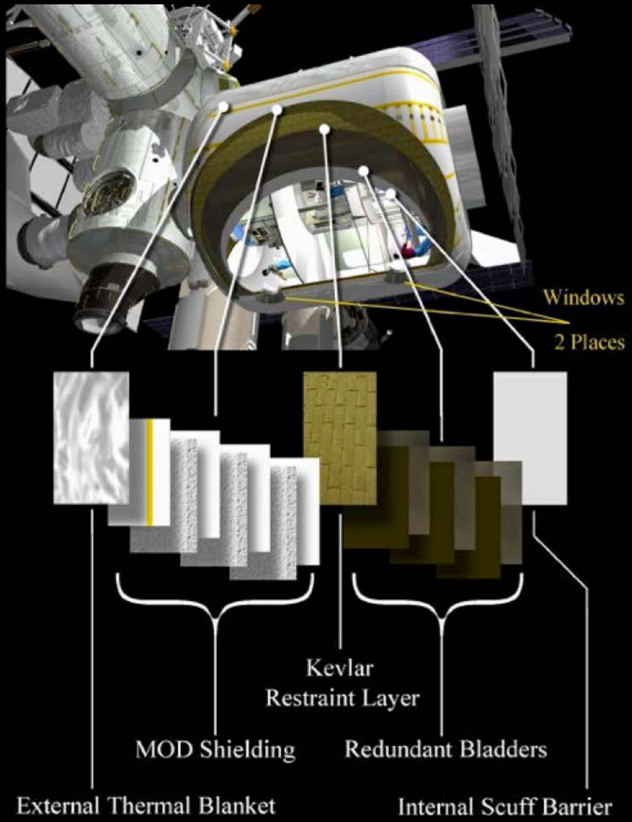
FABRICS IN SPACE ARCHITECTURE: Exterior

Textile architecture for advance space habitats

Images courtesy of NASA

FABRICS IN SPACE ARCHITECTURE: Inflatable

Textile architecture for advance space habitats



FABRICS IN SPACE ARCHITECTURE

Textile architecture for advance space habitats

Image courtesy of NASA

FABRICS IN SPACE ARCHITECTURE: SUIT

Textile architecture for advance space habitats

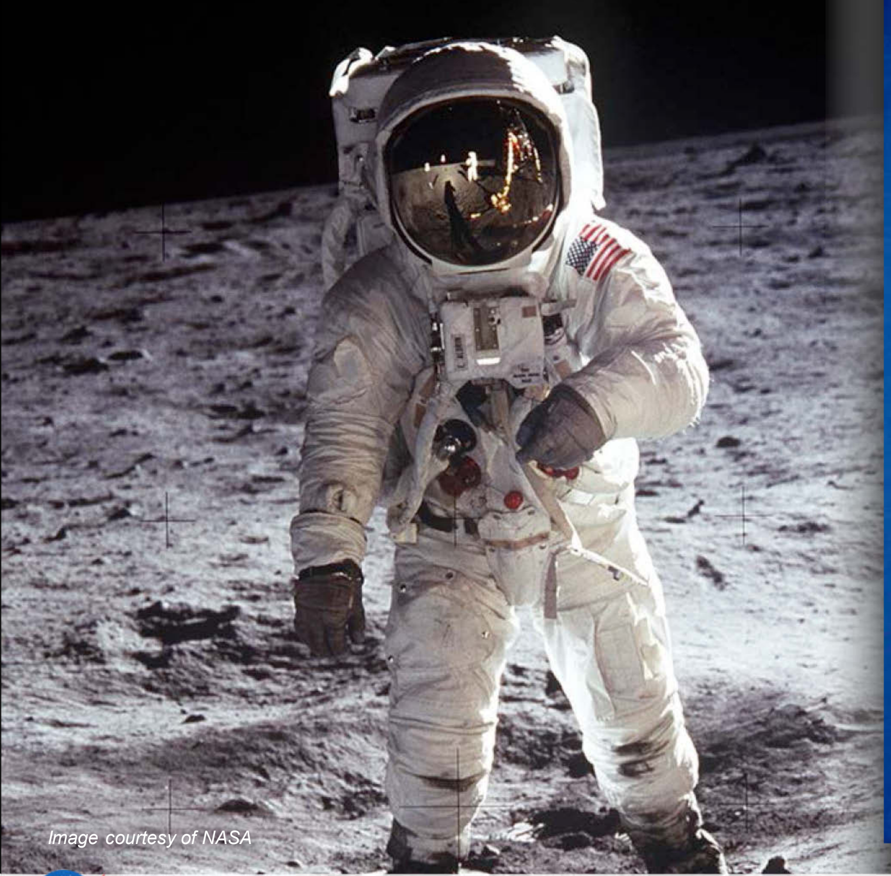
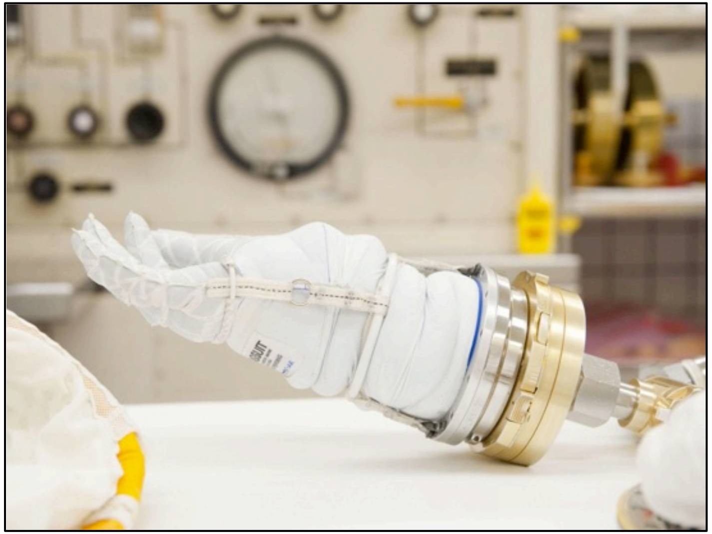


