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CAMELOT III: HABITABILITY CRITERIA
SPACE RESEARCH AND DESIGN STUDIO

SCHOOL OF ARCHITECTURE
UNIVERSITY OF PUERTO RICO

RATIONALE

Acknowledging the importance of human beings on a mission to Mars, the University of Puerto Rico studied both psychological and physiological aspects. Different conditions necessary for human health and well-being were considered. As a result, habitability criteria were developed.

When we speak of habitability, we refer to the state of equilibrium that results from the interaction between the components of the complex "individual-architecture-mission," that allow the person to sustain physiological homeostasis, adequate performance, and acceptable social relationships.

On several occasions the relation of "man-machine-mission" has been referred to as the system that governs actions in space travel. Probably that has been the dynamic within the missions accomplished thus far. However, the mission should not be conceived as a "great machine" that is to be expected to perform an assignment, because humans are not machines, but living beings who react positively or negatively according to the environment that surrounds them. For this reason they should not be treated as objects or pieces of a system, but rather as key figures within it, in keeping with the objectives of the mission, acknowledging the physical and technical aspects that must be taken into account in space travel. This could be compared to a "bee hive" (colmena) that scientists describe as a "living organism" in the whole, because of the mutual dependency and interaction among each of the components of the "colmena." Ultimately it is not possible to really conquer space if the appropriate means are not attained to make it possible for humans to develop there, beyond the level of mere survival.

Thus, architecture as an art-discipline of creation of environments that promote good physical and psychological performance for humans, whatever their needs or activities, must be recognized for its primordial role in the design of the vessels that will become the habitats of space travelers, especially those who will stay there for prolonged periods. Obviously the success of such a mission will be highly influenced by the quality of the architectural design of such a habitat.

It should be pointed out also that the environment in these travels will be made up by the physical (material and technological) parts of the vessel and by the nonphysical and psychological aspects that must harmonize and complement each other. That is, in order to develop the design of the physical habitat, first the nonphysical and psychological aspects of the environment to be created for prolonged travel in space must be studied, to identify and reinforce those desirable conditions that are found, and to repress or eliminate completely those negative aspects that may come out. This endeavor will allow the designer to stay within a correct frame of reference or context, which will guide him as he develops architectural form and as he makes design decisions.

After studying psychological conditions and physiological effects associated with prolonged space travel, we have established a list of intangible psychological aspects that must be considered in the architectural design process to create a realistic physical environment that is to be a positive contribution to the quality of life—not mere survival—of space travelers. These we have called habitability criteria, which later on will be tested or better yet, demonstrated in the architectural development of a specific habitat.

HABITABILITY CRITERIA

In the design of habitats for prolonged space travel the following must be considered:

1. *Personal identification.* Travelers in space actually realize they cross the threshold of space, leaving the Earth behind, as soon as the environment and everything they sense become unfamiliar. From writings and expressions of astronauts and cosmonauts we have learned that they refer to the immediate physical surrounding envelope to establish a sense of identity and relationship to ensure security and as much comfort as possible within such a new, strange, and hostile environment. Many space travelers have expressed their sense of alienation within the surrounding envelope, but also have developed a "sense of belonging" as soon as they are within the vessel. To satisfy such a need, habitable places must be able to be "personalized" with objects and arrangements of family photos, souvenirs, etc. Some degree of flexibility in furniture and equipment arrangement within the specific area in which each traveler is to relate to as his/her dwelling place is also advantageous.

2. *Social interaction.* To be able to share and to feel the presence of others seems to be very important in prolonged space travel. The sensation of knowing companions are nearby promotes a sense of security, of not being alone, and of mutual confidence and trust among travelers. Therefore, it is necessary that within the vessel there be areas designed in such a way that they promote positive group dynamics and good social interaction, since to a great degree that will enhance the inhabitants' sense of being humans.

3. *Unpredictable conditions.* Many of the astronauts and cosmonauts who have had the experience of prolonged stay in space have expressed their profound appreciation for positive surprises, whenever they would find something new, something unexpected that was nonthreatening, or something

was discovered from a hidden condition. There is a deep need to escape routine and tedium. Elements of surprise were incorporated in many special occasions to celebrate and commemorate events, seasons, birthdays, holidays, and anniversaries. In such a confined lifestyle one begins to understand the necessity of major and minor festivals to enhance the liturgical acts of ordinary days. This suggests that besides the specific required areas in the architectural program of the vessel there must be allowed to exist areas without a specific or rigidly defined use, or better yet, areas of universal use that could change surprisingly according to the festivity. On the other hand, elements within the design of the vessel (ceilings, walls, "windows") could be programmed to change unpredictably to impart a sense of variety within the habitual routine of having to live in a very confined envelope. After billions of years of development in the "terrestrial vessel," humans have learned to consider it a punishment to constrict themselves to an unchanging restricted environment. Here it should be viewed, rather, as a protective, friendly, and motherly womb, capable of sustaining as well as entertaining human life in a style of quality.

4. *Contact with nature.* It must be understood that the environment in such missions has two additional key elements: the individual and the architectural. It is necessary to create a system that would maintain equilibrium between them. In such a relationship the greatest contrast exists between the person and the machine-artifact, which we have called "architecture," of the enveloping vessel. For billions of years humans have developed relating to a "natural" environment that is not an artifact or a machine. Thus, prolonged space travel will put humans in a completely artificial relationship with nature, which is important to consider. A different sense of "indoors" and "outdoors" must be developed. Even though it is important that the surrounding universe be perceived through windows that permit vision beyond the limits of the vessel, it is also important, even within such limits, that contact with natural objects be kept and promoted. This contact with nature could be attained through the presence of plants, animals, or aquariums, which may or may not be part of the environmental life support system of the vessel. Besides the scientific value that such a contact may have, it has the practical value of the pleasure and enthusiasm that it gives the travelers as they work with and observe the natural processes taking place: growth, blooming, harvesting, and all the natural processes of life. A great fascination and enjoyment has been reported by astronauts and cosmonauts as they got involved in the observation of such processes that entail changes from the routine. It seems to be a very enjoyable and important contact that can also be coordinated with the life support of the vessel.

5. *Mental landscapes.* When in the study of psychology reference is made to enclosed spaces, such as we find in vessels traveling in space, they are called "acute places." It is important that these acute places contain symbolic elements that would evoke diverse memories and sensations. This is termed "a mental garden." Such gardens and even landscapes help a person to transcend his or her immediate physical reality through images, photos, forms, spatial sensations, colors, textures, and materials.

