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PLANLAB: A Planetary Environment Surface & Subsurface Emulator Facility

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Abstract. The objective of this paper is the description of the PLANLAB facility in terms of scenario, major requirements, elements, Martian and Lunar simulant for an indoor rover facility, positioning and modeling and configuration. The design and accommodation of PLANLAB has been elaborated taking into account some ground rules and considerations like its accommodation in the ALTEC infrastructure, which is feasible and does not imply severe constraints and impacts on the existing building, services and infrastructures. In addition the maximum utilization of the existing structures and services is allowed and considered together with the utilization of standard equipment. The PLANLAB design is also addressed to minimize the operational and maintenance costs.

1. Introduction

The Mission of the PLANLAB as Planetary Environment Surface & Subsurface Emulator Facility will be to allow the execution of activities aimed to:

- The confirmation of the suitability of future probe and robotic systems design to the target environment.
- The verification of the compatibility of the design of the probes and their operations, the support of the training of the ground operators.
- The execution of significant outreach and education activities.

The future robotic explorations will require the development and research about sub-systems not limited to the locomotion aspects and for which specific new laboratories or facilities could be useful (power generation, sample containment, rendezvous, etc.). The exploration programmes will generate and will be sustained by relevant education and outreach activities. These activities, that will be also necessarily based on physical elements (e.g. mock-ups, simulated environments), shall be conveniently coordinated by a recognizable "High-Tech Centre". The definition of the PLANLAB functions and related requirements have been conducted taking in due account several key aspects and facility is required to enable and support the following typologies of activities relevant to the planetary exploration programmes:

- Technology development, enabling meaningful real hardware testing and testing of planetary surface elements (landers, egress systems, rovers, robotic arms, instruments).Testing of ground control systems (H/W and S/W)

– Functional and performance testing of locomotion, robotic manipulation and scientific instruments
– Management of archives and data-bases collecting the results of the researches and explorations
– Engineering Support to Planetary Exploration Missions and Scientific activities and researches
– Technology Transfer and Outreach and Education

The PLANLAB in ALTEC could permit the exploitation of significant synergies like efficaciously streamlining the development of the ExoMars/ROCC MTS enabling development testing on the rover and supporting technological studies. It could permit cooperative initiatives with other space agencies in the frame of a long term space exploration vision. The PLANLAB Strategic relevance as hub of a knowledge innovation triangle. (Fig. 1)

Fig. 1: Knowledge Innovation Triangle

2. Major requirement

The PLANLAB can be utilized for Rovers, Landers and Probes (RLP) requiring extensive and short mission operations support and mission verifications under simulated planetary conditions:

– Allows functional testing of the egress of the rover from the Lander and permits the reproduction/simulation, to an adequate level of realism, of specific operations on planetary surface and some interactions with planets surface.
– Permits the support to the development and verification of a rover locomotion performances, maneuvers, obstacles avoidance and autonomous movement in a short/long range.
– Can be used for testing at system level of on-board software routines and testing of command sequencing, including rover behavior response and command sequence validation.
– Provides a dedicated closed area to simulate extreme planetary temperatures with subsurface ice field or liquid water presence.
– Can be used to perform mission operations emulation of selected science experiments.

3. Elements

The facility includes, in addition to the Arena (Mars terrain, Lunar Terrain, movable platform, Gravity compensation device, Planetary illumination system) and infrastructures:

– high performance lighting and position systems
– permafrost refrigeration capability (to simulate portion of subsurface ice field)
– positioning and modeling elements, control room and communication infrastructure
– wind chamber simulating the extreme planetary condition in terms of temperature, pressure and wind velocity (including sand particles)
– eripheral facilities such as workshops, laboratories, storage space
– virtual reality theatre (Operations engineering/outreach-education) and observation/view windows

4. Arena Elements

The “Arena”will simulate planetary surfaces both of Mars and Moon with the following elements:

– ovable Platform Ramps, to simulate upwards and slopes for the rovers
– Dunes, Sand Traps, Steps & Rocks, to simulate the real conditions of the planetary terrain

- Drilling Area and Materials, to check the possibilities of movements of the rovers
- Ambient Simulation, all the items that help to recreate the planetary environment
- Illumination, which is one of the most important aspects to re-create in the facility, in order to have the control on rover's movement with the use of Panoramic Camera, the control on rovers "light sensors"sensitivity, the possibility to recreate a 3-D vision of the terrain.(Fig. 2)

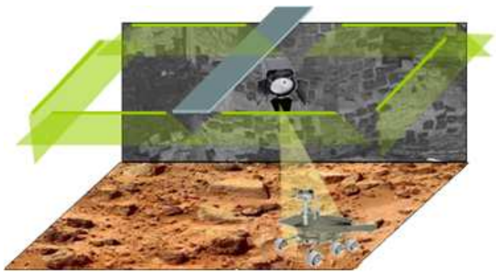

Fig. 2: Terrain lighting schematics

The Mars terrain will cover most of the Facility available area, in order to attempt the latest claims about planet explorations. Furthermore, a permafrost area on Martian terrain and a Surface Ice Simulator on Lunar terrain shall be simulated also. (Fig. 3)

