Nano 2016 Innovation Rome, 20-23 September
Conference & Exhibition

WE LOOK AFTER THE EARTH BEAT

Lightweight materials for advanced space structures

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Ref :

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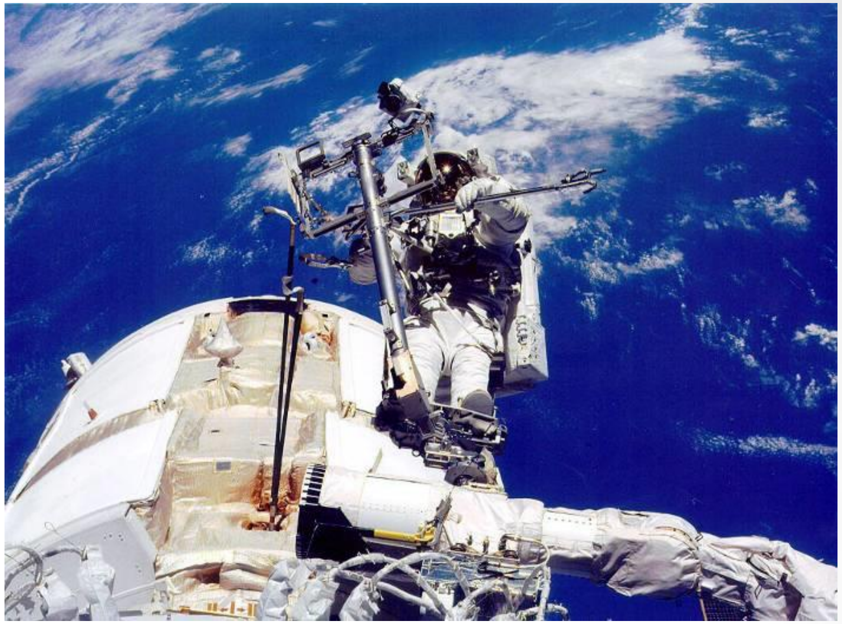
83230913-DOC-TAS-EN-003

ThalesAlenia Space
A Thales / Finmeccanica Company

- **The current status of the art in the development of new generation space manned modules exploiting the inflatable concept matched with lightweight flexible textiles**
- **The possibility to exploit the inflatable technology matched with flexible textiles to realize capture mechanisms able to operate in space**
- **TAS-I breadboard and prototype realization**
- **Textile based structures already in use in running space missions**

Wide experience in Structure & Mechanisms for Systems related to Space Infrastructures matured in nearly 4 decades:



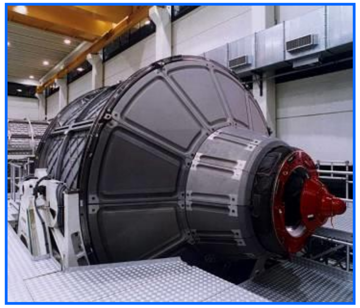
- **Highly consolidated in Metallic Modules**
- **Gradually increasing (from 1998) in the emerging field of the Inflatable Modules**

In total

- **50% of ISS pressurized volume developed by Thales Alenia Space with metallic modules**

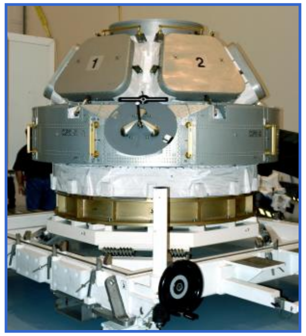
TAS-I has gained in the ISS a central position in the Design, Development & Verification for Pressurized Modules through the cooperation in ASI and ESA projects

MPLM & PMM



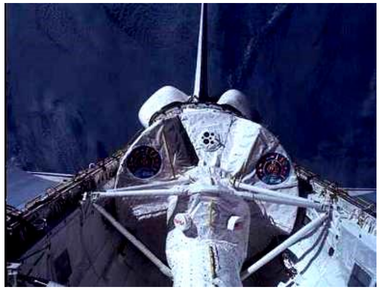
ATV

Columbus

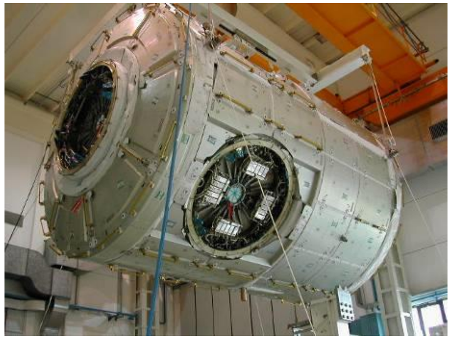


Cupola

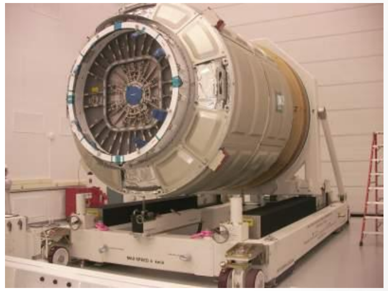
Spacelab



Spacehab



Nodes 2 & 3



Cygnus

1970's → 1980's → 1990's → 2000's

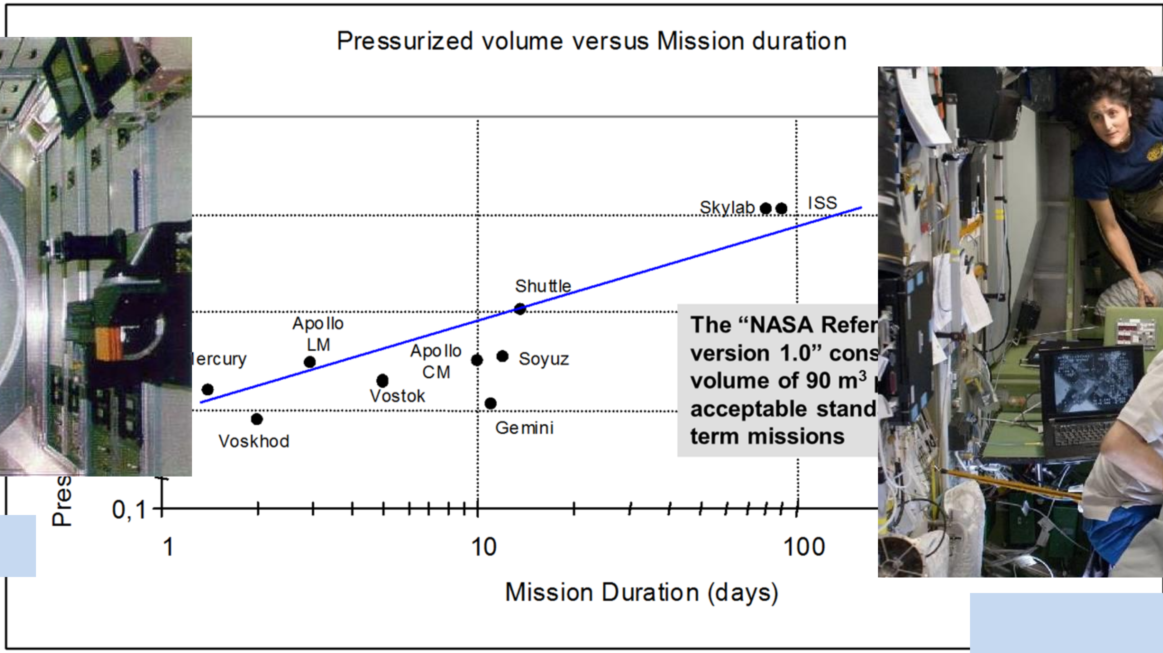
From LEO to Moon and Mars…

Extending human access and sustainable presence to Moon and Mars is the natural evolution of the capabilities acquired in LEO through the participation to the International Space Station

