

APPENDIX A

**HUMAN HABITATION ON MARS
SPACE ARCHITECTURE III DESIGN STUDIO
DESCRIPTION**

Architecture 166-690 - Section 801

Department of Architecture
University of Wisconsin-Milwaukee
NASA/USRA Advanced Design Program in Space Architecture
in conjunction with
NASA-Johnson Space Center
Spring 1992

Instructor Gary T. Moore

NASA/USRA Teaching and Research Assistants

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|--------------------|----------------------|
| Joseph P. Fieber | Janis Huebner-Mothes |
| Kerry L. Paruleski | Patrick J. Rebholz |

Visitors and Visiting Critics

Edward Beimborn, UW-Milwaukee Department of Civil Engineering
Uriel Cohen, UW-Milwaukee Center for Architecture and Urban Planning Research
John Connolly, Planet Surface Systems Office, NASA Johnson Space Center
Vincent A. Cronin, UW-Milwaukee Department of Geosciences
Robert Greenstreet, UW-Milwaukee School of Architecture and Urban Planning
Mary Guzowski, UW-Milwaukee Department of Architecture
Thomas Hubka, UW-Milwaukee Department of Architecture
Calvin Huber, UW-Milwaukee Department of Chemistry
Robert A. Jones, UW-Milwaukee Graduate School Office of Research and Sponsored Programs
Thomas A. Kaminski, Astronautics Technology Center, Astronautics Corporation of America
Michael Roberts, Design Systems Office, NASA Johnson Space Center
Douglas C. Ryhn, UW-Milwaukee Department of Architecture
Irvin Ross, UW-Milwaukee Office of Industrial Research and Technology Transfer

Kathryn Scott, Design Resource Center
Mark Sothmann, UW-Milwaukee Department of Human Kinetics
Dale Thomas, UW-Milwaukee Office of Industrial Research and Technology Transfer

Course

Architecture 166-690 (U/G), La 801 (6 credits)

Location

Engelmann B58; reviews and seminars in Engelmann 128 and 157

Time

Tuesdays, Thursdays, and Fridays 1:30-5:20. Everyone is expected to be present during these times. There will be other scheduled events for special guests, seminars, and reviews.

Office and Hours

Gary Moore / Eng 172 / T 8:30-12:00 (recommended by appointment)
TAs / Studio / during class times

Design Program

The Department of Architecture, through its 6-year Advanced Design Program grant from NASA/USRA, is conducting a series of seminars (fall semester) and design studios (spring semester) on space architecture. The Department is one of only three architecture schools in the 41-university NASA/USRA Advanced Design Program. We are working in cooperation with the College of Engineering and Applied Science. The program stresses the systems approach to design in which we work together like an interdisciplinary A/E professional firm on a major real world project for NASA.

Purpose and Support

Students at UW-Milwaukee have become involved in an interdisciplinary research and design program to work with and present their ideas to a real client--NASA, and to learn about areas of design related to health and safety, psychological and social issues, habitability, underground architecture, interior architecture, construction technology, hi-tech materials, mechanical systems, structural analyses and structural systems, energy systems, site planning, and long-range master planning.

1992 Design Studio Description

In 1991, the National Space Council published *America at the Threshold: Report of the Synthesis Group on America's Space Exploration Initiative* (Stafford, 1991; called the "Synthesis Report").

The Synthesis Report presented two mission durations for Mars exploration: long-duration missions on the order of 1,000 days with a typical stay time on Mars of approximately 500 days (1-1/3rd years, 16-17 months), and short-duration missions on the order of 500 days with a 30 to 100 day stay on Mars (1-3 months). Our thinking lead us to believe that there are more architectural, habitation, and environment-behavior issues to be explored and solved in a long-duration permanent Martian habitat with full research work stations and crew living quarters for living durations up to 1-1/2 or more years. Reviewing other published mission scenarios, our thinking also lead us to believe that an initial short-duration outpost will quickly be followed by one or more exploratory long-duration outposts, which in turn will be followed by a permanent long-term base. The focus of our work for 1992, therefore, was on the long-duration permanent base.