Fig. 3: Arena view

As reported before, the camera simulates the extreme planetary condition in terms of temperature, pressure, wind velocity including suspended sand particles.The camera shall have a number of interchangeable optical windows transparent to ultraviolet and IR radiations and shall reach a pressures from 0.02 to 1000 mbar w/air. The nominal planetary atmosphere in test conditions (max value 10 mbar) shall be composed by 95 per cent of carbon dioxide with contaminants (Argon and oxigen). The camera shall reach low temperatures down to -150 C by the use of liquid nitrogen internal loop, and sustain a continuous use for 16 hours in service (compatible with cryogenic supply); the nominal temperature shall be reached at room pressure in less than 2 hours, including the time for reaching the above reported service pressure. The camera test area shall simulate a laminar flow up to 10 m/s max with dust suspended (granulometry from 0,01 to 0,3 mm) with internal turbines, and accommodate filtering systems capable to isolate the internal atmosphere from the external environment. Two possible configurations have taken into account: three sections and two sections as reported in (Fig. 4) and (Fig. 5)

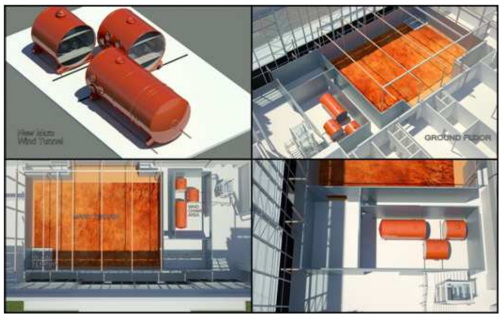

Fig. 4: Wind Chamber views (three sectors)

5. Virtual reality

The virtual reality offers great benefits in many application areas. It provides an easy, powerful, intuitive way of human-computer interaction. The user can watch and manipulate the

Fig. 5: Wind Chamber views (two sectors)

simulated environment in the same way we act in the real world, without any need to learn how the complicated user interface works. In the frame of PLANLAB, the Virtual Reality can be used for engineering operational aspects, for training and for outreach. The (Fig. 6) and (Fig. 7) report a possible VR utilization and testing sequence and the VR display chamber.

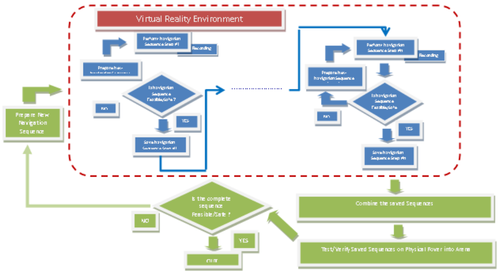

Fig. 6: Example of VR Engineering Operation Application Flow Chart

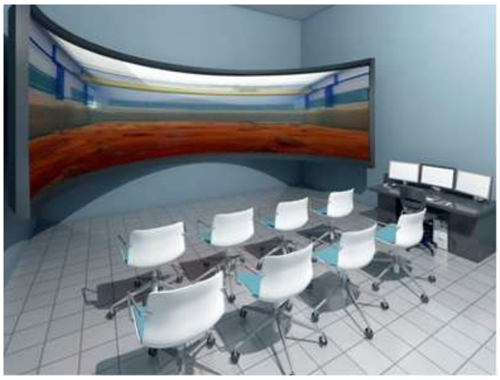

Fig. 7: Rendering of the Virtual Reality Displays Chamber

6. Positioning and Modelling system

The Positioning and Modelling system (Fig. 8) is composed by a recording Camera, in order to detect images from ambient, a Positioning Locator, to evaluate the position of the rover/probe and their accuracy, a 3D modelling camera. Every element will be supported by a dedicated S/W (and HW for Positioning Locator). The PLANLAB positioning system will utilize cameras to track the rover/probe movements by means of targets on it; the built-in digital reconstruction software will provide a model of the tracked object, to be superimposed to the terrain Digital Elevation Model (DEM) received. The (Fig. 9) represents the concept:

Fig. 8: Positioning cameras located on walls

As general conclusion PLANLAB represents a unique opportunity for engineers for testing and verifying the robotic elements on different planetary surfaces. It permits the representation of planetary environment (wind

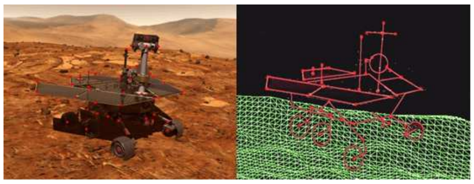

Fig. 9: Left: a rover with targets; Right: the rover's geometrical model put on terrain DEM

Fig. 10: This picture collection represents an overview of the PLANLAB accommodations and infrastructures.

tunnel) with good fidelity. PLANLAB represents a valuable opportunity for virtual reality implementation for engineering and outreach purpose.

The development phase lasts about 18 months including the final testing and verification of the system. At the end of the development phase the operative phase can start immediately.

From Geological point of view the selected simulants permit a good approximation of the Martian and Lunar terrains in terms of performances and characteristics. They are suitable for rover egress and moving testing. The testing and verification capability is increased with the presence of a permafrost area and a drilling simulation area.

A preliminary selection on support elements (Wind Tunnel, position localization, 3D modeling, video camera, virtual reality and control room) has been carried out and widely described in the report. It is clear the more detailed investigations are necessary before the starting of the procurement phase.

References

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