Image courtesy of NASA

FABRICS IN SPACE ARCHITECTURE

Textile architecture for advance space habitats

Image courtesy of NASA



FABRICS IN SPACE ARCHITECTURE

Textile architecture for advance space habitats

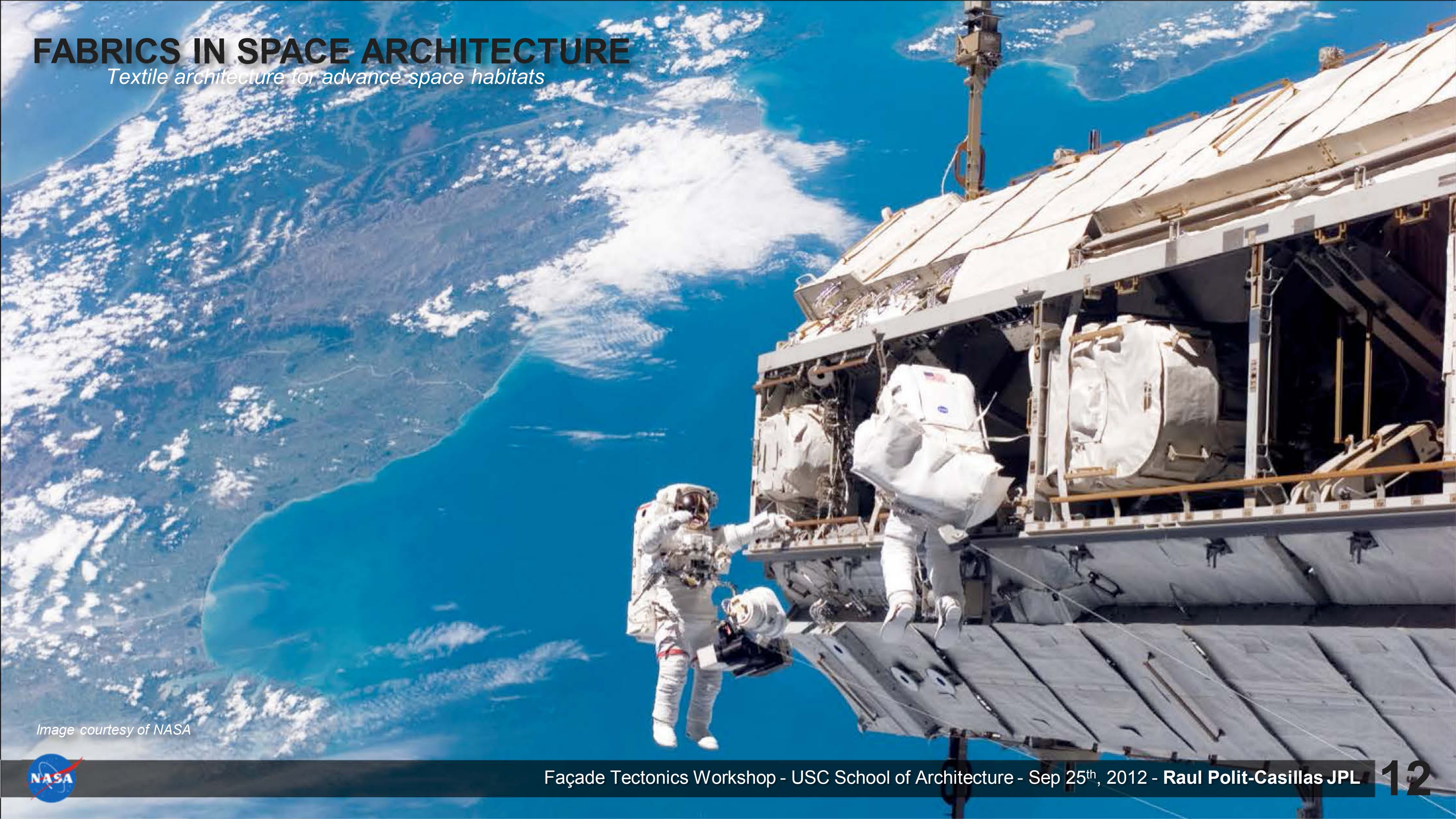
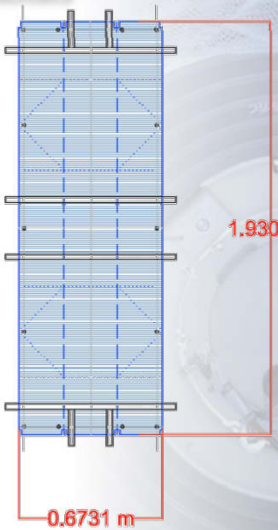
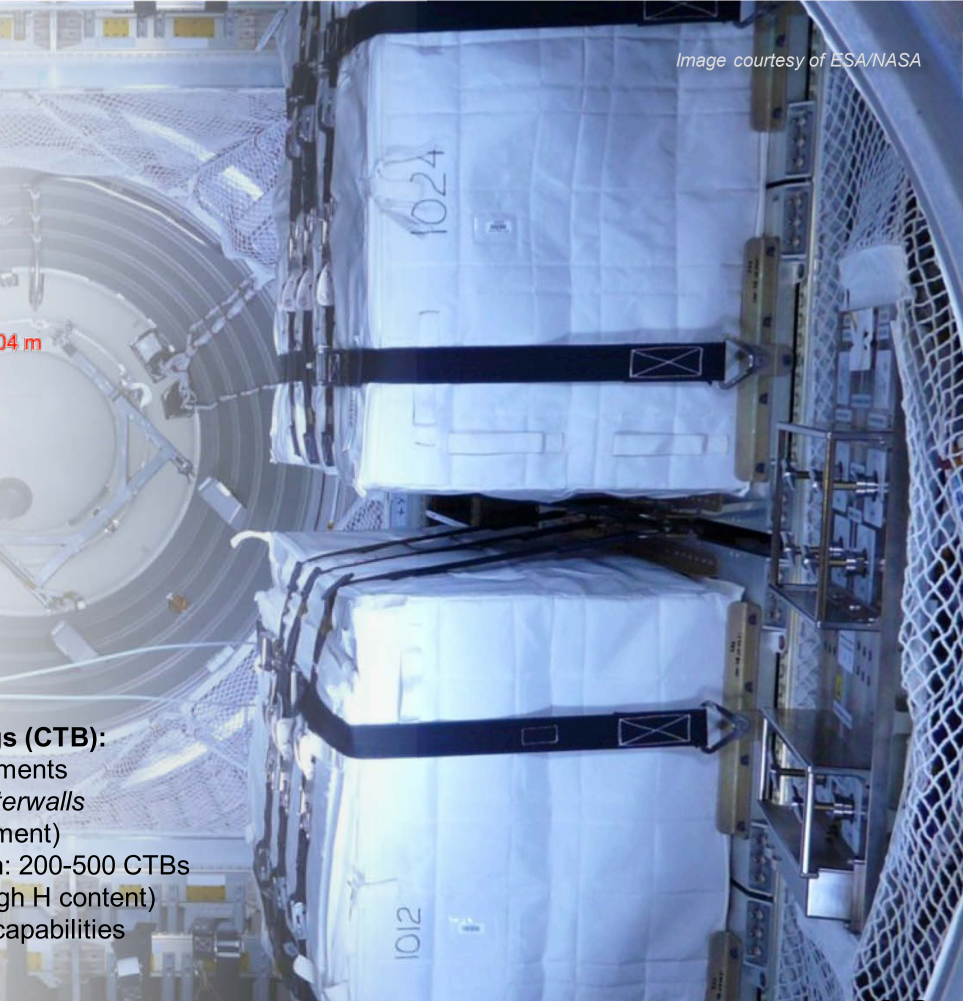


Image courtesy of NASA

FABRICS IN SPACE ARCHITECTURE: CTB Mapper

Textile architecture for advance space habitats





Cargo Transfer Bags (CTB):

