ISRU BASED LUNAR SURFACE HABITAT MODULE

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Summary:

The essence of our concept is a solution for creating a Lunar Surface Habitat Module structure, which can be produced by the utilization of the in situ resources, on the Moon.

Background:

In our previous publications [1,2,3] we have studied structures which enable prolonged human stay and industrial activities on the lunar surface. The essence of these buildings were that they had utilized arched structures, they were built beneath the surface, into chasms or valleys, and were covered by lunar regolith. In our present abstract we focus on determining that what are the requirements for creating surface structures and buildings for long term use, utilizing on-site materials and resources, which, under Lunar circumstances can enable human presence, industrialor technical activities.

Our aim:

Creating and building structure on the lunar surface, according to the principles of the In Situ Resource Utilization (ISRU):

• with the use of on-site resources, materials

• with the use of on-site available technologies

which could provide sufficently large inner structure - which is easy to modify, or variate In this proposal we explicitly address the case of surface placement, where without any outside protection the module is directly and completely exposed to the Lunar surface environment.

Consideration and consequences of the Lunar surface conditions:

• Irradiation: The Solar and cosmic radiation reaches the surface without damping, against which sufficient protection is required. The building itself must serve as a direct protecting device, because otherwise a separate structure must be used to achieve this end, which would increase mission costs.

• No atmosphere, however significant amount of electrostaticaly charged and moved dust is present (because of the radiation)

• 28 day long day and night cycle- day-night 14-14 Days

• Temperature changes: The long day and night cycle creates large temperature changes on the surface from - 170℃ to +130℃, which means approximately 300℃ temperature difference on average. The building and its building material itself must provide proper temperature insulation.

• Meteor impacts: In the absence of atmosphere the effect of micro meteorite impacts can be significant. The building itself must provide shelter and serve as a barrier against smaller impactors (micrometeorites or other ejecta), because otherwise other protective structures must be built, which would complicate the implementation, and would also increase mission costs.

