Architecture for Zero-Gravity: A Habitat Orbiting the Earth

A Masters Thesis Project

by Zachary Meade

Architecture can be defined as the manipulation and organization of materials to delineate specific spaces that allow for new realities. These spaces spawn new sensory perceptions and emotions. They allow us to experience views, light, and the earth through a new perspective. A simple tree house allows a child to see her own backyard from a new height. She is able to experience the leaves of the tree, the shade it casts, and the light as it trickles through the entanglement of branches and foliage. The tree house allows the child to experience what she has only aspired to experience before its existence. Such is the nature of architecture; it is an apparatus that allows for new perceptions of physical surroundings, a manipulation of form that exalts and expands the mind of the user, and a catalyst for an expansion of awareness.

Gravity is a prerequisite that has always been an influence in architectural design. Architecture has evolved over thousands of years as a resistance to the force of gravity. Gravity determines what we are capable of. It determines form, and it determines the nature of architectural space, as we know it. If we take away this assumption, then it can be argued that we are able to study architecture in a more pure form, this being a series of spaces in a three-dimensional environment. This project is a study of the nature of architectural space in an idealized and pure form.

This project is a hybrid between realistic limitations and conceptual ideals. It partly lends itself to both, but it is not entirely restricted to either. The goal of the project was to prove that conceptions of zero-gravity habitats built for users that wish to experience life in Earth's orbit can be realistically designed to enhance the experiences of these users. These conceptions are meant to grow beyond contemporary technological constraints that restrict existing space stations to the engineering limitations that govern them. These conceptions should be based on the needs of inhabitants instead of the limits of engineering. In the future, as technological implications allow, these conceptions will give us a basis from which design implementations can occur.

Figure 1: The proposed habitat orbits the Earth.

In the early conceptual stages of the design process, three-dimensional modeling techniques were used to explore the notion of organic growth in a zero-gravity environment. These explorations allowed for a documentation of one of many explored design strategies. Because there are no limitations on growth in a zero-gravity environment, form is determined by the movement of inhabitants, the organization of spaces, and the management of daylighting among other variables. Zero-gravity habitats are allowed to respond to these variables more directly without spatial limitation. The resulting forms could conceptually become organic in nature, resulting from a more direct response to these design variables (Figure 2). The virtual explorations of this kind of growth were made to represent the movement of users in organic arrangements of form. Virtual modeling allowed for varied conceptual notions of how these forms may evolve.

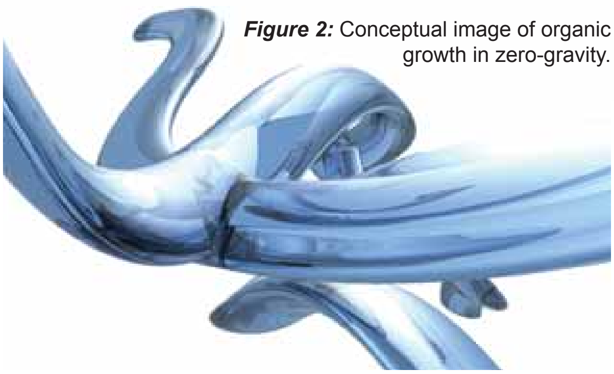


Figure 2: Conceptual image of organic growth in zero-gravity.

