

# **3<sup>rd</sup> IASS Conference**

*Building a Safer Space Together*

*“SPacecrew EMergency system”*

Lorenzo Fiore, Aero Sekur  
CASD, Rome – October 22, 2008

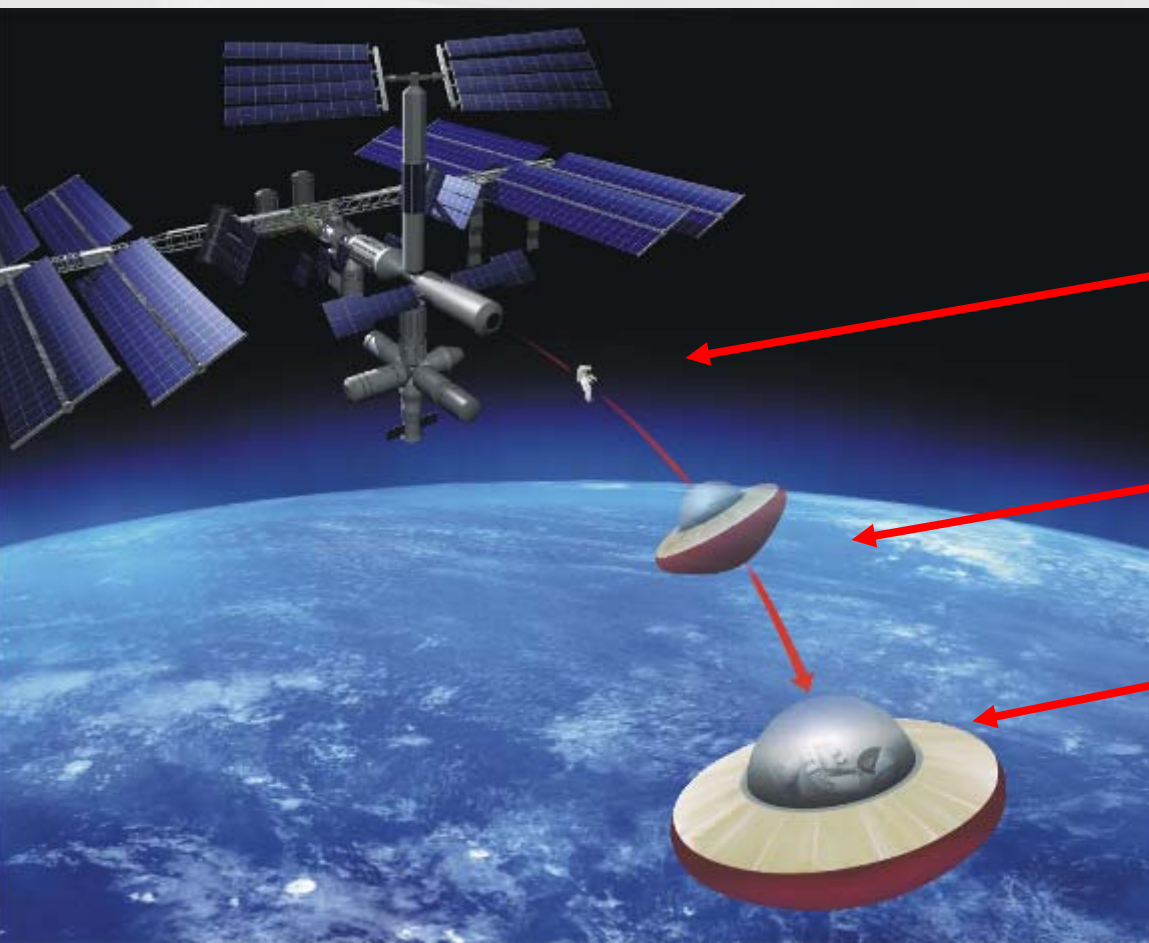
## *What is SPEM(\*)?*

The SPacecrew EMergency system (SPEM) is a concept designed for use as an escape mechanism by orbiting astronauts.

It uses the latest flexible heat shield technologies capable of protecting an astronaut during an emergency reentry.

*(\*) a declined ancient latin word meaning "hope"*

# *What SPEM aims to demonstrate*



Life boat separation

Life boat shell inflation

Atmospheric reentry

# *The concept*

The breakthrough concept of the SPEM was made following the Space Shuttle Columbia disaster in 2003.



