Strutture Gonfiabili per Applicazioni Spaziali

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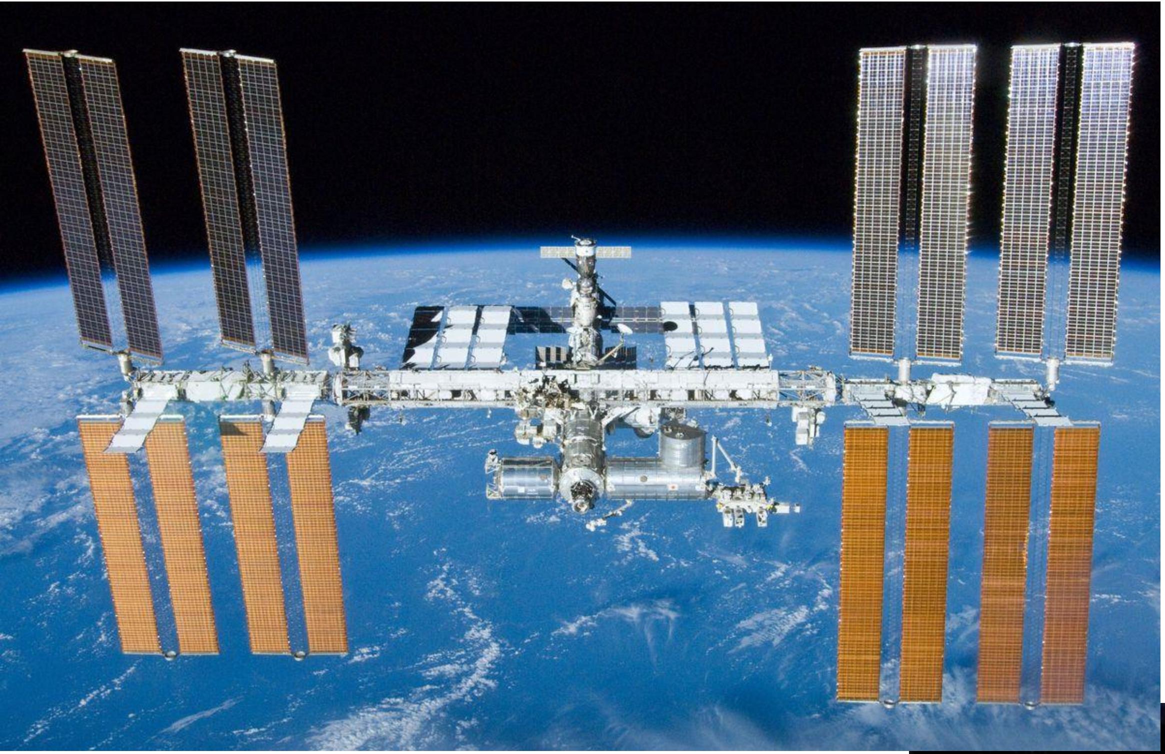
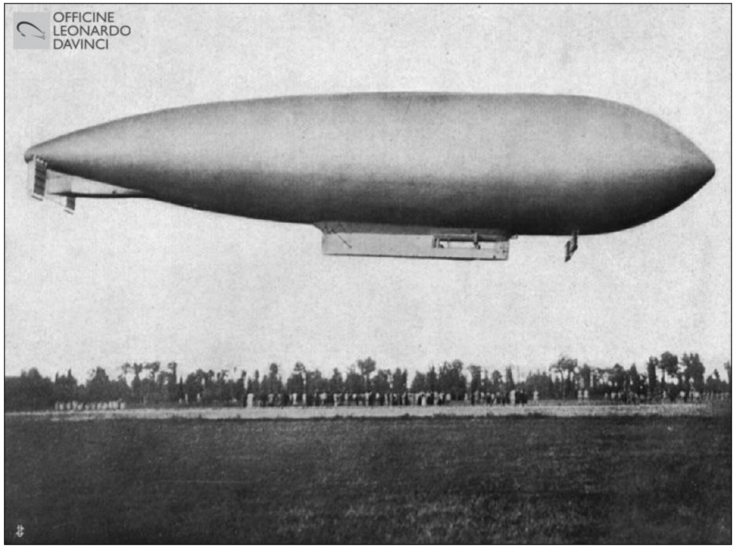


ISS: present

I(?)SS: future

INFLATABLE STRUCTURE VS AERONAUTICS:



Condor_video

Why Inflatable Space Structures?

❖ Strong Weight reduction is mandatory

❖ Less volume available

ARIANE 5 (Pay-load dimensions)	
Diameter of fairing	4,5 m
Height fairing	10,3 m
Max Payload	27 t

Possible solutions:

- ❑ Deployable structures DS
- ❑ Expandable structures ES
- ❑ Inflatable structures IS
- ❑ DS+ES+IS (Gossamer)

Complicating Effects!

❖ **Use of IS as Manned Spacecraft**

Menings of GOSSAMER

Somethingh tenous and insubstantial such as a cobweb floating in the air, drives from goose summer

CONTENTS OF THIS TALK

- **OVERVIEW OF INFLATABLE STRUCTURES FOR UNMANNED AND MANNED APPLICATIONS**

- **EXAMPLE OF SIMULATION OF SIMPLE STRUCTURAL ELEMENTS AND COMPLETE SPACECRAFT (IRDT, IMOD, AIRLOCK ..)**

JUSTIFICATION OF THE INFLATABLE STRUCTURES

Many reasons are on the basis of the choice of inflatable structures for the construction of Space Structures

1. Mainly the mass of these structures is less of that of the traditional metallic ones

2. The inflatable structures can be easily accommodated inside the launcher due to their possibility of folding

3. Greater volumes can be exploited in comparison with the traditional metallic structures

4. Different configurations can be easily obtained during their operative life (for example by the inflation of compartments in several periods)

POSSIBLE UTILIZATION OF THE INFLATABLE STRUCTURES

IS can be classified as Unmanned and Manned Space Structures.

Example of Unmanned Space Structures are:

- **RE-ENTRY CAPSULES**

- **AIR BAGS FOR SHOCK ABSORBER AND DECELERATION SYSTEMS**

- **SOLAR ARRAYS**
- **ANTENNAS AND REFLECTORS**
- **HEAT SHIELDS**
- **SOLAR SAILS**

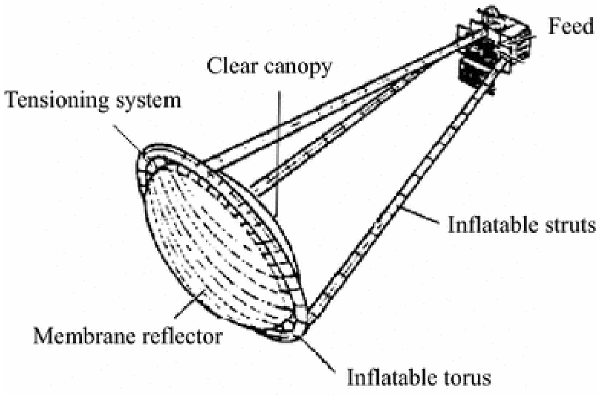
- **ROVER AND LANDER (R/L ELEMENTS)**

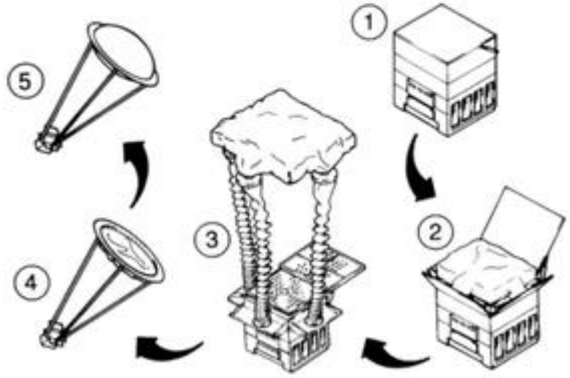
POSSIBLE UTILIZATION OF THE INFLATABLE STRUCTURES

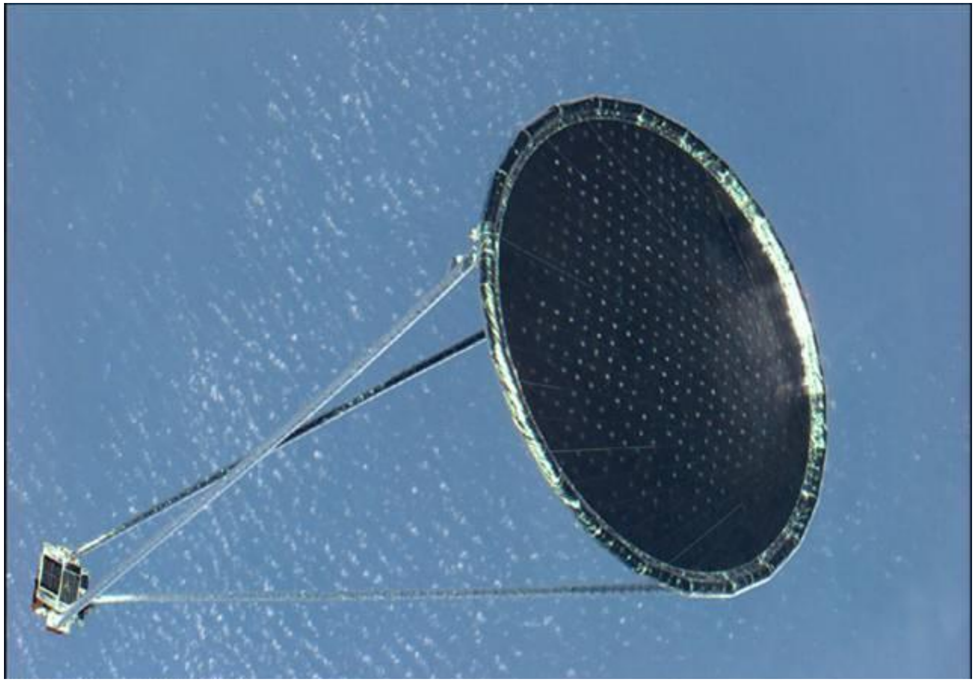
Example of Manned Space Structures are:

- **SPACE STATION (!)**
- **PRESSURIZED MODULES PERMANENTLY ATTACHED TO THE SPACE STATION**
- **PRESSURIZED MODULES FOR INTER-PLANETARY TRANSFERRING**
- **PERMANENT BASES FOR PLANETARY EXPLORATION**

UNMANNED /INFLATABLE STRUCTURES





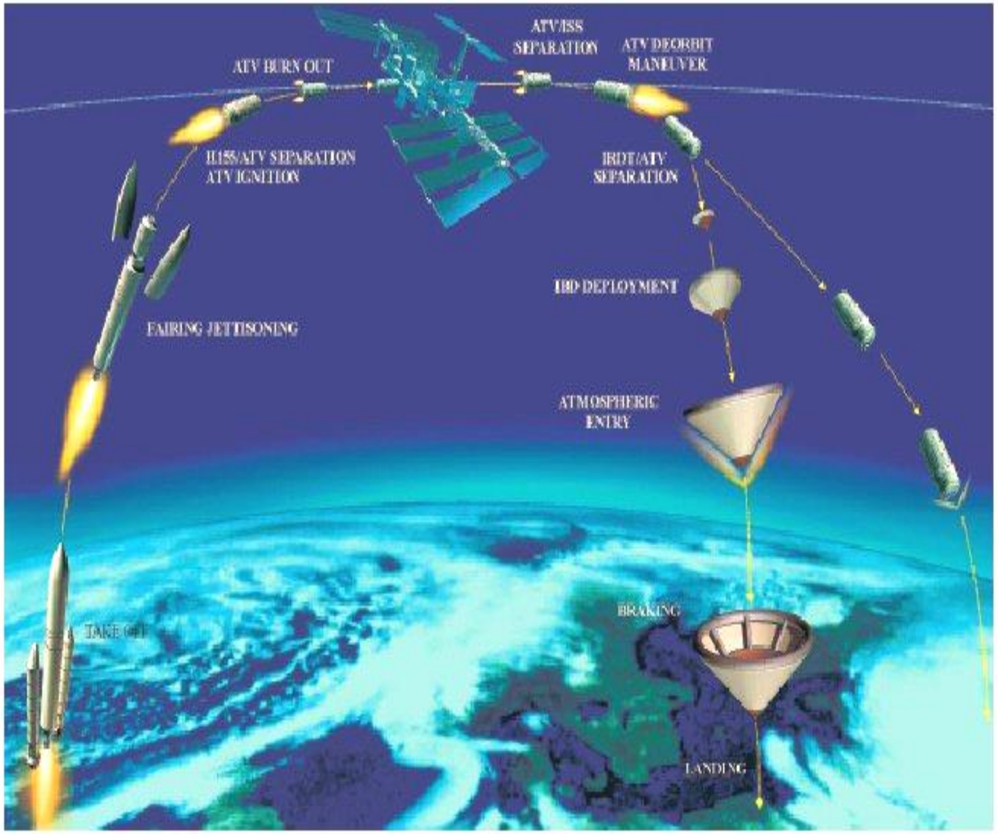


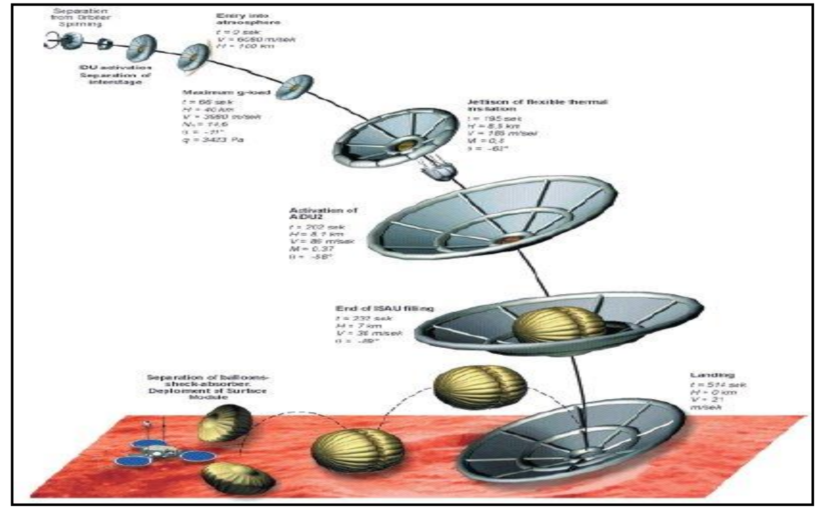
L'Garde Inflatable Antenna

NORMALLY THESE ANTENNAS ARE LAUNCHED IN A ROLLED CONFIGURATION AND THEN THEY ARE DEPLOYED IN ORBIT BY THE USE OF NITROGEN

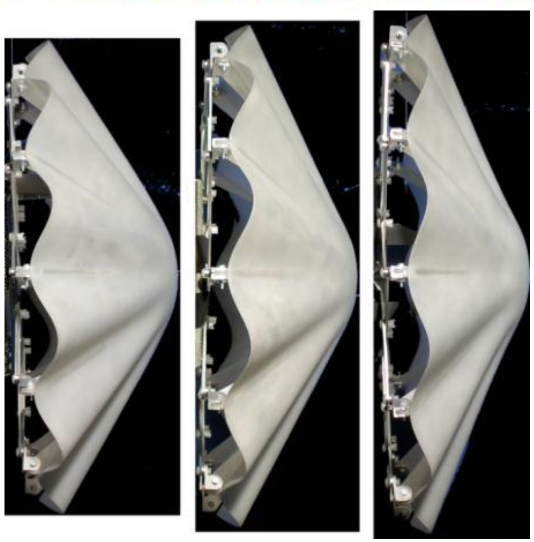
THE REFLECTOR, WHICH IS MADE OF THIN LAYERS, IS TENSIONED BY THE INFLATION OF THE TOROIDAL SUPPORT.

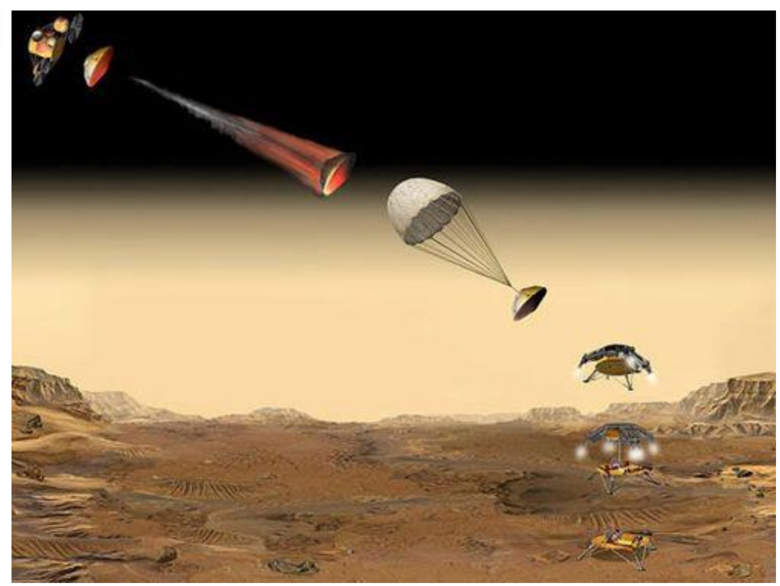
USE OF IRDT (ATV+ ISS)





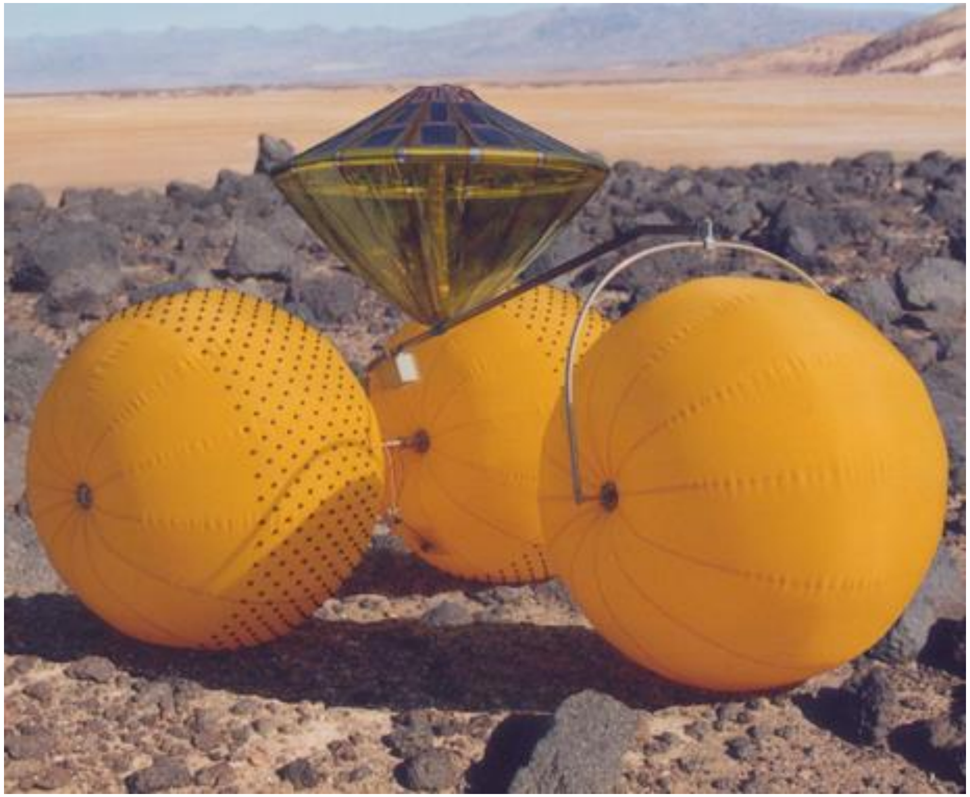
caltech

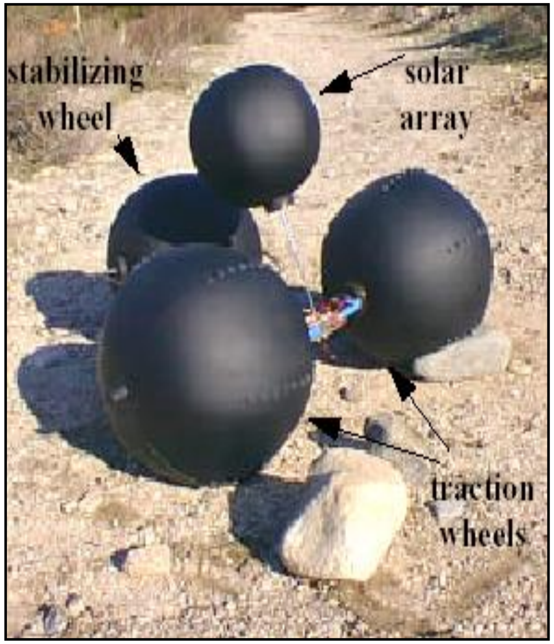


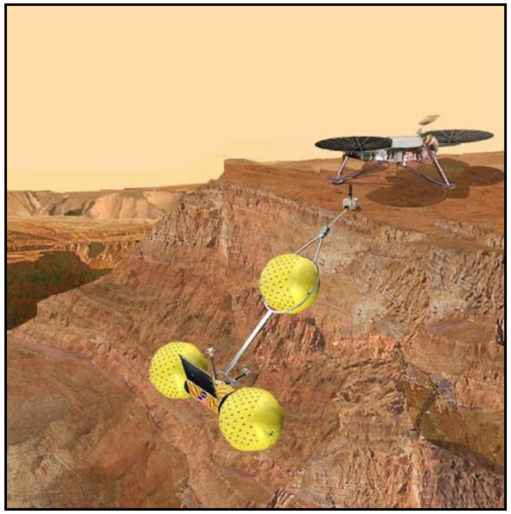


EXAMPLE OF UNMANNED INFLATABLE STRUCTURES

Use of Inflatable Capsule for planetary exploration and for Rover construction







JPL Inflatable Rover per l'esplorazione della superficie di Marte alimentato da Inflatable Mars Rover Solar Array (ILC Dover, Inc.)

EXAMPLE OF UNMANNED INFLATABLE STRUCTURES
FLEX MODULE SHUTTLE CARGO BAY attached to MLPL

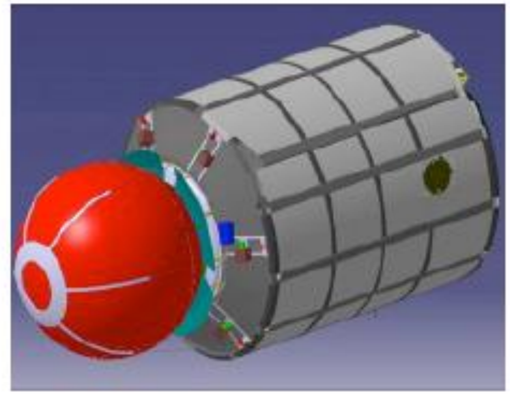


Figura 1.11: Rappresentazione grafica dell'attacco di FLECS al modulo MPLM

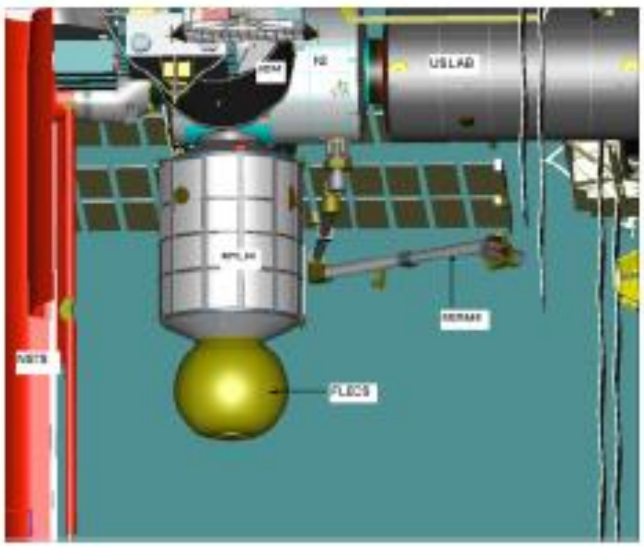


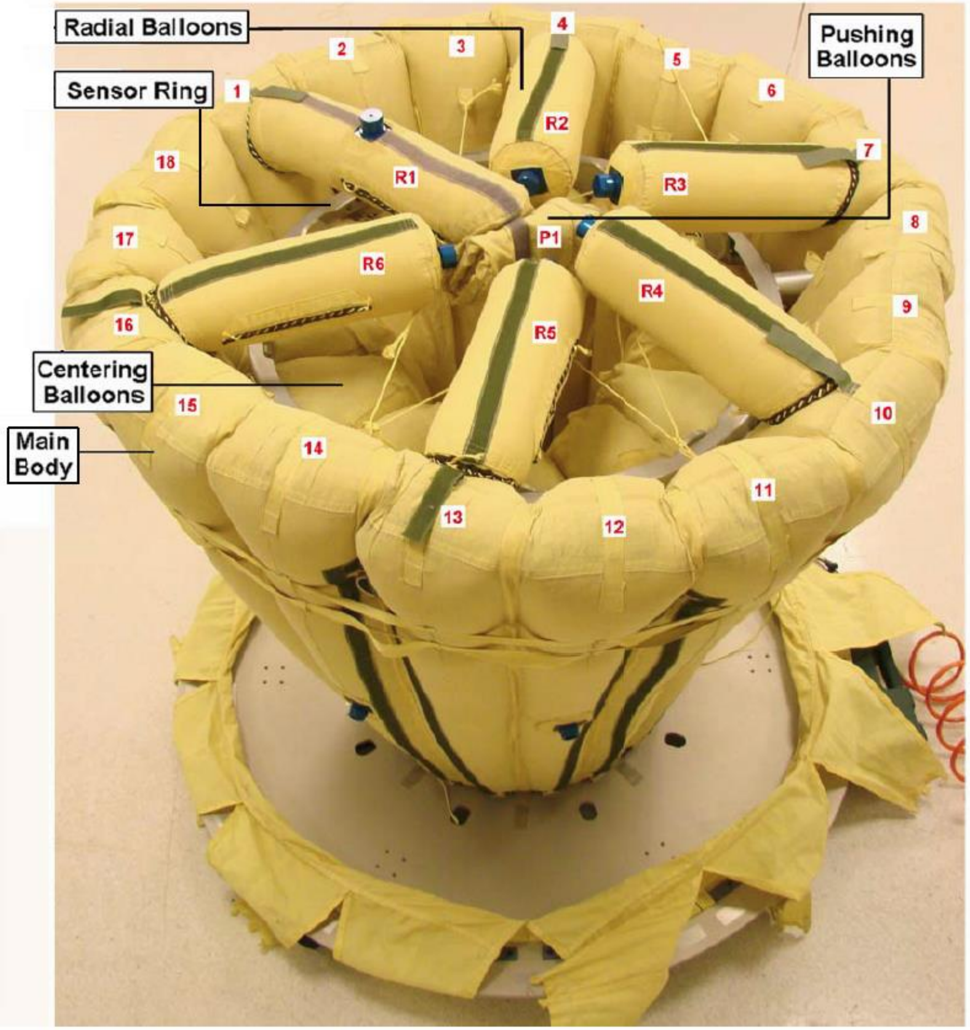
Figura 1.12: Posizionamento di FLECS sulla ISS