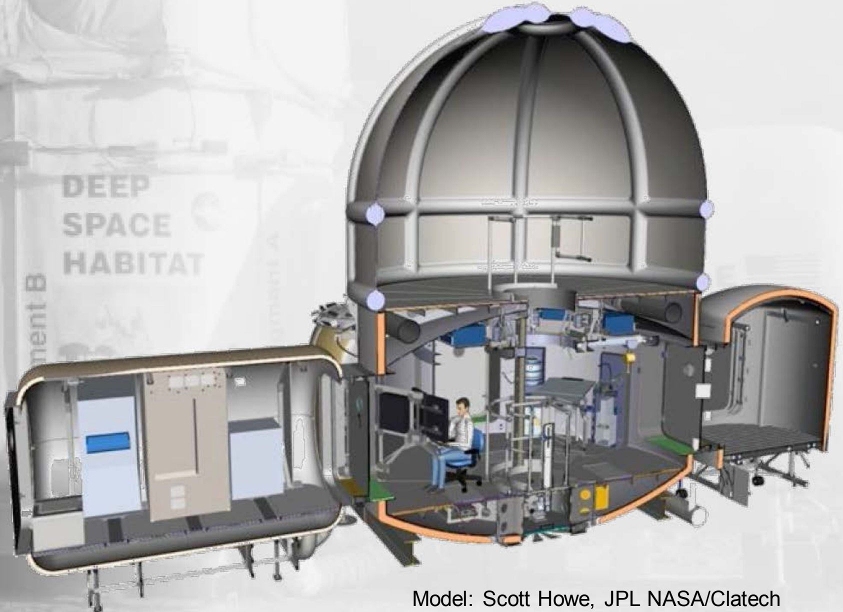
- Current logistics elements
- Could be use as *waterwalls* (waste & water treatment)
- Deep Space Mission: 200-500 CTBs
- Made of polymer (high H content)
- Radiation shielding capabilities
- Flexible

FABRICS IN SPACE ARCHITECTURE: DSH Logistics-2-Sgileding

Textile architecture for advance space habitats

HDU Micro-Hab Hygiene Module

Images courtesy of NASA

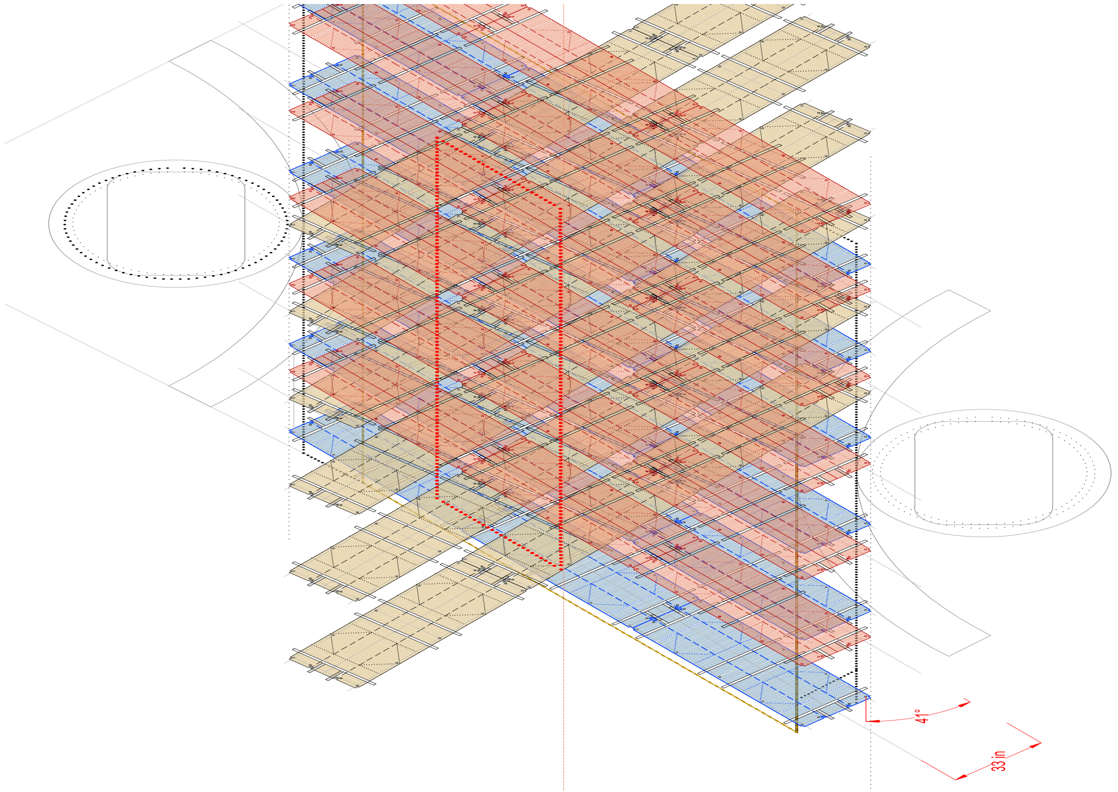


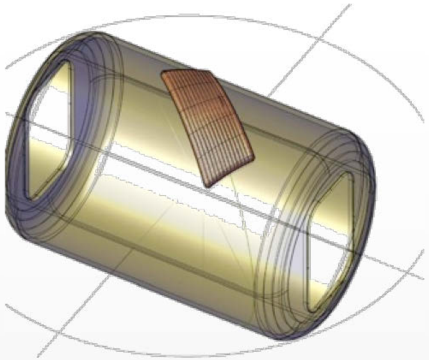
Model: Scott Howe, JPL NASA/Clatech

FABRICS IN SPACE ARCHITECTURE: CTB

Mapper

Textile architecture for advance space habitats





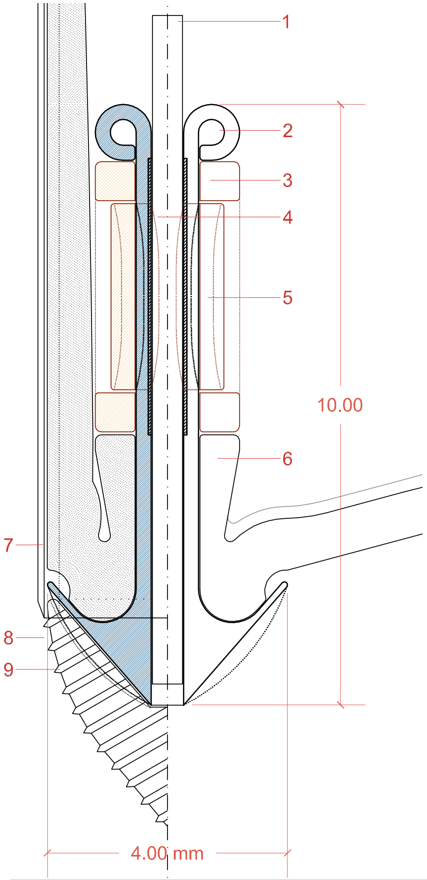
Number of bags by layer: 18
Separation: 840 mm (33 in)
Angle (with respect to axe): 41º

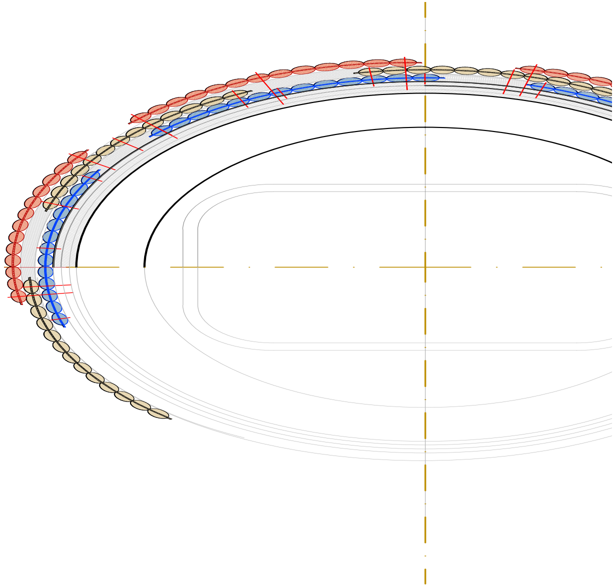
Alignment of bags: One direction
Drawbacks: Different directions / curvatures
Benefits:

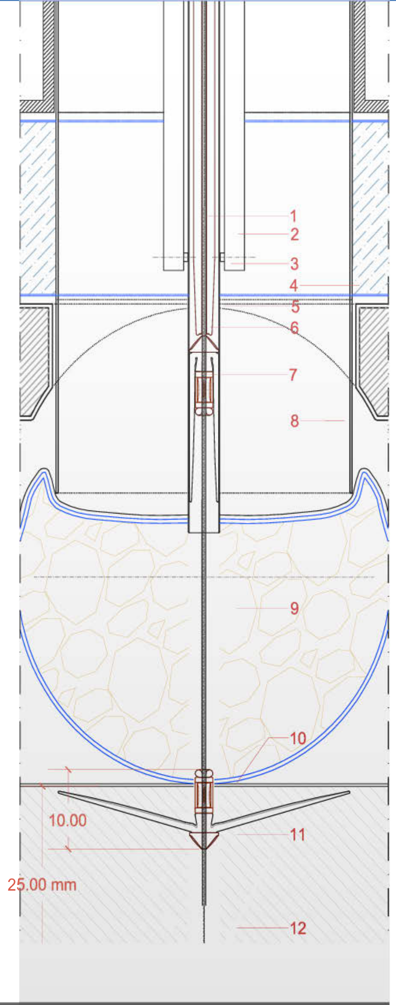
- Supporting points are better distributed
- It uses a fewer or equal number of bags
- % Ae in second layer is lower
- Better resistance against physical impacts
- Areas near airlocks are better covered

FABRICS IN SPACE ARCHITECTURE: CTB Mapper

Textile architecture for advance space habitats





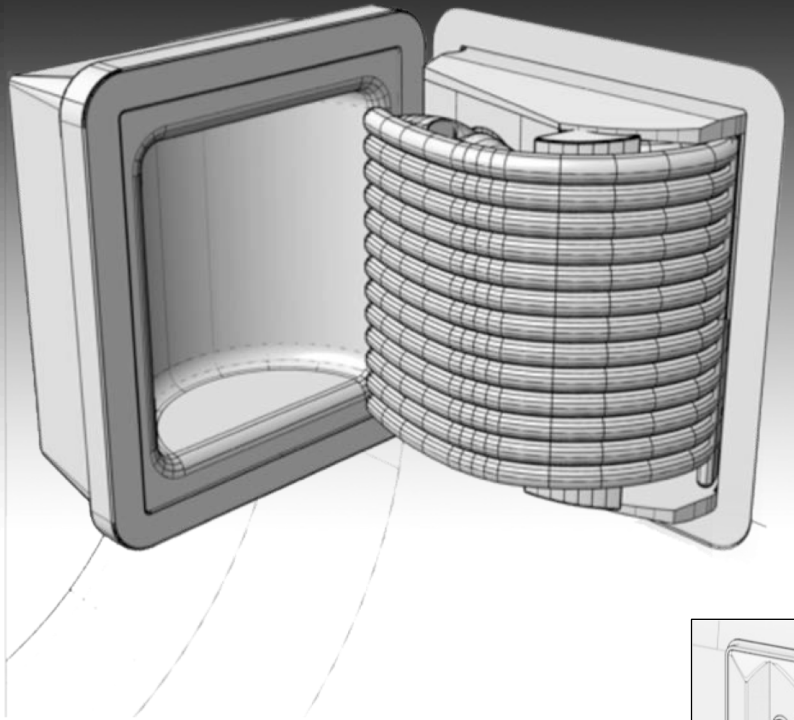


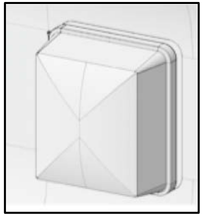
COMPONENTS

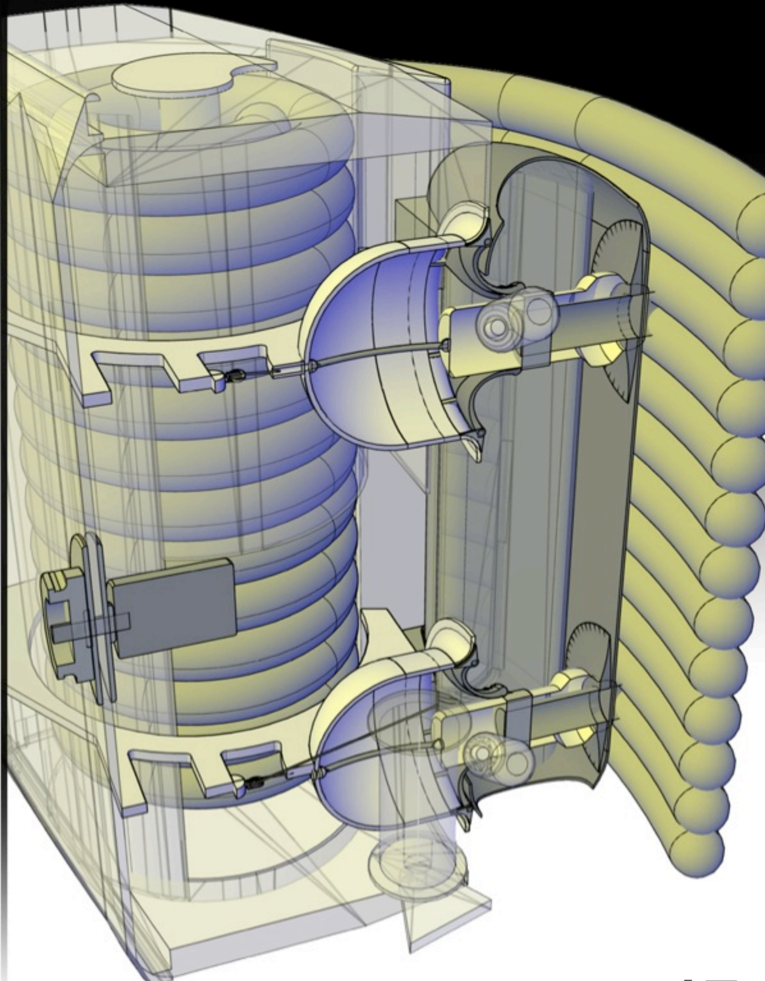
1. Flexible elements (CTBs)
2. Supporting Surface (Force Net)
3. Discrete Elements (Micro-harpoons)
4. Automatic Tool: CTBs Mapper