6. *Privacy.* Even though positive group dynamics must be promoted, and a lot of social interaction between passengers on such vessels should be encouraged, a certain degree of privacy should also be provided. Lack of privacy has been demonstrated to be the most irritating factor to humans in confined and restricted environments. This is true of every culture, although it varies to the degree in which the extension of personal space or territorial dominion is and has been expressed in history and in different socioeconomic strata. It seems reasonable and important as well to assign to each person traveling on the vessel an area that can be made "private," that he or she could call his or her own, so that he or she could arrange and accommodate to a certain degree to his or her taste, needs, or will. Once this is established then the question is how large or how much area is adequate for fulfilling the need for privacy of a person traveling for prolonged periods in space?

This is a difficult question, since its answer is dependent on culture, sex, age, duration of the mission, and the general background of travelers in the vessel. Previous studies such as that published by the architectural firm of Warner, Burns, Toan and Lunde (New York) have concluded that the minimum acceptable volume for a dormitory would be 350 cubic feet. That is approximately the cubage generated by an erect human figure with arms extended.

7. *Equalitarian conditions.* Research performed in Antarctic stations regarding social behavior tend to disfavor strict hierarchical systems of personnel. Such stations were originally organized in strict rank hierarchies of personnel. Later the system was relaxed and emphasis was placed on purpose, rather than rank. Interpersonal relations became more relaxed, group morale was boosted, and group work became easier and more productive. Research by Warner, Burns, Toan and Lunde showed that even though social dynamics vary, a space station would work better under equalitarian conditions among crew and passengers rather than strict hierarchical ranking orders. Architecturally this could be reflected, for example, in the quality, size, and location of the rooms of the travelers. Differences should reflect purpose and functions, as well as individual preferences, rather than rank or hierarchy.

8. *Variety.* Psychological studies suggest that similar elements and repetitive features in the interior of an acute place are boring, and cause irritability and environmental stress. It is important that in the habitable places of the vessel there be a degree of variety in elements, shapes, furniture, partitions, decor, and color.

9. *Functionality.* For a place to be considered "habitable," in the qualitative sense, it must perform well as a dwelling or abode for humans. It must meet physical as well as psychological needs for the sustenance of human life, individually and collectively, supported by all the technical means that aid in the fulfillment of the mission. It must contribute positively to the success of the mission by providing a proper stage or proscenium for the drama of human life to develop appropriately.

10. *Sensory stimulation.* Travelers in space must not be deprived of sensory stimulation. It is fundamental that they have as close to normal and as varied as possible a range of sensory stimulation. Such sensations are the primordial matter

of human experience, and through them the learning process takes place. Surfaces of the vessel should be treated with color, which stimulates the visual sense in a meaningful coding system, as well as texture, which will stimulate tactile sense and would help solve acoustic and friction problems under microgravity. Smells within the vessel must be controlled, since unpleasant odors due to oxidation or other biological processes do not contribute to a positive environment. Food must not only be nutritious, but also should be appetizing to the eye and the sense of taste. The acoustic system should not only guarantee satisfactory communication among the travelers, but also provide for privacy, even in the profound silence of space. Standing waves, flutter echoes, and unpleasant resonances should be eliminated. The atmospheric pressure and gas composition may alter the frequencies in which sound is perceived; thus a voice change will be noticed first, as well as a shift of the musical notes for the discriminating amateur or the professional musician.

11. *Music and environmental sound.* The most critical acoustical problem of the travelers on a vessel moving inertially through space without engines on is that of silence. They would be able to listen to all their visceral movements, would be startled by very minor sudden noise, and would be listening to all the conversations that they may not desire or be entitled to hear. Electronic sound masking and environmental music is a possibility. The air conditioning system could be so designed to produce enough "white sound" to attain a masking effect.

12. *Stability and security.* Stability refers to that tendency or inertia that resists forces that cause motion or distortion. Human reflexes and muscle tone developed in the surface of Earth under normal gravitation will find alien an environment in which there is artificial gravity or a gravitational gradient and a significant Coriolis effect. Thus, the environment must offer means to compensate for the sense of instability and insecurity that will result from being subjected to such conditions.

13. *Comfort.* This includes conditions such as illumination, temperature, humidity, pressure, and atmospheric compositions, which can be accurately determined according to standards that must be objectively applied to the design for the habitable places in the vessel.

14. *Sense of orientation.* In space the sense of up and down as we perceive it on the surface of Earth is absent. In an artificial gravity vessel, up would be toward the center of rotation and down would be away from it. As passengers move toward the center, even that gravity will diminish. The orienting sense of a horizon will not exist and the line formed by the two eyes that provides our sense of stereoscopic vision will become a very subjective personal reference. The architectural design of such places could contribute to reinforce a common sense of orientation for all the travelers rather than ignoring it. It is conceivable that treatment of the surfaces could be such that it would differentiate similar parameters as on Earth, such as floors as surfaces designed to walk on, ceilings as vertical limits of volumes, and walls as work surfaces and area definitions. Colors, texture, light sources, materials, and symbols could order or reinforce an agreed-upon convention, which will create a different sense of orientation to be shared by the travelers.

ARCHITECTURAL DESIGN CONSIDERATIONS

Having established the habitability criteria above, we will use them as a frame of reference or context to develop the habitat for a specific mission and group of travelers on a prolonged stay in space. Architectural design here must translate the habitability interior into a proposal for a physical reality and analyze the following data regarding the mission itself.

Design Factors

Nature of the mission. It is important that the mission objective be restated in terms of its architectural implications, since it is on such a basis that the design process will have its point of departure. The design of the vessel and its habitable places should be done in a way that will promote the fulfillment of the objectives of the mission.

Duration of the missions. Time spent within the interior of the space vessel is a vital component in the understanding of the psychological picture that will arise within the habitat environment. This will serve as guide and context for the design process.

Size of crew and/or number of passengers. This factor will serve as a guide to decide the nature, number, and type of areas and places listed as architectural program requirements for the vessel, as well as its minimum requirements for the vessel and its minimum required dimensions.