ThalesAlenia
A Thales / Finmeccanica Company Space

ICM INFLATABLE CAPTURE MECHANISM

*Designed as an **inflatable device to be installed on board of the Mars Orbiter in MSR mission***
*ICM Tasks: **capture, transfer and safely store a Sample Container (SC)** starting from its free flying condition of an orbital trajectory around Mars*

*The mechanism design **maximizes the use of inflatable items and technologies** with a minimum/partial involvement of mechanical parts to optimize the mass*



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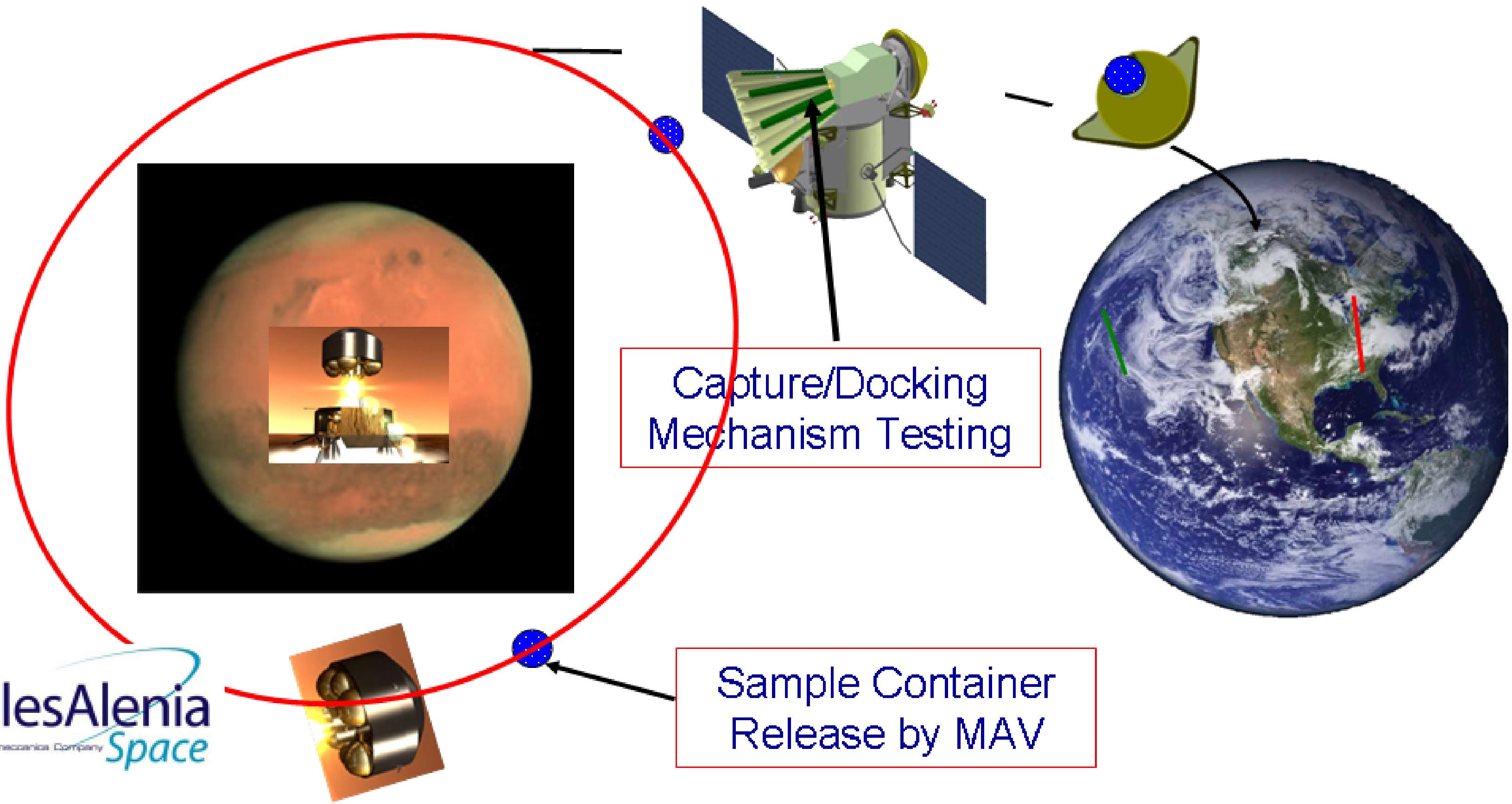
ICM INFLATABLE CAPTURE MECHANISM

THE **MSR** REFERENCE MISSION – RETURN PHASE



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Constraints Introduced By Manned Configuration

1. The shell modules can become very thick due to the necessity of protection against the meteorites

2. The air containment become crucial for the crew survival

3. Then the connections between flexible and rigid parts become a critical topics, not only for the assurance of a suitable mechanical strength but also to avoid air leakage

4. The reaching of a precise operative shape can become sometimes mandatory, then deployable mechanisms can be used as guide to reach this final shape

5. The assurance of a suitable strength of this thick shell to the folding and unfolding stress, as well as to the internal pressure, become very important for the structure survival

Advantages Introduced By IS for Manned Configuration

Due to the fact that these structures must house the crew, the Manned Inflatable Space Modules can exhibit one of their main characteristic:

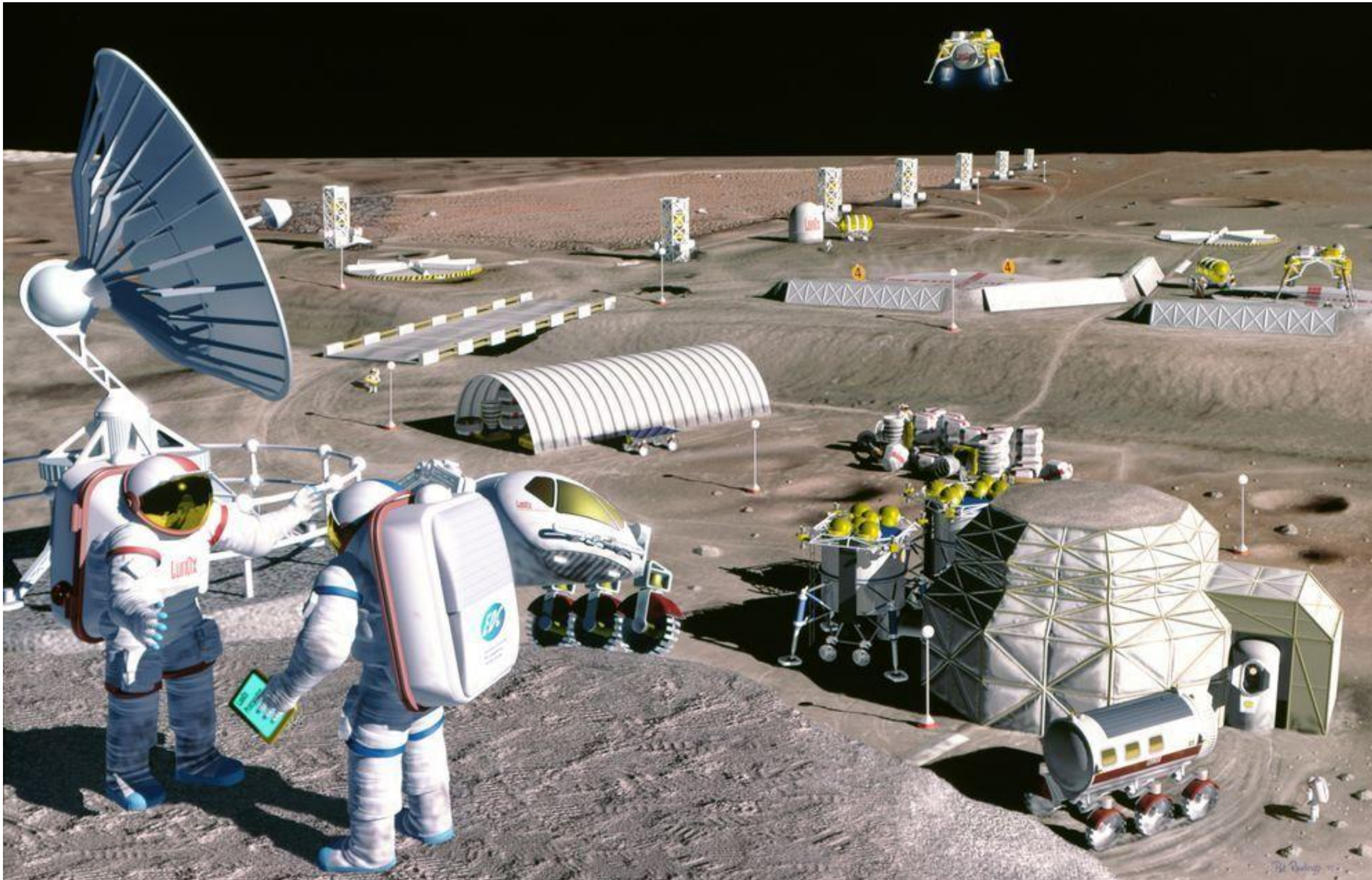
1. **The exploitation of a large habitable volume**

2. **The possibility of increasing the number of crew members and a more comfortable on board life**

3. **A more comfortable internal environment, can give high benefit to the crew, especially for long duration missions**

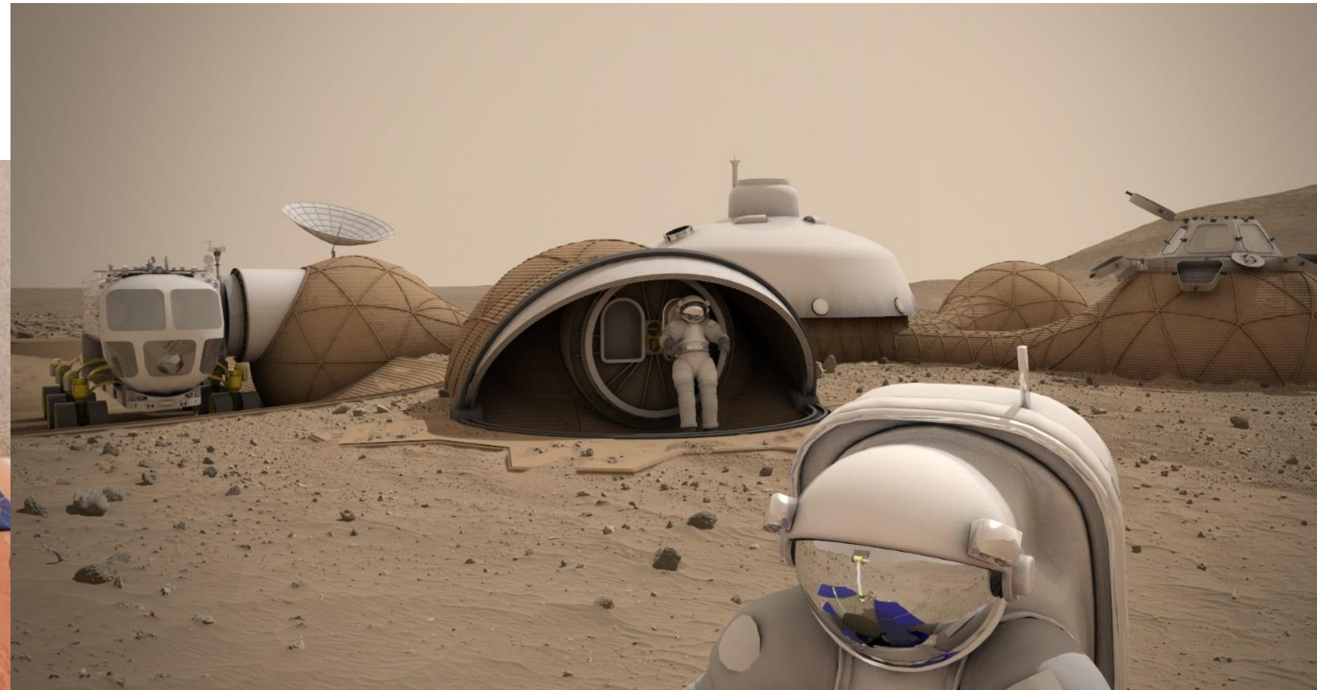
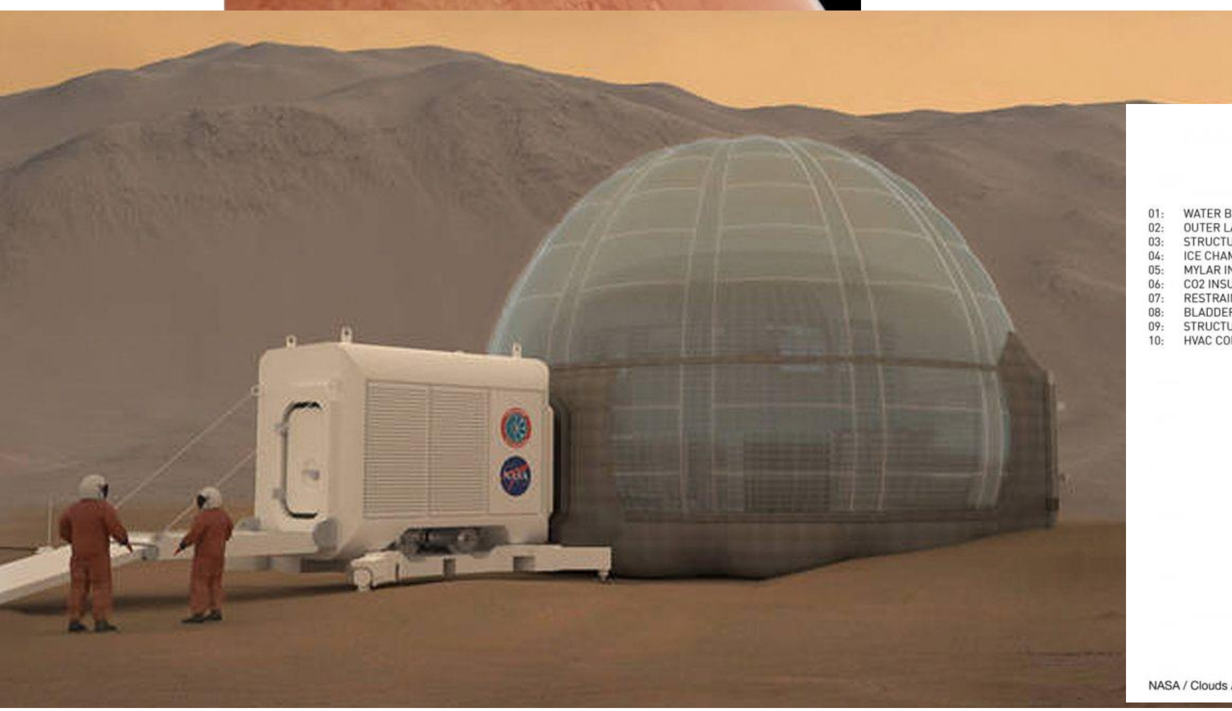
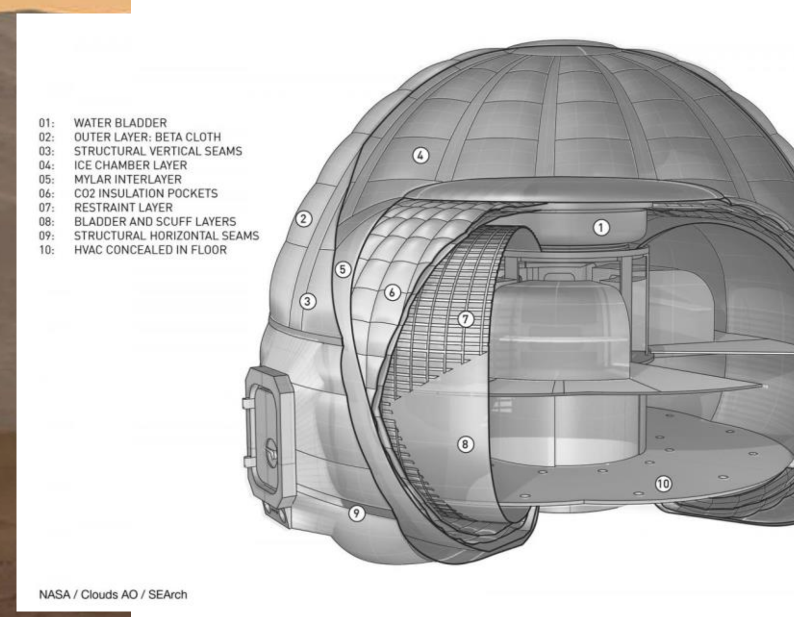
1. **The Manned Inflatable Modules can offer this large habitable, which can be 4 times greater then that offered by the traditional metallic modules.**

Manned Spacecraft

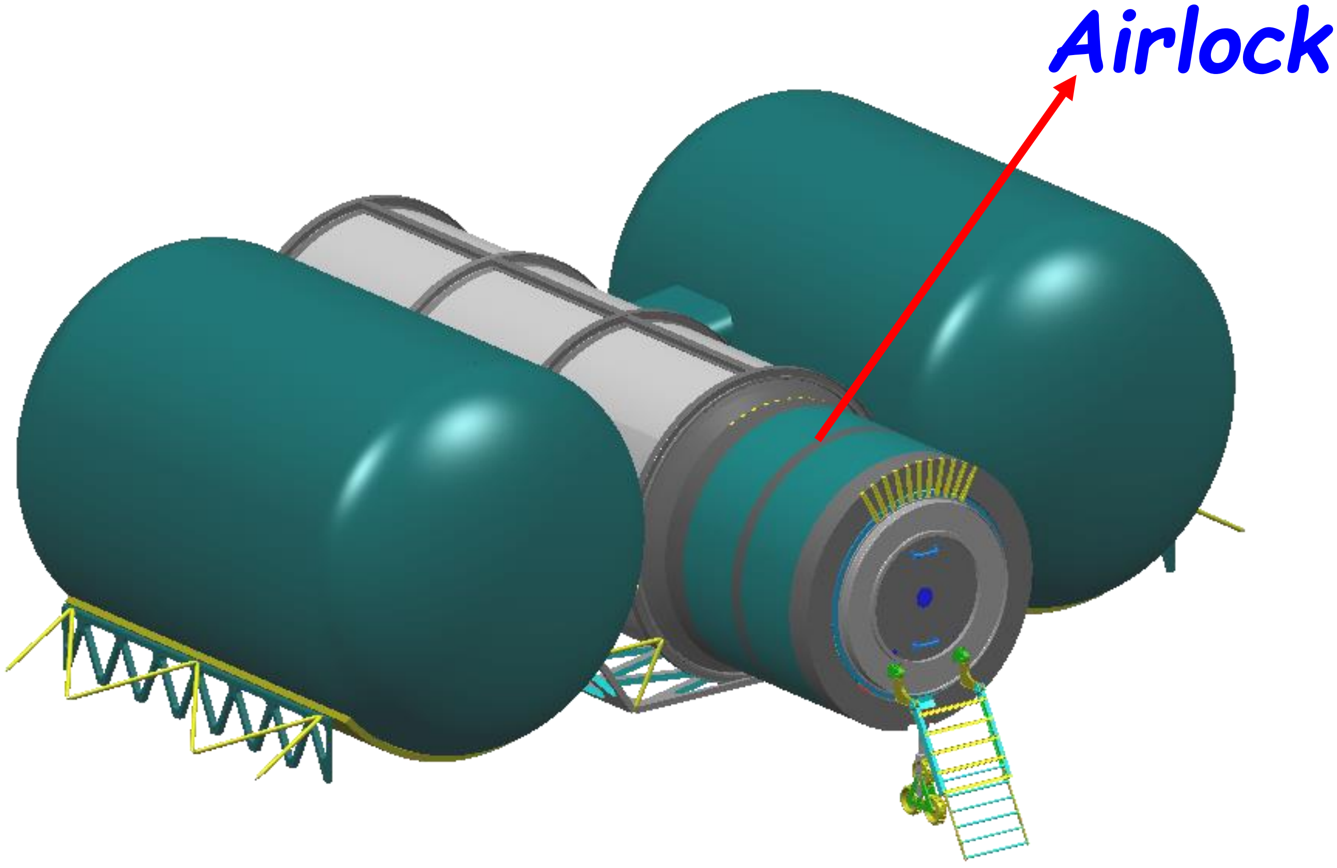


Manned Spacecraft SS



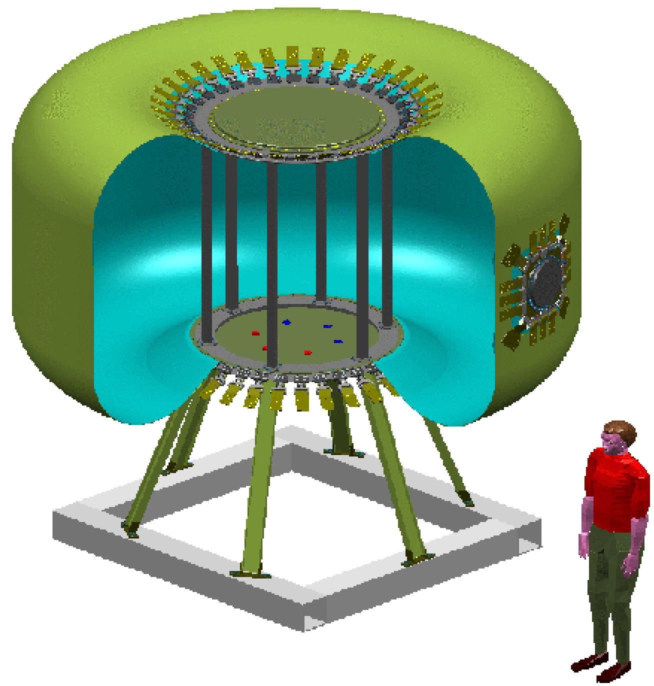



01: WATER BLADDER
02: OUTER LAYER: BETA CLOTH
03: STRUCTURAL VERTICAL SEAMS
04: ICE CHAMBER LAYER
05: MYLAR INTERLAYER
06: CO2 INSULATION POCKETS
07: RESTRAINT LAYER
08: BLADDER AND SCUFF LAYERS
09: STRUCTURAL HORIZONTAL SEAMS
10: HVAC CONCEALED IN FLOOR
NASA / Clouds AO / SEArch

PERMANENT BASES FOR PLANETARY EXPLORATION
AN EXAMPLE ON THE MOON



Manned Spacecraft

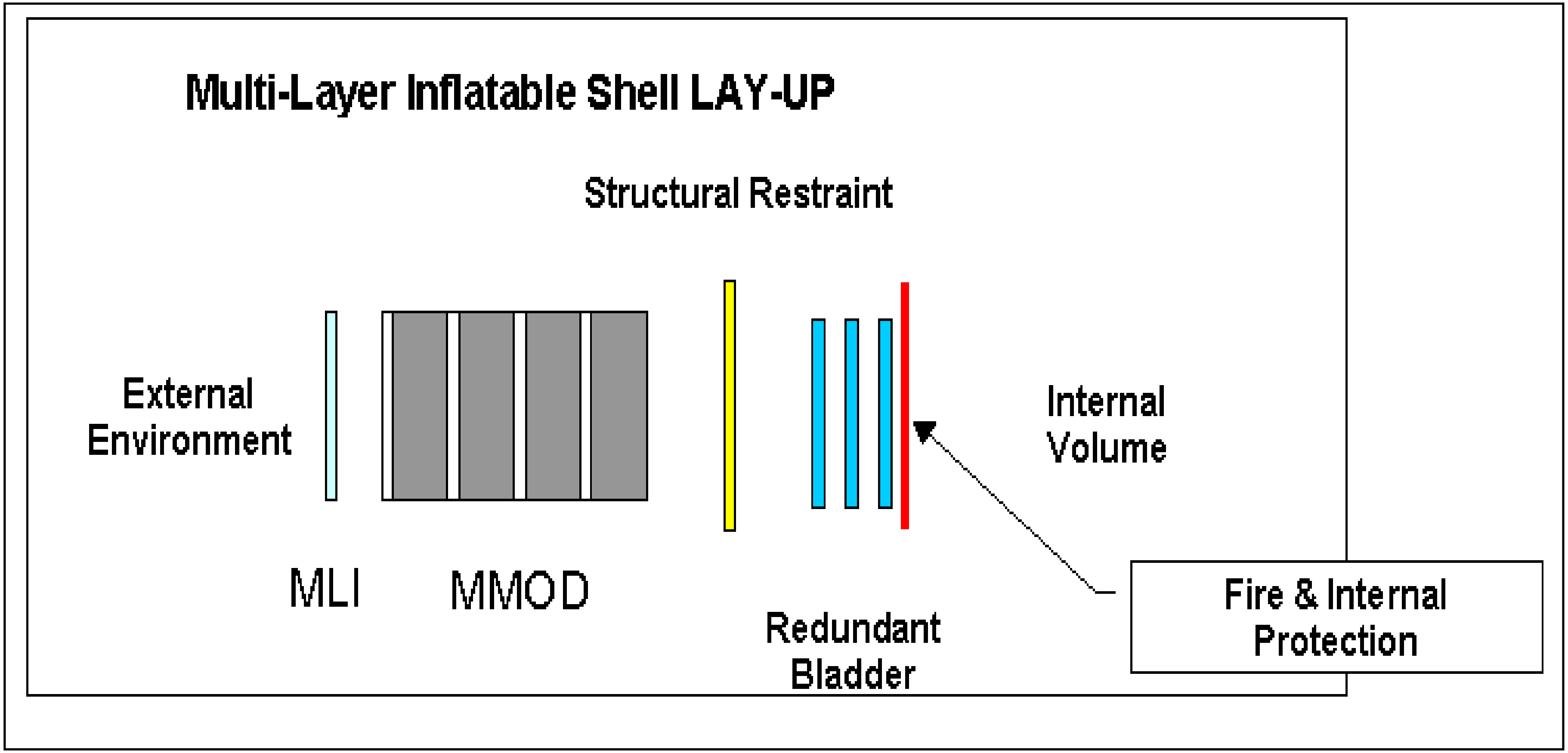
Transhab –ISSA (NASA)



