

A SHORT HISTORY OF A LUNAR BASE DESIGN STUDIO

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The best way to describe the development of the Lunar Base Design Studio is a chronicle of visitors and the presentations we gave them. Without the support and pressures implicit in any of these visits, the studio would have failed.

ARTIST AS DESIGNER: INITIAL DESIGN EXPLORATION

John Clark, Jr., a gifted aero-space artist was our first visitor. His work and experience with military aircraft paintings inspired us in the first week of the project as we looked forward to rendering exotic structures on alien landscapes. He has published paintings of the solar system planets and planetoids. Most exciting, however, was his method of slicing aircraft structures at one foot increments and projecting these slices in perspective.

OUR FIRST SPACE ENGINEER: CONSTRAINTS AND DESIGN CHALLENGES

Our first weeks were spent in elementary literature search and reading. Class discussions primarily revolved around space publications. An early design pin-up was required, without a program and with little published research precedent. We were aware that a program was necessary, and we anticipated our first visit with our "client" representatives from Astronautics Corporation, both engineers.

Often architects, in school, do not understand engineers; they have many negative preconceptions. What a surprise when Mark Jacobs of Astronautics Corporation presented a highly graphic, informative, and compelling afternoon discussion of the complete spectrum of issues and scenarios for 25 years of development on the moon's surface. He was articulate and exacting.

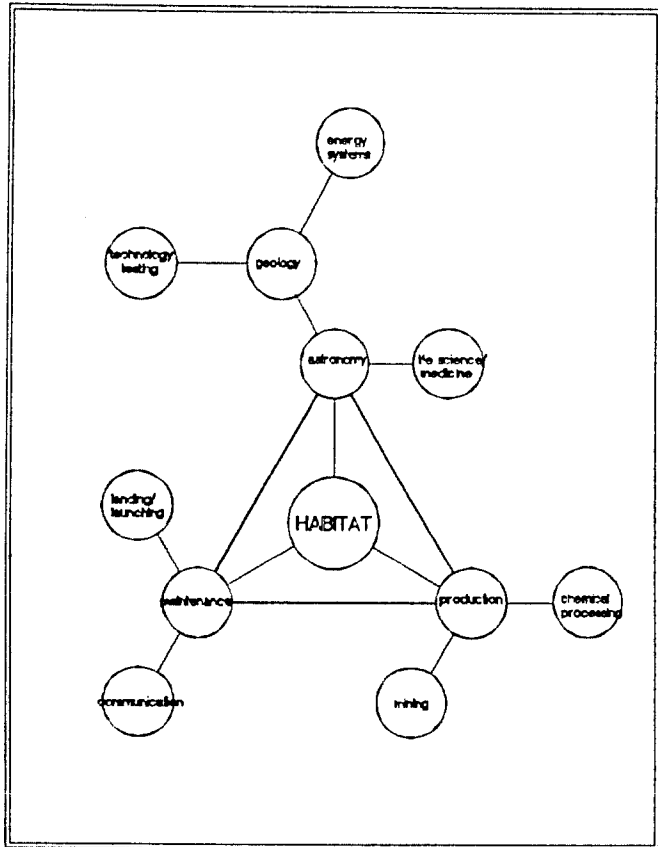
Most of the students were now very troubled. What could they do to add to the kind of grasp of lunar base design that such professionals already have? Should they assume the historic role as an artist articulating NASA's ideas? Thanks to the input from Mark Jacobs and Tom Crabb of Astronautics, the students wanted to contribute more.

INTERSTITIAL TIME: EXPLORATION OF DESIGN ISSUES

After the first four weeks of the semester, the design critique and review process became stale. A gap developed between the massive amount of reading and research available for our study and my insistence upon applied designs without yet having a clear program. I pursued conceptual development, a difficult task in a vacuum. A few of the students staged a rebellion. They refused to pin-up their sketch designs! I conferred with them alone in the hallway.