# *The concept*

Advantages of inflatables over traditional structures:

- Lower mass
- High package density
- Potential decrease of the ballistic coefficient

Know-how inherited by IRT (Inflatable Reentry Technology) ESA programme.

## *Beyond the concept*

The SPEM was originally scheduled to flight with ENEIDE Mission to ISS in 2005.

- Launch with Soyuz capsule
- Separation after Soyuz detachment from ISS

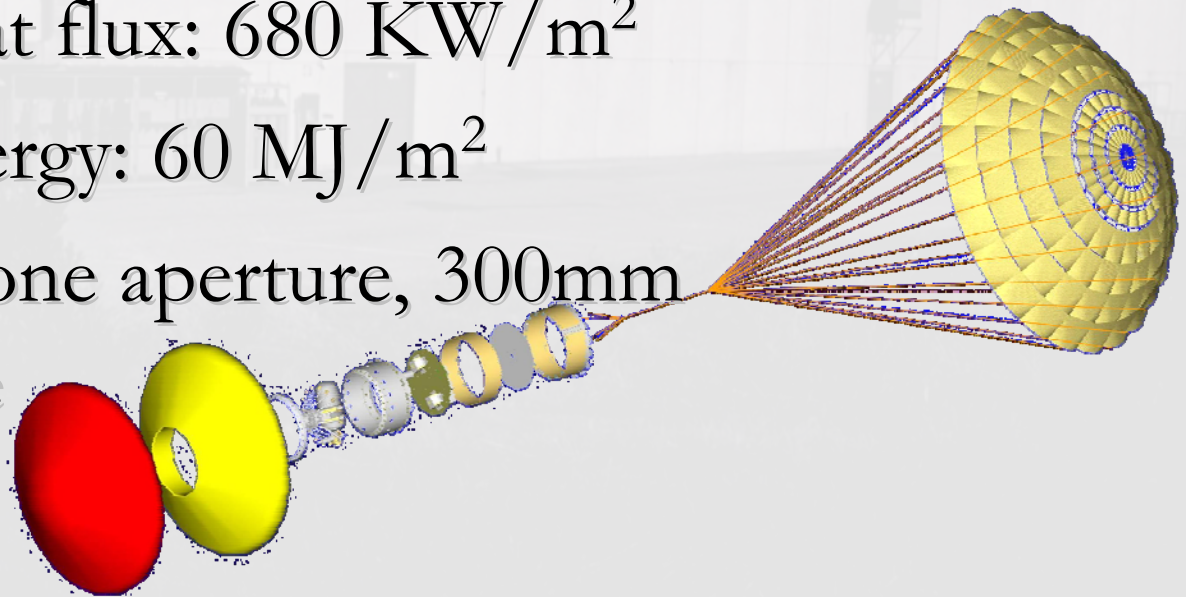
RSC ENERGIA cooperated for the definition of mission and interfaces parameters.

# *Mission Parameters*

- 1m flight test demonstrator
- Controlled separation at 100km
- Stabilization on proper reentry path
- Inflatable TPS deployment once in asset
- Ringsail parachute deployment at 10km
- Data relay system transmission