I-MOD (ESA, TASI)

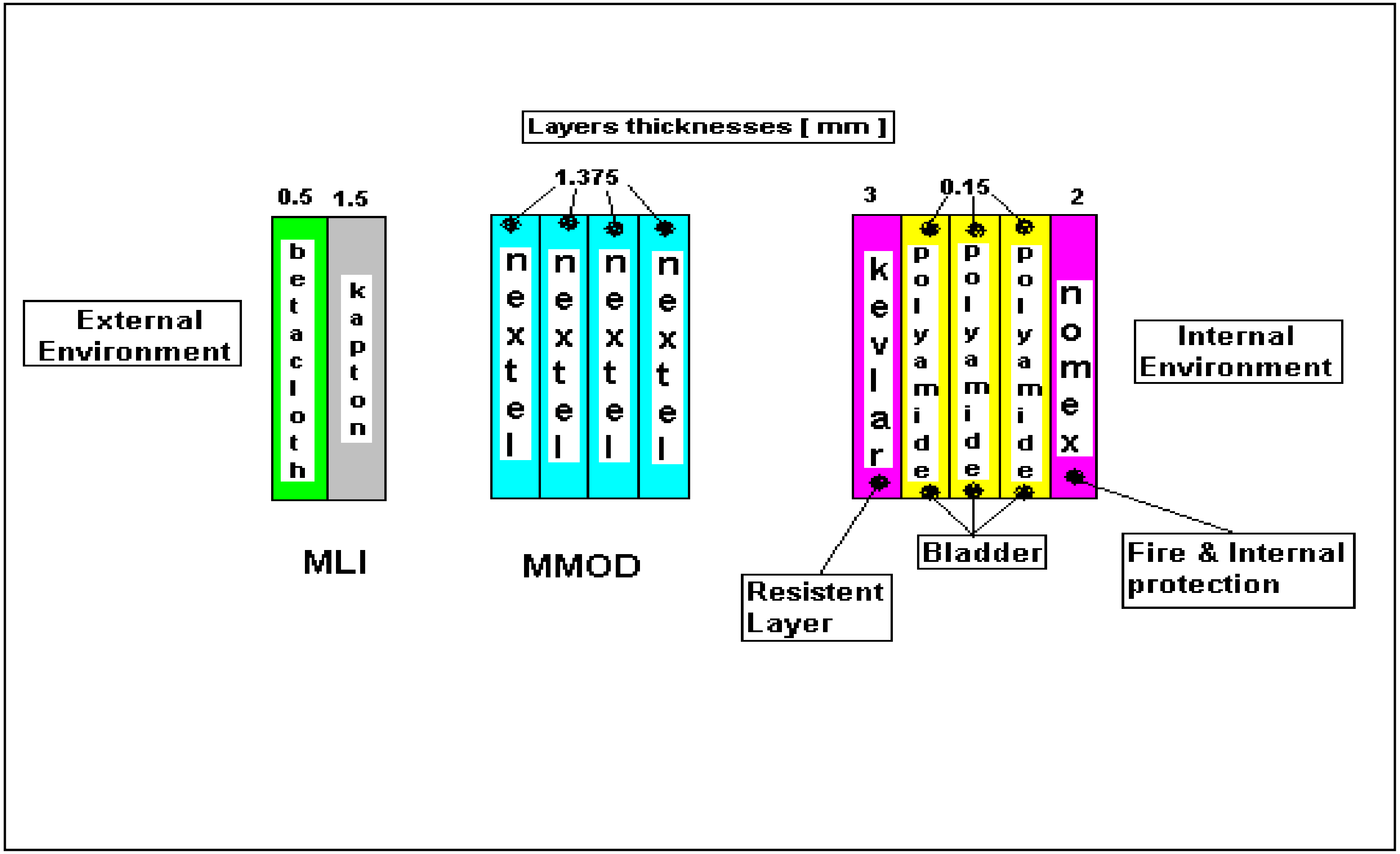
Transhab_video

https://www.youtube.com/watch?v=QxzCCrj5ssE



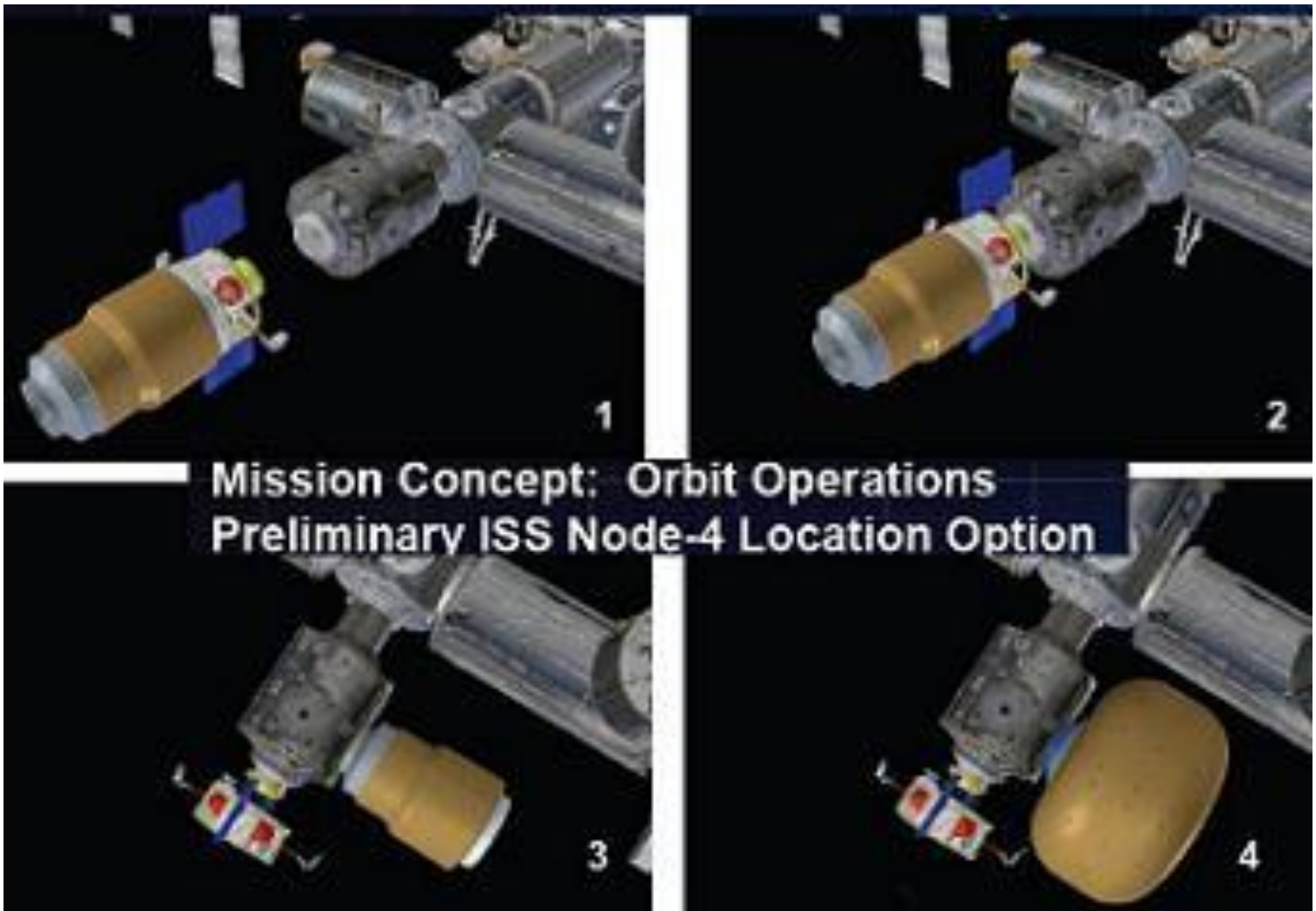
Inflatable Modules shell structure possible sequence

Typical Multilayered Sequence



Inflatable Modules shell structure possible sequence

THE MOST RECENT
GENESIS I & 2 FROM BIGELOW



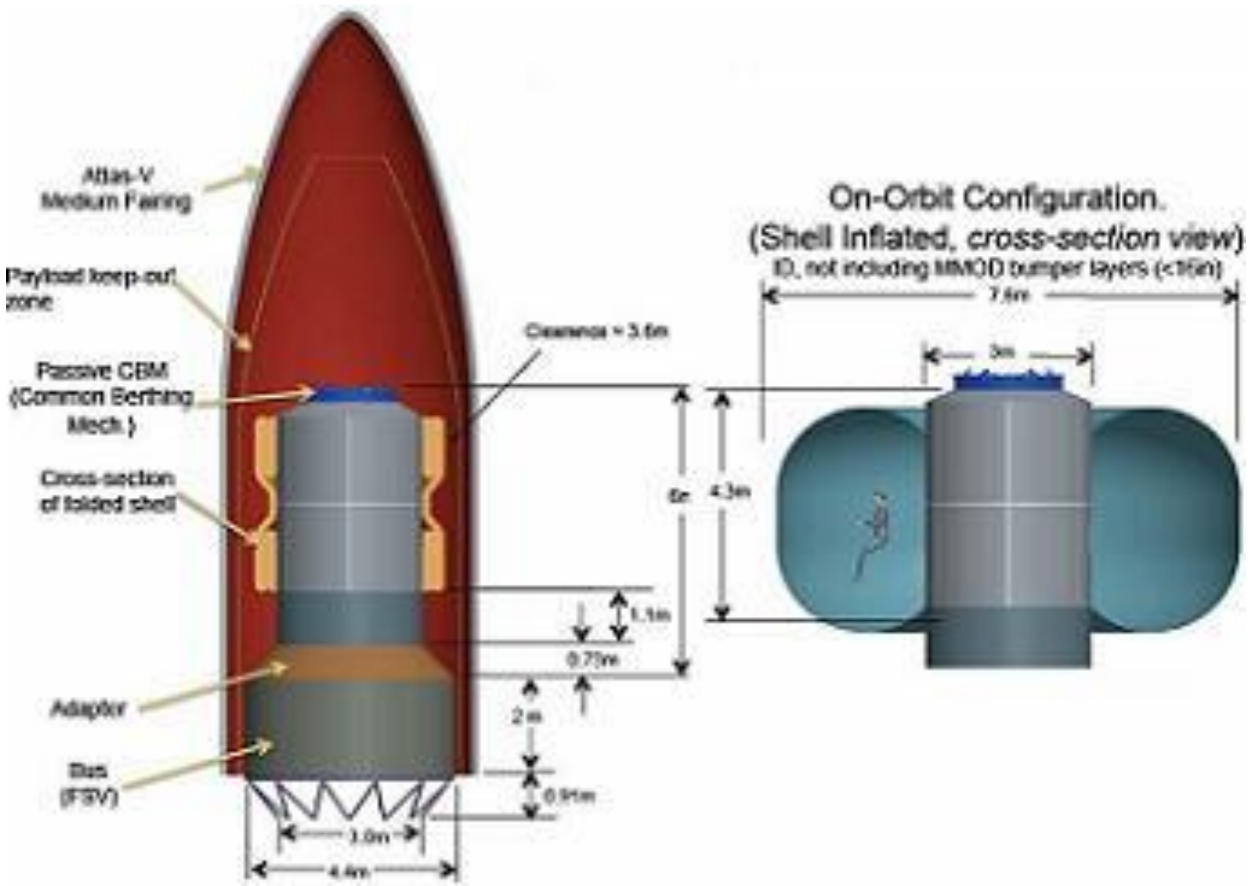
BIGELOW G1 and G2

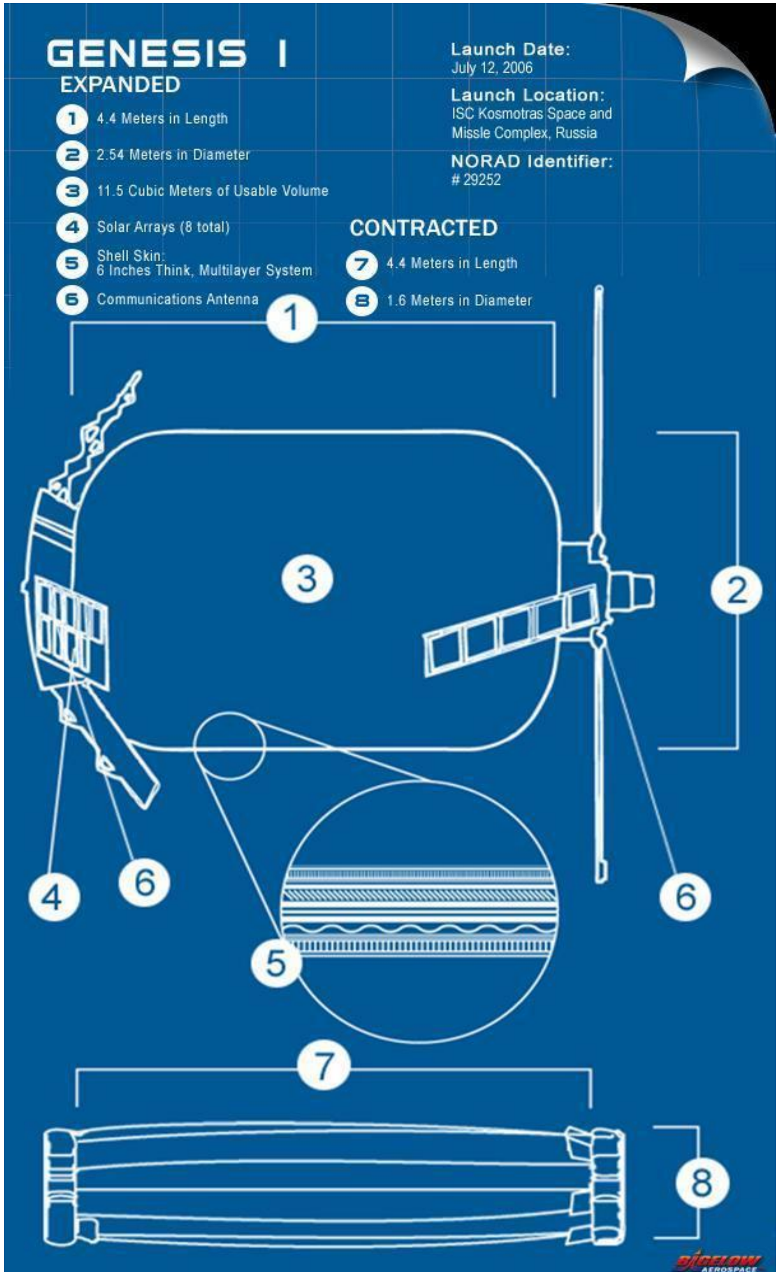
January 2011
International Space Station Program (ISSP) managers at NASA's Johnson Space Center (JSC) in Houston held a two-day meeting this week to discuss the prospect of adding a Bigelow Aerospace inflatable module to the ISS. The Technical Interchange Meeting (TIM) ran on Wednesday 12th and Thursday 13th January

Bigelow would provide the inflatable and inner core structure of the module, and perform all required flight analysis.

“An inflatable module has a rigid center core where the equipment is typically located and where the fabric is stowed for launch. After the module is berthed, it is inflated resulting in a pressurized fabric shell with a cylindrical core structure that houses equipment, etc.”

In-spite of their soft shell, Bigelow’s inflatable modules are more resistant to Micro Meteoroid Orbital Debris (MMOD) strikes than current metallic-shelled I ISS modules





Genesis I

Launched on July 12, 2006 at the ISC Kosmotras Space and Missile Complex near Yasny, Russia aboard a converted Russian ICBM (the 'Dnepr'), Genesis I became Bigelow Aerospace's first operational spacecraft and was a tremendous success.

Specifically, Genesis I accomplishments include:

•The first spacecraft produced by Bigelow Aerospace.

•The first expandable space habitat technology on orbit.

•The development and validation of the necessary seals and metal to softgoods interfaces.

•Proving that an expandable habitat can successfully withstand the vibration and loads of the launch environment.

•Successfully verifying Bigelow Aerospace's proprietary folding and packing techniques.

•Demonstrating in microgravity Bigelow Aerospace's pressurization and deployment process for an expandable envelope.

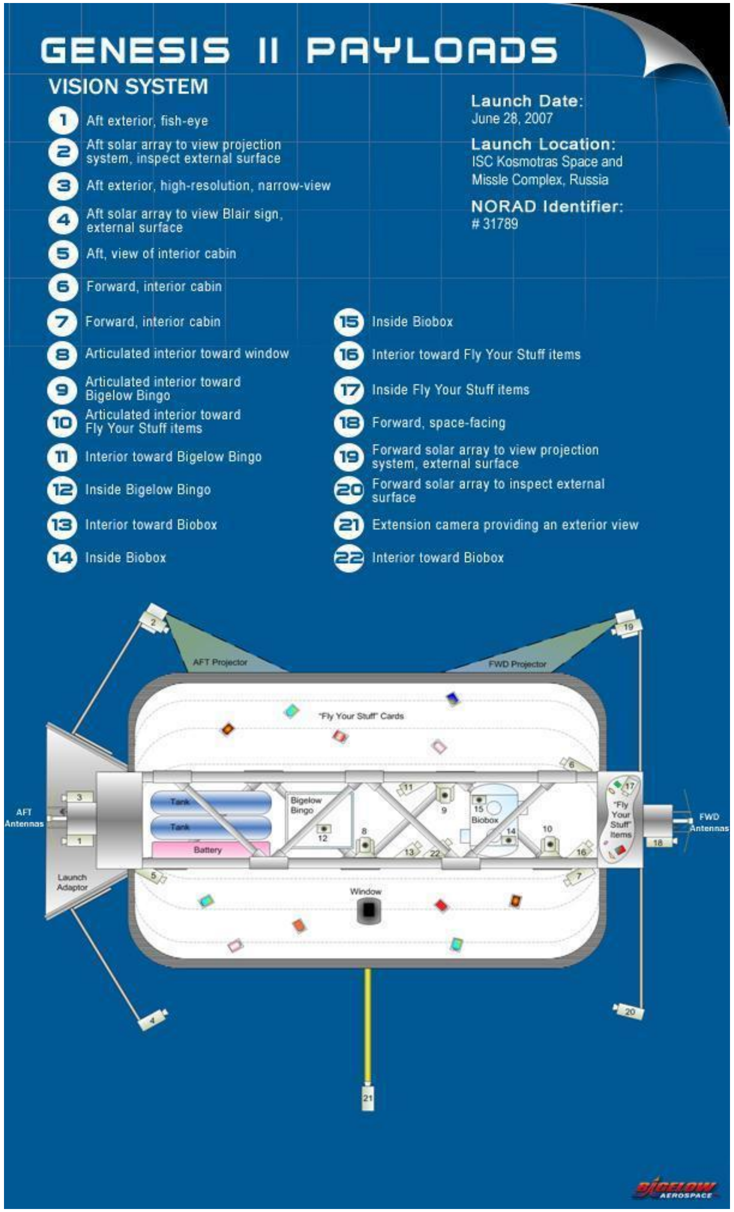
•Marked the first commercial launch to take place at the ISC Kosmotras Space and Missile Complex.

•Represented the first launch of a single, large payload aboard the Dnepr, taking full advantage of this innovative "swords into plowshares" transportation system.

•Likely represented the lowest-cost mission of its kind in the history of aerospace, including spacecraft fabrication and the launch itself.

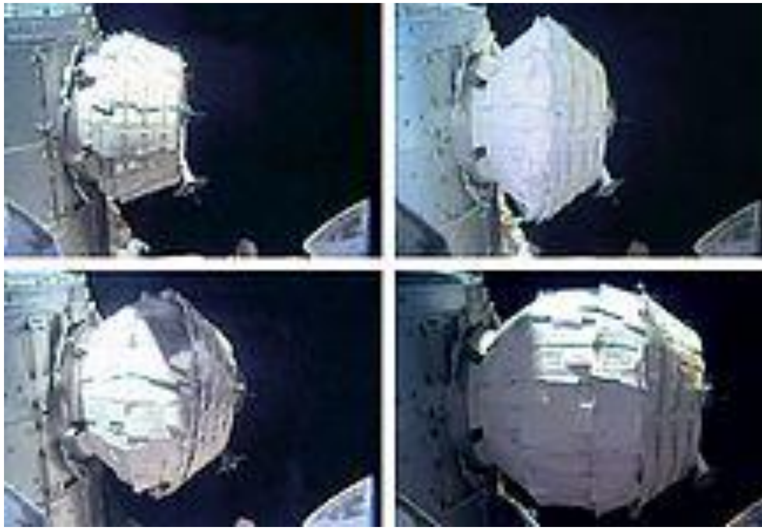
The spacecraft remains in orbit and is operational today, continuing to produce invaluable images, videos and data for Bigelow Aerospace. It is now demonstrating the long-term viability of expandable habitat technology in an actual orbital environment.

July 12th, 2006 by Chris Bergin
A Russian RS-20 Voyevoda (SS-18 Satan) intercontinental ballistic missile, known as a Dnepr rocket has successfully launched the first piece of the Bigelow puzzle, which could lead to the first “space hotel”.
Genesis I, the world’s first inflatable spacecraft, was carried into its 320 mile orbit on top of the converted Cold War-era ICBM at 6:53 p.m. Moscow time



Genesis II is the second inflatable spacecraft to be launched for the private company – which has large scale ambitions to set up a space complex in orbit during the next decade.
The flight and stage separation of the Dnepr performed nominally, with Genesis II separating from its rocket at 15:16 UTC into an orbit with an inclination of 64 degrees.
Bigelow Aerospace established contact with its second pathfinder spacecraft at 22:20pm UTC.
‘Initial data suggests sufficient voltage powering up Genesis II’s batteries as well as expected air pressure,’ noted a release from Bigelow Aerospace. ’While the actual confirmation of solar panel deployment and spacecraft expansion are expected later, the data suggests that deployment and expansion have been successful.’
Before contact, successful communication was considered a long shot on Genesis II’s first pass over the ground station in Fairfax, Viginia. Elevation for the pass was considered low for a successful contact.
‘We don’t even talk to Genesis I that low,’ noted Program Manager Eric Haakonstad.
However, Bigelow Aerospace reported shouts echoing around their Mission Control in Las Vegas of ‘We got it’, as contact was established and Genesis II immediately began sending data back to Earth on its condition.
Data is now streaming from the spacecraft.
‘With Genesis I, it was our first rodeo. We didn’t know exactly what to expect. This time, we were able to perform rehearsals and were more prepared for the launch phase,’ Haakonstad said earlier.
Bigelow Aerospace noted in a later release that a brief communications issue in Russia increased nerves in Mission Control, as there was a delay in confirming Genesis IIâ€™s separation from the Dnepr rocket.
‘Any deviation from nominal magnifys the anxiety. When it came in four minutes later, it was a big relief,’ added Haakonstad.

Beam attached to ISS



[Apertura BEAM reale](https://www.youtube.com/watch?v=QxzCCrj5ssE)
https://www.youtube.com/watch?v=QxzCCrj5ssE

Progetto beam e animazione
https://www.youtube.com/watch?v=ObyJvvhKkVo

Boing space station
https://www.youtube.com/watch?v=Mn_gXEK5XmQ

EXAMPLES OF NUMERICAL SIMULATION

BENCHMARKS:

- ❑ HEAR LOOP TEST
- ❑ THREE SQUARE FLAT MEMEBRANE
- ❑ CURVED MEMBRANES SIMULATING A REALISTIC CASE
- ❑ FLAT & TUBULAR MEMBRANE STRUCTURES

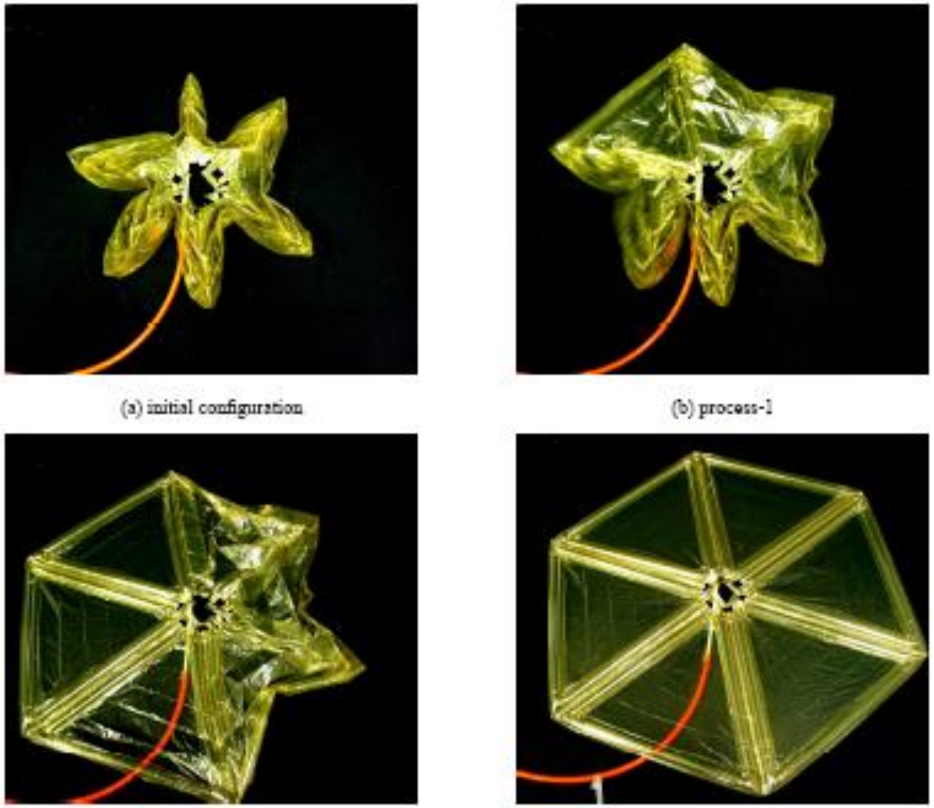
SPACECRAFT:

- ❑EXAMPLE OF INFLATABLE RE-ENTRY CAPSULE ANALYSIS
- ❑FLEX
- ❑IMOD
- ❑INFLATABLE AIRLOCK
- ❑MULTIPARPOSE USE OF INFLATABLE AIRLOCK

Vedi file "*Animazioni Presentazione Carrera*", pag. 1

EXAMPLE OF SIMPLE INFLATABLE STRUCTURES From SDM 2008

Fig. 11 Packed configuration



(a) initial configuration

(b) process-1

(c) process-2

(d) final configuration

Fig. 12 Deployment of inflatable polygon model

Simulations: Involved Disclplines

- **Multibody Dynamics of <u>rigid</u> bodies**
- **Multibody Dynamics of <u>flexible</u> bodies (FE)**
- **Membrane flexibility and Membrane/bending Shell Theories**
- **Layered Structures (manned!)**
- **Inflation simulation (Large areas can be in contact)**
- **Deployment simulation by inflation**
- **Available codes (FE: Ls-dyna, Abaqus, …..)**
- **Nonlinear phenomena are largely involved**
- **Experiments are mandatory!**

HEART LOOP TEST

Example of FEM AnalysisExperimental Validation

Explicit LS-Dyna Simulation of the Heart Loop Flexural Test

Main features of the simulation activity:

- ***Starting from a flat shape of the specimen it is possible to tracing the history of the stresses inside the material, without neglecting the stress stiffening phenomenon.***
- ***To assess the Young's modulus of the material which is unknown from literature.***
- ***Validation of the simulation code by direct comparison with experimental evidences, in terms of shape and maximum deformation.***
- ***Benchmark implicit versus explicit codes.***

Explicit LS-Dyna Simulation of the Heart Loop Flexural Test

test procedure summary :

the test is performed on a specimen which consists of a strip of the candidate material, having the following dimensions :

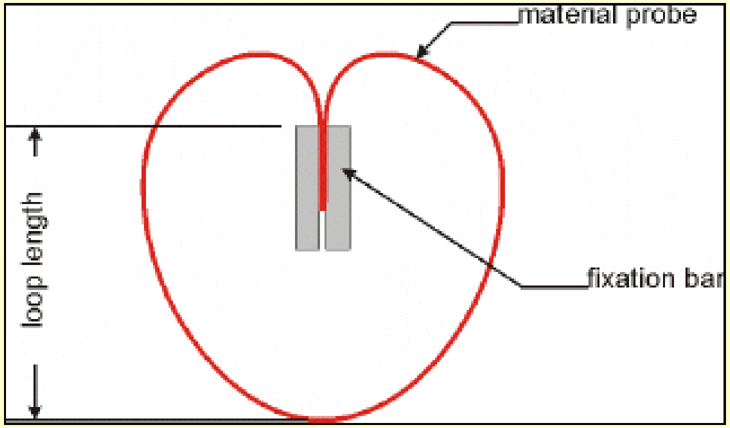
- width of the strip 30 mm
- length of the strip 250 mm

two brass bars (25x75x3) are glued, on a horizontal plane, at the strip ends for a length of 25 mm on each end side of the strip

then, by taking the two bars at the strip ends, the heart shape is obtained

at this moment the strip is suspended vertically at a support

after 60 seconds (stabilization time) it is possible to proceed to loop length measurement (deformation induced by gravity as shown in the figure below.