Size of the crew and passenger characteristics. The success of a mission in space depends to a great extent on the type of dynamics of interaction that is generated or developed between the sidereal travelers. It is very important to analyze the characteristics of this kind of people, and ensure that the architectural design of the habitable places contribute positively to the development of good group dynamics. For example, group recreation areas, meeting rooms, leisure facilities, as well as individual quarters should take into consideration factors such as age, sex, physical conditions, interests, and purpose of the crew and passengers.

Flexibility for change. There always exists the possibility that the number of crew members and/or passengers can change according to circumstances. Nevertheless, design of the habitable areas, as well as the psychological group dynamics, will place constraints and will limit such a possibility in the design of space vessels.

Gravitational force. It has been demonstrated that the absence of gravitational force in prolonged stays in space promotes deterioration in the physiological and anatomical characteristics of humans, particularly if they intend to return to an environment subjected to gravitational force. Thus, artificial gravity by rotation becomes a must, since physiological conditions will be altered by its presence or absence. In a mission to Mars it may suffice to have 0.4 *g* by and large, since it will serve as training and conditioning on the travel towards the planet. Therapeutic actions will have to be taken for the returning crew and passengers as they approach Earth. Measures will have to be taken to provide for security and stability of motion of people due to the presence of a gravitational gradient in every "up" or "down" movement (in or out from the center of rotation) and also in every sideways movement due to the Coriolis effect. The rotation to induce artificial gravity would have to be sufficiently large to offset motion by humans in the opposite direction of rotation so that there is no significant reduction in the centripetal force that creates the gravity effect. The human, being such an adaptable creature, subjected to such conditions for some time, would modify conduct and reflexes in accordance to such an environment. Nevertheless, the architecture should be expected to be of aid in such an adaptative period, as well as the time after the travelers have become familiar with such an alien environment.

Activities. Habitable places must respond to the activities and events in which crew and passengers will get involved during travel. Thus a program of activities has to be developed and the architectural design of the vessel must include a degree of flexibility to satisfy and support such activities.

Technology. Obviously, and in all humility, such vessels cannot be designed by architects. The aerospace engineer, the scientist, and the technician must come into the process before the architect. Specialization must provide the answers to prolonged travel in space before the architectural design can effect its integrating function and the imposition of aesthetic orders, social, psychological, and other quality-of-lifestyle considerations. Space vessels must have operational systems, both interior and exterior, which have a greater priority in the sustenance of life.

ARCHITECTURAL TRANSLATION OF HABITABILITY CRITERIA

Strategies

Having established habitability criteria and the factors that will serve as design parameters for space vessels and their habitable places, we should consider the strategies for developing architectural concepts in such a design process. This way the habitability criteria can be translated from a conceptual to a physical reality. An explanation of the way we conceive such a strategy follows.

Fixed Volumes

When the interior areas or volumes of a space vessel are to be designed, in our case CAMELOT III, it should be decided what type of system is to be utilized in order to define such volumes. The system can use furniture, as well as vertical and horizontal plane divisions (using terrestrial parameters of horizontal, meaning along the circumference of rotation, and vertical, meaning toward the center of rotation, to create artificial gravity). These can be fixed or flexible, modular, or a combination thereof. Whichever option is selected, it must reflect the habitability criterion related to functionality. Nevertheless, each possibility has positive and negative aspects that must be weighted. Fixed volumes provide security and stability, since each area would be designed for a specific use or uses. However, since there would be no flexibility and no possibility of change, this can cause a decrease of motivation and excitement in the travelers and be boring after a while.

Modular Volumes

A system of furniture and vertical partitions that are modular can be utilized to organize the habitable areas of the vessel. All its elements are designed in such a way that forms and dimensions are congruent, but each is potentially capable of existing in formal terms alone or combining with each other to form a greater complex. Such a system requires a coordinated relationship between parts and the total design of the vessel, since the whole and the parts must complement and fit each other. This system can provide certain varied possibilities limited by its inherent characteristics. Thus, according to the manner in which elements are combined, there could be variety in the habitable areas, since configuration could be altered according to design. This type of system fulfills the criterion of variability, as well as that of equalitarian conditions among travelers by providing the potential for all to develop the quality of places. However, the possibility of making changes allows space travelers to rearrange certain areas according to their preference aiding their personal identification with such habitable areas.

Flexible Areas and Volumes

A flexible volume is that which can have its configuration completely altered. This means ceiling heights, movement of walls, movement of furniture, lighting changes, and even use change. Such a system has its advantages, since it reinforces the following habitability criteria: variability, functionality, personal identification, and social interaction. Travelers can program such changes in volume through the use of computers including random variables in order to fulfill the criterion of unpredictable conditions. Floors and walls could be made of a moldable material that could change its configuration at the proper command. If it is decided that the habitable places in the vessel have to be flexible, then rules and parameters must be established to guarantee that the objectives and the mission can be fulfilled and also that the common welfare of the travelers can be assured.

Combined Volumes

A combination of the aforementioned alternative systems is one of the better options that the designer has for the solution for these volumes. Some areas, such as kitchen, bathrooms, laundry, etc., lend themselves to a fixed system because of the hardware and fixtures involved. These should be considered first. Then modular volumes could be considered, since changes here can be affected with constraints. Finally, the flexible areas will be considered as stages on which many things can happen. This combination has the advantages of all the previous and also reinforces all the individual criteria of habitability that each fulfills separately. The criteria included are variability, functionality, unpredictable conditions, personal identification, social interaction, and equalitarian conditions.

Concepts

Besides deciding the design strategy to be utilized in reference to fixed volume, modular, flexible, or combined volumes, architectural quality must be considered. For such consideration we should point out the following concepts:

Spatial sensations. Each one of the habitable places in the vessel must possess a proper identity according to its use and the way it was designed. In each of the habitable places space sensations and the way they are perceived will depend on the use of color, texture, materials, size, utilization of the furniture, and the kind of impression that is to be made on the user of the place. These sensations on the user can be termed as privacy, intimacy, monumentality, pleasure, security, etc. Habitability to be enhanced with these sensations will depend on the effect to be attained. Obviously all could be fulfilled in general, or some specifically, but it becomes clear that no matter what kind of spatial sensation is accomplished by the design, there would be a generous sensory and perceptual stimulation.

