GENESIS LUNAR OUTPOST CRITERIA AND DESIGN

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June 11, 1990

GENESIS LUNAR OUTPOST: CRITERIA AND DESIGN

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This project and report were produced under a grant to the Regents of the University of Wisconsin System, University of Wisconsin-Milwaukee Center for Architecture and Urban Planning Research. Universities Space Research Association/Universities Advanced Design Program operates under Grant NASW-4435 from the National Aeronautics and Space Administration.

ABSTRACT

This design study -- the third in the space architecture series -- focused on the requirements of an early stage lunar outpost. The driving assumptions of the scenario was that the base would serve as a research facility and technology testbed for future Mars missions, a habitat supporting 12 persons for durations of up to 20 months, and would sustain the following five experimental facilities: Lunar surface mining and production analysis facility, construction technology and materials testbed, closed environmental life support system (CELSS) test facility, lunar farside observatory, and human factors and environment-behavior research facility.

Based upon the criteria set forth in a previous programming document, three preliminary lunar base designs were developed. Each of the three schemes studied a different construction method and configuration. The designs were then evaluated in terms of environmental response, human habitability, transportability, constructibility, construction dependability and resilience, and their suitability in carrying out the desired scientific research. The positive points of each scheme were then further developed by the entire project team, resulting in one integrated lunar outpost design.

PUBLICATIONS IN ARCHITECTURE AND URBAN PLANNING

Center for Architecture and Urban Planning Research
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P.O. Box 413
Milwaukee, WI 53201-0413

Report No. R90-1
ISBN-0-938744-69-0

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1. EXECUTIVE SUMMARY

Students at the University of Wisconsin-Milwaukee Department of Architecture (UWM/DAR) undertook a study of lunar habitats during the 1989-90 academic year. These studies involved an informational seminar in the fall semester, followed by a design studio in the spring. Students from architecture and mechanical and structural engineering were involved, some bringing previous backgrounds in interior design, biology, andconstruction technology. These studies resulted in three alternative scenarios for lunar habitation, and an integrated design for a early stage Lunar Outpost.

On the 20th anniversary of "One giant leap for mankind," President Bush this year announced a goal to land people on the moon by 2005, and this time to stay. Project Genesis is proposed as the first early stage, permanently occupied habitat on the moon.

Called Genesis, this early, evolutionary outpost is proposed both as a long-term testbed for all materials, processes, and development strategies to be employed in a mature lunar colony to be undertaken over the next 20 years, and as a testbed for all processes to be employed in the exploration and eventual settlement of Mars.

Following guidelines provided by consulting engineers and scientists at NASA's Johnson Space Center (NASA/JSC) and its prime contractors, the UWM design team designed Genesis for a full-time crew of eight to twelve persons on rotations of six to nine months with a maximum duration of 20 months. Crew gender, nationality, and ethnicity are expected to vary as the consortium of world aerospace partners all become involved in free-flowing scientific, architectural, and engineering communication.

There are five mission objectives for Project Genesis: (1) lunar surface mining and production analysis for lunar oxygen (Lunox), helium 3 (H3), and other minerals; (2) lunar construction technology and materials testbed for testing high technology construction with inflatable, the use of lunar regolith for radiation shielding, lunar glass, lunar concrete, and sintering techniques using advanced telerobotic systems; (3) closed system ecological life support system (CELSS) test facility; (4) lunar far side observatory; and (5) human factors and environment-behavior research facility.

The first manned mission to establish the outpost, which is expect to land on the moon in 2005, could last as little as 14 days. The astronauts, architects, and engineers will live inside their lunar landing vehicle (LLV) and spend much of each day performing extra-vehicular activities (EVA) involved in the initial base construction. A pressurized construction module will be the first order of business, followed by the evolutionary development of phased construction of the rest of the Genesis. Once all systems, subsystems, and backups have been verified, and the initial operation configuration (IOC) has been put in place, crew change outs will occur every nine months to a year as the astronauts and their partners perform research and manufacturing operations at the Lunar Outpost.

