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Sample Return Capsules Challenges and Technologies #8037

11th International Planetary Probe Workshop
June 16-20, 2014 - Pasadena (CA, USA)
Session : Cross-Cutting Technologies

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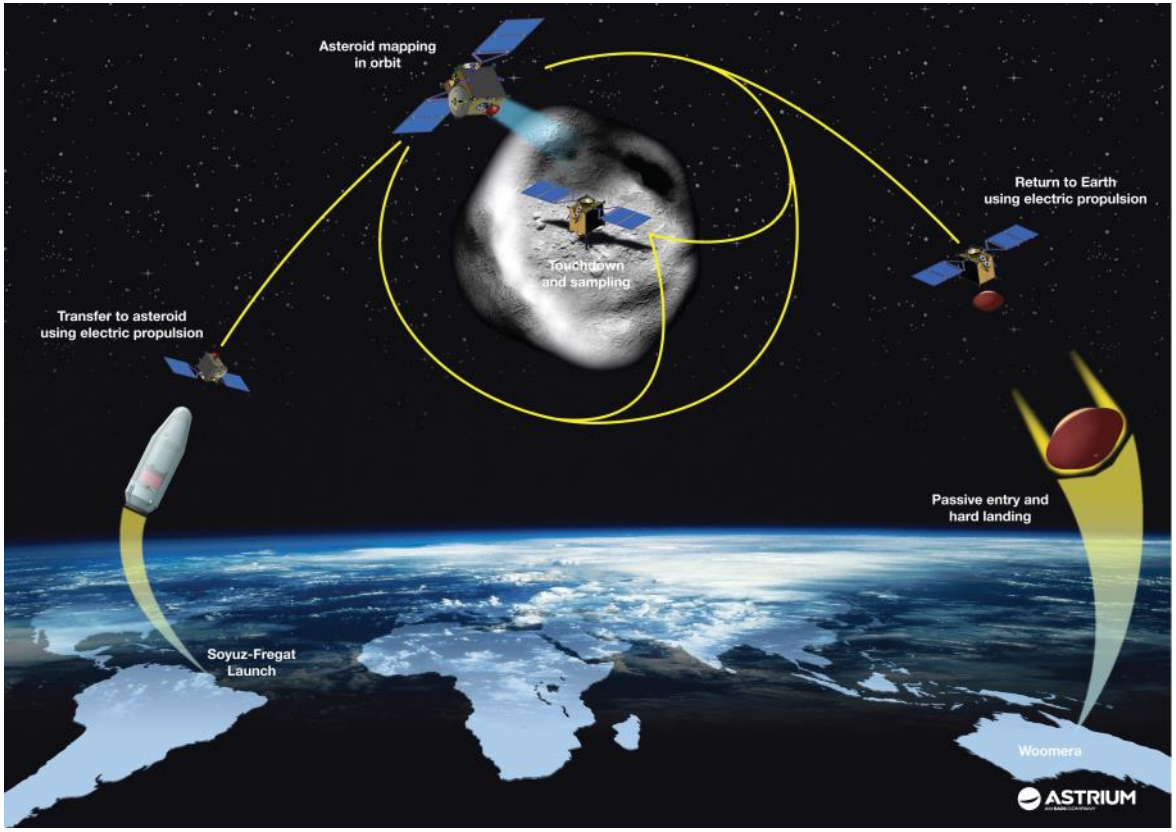
Sample Return Capsules Challenges and Technologies Overview

