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# Geological Astroikos †

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**Abstract:** Establishing a human colony on a planetary body different from the terrestrial one will entail combining those factors that can favour the good development of life in that place. However, which of these possible parameters are essential to the creation of a shelter for a long stay?

**Keywords:** geological astroikos; astroikos; space architecture; planetary architecture; architecture; geological habitats; habitats; geosciences

## 1. Introduction

In theory, human beings who are willing to abandon their natural environment in order to open new extra-terrestrial settlements for present and future generations will have to stay long hours cloistered in volume in units built in a quite hostile environment. They deserve to live within a habitat that not only makes them feel protected, with the tranquillity and comfort that entails, but also provides an environment capable of transmitting the desire to live and to be.

Astroikos, a term whose suffix *Oikos* ("house", in Greek) defines in classical antiquity the set of goods and people that constituted the basic unit of society, allows us to conceptualize a new planetary habitat as the possible refuge of a multidisciplinary team of astronauts aiming at colonizing other worlds. This new planetary habitat would be based on four fundamental pillars:

1. The humanization of space architecture.
2. The possibility of the use of indigenous materials, resources and natural geological structures, as well as the recycling of elements of space vehicles.
3. Self-construction.
4. Security.

## 2. The Colonization of Other Planets

In December 2014, under the title "NASA's Journey to Mars" [1], the US National Aeronautics and Space Administration itself acknowledged that "engineers and scientists around the country are working hard to develop the technologies astronauts will use to one day live and work on Mars, and safely return home from the next giant leap for humanity". This proposes the possibility of having habitable sites both on the Moon and on the Martian surface by means of several appeals—public competitions, among them—with the purpose of calibrating the possibilities of construction with the greatest guarantees of safety for the crew, the reduction of material to be transported in space vehicles, and lower environmental impact and energy expenditure, among others.

In this regard, the astrobiologist Christopher P. McKay, planetary scientist at the Ames Research Center of NASA, indicated that it is essential that we first gain experience in making space bases on the Moon before venturing to Mars because a lunar base would give us the opportunity to test habitats [2], among others things.

## 3. Safety

In the same line of research on planetary habitability, the experience of the International Space Station (ISS) has been revealed as essential, so that astronauts on the orbiting laboratory can help us research many of the technologies and communication systems needed for human missions to deep space, including Mars. The space station also advances our understanding of how the body changes in space and how to protect astronaut health [3]. In this way, when analysing any possible site prepared to receive such users, even beyond the scope currently covered by a space station as we know it today, we must prioritize the field of security not only by examining the parameters of the hostile environment of a landscape in conditions other than those that promote the natural development—without artificial help, or external devices—of human life, but also by considering the physiological aspects of the human being in the face of the type of known adversity with which the human body must deal during this type of space mission.

Through testimonies such as that of Scott Kelly, detailed in his book *Endurance: A Year in Space, A Lifetime of Discovery*, we know concrete aspects of the development of human life inside the station, assimilating to their stay in it as if living in a building. He relates that, "when you live for months inside, you do not perceive it as an object, but as a home, a very specific place with its own personality..., with rooms and more rooms...," each with "a unique sensation and smell...". In the same way, he conveys the importance of the conditioning of the premises, pointing out as relevant information his experience with the headaches that he suffered when he was too far from the clean air vent that they had inside the station during his stay in space. This opens the door to reflection on the possible health problems faced by human beings in this type of enclosure, outside the terrestrial sphere (Figure 1).

The collected experiences, such as the type described above, reinforce the need to reflect carefully on future planetary habitats. Scientists will have to configure a type of planetary architecture whose conception is established on the premise that it caters to the needs of the astronaut as a human being. It is a type of architectural project whose function is focused on sensitive users who need an environment that cares for the physical and mental health of its inhabitants. Therefore, it is necessary to point out the field of sanitary architecture as another reference in this research. Just as in a hospital, it is essential to pursue the comfort of the user. Sanitation must be an influential factor both for the general health of the astronauts (especially for a long stay) and to eliminate the possibility of nosocomial diseases through prevention—that is, asepsis—along with other environmental qualities such as shapes, colours, smells, sounds, materials, lighting, temperature, radiation control, encounters, travels, and relationships between specific spaces, accesses, signs, openings, and levels. Through research into architectural matters, it is possible to equip the members of a crew destined to establish their home in another celestial body with the necessary parameters for their physical and psychological well being. Based on practice and studies, "a comfortable stay for the patient means a better and faster cure," (Le Corbusier, in relation to his project for the Hospital of Venice, 1961). With a similar approach, we will also be able to take a leap forward in terms of spatial architecture as the first prototypes of habitats with which we will have to accommodate a possible planetary settlement distant from the Earth; it will not only be a "home for man" but will also have to have health centres and hospitals for the astronauts.