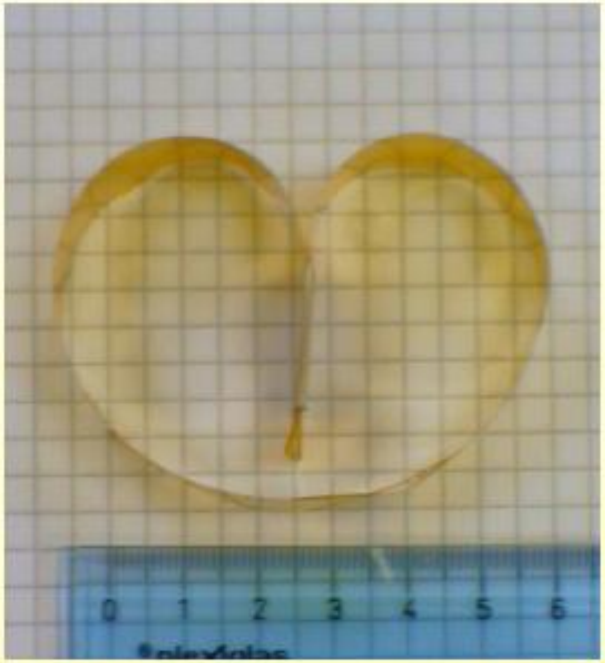


Starting model

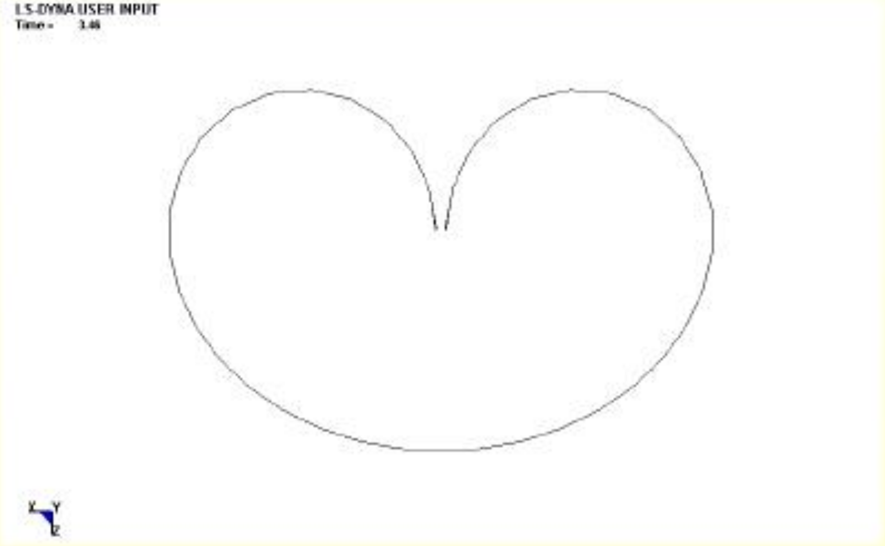
Before Gravity Application

Kapton

Experimental



Numerical



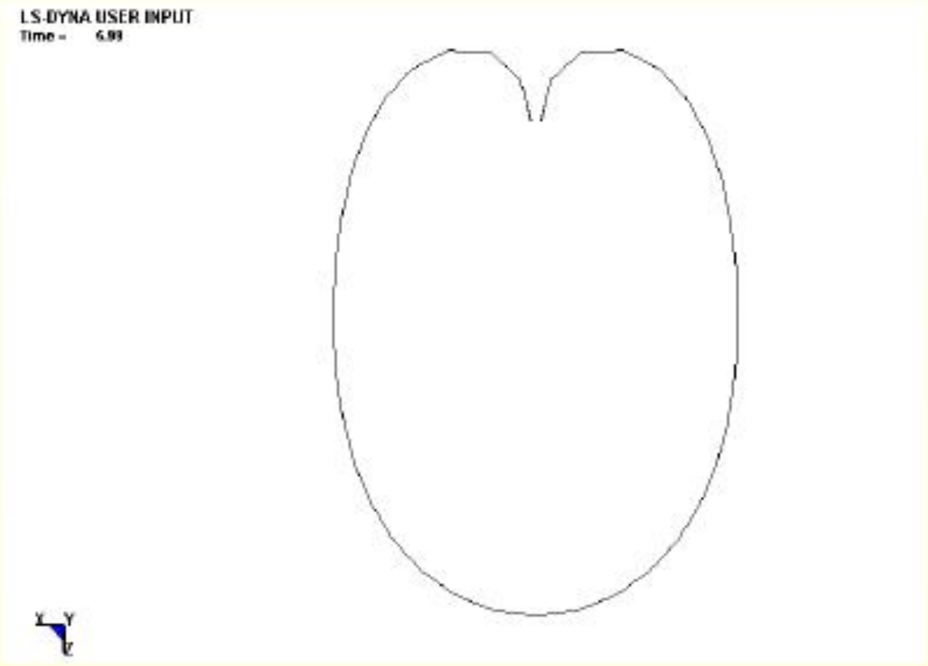
Starting model

After Gravity Application

Kapton

Experimental

Numerical



THREE FLAT RECTANGULAR MEMBRANES

The purpose of this test case is to assess the capability of the SAMCEF Mecano code to simulate a simultaneous problem of :

- *Large Displacement of thin membrane structures*
- *Contact among membrane structures, extended to a wide areas*
- *Simultaneous contact on both sides of a membrane structure*

- The membranes characteristics are the following :
  - membranes long side length a = 1000 mm
  - membranes short side length b = 500 mm
  - membrane thickness t = 0.26 mm
  - membrane uniform pressure load q = 0.014 MPa
  - Young Modulus E = 4200 MPa
  - Poisson ratio ν = 0.36
  - constraints : fixation of the membranes short sides
- The analysis duration is from 0 to 1 s.
- The three membranes are placed as follows :
  - distance between the upper and the middle membrane : 30 mm
  - distance between the middle and the bottom membrane : 20 mm

THREE FLAT RECTANGULAR MEMBRANES

The following Figures 12 and 13 show respectively : the three membranes geometry and the

Finite Element Model. The applied uniform pressure load time history is a ramp from 0 to 1.

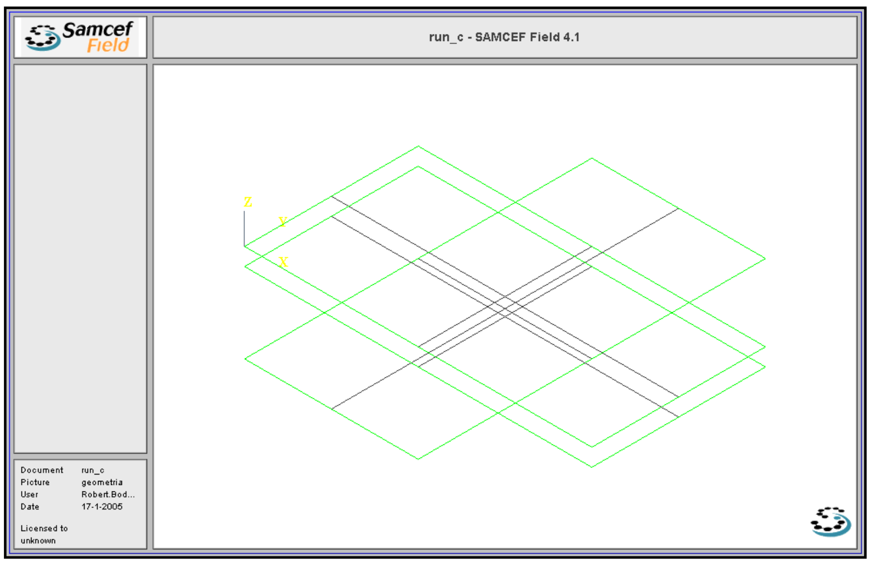


FIG. 12 – Membranes geometry

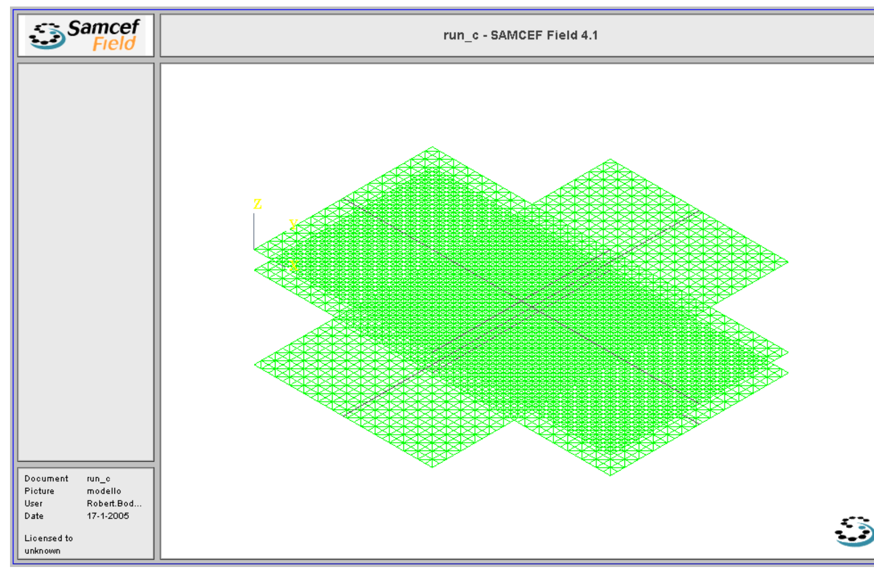
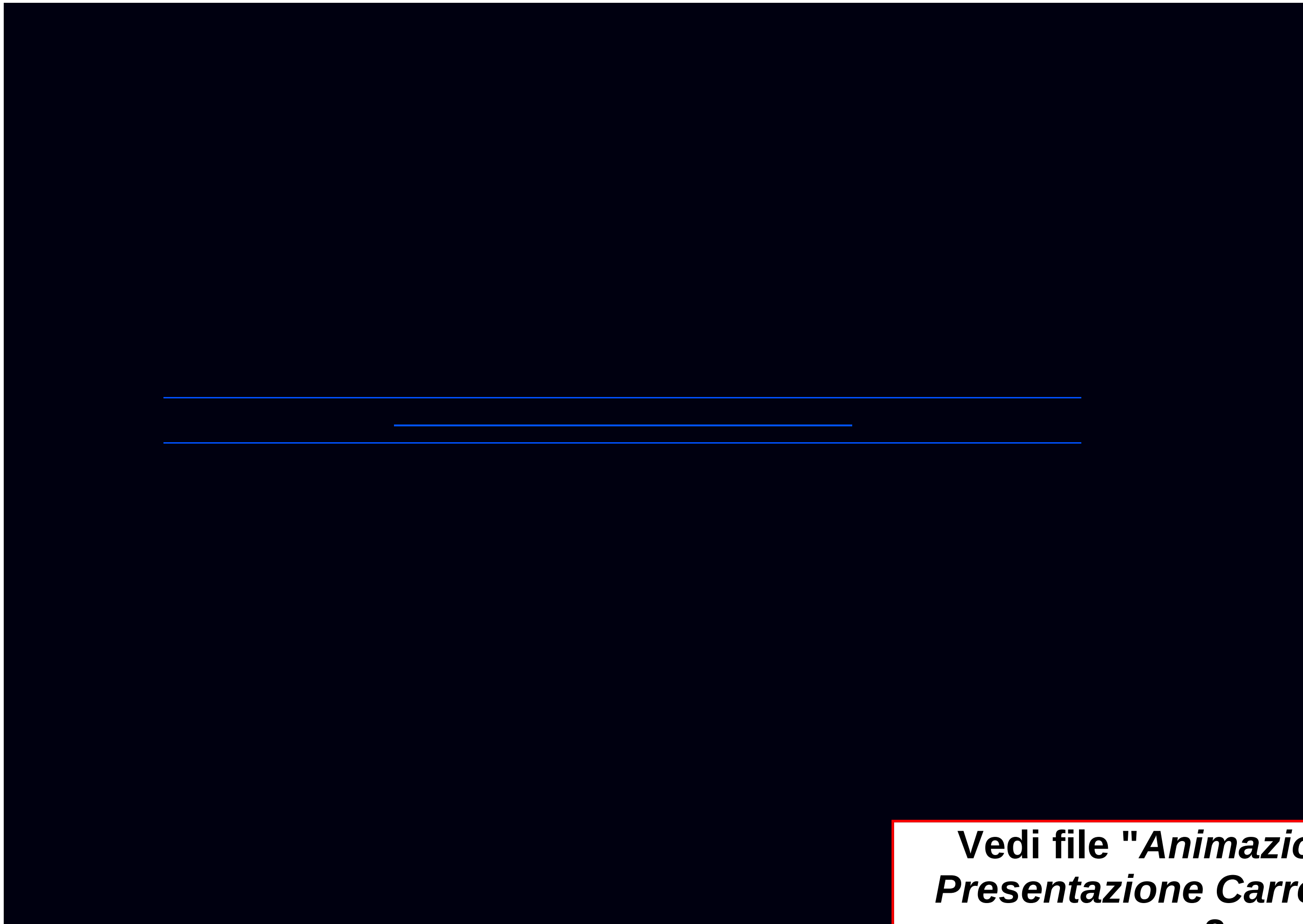


Fig. 13 : Finite Element Model

THREE FLAT RECTANGULAR MEMBRANES



Vedi file "*Animazioni Presentazione Carrera*", pag. 2

CURVED MEMBRANES SIMULATING A REALISTIC CASE

The purpose of this test case is to simulate a shell which is quite similar to that foreseen for a Manned Inflatable Space Module

For long term missions, care must be taken to protect the crew and the integrity of the structure against : radiation, atomic oxygen, thermal environment ,micro-meteorites and debris impact

Due to this protection necessities the shell of a Manned Inflatable Space Module becomes a large Multi Layer - Multi Functions Shell.

Next Figure 25 shows an hypothesis of shell structure.

Starting from the previously shown shell structure, a slightly simplified shell has been used to schematise an example of Inflatable Manned Space Module.

Next Figure 26 shows this shell structure, which will result in a three layers composite shell

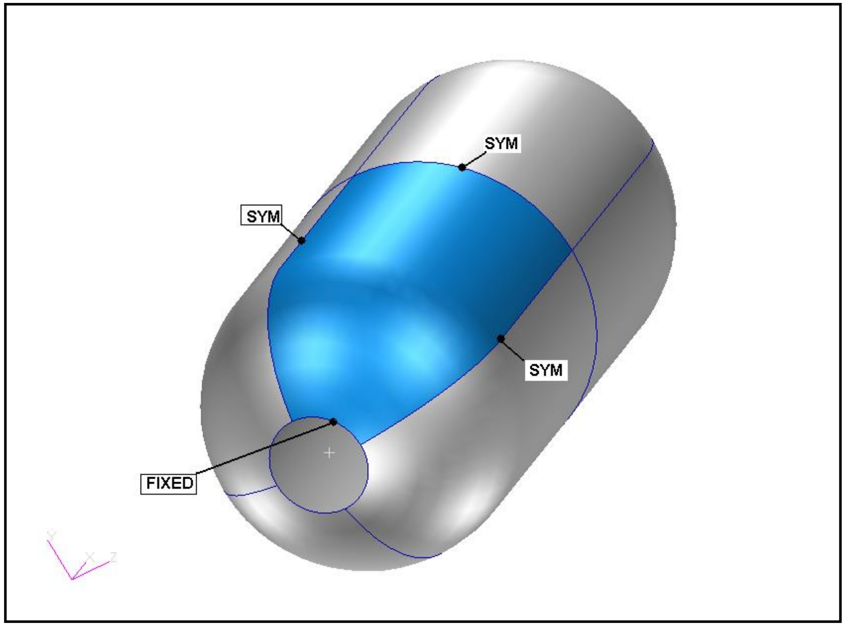
CURVED MEMBRANES SIMULATING A REALISTIC CASE

- The geometric characteristics of the model are the following :

inner module radius	R_i	=	1600	mm
outer module radius	R_e	=	1609.225	mm
module overall length	L	=	7640	mm
opening radius	r	=	500	mm
MLI thickness	t_{MLI}	=	2	mm
MMOD thickness	t_{MMOD}	=	5.5	mm
INNER layer thickness	t_{IL}	=	5.45	mm
total shell thickness	t_{total}	=	12.95	mm

- In the model, each layer is placed in the middle of each shell composite.
- The model geometry as well as the applied constraints is shown in the next Figure 27
- Do to symmetry conditions only 1/8 of the model is schematised
- The Finite Element Model is shown in the Figure 28.
- The load is applied as internal pressure with a ramp ranging from o to 3 MPa
- The analysis duration is from 0 to 1 s.

CURVED MEMBRANES SIMULATING A REALISTIC CASE



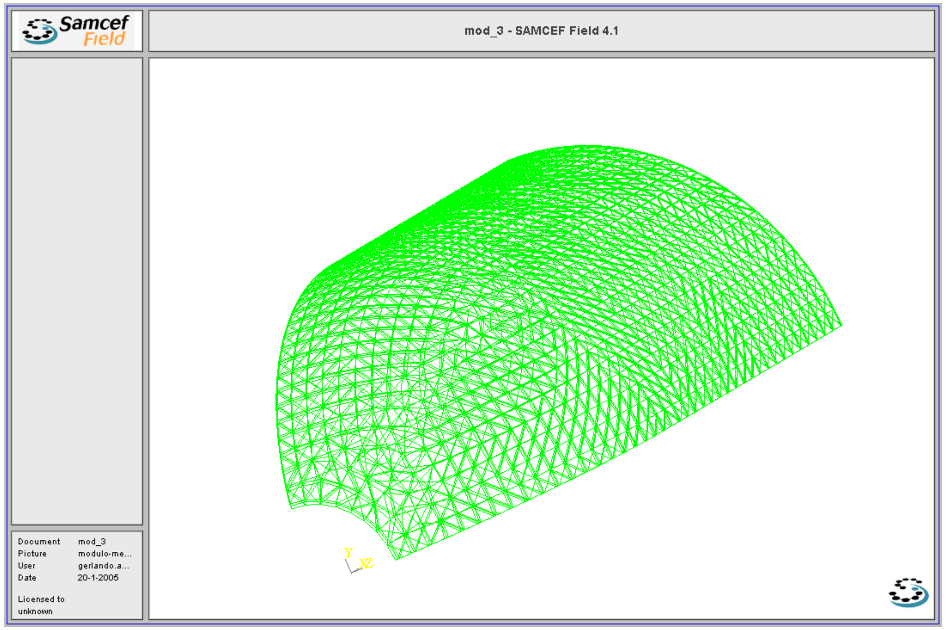


Fig. 27 :Geometry and constraint of the Inflatable Module test case

Fig. 28 :FE model of the Inflatable Module test case

CURVED MEMBRANES SIMULATING A REALISTIC CASE

- The Figures 29 and 30 show the results, in terms of displacements and contact pressure on the middle layer

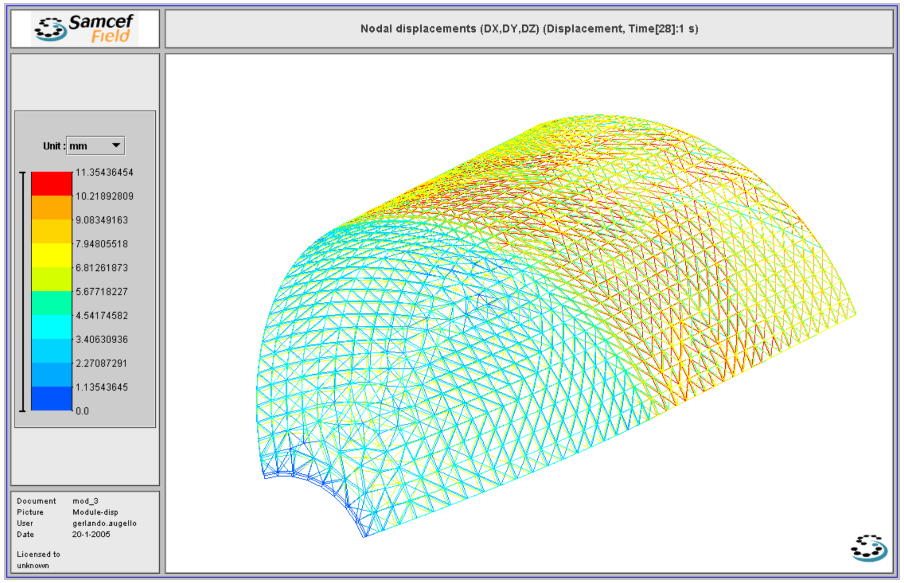


Fig. 29 :Displacement of the shell

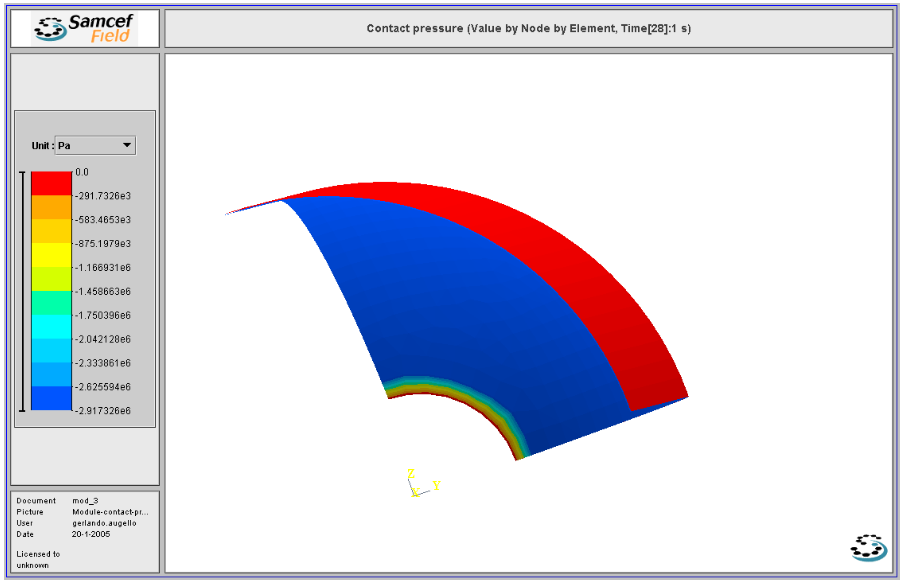


FIG. 30 – Contact pressure on the middle layer

FLAT & TUBULAR MEMBRANE STRUCTURES

- **The purpose of this test case is to simulate a flat composite membrane shell which interacts with tubular thin membrane structures.**
- **Important phenomena in this test case are :**

 Large Displacement of a membrane structures

 Contacts among flat and tubular membrane structures, extended to a wide areas

 Different time histories for the loads applied to the tubes and to the shell

The geometric characteristics of the model are the following :

- Tubular Stucture :

tube radius = 200 mm
tube Length = 1000 mm
tube wall thickness = 0.26mm

- Membrane Shell Structure :

radius of shell curved parts = 201 mm
angle of the shell curved parts = 270 deg
shell width = 1000 mm
shell length = 2000 mm

- **The flat composite membrane shell has been schematised as a four layers composite shell , while the tubes are schematised as single thin membrane shell**
- **The duration of the analysis is from 0 to 2 s.**

FLAT & TUBULAR MEMBRANE STRUCTURES

Next Figures 34 and 35 show the geometry of the tubes and of the flat shell respectively