- ISS Completion & Exploitation as Exploration Technological Test Bed
- Exploration :**Manned space system and infrastructures**
- Transportation Systems and Technological Demonstrators
- Next Generation Launchers

5

In Flight



In service

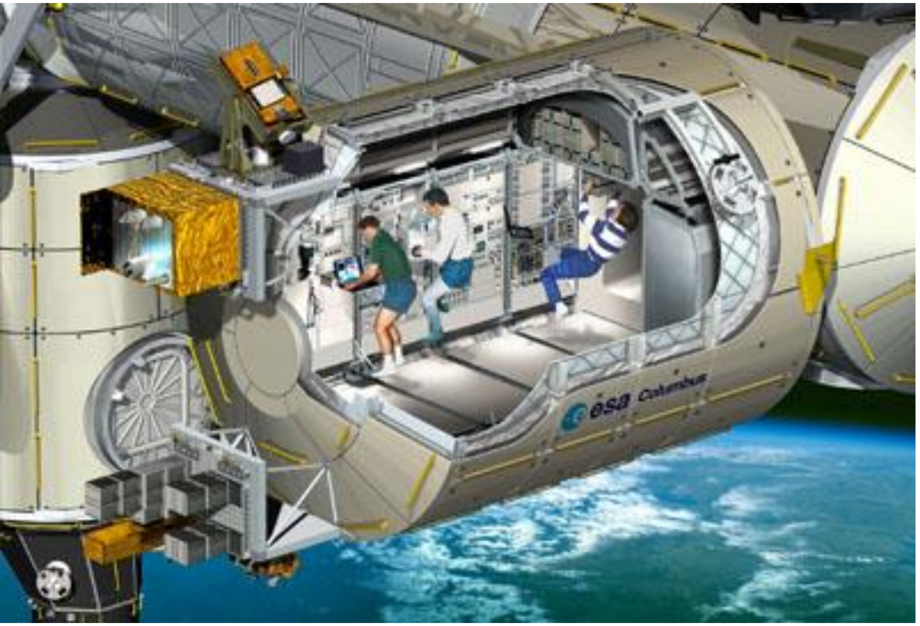
High habitable volumes in manned space vehicles are primarily requested for:

- **Availability of a minimum crew individual volume (mainly dependent on the mission duration) to guarantee <u>acceptable life conditions in terms of comfort & privacy</u>**

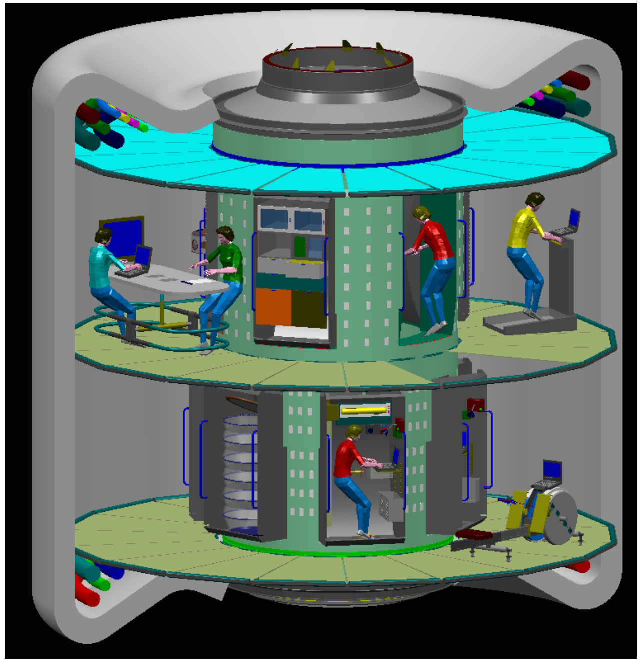
- **<u>Accommodation of sub-systems, crew equipment and payload experiments</u>**

Need to increase the current metallic modules volume reducing mass launch

Current Metallic Module (ISS Columbus)