Introduction
- Potential Targets
- Main features

ERC Overview
- Challenge #1
- Challenge #2
- Challenge #3

Maturation of required technologies

Concluding Remarks



MarcoPolo-R Mission Scenario

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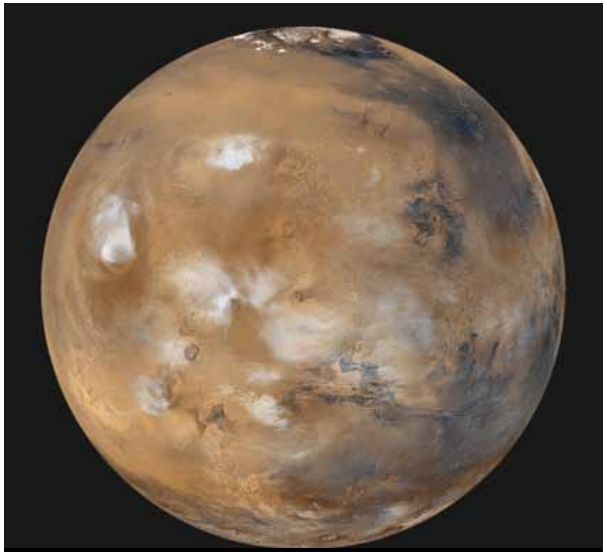
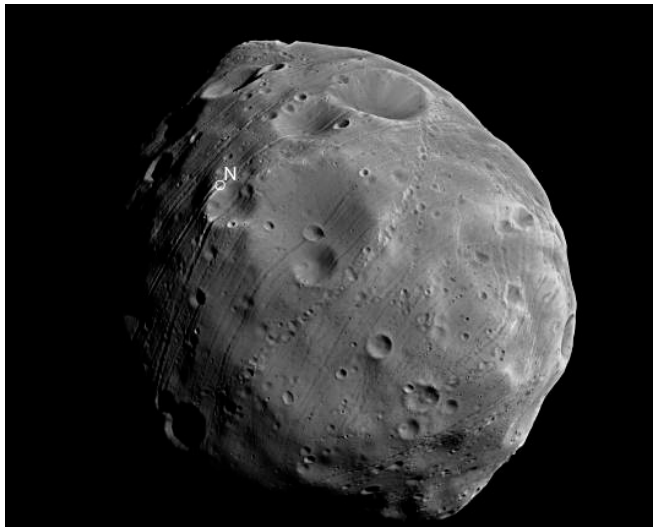
Potential targets:
Mars, Moon, Moons of Mars, asteroids

Credit: HiRISE, MRO, LPL (U. Arizona), NASA