Sense of scale. It is important that the design of the vessel and its habitable places take into account the physical dimensions of the human body and proportion the sizes of the volumes of the places to be created accordingly. This is termed in architecture as "sense of scale." The human would fit comfortably in places that correspond adequately to his physical dimensions. This does not mean that all spaces must be of a specific or standard dimension, but that there be a correlation between the elements utilized or the strategies followed that reflect or refer to the user—the space traveler, in this case. The sense of scale will depend also on the furniture, equipment, fenestration, ceiling heights, materials, etc. Among the habitability criteria reinforced by this factor are personal identification, privacy, orientation, and comfort.

Gardens. Architects have always harmonized their designs (artifacts) with nature, and the use of the interior gardens has been one of the resources with which such an intention has been accomplished. Obviously, by virtue of the conditions of the extraterrestrial vessel, contact with nature through interior gardens is very important. Such resources must be used in strategic places within the configuration of the vessel, so that they would positively contribute to the activities programmed to occur in such places.

Appropriate technology. Architectural design of such a vessel must be able to incorporate the latest available technology to attain functionality, psychic comfort, variability, unpredictable conditions, and variety in spatial sensations. To that end, it should utilize holography, videos, computer resources, cybernetics, chemotecture, biotecture, cryotecture, etc.

Lighting. Illumination is one of the most important elements that a designer has to enhance habitable places. In this case all lighting is artifical or manmade. It should correspond to the kind of volume, the use that it must respond to, and the spatial sensations that are to be created in it. The type of illumination utilized will also influence the physical and psychological reaction of the travelers and will contribute directly or indirectly in all the habitability criteria. Unpredictable variations could be introduced so that lighting can have a degree of variability similar to the terrestrial environment.

Interior design. Selection and design of equipment and furniture must also reflect good design to reinforce the fulfillment of habitability criteria. Dimensions of the humans, proportions of the body, and the alien conditions of microgravity or artificial gravity will have to be taken into account.

Other considerations. Symbolism relating to culture will aid in creating mental gardens and landscapes to enhance the quality of life in the vessel; form and traditional vocabularies that make reference to terrestrial life and the history of the Earth, and the enjoyment of the peak artistic accomplishment of humanity through recordings in fields such as the performing arts, and in the visual arts by means of holography, will all contribute to the quality of life during travel in the vessel.

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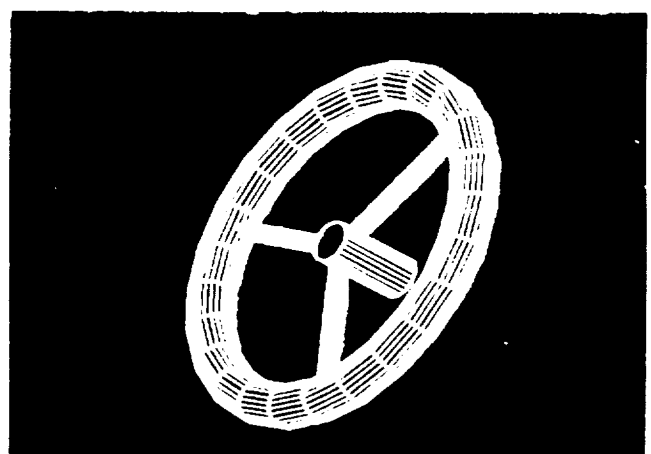
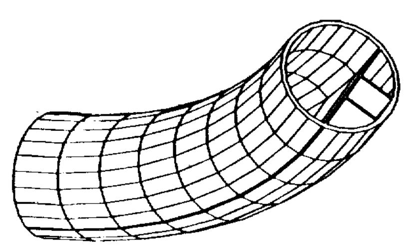
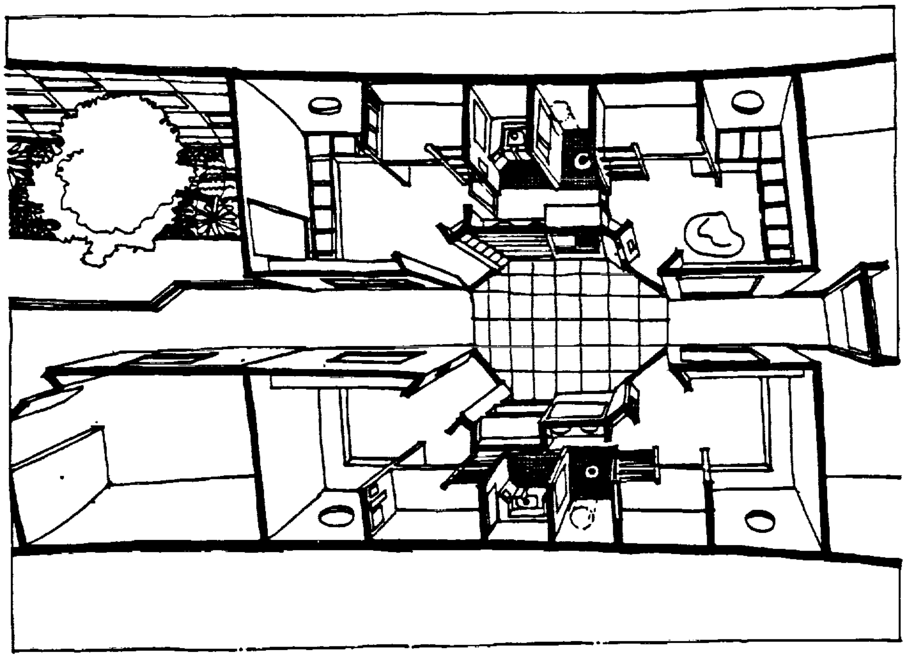


Apollo Workstation Views of Camelot III.

