DOMUS I AND *DYMAXION*: TWO CONCEPT DESIGNS FOR LUNAR HABITATS

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Abstract

Two concept designs for lunar habitat missions were explored and developed. In contrast to other work on lunar habitat designs, the driving force was habitation objectives and habitation performance requirements based on human factors/environment-behavior considerations. Attention was given to site selection and site planning requirements, first lunar outpost requirements, and initial operating configuration design requirements (both quantitative and qualitative). After review of 5 technological options and 12 previously published lunar habitat concept proposals, it was decided to further explore two concepts. The first is a pressurized self-supporting membrane structure (PSSMS) proposed by Chow and Lin, and the second a dymaxion dome structure based on the work of Buckminster Fuller. The master plan, construction sequencing, building system, technical subsystems, and interior configuration of one of the concepts is presented in this paper. *Domus I* consists of three entrance/EVA modules connected to a rigidized, inflatable torus containing all research laboratories and mission control, and a domed interior of an rigidized, inflatable ellipsoid containing all crew quarters and the crew support facility. (*Dymaxion* consisted of three hard module research laboratories/EVA chambers, a mission control core, and a two-floor habitation inflatable.) The relative advantages and limitations of the PSSMS concept are briefly reviewed. In summary, the concept seems extremely feasible and deserves most serious exploration by the various lunar program offices at NASA.

Introduction: Project Goals

A final mission design has as yet to be determined by NASA for either the First Lunar Outpost (FLO) or the first Permanent Lunar Habitat (PLH). Open to a wide variety of conceptual suggestions, NASA looks to internal ideas as well as to those from industry and academia. The Advanced Design Program in Space Architecture at the University of Wisconsin-Milwaukee hopes to make an impact. Students play the pivotal role participating in a combined educational and research process resulting in a variety of aerospace design proposals. Each proposal is presented not only in the USRA conference proceedings, but also in a series of technical reports, monographs, technical papers, and, when possible, at NASA seminars and technical interchange meetings.

In the broadest sense, the priority of a lunar base proposal is to provide a safe, productive environment to sustain human habitation and experimentation. To achieve this end, materials should be of near-term technology requiring minimal extravehicular activity (EVA) time for crewmembers. A lunar base represents humankind's ability to expand its own horizons, challenge technology that currently exists, and push the same technology to address unique situations. There is potential, as has been demonstrated by shuttle missions, of utilizing new advances to better life on Earth. We are upon the threshold of achieving the goal of permanent settlement on another celestial body. Estimates of commencing this venture vary, yet many feel that within the first decade of the new century, the goal is within reach.

The project goals were to research available concept options, evaluate them and select the most promising for further study, develop detailed habitation performance requirements, and study the feasibility of outfitting the most promising concepts following those requirements for human habitation on the moon. The resulting final product was two complete lunar base designs based on the two most promising concepts (only one concept is developed here; for the second, see the monograph by Huebner-Moths, Rebholz, & Moore, 1993). *Domus I* is available as a complete AutoCAD slide program, rendered in Animator-Pro and 3-D Studio programs. An animated fly-through provided a brief overall perspective of the base exterior and interior components.

Assumptions and Constraints

The surface mission objectives for a permanent lunar presence including the following:

- advance scientific knowledge in microbiology, life sciences, astrophysics, geomorphology, botany and plant growth, and astronomy with on-site laboratories and human participation as well as telerobotic research
- study effects on humans of a lesser gravitational field and of various protective measures against temperature extremes, environmental vacuum, and radiation hazards

To support these surface mission objectives, the following are the key, high-level requirements for lunar habitation:

- support a crew of 12 international astronauts for stay times up to 9 months, with first launch around 2005
- support the crew being able to perform command and control functions, science objectives, and habitat maintenance
- minimize life-critical and mission-critical risks associated with solar storms, radiation, fire, contamination, and depressurization, physical deconditioning, and stress and other psychosocial performance factors
- address what have been called "mission-discretionary" psychological and sociological issues (Cohen, 1993) related to long-term isolation and confinement, including but not limited to space for shelter, privacy, and recreation, space for rest, relaxation, exercise, and entertainment, and psychological support, e.g., communications home, and other factors leading to improvements in productivity and the quality of life for the crew

The principle technological constraints are the following (based in part on Moore & Campbell, 1993):

- utilization of FLO as a starting point for PLH
- minimum construction operations, and especially minimum EVA operations
- construction technology exhibiting advancements in material design, weight reductions, and compactability for transport
- ability to reconfigure/expand the habitat where/when applicable

Alternative Technological and Design Concepts

A large number of technological alternatives for lunar habitats and an equally large number of architectural design concepts have been published in the aerospace literature and in internal NASA documents (cf., for example, the references in Moore, Huebner-Moths, Rebholz, Fieber, & Paruleski, 1992, and the comparative analysis of five design concepts in Moore & Rebholz, 1992). Unfortunately, all too often engineering or architectural designers proceed as if they were the only ones with decent ideas, paying no critical attention to the concepts that have been published and critically reviewed in the scientific and engineering literatures.

To not repeat this unfortunate precedent, the study team collected and critically reviewed 5 different technological options and 12 different concept designs. Each design concept was evaluated in terms of ease of construction, simplicity of design, near-term technology, minimizing EVA involvement, number of facility components, volumetric allowances for specific functions, and habitability.