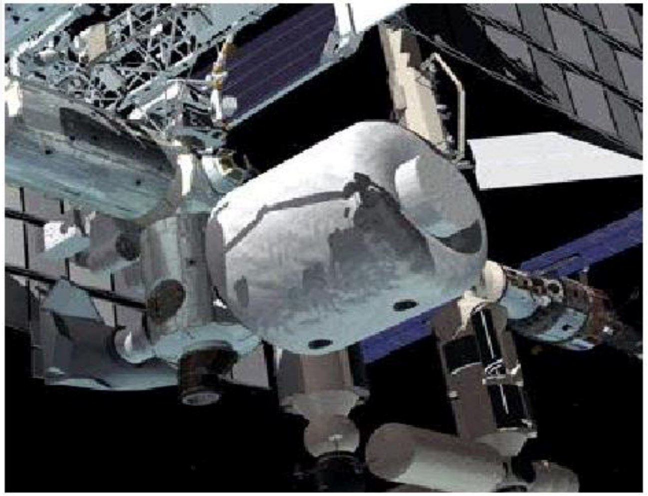
New Generation Inflatable Module



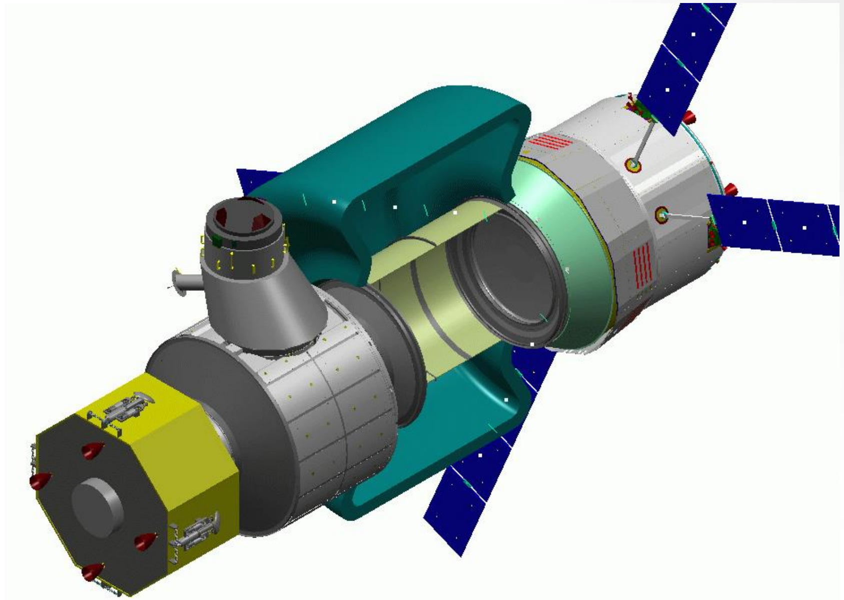
Volumes from 100 m^3 to 400- 500 m^3

Mass reduced from 30 up to 40%

Launch cost : 25 up to 40 Keuro/kg

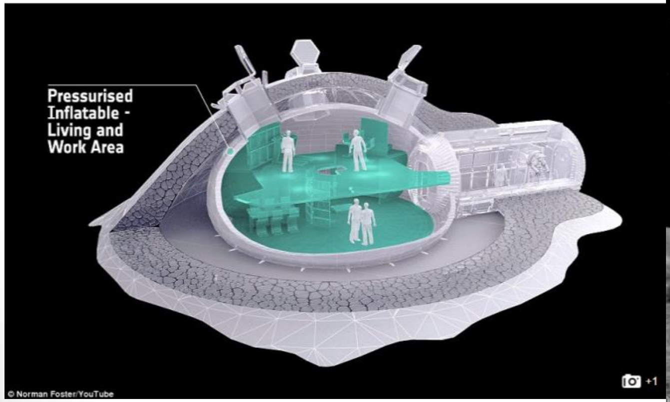


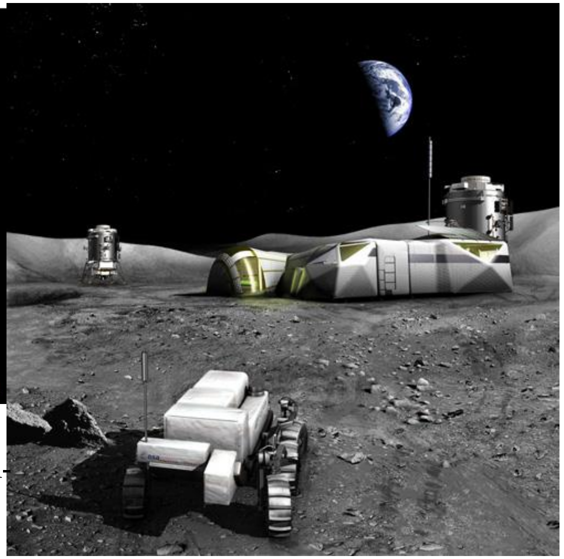
[ISS attached]: to increase the current volume or for future replacement of end-of-life metallic modules

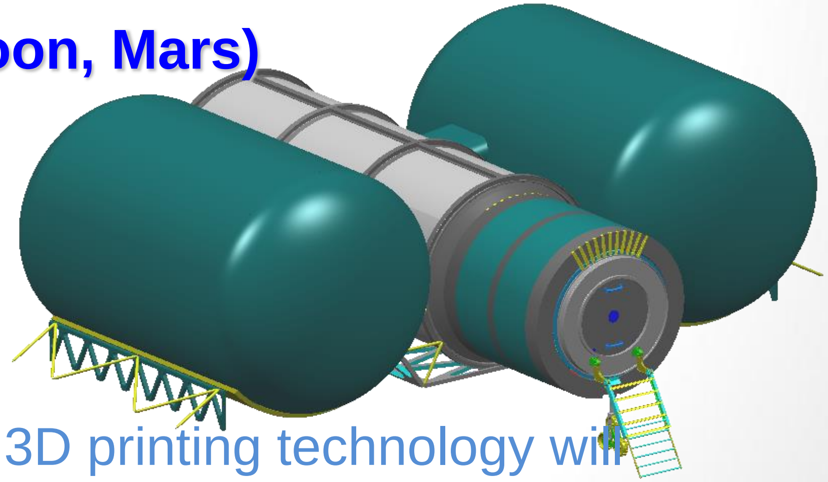


[Free Flyer Orbiting] (LEO, LLO, L1) or [Interplanetary Transfer] Modules

[Surface Habitats] (Moon, Mars)