Credit: NASA – Solar System Litograph Set



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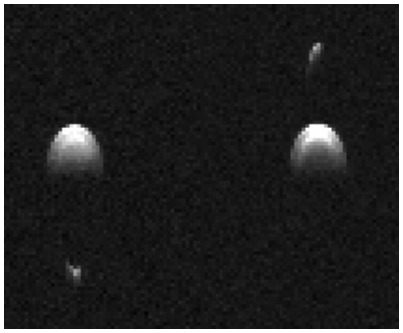
Credit: NASA – Solar System Litograph Set



1996FG3 (binary)

2008 EV5

High interest for a
Sample Return mission

Which mission first ?
TBD according to scientific priorities

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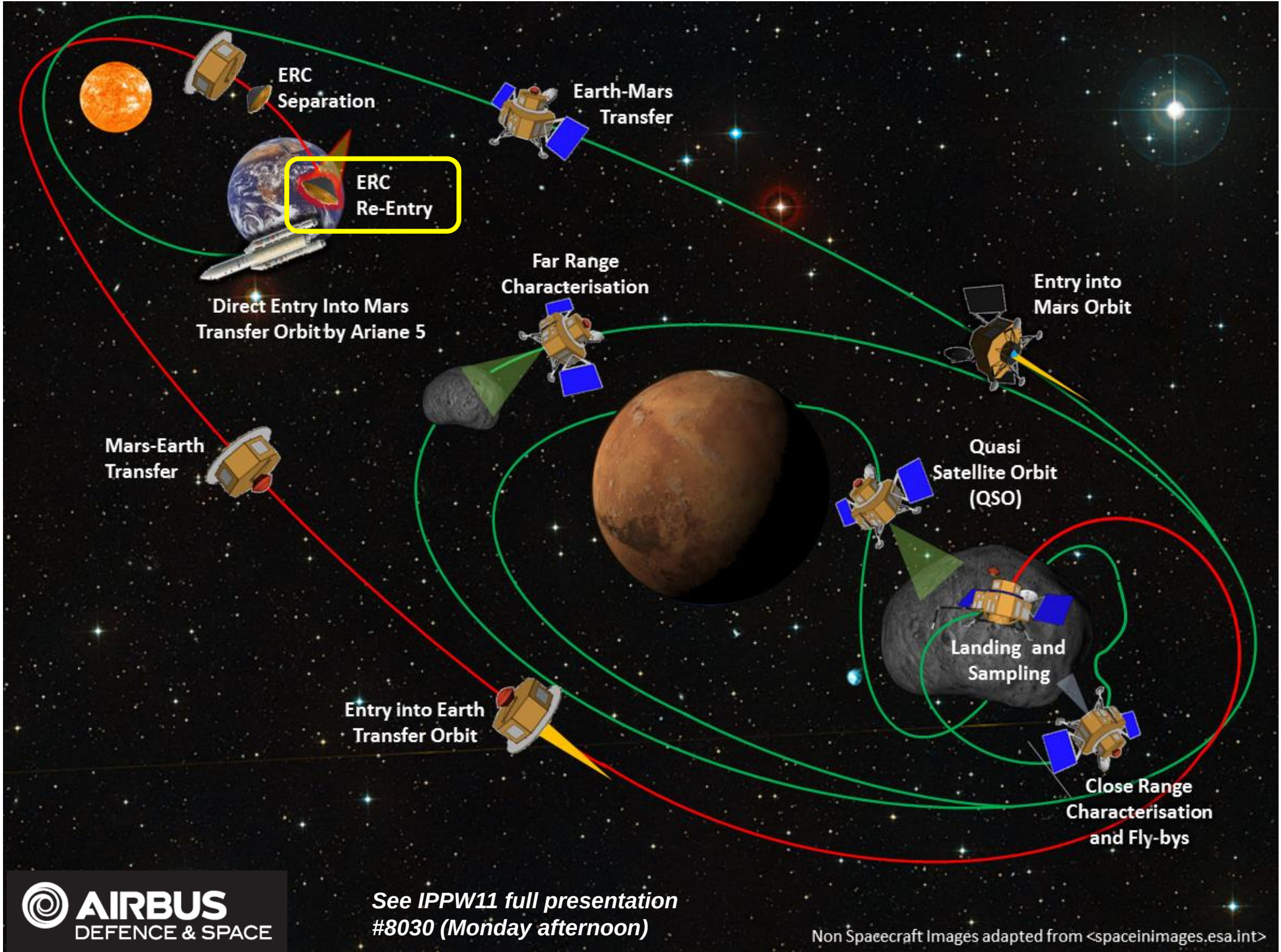