**Figure 1.** National Aeronautics and Space Administration (NASA) astronaut Scott Kelly, Expedition 25 flight engineer, is pictured in the Cupola of the International Space Station on 14 October, 2010. Image Credit: NASA.

## 4. The Humanization of Space Architecture

We intend to configure a type of planetary architecture whose conception is established around the pursuit of the astronaut's needs as a human being. Thus, starting from the above, and taking the user—in this case the astronaut—as the main principle around which possible habitats should be developed, we should consider a type of space that "rotates" around the person. Such an enclosure must accommodate conditions unlike those on Earth, helping to reduce cardiac problems, decalcification, muscle loss, and stress, which astronauts suffer once in space, in addition to preventing problems incurred by exposure to cosmic and solar radiation, with which the astronauts will have to contend during their long stay on the lunar satellite and even, as the case may be, on the planet Mars.

When planning a planetary enclosure, we must then take into consideration how to combine the generation of positive stimuli to accompany an astronaut during an extended stay, the purpose of the enclosure above all as a shelter, and other factors related to the ideal development of human life inside the structure. These considerations then lead us to the humanization of space architecture as one of the goals proposed in our research.

The idea is to promote the development of human activity in all of its possible forms, within the expectations that the scientific community has about the possible establishment of an extra-terrestrial human colony and try to demonstrate the capacity of planetary architecture once it has been thought out in service of the human condition. The aim is to establish criteria and guidelines for the projection and materialization of planetary habitats specifically intended for the purpose, among others, of contributing to keeping the astronauts in the best possible physical and emotional state during their stay for long periods of time inside those habitats, based on environmental comfort conditions such as lighting, thermal, acoustic, material, form and composition, and relationship with other spaces necessary for favourable development, as well as protection against external harmful agents. In this way, we seek the comfort and positive response of the astronaut's health, using planetary architecture to be considered in accordance with those aspects related to functionality, construction outside the terrestrial environment and even form, which would entail reaching the same aforementioned guidelines.

At this point, once the architectural needs for the conformation of the habitat have been recorded, we consider the formal aspects related to the habitat, particularly the study of indigenous material and the location itself. Take into consideration, in particular, the teachings of Marco Lucio Vitruvio (1st century BC), Roman architect, engineer, and author of the celebrated treatise "De Architectura", regarding the understanding of the architectural discipline in which he indicated that the discipline should not be understood without providing the proper and best possible use of materials and land and to procure the lower cost of the work achieved in a rational and powerful way [4]. We cannot fail to emphasize the importance of geology in planetary architecture, given the implications of the lunar and Martian regolith in the natural habitats to be colonized. Then, if on Earth we have come to take into consideration these principles of economy in relation to the construction materials to be used—from antiquity—we should pay yet more attention to them given the added difficulty of the missions that concern us in space.

## 5. The Architecture of the Place

Continuing with the annotations in the previous section, it is essential to take into consideration the concept of vernacular architecture (from Latin, "vernaculus", meaning "domestic, native, indigenous") for its implementation in the planetary formations to be treated. One of its main characteristics is the use of materials based on local natural resources that may remain in their place of origin once their life cycle has elapsed, without the risk of contamination and without injuring it. In this way, this contributes to estimating the necessary factors to avoid natural conflicts and project the implantation of the possible refuges by estimating the bases of geoethics, an essential discipline in the field of Planetary Science.

In this way, we must count on—both in the lunar sphere, as in the Martian one—the geological resources that are given to us, these being, in the case that concerns us, the main natural resources to be used. They would follow the guidelines of the exposed thing when considering the same resources—together with the natural formations that have developed through geologic activity—for the implementation of safe planetary habitats for possible crews in a space mission, and the establishment of habitability criteria according to the conditions of stability of the different mineralogical associations and textures that present the aforementioned materials and resources (minerals and rocks) existing in the satellite and planet considered, such as jarosite, gypsum, epsomite, and basalt [5].

The igloo, typical of the Arctic, shows us an example of how the environment itself, nearly, can provide the material that will form the structures that give safe shelter to its inhabitants without the need to spend more energy or expend resources, beyond essential needs. Habitats must be compatible with the conditions and resources of the specific environments considered—in this case—for its possible continuity over time and economic and energy savings, so that we can generate efficient work in the scope of the planetary architecture.