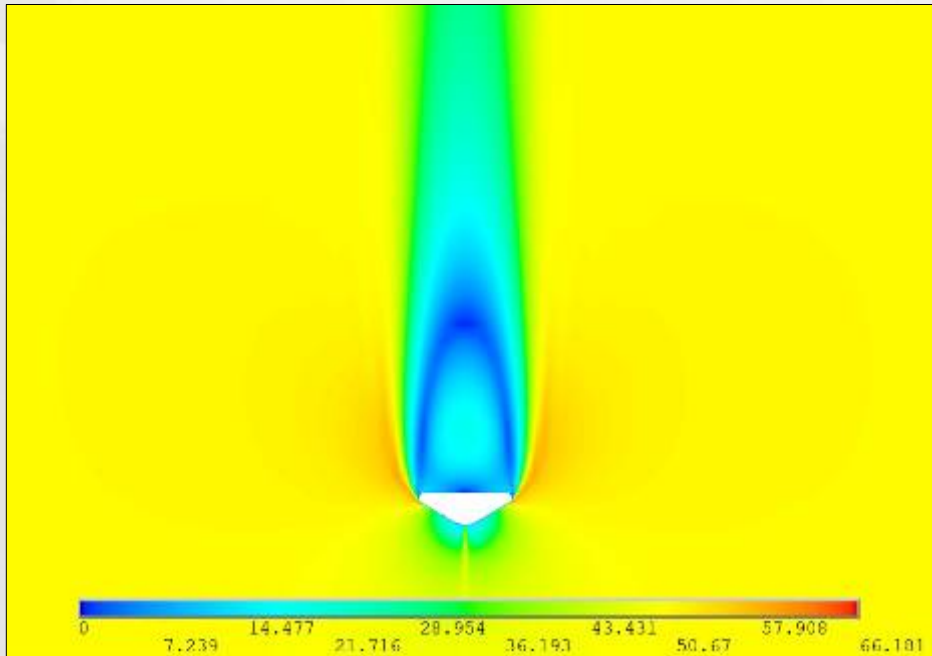
# *Design architecture*

- No payload (only inflation system, electronics and parachute system)
- Maximum heat flux:  $680 \text{ KW/m}^2$
- Maximum energy:  $60 \text{ MJ/m}^2$
- $60^\circ$  degrees cone aperture, 300mm spherical nose radius



## *CFD analyses*

Velocity



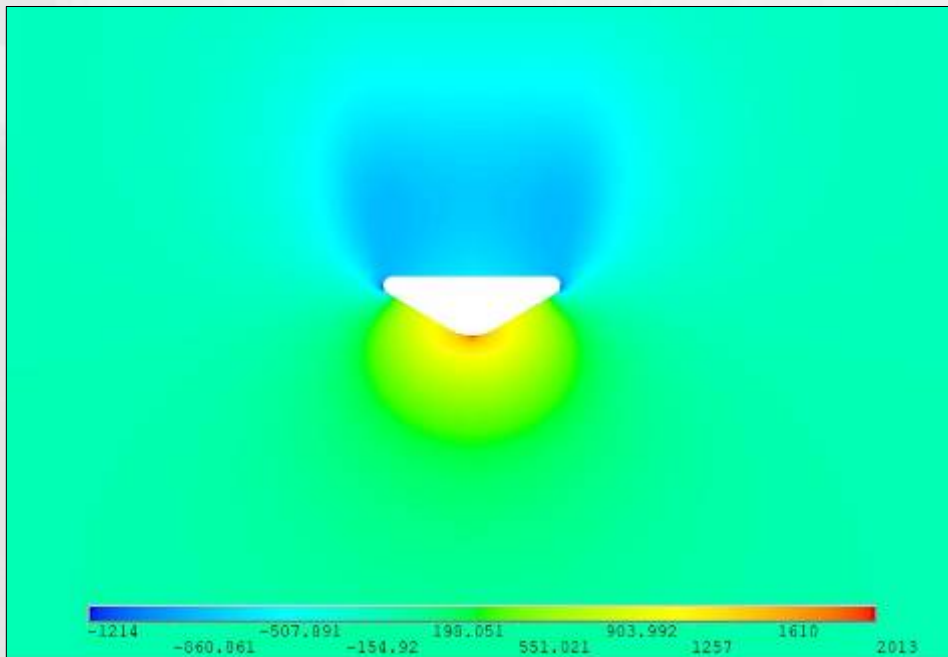
Input: free fall velocity.

Output: flow velocity profile.

It was used to evaluate the end of recirculating region to define the distance to be achieved by the parachute ejection system.

# *CFD analyses*

Pressure

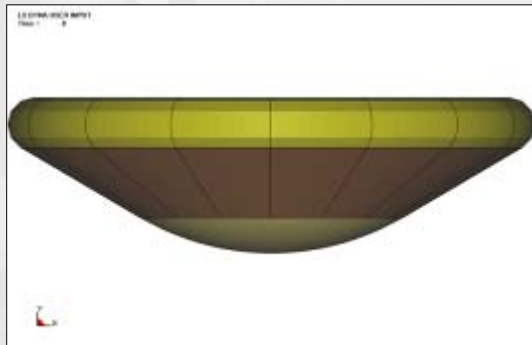


Input: free fall velocity.

