# Radiation-Shapes-Thermal Protection Investigations for High Speed Earth Re-entry

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RASTAS SPEAR

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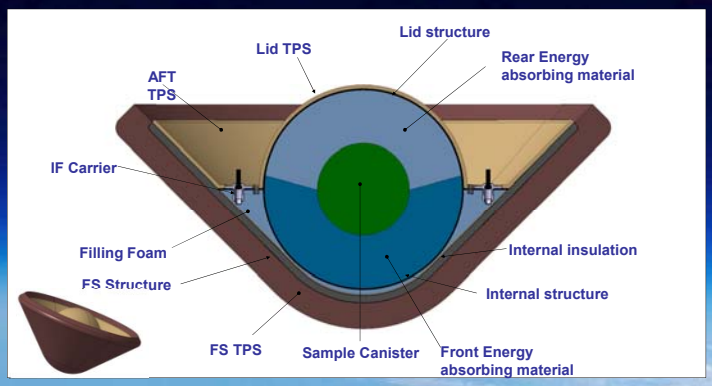
Total Budget: 2.3M€

## Objective:

"To increase Europe's knowledge in high speed re-entry vehicle technology to allow for planetary exploration missions in the coming decades"

## 10 partners from 8 European countries

## CONCEPT: FULLY PASSIVE SAMPLE-RETURN VEHICLE FOR BALLISTIC EARTH RE-ENTRY




## Key Technologies for High Speed Entry

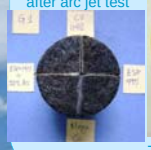
**Thermal Protection System (TPS) with joints**

- Selection and arc jet testing of a gap/seam adhesive for a tiled TPS
- Manufacturing of a technological breadboard featuring key aspects of an actual capsule

**Crushable Material for hard landing impact attenuation**

- Development and operation of a suitable 2-step test strategy based on static tests and on high speed dynamic tests using air cannon
- Numerical simulation of impact tests with LS-Dyna, show a good correlation between experimental and computed data on PU foam

Asterm sample with joints after arc jet test



Technological breadboard 0.9 m

Air cannon bullet impacting crushable target

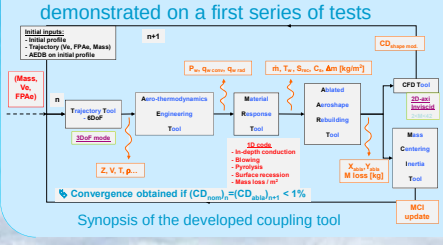
## Ablation- Flight Mechanics Coupling assessment

**Implementation and operation of a coupling tool**

- Trajectory, Aerodynamics, Thermal Response, Ablation, MCI Evolution
- Assessment of coupling effects on the Rastas Spear capsule, showing quite low influence
- Parallel multi effects CFD computations, to consolidate the correlations used in coupling tool : complex work, requiring further enhancement

**Experimental assessment of radiating species around ablating materials**

- Interest of this newly installed facility and associated diagnostics demonstrated on a first series of tests




Synopsis of the developed coupling tool

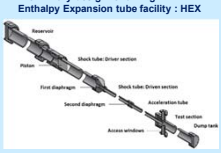
Plasma torch and Asterm sample during test

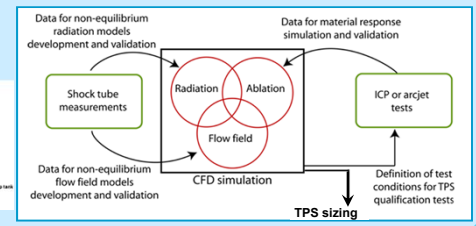
## Ground Facilities Improvement

*Main outcomes:*

1. Review of various types of facilities
   a) No hyper velocity wind tunnel in Europe, 4 in the world
   b) Suitable plasma facilities available in Europe
   c) Satisfactory wavelength range for radiation diagnostics
2. Preliminary design of a high enthalpy Expansion Tube
3. Proposition of a test strategy combining arc jet tests for TPS evaluation and shock tube experiments for flow modelling

Preliminary design for an high Enthalpy Expansion tube facility : HEX






## Gas-Surface Interactions Modeling

**Ground experiments**

- Definition and performance of a Wind Tunnel Test series at Onera R2Ch
- Measurement of heat flux on a porous ceramic specimen, varying multiple parameters (flow pressure, material roughness, gas blowing across surface)

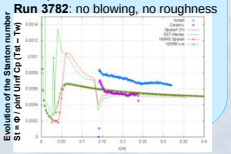
**CFD modeling**

- Review of surface roughness and blowing influence
- Comparative reconstruction of experiments using different CFD codes
  - Then application to an Earth Re-entry Capsule case

**Outcomes**

- Decrease of heat flux with blowing is observed as expected and well reproduced numerically for lowest blowing rates
- Observed decrease of heat flux on a rough wall remains unexplained

**Example of reconstruction**
**Run 3782**: no blowing, no roughness

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SPA.2009.2.1.01 Space Exploration