Thales Alenia Space R&D activities in Torino

HUBBLE-2 Boosting Local Enterprise

Leicester, 16 October 2013

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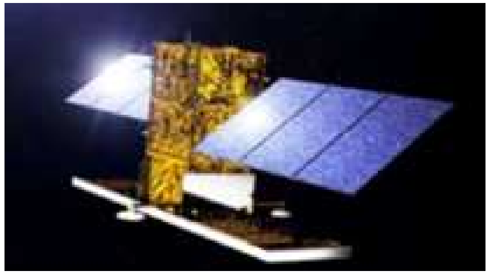
Thales Alenia Space Presence in the Space Market

Telecommunications

- Fixed / Mobile
- Broadband
- Dual / Military
- Secured

AMC 21, Amos 4/5, Arabsat , Arsat-1, Athena-Fidus, Ciel 2, EuropaSat, Express MD1/MD2, Globalstar , Hispasat , Iridium Next, Kazsat 2, Koreasat 6, Loutch 5/6, Nilesat 201, O3B, OverHorizon 1, Palapa-D1, RascomStar-Qaf 1R, Satcom BW 2a/2b, Sicral 1B, Sicral 2, Syracuse 1/2/3, Thor 6,Turksat 3A, W2A, W3B, W3C, W3D, W7,W6A, Yahsat 1A/1B, Yamal 401/402

Observation



- Climate Change
- Meteorology
- Oceanography
- Intelligence
- Surveillance

Meteosat/MSG/MTG Jason, Calipso, COSMO-SkyMed, Sentinel 1&3, Envisat, ERS, GOCE, Helios, IASI, Pleiades, SPOT, CSO, Gokturk…

Navigation

- Localization
- Aeronautical Communications
- Data collect

EGNOS, Galileo, MTSat…

Exploration/Science

- Planetology
- Fundamental physics
- Astronomy
- Human spaceflights
- Space transportation systems

Herschel,Planck, Exomars, Alma, Corot, Cassini-Huygens, Node 2&3, Columbus, Cupola, MPLM, Automated Transfer Vehicle (ATV), …

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Domain : Exploration and Science

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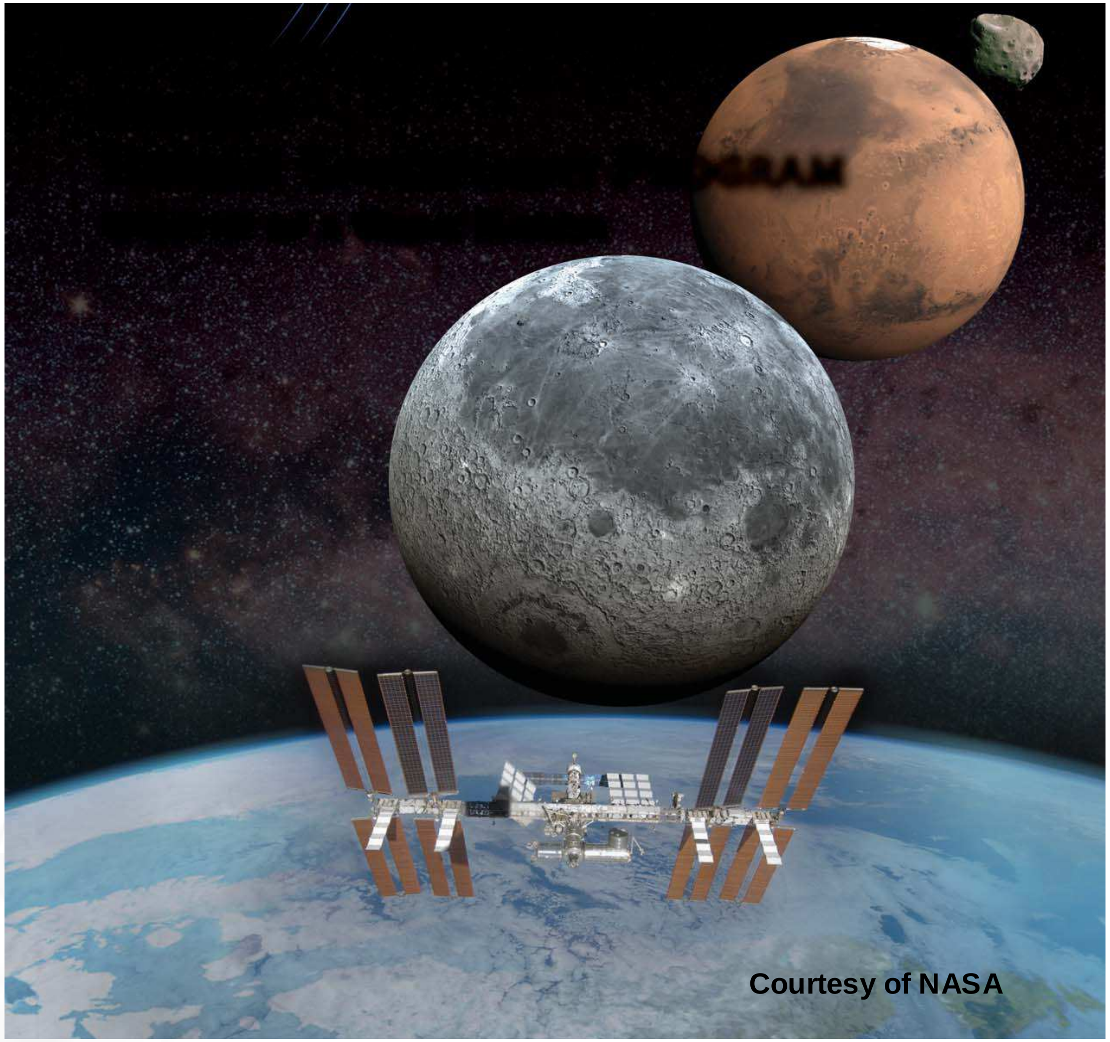
Space Exploration



Courtesy of NASA

Opportunity for the Humankind to pass the boundaries of the Hearth, colonizing new worlds where it will be possible to live and operate