The technological options for lunar habitats include the following:

- membrane structures
- tents and screens
- laminated bladder systems
- resin foam-rigidized structures
- aluminum alloy hard-modules

The alternative design concepts published to date include the following:

- inflatable and hard-module concept
- LEO-assembled hard-module concept
- pillow-shaped tensile concept
- pre-assembled hard module concept
- suspended inflatable concept
- earth-sheltered family home concept
- hard-module rack concept
- linear underground hard-module concept
- hybrid triangular inflatable and hard-module concept
- hybrid underground inflatable and hard-module concept
- dymaxion dome concept
- pressurized self-supporting membrane structure concept

The full details of this evaluation are given in Huebner-Moths et al. (1993; for an earlier more detailed evaluation of five concepts, see Moore & Rebholz, 1992).

Habitability Performance Requirements

There will be four major elements to the PLH base: the solar panel collection fields, nuclear power facility, the habitat, and the launch and landing site.

Site Requirements

Permanent landing pads should be located between 3 and 5 km from the habitation zone, and no further than 5 km away from FLO. The base should have a north-south axis, the habitat centrally located within this axis, with the power and landing areas on opposite ends of the axis. This will allow a protective envelope for the habitat guarding against spacecraft fly-over and potential hazard. The nuclear power facility should be located 1 km from the habitat, accessible by road along the axis. This allows for a measure of safety while limiting the distance current must travel. The solar fields should be located where little exploration is expected, limiting dust contamination. Future field operations and lunar scenery should be taken into consideration.

According to the latest NASA thinking and requirements (Carpenter, 1992; Perkinson, Adams, et al., 1992), a large number of detailed human factors/environment-behavior (EB) habitability performance requirements must be met in the design of the habitat of any FLO or PLH. Details are given in Carpenter (1992), Perkinson et al. (1992); salient performance requirements for the design of the habitat itself (i.e., excluding technical requirements for hatches, scientific surface mission operations, transportation vehicles, etc.) have been extracted and summarized in Huebner-Moths et al. (1993).

General Human Factors/EB Requirements

A few, sample, high-level requirements for the habitat/research laboratories as a whole include the following:

- the architecture should be configured to accommodate evolution of the outpost, e.g., potential additional volumes including future integration of an additional pressurized volume to provide for outpost expansion, airlocks, logistics containers, other habitats, etc.; growth should accommodate spatial adjacency between similar activity centers and not jeopardize crew well-being
- the architecture should be designed for simple interfaces, modularity, and replacement; this modularity should provide quick disconnect for hardware and electrical equipment
- to overcome the stresses induced by the mission environment, mental health should be preserved by providing appropriate design and psychological support
- the architectural layout should insure that adjacent volumes are set aside for similar or compatible activities and that interfering activities be separated, e.g., compatible activities such as hygiene and waste management functions can be adjacent, while interfering activities such as food preparation and waste management should be separated
- the architecture should provide a marked emergency route for contingency operations
- the habitat should support internal operations by space-suited crewmembers, e.g., emergency cases will require suited crewmembers to operate inside habitable elements
- the architecture should accommodate unimpeded translation and circulation paths within the habitat; traffic paths should be sized according to activities, location of crew stations, and size of cargo/crew; a range of scenarios that focus on the size of equipment and crew moving through the habitat need to be addressed
- the intra-vehicular activity (IVA) architecture of the habitat shall provide a minimum of 10.0 cubic meters of habitable volume per crewmember (by habitable volume is meant free volume that the crew can access for working, sleeping, eating, personal hygiene, recreation, exercise, etc.)
- external viewing shall be provided for the crew; windows or video are essential for crew use in observing their external environment
- the architecture should provide multipurpose/flexible activity centers and volumes; multipurpose utilization will increase the efficiency of the habitat, e.g., the wardroom can fold away to create an open area for exercise equipment
- the architecture should provide a consistent orientation throughout the habitat, to provide a familiar and comfortable living and working environment for the crew
- the habitat shall provide two independent paths for crew egress; in the event of fire or other emergency which may block crew access to the airlock, a minimum one emergency exit (hatch) must be provided for crew egress

Research Functions

At the present time (Carpenter, 1992), it is expected that the primary mission operations for FLO and by extension for the first PLH will consist of four primary research functions:

- space physics and astrophysics including telerobotic monitoring of at least three remote astronomy telescopes: Lunar Ultraviolet Transit Telescope (LUTT), Small Research Telescope (SRT), and Small Solar Telescope (SST; Eppler in Carpenter, 1992)
- engineering research including tests on the lunar surface, in-situ resource utilization (ISRU) demon-

stration, evaluation of subsystems and prototypes of future equipment, demonstration of prototypes for future lunar surface processes, and test-bed functions for new materials and construction processes for future Mars missions
- life sciences including botany, microbiology, plant growth, health maintenance, and monitoring of human performance and biomedical parameters, and for operating experiments in human physiology, exobiology, and gravitational biology
- geosciences including geomorphology, monitoring geophysical activity and environmental characterization and regional exploration of the lunar surface

In all phases of the mission, the crew will be interacting with various workstations. Designing these stations around crew capability can maximize productivity (Brown & Bond in Carpenter, 1992). Adequate and appropriate space for these scientific mission operations (both crew-tended and telerobotic) must be provided. Crew size, viewpoint, reach, and restraint should be considered. The gravity environment, required visual data, room to use tools and equipment, and location of task should be considered to maximize crew capability.