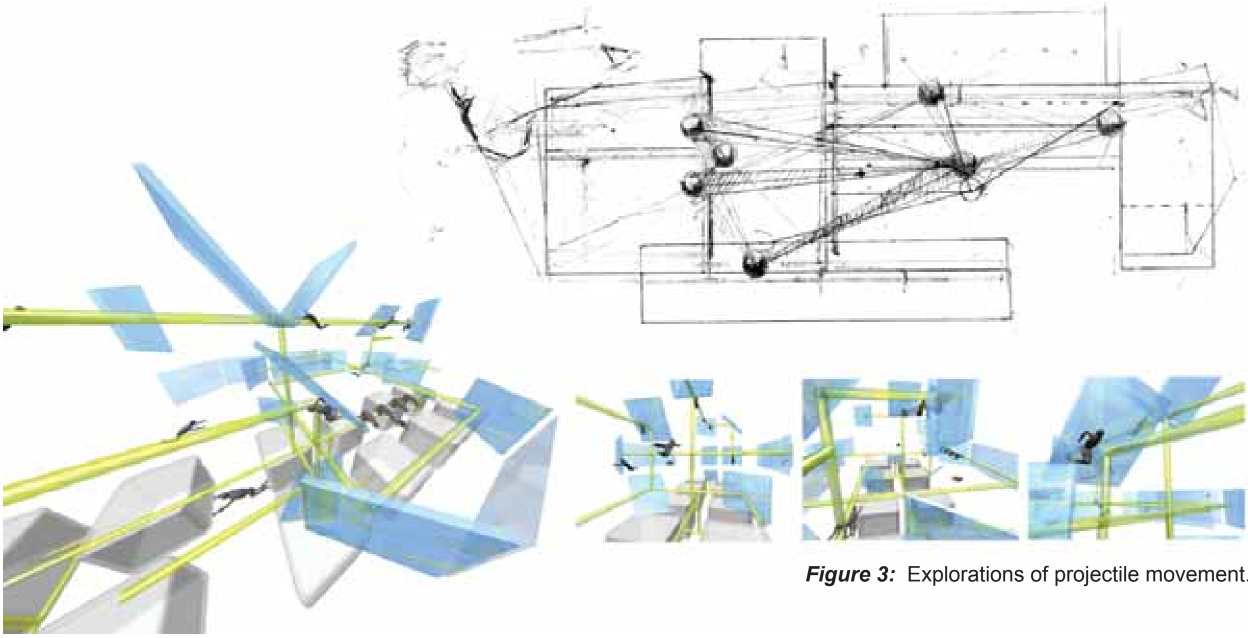


Figure 3: Explorations of projectile movement.

Following these explorations came the identification and mapping of movement the inhabitants of a conceptual zero-gravity environment. A simple program was developed both in a physical model and a computer generated three-dimensional model. The projectile movement of users was proposed and mapped throughout the environment in both models (Figure 3). Nodes of projection were identified and delineated with planes. These planes began to develop into a larger form, which became the basis for the final design (Figure 4). This three-dimensional mapping was essential for the development of this particular design strategy. Specific determinations of the implementation of projectile movement became apparent in the computer model and the advantages, and accordingly disadvantages, of this strategy were revealed. In the virtual realm, the paths of the users took life in all dimensions. They were able to grow out of two-dimensional sketches and take on actual form.

Figure 4: The explorations began to develop form.

The final design project (Figure 5) was completely developed in computer-generated three-dimensional space. The design consists of a 20-person habitat orbiting the Earth at a determined inclination with spaces for living, working, relaxing, and recreation. The habitat was developed in a virtual environment to help eliminate preconceived notions of a ground plane from which structure must grow. The three-dimensional model has no absolute "top" or "bottom". Instead, it simply has a side facing the Earth and one that faces away. The interior orientation of the users is not constant throughout the habitat. It skews and manipulates to best facilitate user utilization, proper adjacencies of spaces, and the shielding and filtering of light. Accordingly, a virtual three-dimensional model was needed to fully explore what the experiences of the users would be in specific spaces with varying local orientations.

The form of the habitat is directly related to the site variables discussed. Spaces are organized around two main circulation corridors. Particular arrangements of form allow for views to Earth or stars depending on the use of space. View corridors were established and subjected to a layering technique of spatial arrangement that filters light throughout the habitat from active to more private spaces. The result is a varied and complex arrangement of forms that directly relates to the comfort and well-being of the user. Virtual modeling techniques of extrusion were used to explore and refine the varied spaces throughout the habitat. They allowed for quick tests and studies of how the implementation of adjacencies affected user experience.