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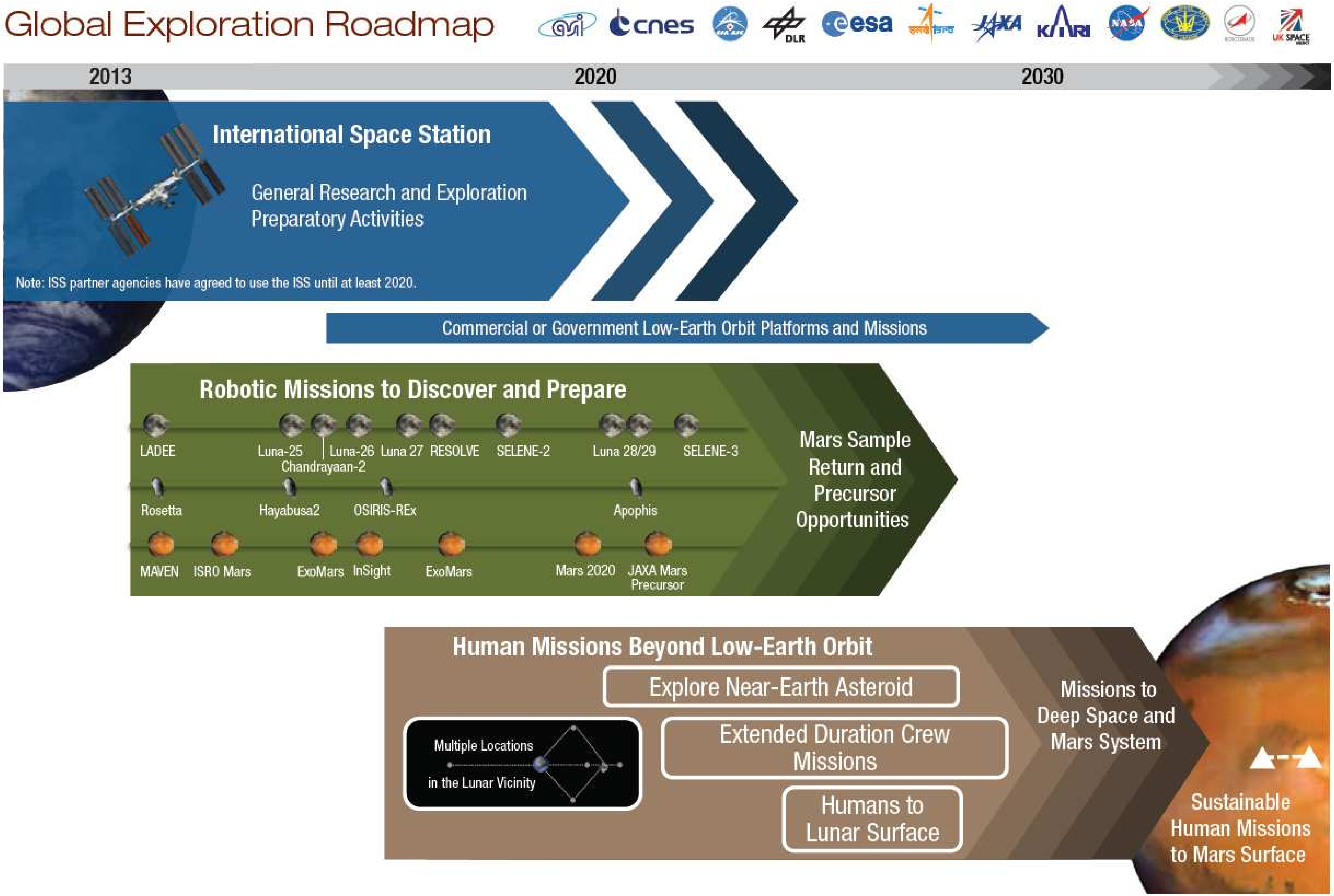
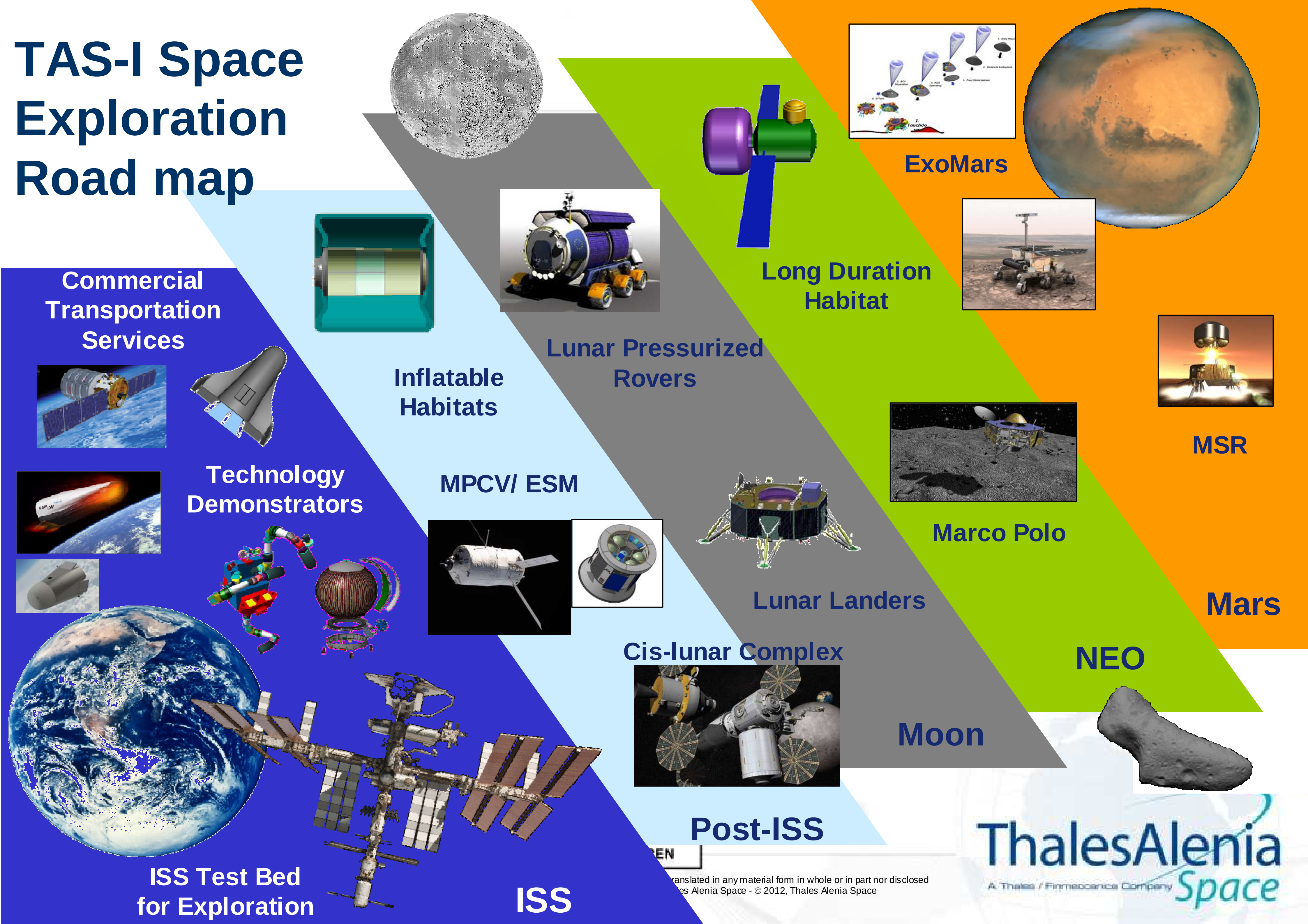
International Scenario (GER 2.0)





TAS-I Space Exploration Road map
Commercial Transportation Services
Technology Demonstrators
ISS Test Bed for Exploration
ISS
Inflatable Habitats
MPCV/ ESM
Post-ISS
Lunar Pressurized Rovers
Lunar Landers
Cis-lunar Complex
Moon
Long Duration Habitat
Marco Polo
NEO
ExoMars
MSR
Mars
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Research and Development