Crew Functions and Crew Support Requirements

For the crew to be able to perform these scientific and engineering functions at full productivity, adequate and suitable crew spaces and crew support spaces must be provided in the PLH. These include space and appropriate design for each of the following:
- safe haven
- centralized command and communications center
- mission operations laboratories and workstations
- health maintenance facility capable of emergency surgery and critical care
- exercise countermeasures facility
- wardroom for all eating, meetings, and passive recreation, including adequate space for 12 crewmembers to be seated, share meals and celebrations, and conduct briefings, table able to be reconfigured to seat fewer numbers, especially 6 at one time, communication system for teleconferencing, lighting to allow for task and general illumination, and materials to permit easy maintenance and cleaning
- galley for all food preparation and stowage of consumables, cleanup post-mealtime, and waste management, including space for more than one crewmember to prepare food, food stowage compartments, refrigerator/freezer, microwave/convection oven, food preparation equipment and stowage, food consumption utensils, sink, trash management container, cleanup supplies and stowage, material surfaces conducive to easy maintenance, and illumination for tasks and general activity
- recreation area dedicated to crew relaxation and communication including audio/visual projection system, stowage compartments for video or audio tapes and compact discs, seating for smaller groups of crew members, seating to accommodate quiet activity like reading, space for game playing, space designed for small group casual conversation, and stowage for hard-copy printed books for leisure
- sleeping quarters for both single and double crew occupancy for sleep, privacy, and retreat, including horizontal sleeping space (bed), personal work space, personal stowage compartments, controls for communications and caution/warning system, and accessibility to hygiene facility
- personal hygiene facility and limited hygiene facility near the exercise countermeasures facility and research laboratories, including hand, face, eye cleansing capability, toilet, shower and full body cleansing, mirror, stowage for general supplies, ventilation for humidity control, adequate volume to allow donning and doffing of clothing and drying off after shower, and lighting system for proper visual acuity for personal hygiene
- laundry
- trash management facility
- logistics-stowage area for consumables (oxygen, nitrogen, water, food, refrigerated/frozen food, etc.) and equipment
- suit stowage and maintenance area
- suit donning/doffing area, dust-off, and EVA/IVA compression chamber/airlock

Detailed performance requirements for all of the above and for modular rack components, furnishings and equipment, illumination, and materials, colors, and finishes are given in Huebner-Moths et al. (1993).

Building System Requirements

Detailed building system requirements have been developed for each of the following (and are reported in detail in Huebner-Moths et al., 1993):
- materials
- construction system
- structural system
- connections
- hazard shielding
- energy considerations
- construction sequencing
- expandability and retrofit

For example, the structure system requirements were the following:

- internal pressure of 101.4 kPa
- sustain load from regolith cover or ability to withstand radiation exposure
- survive impact of micrometeoroids
- support internal rack systems
- handle live loads
- support entrance and exit points
- withstand radiation exposure
- flexible
- easily erected and retrofitted

Based on these performance and technical requirements, and on the evaluation of 12 different concepts, a FLO concept was selected, and two concept designs were developed in sufficient detail to learn if the concepts were feasible in terms of research operations and habitability considerations.

First Lunar Outpost (FLO)

In response to requirements like those above, we have chosen to incorporate a FLO scheme developed in the Advanced Design Program at the University of Puerto Rico for several reasons:

- based on the strengths and limitations of an earlier NASA-JSC scheme
- particular attention to human factors in its design
- proposes interesting ways of handling radiation protection/safe havens for short duration stay-times without regolith covering

The scheme is a vertical pressure vessel habitat designed to be integral with the FLO lander, in fact the habitat is embedded within the lander legs and fuel and oxygen tanks rather than being a horizontal habitat resting on top of the lander and tanks as in the earlier NASA-JSC concept (cf. Perkinson et al., 1992). This arrangement provides some radiation protection for the habitat and research spaces. The safe haven is the second lowest level of the habitat.

FLO is divided horizontally into four floors. The lowest level is the airlock and ingress/egress module. The second level is the crew quarters, double-functioning as a safe haven. The third level is the research level. The top level is the crew support facility.

While this scheme has some limitations (e.g., awkward zoning from public entry to private crew quarters to semi-private work spaces to public recreation spaces), it has the distinct advantages of being protected by the structure and tanks of the lander and providing a natural safe haven.

With the proximity of the FLO module(s), the astronauts will have the capacity to reside in FLO while conducting the construction of *Domus I*, or *Dymaxion*.

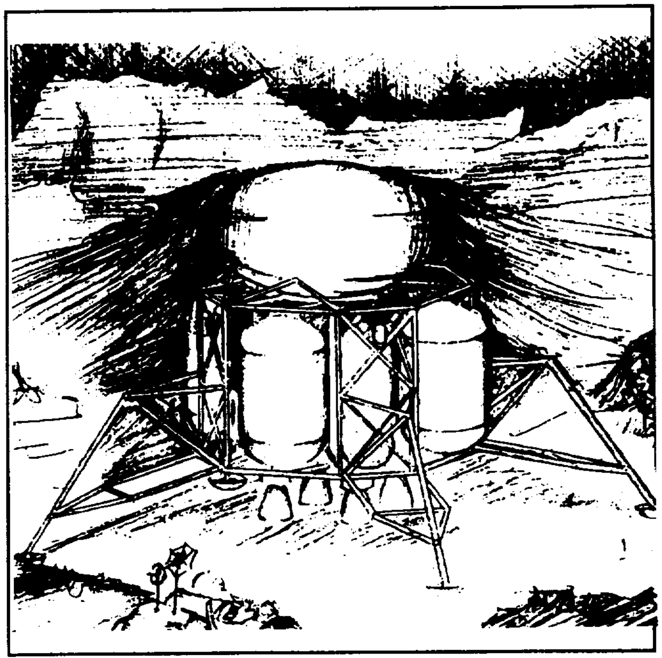

Figure 1. First Lunar Outpost, designed by the University of Puerto Rico Advanced Design Program.