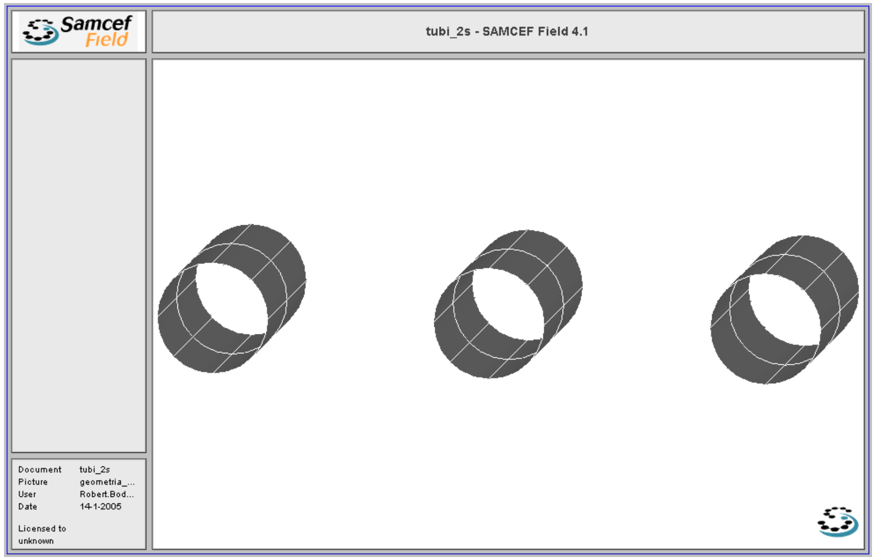


Fig. 34 :Geometry of the tubes

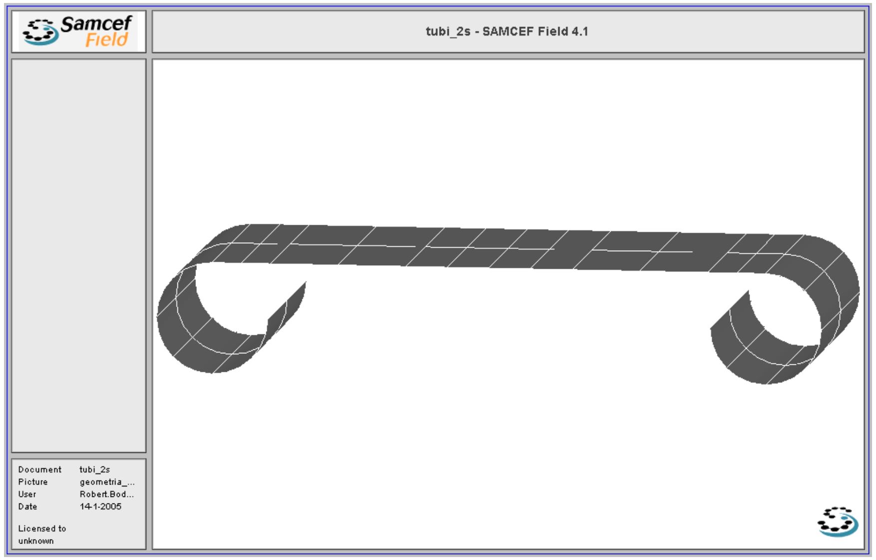


Fig. 35 :Geometry of the shell

FLAT & TUBULAR MEMBRANE STRUCTURES

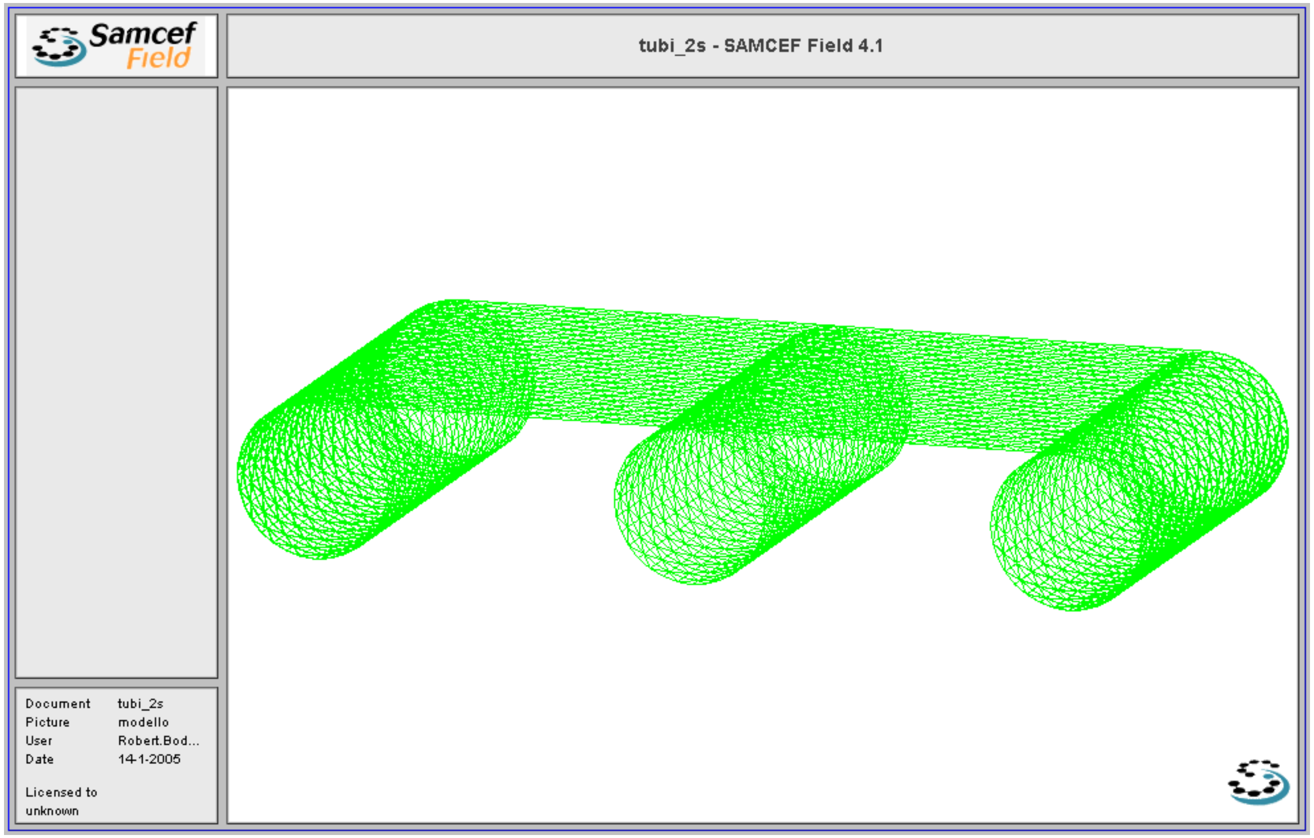
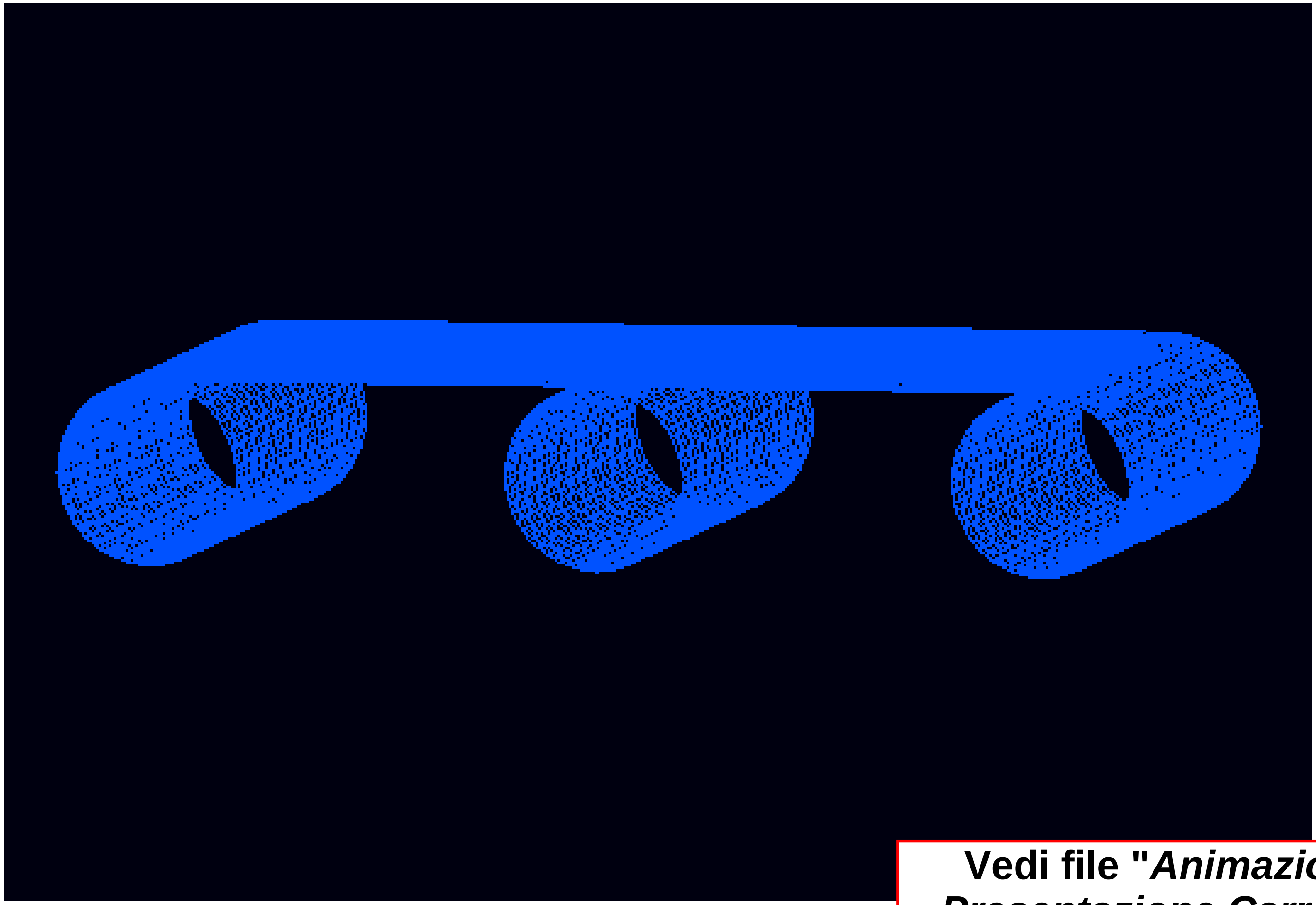


Fig. 36 :Finite Element Model

FLAT & TUBULAR MEMBRANE STRUCTURES



Vedi file "*Animazioni Presentazione Carrera*", pag. 3

FLAT & TUBULAR MEMBRANE STRUCTURES

On the basis of the results related to this test case, one can say that :

- **the behaviour of the flat membrane falls within the large displacement problems**

- **the contact phenomena are simulated in good agreement with the expected physical behaviour of a flat membranes which go in contact with tubular membranes**

- **the interaction between pressurised flat and tubular membranes is very well simulated**

EXAMPLE OF INFLATABLE RE-ENTRY CAPSULE ANALYSIS

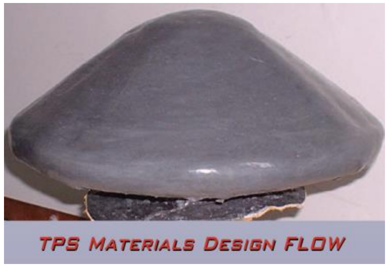
- **The SAMCEF MECANO code has also been used to verify the design of an Inflatable Re-entry Capsule, in the frame of an ESA Technological Study named IRT (Inflatable Re-entry Technology)**

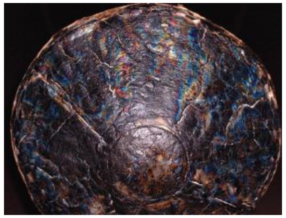
- **The re-entry capsules are foreseen for applications such as International Space Station sample return and the return to Earth of launcher upper stages**

- **The entry capsules can also be foreseen for the delivery of networks of small stations to the Martian surface**

Example of Inflatable Re-entry capsule analysis

The CAD model of the capsule is shown in the next Figures 39, while the Figure 40 shows the 1/8 CAD model used to perform the analyses.





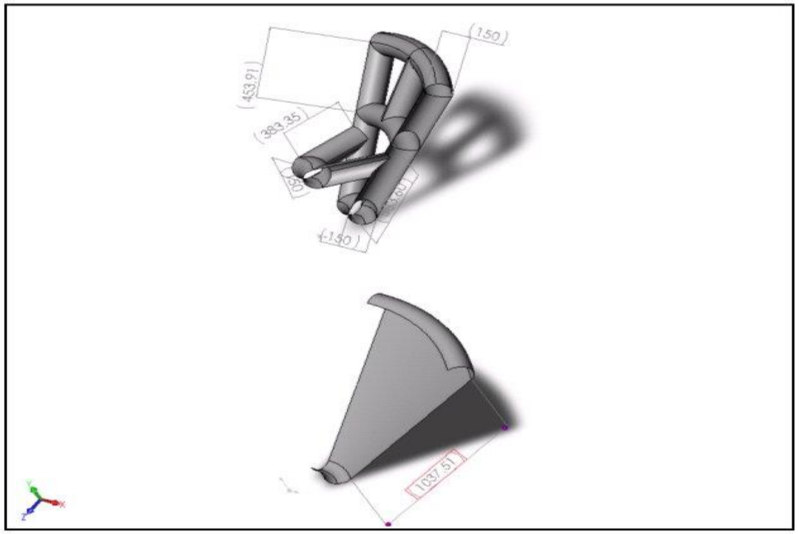


Fig. 40 :–1/8 CAD model – exploded view

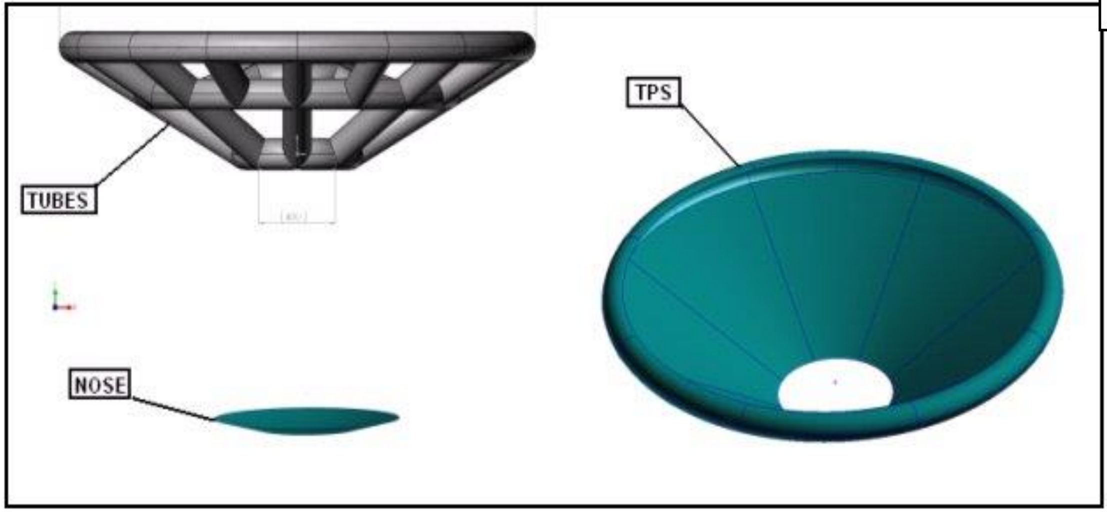


Fig. 39 :– IRT CAD model – exploded view

EXAMPLE OF INFLATABLE RE-ENTRY CAPSULE ANALYSIS

Next Figures 41 and 42 show the Finite Element models of the pneumatic (tubes) structure and of the TPS (Thermal Protection System)

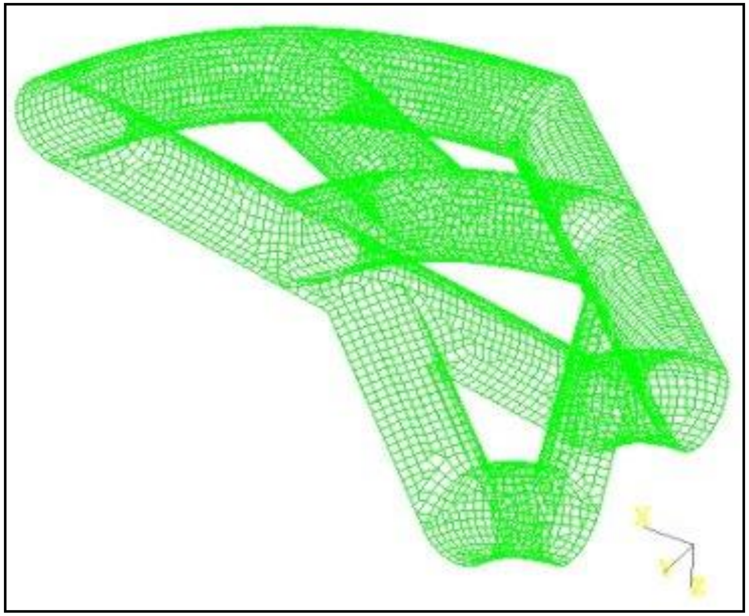


Fig. 41 :– IRT tubes FEM

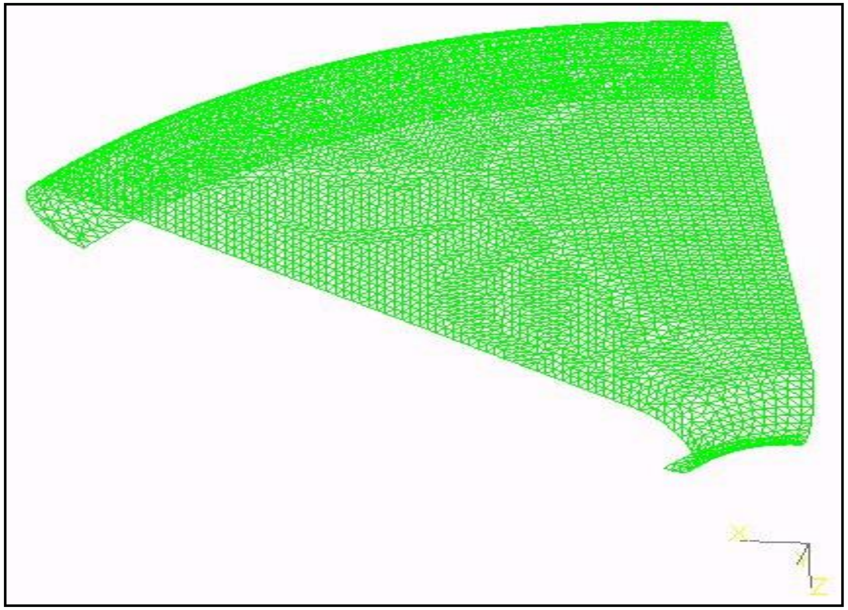


Fig. 42 :– IRT TPS FEM

Example of Inflatable Re-entry capsule analysis

The tubes are schematised as a single layer shell, while the TPS is schematised as a composite multilayer shell. Next Figure 43 shows a pictorial view of this multilayer shell

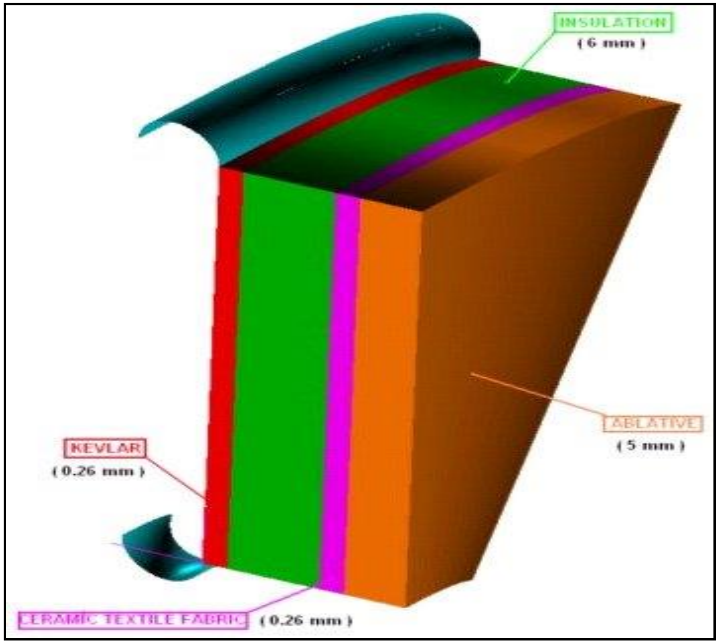


Fig. 43:– TPS composite shell structure

Example of Inflatable Re-entry capsule analysis

The loads applied to the structure are the following :

- **internal differential pressure applied to the tube of the pneumatic structure of 120 KPa**
- **dynamic pressure applied to the TPS of 7 Kpa**
- **temperature distribution, varying a long the thickness, applied to the TPS shell**
- **constant temperature applied to the tubes of the pneumatic structure**

EXAMPLE OF INFLATABLE RE-ENTRY CAPSULE ANALYSIS

- **The results in term of displacements is shown in the next Figures 48**

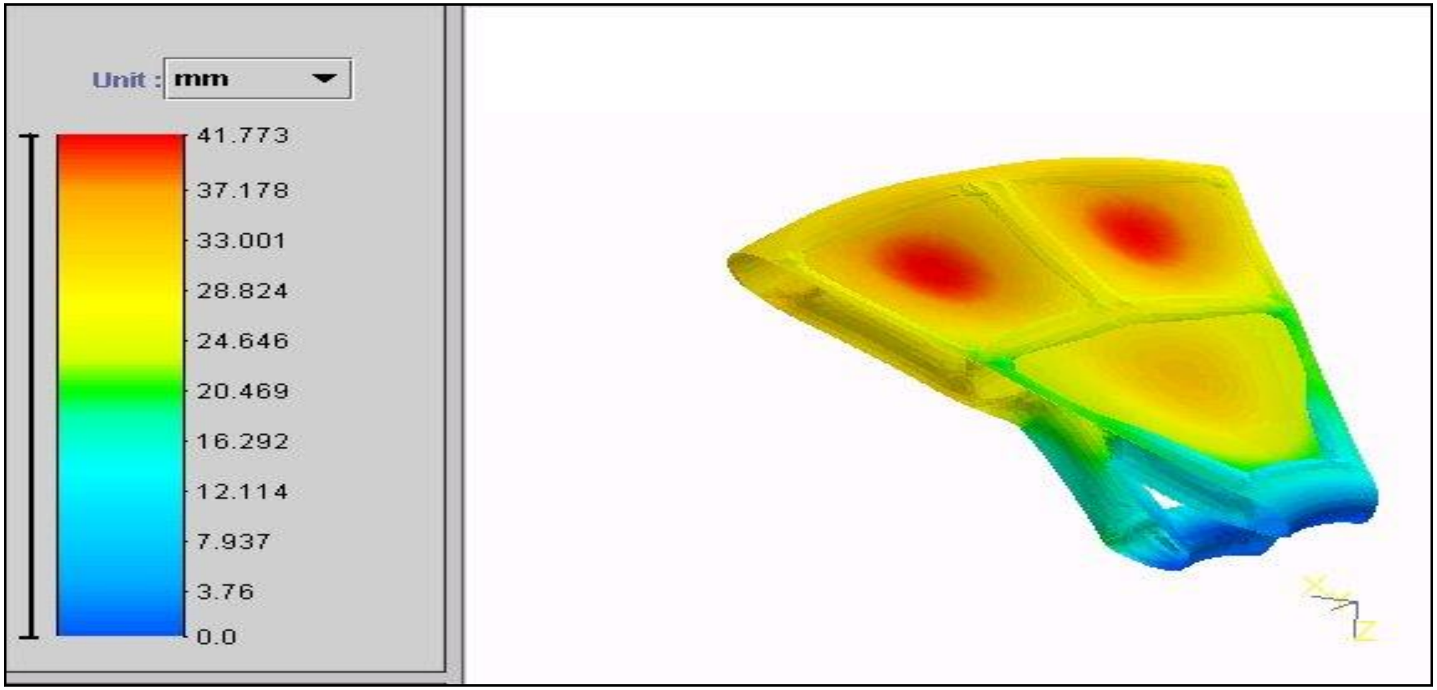
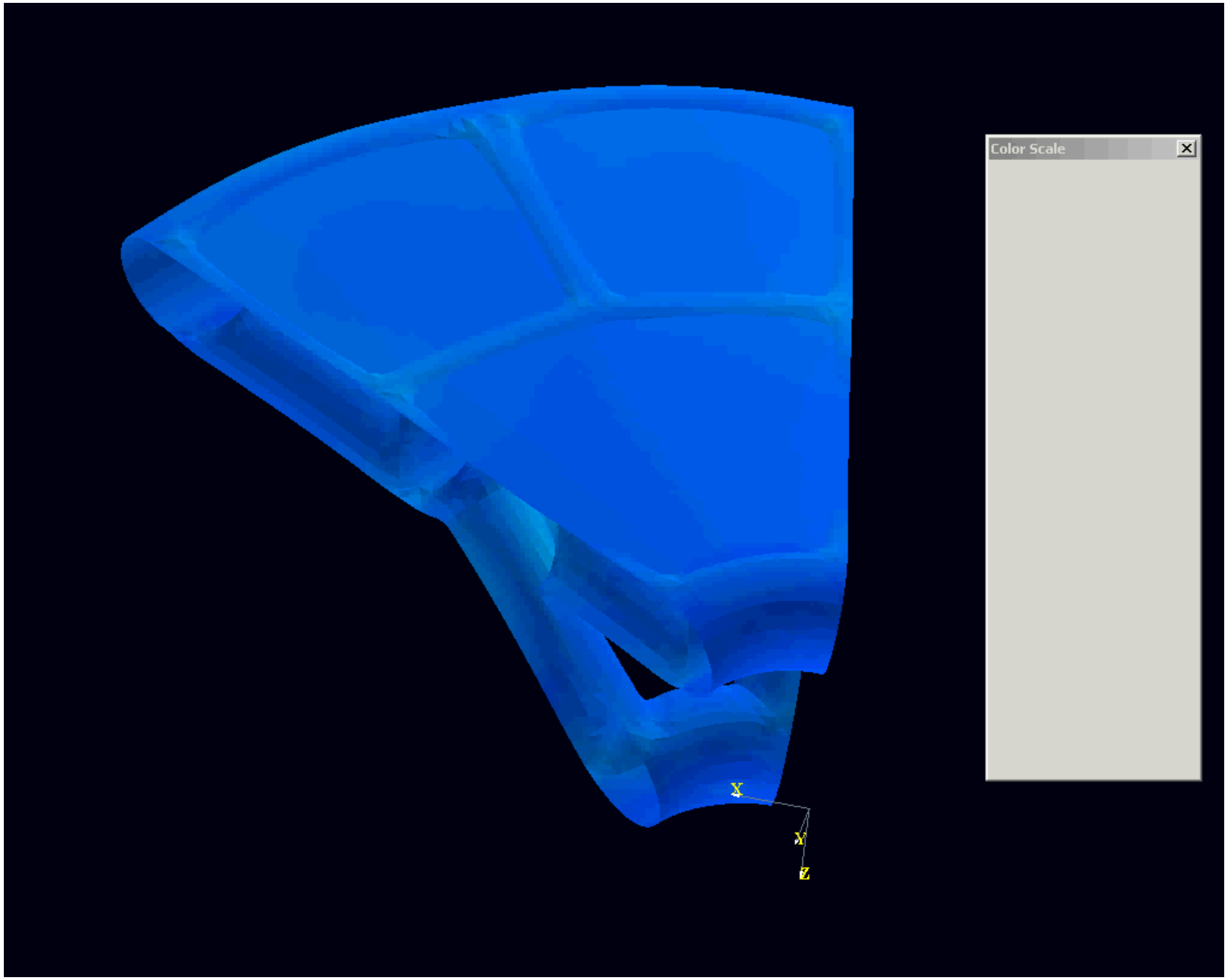
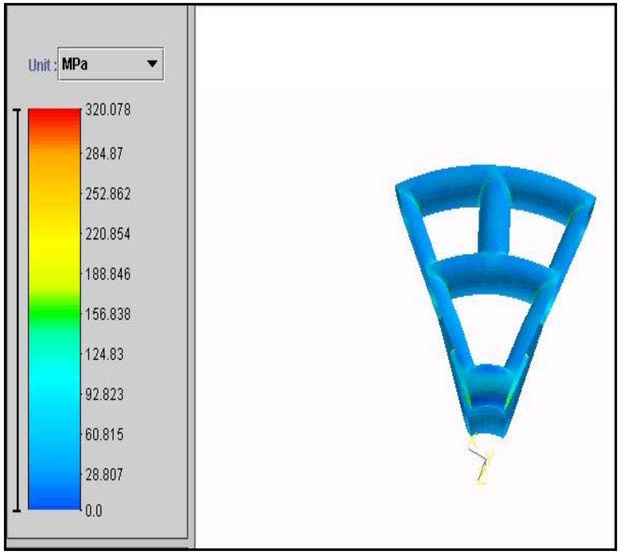