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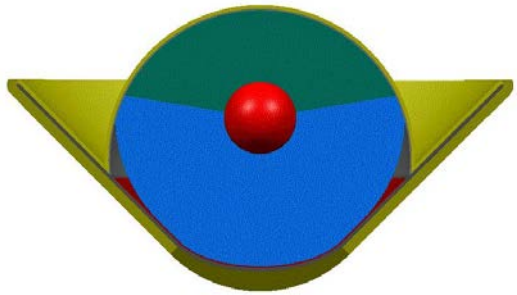
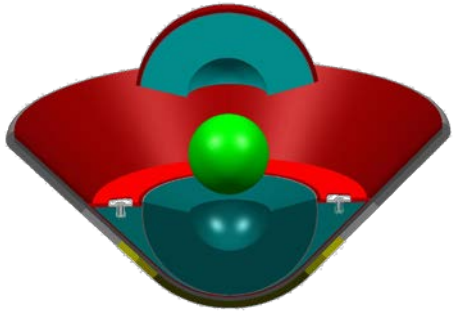
Sample Return Capsules 2004-2014 studies

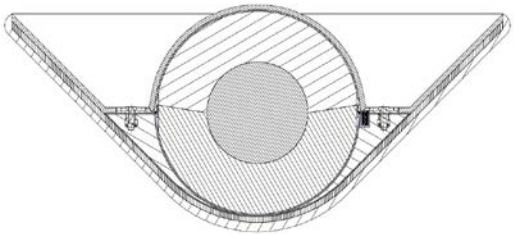
MSR 2004



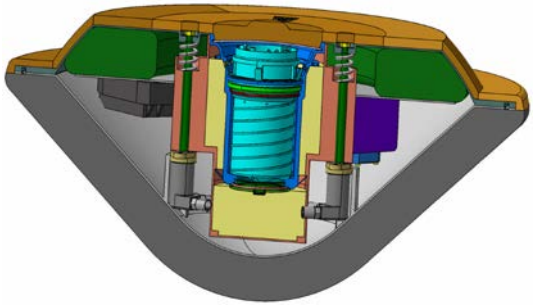
EVD 2005



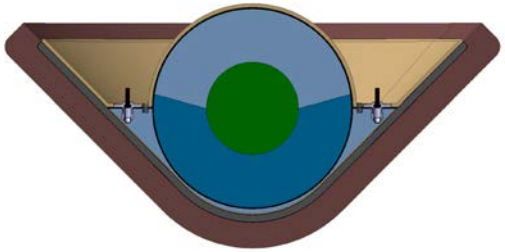
NEA 2007



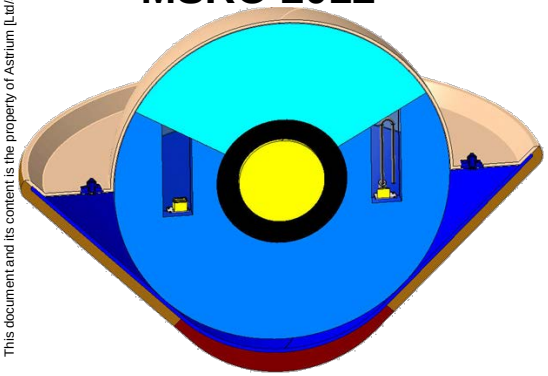
Marco Polo 2009



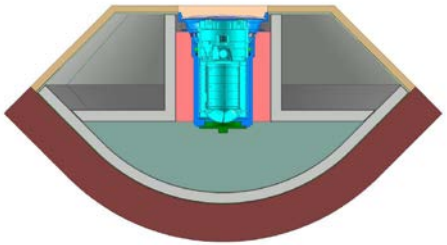
Rastas Spear 2010



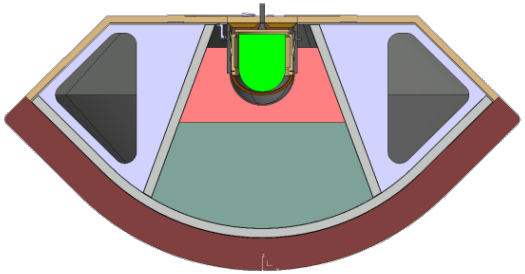
MSRO 2012



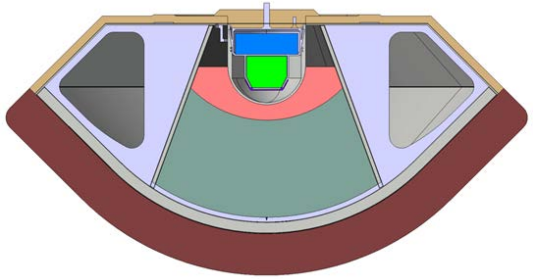
MMSR 2012



MarcoPolo-R 2013



Phootprint 2014



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Proposed as reference	Discarded for baseline	Potential Backup	Open

General concept	Fully passive (hard landing)	Subsonic parachute	Supersonic parachute		
Aeroshape	Hayabusa	EVD (Pioneer)	Huygens		
Aft body shape	Hayabusa	Adapted aft body shape			
TPS – Front Shield	ASTERM standard density (~0.28)	ASTERM medium density (~0.35)	Other high density TPS	Aleastrasil	
TPS – Back Cover	Outgassed Norcoat Liege	ASTERM standard density (~0.28)			
Structure – Front Shield Internal structure	Metallic Al	Metallic Ti	CFRP monolithic	CFRP Al sandwich	Ti sandwich
Structure – Back Cover	Metallic Al	Metallic Ti	CFRP monolithic	CFRP Al sandwich	Ti sandwich
Crushable material	Al Foam	PU Foam	Carbon Foam	Hollow Sphere	Honeycomb
Equipment	Battery	Beacon	External device /observation		
Spin and Ejection Device	Separation / Spin-up				
Sample container interface					
Lid & lid closure mechanism					