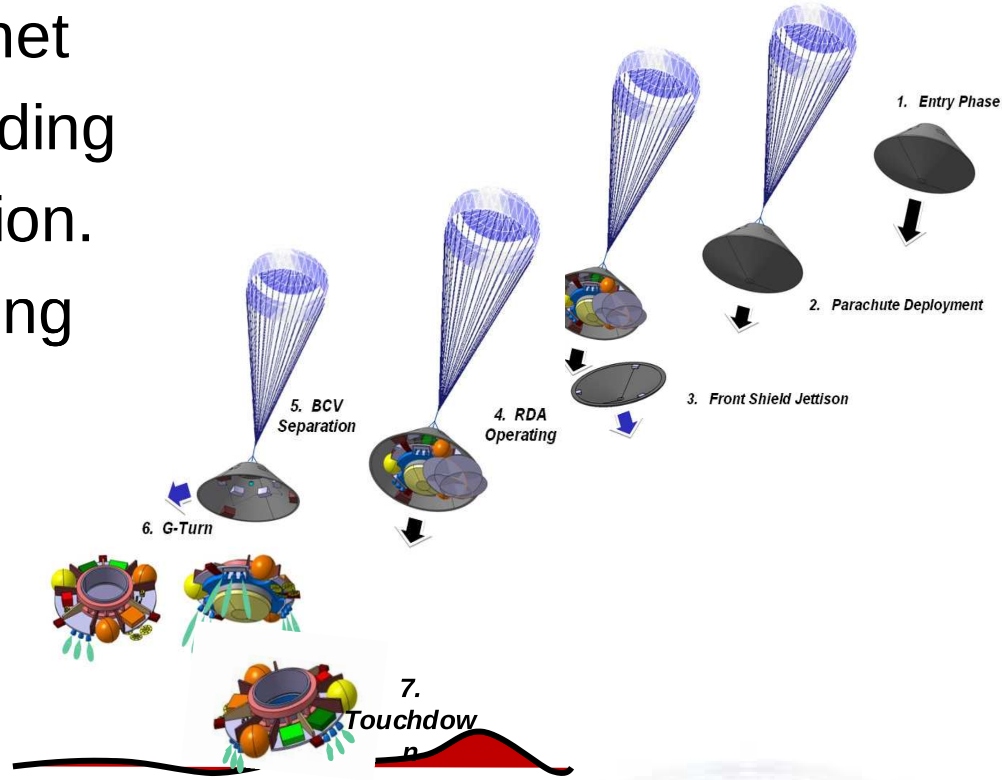
Robotic and human exploration of the solar system require several enabling technologies:

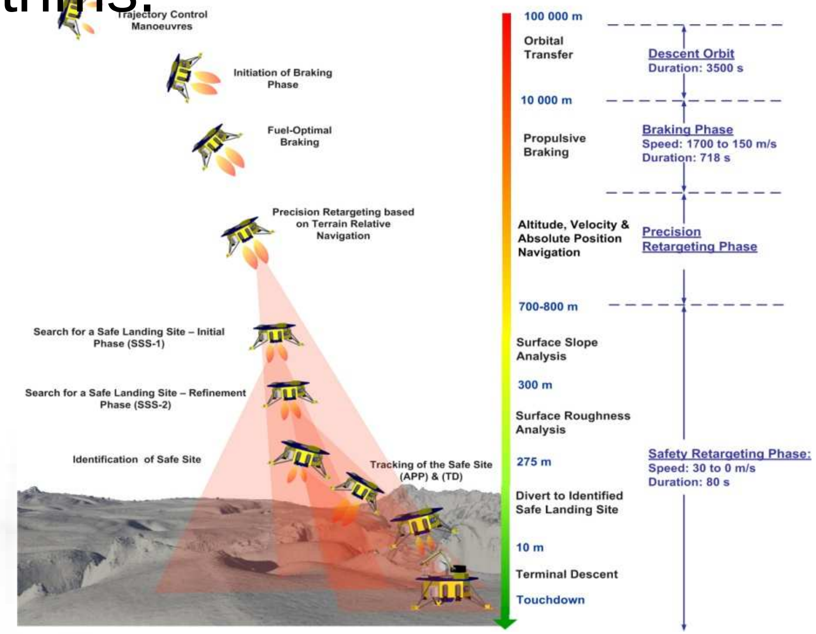
- Entry Descent and Landing (EDL)
- Landing legs
- Robotics and autonomy for surface exploration
- Inflatable structures
- Regenerative life support
- Aerothermodynamics and TPS
- Crew collaborative robotics
- Fuel cells
- Health management systems
- Rendezvous and Docking / Capture

Thales Alenia Space Torino is engaged in all these developments

Entry Descent and Landing 1/3

Identification of safe landing site on planet surface and guided soft and precise landing are key technologies for space exploration. They need vision based image processing algorithms as input to dedicated GNC algorithms.





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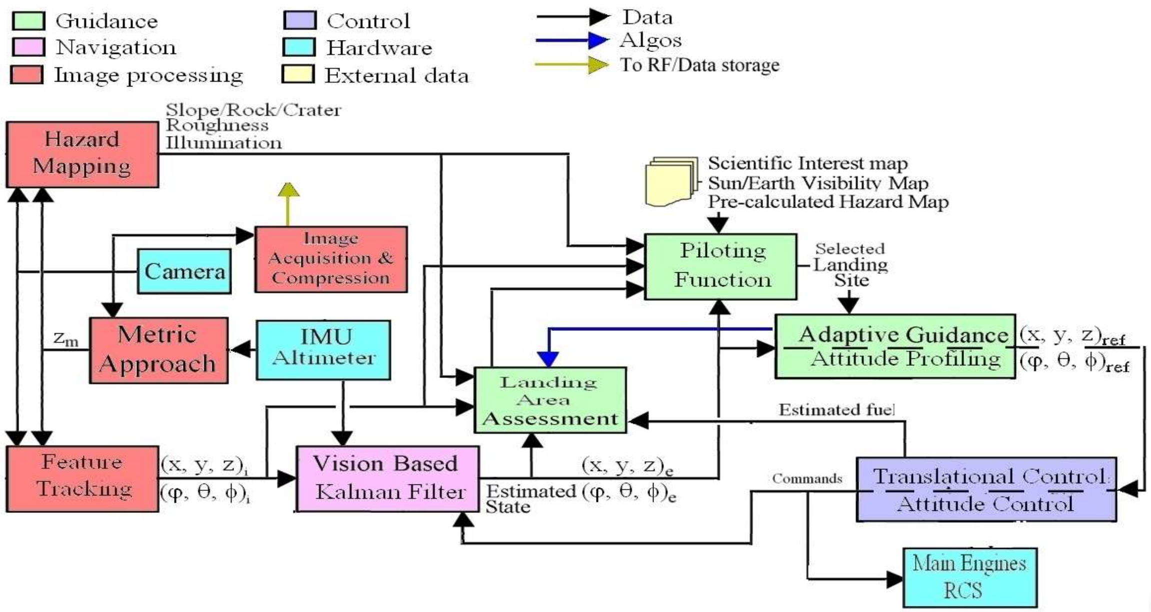
Entry Descent and Landing 2/3

Image Processing algorithms have been developed and tested using a facility set up which is a scaled representation of the Mars terrain. Images are acquired by a drone.