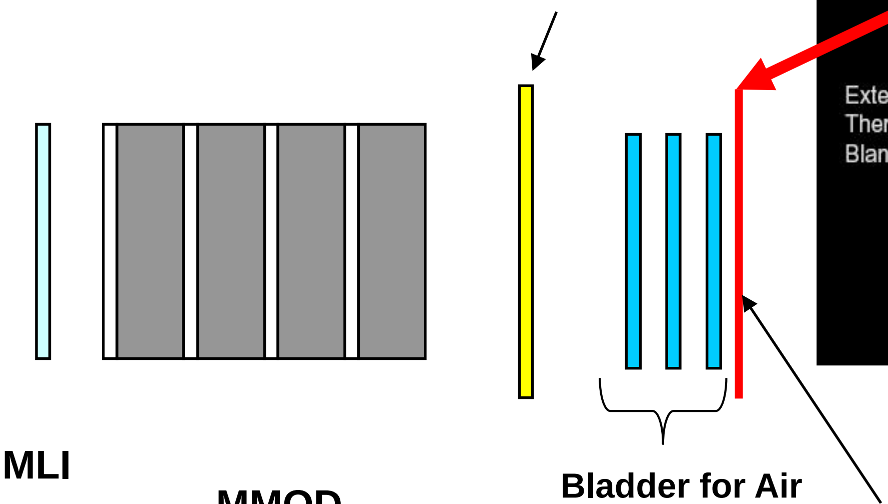


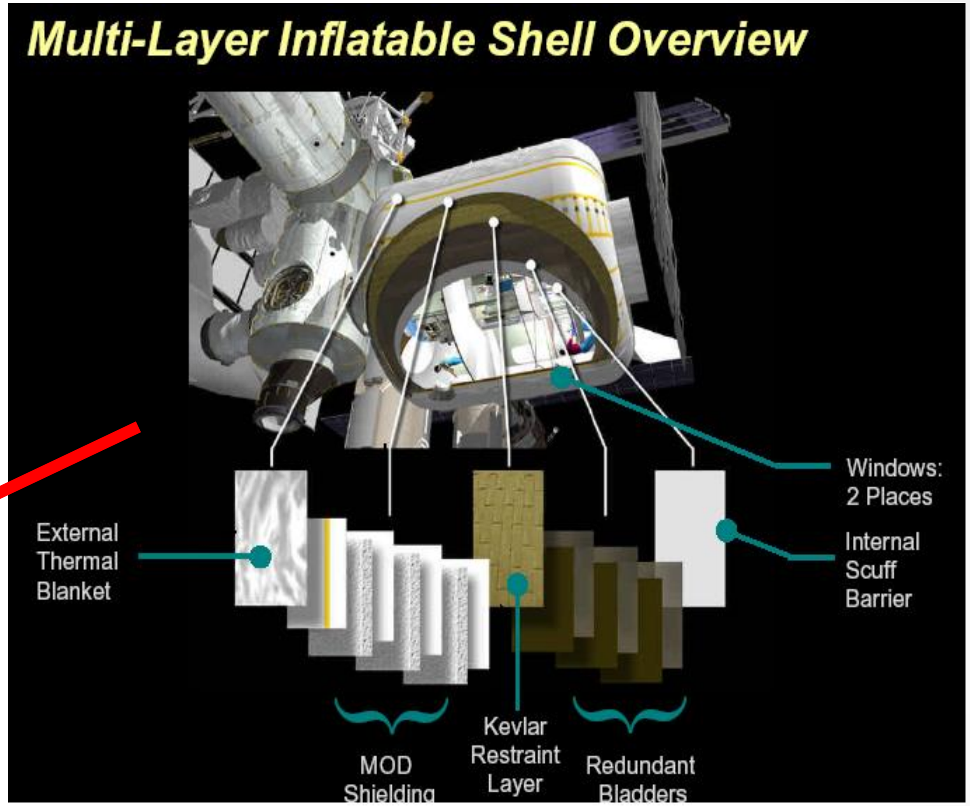


http://www.dailymail.co.uk/sciencetech/article-2824282/A-home-MOON-European-Space-Agency-reveals-plans-human-settlement-outside-Earth-says-inflatable-base-3D-printing-robots.html#ixzz4J6oqCvHE

3D printing technology will transform raw lunar soil into livable domes, covering inflatable structures

Complex Functional Layer Sequence





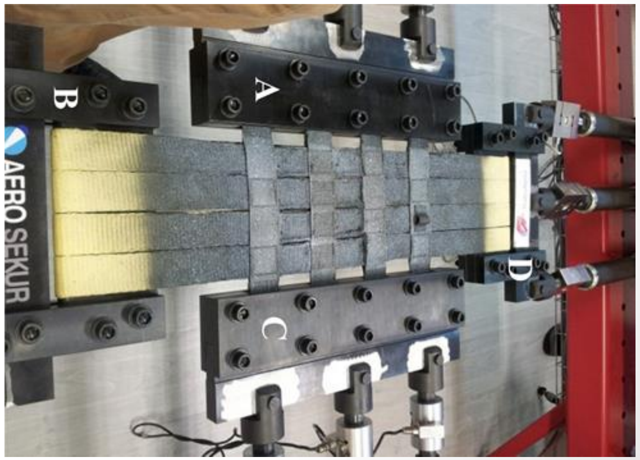
All the functional layers are based on <u>polymeric materials</u> as textile or bulk

Materials	Density [g/cm^3]	Tensile Strength [GPa]	Abrasion Resistance	UV Degradation
Kevlar 49	1.44	3.0	Fair	High*
Technora	1.39	3.4	Fair	High* (< Kevlar)
Twaron	1.44-1.45	2.4-3.6	Fair	High*
Spectra 1000	0.97	3.5-4.0	Excellent	Low
Dyneema SK75	0.97	3.3-3.9	Excellent	Low
HT-Polyester (PES)	1.38		Good	Medium
Vectran HS	1.4	2.8-3.2	Excellent	Extremely High*
Zylon PBO	1.56	5.8	Medium	Extremely High*

Engineered fibers
For the internal barrier
And structural restraint

Multilayer high tightness layer
For bladder

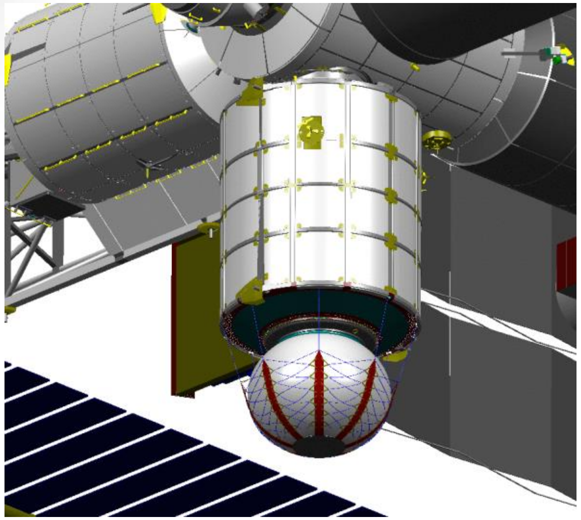
Ribbon net tested up to 150 KN



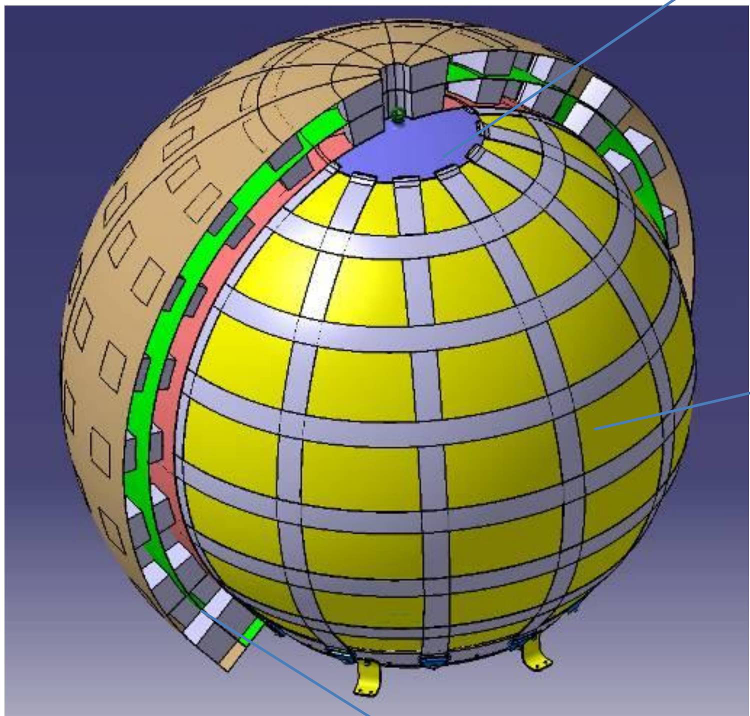
Polymeric and ceramic textile for the MMOD

Lightweight Materials

Manned Inflatable Modules Prototyping – FLECS (Flexible Expandable Commercial Module)