Our work built off what the Synthesis Report referred to as the Mars "Waypoint" (by which is meant Mars planetary activities for human exploration of Mars, i.e., as a waypoint to later exploration into the Solar System). Phasing the development of a permanent base, we accepted the Synthesis Report recommendations of an initial crew size of 18 crew members for the initial human-tended outpost for change-out durations of 500 to 600 days on the Martian surface, assuming a closed-loop life support system and remote automatic emplacement, checkout, and verification of as much of the habitat and life support system as possible for turnkey operations by the crew when they arrive.

Thus, in the spring of 1992, the Space Architecture Design Studio designed a permanent, long-duration base for the surface of Mars. Subsequently named *Pax* (for the international Peace Settlement, opposite of the Latin name of the planet, *Mars*, the God of War), this first Martian permanent base will provide housing, research space, mission control space, and all amenities for 18 astronauts to live on Mars for durations up to or exceeding 1-1/2 years.

An important part of the capstone design studio is the inclusion of experts-aerospace engineers, architects, human factors experts, and NASA scientists and engineers—to advise and critique the work at preliminary design reviews (PDRs). We also used grant funds to allow one or two people to attend important national conferences to bring back state-of-the-art information to the studio.

Structure

The studio was structured in six segments:

1. Readings, lectures by the instructor and TA/RAs, seminar discussions, and lectures and events (field trips) that required travelling. Starting immediately and throughout the semester, but with heavy emphasis through the middle of February. 4 weeks. Reviews of student progress at periodic intervals (graded on understanding of subject matter, familiarity with literature, and class participation—20%).
2. Two-part charette sketch design. 1 week, January 23 and 30. First Preliminary Design Review (PDR), i.e., PDR-IA, January 23 in studio and PDR-IB, January 30, Room 128, 3:30 p.m. by instructor and TAs (equivalent to pin-ups in other studios—not graded).
3. Schematic design—master and site plans. Detailed scenario presentation (TAs) followed by research and schematic design studies to develop and explore different full base layout master and site planning parti. 1 week, February 4-11. PDR-II (graded) on February 11 (place TBA) by instructor and visiting critics (this would be equivalent to a project due date and jury in other studios—10%).
4. Schematic design—particular spaces. Research and schematic design studies of particular spaces, e.g., wardroom, crew quarters, recreation spaces, hygiene facility, research labs, translation spaces, etc. 4 weeks, February 13 to March 3. Pin-up on February 20 in Room 128 at 1:30 p.m.. PDR-III (graded) on March 3 at 1:30 p.m. in the Exhibit Space by instructor and visiting critics (another equivalent project due date—25%).
5. Design development and integration of master plan, site plan, and detailed designs for different parts of the permanent, long-term Martian base. 4 weeks, March 5 to April 14. Pin-ups on March 12 and April 2 at 1:30 p.m. in Room 128. PDR-IV (graded) on April 14 at 1:30 p.m. in the Exhibit Space with national guests (25%).
6. Presentation. 3 weeks, April 16 to May 7. Final Design Review / Final Jury (FDR), Thursday, May 7, 1:00 noon to 5:30 p.m., in Room 128 (with dinner and a party following—20%).