Domus I Lunar Habitat and Research Facility

Initial Operating Configuration (IOC) will be achieved with the outfitting of all interior spaces of the PSSMS concept. After inflation and hardening of the rigidized foam, the structure will be depressurized, allowing easy movement of partitions, equipment, and furnishings into the habitat and research areas. Wall partitions, mechanical systems, hatches, scientific equipment, and all other equipment and furnishings for the research spaces, mission control, crew quarters, and crew support facility will be moved into the structure, deployed, and put into operational mode. Once completed, the three major ingress/-egress hatches will be closed and the entire structure repressurized, thus achieving IOC.

The habitat will be organized as the center of a linear base plan. This central habitation zone will consist of the PSSMS habitat connected to FLO along with a solar collection field.

There are two major component that comprise the habitat. These include three airlocks and a pressurized, rigidized ellipsoid with perimeter torus.

The primary airlock will have a dust-off entry system. The other airlocks, positioned to provide egress capability from the ellipsoid and torus, have rover docking collars. Each can be used for emergency egress with or without a rover docked to it.

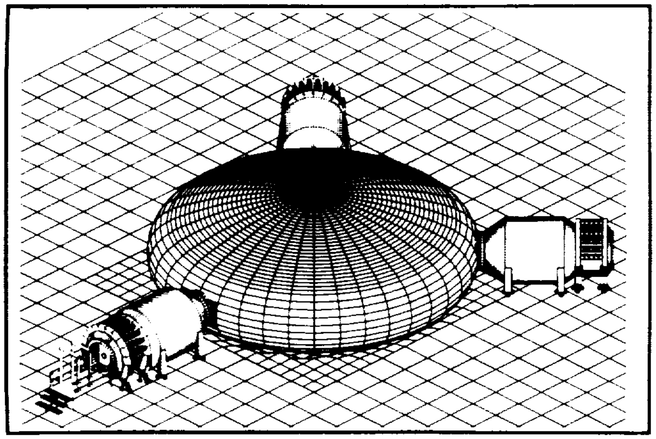

Figure 2. Overall axonometric view of *Domus I* shown without regolith radiation protection system.

To support mission directives, a single-floor semi-public/semi-private outer torus houses life and physical science laboratories, the health maintenance facility (HMF), and the Mission Command and Communications Center (MCCC).

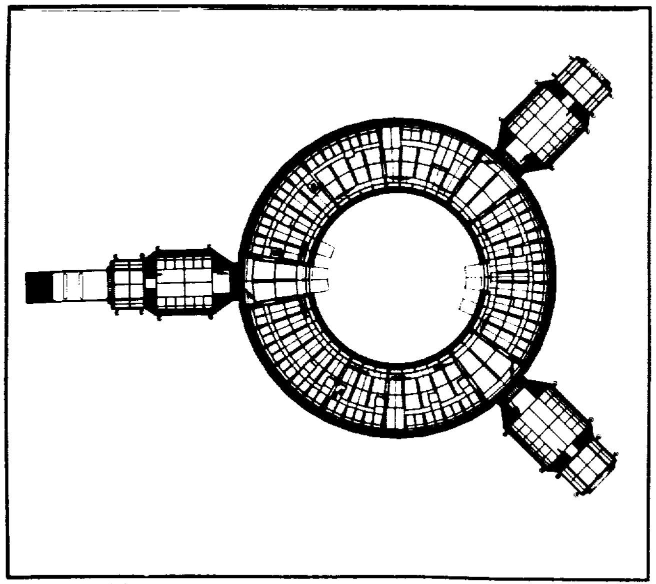

Figure 3. "Mezzanine" level floor plan of *Domus I* -- research laboratories, mission control, and the three airlocks.

The domed portion of the ellipsoid is two-floors-- separating the private crew quarters (lower level floor) from the public crew support facility (upper level floor).

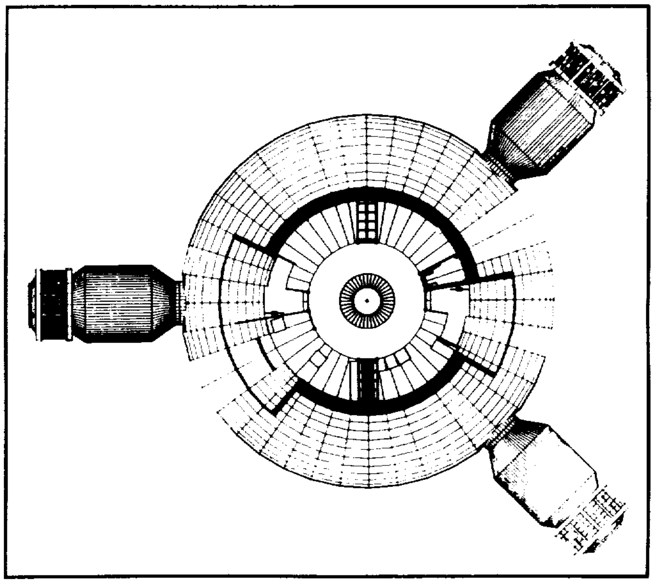

Figure 4. Upper level floor plan *of Domus I* -- crew support facility (wardroom, galley, library, recreation, exercise facility).