FABRICS IN SPACE ARCHITECTURE: CTB Mapper

Textile architecture for advance space habitats







FABRICS IN SPACE ARCHITECTURE: Lunar Self-deployable Hab

Textile architecture for advance space habitats

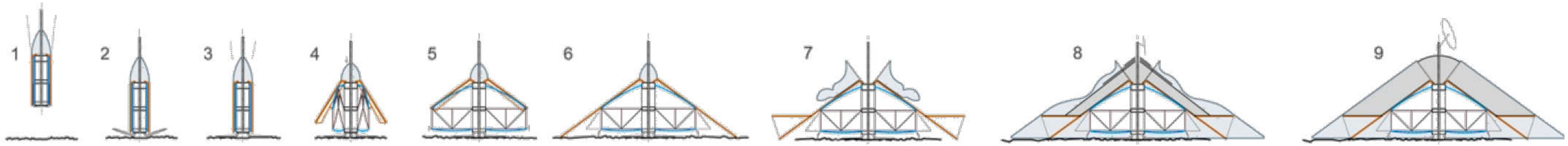
Credit: ESA - S. Corvaja, 2011

Mission and launcher

- **Mission Elements:** Launcher system (2 Ariane V ES), habitat module, propulsion unit and moon lander
- **Launch vehicle:** Ariane V up to 21 tons of payload14
- **Crew:** 6 astronauts
- **Duration:** 180 days or more
- **Location:** It should be able to adapt to any landing site. It is assumed a sensible flat surface would be chosen.
- **Operations**: Tele-operated from Earth. The system should not require any previous human presence or activity.
- **Logistics:** Fully autonomous but not fully equipped. Consumables and equipment would be shipped later.
- **Analogs:** Both technology and concept should be able to be tested on Earth previously (with gravity present)
- **Technology:** Any system should use a technology with enough TRL.

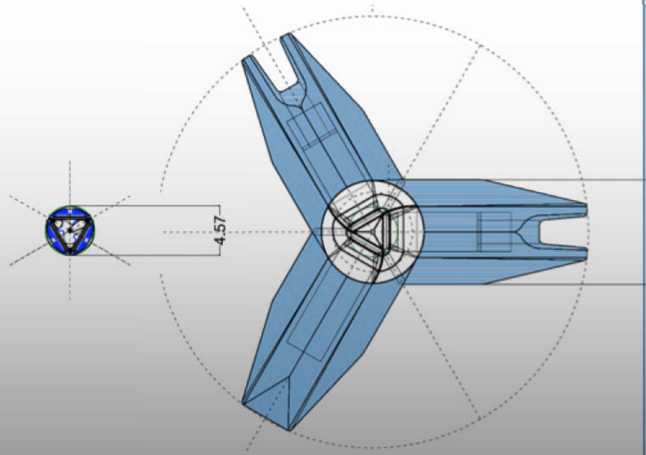
FABRICS IN SPACE ARCHITECTURE: Deployment

Textile architecture for advance space habitats



Reducing mass, volume and energy budgets using fabrics

- **In situ resources Utilization (ISRU):** Using regolith as construction element
- **Radiation protection:** ESA 1992 – shielding of 400 g/cm2 recommended during solar flares
  - 2 - 3 meters would suffice, while 4 to 5 meters will protect even during solar flairs
- **Volume:** It has to fit in an Ariane V fairing. Adaptable architecture
- **Mass:** Reduce mass budget to the maximum. Increase multipurpose elements
- **Terrain**: Flat or flatten terrain, however the system has to be adaptable
- **Human Factors**: Respect to basic habitability measurement
- **Simulation and testing**: Feasible testing methods should be available



FABRICS IN SPACE ARCHITECTURE: Stowed

Textile architecture for advance space habitats

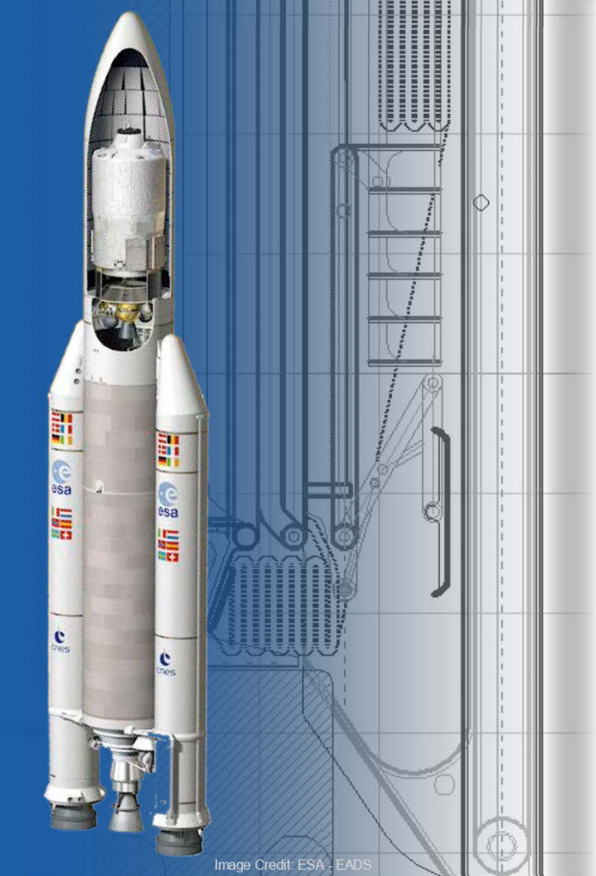
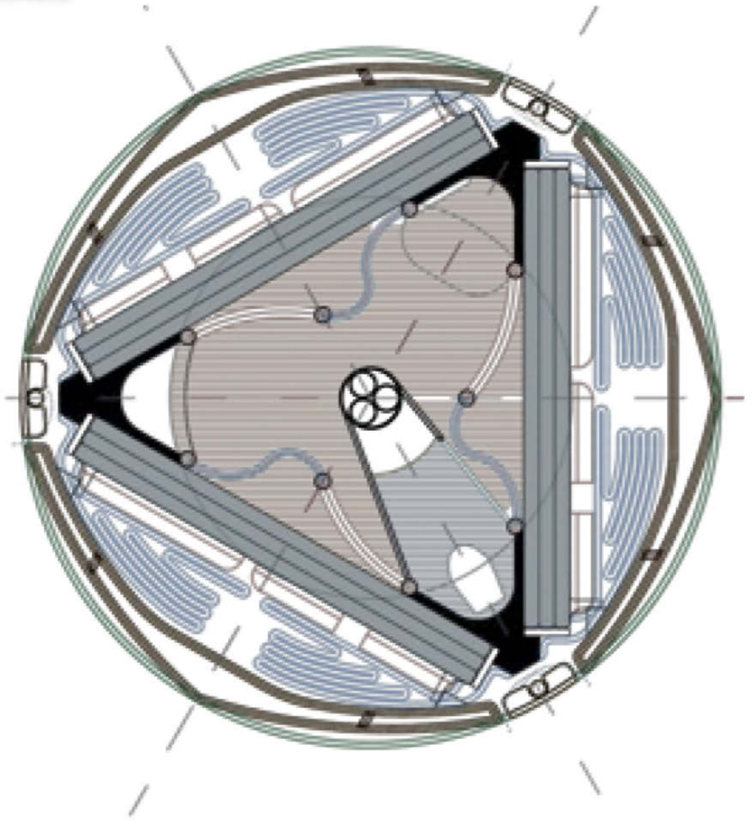
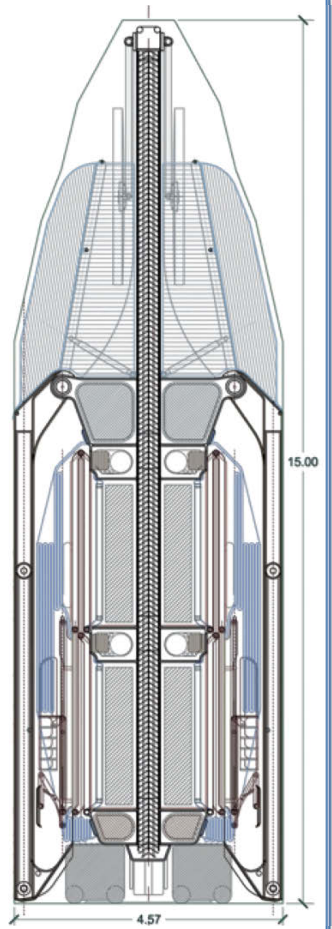