Slowly, however, certain issues began to emerge which would eventually form the basis for the studio design goals and program. Three of these issues were (see the following section on "Goals and Design Principles" for the others):

1. Cost-Efficient Least-Weight Design. Although we understood the need for cost efficient design, and therefore for least-weight design, due to the extreme expense of space ventures, application of this idea was not realized until late in the semester.
2. Radiation. Realization of the hazards due to radiation became apparent early in the process. The long-term astronaut will receive dangerously high levels of solar radiation without proper protection. Shelter from additional danger such as cosmic radiation and meteorites is also a concern. The design scenarios presented later were based on habitation durations of greater than one year. The studio refused, however, to accept the notion that their designs must be buried beneath the lunar soil.
3. Boredom and Confinement. Despite all the danger and glory associated with being an astronaut, analogous research shows that boredom encountered in closed environments can be life threatening (National Aeronautics and Space Ad-



Schematic "bubble" diagram for a base design

ministration, n.d.). Submarines, polar continent exploration, and science missions have indicated the rigors of confinement and cramped quarters.

ARE WE DESIGNING YET?

Ready or not, our first major design presentation approached. We presented to a group of four engineers and human factors experts from Astronautics Corporation. Included was Thomas Crabb, the Manager of the Space Station Section of Astronautics Technology Center, the person in charge of the company's lunar base investigations.

In preparation for this presentation, the students began to express some key design concepts. Included were biological analogies such as a sea creature carrying its own shell, and more pragmatic thinking like the utilization of the lunar site conditions and materials to reduce the dependency on earth-manufactured modules. Such thinking was well received by the Astronautics staff. The students awareness and understanding of radiation dangers had also become stronger. While many of the instincts against burying a lunar base persisted, most schemes addressed the issue of site utilization in an effort to avoid direct solar radiation. Sites were chosen along craters and rock up-lifts for their shading abilities. Vertical integration concepts were also developed. Many schemes programmed space to allow activities where the most time would be spent residing in the lower portions of the base, with shorter duration activities occurring closer to the surface.

The students remained rather insecure about their work, nevertheless. Presentation to experts in the field was quite intimidating. The work did include good speculative thinking, however, and many of the students with CAD deficiencies were beginning to come up to speed.

The presentation to the Astronautics team was labeled a success. The student's rehearsed presentations were both relaxed and clear. Most of the students worked in teams and shared concepts and CAD elements. Discussion following the presentations explored further issues and new strategies were devised. The visit to the Astronautics Corporation office in Madison resulted in many new ideas and directions.

STAGE TWO: THE ARCHITECTURE OF SPACE INTERIORS

During the weeks prior to the second major design presentation, the studio was visited by an alumnus of the UWM School of Architecture and Urban Planning, Claudio Veliz, a practicing architect in New York City whose interests lie in the interiors of space and Manhattan habitats. His knowledge has been gained from work with NASA's Ames Research Center. He spent an afternoon sensitizing the students to the myriad of needs that a lunar base must supply the inhabitants. The studio, which to this point had been concerned only with external issues such as construction sequences, phasing, and radiation protection, was exposed to the an enormous list of very human and utterly critical requirements, and to the importance of well designed interiors. The added new stress of interior considerations again overwhelmed the studio.

This experience created the realization that no one student could possess the knowledge necessary to design a perfectly "correct" lunar base. Team effort became more important with the time constraints and the realization that perhaps the task was somewhat beyond what a four- to five-month studio could accomplish.

THE SECOND PRESENTATION: CRITICAL ANALYSIS

Another distinguished critic was invited to review the students work. Larry Bell, Director of the Sasakawa International Center for Space Architecture as well as the Center for Experimental Architecture at the University of Houston was known to the students through his publications in the field (see, for example, Bell, 1987, n.d.). By this point, each student had achieved a much clearer understanding of space architecture, yet Larry Bell represented an academic position. The students were unsure of the responses to the previous months' work, and the fear of a juried response loomed.