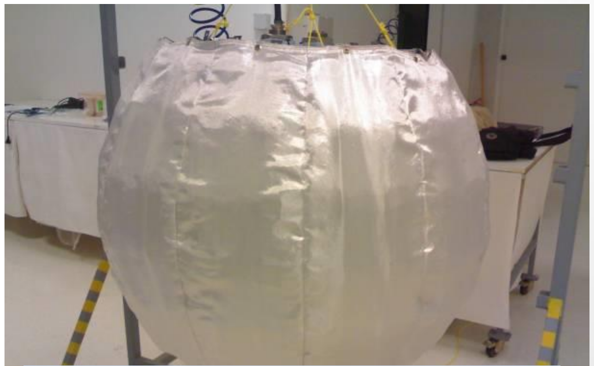


FLECS: ISS Attached



Bladder

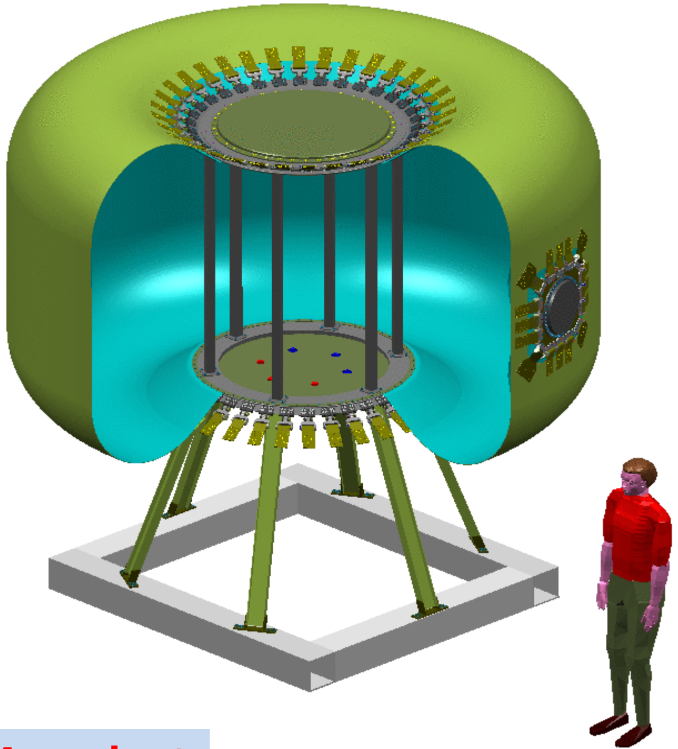
Structural restraint



MMOD Protection

Manned Inflatable Modules Prototyping (IMOD)

Reduced scale BB of 3 m diameter & 2 m height has been designed, manufactured & tested



Air Bladder inflation

Structural Restraint Installation

Ground deployment

Ground packaging

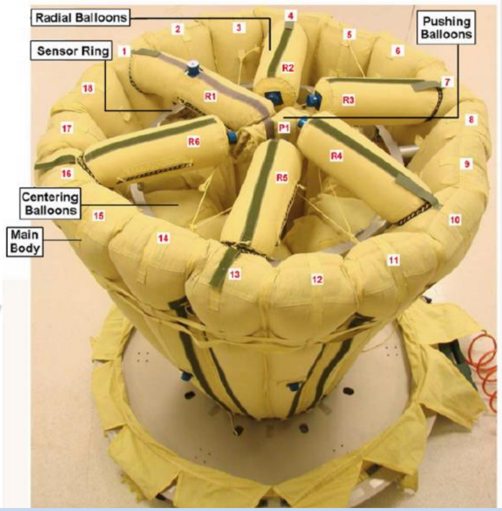
ESA project

AERO SEKUR

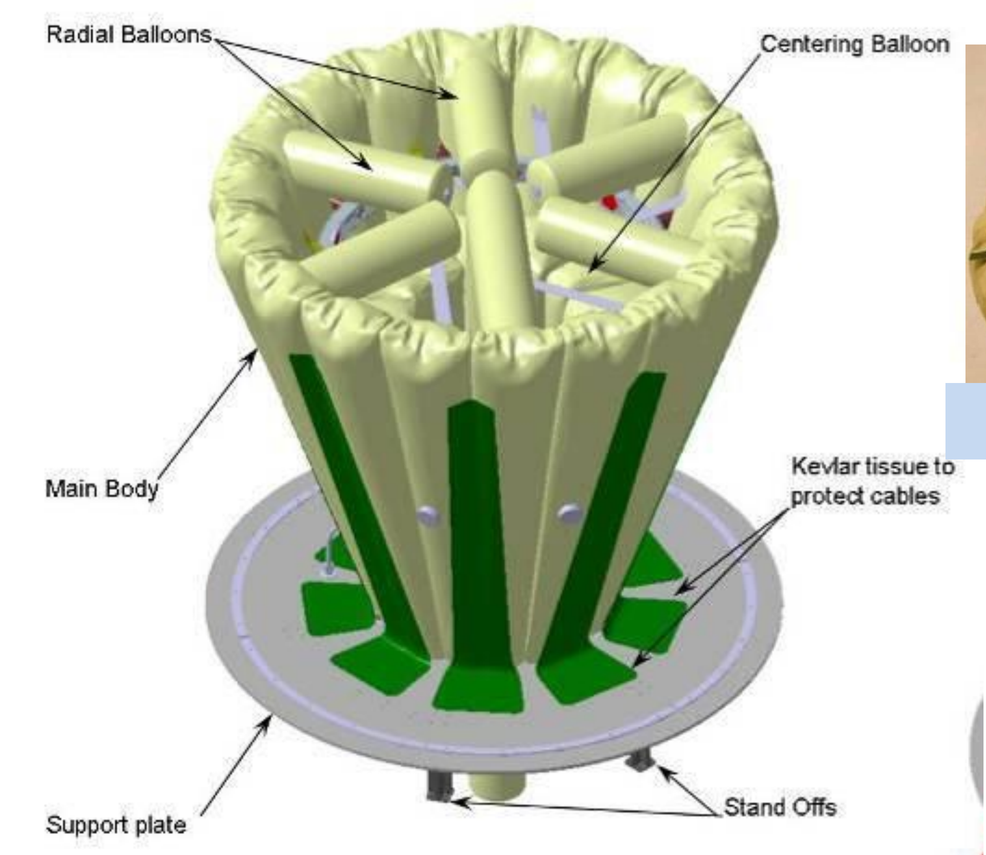
ICM (Inflatable Capture Mechanism) Constituent Parts

The constituent inflatable parts are the following:

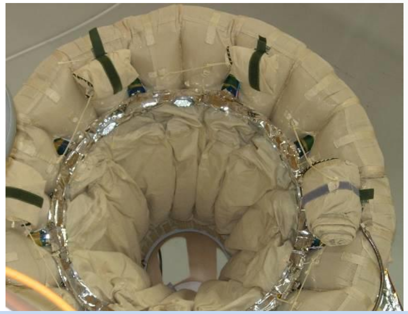
- **Main Body conical container : Height 1040 mm**
- **Radial Balloons securing of SC (Sample Container) inside Main Body**
- **Centering Balloons confining of SC in a central corridor**
- **Pushing Balloon assuring transfer of the SC in the spacecraft**