Schedule

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|-------------|--|----------------------|------------------|--------------|
| January 21 | Introduction | Gary | Studio | 1:30 |
| | History of the US Space Program | Jan | Studio | 2:00 |
| | Scenarios for Studio | Jan | Studio | 3:00 |
| January 23 | About Mars | Renee | Room 157 | 1:30 |
| | Site Selection Criteria and Recommendations | Jan, Renee & Andy | Room 157 | 2:30 |
| | Sketch Design IA | | Studio | 3:00 |
| | PDR-IA Pin-up | | Studio | 4:30 |
| January 28 | Madison AIAA Field Trip and Robert Zubrin Lecture | | Madison | 3:00 7:30 |
| January 30 | Sketch Design IB | | Studio | 1:30 |
| | PDR-IB Pin-up | | Room 128 | 3:30 |
| | Master and Site Planning Considerations | Joe & Kerry | Room 128 | 4:30 |
| February 4 | Detailed Scenario Presentation | TAs | Studio | 1:30 |
| | Start Parti Development/Full Base Master Plan and Site Plan (GTM & PJR presenting paper at AIAA) | | Studio | 2:30 |
| February 6 | Research Questions and Diagrams | | Room 157 | |
| February 11 | PDR-II Base Layouts/Schematic Design | | Room 128 | 1:30 |
| February 13 | Human/Environment-Behavior Factors | Gary & Pat | Room 157 | 1:30 |
| | Start Preliminary Design/Particular Spaces | | Studio | after |
| February 18 | Human/Environment-Behavior Factors | Gary & Pat | Room 157 | 1:30 |
| February 20 | Schematic Design/Spaces Pin-up (GTM in Moscow reviewing Russian Space Architecture work--February 24-29) | Joe | Room 128 | 1:30 |
| March 3 | PDR--III Particular Spaces/Schematic Design | NASA Reviewers | Exhibit Space | 1:30 |
| March 5 | Start Design Development/Entire Base | | Studio | 1:30 |
| March 10 | Mid-term | | | |
| March 12 | Design Development Pin-up | | Room 128 | 1:30 |
| April 2 | Design Development Pin-up (TAs presenting paper at EDRA--April 9-11) | | Room 128 | 1:30 |
| April 14 | PDR-IV Entire Base/Design Development | | Room 128 | 1:30 |
| April 16 | Start Final Presentation | | Studio | 1:30 |
| April 21 | Arch 302 AHB Lecture on Space Architecture/Human Factors | TAs | | 9:00 |
| May 7 | FDR/Final Review and Jury Dinner and Party After | University Reviewers | Room 128 Moore's | 1:30 5:30 |

Key A/E Design Issues

Based on a self-critique of our last two year's work, and very helpful suggestions from colleagues around the country, we decided to focus on the human/environmental factors dictating design decisions. The studio stressed an environment-behavior or human factors approach to design. In addition, we also subjected ourselves to several formal architectural critiques, considered the Martian environmental context of our design decisions, and learned from and borrowed the results being developed by other universities in the USRA net.

Eligibility/Prerequisites

The studio was open to undergrad and grad architecture and engineering students. Junior standing is necessary (senior or grad preferable). Students from architecture (undergraduate and graduate) and from engineering (especially mechanical, structural, and industrial/systems) were welcome to join the studio. No previous space architecture experience was needed. The most important prerequisites were previous design experience equivalent to the Level II sequence in the Department of Architecture and a commitment to aerospace studies. It was strongly recommended to have also taken Arch 302, Architecture and Human Behavior. The course counts as studio credit in both the undergraduate and master's programs in the Department of Architecture.

Enrollment is limited to 12 students; if more than 12 preregister, selection is based on qualifications before the first class. Final 1992 enrollment included one graduate student, one second-degree undergraduate student, nine undergraduate students, and one 6-credit independent study graduate student pursuing two independent but related projects.

Instructor and TAs

The instructor, Gary Moore, Ph.D., is Professor of Architecture and Project Director of the NASA/USRA Advanced Design Program in Space Architecture. The RA/TAs, Joseph Fieber, Jan Huebner-Moths, Kerry Paruleski, and Pat Rebholz are advanced undergraduate and graduate students in the Department of Architecture; all have worked for the aerospace industry (Fieber/Paruleski/Rebholz at NASA-Johnson Space Center and Huebner-Moths at Orbitec in Madison); and all are part of the Space Architecture Design Group. Each year, we are joined by special lecturers and visiting critics invited from the Advanced Programs Office at NASA-JSC, NASA/USRA, McDonnell Douglas, Astronautics Corporation, Orbitec, and private A/E firms. Other faculty from the UW-Milwaukee Departments of Architecture, Mechanical and Civil Engineering, Geosciences, and Human Kinetics also serve as guest critics. Reviews at key milestones (preliminary, intermediate, and final design reviews) are conducted by the studio faculty and these visiting critics.