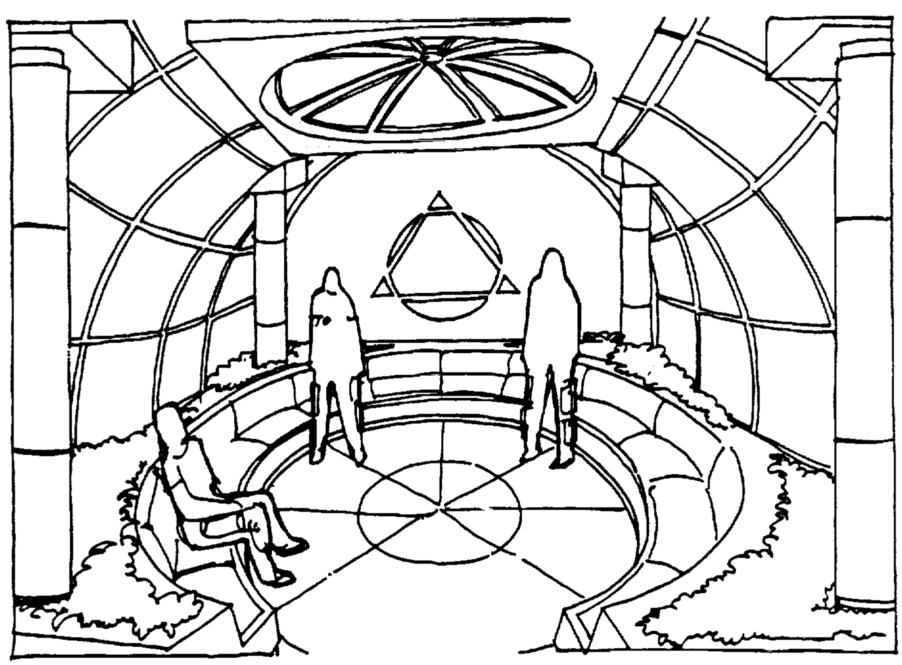


Isometric Section.

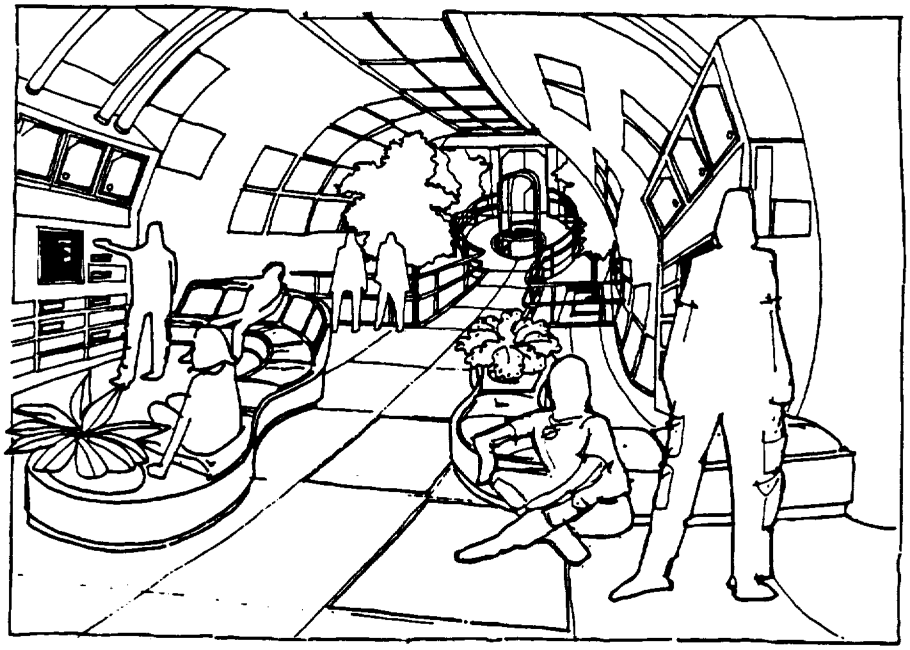
Illustrations continue on following pages



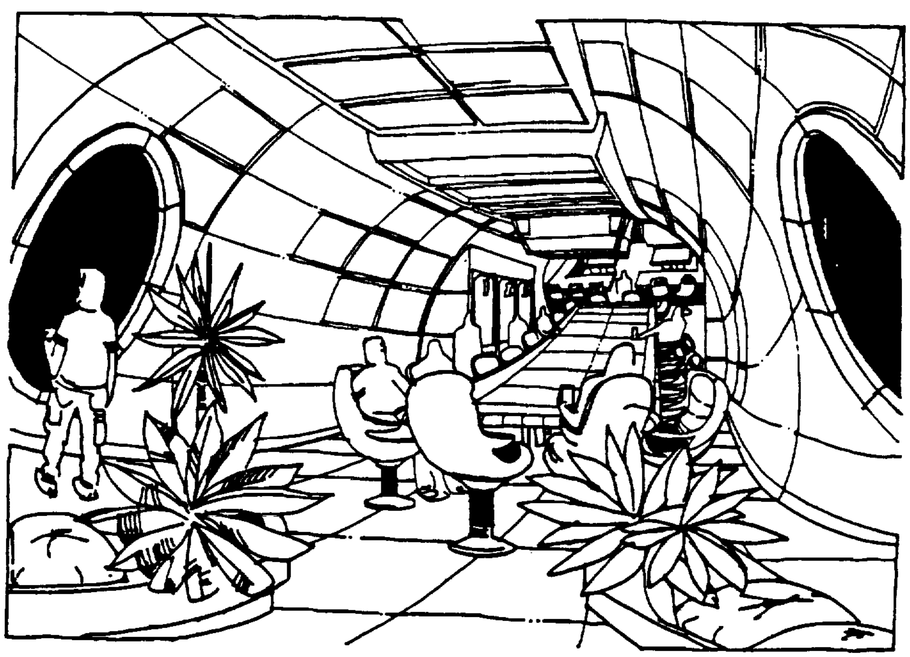
Bedrooms (3.04 m × 3.04 m): The cabin arrangement for passengers allows the individual users to have a private place. It has a sleeping area in the left and small living area, work space, or small office. Each room shares a bathroom/toilet with the adjacent room, except in the case of crew who have individual bathrooms and a large area. The organization of these cabins took communal relations into account. Rooms were aligned along a hallway where trees and plants that are parts of the CELSS development, creating a sense of contact with nature and a feeling of "outdoors" and vegetation. There is a communal area in the center with a small lounge and a laundry.