GNC architecture and algorithms have been developed, and modeling of Mars terrain and winds has been carried out.

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Entry Descent and Landing 3/3

Current space qualified computers do not provide the needed computational power. New computer architectures based on processor/co-processor configuration are under study.

Avionic test bench has been set up consisting of flight segment , ground segment, real time simulation environment and development environment.

Flight representative processors, coprocessors, FPGA and data busses are used to investigate performances of demanding algorithms (Image Processing, Hazard Detection and Avoidance, Model Predictive controllers)

Mass Memories are needed to store data for successive ground transmission. Usage of FLASH memories in Space environment means reduction of mass and power consumption. Activity is in progress on that.

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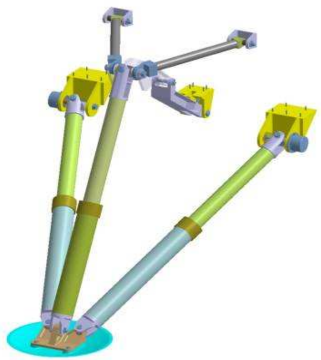
Landing legs

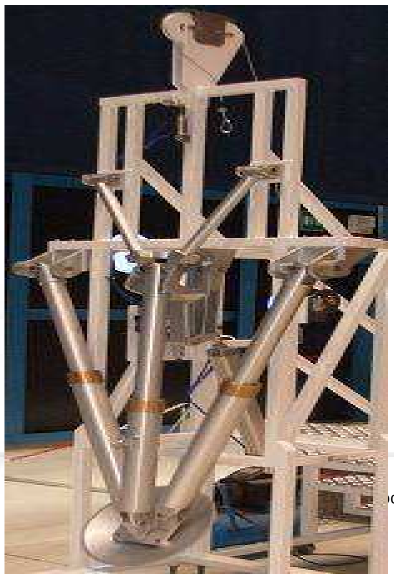
Landing legs are required to perform a soft landing of a spacecraft onto a planetary surface and assure a final reference position with respect to the ground to deliver a rover or facilitate crew egress in a manned mission.

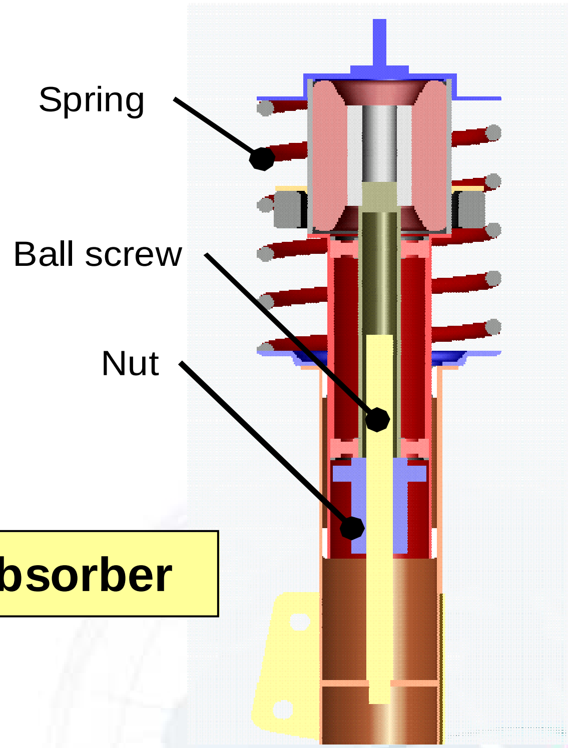
In the specific of the soft landing, the objective is the development of an active system for impact absorption based on adjustability after landing. This is considered highly reliable w.r.t. the passive (e.g. crushable honeycomb cartridges) due to additional possibility to cope with terrain roughness and slopes.

Lander Configuration



Landing Leg





Shock Absorber

Robotics and Autonomy for surface exploration 1/3

Robotics Surface exploration requires a great deal of autonomy for the environment description, viable path identification and execution minimization of risk of hazard.

Navigation, based on stereo vision, has been developed together with localization and hazard mapping functions needed to generate the path for the rover motion.

Visual odometry has been studied to improve the localization accuracy.

A flexible test bench for development and test of innovative GNC systems tailored for mobile robots has been set up and improvements of this paltform shall be implemented including new sensors (OmniCamera, Time of flight Camera) to enhance the navigation performance

Stereo Cameras
=> Map generation

Stereo Cameras
=> Visual Odometry

Omni Camera
=>Map generation

Time Of Flight Camera
=>Map generation

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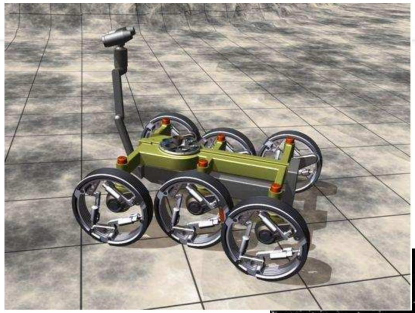
Capability to handle samples is requested by the typical exploration mission on planet surface. A robotic arm is about to be integrated on the rover platform to develop sample approach and grasping.

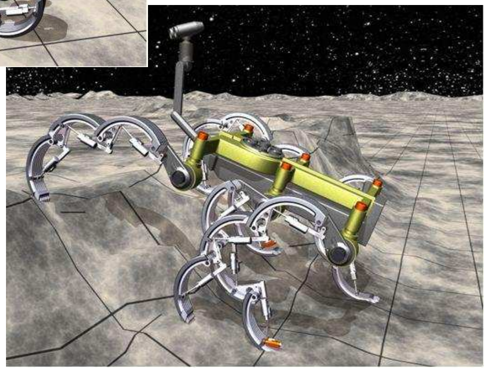
Cooperative rovers formation is requested for middle/long term missions to build infrastructures and wide range surface exploration.

Robotics and Autonomy for surface exploration 3/3

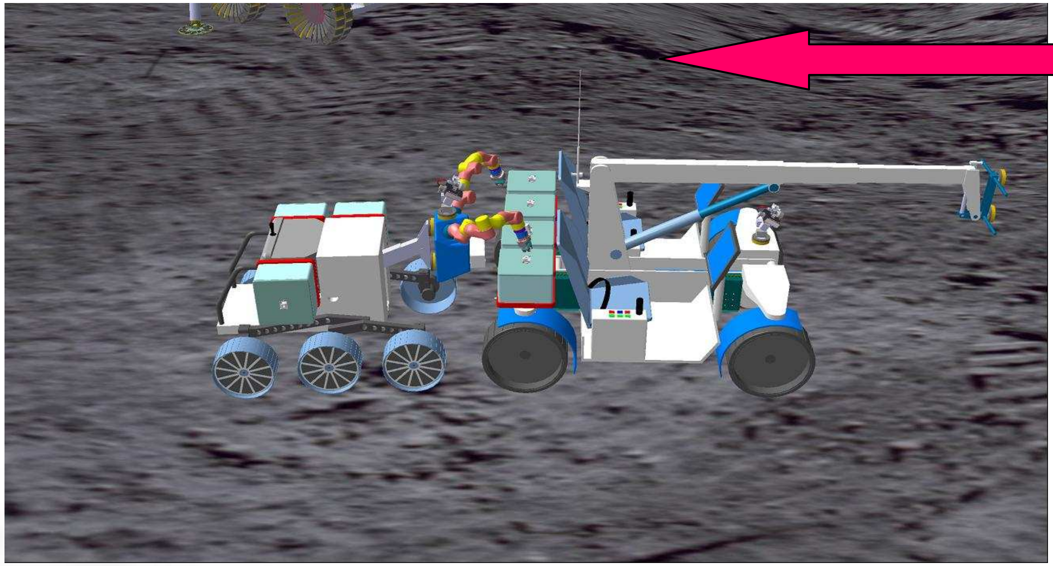
New concepts for robotic systems are under study, whose objective is the reduction of mission costs using re-configurability and reusability.