Readings

It is critical that all students--new and old--prepare themselves thoroughly in the first four weeks by carefully reading and analyzing the case materials prepared for this course. Knowledge of the material in readings will be a portion of the final grade. Other critical documents are the four reports from previous years. Copies are available in studio, and are available for purchase from the Center for Architecture and Urban Planning Research. All readings are to be done prior to the seminar or slide lecture at which they will be discussed.

Assignments

The principle assignments are the three design projects plus the readings, periodic assigned papers or reports, and the final presentation.

Final Products

The final product was a slide presentation based on photographs of models, together with this final report. Several supplementary reports may be written on specialized engineering designs for component parts (e.g., workstation designs, structural system, etc.).

Conferences

The final slide presentation together with representative drawings and a final model will be presented by the students at the annual NASA/USRA Summer Conference in Washington, DC, supported by the NASA-Goddard Space Flight Center, June 15-19, 1992. Additional papers were presented at the AIAA Aerospace Design Conference in Irvine, California in February, EDRA Conference in Boulder, Colorado in April, and ASCE Space '92 Conference in Denver.

Evaluation

Evaluation was based on how much students personally developed over the semester, and was based on evidenced mastery of the material from the readings and lecture/seminars including seminar participation (20%), schematic base layout design (PDR-II; 10%), schematic design of particular spaces (PDR-III; 25%), design development (PDR-IV; 25%), and contribution to the final presentation and product (FDR; 20%). Final grades were assigned by the instructor from using the internationally recognized grading criteria of the University of Toronto.

Funding

The Advanced Design Program in Space Architecture is being underwritten by a grant from NASA/USRA which supports the RA/TAs and will pay for out-of-pocket expenses on the project and most of the travel expenses to the mid-June USRA conference for selected students (B+/A- grade requirement).

Special Conditions

This course is very different from any that students have taken previously. The course is three things: a learning studio, a federally funded research and design project, and a group of aerospace nuts working and having fun together. The instructor's commitment is two-fold, and they are equal: to student education as a professor; and to the project and NASA as a principal investigator. Student commitment needs also to be two-fold--to education and to the project--and it needs to be a very real commitment. This is a team project--we all (instructor, TAs, and other students) must pull our oars equally. I do not tolerate slackards; I have been known to ask students to drop the course. On the other hand, the TAs and I all give a tremendous amount of time to the course, not only during class periods, but evenings, weekends, entire weeks if that is what it takes. The work is never done until it is done right. The project is demanding, perhaps more so than any course or studio you have ever taken. But it will also be rewarding, and it should be fun, perhaps more so than any course or studio you have ever taken. Already we have planned involvement in a regional conference that will include nationally recognized aerospace speakers (you'll have a chance to meet them over dinner, and to have them review your work at a late-night soiree). The best students will represent the project at the NASA/USRA conference in Washington in June. During the last two years we were interviewed by radio, newspapers, and TV, and made presentations at a variety of local events. We prepared an exhibit of our work which was displayed twice in Wisconsin and once in Illinois--and now is on permanent exhibit in a state-wide science museum in Madison. The students have received three design awards for their work, two from the Environmental Design Research Association (EDRA) and one from the School of Architecture and Urban Planning, along with lots of informal very positive feedback from national experts, scientists, and engineers.

Further Information

The syllabus for this studio was published in a collection of innovative architecture courses. For further information, the reader is referred to Moore (1991b).