Of particular interest was the development of the residential nodes that rest along the Earth-facing side of the habitat. A form was developed for these nodes that allows

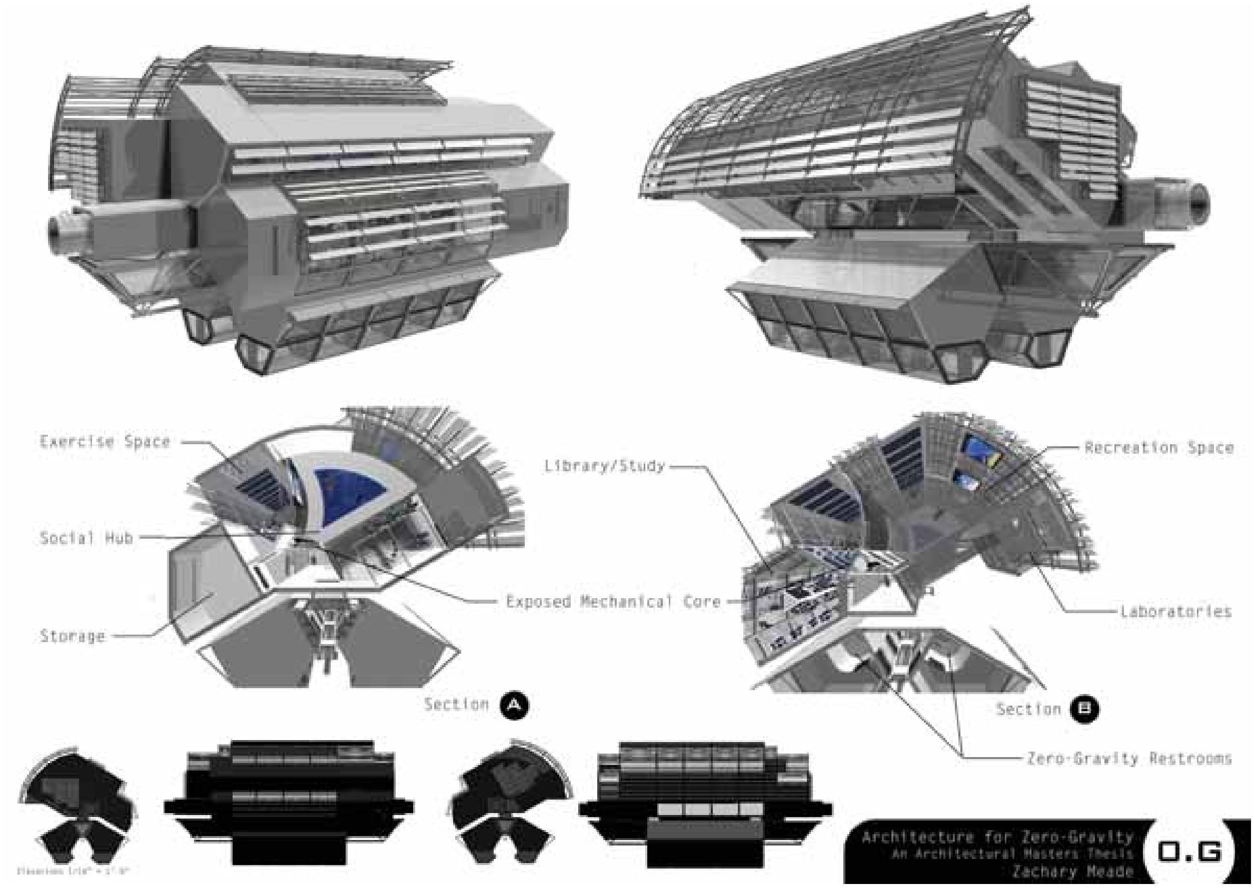


Figure 5: The final design of the habitat.

the users to determine individual orientation within the space. This form can be utilized in a minimum of three different orientations. Users are able to personalize these spaces and create individual environments that best suit their living habits. These forms were developed in the virtual realm and duplicated. By rotating different versions of the same form, multiple perceptions of orientation were explored.