Fig. 48 – IRT displacements field


Color Scale
X
Y
Z

EXAMPLE OF INFLATABLE RE-ENTRY CAPSULE ANALYSIS

- **The overall stress field as well as the detailed one are shown in the next Figures 49 and 50.**



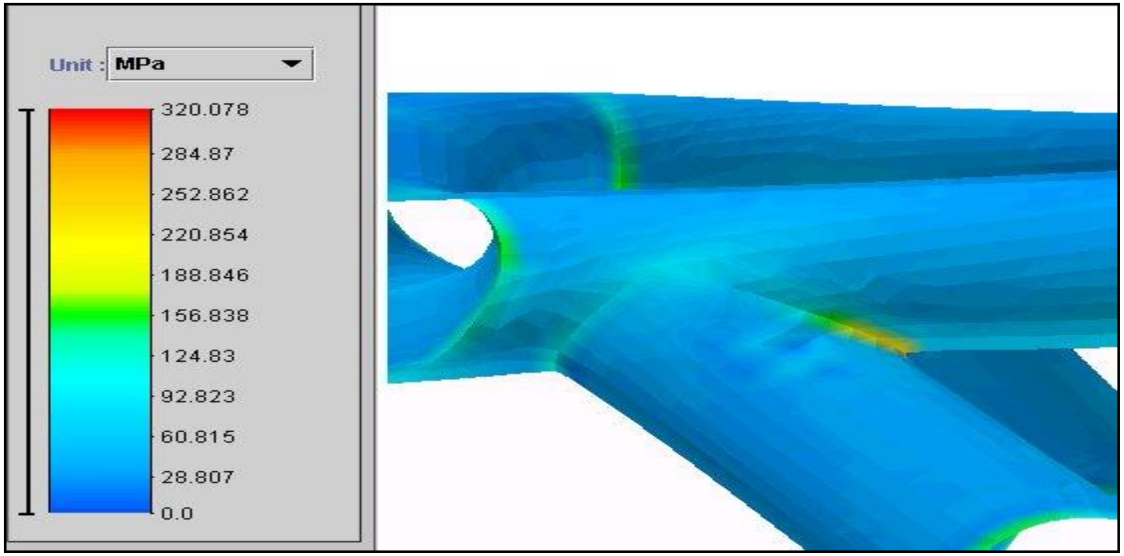
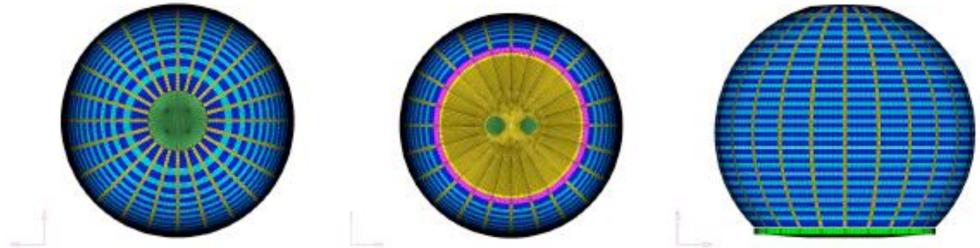


Fig. 49 – Tubes structure stress field

Fig. 50 – Detail of Tubes structure stress field



(a) (b) (c)

FLEX MODULE
SHUTTLE CARGO BAY
attached to MLPL

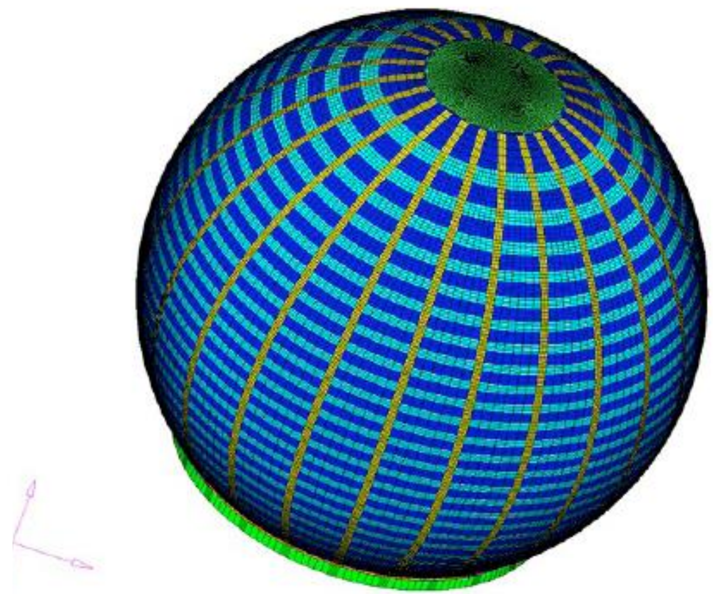


Figura 6.1

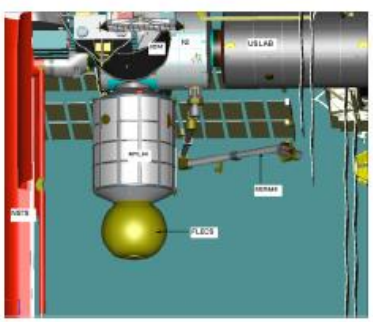


Figura 1.12: Posizionamento di FLECS sulla ISS

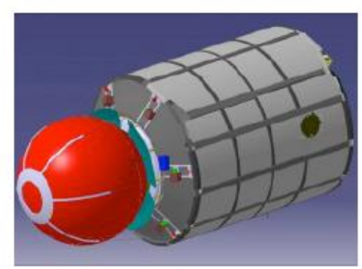
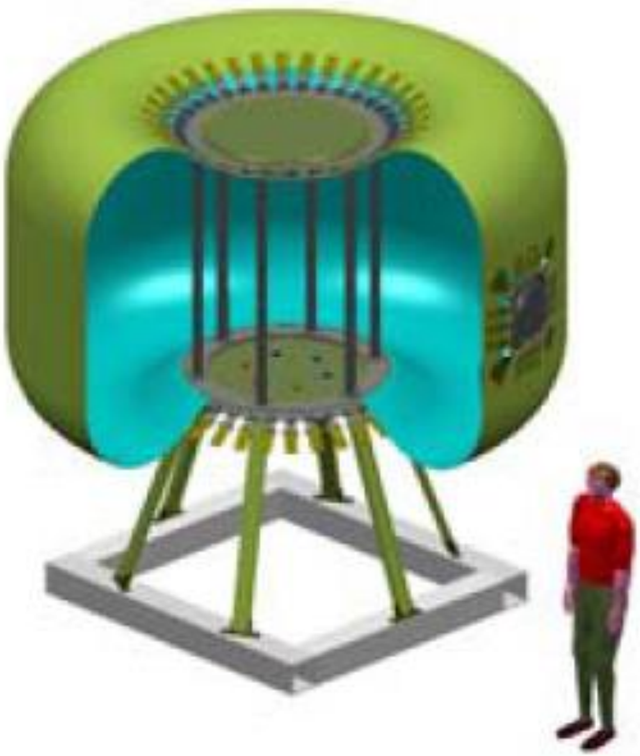
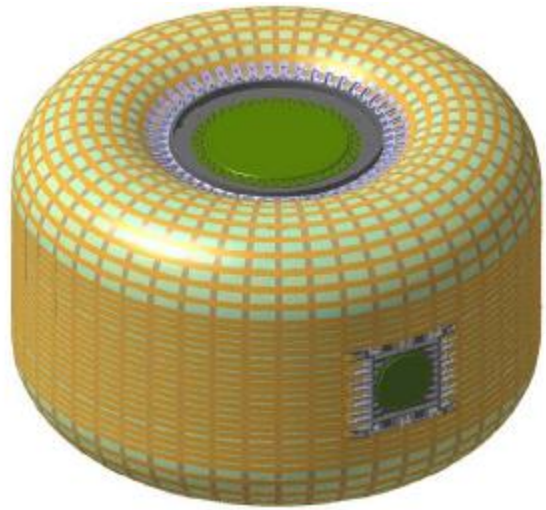
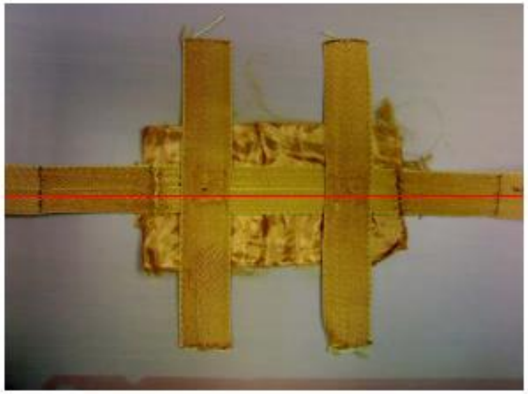


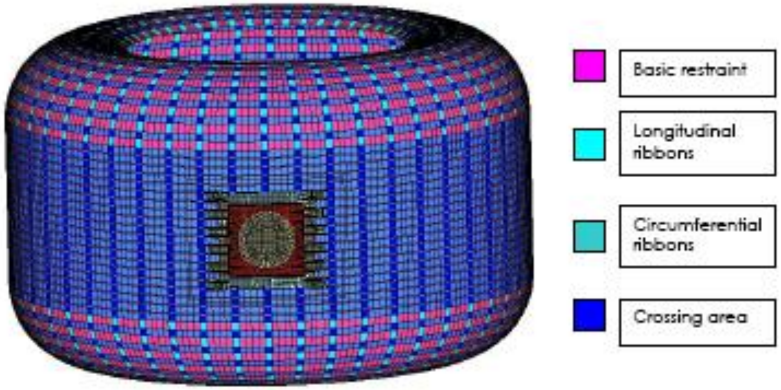
Figura 1.11: Rappresentazione grafica dell'attacco di FLECS al modulo MPLM

FE ANALYSY OF IMOD INFLATBALE MODULE



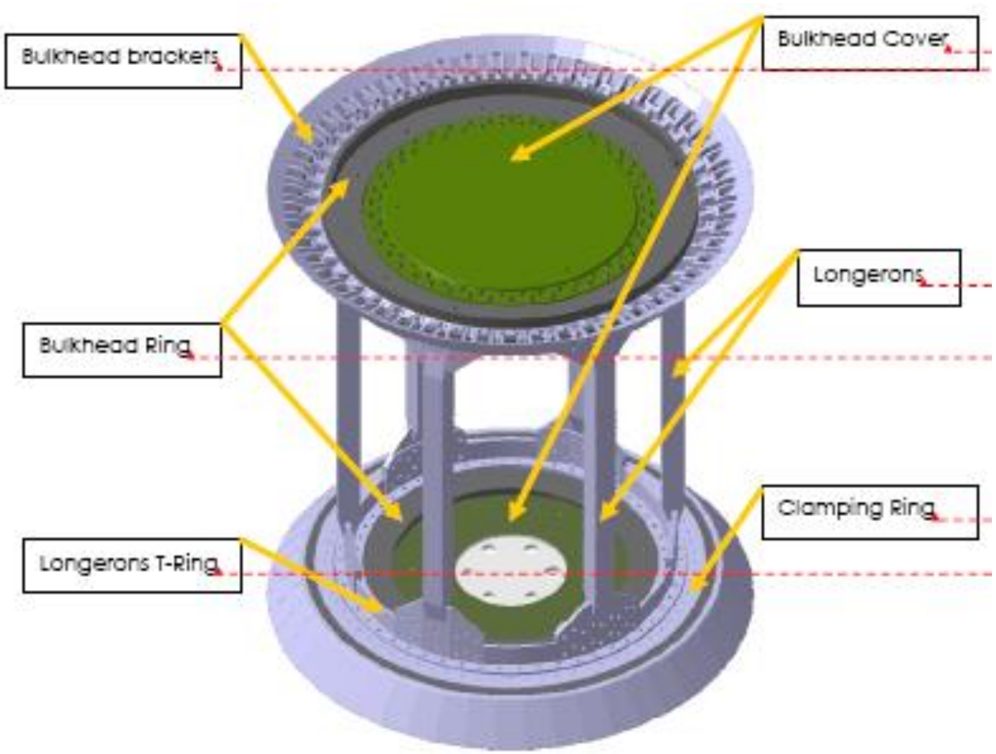




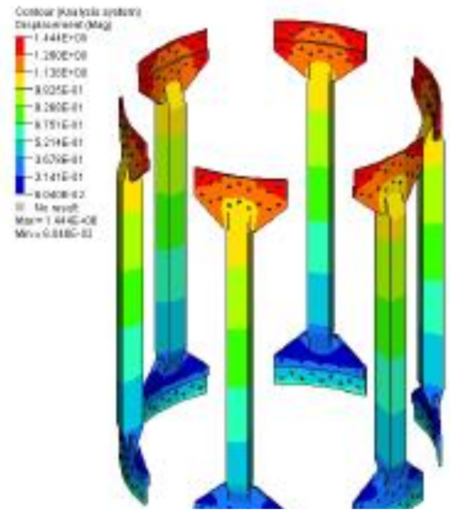


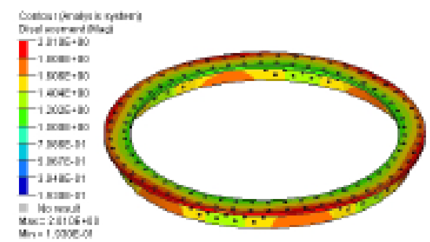
ThalesAlenia Space

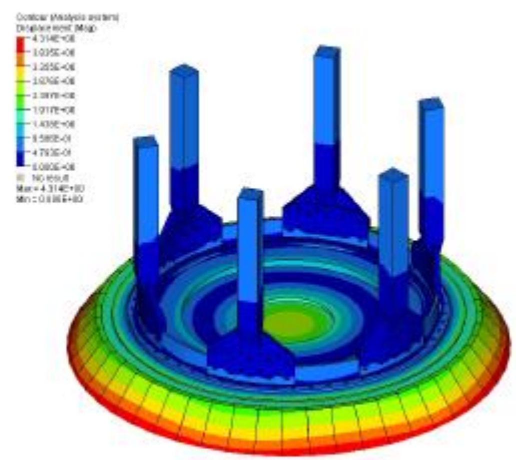
IMOD



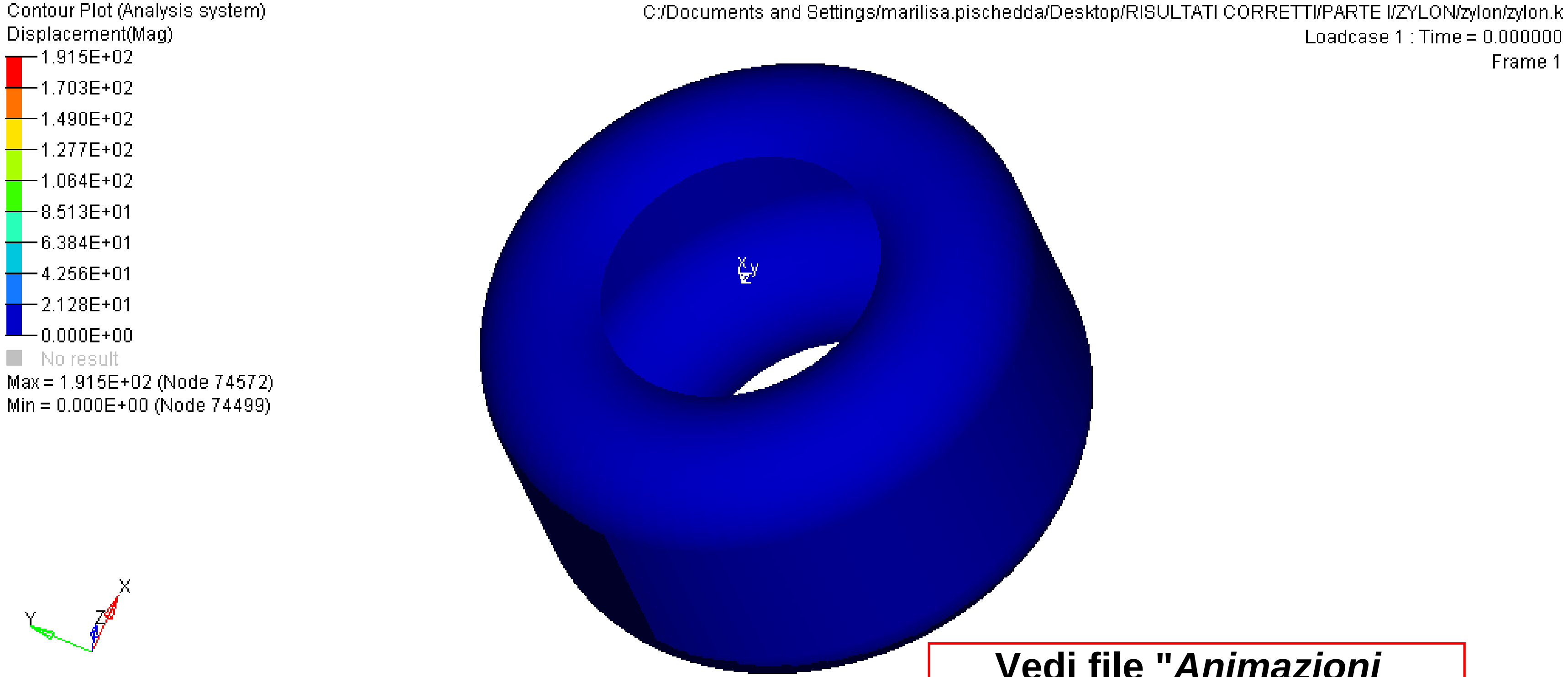
Bulkhead brackets
Bulkhead Cover
Longerons
Bulkhead Ring
Clamping Ring
Longerons T-Ring





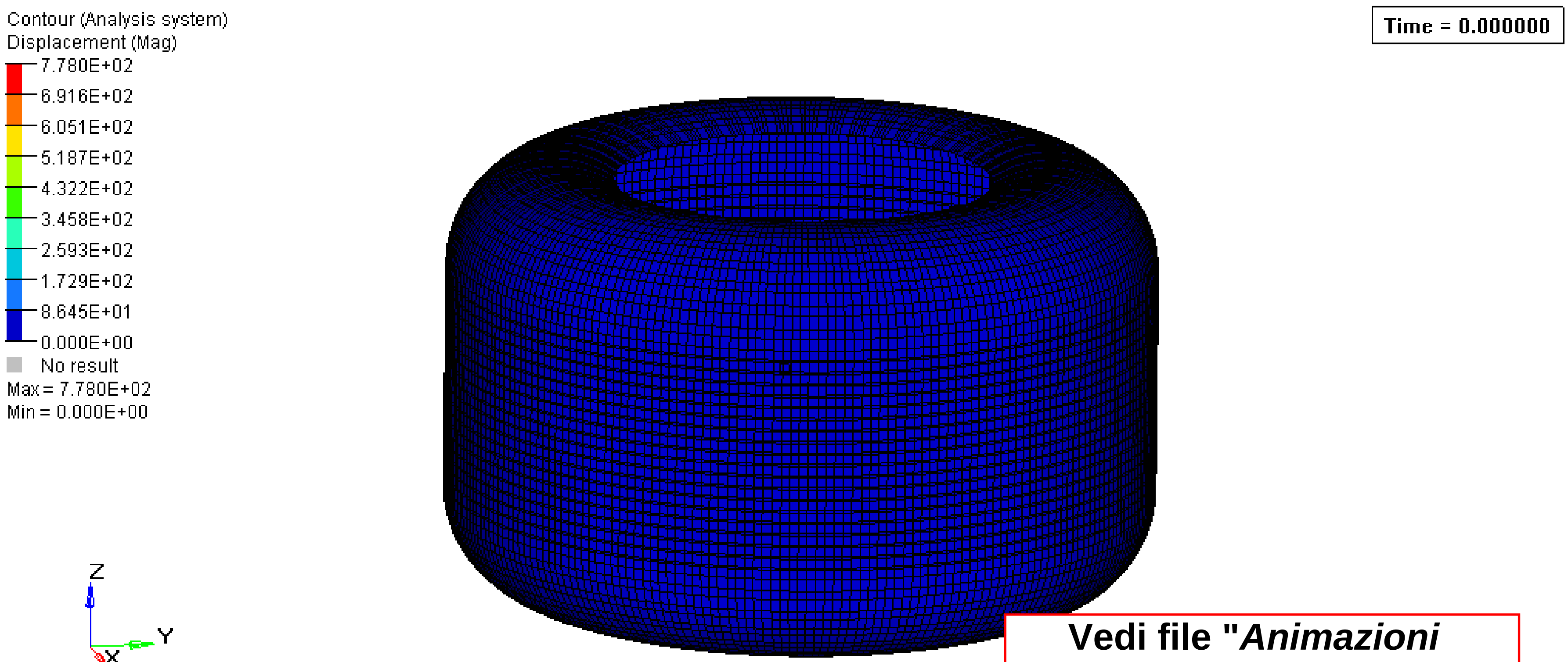


FE ANALYSY OF IMOD
INFLATABLE MODULE



Vedi file "*Animazioni Presentazione Carrera*", pag. 4

Folding Simulation.



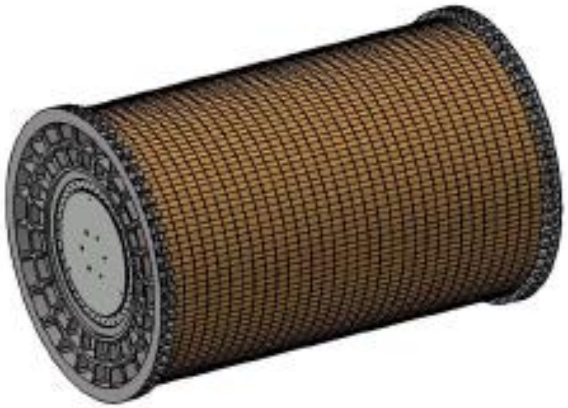
Vedi file "*Animazioni Presentazione Carrera*", pag. 5

IMOD INFLATABLE MODULE



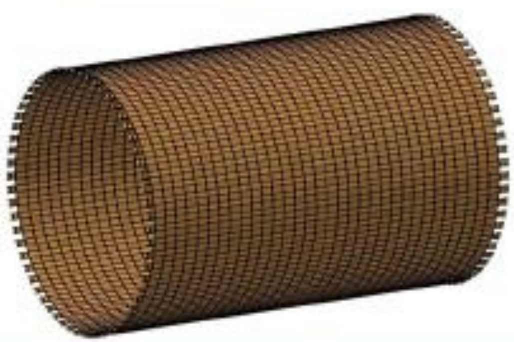


IL MODULO



Il Bladder
Film di PTFE o
Nylon rinforzato

Scheletro interno



Il Restraint
Cinghie di Kevlar
o Zylon

Flangia di Connessione

Paratia Esterna — ? — Bladder

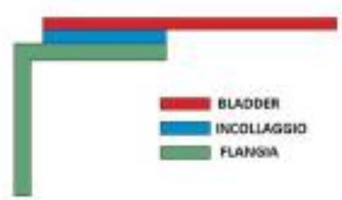
Interfaccia adeguata che garantisca la tenuta pneumatica.

