Mem. S.A.It. Vol. 82, 455

Memorie della

Systems and Technologies for Space Exploration: the regional project STEPS

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Abstract. The Aerospace technology network of Piemonte represents ∼25% of the italian capacity and handles a comprehensive spectrum of products (aircraft, propulsion, satellites, space station modules, avionics. components, services). The cooperation between the Comitato Distretto Aerospaziale Piemonte and the European Regional Development Fund 2007-2013 has enabled Regione Piemonte to launch three regional Projects capable to enhance the synergy and competitiveness of the network, among which: STEPS - Sistemi e Tecnologie per lEsPlorazione Spaziale, a joint development of technologies for robotic and human Space Exploration by 3 large Industries, 27 SMEs, 3 Universities and one public Research Centre. STEPS develops virtual and hardware demonstrators for a range of technologies to do with a Landers descent and soft landing, and a Rovers surface mobility, of both robotic and manned equipment on Moon and Mars. It also foresees the development of Teleoperations labs and Virtual Reality environments and physical simulations of Moon and Mars surface conditions and ground. Mid-way along STEPS planned development, initial results in several technology domains are available and are presented in this paper.

1. Introduction

In Piemonte Aerospace industry is long-lived (since 1909) and represents a strong and wide network of competences in a comprehensive spectrum of products (aircraft, propulsion, satellites, space station modules, avionics. components, services), summing up to ∼25% of italian aerospace:

- 2,6 Bln annual turnover
- 12.500 employees
- 4 world class manufacturers / integrators of complex systems
- 20 mid size production units
- More than 200 active businesses in the supply chain of system integrators
- 3 Universities, 4 research centers involved

Several institutional initiatives reflect the relevance of Aerospace for Regione Piemonte:

- Comitato Distretto Aerospaziale Piemonte
- Torino Piemonte Aerospace by the Turin Chamber of Commerce, for the international promotion of local space businesses
- Aerospace & Defence Meetings, the italian international convention for aeronautics, space and defence
- Major events sponsored, such as the recent 5th Meeting of the International Committee on Global Navigation Satellite Systems (ICG 2010)

The synergy between

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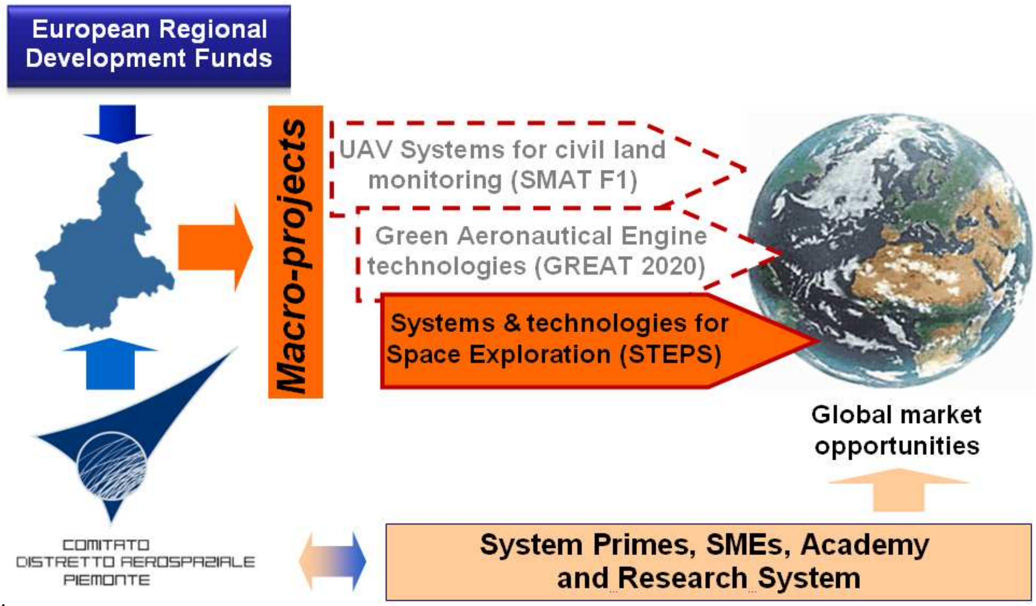

Fig. 1.