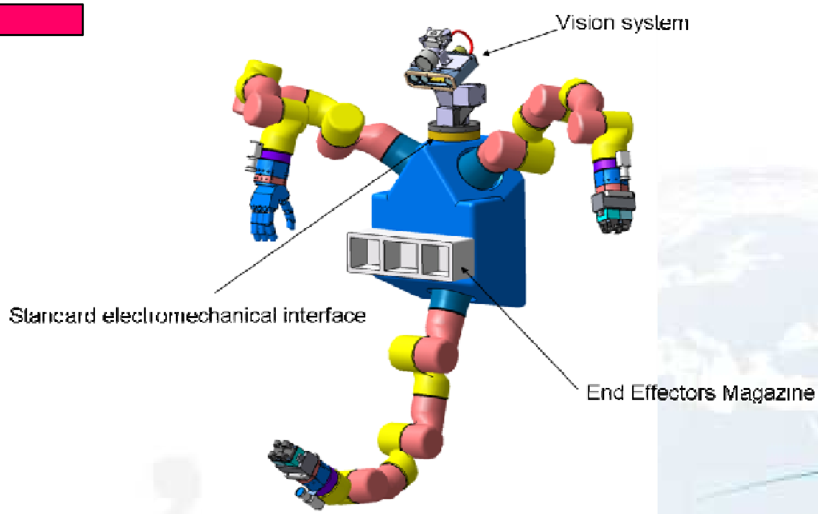
RECONFIGURABILITY





REUSABILITY





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Inflatable Structures

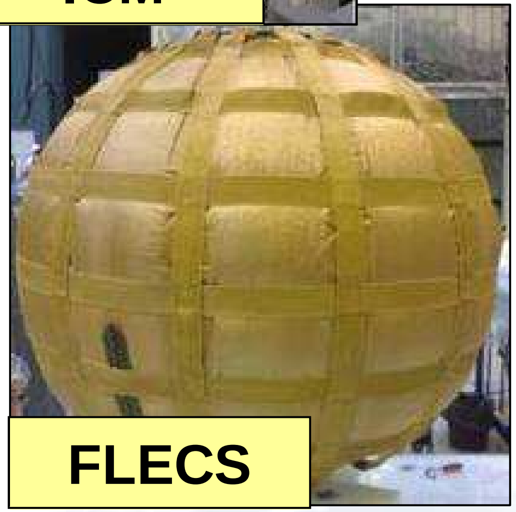
The "inflatable technology" is world-wide recognized as an enabling capability that will play a fundamental role in the future of LEO infrastructures but also in exploration missions, with particular regards to the development of Moon/Mars surface outposts.

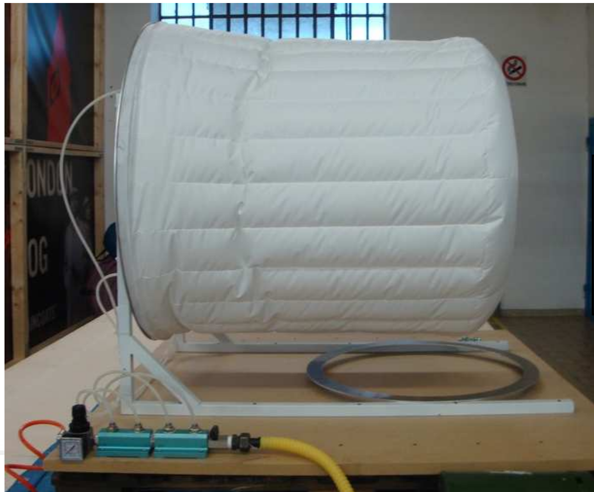
In fact, the need for larger habitable volumes in long-duration missions and larger deployable structures will have to cope with the limited volume and launch capability of both existing and future launchers. This means that a high compaction at launch offers the possibility for on-orbit deployment of huge volumes and surface extension unreachable with current rigid metallic structures.

The objective is to further develop knowledge and technologies for inflatable space systems dedicated to both manned & un-manned structures in terms of materials & processes, overall design of multi-layered structures & testing.


IMOD


ICM


FLECS


INFLATABLE AIRLOCK

Advanced Life Support technologies and subsystems can maximize efficiency (% recovery, equivalent mass, reduced consumables…) and application flexibility (Planetary or μg) of Environmental Control and Life Support (ECLS) systems for Space Infrastructures and Human Exploration. In particular, for planetary exploration mission the utilization of resources available on a planet (ISRU - In Situ Resource Utilization) can also be considered

The objective is to develop technologies related to the production, processing and regeneration of vital resources as food, water, oxygen, also by the processing of solid and liquid waste materials.

RecycLAB is aimed to research on Regenerative ECLS technologies and subsystems based on the experience and knowledge already accumulated by TAS-I during the design and the integration of the ISS module but the study for exploitation of Martian and Lunar regolith (working with simulants) is also proceeding.

P.I.ECO - WATER REGENERATION

EDEN Episode 2

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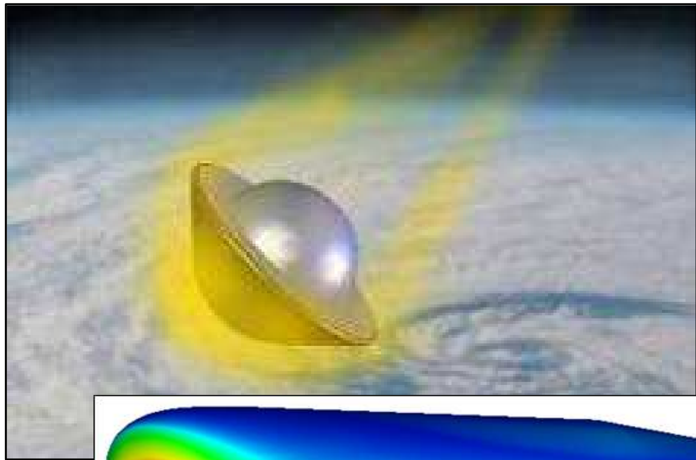
Aerothermodynamics and TPS