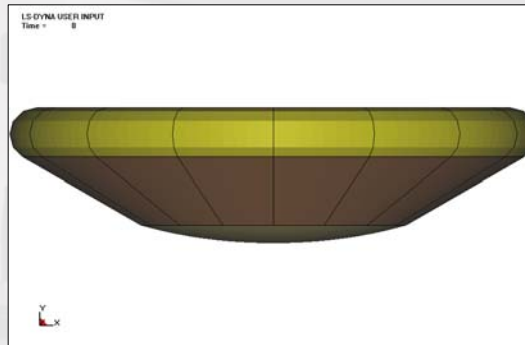
Output: pressure profiles.

It allowed to evaluate the structural mechanical loads on the TPS and therefore on the inflatable support structure.

# *Structural analyses*



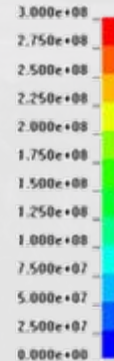
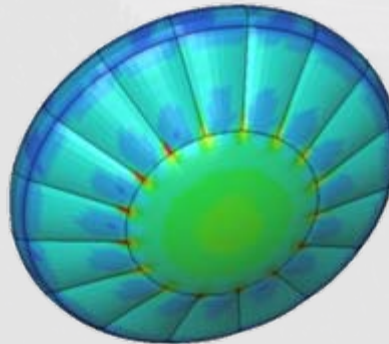
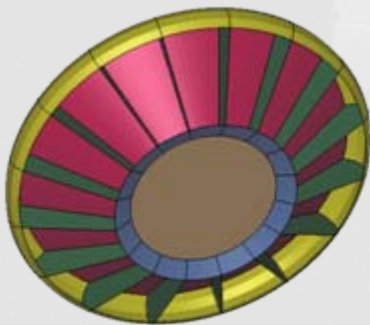
design profile



constructive profile



inflated profile



maximum stress level:  
200 MPa

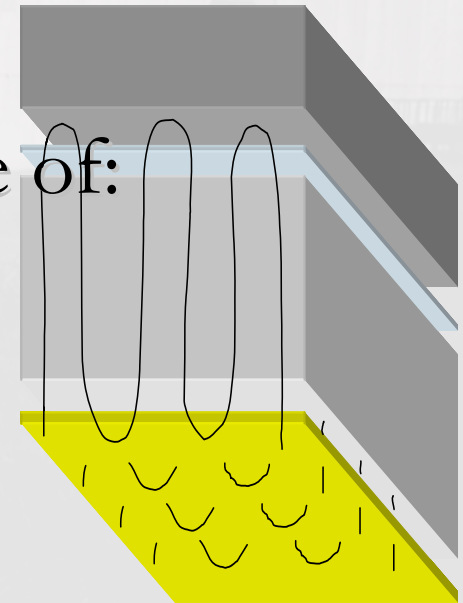
aramidic structural  
layer stress limit:  
698 MPa

# *Thermal Protective System*

The TPS has been designed using know-how and experience made by Aero Sekur on IRT.

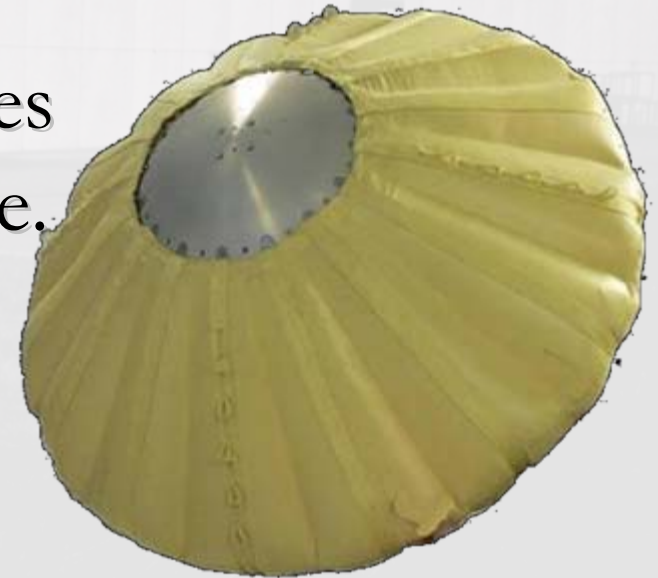
It's a sewn multilayer structure made of:

- a) Silicone ablative compound
- b) Structural support layer



## *Inflatable structure*

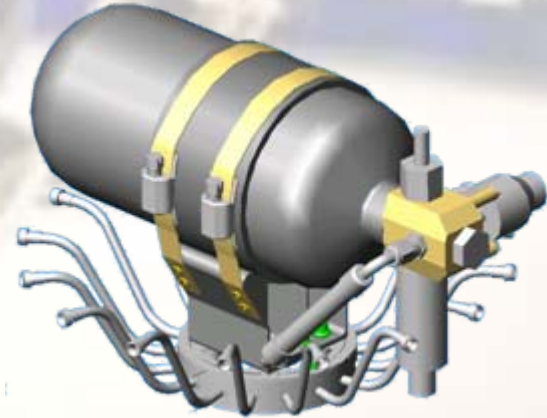
The SPEM TPS is fixed over an inflatable structure divided into 16 sectors. It provides the support to the TPS in order to withstand the mechanical stresses induced by the dynamic pressure. The textile structure is made of sewn aramidic fabric.



## *Inflation system*

Is activated by a Shape Memory Alloy device designed and manufactured by Aero Sekur.

The manifold is separately linked with each inflatable sector to allow reliability and uniform inflation of chambers.

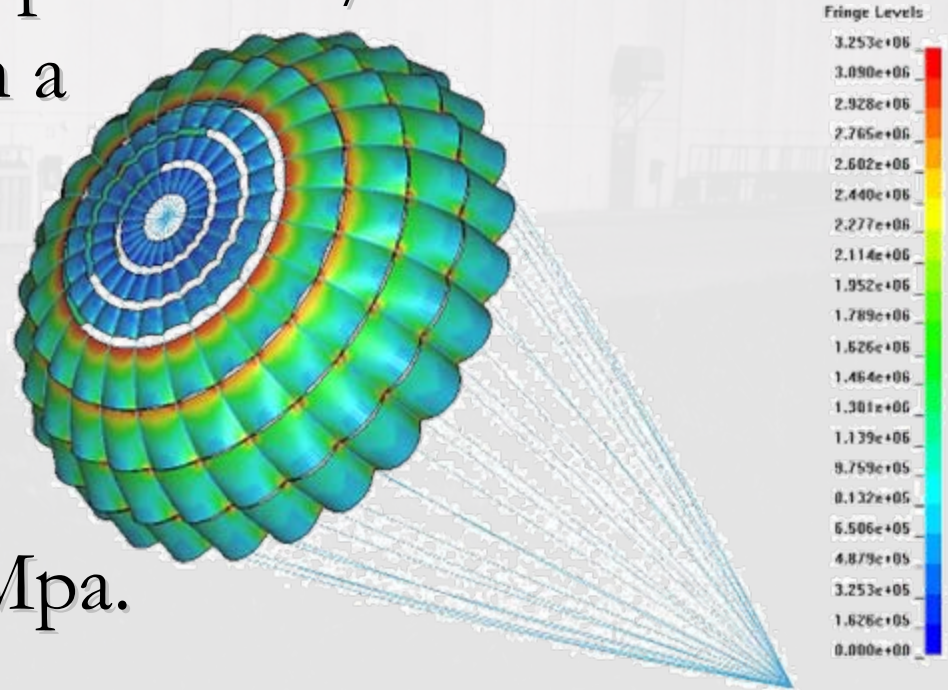


# *Parachute*

The 2m ringsail parachute allows to slow down the descent speed from 60 up to 10 m/s.

CFD analysis resulted in a maximum tensile stress of 3.25 Mpa.

The aramidic material used has a maximum tensile strength of 280 Mpa.



## *On-ground test*

Unfortunately, it was not possible to perform the flight test of the SPEM demonstrator with the ENEIDE mission.

While waiting for a flight opportunity, a fully representative on-ground qualification test has been performed in the Scirocco<sup>(\*)</sup> Plasma Wind Tunnel of the CIRA in Capua (Italy).

*(\*) a characteristic Italian hot wind*

# *CIRA “Scirocco” PWT*

The CIRA Plasma Wind Tunnel facility is devoted to aero-thermodynamic tests on components of aerospace vehicles.