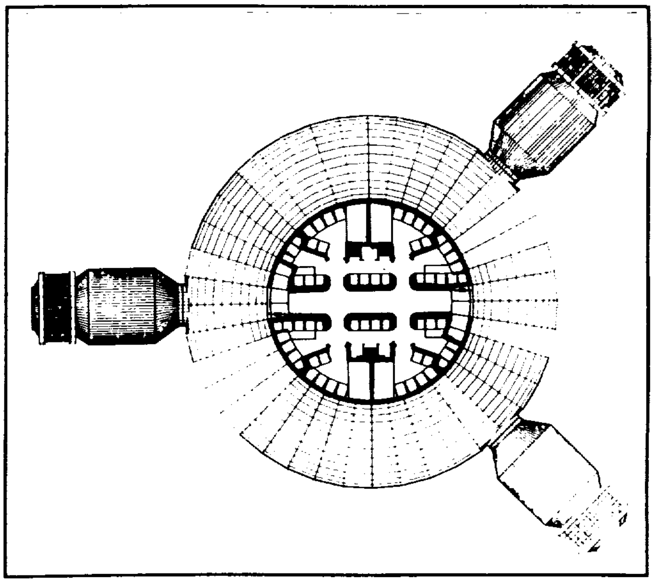

Figure 5. Lower level floor plan *of Domus I* -- crew quarters and personal hygiene facilities.

Kit of Parts, Racks, and Workstations

There are three basic types of workstations that were designed for Domus I. Each workstation is a derivative of a basic rack. The basic rack was divided into a 2 by 8 matrix so that a standard "kit of parts" could fit into this rack. The MCCC workstation, laboratory workstations, and the backup workstation utilized this standard matrix.

The rack dimension is 2.3 m high, 1.2 m wide, and 1.2 m deep. This rectangle is bisected twice. The rear stowage rack is bisected into halves. The front rack is divided into 2 equal unit mods horizontally and 8 units vertically. These are designed as interchangeable parts with different inserts to accommodate various stowage requirements.

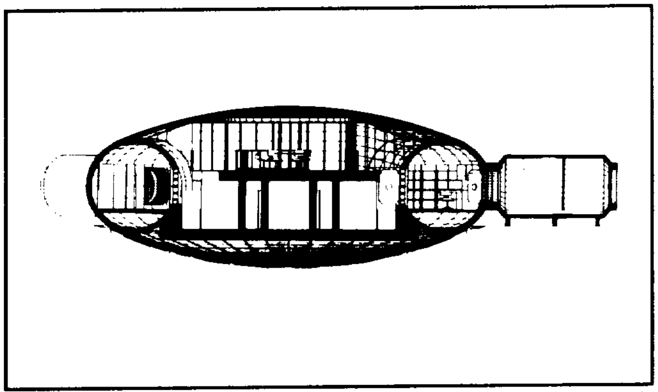

Figure 6. Section through *Domus I* showing the research labs (outer), crew support facility (upper), and crew quarters (lower).

Research Laboratories

The torus is divided into three functional crescents. The laboratories are allocated into the crescents by function and similarity. The human sciences crescent contains microbiology, life sciences, and the HMF. The physical sciences crescent contains two geomorphology labs, botany, and the plant growth chamber. A third crescent contains Mission Control and Communications.

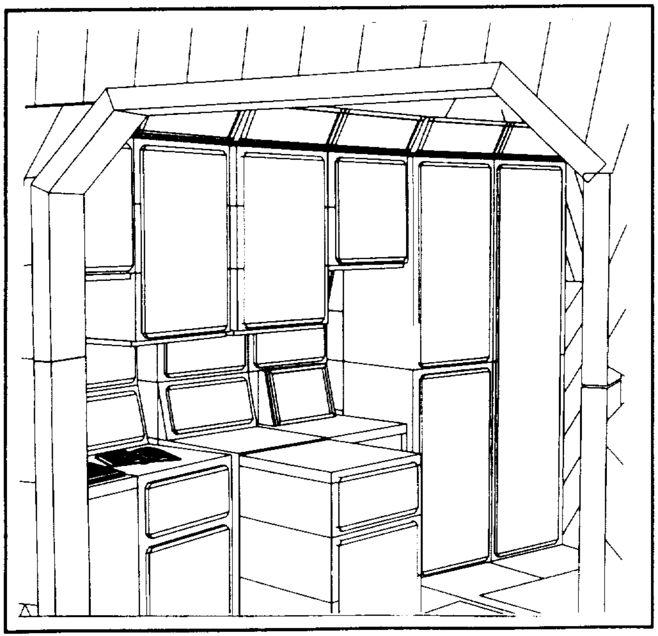

Figure 7. Part of the life sciences laboratories showing the modular rack system and workstations.