→ Ricerca e Analisi di soluzioni già esistenti

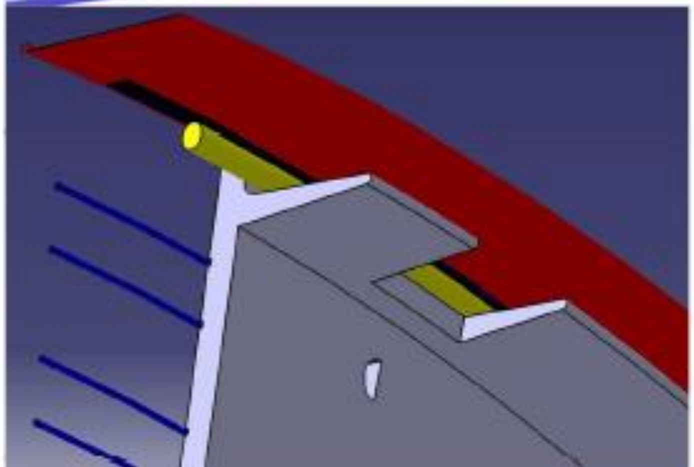
→ **Bigelow Aerospace**

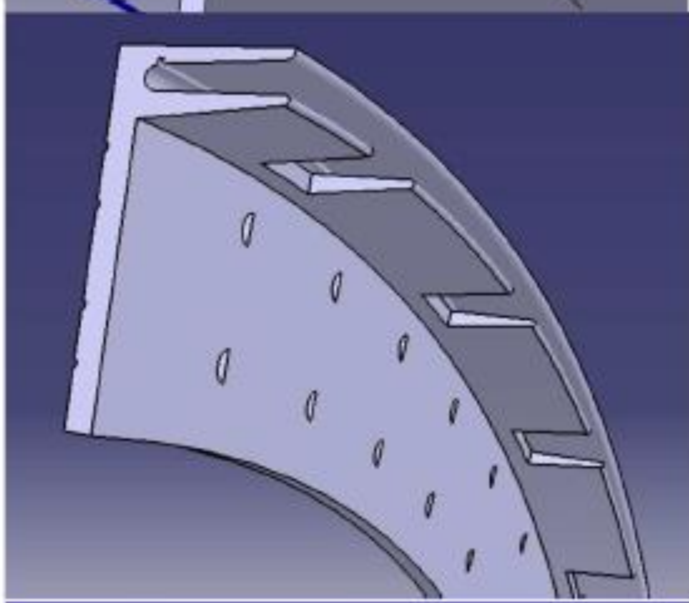
→ **Trans-Hab**

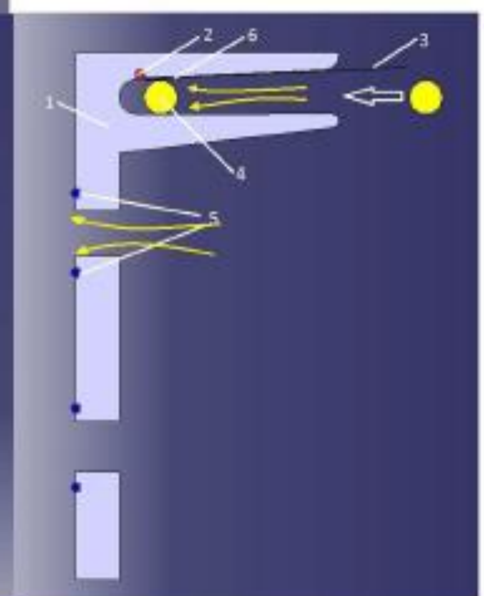
→ **Soluzione TAS-I basata sull'incollaggio del bladder sulla flangia.**



II SOLUZIONE PROPOSTA







Utilizzo di un anello con guarnizione

Pro

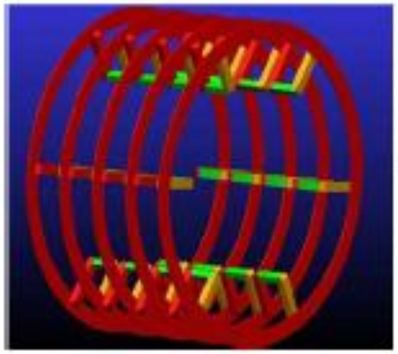
- ↓ peso
- Possibile Smontaggio
- No strisciamento
- No grinze

Contro

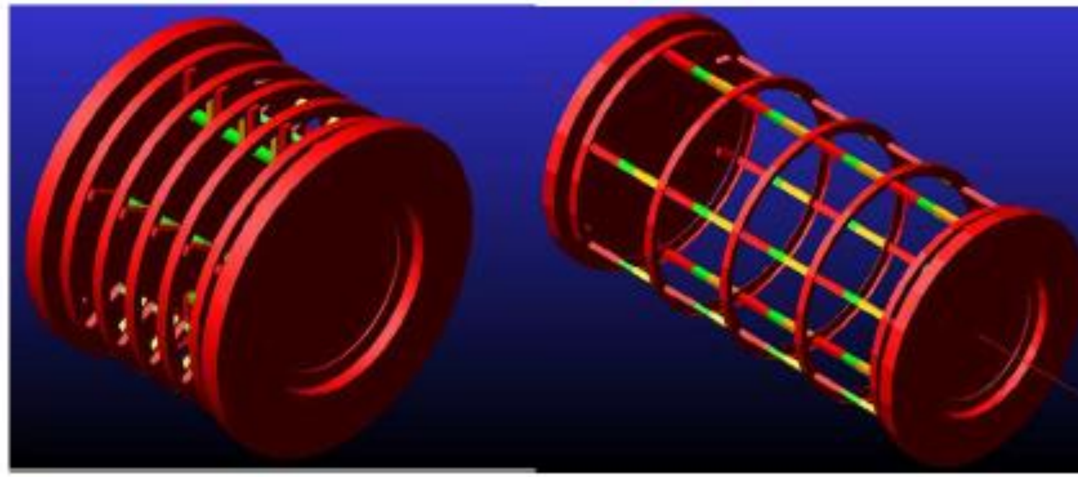
- Soluzione più complessa

IL MODELLO

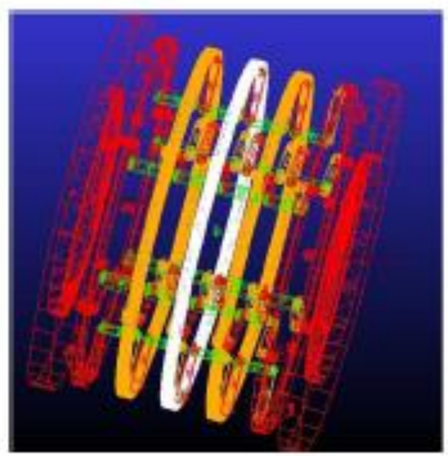
Prototipo del Modello



Modello Rigido

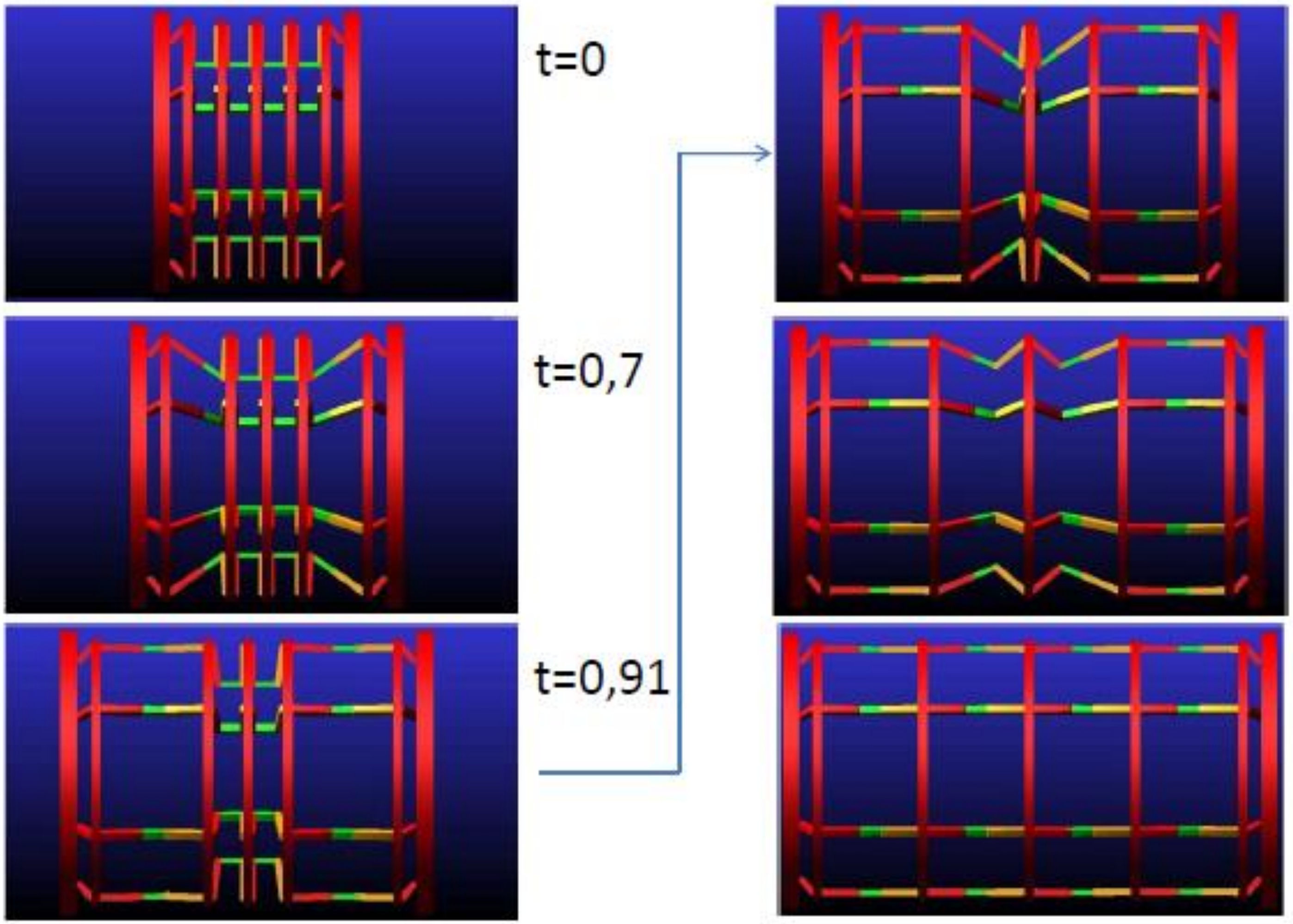


- **Carichi**: modellizzazione della pressurizzazione e del contributo del restraint.
- **Giunti**: collegamenti cedevoli tra le bielle assimilabili a cerniere.
- **Finecorsa**: modellizzazione degli incastri per mantenere allineate le bielle

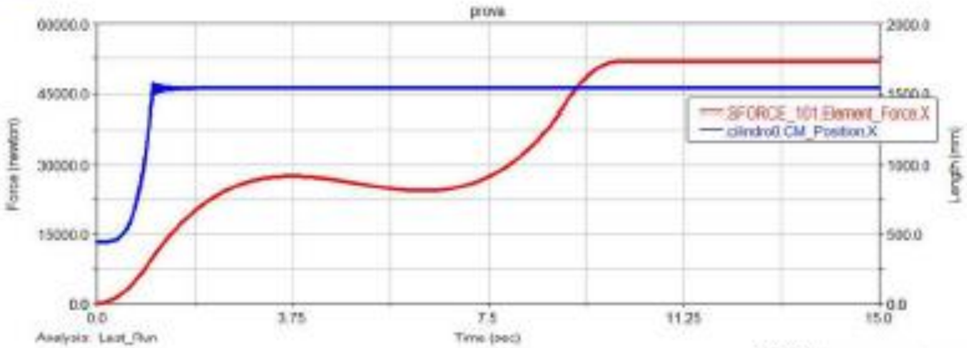


Modello Flessibile (in parte) attraverso l'utilizzo del processore interno di ADAMS per la discretizzazione agli elementi finiti.

Dispiegamento

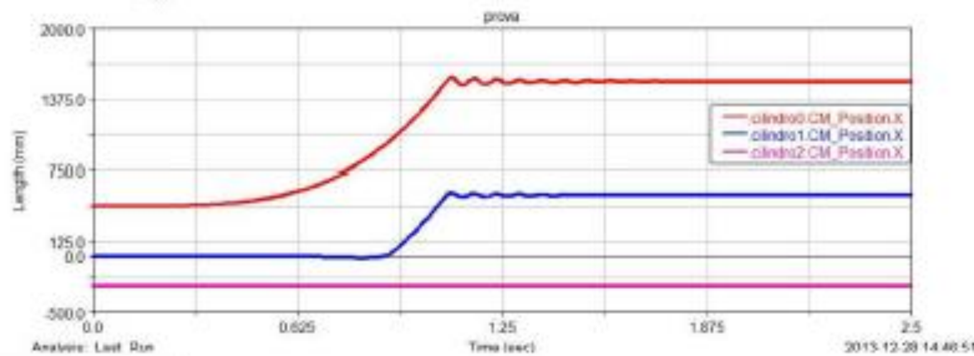


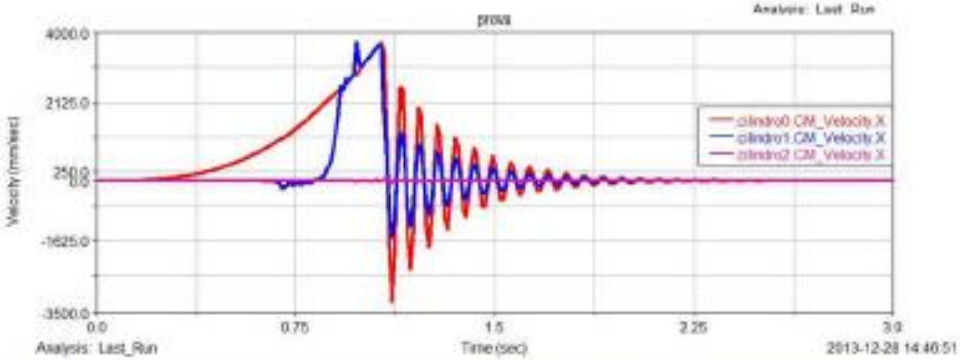
Alcuni Risultati del Modello Rigido…



Forza di Pressurizzazione

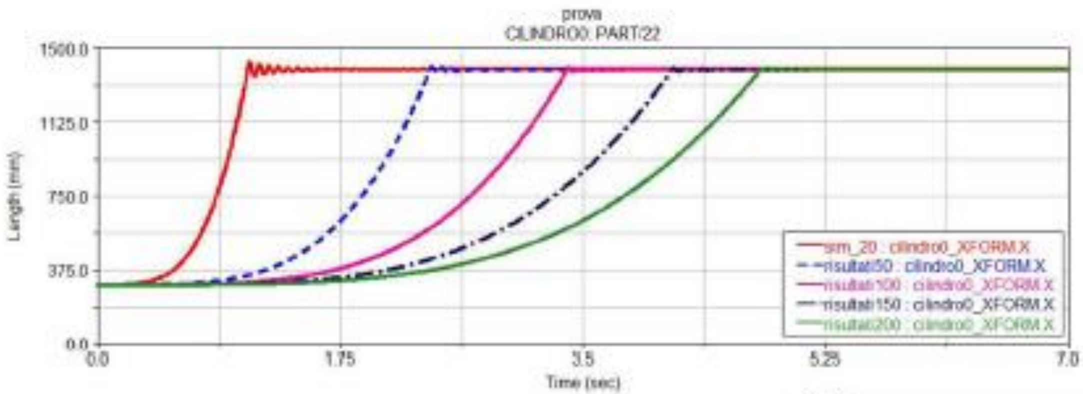
Posizione





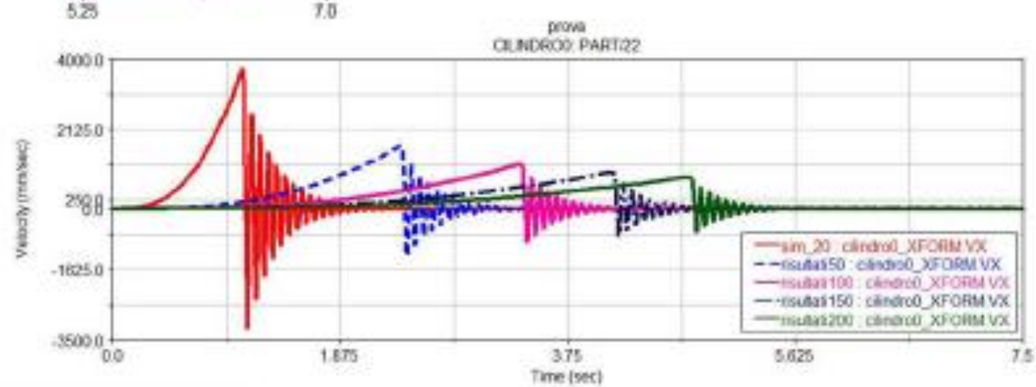
Velocità

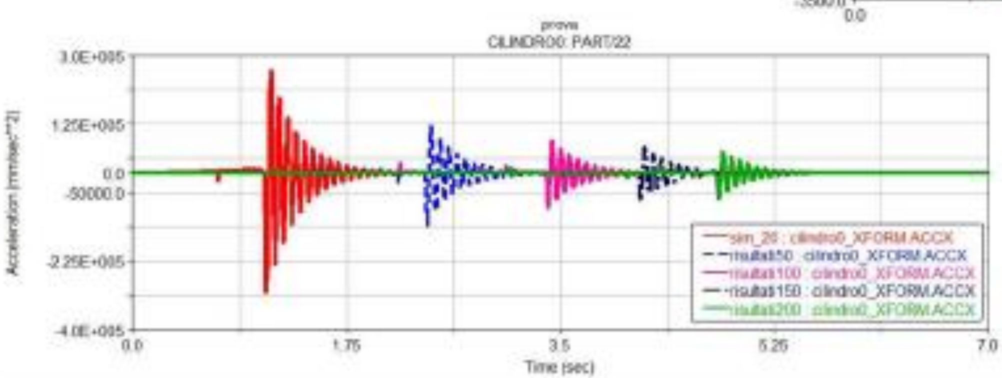
Alcuni Risultati del Modello Rigido: Diversi tempi di pressurizzazione



Posizione

Velocità

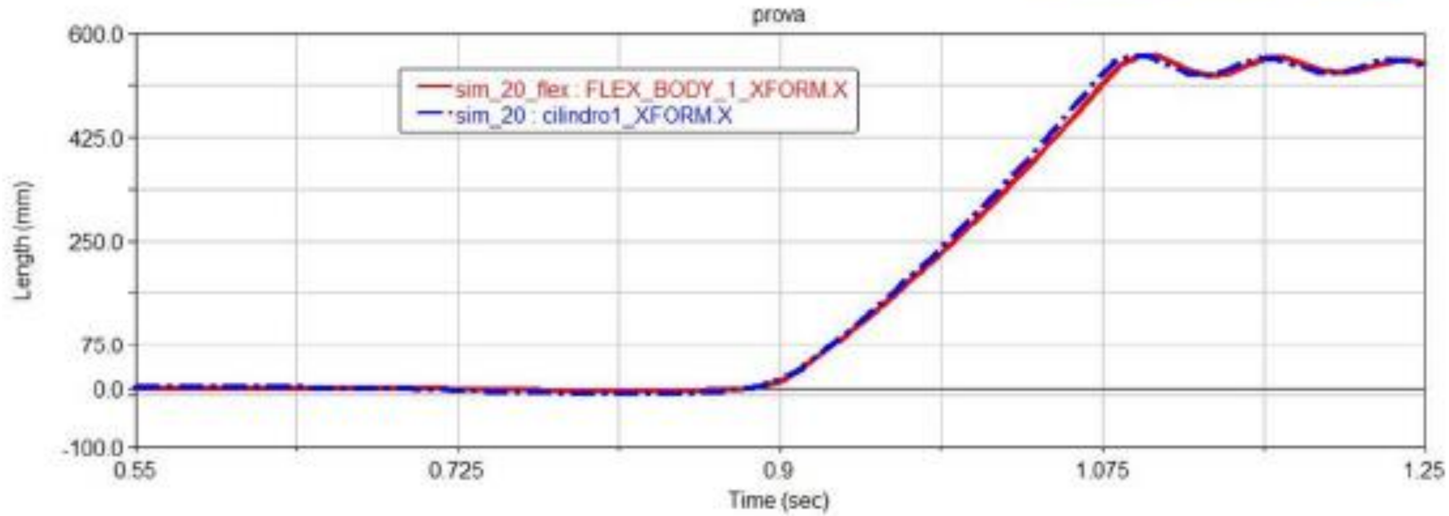


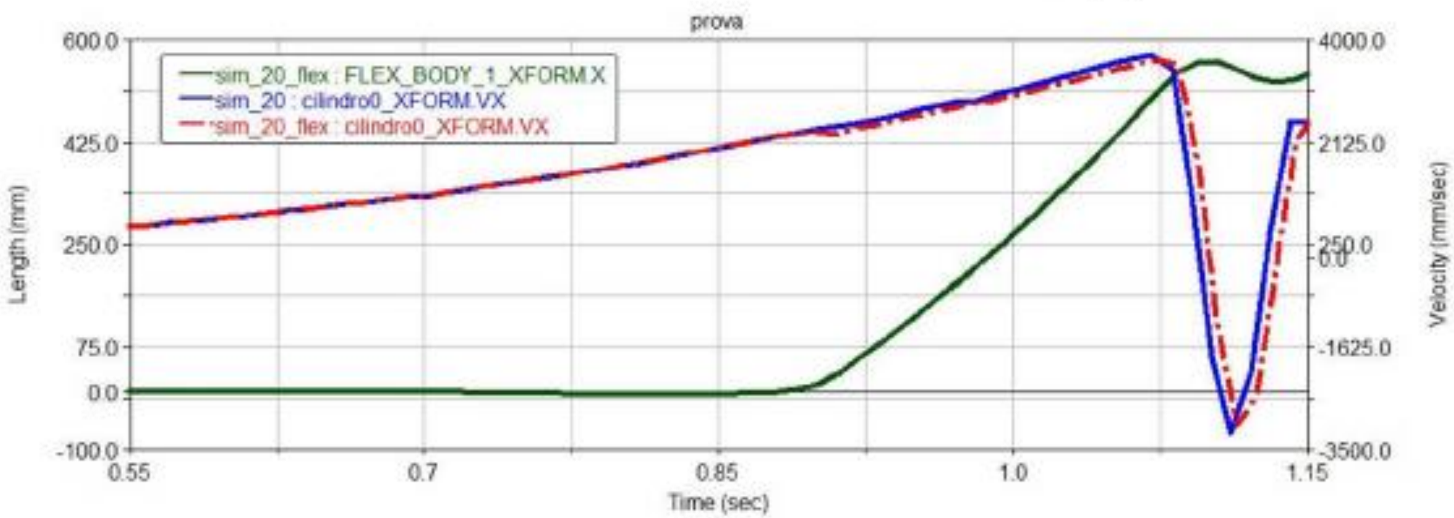


Accelerazioni

Confronto Risultati
Modello Flessibile/Modello Rigido

Confronto Posizione

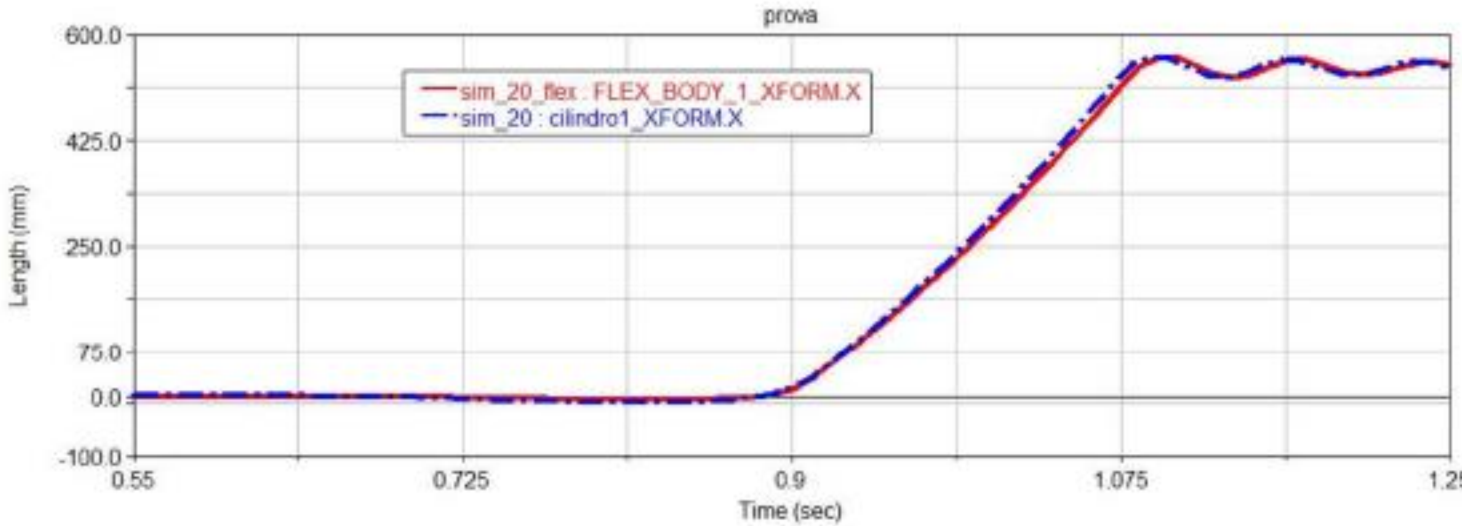


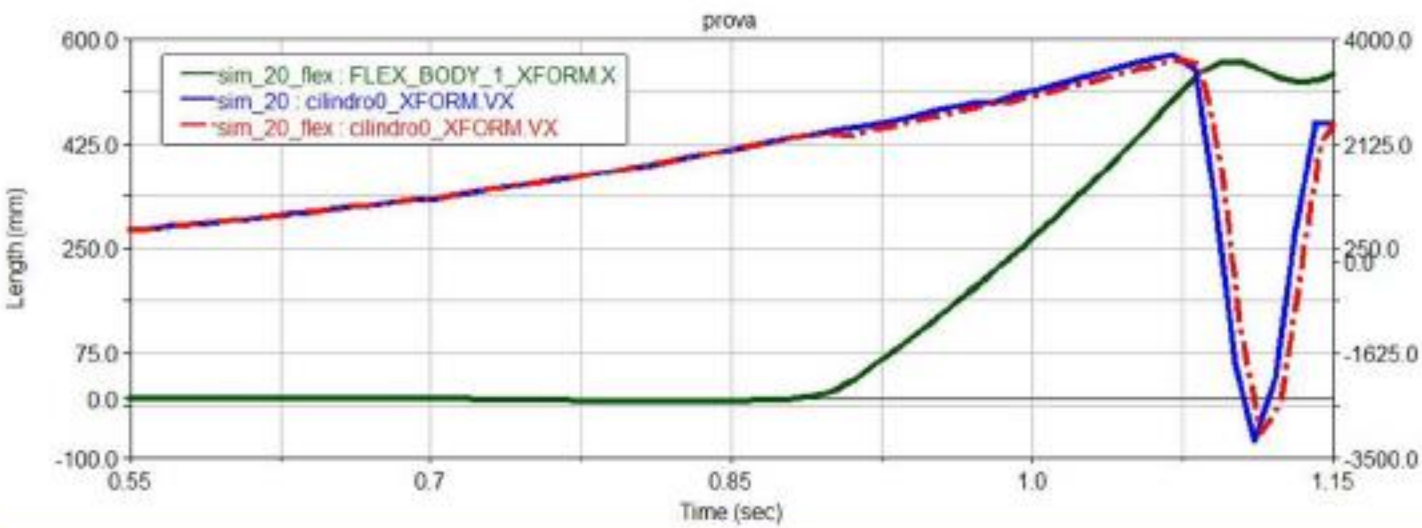


Confronto Velocità

Confronto Risultati
Modello Flessibile/Modello Rigido

Confronto
Posizione





Confronto
Velocità

Pagina intenzionalmente lasciata bianca

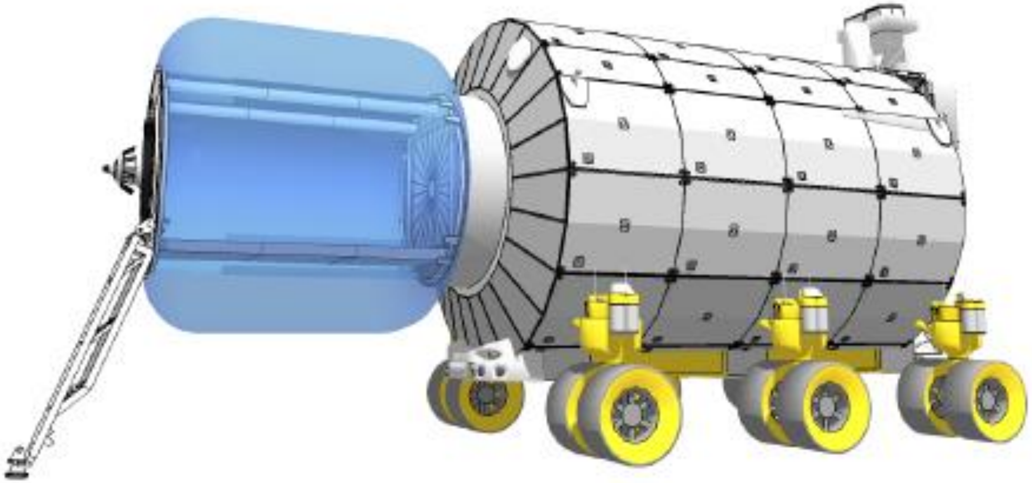
INFLATABLE AIRLOCK

Inflatable Airlock IAL

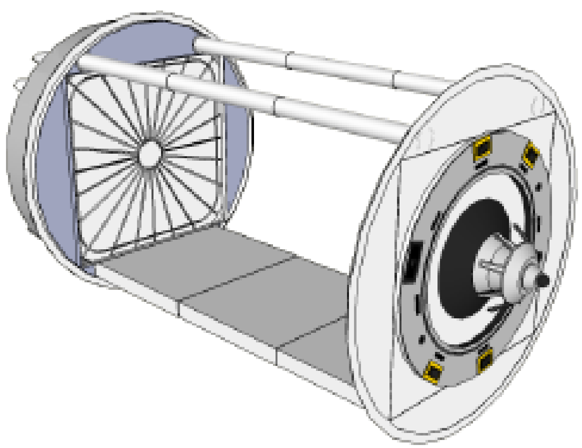
Inflatable Technology Target Application