It was not in vain that the Egyptians incorporated the hypogeo (in Greek, underground chamber) as architecture excavated in the rock as a constructive typology after the pyramid, at less cost—both in terms of its execution and maintenance—than for the aboveground components and giving greater security to the bodies inside. For decades, these dwellings of eternal rest constituted the constructions chosen to safeguard the protection of the deceased with the necessary means to erect them, together with their valuables, under the thought of keeping them intact, thus prolonging their existence without temporal limits. Hypogeos were effective protection not only from inclement weather but also from the looting of monuments such as the pyramids. The volcanic formations evidenced both on the Moon and on Mars, both in their complex structure—with different branches (lava tubes), as if corridors of a funerary monument—and multiple sizes, as in their simplest forms, hobbit cave type, show us the field of action by contemplating them as possible "castles of eternity" in the face of the danger of impacts by flows of micrometeorites and cosmic radiation existing in such environments, or in the face of possible damage by the volume of sand moving after such a storm in the Martian environment.

## 6. Self-Construction

We consider the identification and analysis of underground spaces that are potentially valid for the location of habitats, such as natural formations including lava tubes in the lunar and Martian environments (Figure 2), to be crucial as a human habitat in an extra-terrestrial environment, as well as in the study of the architectural configuration with which we can provide them as a type of habitable enclosure; with the possibility—also study—of complementing these enclosures with artificial structures as valid prototypes of support for the indicated formations. This is done in search of an environment conducive to the development of life and the protection of the individual in the face of the possible colonization of the satellite, on the one hand, and the planet, on the other, thus combining with the following premise or objective of our research process, such as it is: self-construction (Figure 3).

**Figure 2.** 2016-10-26_LavaTube-Traverse2-S.Sechi-GH3-012.The first Pangaea course took place in 2016 to train astronauts in identifying planetary geological features for future missions to the Moon, Mars and asteroids.

Through the principle of effemerization, coined by the American architect, writer and inventor, Richard Buckminster "Bucky" Fuller (1895–1983), and given the importance and limited resources that the human being can count on at a given time, the emphasis is on being able to do more with less [6], thus proposing the recycling of resources and waste material in order to create valuable products, increasing the efficiency of the entire process [7] [8] [9]. This economy of means will facilitate not only the work of the astronaut in his already complicated space journey but also the work of the different space agencies in terms of transport or transfers of pieces for the achievement of missions in terms of space colonization.

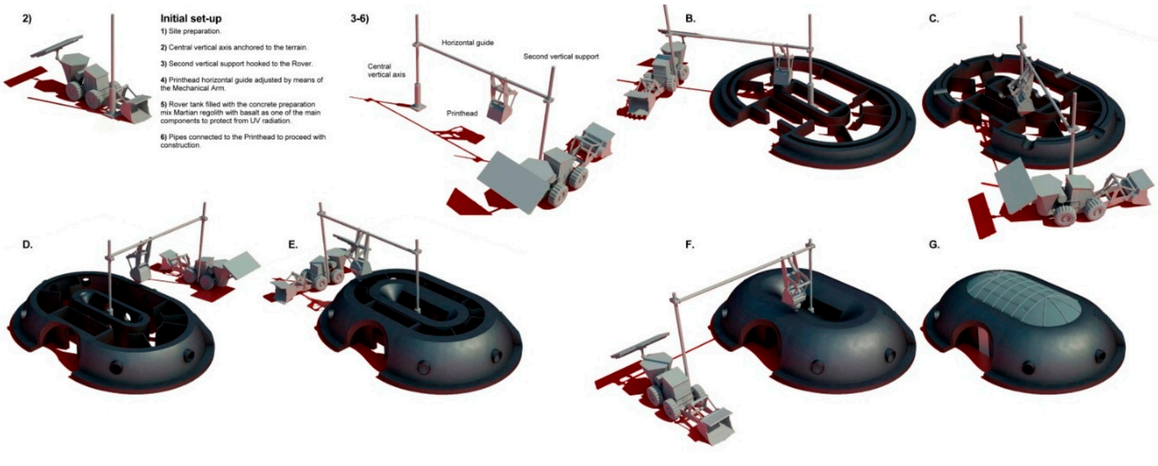


**Figure 3.** Phases of self-construction of a habitat. Project FALLAMARS (2015 3D-PRINTED HABITAT CHALLENGE). Team: Yasmina Eid-Macheh y Sánchez[1], Jesús Matínez-Frías, Juan José García Valverde[1], Antonio Torres Ferrer, John Aaron Graves. [1]GAREID PROYECTOS, Planetary Architecture Study.