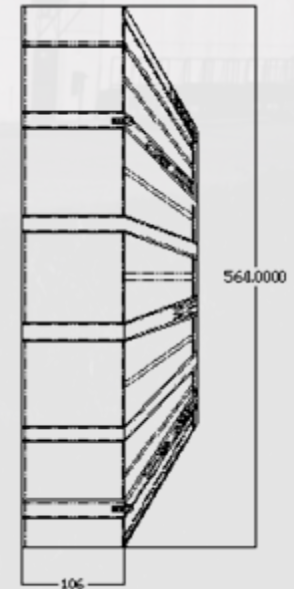
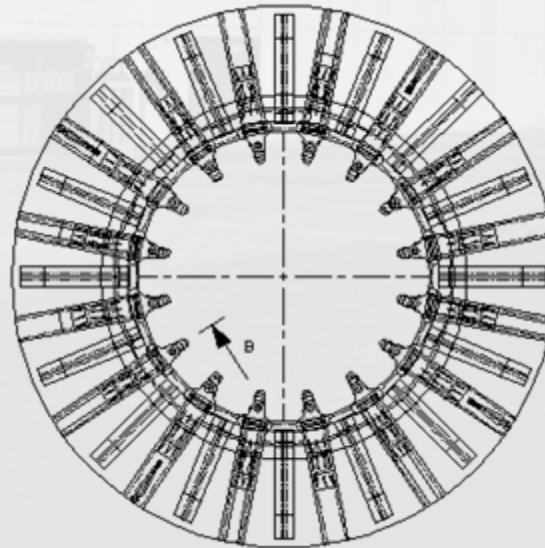
Due to the challenging test requirements, the diameter of the SPEM test article has been scaled to 560mm.



# *PWT test article*

Heat flux at stagnation point:  $430 \text{ kW/m}^2$

Total energy per unit surface:  $45 \text{ MJ/m}^2$



## *PWT test*

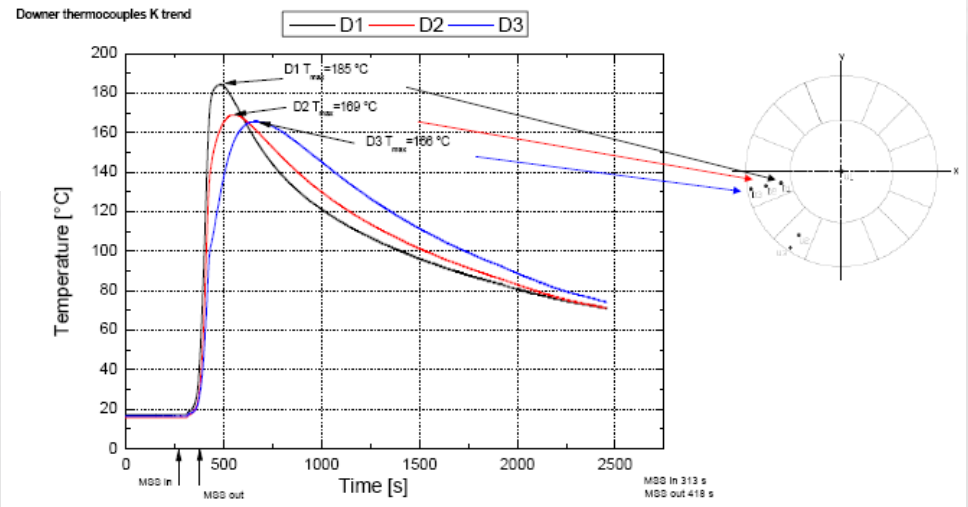
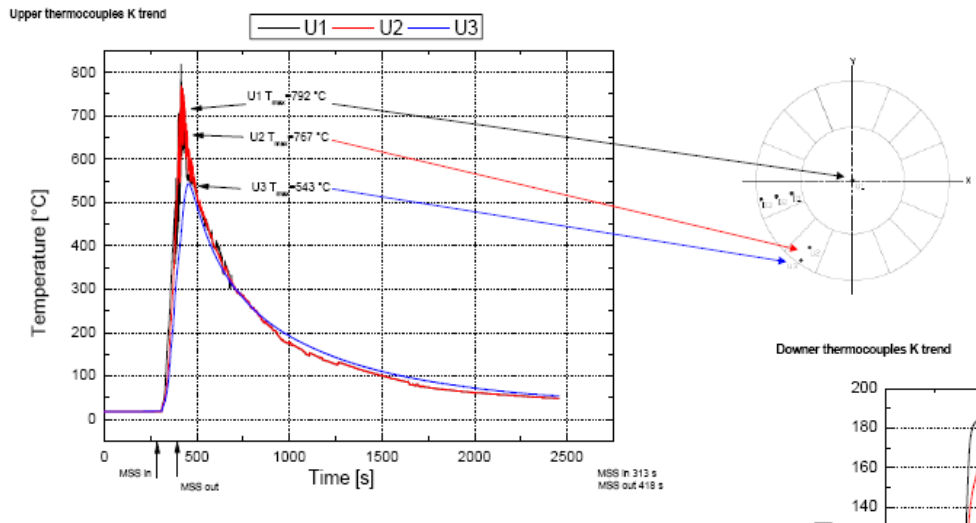
Successfully held on Sept. 26, 2008.