Image Credit: ESA - EADS

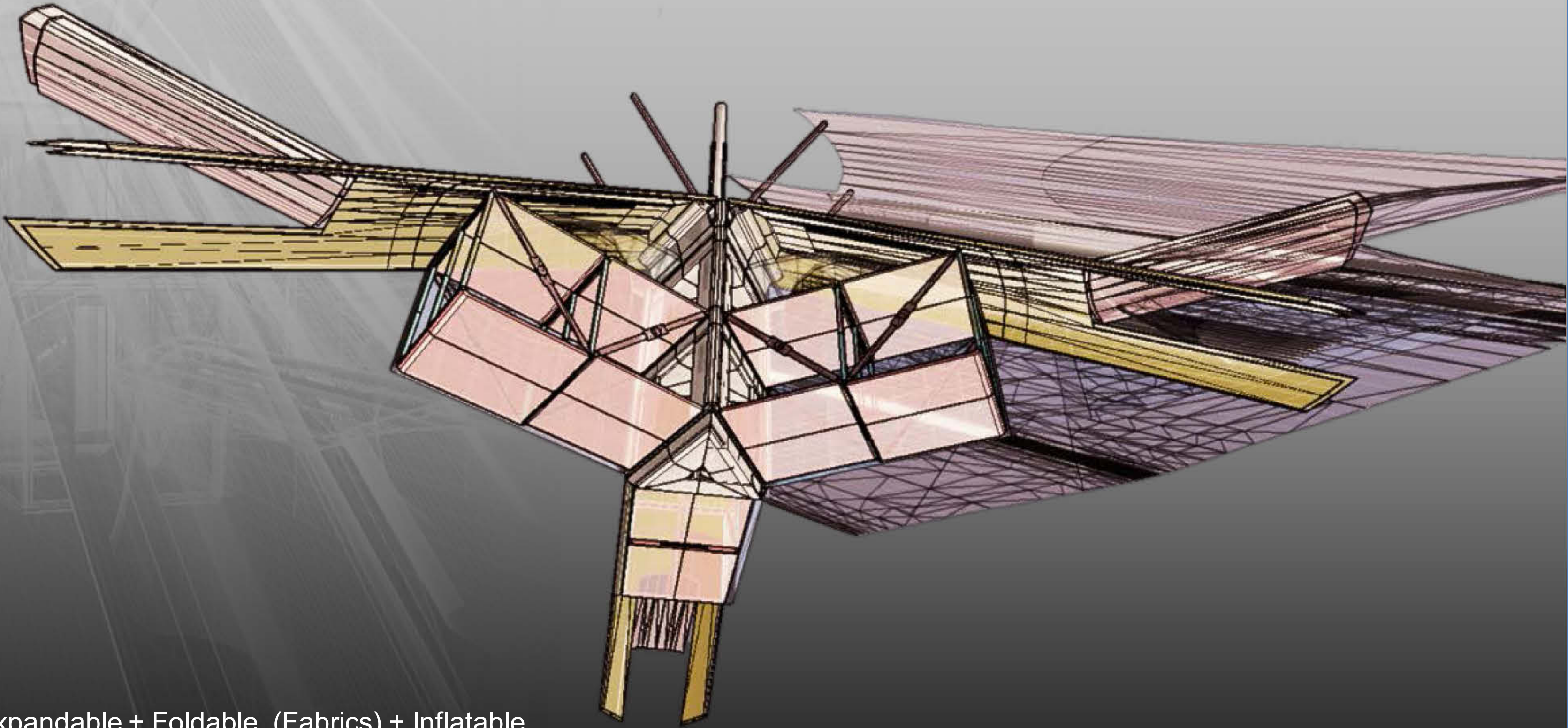




Self deployable habitat for a crew of 6. Fitting within the 4.5 m diameter of an Ariane V launcher fairing volume, mass and energy budgets should be reduced to maximum.

FABRICS IN SPACE ARCHITECTURE: Structure

Textile architecture for advance space habitats



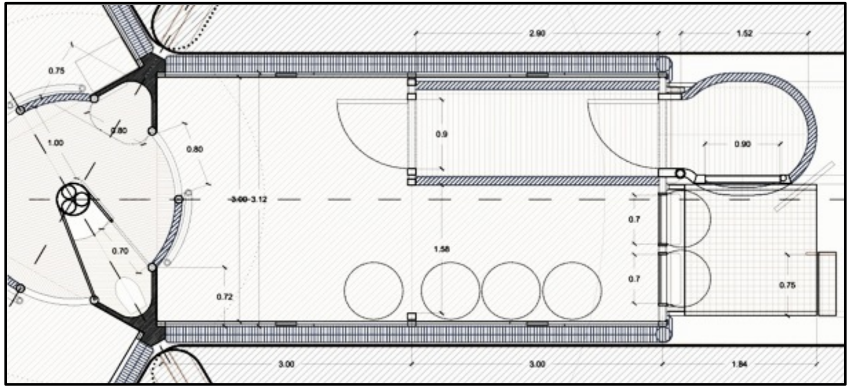
Adaptability = Expandable + Foldable (Fabrics) + Inflatable