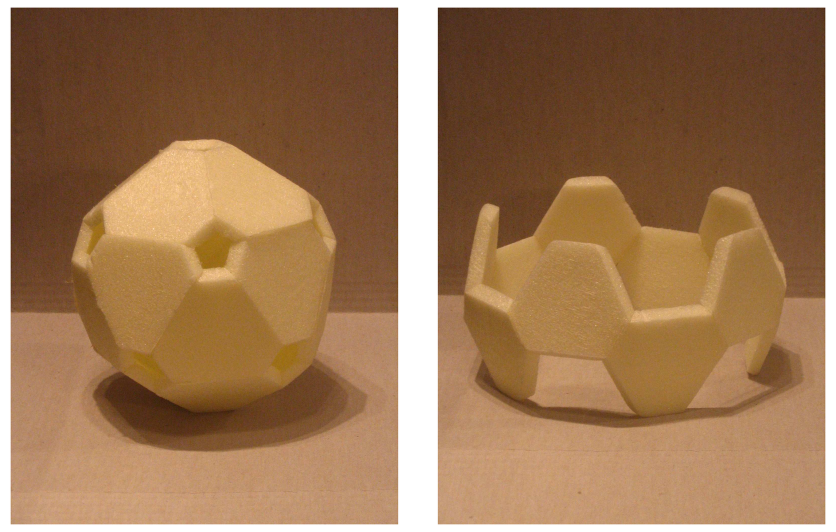

***Fig.1-2**. Shape of the building structure and the side support built from the basic elements*

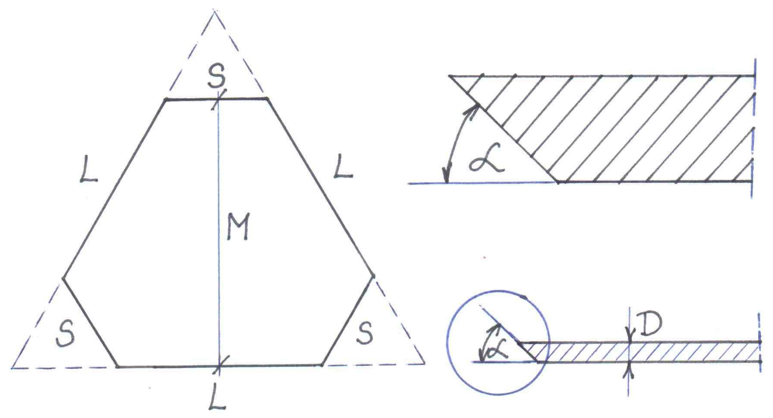

***Fig.3.** The shape of the basic building element, and the slope of its sides*

The essence of our proposal:

Creating a surface habitat module, which can be easily assembled at the Lunar surface, and comprises of building elements which can be created on site relatively easily, and which contain mostly local lunar material. To achieve this, two conditions must be met:

• A proper geometrical shape which would form the basis of the habitat module

• Proper technology regarding the creation of the building elements. This is also required for the in situ building of the module from the individual elements.

Geometry:

The shape itself is a quasi (truncated) icosahedron, which is built from the same building elements and complementary elements for the vertices. The complementary elements can be simple closing panels, a windows, or some technical devices. The basic shape: equilateral triangle with truncated vertices, it thus forms a hexagon, which can be placed indefinitely next to itself. The basic shape posseses sloped edges at its sides, which enables joining several of them into a closed 3D object.

Architecture, manufacturing and assembly:

The created 3D object is an icosahedron, with its vertices missing, to these parts further closing elements must be placed. These closing elements can serve various purposes e.g. outside illumination, window, they can also serve as entrance points for different types of equipment and supply cables. To create this geometrical body only one type of basic shaped building element must be constructed, and using these and smaller complementary closing elements a closed interior space can be created on the Lunar surface, which can be used as a habitat module, or industrial module.

It is important to note that the complete body consists of relatively few building elements (5 on top, 5 on the bottom, and 10 on the sides). This results a completely closed, and very spherical form, which shape is ideal for space and heat management. The sphere has the smallest surface area for a given volume, this makes this type of building especially beneficial. The joining of the building elements in a different manner enables the creation of a larger structure with grater inner diameter. This positioned at the sides of the main icosahedron can serve as a supporting side structure.0