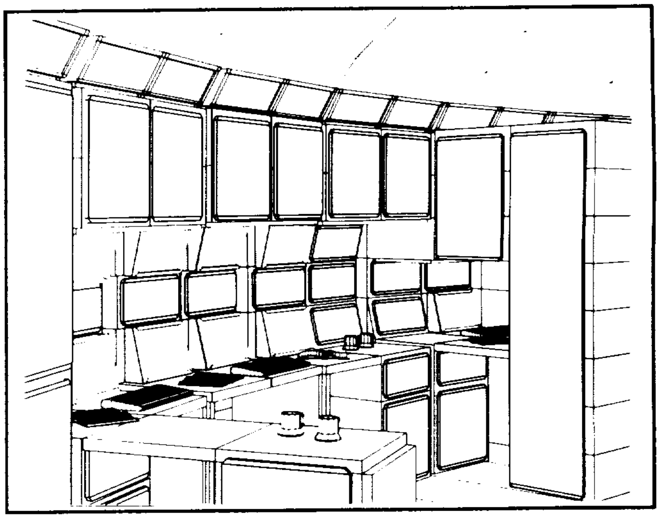

Figure 8. Mission communications and control center in the torus.

Crew Quarters

The crew quarters of *Domus I* are located on the lower floor of the domed interior of the ellipsoid. The are designed to accommodate a crew of 12, with four double and four single crew compartments. These are paired with two full hygiene facilities. Throughout the area, curved bulkheads have been introduced as a safety feature for movement. All the doors are retractable, requiring no additional volume for stowage or opening and closing. Crewmembers will have the option of personalizing their quarters with a number of interchangeable components and color choices.

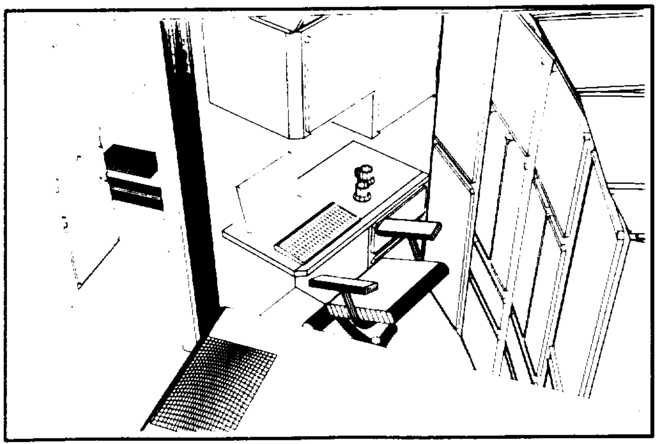

Figure 9. View into one of the single crew quarters looking down at the personal workstation and stowage compartments from the raised bed.

The crew quarters can be isolated from the balance of the habitat at the bounding platforms. The crew floor, being the most protected both by regolith and by the remainder of the ellipsoid and torus with their stowage racks, is the designated safe haven for the crew. This floor can be isolated by airlock hatches from the torus. Caution and warning systems as well as mission control capability are integrated into the personal quarters.

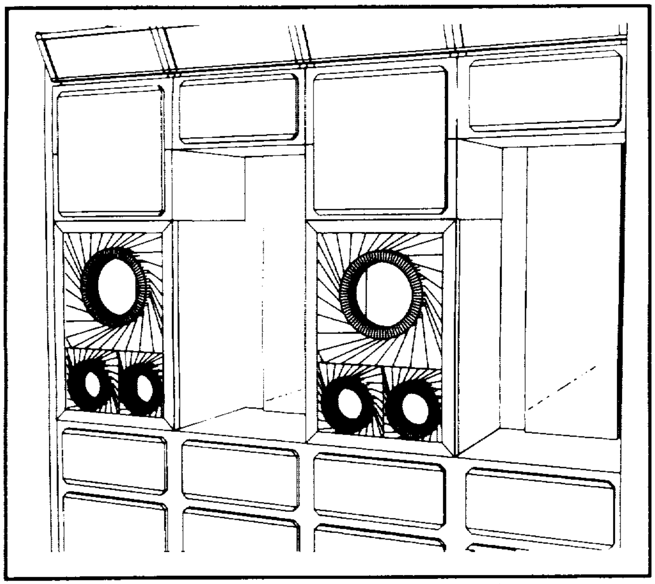

Figure 10. Part of the personal hygiene facility showing the hand and face washing system, mirrors, and personal stowage compartments.

Crew Support Facility

To respond to requirements for privacy and social interaction, the crew support facility provides semi-public meeting places as well as semi-private recreation spaces. Contained in the upper-floor crew support facility are a central wardroom surrounded by an entertainment center, library, exercise facility, galley, and limited hygiene facility. Bounding platforms connect the crew support facility with the research labs and the lower crew quarters.

The wardroom will serve as a central focal point for all the crew's leisure activities and celebrations as well as double function for group briefings and mission telecommunications. The dominant feature is the wardroom table. This table has the ability to be configured in a number of ways to allow for a flexible seating program. With panels stowed in the floor compartments directly below the table's perimeter, a crewmember will be able to easily access the panel and install it on the existing pedestal. The table can also be completely removed to allow the entire space to be open. The chairs that have been designed for the habitat are mobile and can be drawn up to the table to provide seating.