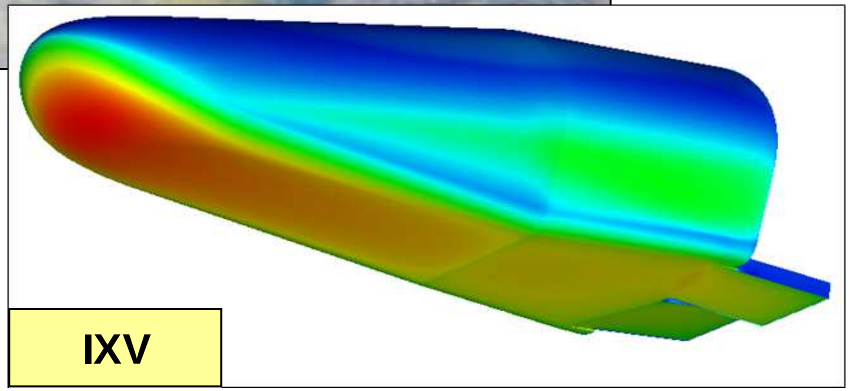
During atmospheric entry or re-entry phase, any space vehicle undergoes a relevant overheating due to the friction with the planet atmosphere which can damage or completely destroy the spacecraft. On the other side, the external shape and surface characteristics determine the entry trajectory or flight behavior of the vehicle giving the possibility to determine and possibly control the accuracy of the Entry Descent and Landing phase.

Ablative light TPS materials are a cost effective solution for thermal control of the external layer of the structure of vehicles for planetary missions through phase change and mass loss.

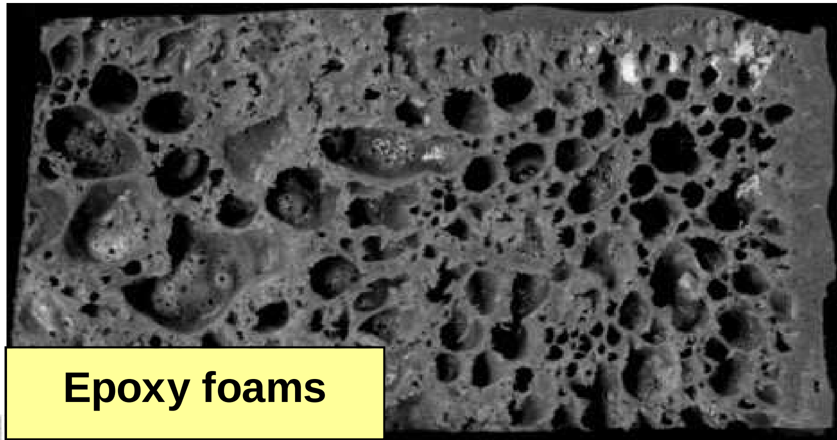
On the other hand re-usable TPS materials are a valid solution for reusable manned reentry vehicles.

The prediction of the multi-physics behavior of a vehicle body with a thermal shield (integration of aerothermodynamics and TPS thermo-structural behavior) requires the development of sophisticated simulation tools which can be combined with algorithms for the multi-disciplinary optimization of the architecture of such complex systems.





IXV



Epoxy foams

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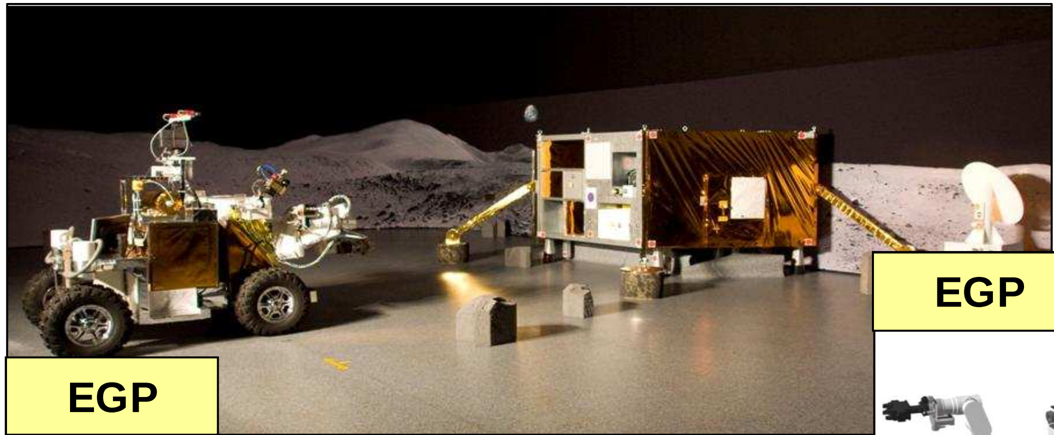
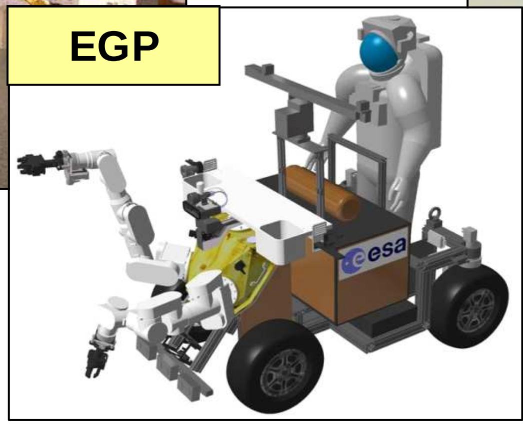
Crew Collaborative Robotics

The presence of humans on orbital infrastructures for maintenance and servicing operations (Intra- and Extra Vehicular Activities) or in future Exploration missions (including establishment of manned planetary outposts on Moon and Mars) increases the possibility of solving unexpected situations but could also require the support by robots or other automatic/semi-automatic devices which shall properly collaborate in the same environment with the human.

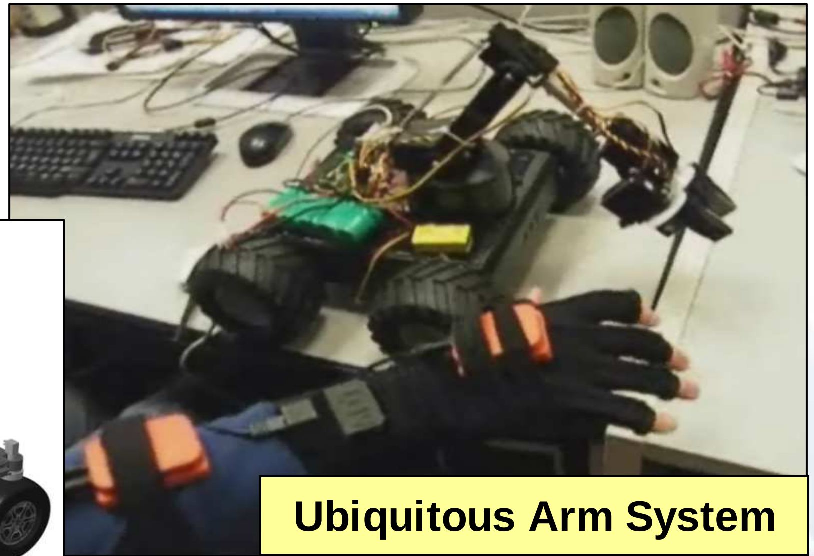
The objective in the ambit of command and control systems is then to develop an integrated Human Machine Interface (HMI) permitting both remote or in-situ control of a robot (e.g. Ground station for the control of a unmanned rover equipped with a robotic arm on 1G and time delay conditions or augmented reality interface for robot control on EVA, µG, real time conditions) and the definition of proper robot Artificial Intelligence architecture for permitting robot's autonomous activities and collaborative task (Crew Collaborative Robotics with sliding autonomy).