In addition, three-dimensional modeling allowed for the exploration of the nature of interior space in the habitat. Several spaces were developed to the extent of imagined habitation. These renderings illustrate specific examples of the implemented design strategies and the design intent. Without interior exploration, the habitat appears simply to be an odd arrangement of forms without defined meaning. By developing interior spaces, meaning and explanation of form is clearly illustrated.

This project was realized to its full potential only because of the use of computer generated three-dimensional modeling. From conception to final design, techniques and strategies were explored using this medium that would otherwise have been either ignored or developed only to a limited potential. These design strategies became an integral part of the design process. The nature of the project itself demanded a mastery of the relationship of form and the elimination of an absolute orientation. The virtual explorations allowed for the successful implementation of these.

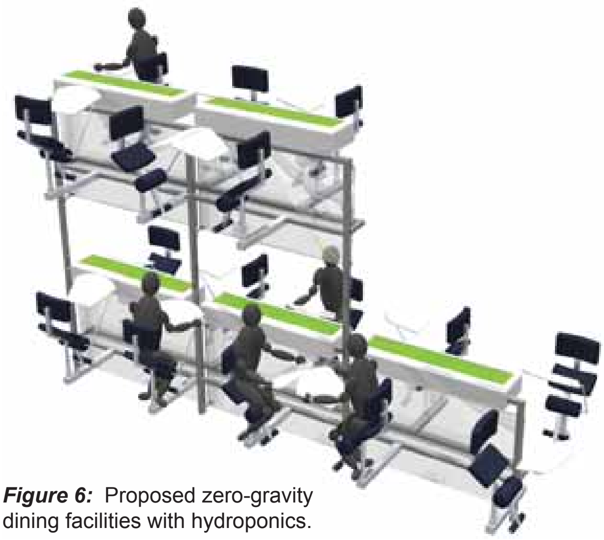


Figure 6: Proposed zero-gravity dining facilities with hydroponics.

The project is a response to the site; it acknowledges and reacts to it. Though no soil and topography exist from which the structure must grow, less tangible site variables produced a very tangible and ultimately intriguing design. With the absence of gravity, the additional design variables become exaggerated. The user is enhanced and the architecture is allowed to better suit her needs. The form in itself becomes more pure and more responsive to utilization. This project was a study of the basic principles, which guide the manipulation and delineation of space.