From this central point within the crew support area, the projection screens of the entertainment center are visible. A crew member can prepare a meal in the galley and may use the table for eating. Small groups or the entire crew can be seated comfortably with generous surface space for working. A lighting system in the center of the table will provide task illumination for the crew. There will be a power supply and cable access to install laptop computers. Circumscribing the wardroom space, an illumination light ring will provide general illumination. The key feature of this interior volume is the reconfigurability and allowance for crew involvement in its spatial arrangement.

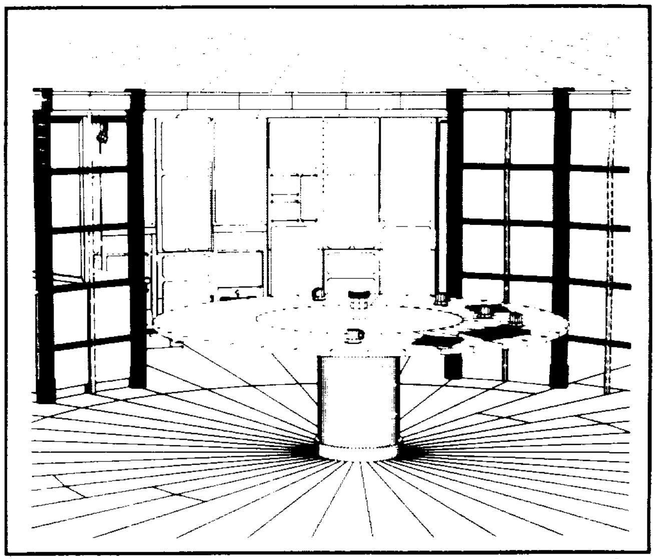

Figure 11. Wardroom view illustrating the wardroom table fully deployed.

The galley is designed for efficiency in food preparation with ample and convenient stowage for consumables and cooking implements. Foods will be stored in ready-to-eat form, dehydrated, thermostabilized, or freeze-dried. Storing additional food will be accomplished by using refrigeration/freezer units. Fixed appliances designed into the rack system are the sink, dishwasher, and microwave/convection oven, along with a hand and face-wash system. Cleanup will be easily accomplished. Counter space has been designed as working surfaces. Lighting is built into the wall rack system. Surface colors and textures as well as the illumination type will compliment the space.

A quiet library location has been provided to access personal choices of reading material. The choices can be electronic as well as hard copy. The library is adjacent to the galley, yet divided by a rack component system. The torus has a window emplaced and provides a viewing port into the plant growth laboratory. Comfortable seating, desk space, and computer capability are provided. Stowage for hard copy and electronic information is included.

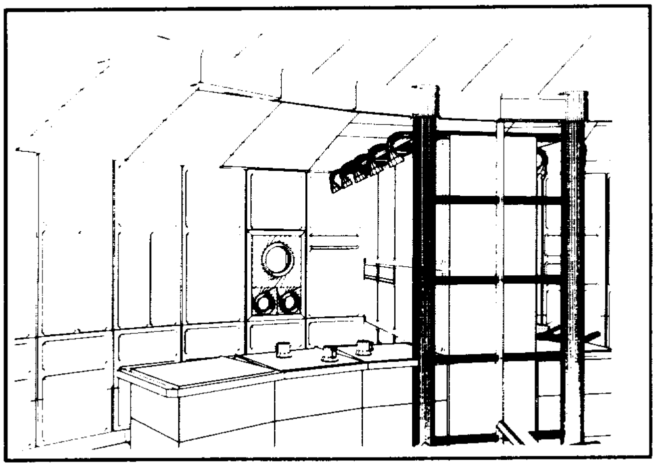

Figure 12. Galley as seen from the wardroom.

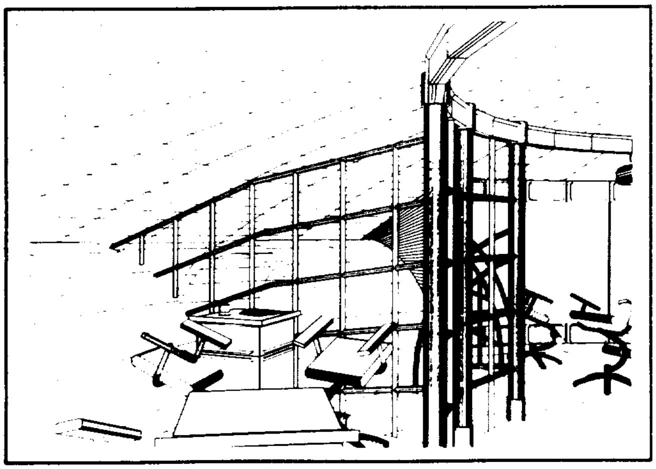

Figure 13. Library and small group recreation area.

A recreation area has been designed with a large projection screen as the focal point. A rack component system spatially divides the recreation area from the exercise countermeasure facility. Yet this entire space is clearly visible from most points within the upper floor of the habitat. The design was driven by the proximities of the galley and wardroom, and the desire to allow the crew to enjoy a video or a viewing of the surface of the Moon during relaxation, while eating or preparing their meals, or while exercising. A major benefit of the large screen system is the ability to conduct full-crew, unobstructed briefings with all seated at the wardroom table. The projection system is located above the table, attached to the light ring.

Stowage components have been included to allow room for tapes and any additional equipment deemed necessary for listening to music or watch the monitor. The floor space was purposely left open to allow the crew the option to bring a chair into the space or to lounge on the floor.