EGP



EGP



Ubiquitous Arm System

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Fuel Cells

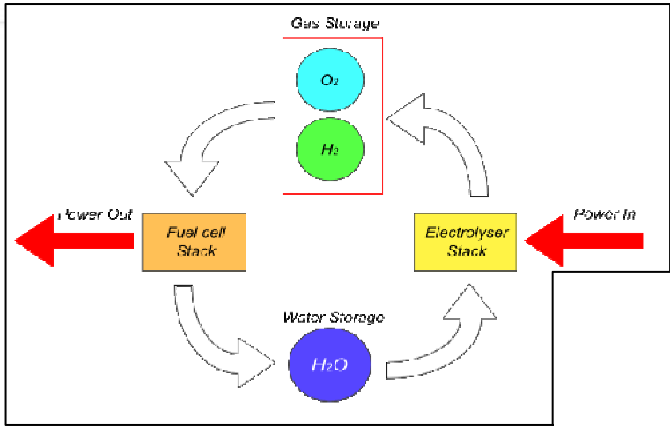
Future planetary exploration will require advanced energy storage technologies in order to provide higher power and higher storage densities than secondary chemical batteries.

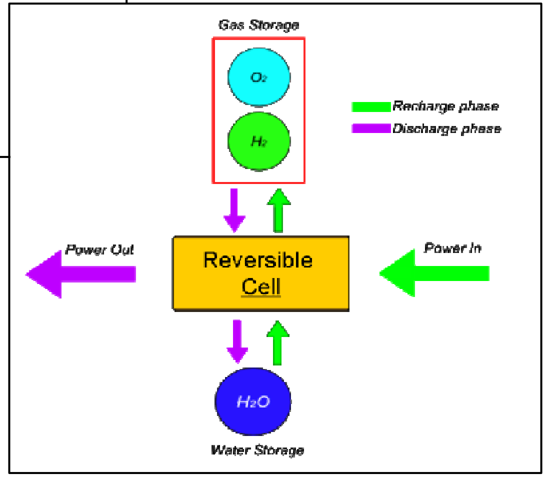
The proposed solution is an energy storage system based on Regenerative Fuel Cell technology.

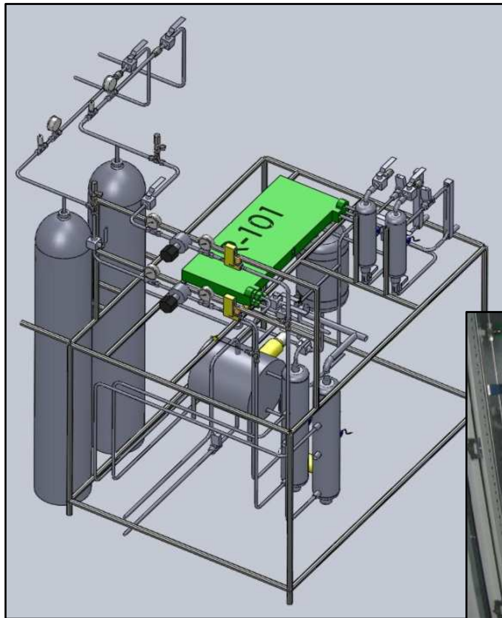
Such technology (already used in the Gemini and Apollo programs in the 60's and also for the Space Shuttle) has recently came back to be interesting thanks to the development in the frame of the "Green Economy"

The present research aims at developing a Regenerative fuel cell system composed by a fuel cell and an electrolizer for the application on space exploration missions (e.g. planetary base, rovers).

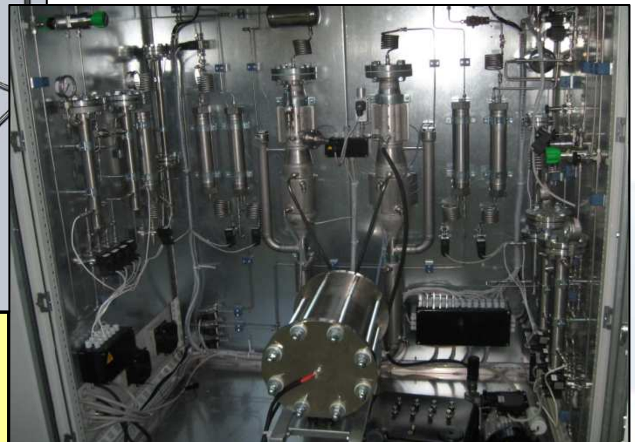
In the future an integrated Reversible Stack able to act both as fuel cell and electrolyser will be developed based on the Alkaline technology.







RFCS Breadboard Assembly



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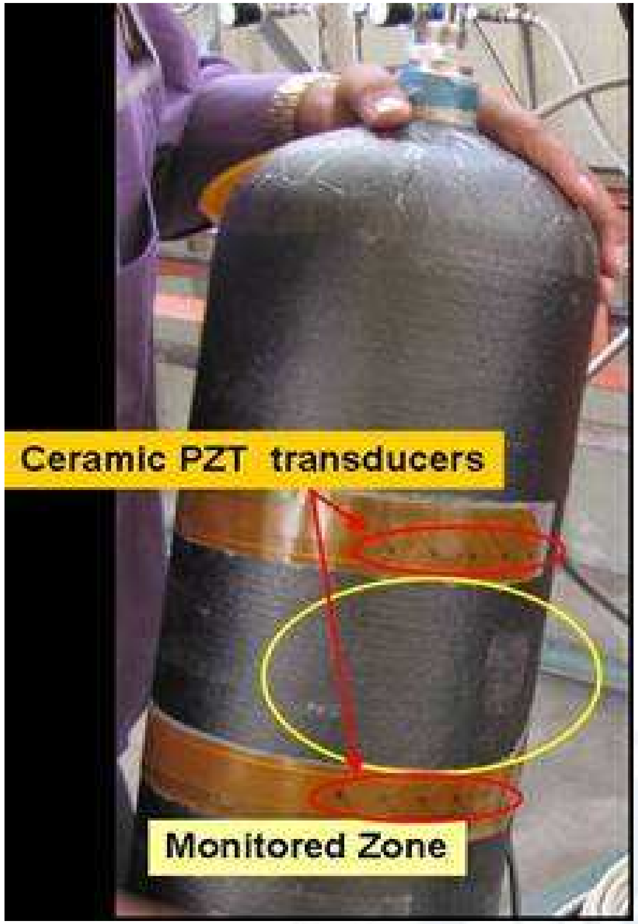
Health Management Systems

Structural Health Management methodologies permit the monitoring also during operations of the conditions of a structure and the decision about which best mission or maintenance actions are required to limit the risk of a failure. In particular, with respect to space transportation, health management is a pivotal step for supporting affordability and sustainability of future reusable re-entry vehicles.