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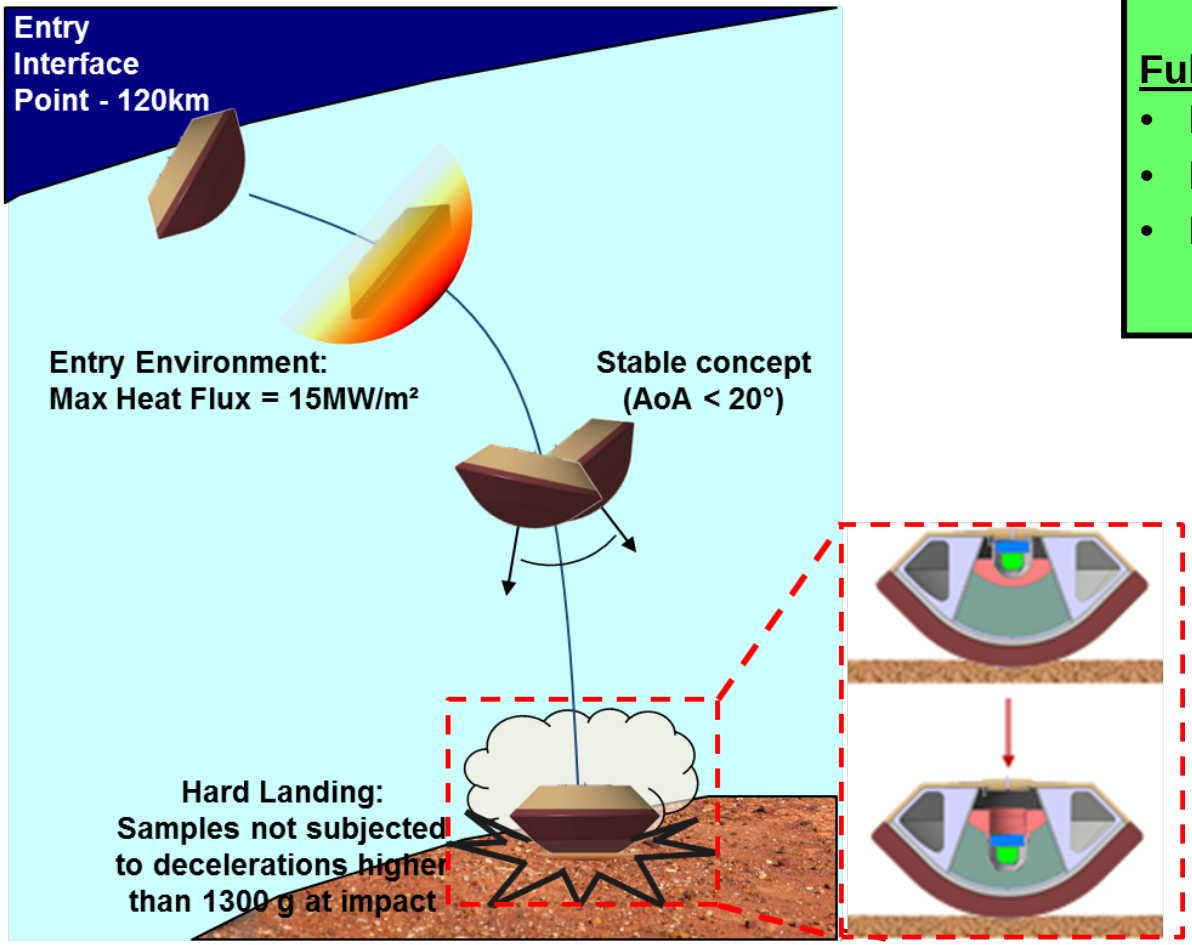
Earth Reentry Capsule Overview (Phootprint)

ERC Mission: to safely deliver the samples on Earth



Entry Conditions:

	Sizing	Nominal
Relative Entry Velocity	12.05 km/s	11.2 km/s
Entry Fligh Path Angle	-10deg	-9.8deg

Fully Passive Concept:

- No control/guidance during entry
- No parachute
- Hard landing on ground

Reliability:

- A main driver for concept selection
- Required for Planetary Protection

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ERC Challenge #1
TPS for High Speed Re-entry

Entry velocities above 12km/s
→ Extreme heating
Frontshield TPS = enabling technology
- Important contributor to reliability demonstration
  - Need to gather multiple test data
  - Define margin philosophy

ASTERM: low density carbon phenolics
- Developed for such missions
- Pretty wide range of applications
- Also capability for variations / adaptations

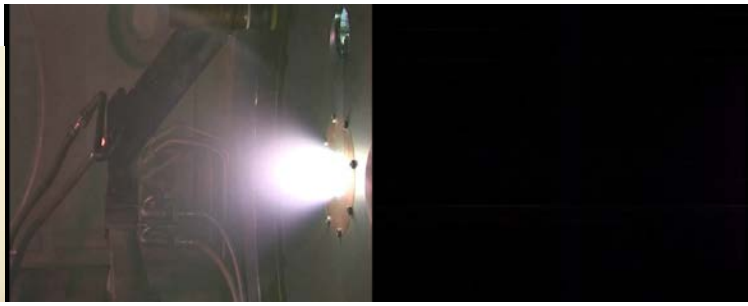
Main Subchallenges
- Material elaboration
- Manufacturing and assembly process
- Ground testing (up to 16 MW/m² - DEAM2)
- High Fidelity Modelling

