‘Lunar Real Estate Development’

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David M. Ladewig

Sasakawa International Center for Space Architecture (SICSA)

University of Houston - College of Architecture

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David M. Ladewig

[1]Sasakawa International Center for Space Architecture, College of Architecture, University of Houston, 122 College of Architecture Building, Houston, TX 77204-4000; Ph (832) 527-1418; email: dmladewig@uh.edu

ABSTRACT

What seems to be almost sure is the solutions to space travel and living in space will be found when the possibility of profit from development of technologies in and for space is seen as immediately at hand. In other words when the people see opportunity to profit from space, solutions will come quickly.

Using analogues of how cities on Earth have evolved because of the creation of new technologies and markets, the paper discusses how the future settlement and development of a lunar habitation can be predicted. The goal of this study will be to see through the habitation process from a real estate developer's perspective and demonstrate how to attract interest from the public, as well as potential investors. The report will utilize SICSA's design of a self-sustainable lunar habitat, for the Houston Museum of Natural Science, to illustrate the project's feasibility and room for expansion.

BACKGROUND

The purpose of this paper is to apply traditional real estate principles in the design of a self-sustainable lunar habitat on the Moon. Concepts presented are designed to project a feasible roadmap for creating interest for lunar colonization. The major topics are organized as being the most pertinent for a real estate development deal and should be considered as an objective view of such a plan.

The paper discusses a roadmap for real estate developers to extend their reach to an extraterrestrial body; in this specific case, the Moon. The specifics of such an endeavor can become a long drawn out web of bureaucratic policies and it is this paper's mission to identify the major concepts that will attract a greater audience to become interested in investing in technology for the Moon

IN-SITU RESOURCE UTILIZATION

Self-sustainability on the lunar surface is critical to surviving the monetary and environmental risks of an extended stay in space. Utilizing in-situ resources for the cultivation of technologies such as construction, energy, and propellant for vehicles can help establish some form of economic payoff. Similar to land development on Earth, further research and innovation of the site can be conducted by the crew to determine advanced uses that can either benefit or become hazardous in future endeavors. Currently, the Moon has not facilitated humans for a great duration of time. Allowing the opportunity for humans to utilize such intimate skills as critical reasoning and judgment can uncover mysteries of the Moon that are not yet known.

ESTABLISHMENT OF A SURFACE INFRASTRUCTURE

Infrastructure refers to all of the elements that need to be pre-configured on the surface in order for the habitat to operate properly. These elements include but are not limited to: launch/ landing zone that is easily accessible yet far enough way to not cause damage to the habitat, power grid consisting mainly of solar panels to harvest the sun's solar energy, transportation vehicles for crew to have accessibility to and from the habitat, in-situ resource utilization, life-support systems, and habitation elements. For purposes of this study, these areas are highlighted as being important characteristics of any real estate development on the Moon. Further investigation in these core areas can identify the necessities required to see them into implementation.

FINANCING

Financing a lunar colony is a very complex and difficult task in the current model for the funding of space exploration. Governments can no longer be the major beneficiary of support for the lunar colony. The planning and development is best suited for private companies to attract their own private sources of capital and determine their target investment potential.

An effective method for funding of the lunar colony is in the formation of a Real Estate Investment Trust. The trust or (REIT) operates solely on a compilation of a group of investors who are willing to contribute towards a common goal in expectation of some sort of return for their investment. REITs provide a way of carving up real estate ownership into small entities that many people can afford. This can provide an attractive pitch to investors that will not only raise capital but service the marketing campaign as well.

For this example, consider the benefits of forming a REIT and the strategy to enhance the public's interest in the project. During the engineering and development phase, manufactured pieces such as the nuts and bolts of the habitats can be funded by members of the REIT. The nature of this REIT in particular is that anyone can participate. Every element, no matter the size, quantity, or cost can be owned by the public or private donor, anywhere from $1 to $100 million. In addition to owning pieces of the first lunar habitat, certificates of investment can be distributed to the investor for proof of ownership. Thus creating the opportunity for anyone to contribute and appealing to a greater audience.

MULTIPLE STAGE DEVELOPMENT

The case study represented in this paper utilizes the design and construction of a lunar habitat that is capable of sustaining an 80 person crew for an infinite period of time. The concepts of the design were chosen to facilitate the idea that the habitat must be self-sustainable. Therefore, the best possible solution to any design problem is to look at previous examples to learn from the successes and failures of similar projects.