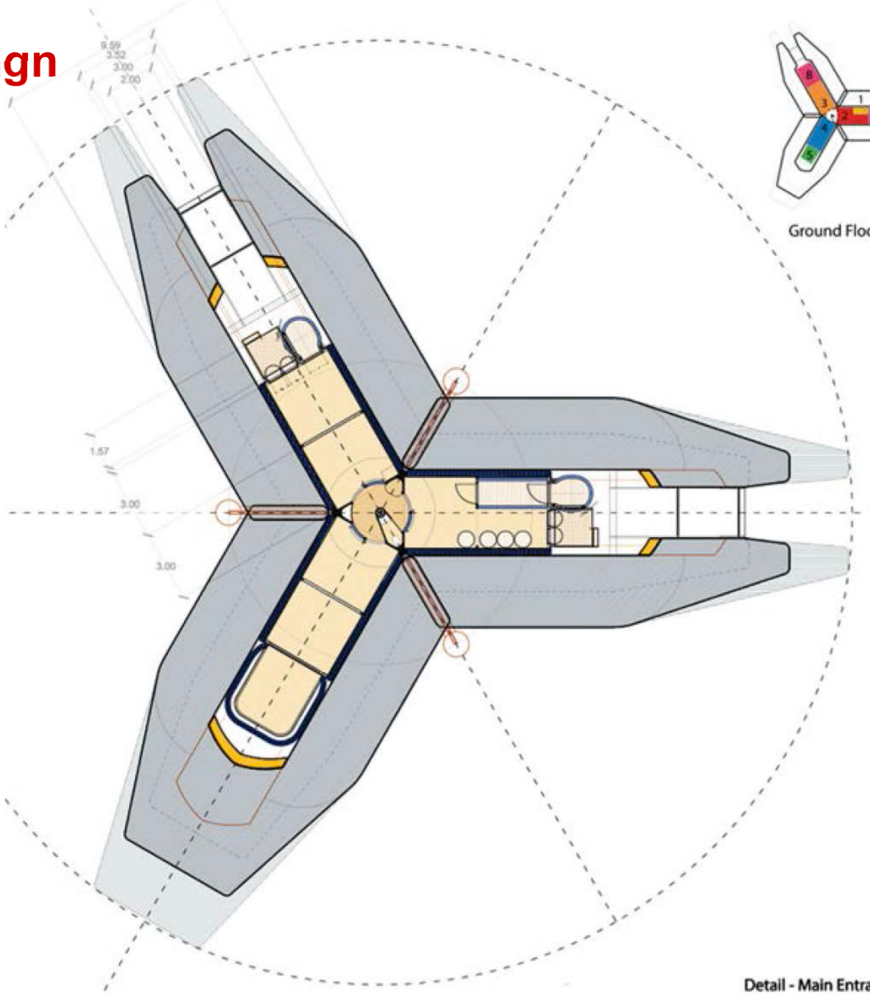
FABRICS IN SPACE ARCHITECTURE: Design

Textile architecture for advance space habitats

PROGRAMME DISTRIBUTION	
A MAIN ACCESACCESS	12 m²
B SECONDARY ACCESS	12 m²
1 DUST CONTROL	3.2m²
2 ACCESS OPERATIONS/STORAGE	14 m²
3 LIVING AREA / KITCHEN	18 m²
4 SCIENCE AREA	18 m²
5 GREEN HOUSE	10 m²
COOMMON AREAS/BATHROOM	4.8 m²
TOTAL	92 m²

Lower deck





Ground Floor Deployed

Detail - Main Entrance Sector

FABRICS IN SPACE ARCHITECTURE: Design

Textile architecture for advance space habitats

PROGRAMME DISTRIBUTION

A	MAIN ACCESACCESS	12 m²
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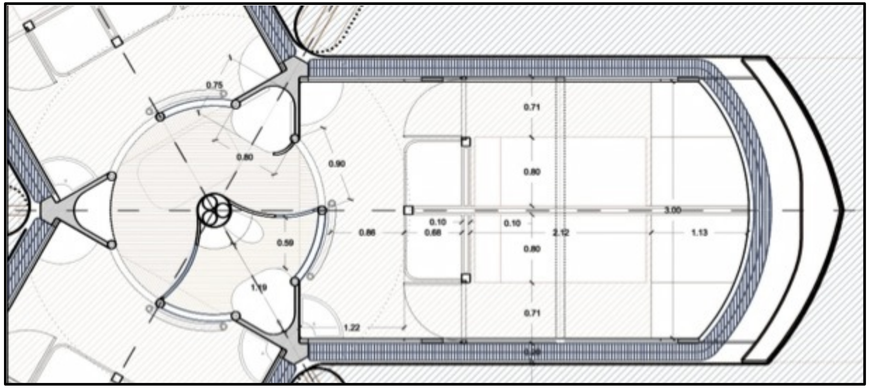
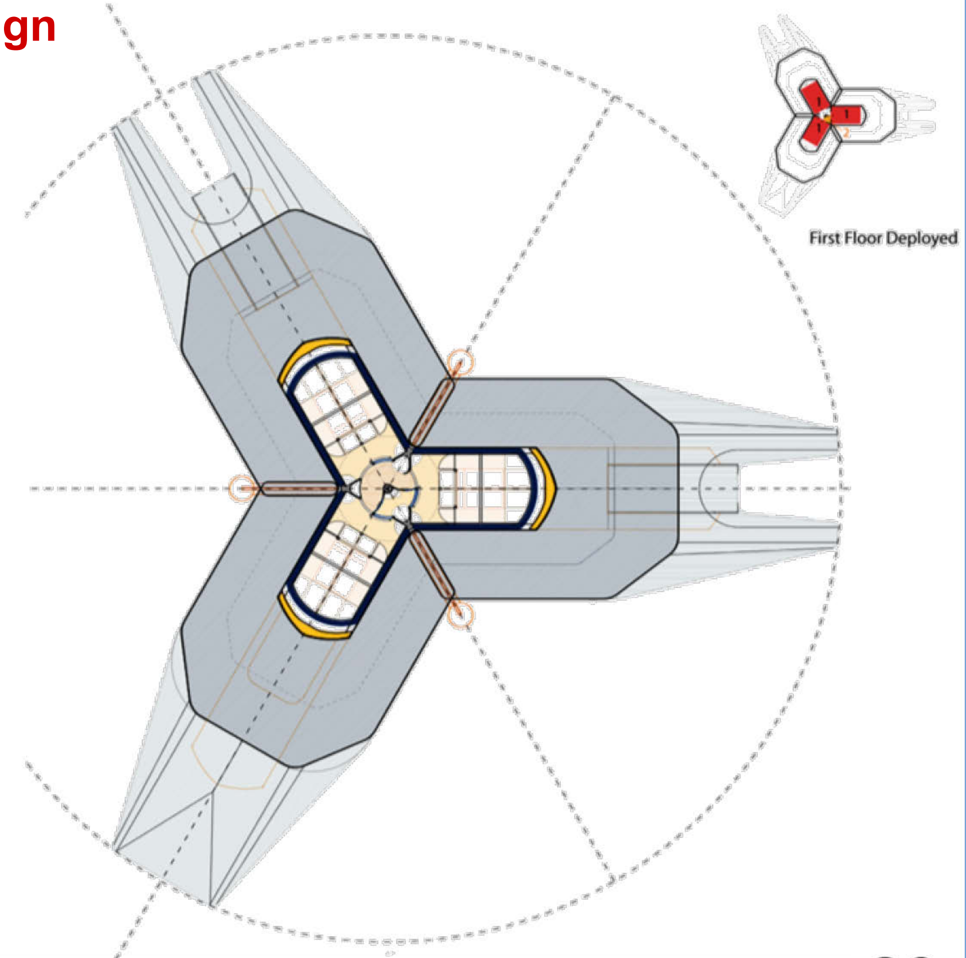
	COOMMON AREAS/BATHROOM	4.8 m²
	TOTAL	92 m²

