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Design and Demonstration of Minimal Lunar Base

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Introduction: We propose a conceptual analysis of a first minimal lunar base, in focussing on the system aspects and coordinating every different part as part an evolving architecture [1-3]. We justify the case for a scientific outpost allowing experiments, sample analysis in laboratory (relevant to the origin and evolution of the Earth, geophysical and geochemical studies of the Moon, life sciences, observation from the Moon).

Research: Research activities will be conducted with this first settlement in:
- science (of, from and on the Moon)
- exploration (robotic mobility, rover, drilling),
- technology (communication, command, organisation, automatism).

Life sciences. The life sciences aspects are considered through a life support for a crew of 4 (habitat) and a laboratory activity with biological experiments performed on Earth or LEO, but then without any magnetosphere protection and therefore with direct cosmic rays and solar particle effects. Moreover, the ability of studying the lunar environment in the field will be a big asset before settling a permanent base [3-5].

Lunar environment. The lunar environment adds constraints to instruments specifications (vacuum, extreme temperature, regolith, seism, micrometeorites). SMART-1 and other missions data will bring geometrical, chemical and physical details about the environment (soil material characteristics, on surface conditions . . .).

Test bench. To assess planetary technologies and operations preparing for Mars human exploration.

Lunar outpost predesign modular concept: To allow a human presence on the moon and to carry out these experiments, we will give a pre-design of a human minimal lunar base. Through a modular concept, this base will be possibly evolved into a long duration or permanent base. We will analyse the possibilities of settling such a minimal base by means of the current and near term propulsion technology, as a full Ariane 5 ME carrying 1.7 T of gross payload to the surface of the Moon (Integrated Exploration Study, ESA ESTEC [1,2]).

We will focus on the easiest and the soonest way in settling a minimal base immediately operational in scientific experimentation, but not immediately autonomous. It will prepare the next permanent lunar base by assessing its technologies, and give scientific results about the environment. The autonomy will be gained in the evolution of the base, and added equipment.

A lunar outpost in a polar region would allow missions longer than 14 days, and a frequent addition of equipments. Moreover, a polar outpost will get both advantages of far-side for simulating direct or indirect communications to Earth and dark-side for observations. The low solar rays incidence may permit having ice in deep craters, which will be beneficial for the evolution of the outpost into a autonomous base. The South Pole, by its position on the edge of the South Pole Aitken (SPA) Basin, will allow different fast new data in analysis mantle samples, easily reachable due to the crater morphology. These samples will constrain the putative Late Heavy Bombarment (LHB). After a robotic sample return mission, a human presence will allow deeper research through well chosen geological samples [6].

In this modular concept, we consider various infrastructure elements: core habitat, EVA, crew mobility, energy supply, recycling module, communication, green house and food production, operations.

Many of these elements have already been studied in space agencies' architecture proposals, with the technological possibilities of industrial partners (lunar landers, lunar orbiter, rovers . . .). A deeper reflection will be therefore done about the core habitat and the laboratory equipment, proposing scientific priority experiments.

Each element will be added in a range considering their priority to life support in duration [7]. Considering surface operations, protocols will be specified in the use of certain elements.
After a reflexion on the different dependancies and priorities between these modules, a demonstration can assess the reliability of the concept and develop the evolution according to the practical needs. We shall also discuss experience form the ExoHab project and EuroGeoMars cmapign at Mars Desert Research station.

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