18 inflatable chambers for main body



Radial Balloons Deployed



Radial Balloons Stowed

Pushing Balloon Stowed

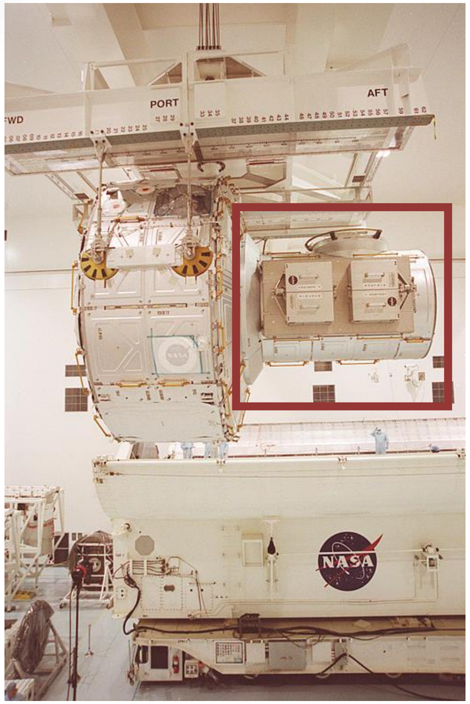
Functionality Test

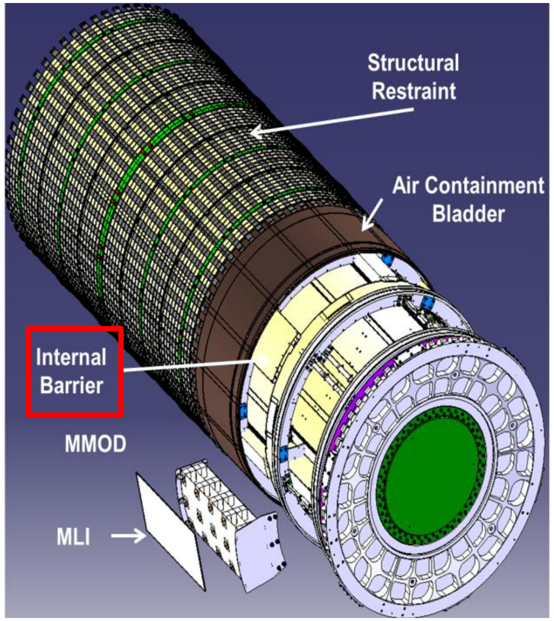
STEPS2-Expandable Crew lock prototype

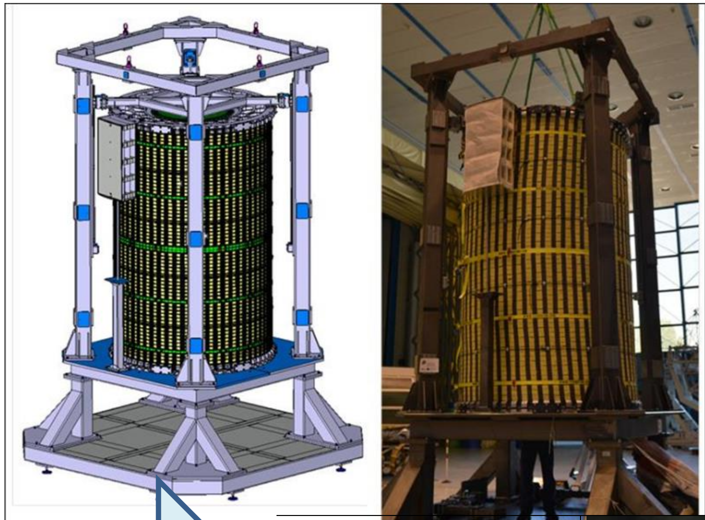
The ISS Crew Lock as case study:

Full scale dimensions

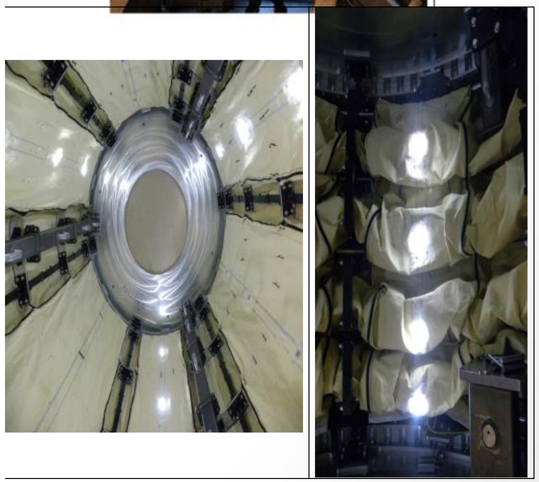
(Diameter of 2 m & Length of about 3 m)





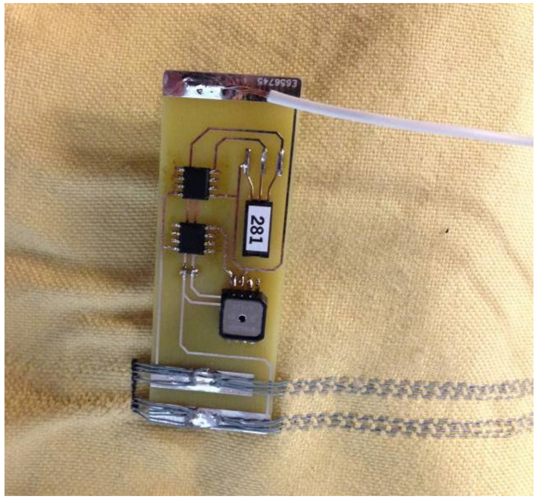


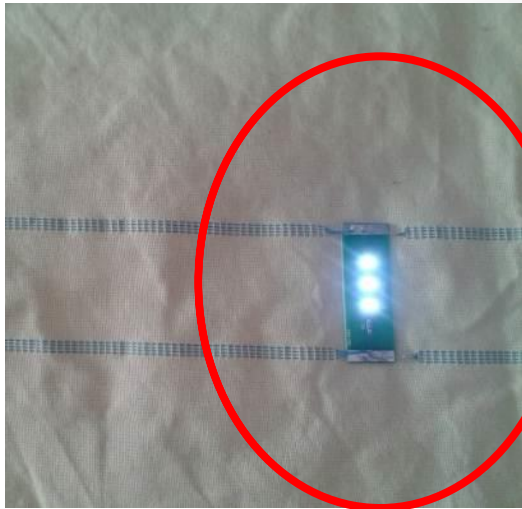
55 % Packaging Efficiency



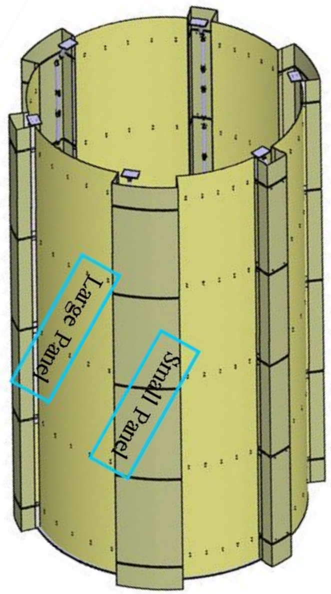
MULTIFUNCTIONAL LAYERS

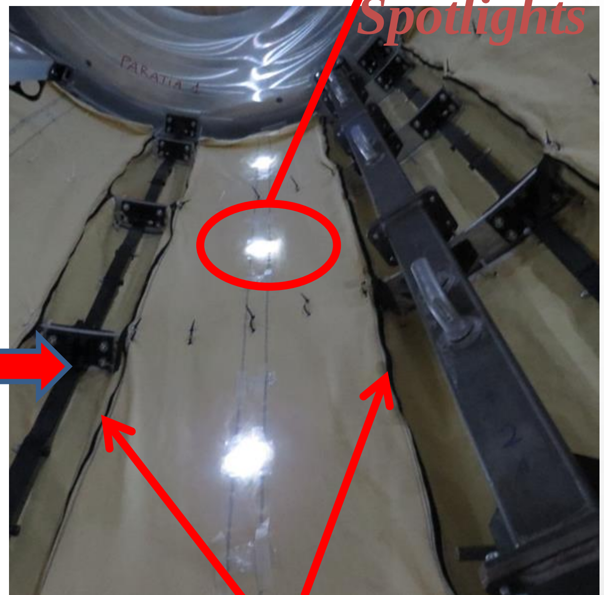
- **Antiabrasion layers**
- **lPower Cables by co-weaving of textile to feed sensors and spotlights**
- **Connection of Environmental Sensors for Pressure, Temperature and Humidity control on dedicated Cards discretized on the internal barrier internal zones of the pressurized volume**
- **Internal lighting provided by discretized LEDs spotlights**
- **Antibacterial nanostructured coating to reduce biodegradation**