A full day was devoted to Larry Bell's visit and critique. The morning was used as an open presentation of his work and programs at the University of Houston focused around two lectures and a research seminar. In the afternoon, each student gave a 15 minute presentation consisting of color slides and/or large plots. The second presentation showed excellent process even though many problems

were still not fully understood. The resulting discussions were quite pointed, controversial, and stimulating. The students had received the first severe analysis of their work and again new directions were established. Perhaps Larry Bell should have visited the class earlier in the semester; perhaps it is better that he came when he did.

The events that transpired that day provided an excellent process for engaging in ideas. I spoke individually to most students after the critique and found little resentment about what happened. In every case, it was clear that we were beginners with little knowledge of the tremendous sets of deterministic forces. And in every case, students developed valid ideas that were conceptual counterpoints to the rigors of the many severe forces.

FINAL PRESENTATIONS: REALIZATION OF DESIGN PRINCIPLES

Slightly more than a month remained in the semester. Armed with a better comprehension of the goals, the program, and the emerging design principles, the students began their final push. The engineers from Astronautics returned the following week to help the studio integrate the new issues and concerns. The usual lull after a big presentation did not occur.

The students realized that much of their former work was "incorrect," but each student had mastered CAD in some form. The students willingly abandoned former module designs based on terrestrial thinking. Realization that rectangular vessels containing one atmosphere of pressure (2074 psf) would "cost" significantly more in weight than "aluminum balloon" structures was a major step. Design also included a mature awareness of the inconsistencies of radiation. Soil shielding became the accepted norm. Interior spaces became double-functioning, even multi-functional, and therefore economical. Efficient construction sequences took on new importance; lunar construction is dangerous, one slip, cut or puncture could be fatal.

The last month was exhilarating. When students were polled about a current profound professional question like "can an architect really design using CAD?," they quickly excused themselves to get back to their design - on a computer.

Several large issues were clarified during this final phase, including lunar construction sequences, cross-over points where lunar materials are utilized in combination with earth-shipped materials, and adaptive, highly programmed interior spaces.

The final presentation utilized a direct computer presentation system. Each student presented the viewers with a highly orchestrated script explaining the design scenario. The presentations were designed to bring the viewer from earth into the realm of the lunar habitat. Each student presented approximately a 20 minute show that was well received by the jury. Unable to end with a wrap-up discussion, the studio decided to meet for the last time to celebrate the project's completion. Buried beneath a recent Wisconsin snowstorm, 1/2 meter compacted, we spooned ice cream and thanked each other for the wonderful help each gave.

ARCHITECT'S DESIGN PROCESS IN SPACE

Architects are funny people. They romantically recall themselves master builders. They hire engineers to make their designs work. In space ventures, they are known as general problem solvers and are valued for their organizational abilities. In the foreword, I referred to certain unique abilities that architects manifest. They practice a process which includes pragmatic thinking, technical know-how, and artistic expression. Architects, for better or worse, represent a culture's meaning. The role to date of architects in the space program has been minimal. The space program has been a highly technical, highly engineered, highly scientific endeavor (e.g., Seamans, 1987). Artists have been employed to feed the public's imagination and to raise iconic flags for the next round of governmental appropriations (e.g., Kilgore, 1987).

I suggest that architects be included in space development. The work of 10 international students, each striving to become an architect, indicates a vital combination of process that is unique to our field. Architects rationalize graphically. Architects using computers think graphically using the most sophisticated information technology available. While our studio lacked a full database and limited research activities, in 15 weeks the young architects probed and simulated environments that will not be realized for at least 25 more years. Their first designs were naive, their second presentations conceptually stimulating, but still not technically

possible, but their final work begins to arrive at issues and approaches never before considered.

There is an important movement in architecture to measure the success of the designer in not only understanding the problem but also in programming the facility and evaluating how people behave and use the building after the architect and contractor have completed the process (see, for example, some of the latest work on programming and post-occupancy evaluation in Zube & Moore, in press). This method could prove very fruitful for space based design. The studio method is an evolutionary process. Architects synthesize and speculate with drawings. CAD allows architects to draw a space frame or a space movie. The architect's purpose is to think critically about how people live and function in an environment. Those who make decisions regarding space policy and design owe it to those who will ultimately inhabit their creations to include architects in the design process.