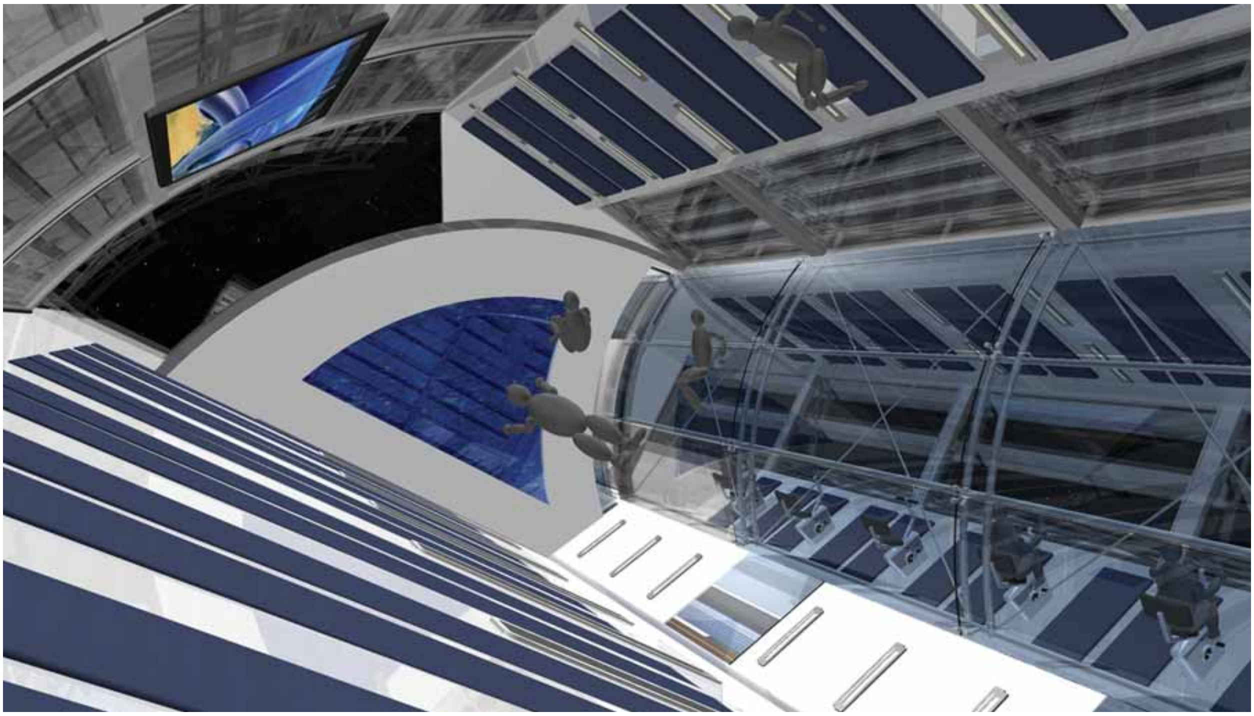


Figure 7: Recreational Facilitiy.

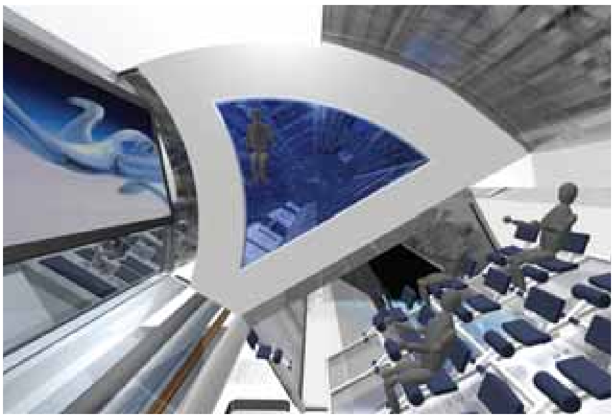


Figure 8: Social Hub with water wall.

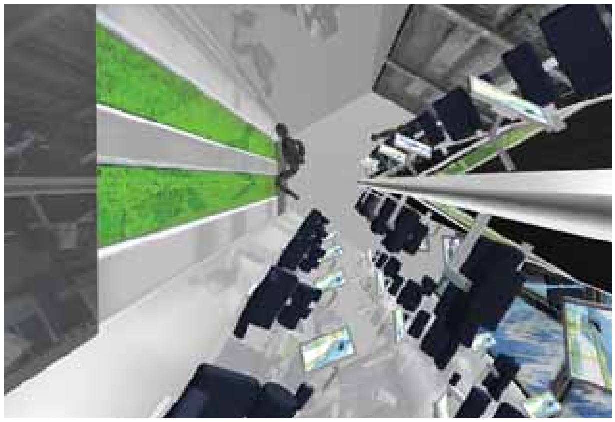
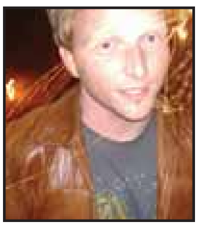


Figure 9: Library with hydroponics.



Zachary Meade received a Masters of Architecture degree in 2007 from the Newschool of Architecture and Design in San Diego, California. His architectural education began in 2003, when he studied architectural history and participated in an advanced urban architectural studio for a semester at Lund University in Lund, Sweden. He is currently working in Wellington, New Zealand pursuing his goal of becoming an architect and learning varying design methods and construction techniques across the world. He actively engages in virtual modeling in his spare time, and is seeking to advance the practice of utilizing virtual techniques in conjunction with photography and two-dimensional graphic media to produce works of art. It is his hope that virtual technology will eventually be recognized as both a practical and inspirational method in all areas of design.