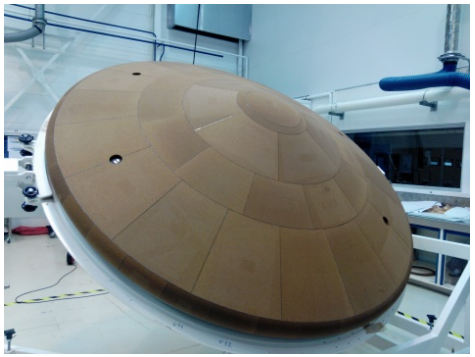
Back-Cover TPS = heritage technology
- Norcoat-Liege (Beagle2 2003, ExoMars 2014)

Asterm machining from a large block

Asterm Breadboard Ø450 mm

Asterm Tiled Breadboard Ø920 mm





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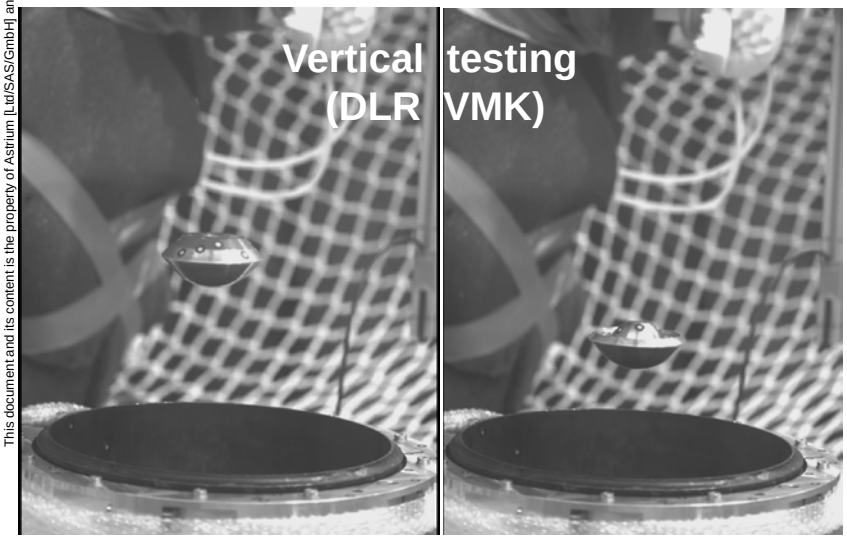
ERC Challenge #2
Capsule stability during entry

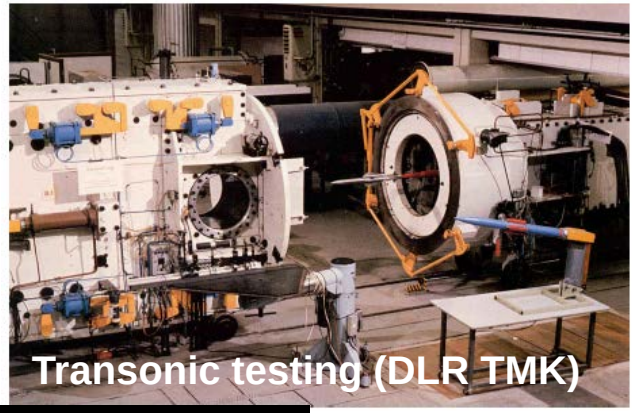
Fully passive ERC → Stability relies only on the aeroshape and the associated centring.
Transonic and subsonic regions are known to be critical for capsule's stability.

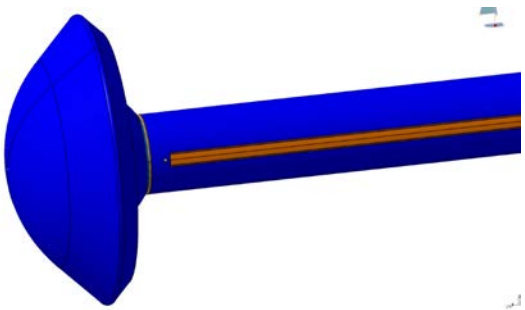
Hayabusa aeroshape is baselined → Heritage from Jaxa Hayabusa mission (centring at ~30%D)

On-going investigations:

- Dynamic stability tests in subsonic/transonic regime (vertical testing, free flight tests, balloon drop test…)
- Optimization of the back-cover shape







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ERC Challenge #3
Hard landing