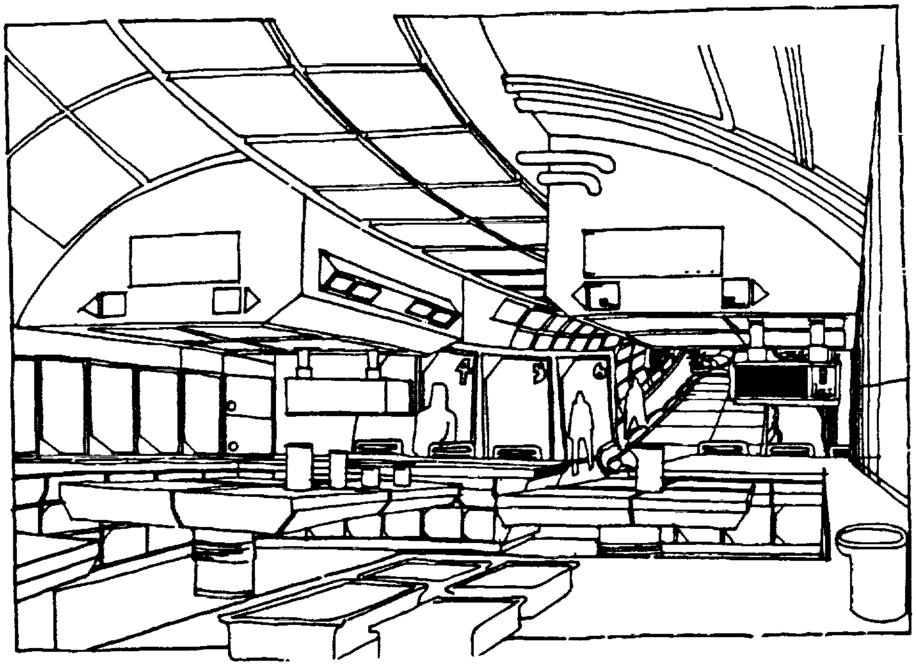
Chapel (8.23 m × 7 m): This is a place for quiet meditation that can alter its environment through light effects and holographic projections. It should lend itself to individual prayer, as well as corporate acts of worship. It will have a quiet and ecumenical character, so that it can serve all faiths.



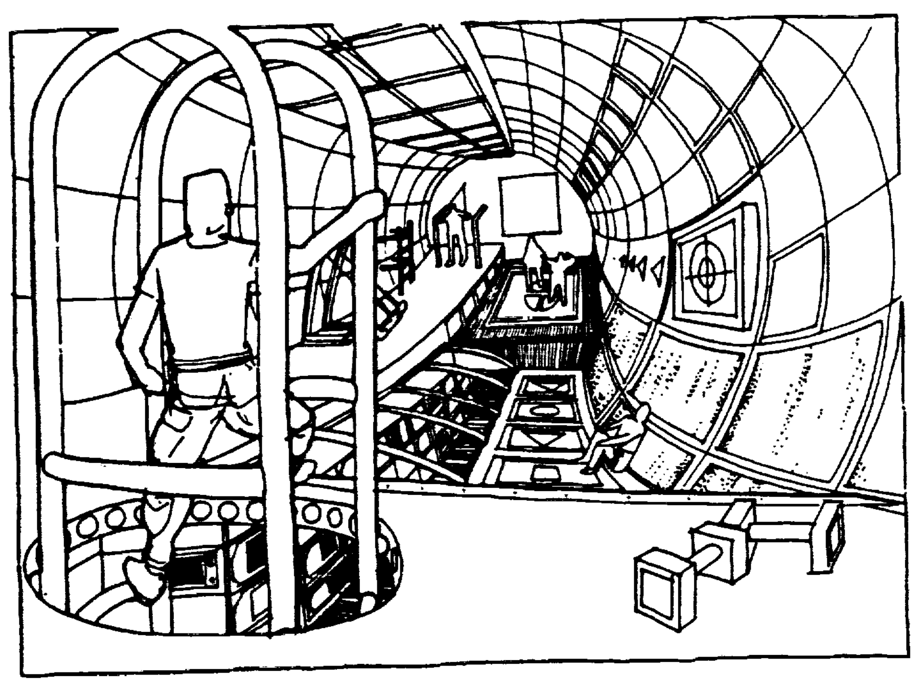
Lounge (12.8 m × 7 m): An area for passive recreation, conversation, and sharing. It will have video system, sound systems, books, and microfiche, in areas with individual as well as communal seating.



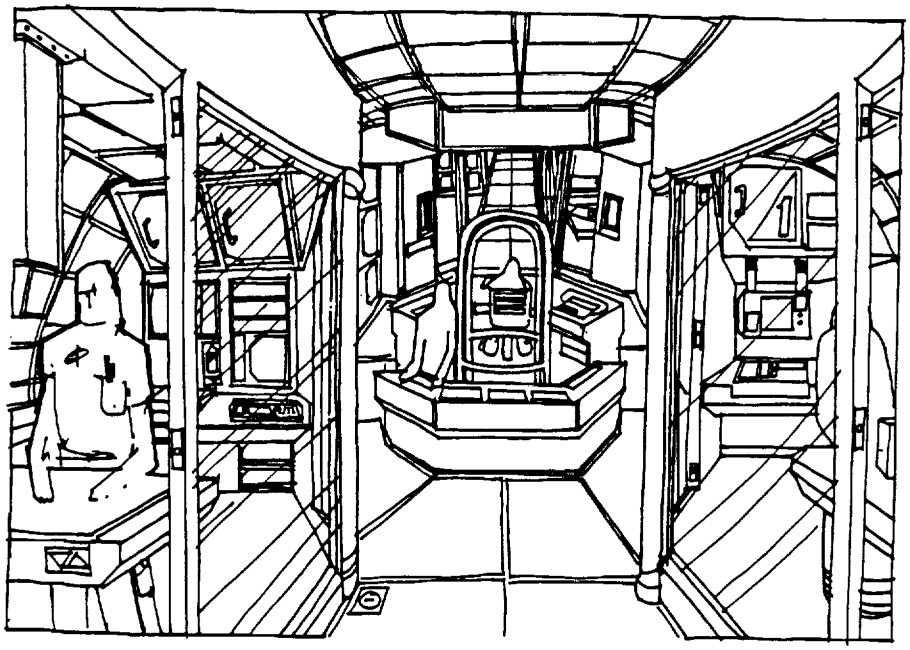
Conference/Dining (14.63 m × 7 m): An area with two main purposes: one for eating, the other for meetings of all passengers and crew or special occasions and/or emergencies. It houses a large conference table, a counter area, and is adjacent to the kitchen, freezer, and a small lounge area.