Exercise countermeasure equipment that dual functions has been included in this area. Visually, the crewmember will focus on the wall ahead of the machines. In this space, projection monitors have been installed to provide a variety of settings in which to exercise. The equipment itself is capable of being stowed in the upright position, compacted into the wall rack system. This removes the equipment should additional space be required for crew functions. Although full hygiene facilities are located just below the crew support level, a limited hygiene facility was designed adjacent to the exercise area.

Bounding Platforms

Bounding platforms, rather than stairs or polls, will allow easy access in 1/6th reduced gravity between the three levels of the habitat (see the section in Figure 6 above). The bounding platforms have been designed to accommodate a fully-suited crewmember. Visual access is permitted by the split level positions of the platforms. From the research areas in the torus, a crewmember can see into the crew support facility. Translating down one platform, visual access is gained to the central hallway of the crew quarters area, but not to the crew compartments or hygiene facilities. Lighting of the platform and handholds are provided to assist locomotion.

Conclusions: Critical Design Features -- Strengths and Limitations

Domus I is the result of a feasibility study of the Chow and Lin PSSMS concept on the lunar surface. The results of this design analysis indicate the concept is very feasible from habitability, human factors, and environment-behavior considerations. The PSSMS structure is easily able to be made habitable. The torus versus the inner part of the ellipsoid allows easy separation of work from living areas. The two floor possibility in the ellipsoid allow separation of public crew support spaces from private crew quarters. Orientation and circulation are clear. Translation pathways allow for unobstructed movements of components and crew. Dual egress is assured. Variety of space within tight quantitative space limitations is accomplished. Creating two separate environments within one envelope--the torus and the domed center of the ellipsoid--lessens the number of materials interfacing with one another.

Some additional critical design features of this concept. *Domus I* allows separate work and relaxation realms within the habitat. The separation of work and relaxation may be vital to the well-being of crewmembers. It is a feature found in terrestrial architecture and allows the human being time to refresh and regroup. As productivity is a major component in the success of a lunar mission, creating a positive work environment is essential.

Another feature of *Domus I* addresses the visual and spatial variety of the habitat. Though there are only three major levels of operation--laboratories, crew quarters, and crew support levels are designed with spaces that flow and blend with one another, while being distinctly different in style and character. The torus portion, dedicated to the laboratories, differs in geometry, color scheme, and workstation arrangement from other parts of the habitat. Work spaces are open; walls have windows emplaced to promote a visual sense of spaciousness. Those areas dedicated to the crew are in the central domed ellipsoid. Some spaces, like crew quarters, have curved outer walls. Translation spaces in the crew quarters are rectilinear, centrally located, and clearly connected to the bounding platforms. The ceiling of all crew support social spaces is slightly domed, giving a more spacious feeling for these relative large group spaces.

The crew has a choice of single or double quarters, in agreement with various aerospace professionals who encourage spaces be designed that will allow a crewmember to be alone for some period of time. Personalization is encouraged with interchangeable panels of differing colors, and privacy when needed is assured.

The crew support facility is separated from the private crew quarters. It is designed as an open-plan arrangement with a larger central volume to serve the entire crew and supporting facilities on the perimeter. This area allows visual and social interaction among the crewmembers.

Safety is a prime requirement of any structure housing human life. All levels and spaces in the habitat have been designed with dual means of egress and the ability to "lock down" a specific area in the event of a system failure or solar flare. Communication and computer systems can be accessed in numerous locations throughout the habitat. Provisions for short-term stays in the safe haven area--the crew quarters--have been included.

The rack component system allows for change-out and can be shifted within several areas. These designs respond to the change in the anthropometric alignment of the body in the 1/6th *g* of the Moon.

The construction method of the habitat has not been perfected. Yet, it appears that the construction may be relatively easy to achieve. Site preparation that requires little EVA time for the crew will be beneficial.

Outfitting the interior of the habitat in a shirt-sleeve environment will permit the crew to work without the bulk of spacesuits. There are few components to the entire facility. This fact will allow for easy expansion at the airlock locations. Fewer components means fewer interfaces or potential points of failure.

The volume of the habitat is not expansive, yet every effort has been made to have the geometry appear as though it is. When coupled with the component system flexibility, these spaces should serve a variety of individuals who will inhabit the facility during their tours of duty in a diversity of different spatial settings.

As yet, widespread testing of inflatable technology--and of the PSSMS system in particular--has not been accomplished. The theory behind inflatables, e.g., great volume attained with a reduced amount of packing volume, less weight at liftoff relative to great amount of resultant space, etc., are important characteristics dictating further promotion of the technology. Adding the use of rigidizing foam to enhance the structural integrity is of considerable value added.

With the technology of inflatables still in the discovery stage, *Domus I* has been developed under the assumption that living within a pressurized, reinforced-fabric envelope is not only feasible, but practical. Still to be determined is the method of packaging the envelope and the best strategy to deploy the habitat on the surface of the Moon.

The major limitation of *Domus I* lies in the currently uncorroborated technology of the construction methods and materials. The construction process will demand the use of various types of equipment yet to be developed. In the interior portion of the habitat, further testing will be required to evaluate locomotion within a torus (in 1/6 g). Post-occupancy evaluation (POE) will be vital as lunar bases of the future are constructed and inhabited for any length of time.

In summary, the PSSMS *Domus I* concept seems extremely feasible and deserves most serious exploration by the various lunar program offices at NASA.

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