For this example, the design of the core habitat elements and life support systems stemmed from many of the concepts of the International Space Station. The most important function of the lunar habitat in order to become a fully operational self-sustainable colony is the multiple stage development process for which it will be constructed. Once enough capital has been raised from the REIT to develop the hardware and systems to deliver the elements to the Moon and establish the infrastructure, the first stage of development will be complete. It is important to develop in different stages so that the total cash flow in and out of the project is not so significant that any problems could jeopardize the entire project.

Table 1. Habitable Area.

Pressurized Modules (Totals)	**Pressurized Volume (571,657)**	**# of Modules (85)**	**Volume ft^3/ Module**
Airlock Modules	5,304	2	2,652
Vertical Circulation Modules	91,168	34	2,652
Horizontal Circulation Modules	109,782	27	4,066
Inflatable Modules	366,388	22	16,654

This first stage is the most critical because it serves as the first opportunity for investors in the REIT to see the credibility of their investment. Success in this stage will set the tone for the rest of the development. Success for this development is defined as the ability to satisfy the investors' expectations and to effectively operate a functional habitat. It is important to note that because governments are not the major beneficiaries involved in the lunar development process, any company from any nation that has the means to raise such funds to contribute to a lunar habitat can freely participate without any biased selection process.

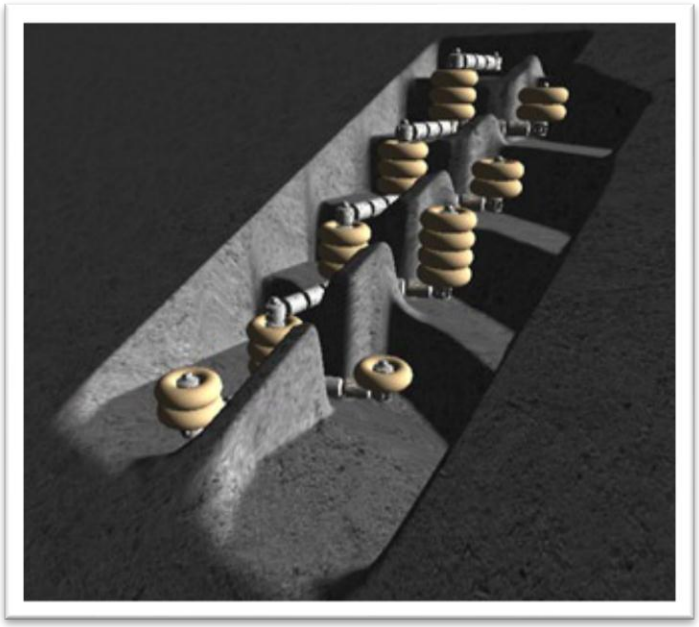

Figure 1. Final Stage Aerial View.

The design of the habitat will utilize hybrid elements of ISS modules and inflatable concepts. Inflatables allow for a maximum amount of volume compared to a minimum compressed volume required for delivery to the surface. The nature of the design is consistent with the ISS in that it is fully capable of adapting to expansion. The modularity and redundancy of these modules is important because it will simplify operating expenses and promote an international standard for the construction of each module.

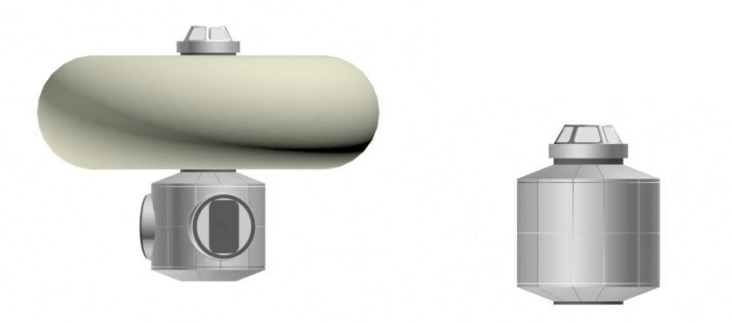

Figure 2. Vertical Circulation Modules.

OPERATIONS AND MANAGEMENT

Costs of the lunar habitat will be the highest during the operations and management stage due to the longevity of its presence. This is an area where the efficiency of the design and protocol set in place prior to construction is of most importance. The self-sustainability of the lunar habitat will prove a major tradeoff of investment by reducing operating expenses and ensuring the survival of the habitat. The ability to utilize such resources as stated before will complement the design for its intended use.