The Health Management System will then permit to acquire system data about the integrity status of a space vehicle and to process them into information to support operational decisions, spanning both flight and ground phases.

In case of either unexpected ageing, or anomaly, or jeopardizing damage detection, the HMS will ideally raise early warnings to the vehicle operational interfaces and support the definition of remedial strategies before off-nominal conditions would lead to major/critical failures.

This will result in improved vehicle safety and reliability, minimized maintenance actions, improved readiness and availability, vehicle life extension.



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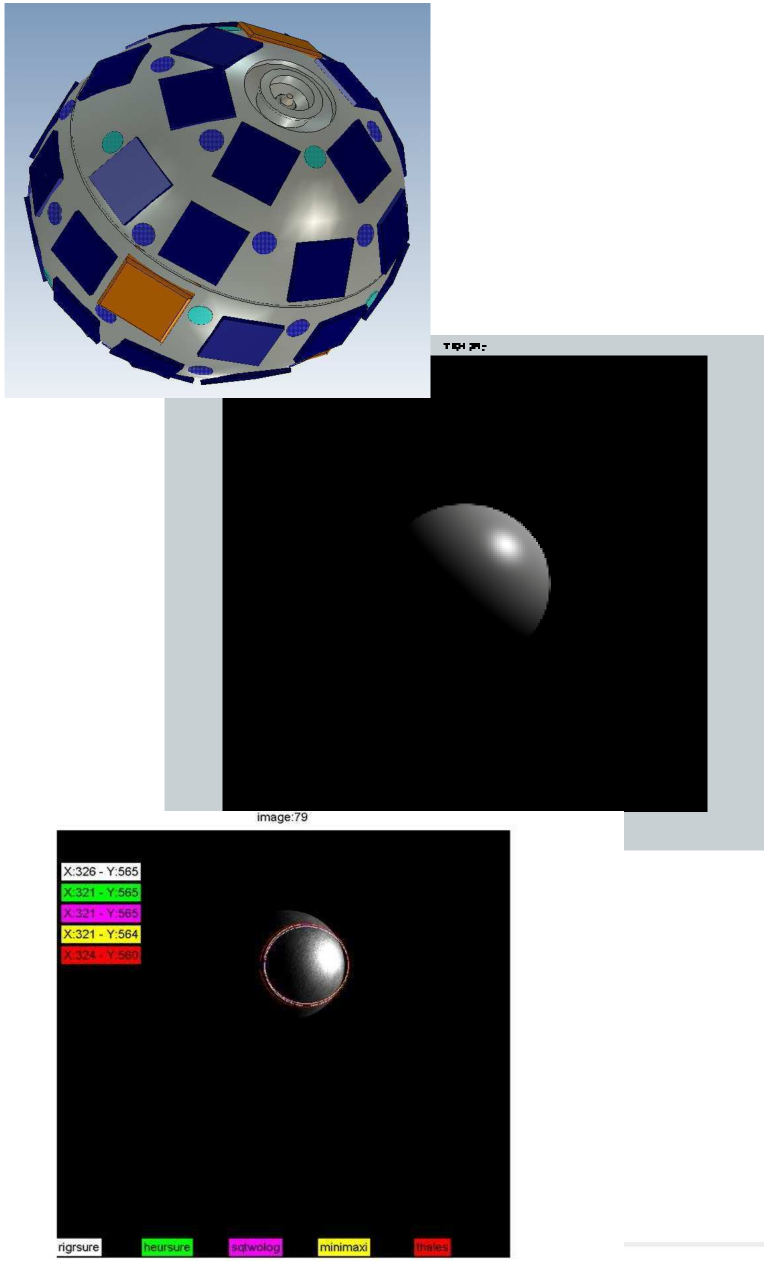
RV&D / Capture (1/2)



Rendez-Vous & Docking is a mandatory capability to support exploration missions characterized by complex systems architectures and operations. It is needed to:

- collect samples from the planet surface and bring it to Earth
- assembly different spacecrafts both on-orbit and on planets
- Surface

New Navigation algorithms are requested during the RV phases for fuel saving based on Model Predictive Controllers, as well as the improvement of autonomous RV&D system implementing Model Predictive Controller techniques in Martian, Lunar and LEO scenarios.

Image processing is used in this scenario to identify:

- Non cooperative target orbit in the long range phase as non stellar object
- Non cooperative target position and attitude in the short range phase

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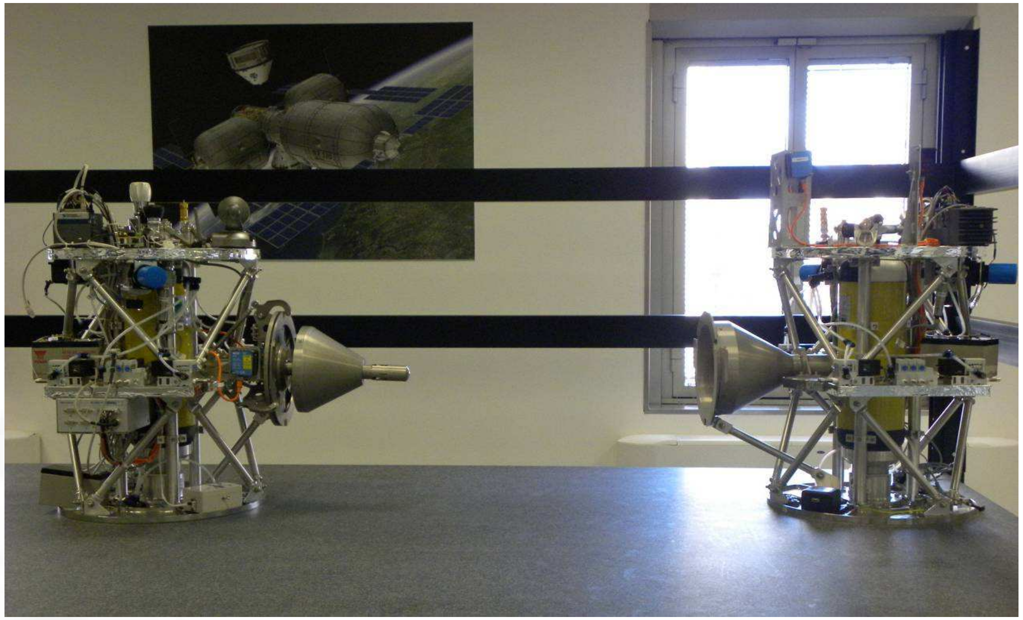
RV&D / Capture (2/2)

The Rendez-Vous & Docking capability would also permit the development of Space Tugs for servicing, maintenance operations.

The ongoing development of a docking mechanism is proceeding in parallel with the realization of an engineering technological area for testing the mechanism on the two target and chaser vehicles, which also includes proper GNC algorithms, a supervisor module, and a control station.



Chaser/Target Vehicles

Docking Mechanisms

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