Our goal is to project a habitat for human beings capable of contributing to the progress of life and science. These people will have to be willing to abandon their natural environment in order to open a new horizon that can help establish a new settlement with new and advanced parameters of survival, for present and future generations. They will also have to spend long hours cloistered in a habitat built in a quite hostile environment. This habitat will not only have to make them feel protected, with the tranquillity and comfort that this entails, but also provide an environment capable of transmitting the desire to live and to be.

We have named the possible new planetary habitat based on natural geological formations with the new term Geological Astroikos. Its suffix, *Oikos* ("house", in Greek), helps us communicate a concept that in classical antiquity used to define the set of goods and people that constituted the basic unit of society, allowing us to identify it as the possible refuge of a multidisciplinary team of astronauts in order to colonize other worlds, which would be based on the ideas mentioned. It is not just any shelter but one that would originate fundamentally from a formation with geological material typical of the place.

After all, the history of architecture, and of civilizations, opens our eyes to the fact that we will need to establish such human colonies within natural formations that are more or less like deep underground caves, as we have already conveyed the idea of being able to live in such an enclosure different to a module or standard housing, in the best way. Expressed in the words of a great novelist, poet, linguist philologist and British university professor, JRR Tolkien, the ideal habitat for those who became his most beloved and recognized characters, the hobbits, who needed attention because of their short stature and need for protection, were holes in the ground:

> Not a wet hole, dirty, disgusting, with the remains of worms and the smell of mud, nor a dry hole, naked and sandy, with nothing to sit on or eat: it was a hobbit hole, and that means comfort [10] (Figure 4).

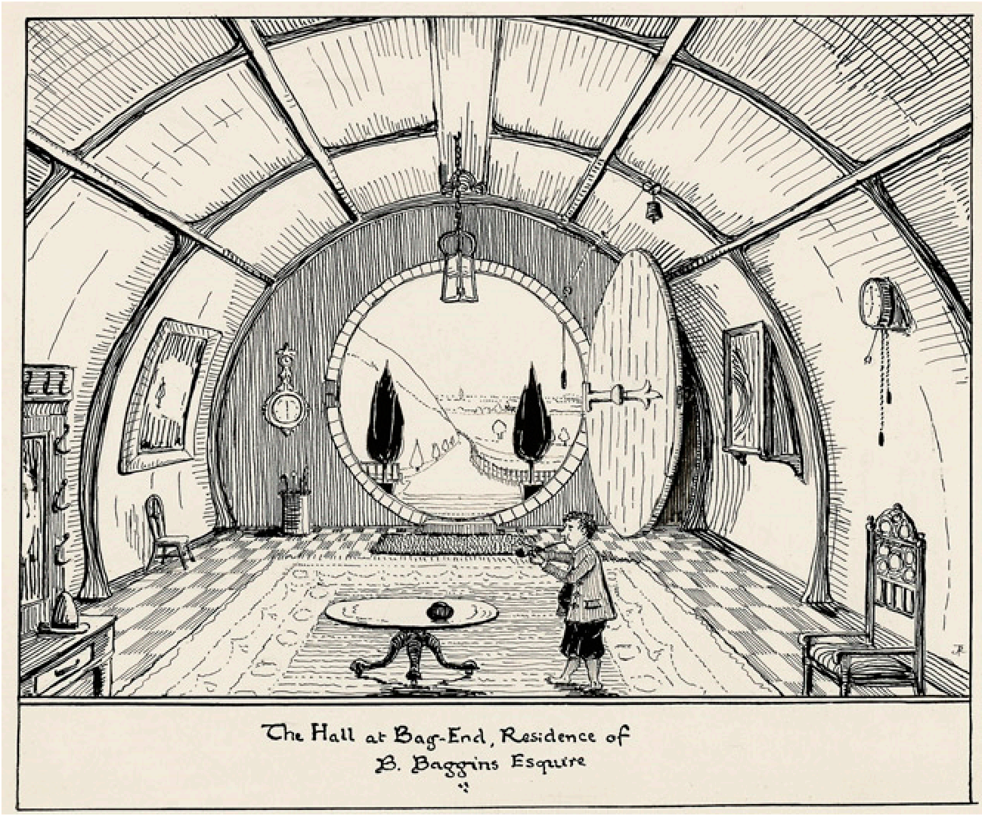


**Figure 4.** "The Hall at Bag-End, residence of B. Baggins Esquire". Bodleian Library, University of Oxford, from the Ms Tolkien Drawings.

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