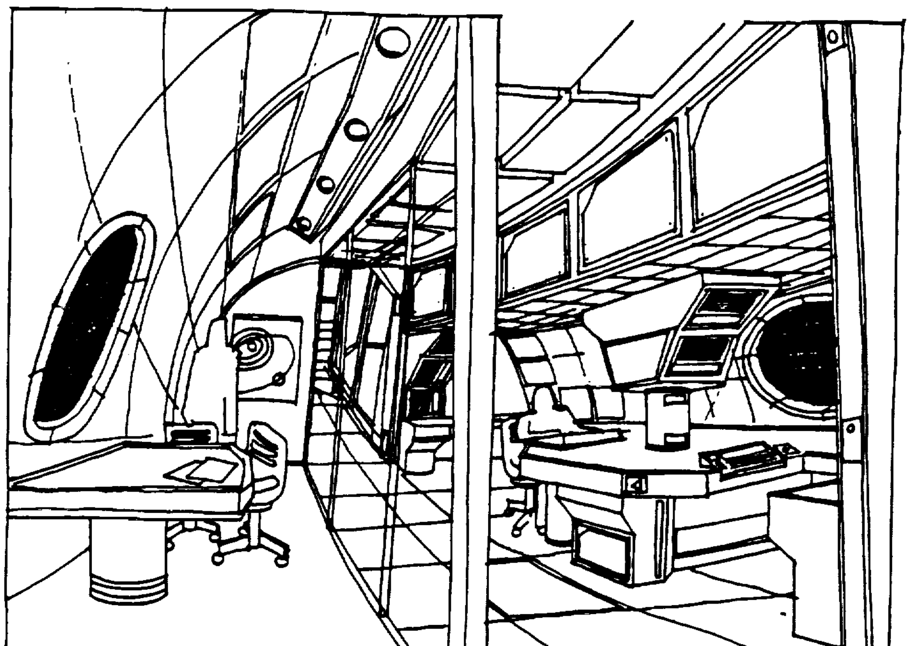
Kitchen (4.57 m × 7 m): The kitchen is totally automated for greater flexibility and convenience. Food will generally be programmed, even though customized food preparation should be possible on occasion. Each person will have free access to storage cabinets, counters, and seating, and will be able to prepare his or her own meals using microwave ovens, etc.



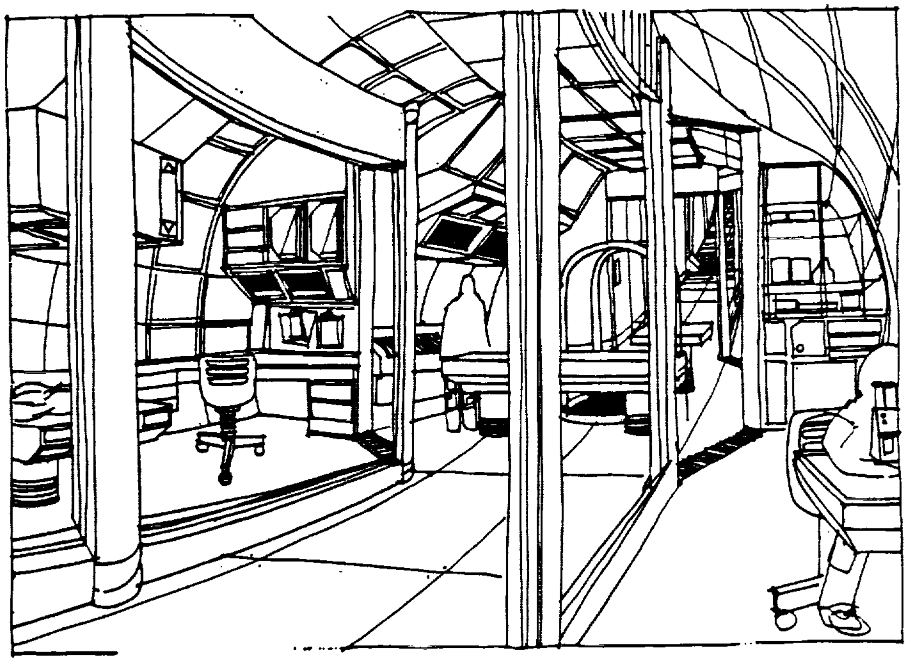
Gymnasium (9.14 m × 7 m): This is a place to ensure muscle tone, physical well-being, and general satisfaction and enjoyment of the passengers and crew. Exercise and activities will be programmed and designed taking into account the artificial gravity conditions with special machines for exercise calisthenics and aerobics. Some parts will have double height to take advantage of the 0.4 *g* gravity.



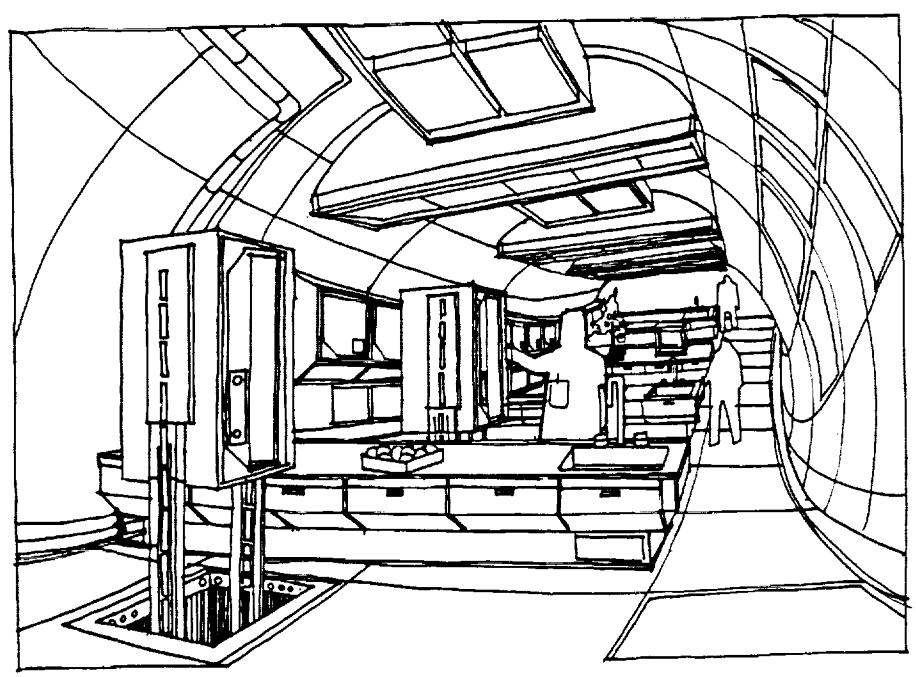
Laboratories (24.69 m × 7 m): There is a central control area in the laboratory complex from which all the work could be monitored. It is surrounded by six laboratories for scientific work on the vessel, as well as support for the Medical Center. Circulation is similar to that of the Medical Center itself, thus providing access through a hatchway and connection to the circumferential transport. Laboratory areas could also be customized according to the specific needs of individual travelers on each mission.