The SPEM performed in the plasma jet for a time longer (108s) than scheduled (100s).



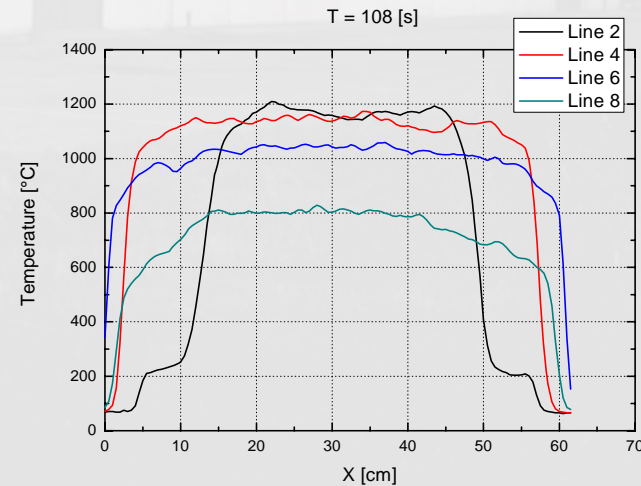
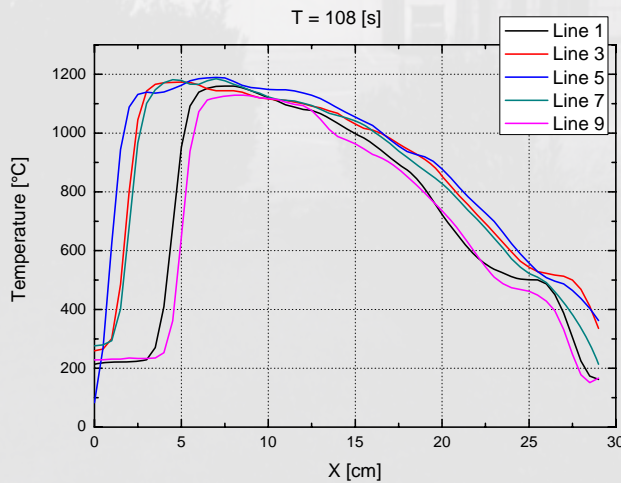
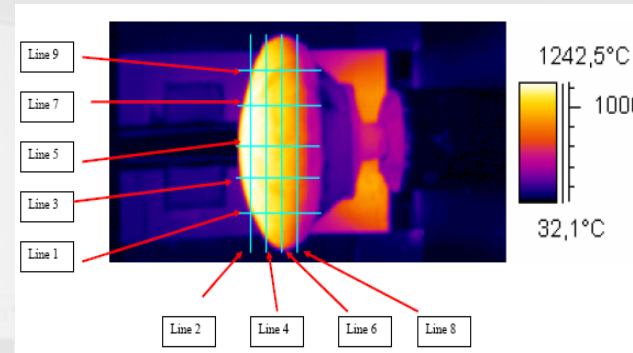
# Thermocouples readings

interface between  
ablative silicone  
and thermal mattress



# Thermographic data

Maximum shield temperature reached:  
ca. 1250C°



## *“The day after”*

Flexible thermal protective materials have demonstrated their suitability to withstand thermal loads during the hot phases for reentry trajectories.



*...and now?*

Design and test activities performed, suggest the suitability of this kind of technology for:

- Astronauts safety
- Heavy payload landing on planets with rarefied atmosphere (like Mars)
- Earth reentry of sample containers from space (NEO/MARS sample return missions)

Thanks for your attention

>> PS: We are seeking for volunteers!!!! <<



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