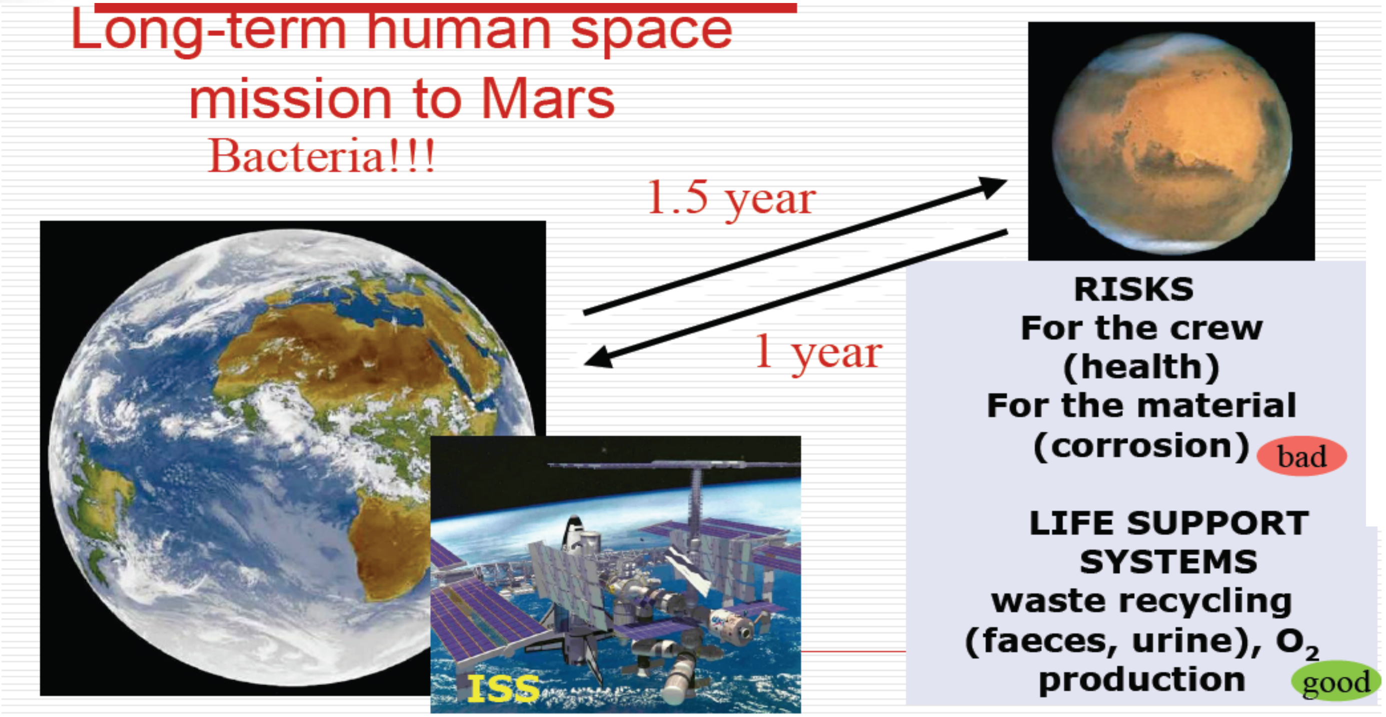
Sensors Cards





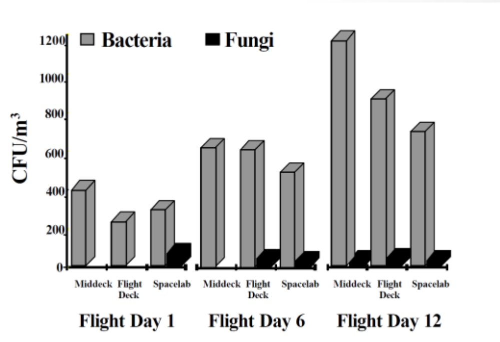
Spotlights

Joining Zips



M. Mergeay Life Support in Spaceflight and Planetary Stations: Microbes may help for Energy Efficiency-CROSSTALKS Science&Industry "Energy Efficiency Perspectives" VUB, 12NOV2008

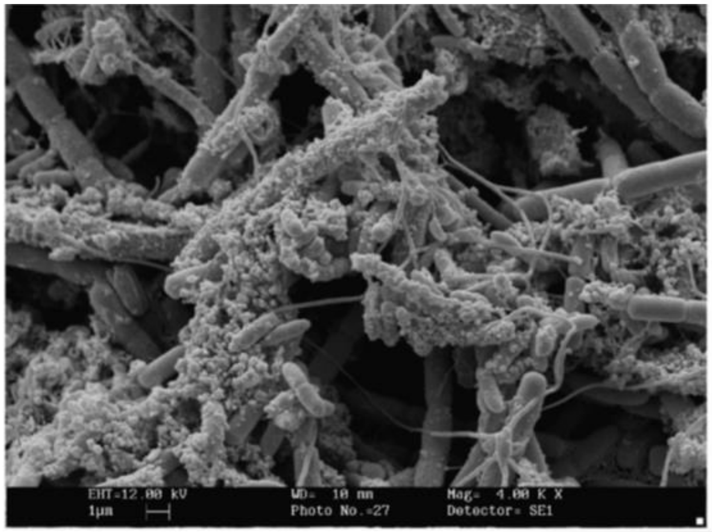
Crewmembers are the primary source of microorganisms



D. L. Pierson-Microbial Contamination of Spacecraft

234 Specia of microorganisms

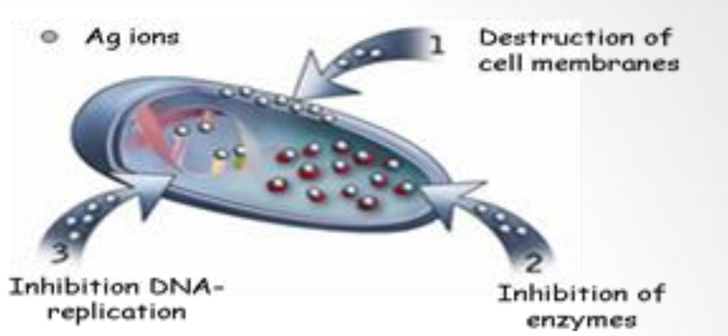
N. Novikova "Review of the knowledge of microbial contamination of the Russian mannedspacecraft"
http://ecls.esa.int/ecls/attachments/ECLS/Russianspacebiocontaminantion/russianspacecraftcontam.pdf