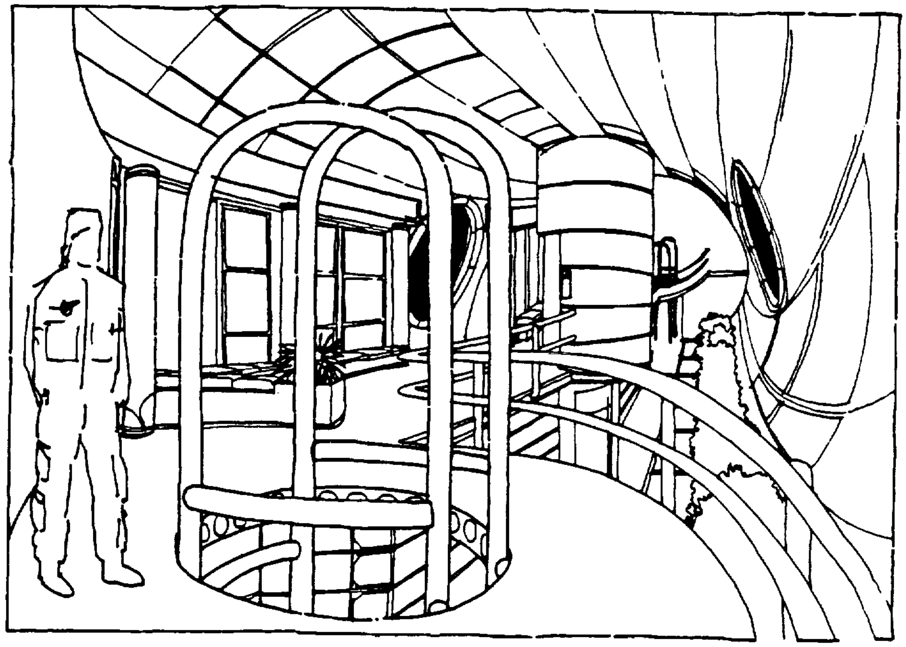
Torus Control Room (4.87 m × 7 m): This is an area within the Torus that will allow the crew to control and monitor all systems on the vessel without having to go to the Central Hub, where there is a similar facility (but under microgravity conditions). It is adjacent to a small office for meeting with individuals and is located within the work sector of the vessel, which also includes laboratories, the Medical Center, and the Master CELSS. It should be considered an auxiliary and subservient facility to the Hub Control Room, which is the main command bridge of the vessel.



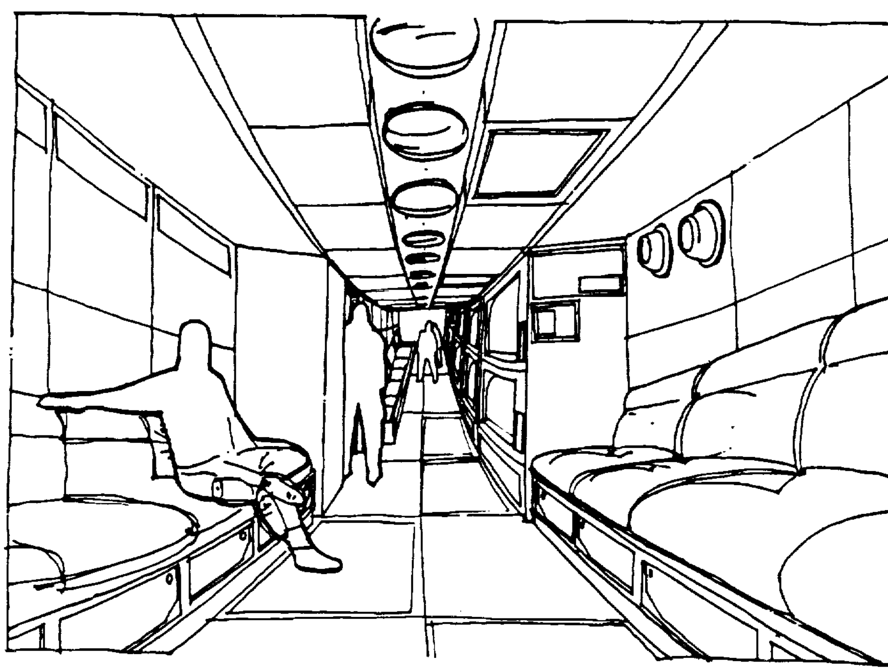
Medical Center (8.53 m × 7 m): This is conceived as a place for the attention and treatment of medical emergencies, illnesses, and routine check-ups of passengers and crew. It has a vertical access as well as a circumferential transport that can move a patient from any place on the vessel along the main corridor. It features four main areas: surgery, control, bathroom, and convalescence areas.



Master CELSS (201 m × 2.74 m): This is a control and inventory area for the "Controlled Environmental Life Support System" (CELSS). The system takes advantage of all the minor spaces throughout the vessel, especially those that do not have suitable shape or proportions for human habitation just as cargo compartments work in an airplane. The whole system is operated or monitored from here. It is accessible also through the circumferential transport as well as the appropriate hatchways. It has work tables besides the controls and indicators that monitor the life and chemical processes of the plants and animals of the system. This is the place in which the carousel drawers containing plant life can be pulled up for cultivation.



Spoke Elevator (12.19 m × 7 m): This provides access from the Central Hub to the Torus habitable spaces that feature artifical gravity of 0.4 *g* by rotation of 3.22 rpm in three different locations. It features a reception lounge and area of double height with vegetation. It has two access hatchways to the main corridor and windows to permit a view of the outside of the vessel.



Safe Haven (20.12 m × 7 m): This is a shelter on the vessel for emergencies and protection from radiation of solar flares. There will be 3 of these, but each is capable of housing the 20 occupants of the vessel, since they may not have enough time to distribute themselves along the vessel once an emergency alarm signals the need for shelter. The individual niches provided for each person are similar to the facilities of a Japanese Hotel that provides enough space for lying down and individual entertainment.