– Comitato Distretto Aerospaziale Piemonte, and
– European Regional Development Fund (E.R.D.F.) 2007-2013

has enabled a co-funding action by Regione Piemonte, that commands the concentration and integration of resources on comprehensive projects of high impact on the competitiveness of the local aerospace technology network.

2. The Project STEPS

STEPS - Sistemi e Tecnologie per lEsPlorazione Spaziale - is a joint development of Technologies for Space Exploration by 3 large Industries, 27 SMEs, 3 Universities and one public Research Centre. It is coordinated by ThalesAlenia Space Italia, Torino Business Units (Space Infrastructures & Transportation, and Optical Observation and Science), in the framework of robotic and human Space Exploration. STEPS develops virtual and hardware demonstrators for a range of technologies for the descent, soft landing and surface mobility of both robotic and manned equipment on Moon and Mars. It also foresees the development of Teleoperations labs, Concurrent Engineering and Virtual Reality environments and physical simulations of Moon and Mars surface conditions and ground. Two key hardware demonstrators (Lander and Rover demonstrators) fit in a context of international cooperation for the exploration of Moon and Mars, as envisaged by leading Space Agencies worldwide.

3. Initial results

Mid-way along STEPS planned development, initial results in several technology domains are available:

– Automatic thresholding
– Light pose estimation
– Crater matching approach

for the **Entry, Descent & Landing system**, whereby information is provided by an optical camera for the identification of a safe landing site and for GNC to take the necessary trajectory corrective actions;

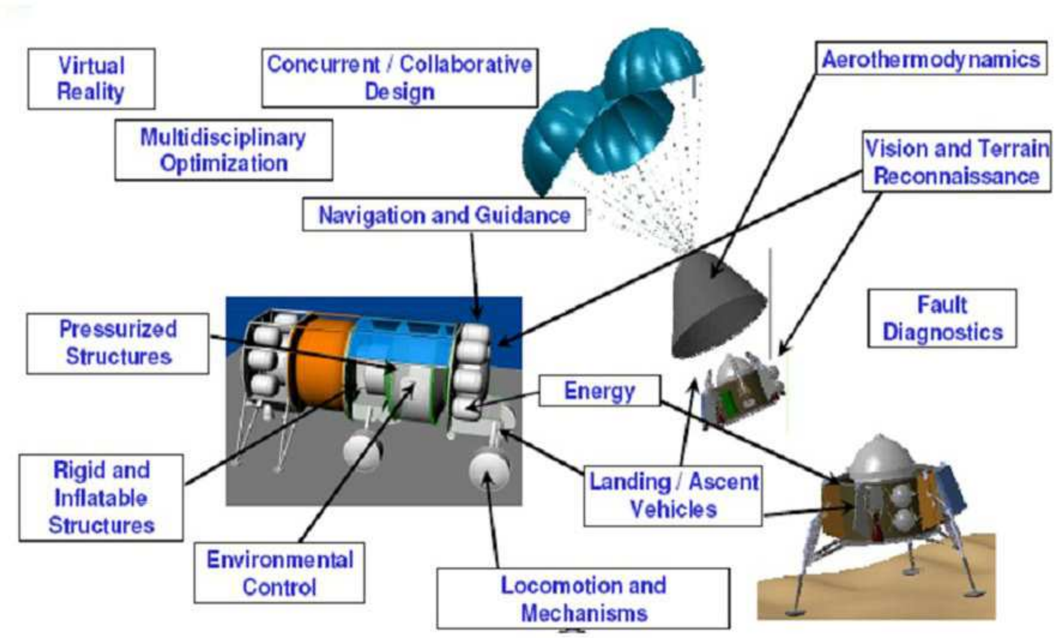

Fig. 2.