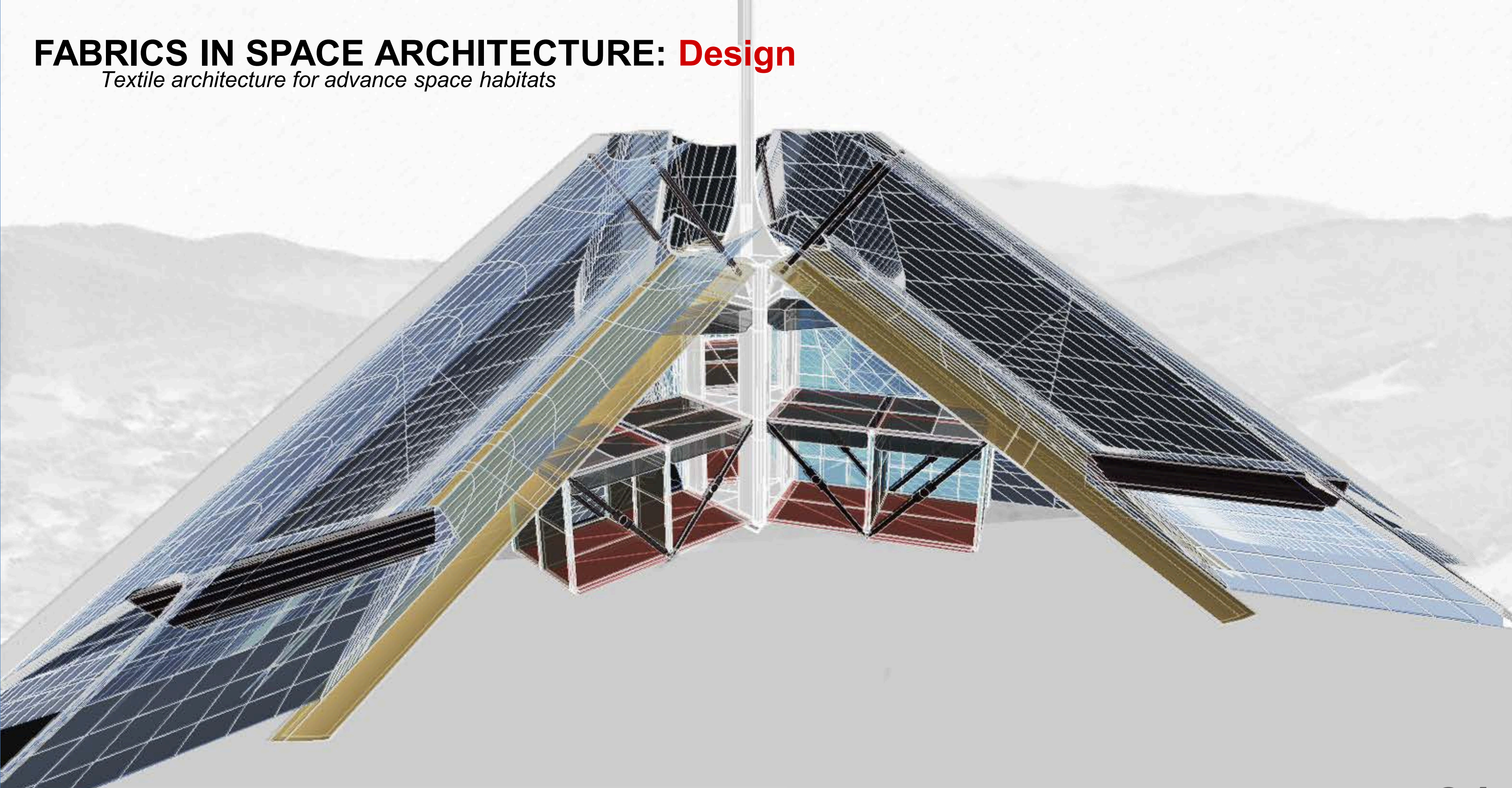
Upper deck




First Floor Deployed

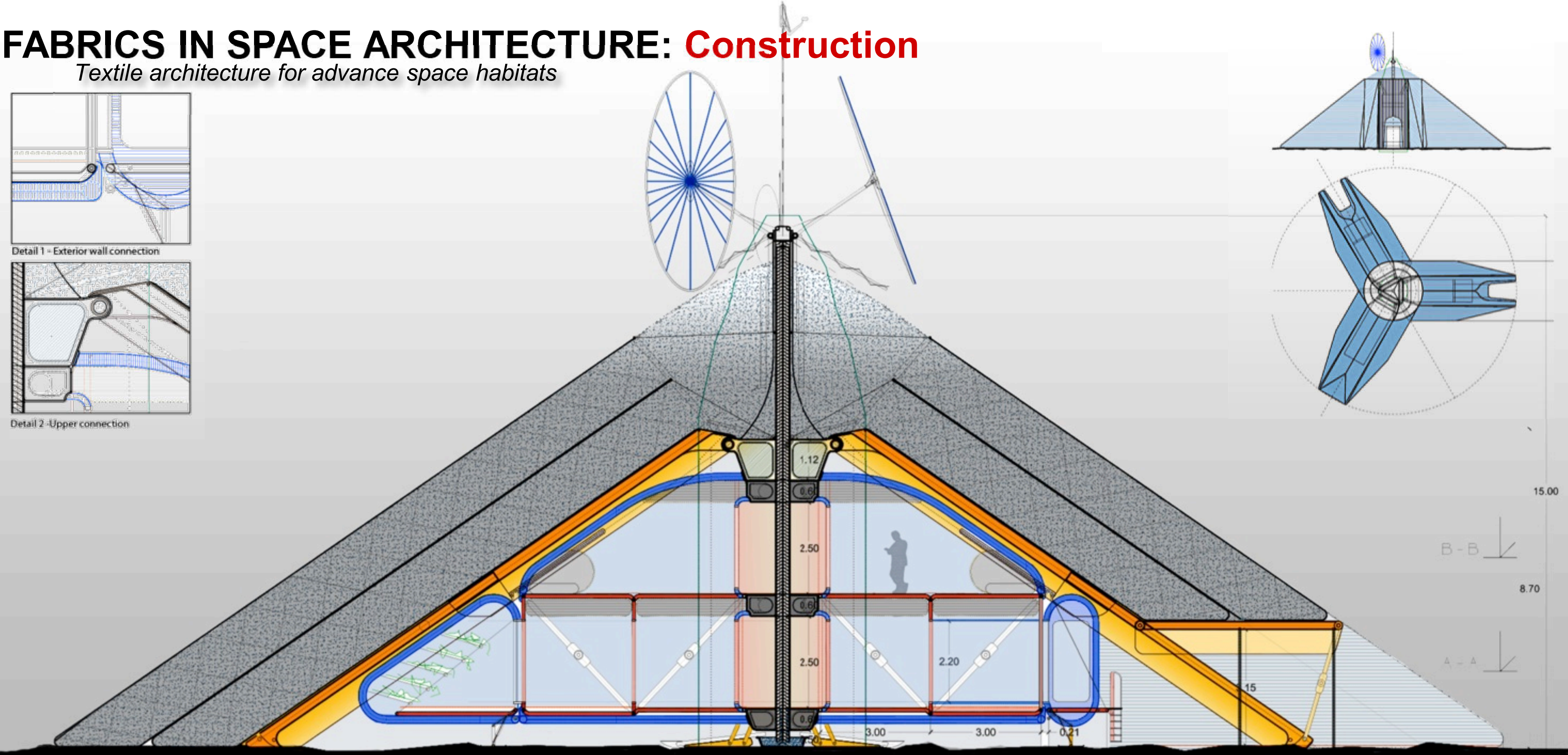
FABRICS IN SPACE ARCHITECTURE: Design

Textile architecture for advance space habitats



FABRICS IN SPACE ARCHITECTURE: Construction

Textile architecture for advance space habitats



THANK YOU…

Image courtesy of NASA