No parachute to decelerate

→ ground landing with **<u>crushable material</u>** to absorb the impact

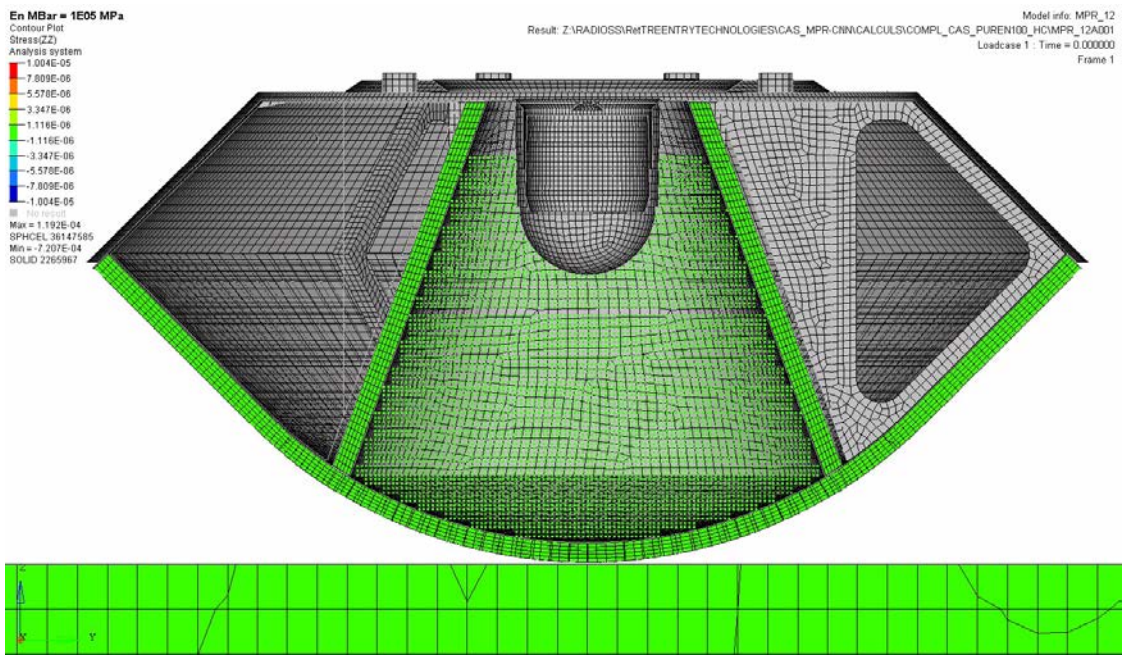
Maximum deceleration from 500g to 2000g

→ Specified value depending on the mission

Main Subchallenges

- Material selection : families with the proper range of damping characteristics
  - Al Foam / PU foam / Carbon foam…
- Adequate characterisation to derive proper material model
  - Enables then a fair design with the right thickness and the right material density

- Additional aspects before final validation
  - Influence of soil properties, angle impact…
  - Thermal response after impact
- Further step = Scale 1 (drop) test



Impact simulation of MarcoPolo-R capsule
(Airbus Defence and Space R&T)

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Crushable Materials for Hard Landing High Speed Tests

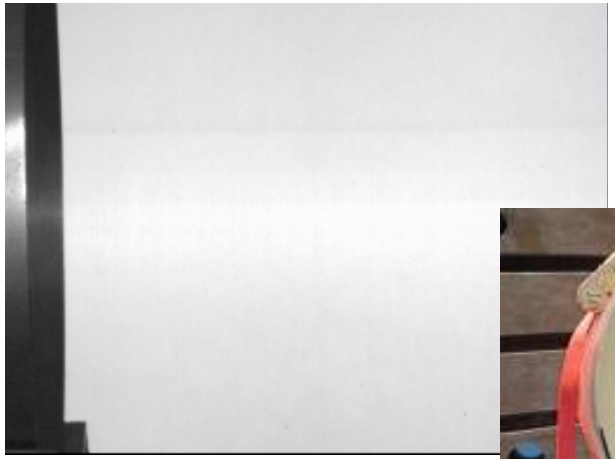
Step by step test campaign

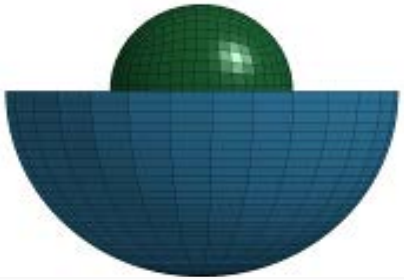
- Static, reduced scale impact, full-scale impact