IAL main target:

- allows EVA (Extra Vehicular Activity);



Requirements

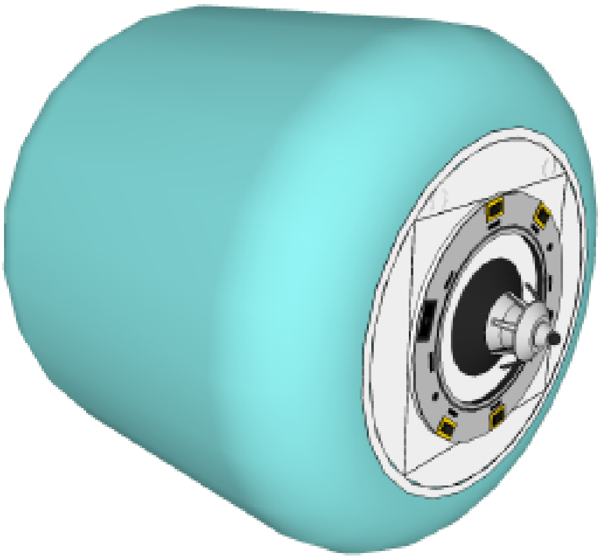


IAL functional elements:

1. Deployment Mechanism;
2. Inflatable Wall;

- Withstand the applicable loads;
- Perform correct deployment;
- Allow internal and external attachment of secondary structures;

Requirements



IAL functional elements:

1. Deployment Mechanism;
2. Inflatable Wall;

- Withstand the internal pressure;
- Inflate under the action of the air;
- Satisfy the daily leakage requirement in terms of global air loss;

Evaluated Configuration

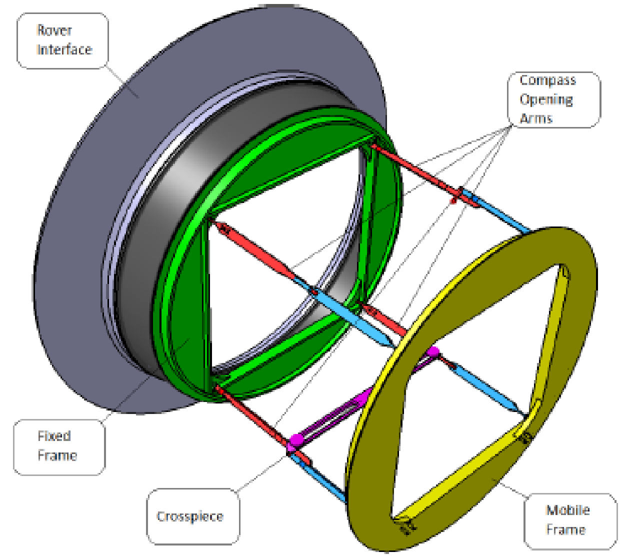
Dimension	[mm]
diameter D	1900
length l	2400

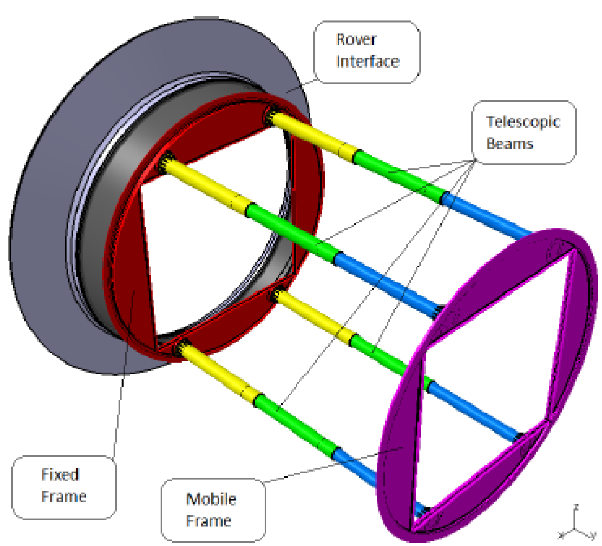
Main Requirement:

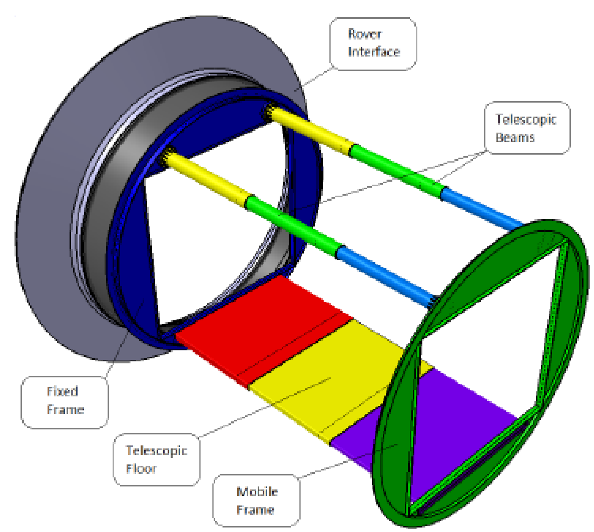
The DM is through as a passive element.

Configurations:

1. Compass Opening Arms;
2. Telescopic Floor;
3. Telescopic Beams;







Ribbon Capability at ultimate: 39500 N

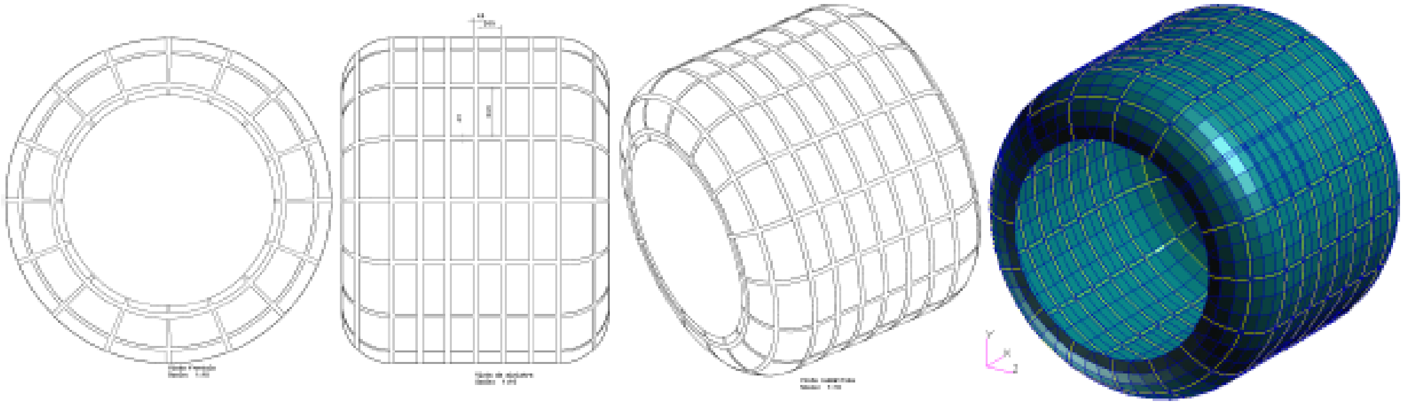
Load
- Fluxes
- Dimensions

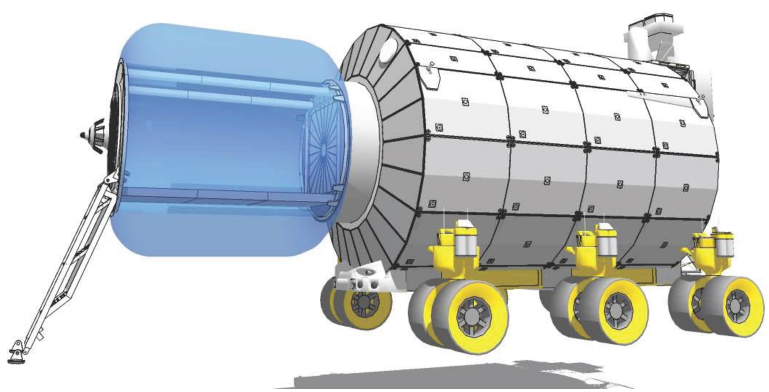
$\longrightarrow$

Ribbons Number
- Ribbon Capability at Ultimate

$\longrightarrow$

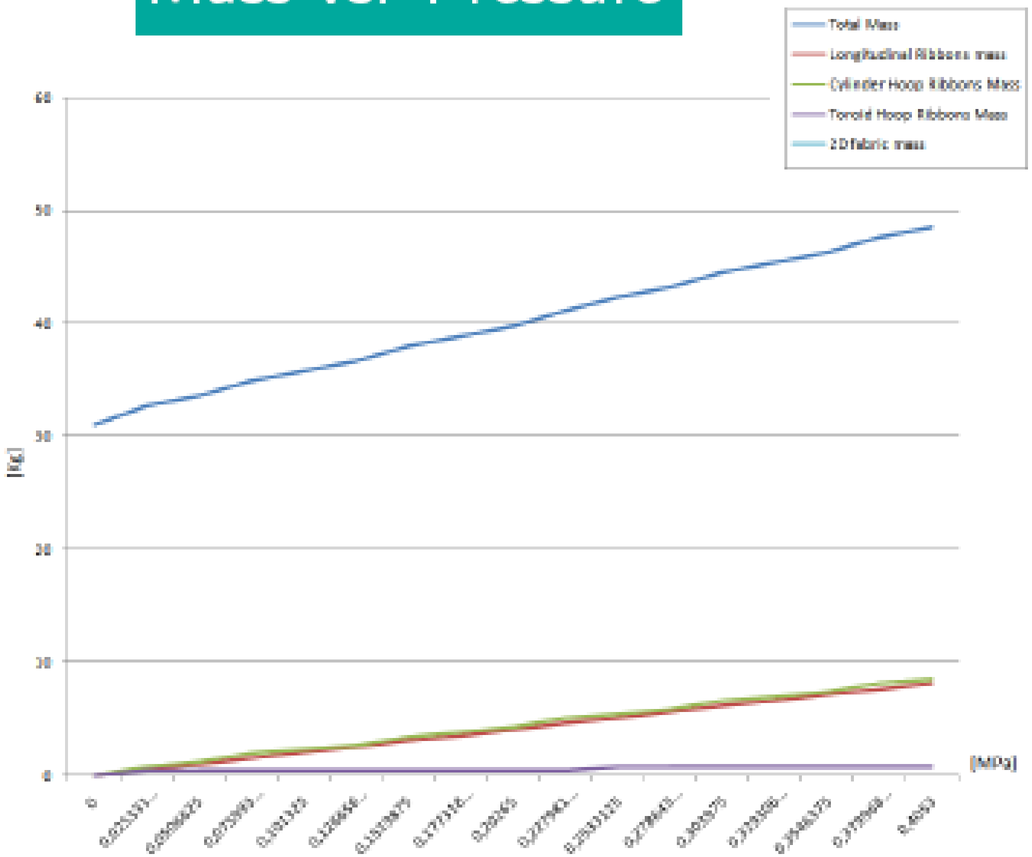
Spacing
- Ribbon Width

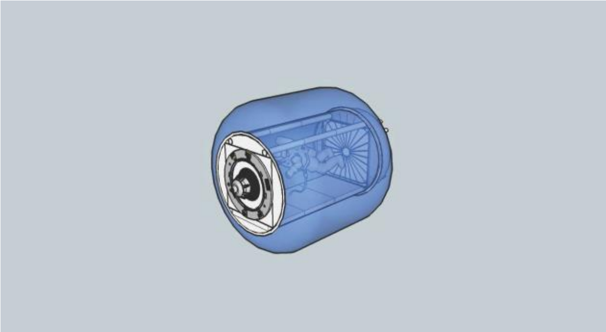


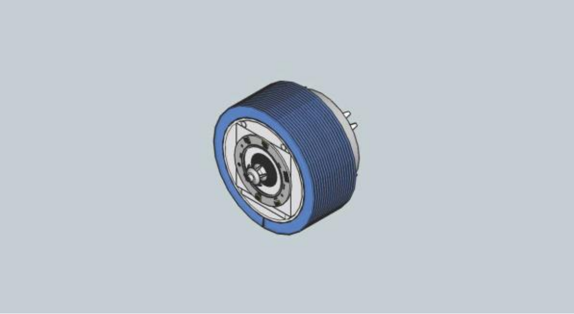


CAN BE USED FOR OTHER APPLICATION WITH A FEW MODIFICATIONS

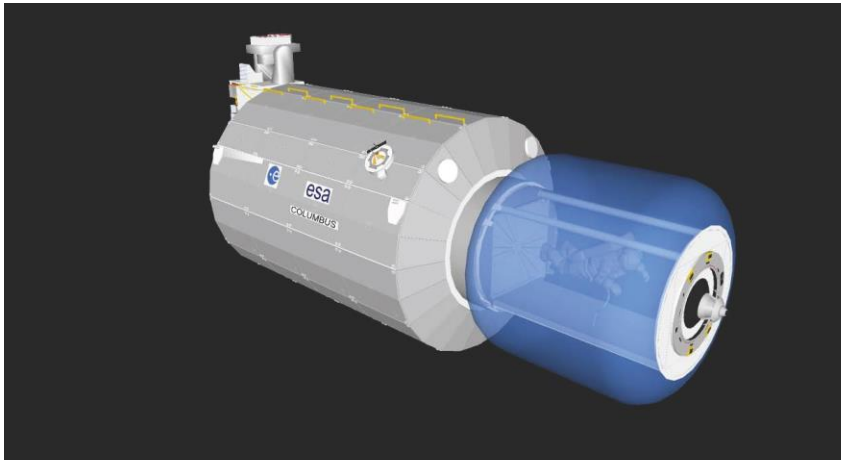
Mass vs. Pressure

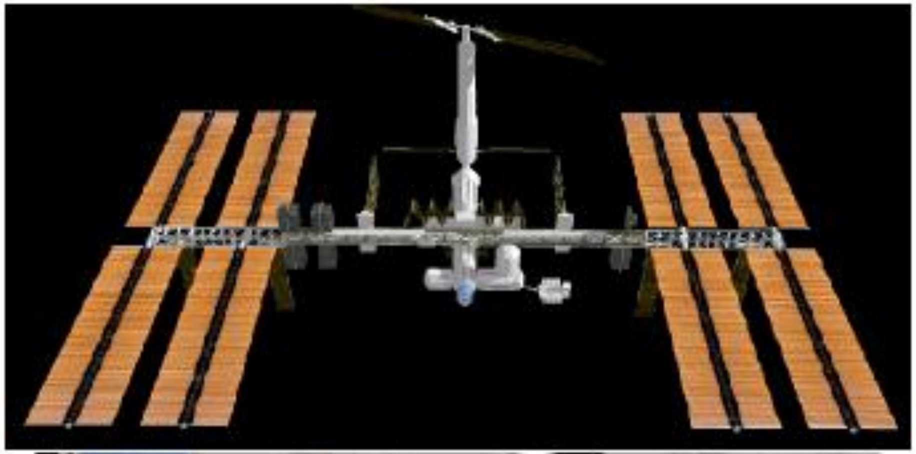


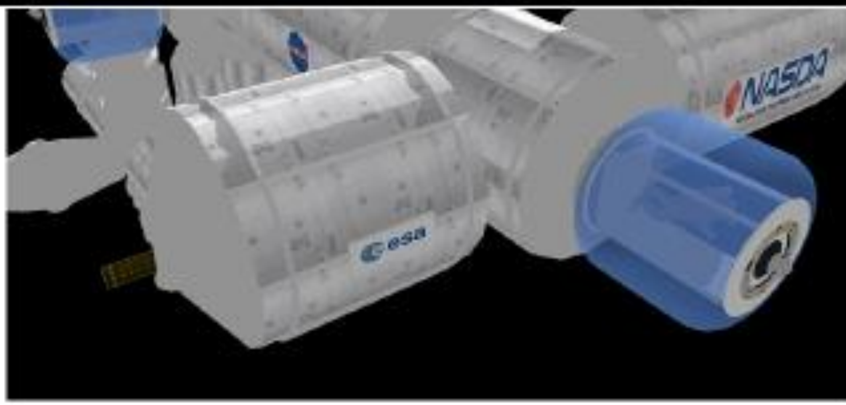




- Exploration Rover;
- ISS Module;
- Space Shuttle Orbiter;
- ATV;
- Unmanned Satellite;







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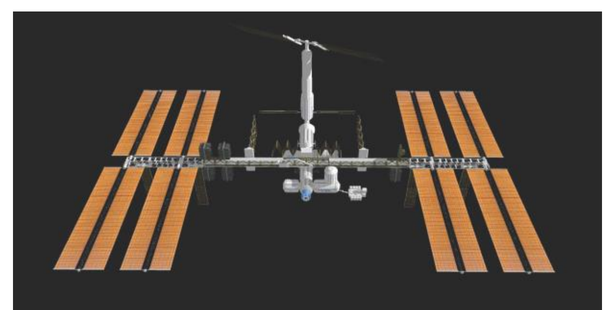

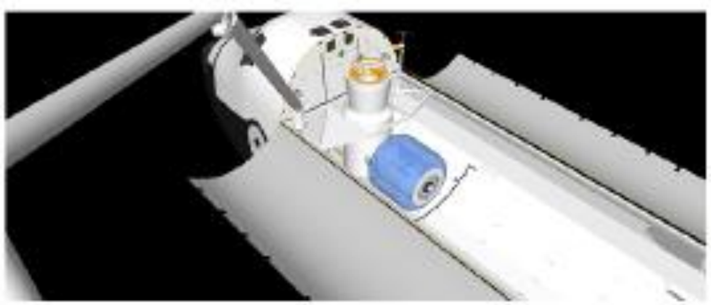

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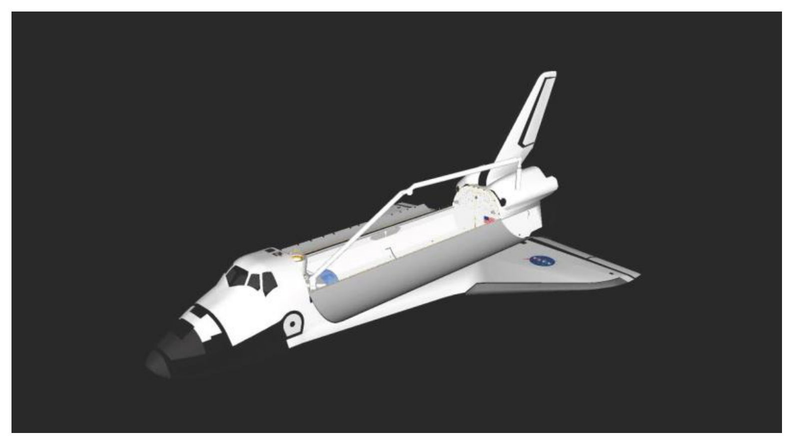

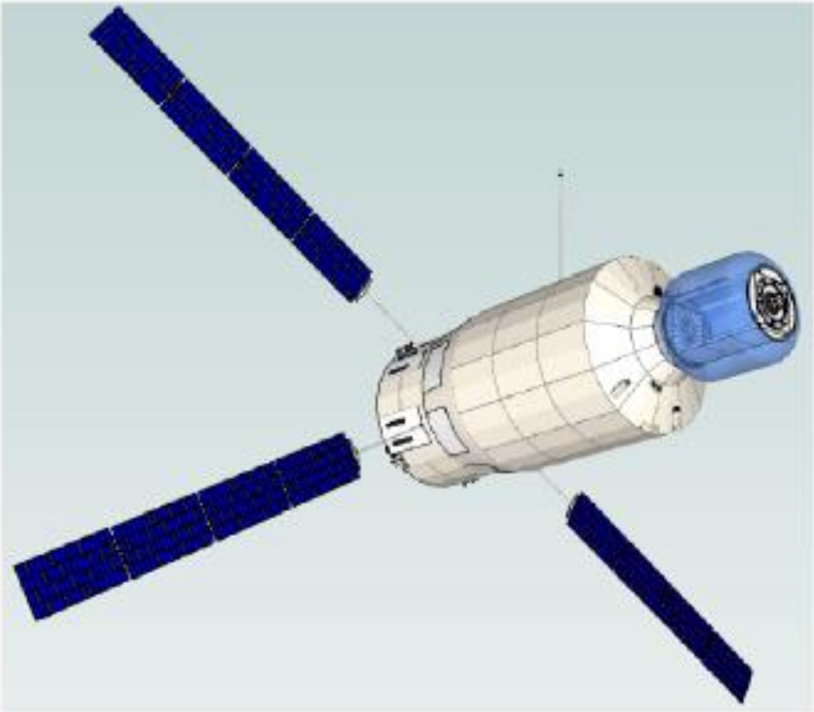

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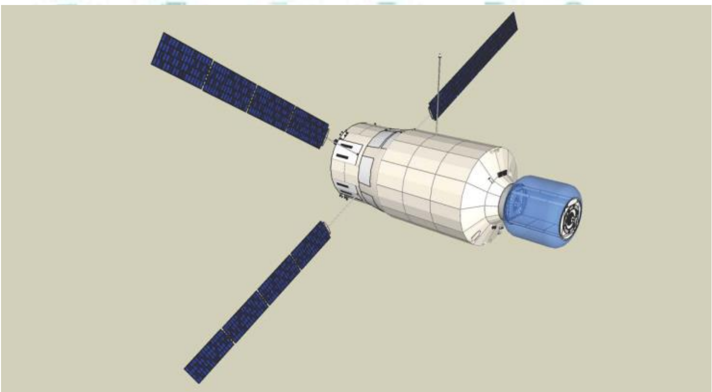

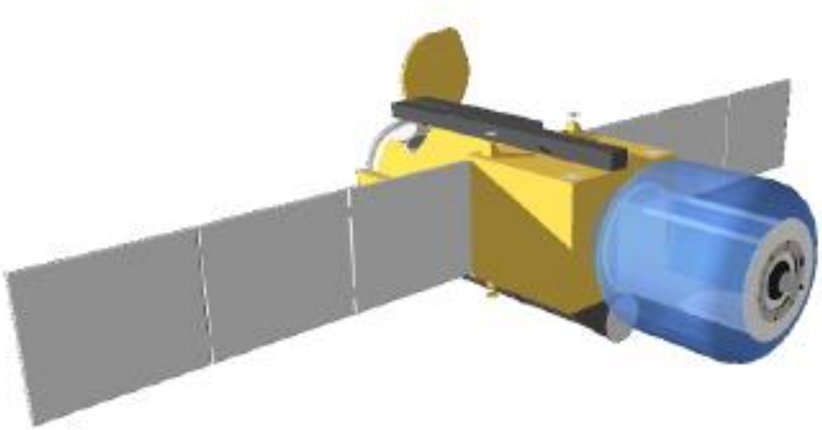

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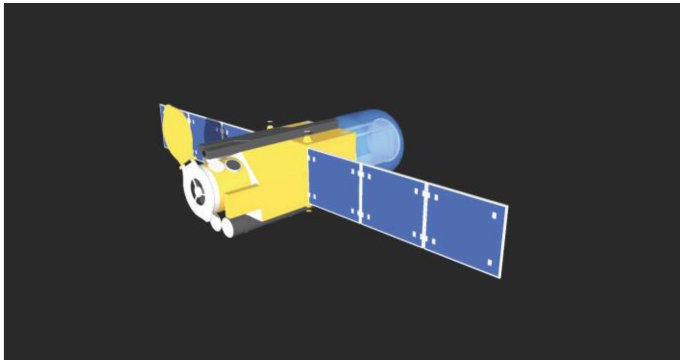

CONCLUSIONS

- **IS represents a valuable technique to be considered in next generation manned and un-manned space structures**
- **IS are ‘probably’ the only solution to construct large spacecraft**
- **Computational mechanics can be able to make simulation of Inflatable structures with severe limitations**
- **Available materials can be very much improved, dedicated one would be welcome (development on nanotech's could play a very significant role)**
- **Experiments are mandatory**

  Boeing space station

  https://www.youtube.com/watch?v=Mn_gXEK5XmQ

FULL COMPOSITES PRANDPLANE

WITH INFLATABLE WING : HALE ELOTAC

Earth
LOok
TAke
Care