– Path planning & framework definition and visual odometry

for an **Autonomous Rover Navigation**, whereby a stereo camera determines the terrain morphology, as an input for the rover guidance;

Novel Design & Development Tools, such as:

– Rover S/W Simulator
– DEM Viewer SW prototype
– Rocks creation/ visualization SW prototype

Implementation and preliminary tests of:

– Guidance and Control Functions, and
– image-processing algorithms for Navigation state estimation

in **Guidance, Navigation & Control system**, which provides Vision-based GNC for last leg of Mars Entry, Descent & Landing sequence, Hazard avoidance capabilities and complete spacecraft autonomy;

– Development of motor-wheel building blocks
– An air filter prototype for aggressive environment
– Characterization of lunar regolith simulant
– Process for obtaining submicron Fe0 particles

in **Mobility & Mechanisms**, which provide an Integrated Ground Mobility System, the Rendezvous & Docking system, and the identification of and protection from Environment effects;

– Design of fabrics containing wires and sensors.
– Multidisciplinary analysis of the smart skin
– Multi Body simulation for the Apollo-like touchdown on slope
– Development of a dynamic model of the legs

in the frame of **Innovative Structures** such as Inflatable structures and Junctions, Smart & Multifunction Structures, Active Shock Absorber (ASA) for safe landing, balance restoring and walking;

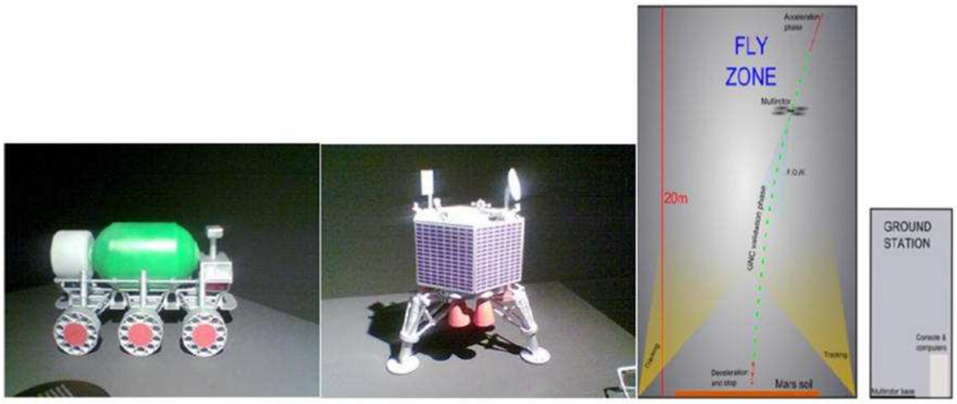

Fig. 3.

- Hierarchical Task Analyses
- Architecture definition for biomedical data management simulator
- Augmented reality for procedural aids
- Multimodal interfaces

as **Human-machine interface** features of a Predictive Command and Control System;

- A Water management laboratory (RecycLAB) set-up to host RFCS critical technology breadboard
- The "proof-of-concept"demonstrator of a Regenerative Fuel Cell system

as part of the development of an **Energy Management** system based on RFCs for energy production, storage, transportation and utilization.

An application environment, a landing/docking simulator and a rover simulator as **Virtual Models** to validate and test the technologies; Initial hardware and software for Physical Demonstrators of soft Landing / autonomous Docking and Surface Mobility / Robotics.

4. Conclusion

The Piedmont Regional Government involvement in the support of space technology advancement is based upon the needs to both defend and develop an important scientific and industrial stream of the manufacturing tradition of Piedmont. This goal is intended to be achieved by R&D projects intertwining the regional scientific and industrial systems with a special focus about SMEs participation and clustering.

In this perspective the STEPS project is a successful supporting action aiming to link the local competitive advantage to the global space challenges in order to engage new investments from the national and EU level as well as new order from the institutional and business players.

Since the performance of the Piedmont aerospace cluster and of its coordination boad, the Comitato Distretto Aerospaziale Piemonte, is directly linked to the sparkling of such a new wave of development based upon self-propelled capabilities and opportunities, the structural agreements between the scientific and industrial side of regional space industry and the persistence of the regional government support by the Regional Competitiveness Plan are designed to be the major scaffolds to build the future "steps"of the Distretto.