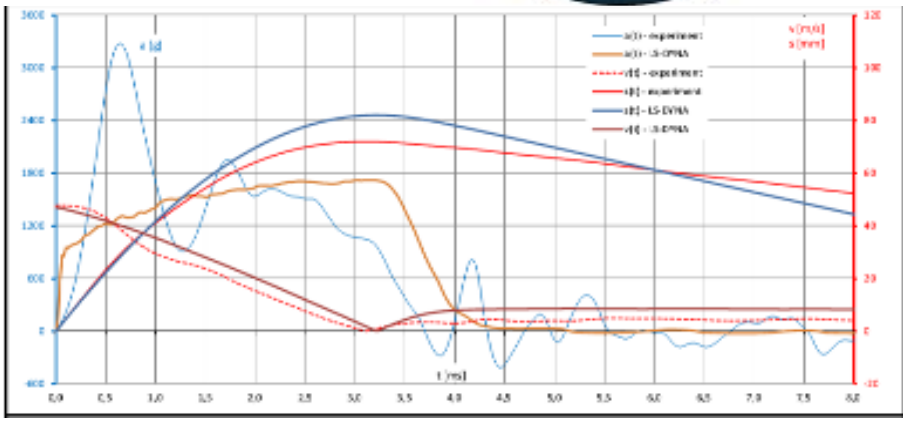
Full-scale impact test of chosen material for:

- bullet mass m=5 [kg]
- impact velocity v= 45 [m/s]
- material thickness t = 0.115 [m]

Test data analysis and excellent comparison with numerical simulation







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Maturation of required technologies overall approach

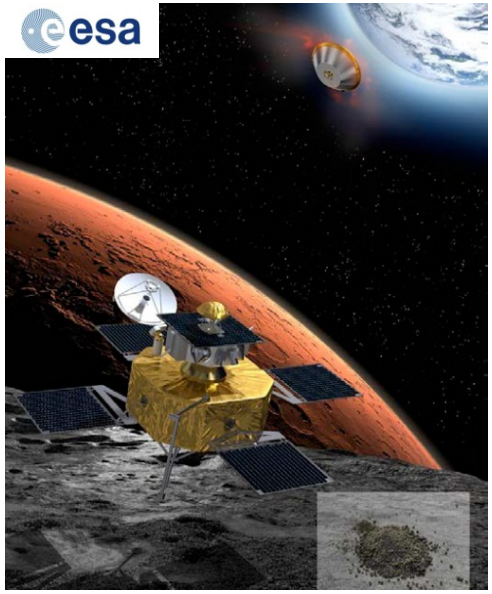
Several complementary activities 2009-2014

R&T project
Reentry Technologies

Technology studies (TRP, ETP, GSTP)
DEAM2, AMOF, crushable material and design, MarcoPolo scapsule tability,…

FP7, H2020 programs
Rastas Spear, HYDRA, Ablamod,…

Adequate Technology Readiness for starting the development of an Earth Return Capsule for an actual Sample Return mission



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Concluding remarks

Development of challenging technology bricks is being completed

This will become available in short term, and thus compatible with currently envisaged Sample Return missions

Outcomes will also be applicable to several possible missions

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A few references

1. ESA's planetary probes - D.Agnolon & P. Falkner - IPPW10,
2. Small body sample return mission candidates at ESA - D.Agnolon, D. Rebuffat, J. Romstedt - IPPW10
3. RASTAS SPEAR: Radiation-Shapes-Thermal Protection Investigations for High Speed Earth Re-entry - J-M. Bouilly et al - 10th International Planetary Probe Workshop - June 17-21, 2013 - San Jose (CA,USA)
4. MarcoPolo-R: Mission and Spacecraft Design, L. Peacocke, IPPW 10 2013, San Jose, USA
5. ASTERM : Maturation of a new low density ablative material, J-M Bouilly, C. Plaindoux, 4th International ARA Days, May 27-29, 2013 - Arcachon, France
6. Sample Return Missions Requirements for Earth Re-entry Capsules TPS, D. Rebuffat, 7th European Workshop on Thermal Protection Systems & Hot Structure, ESTEC Noordwijk (NL) – 8-10 April 2013
7. Ongoing European developments on entry heatshields and TPS materials, Heiko Ritter et al., 8th International Planetary Probe Workshop, 2011
8. ESA TPS Activities for Sample Return Missions - H. Ritter, D. Agnolon, L. Ferracina - 9th International Planetary Probe Workshop, IPPW9, 2012, Toulouse (F)

9. Postflight Analysis of the first European Sample Return Capsule, IPPW25, 2028 ?

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THANK YOU

FOR YOUR ATTENTION.

ANY QUESTIONS ?

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The main challenge ?

€£¥$

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