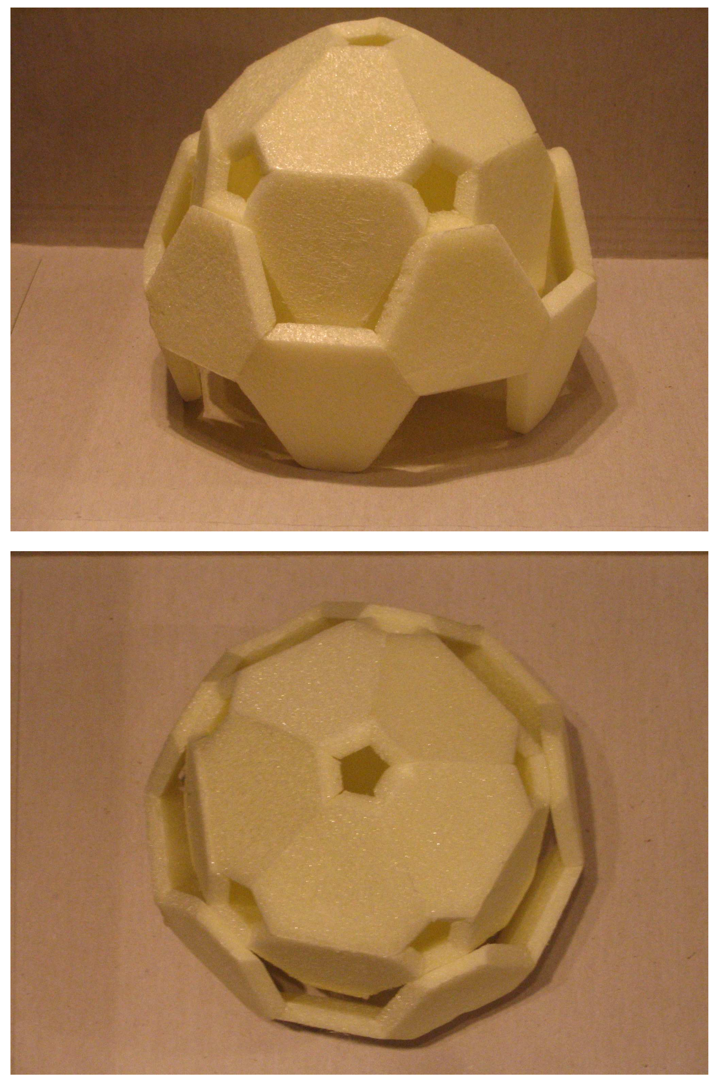

***Fig.4-5.** The building structure accompanied by the side support from different views*

Feasibility study:

The first step is the manufacturing of the basic building elements.

▪The surface regolith should be layered into a proper building mold by a conveyor belt, or other means of transportation, (this can be done by shovels, our pouring from some holding device. This requires grinded regolith with sufficiently small grain size. This can easily obtained at the Lunar surface in large quantities.

▪Binding the regolith in the layers together, with microwave baking [1,4,5,6] or by some binding material.

▪Repeating the previous step over and over thus creating a rigid building element with sufficient number of layers and arbitrary width.

The creation of the basic shape is done by making a multy layered structure described in the previous paragraph. This element thus possesses a layered structure where the individual regolith layers are also bound together. This in same cases can give the otherwise rigid regolith structure sensitive to cracks, and vibrations, some resistance to outside dynamical effects (effects arising from the normal use of the module).

The layered structure also lowers the possibility of fracturing and cracking of the building elements in comparison to the completely homogeneous situation. The durability of the building elements can also be futher increased by adding internal supporting structures among the layers during their creation e.g.glass fiber or other commonly used material. The second step is the assembly and construction of a building structure from the building elements. The formation of the 3D structure of the building is done by placing the building elements next to each other and binding them together by their sides. The joining of the building elements must be done properly. Possible methods for this are the following:

• Using adhesives

• Using binding materials

• By form fitting them (like a puzzle, by having tenons or other connecting structures).

By the study of small scale proportionate models it can be shown that if a building element longer side is L=4.2 m from 20 of these elements a building with approximately 13 m outside height, inside which four separate floors can conveniently be placed (calculated with 2.5 m height per level and 0.3-0.5 m slab height. In this scenario the full internal volume of the building is more than 1000 m3.

Advantages:

From mostly one type of building element a closed, easily built energetically efficient building can be constructed. The main structural elements can be manufactured from lunar materials (from properly grinded lunar regolith), thus only the most important materials must be transported directly from Earth. The manufacturing technology permits the construction of arbitrary number of building elements, and complete buildings. The simplicity of the overall process permits the easy transportation of manufacturing capabilities, thus reducing the need for the transportation of the completed building elements.

References: [1] T. P. Varga et al. “Process for producing building elements with multilayer structure from lunar regolith by microwave heating” 43. LPSC 2012 #1560. [2] Boldoghy et al. “Construction of a lunar architectural environment…” 37. LPSC 2006 #1152. [3] Boldoghy et al. “Complex architectural concept and technology for creating buildings of great inner space on the moon…” #4074 Joint Annual Meeting of LEAG-ICEUM-SRR 2008, [4] L. A. Taylor et al. Microwave processing Apollo soil… Earth and Space 2006, [5] M. Barmatz et al. Development of a microwave facility for processing Lunar Regolith Habitation 2006 Conference, [6] L. A. Taylor Microwave sintering of Lunar soil… ” JOURNAL OF AEROSPACE ENGINEERING ASCE / JULY 2005