REGULATORY ENVIRONMENT

It should not be overlooked that an important element in regulating building functions is on the reliance of zoning and building codes that set the standard for future developments. We have this luxury on Earth however it will not be present on the Moon. This sets some interesting dynamics in motion.

The best solution available to set a standard of development is to create a Lunar Economic Development Authority [2]. The LEDA will consist similarly to a Port Authority in that it is comprised of a group of selected people (in this case a representative from each company or individual involved with the project) that manages the infrastructure and future developments. The LEDA operates on its own financial funding but carries the legal power over the entire project on the Moon. It is not of interest in this study to delve into the complex nature of governance and legal precedents. However, it is important to understand why it is necessary to establish a representative body that can maintain the habitat and facilitate its expansion.

MARKETING

Coupled with exposure the project will receive from interest in the REIT, the marketing phase is very important to insuring not only that the space is leased up but that the public remains interested as well. In this case, appealing to the target market is simply not enough. There is already a very high demand for research opportunities on the Moon so finding tenants who are willing to upfront the cost for space in the habitat will be a relatively simple task.

The majority of marketing will be directed towards the public, specifically youth. A great method of reaching out to youth to explain the importance of the lunar habitat is

through augmented reality. This technology allows us to create a virtual lunar habitat environment that enables anyone to interact as if they were actually living on the Moon. Establishing this Earth-Moon connection is a critical component to the success of the lunar habitat. It not only serves as a base for lunar citizens to contribute their knowledge and experiences to Earth but allows our future generations the avenue to become involved in the program. The Houston Museum of Natural Science currently has a program that demonstrates this function by using video game technology to allow many kids to interact with their planetarium shows where the environment is projected onto an inflatable dome. Multiplying these shows worldwide will take advantage of today's dependence on technology which is very popular amongst our youth.

REVIEW OF LUNAR REAL ESTATE DEVELOPMENT

In conclusion, the following timeline describes the stages of the lunar habitat economics in regards to the fulfillment of revenues.

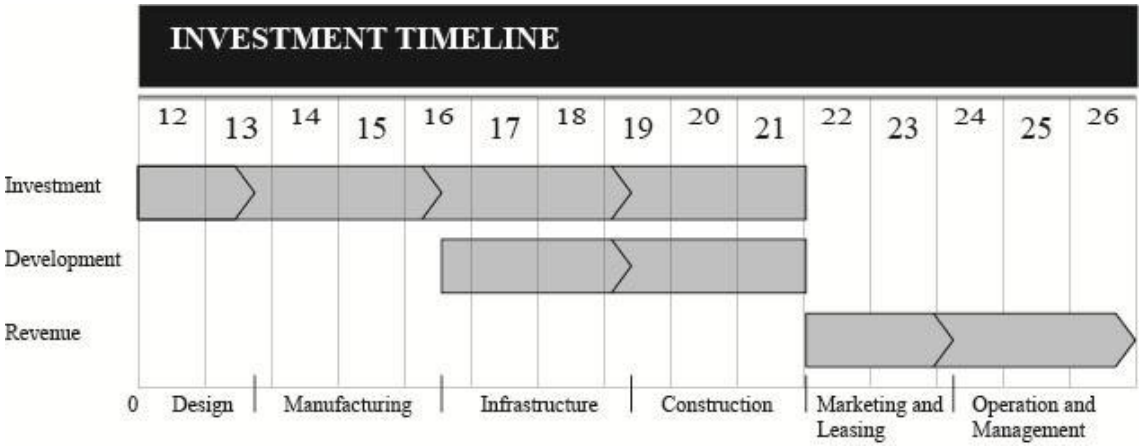

Figure 3. Lunar Real Estate Development Roadmap.

The lunar habitat has at least a 10-year permanent financing lifetime in order to ensure that the design, manufacturing, infrastructure, and construction stages are properly funded. Investors should be aware that this project requires a long term commitment and the projected completion may change frequently due to various weather and logistic factors. The habitat is projected to be 100% pre-leased prior to completion based on the demand for research and positioning on the Moon. Tenants will sign a minimum 5-year lease with the option to renew after the third year if the research needs to be continued. This will insure that the tenants cycling to and from the habitat will continue to bring new research projects and ideas to exploit resources on the Moon.

In the event that greater space is needed to meet the demands, this model can be repeated to accommodate expansion efforts. The survival of the lunar habitat relies heavily on the ability to market the product to prospective tenants, investors, international community, and youth. The experience of its citizens will provide invaluable insight into unlocking the secrets of sustaining humans on other extraterrestrial bodies.

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