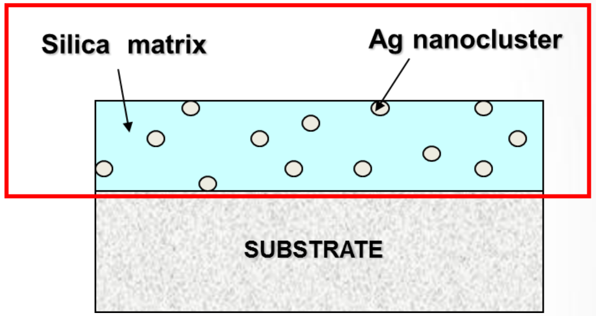
Ji-Dong Gu- International Biodeterioration & Biodegradation 59 (2007) 170–179

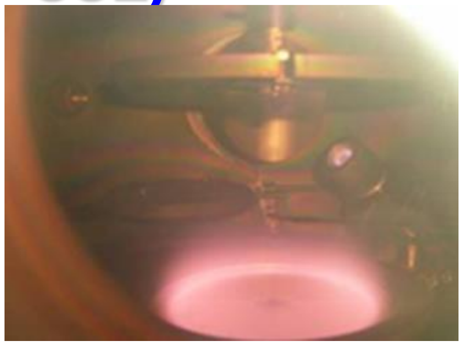
- **Biocide and antimicrobic layer**
- **High resistant in harsh environment**

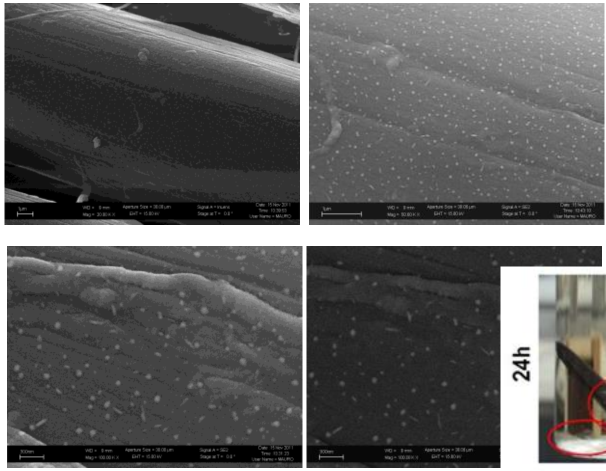
  (e.g Thermal cycling, vacuum)
- **Inorganic based material to avoid outgassing**
- **High efficacy due to silver nanostructured (high SSE)**



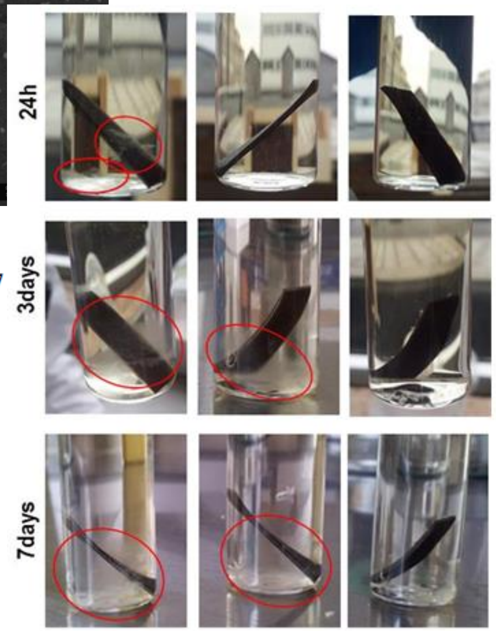
SILVER NANOCLUSTERS-SILICA COMPOSITE COATING







J Nanopart Res (2012) 14:1287



Thin layer from 60 to 300 nm

Proliferation of the fungal specie is inhibited in the most severe conditions (e.g immersed in a fungal broth)

Bigelow Expandable Activity Module

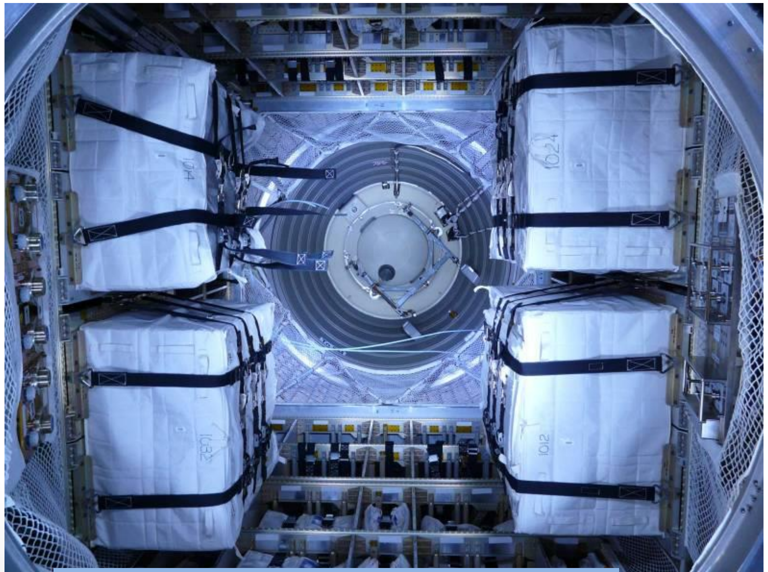
Full-scale mock-up of BEAM at JSC

- **Material**: Inflatable shell
- **Length**: 4 meters
- **Diameter**: 3 meters
- **Weight**: ~ 1300 kilograms
- **Overall Volume**: 16 cubic meters

Credit: Bigelow Aerospace

https://en.wikipedia.org/wiki/Bigelow_Expandable_Activity_Module

SOFT BAGS, BELTS & NETS IN ATV MISSION



Transport Bags & Belts Restraint

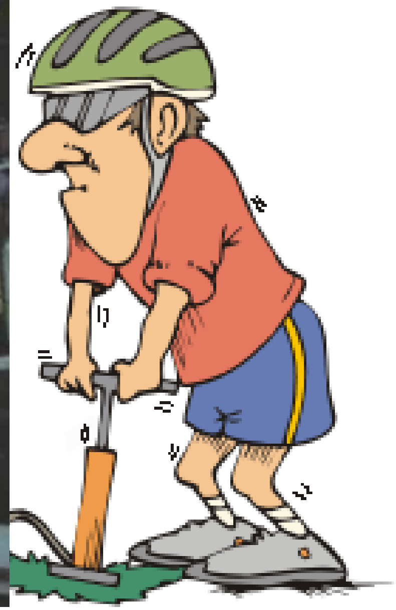
Containment Nets

Crew Access to ATV

CYGNUS PCM: FABRIC BAGS & BELTS

Restraining Ribbons from SABELT (leader in automotive safety devices)

THANKS



Questions ?