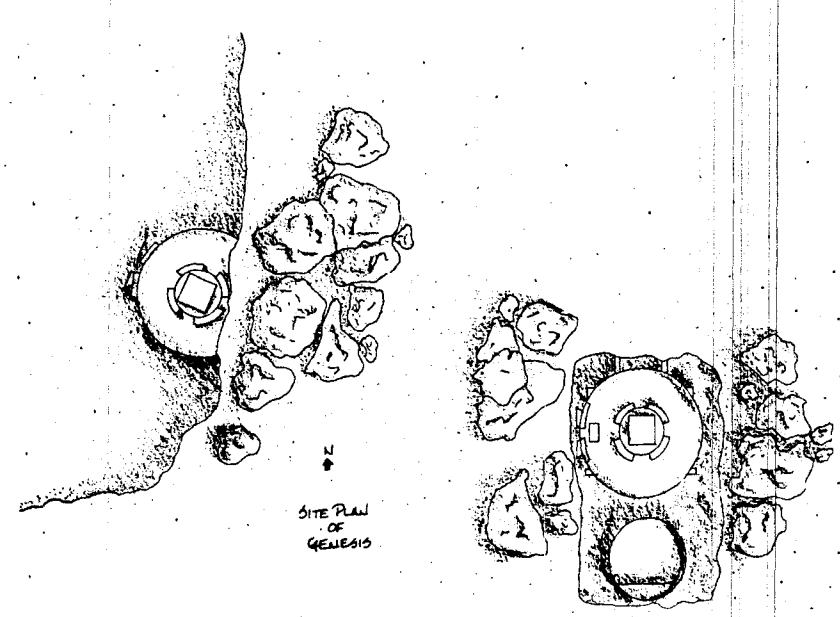
Research, design, and development of Project Genesis was initiated in mid-1989 by the UWM Center for Architecture and Urban Planning Research and Department of Architecture in cooperation with the College of Engineering and Applied Science under the first year of a three-year grant from NASA/Universities Space Research

Association (NASA/USRA) University Advanced Design Program. UWM/Architecture is one of only three architecture schools in the 44-university NASA/USRA University Advanced Design Program. The program stresses the systems approach to design in which the class works together on a major "real world" space design project.

The project was performed over the course of two academic semesters. In the fall of 1989, an information seminar was conducted (Architecture 392/792, 3 credits) in which interested students received lectures, read extensively, and conducted simple sketch designs to come up to speed on information needed to design a lunar habitat. In the spring of 1990, a space architecture design studio was conducted (Architecture 690, 3 or 6 credits) in which the actual designs were developed. Three students served as team leaders for the various design and analysis teams.

Initially three different design scenarios were explored based on differing sets of engineering and architectural assumptions: (1) use of Space Station Freedom-type hard modules and other earth based construction technology; (2) use of the lunar surface craters and lava tubes; and (3) use of inflatable structures. Results of these scenarios were presented to and reviewed by NASA, USRA, industry, and university personnel. The best of each scenario was then combined into a final integrative design featuring design responses to human habitation requirements, the lunar environment, and advanced construction technology.

We recall the words of former Chancellor Clifford V. Smith, Jr. of the University of Wisconsin-Milwaukee, as quoted in the Milwaukee Journal and elsewhere, "With this sizable grant and the unique challenges it brings, the University of Wisconsin-Milwaukee and its students, faculty, and administrators have taken a giant stride toward the future."



2. PREFACE

This report presents the architectural design for a lunar base habitat and research facility to be constructed for eight to twelve people at the proposed Apollo 18 site, Marius Hills, located 56 degrees 45 minutes West by 13 degrees 10 minutes North. Construction would begin in 2005, and full operating configuration would be achieved by 2015.

Following President Bush's goal to land people on the moon by 2005, and this time to stay, the base was planned for a construction start date of 2005. Design and construction will be led by a team of astronauts, scientists, architects, and engineers working together to build a permanently occupied habitat on the moon.

Called "Genesis," this evolutionary outpost is planned both as a long-term testbed for all materials, processes, and development strategies to be employed in a mature lunar colony to be undertaken in the next 20 years, and as a testbed for all processes necessary for exploration and eventual research and habitation of Mars.

Background

Faculty and students of the University of Wisconsin - Milwaukee School of Architecture and Urban Planning (UWM/SARUP) have been actively involooved in the research, analysis, and design of extraterrestrial environments since the spring of 1987.

In early 1987, the School began working with the Astronautics Corporation of America's Technology Development Center, a world-wide aeronautics and aerospace company headquartered in Milwaukee, to define space design issues and criteria. In the fall of 1987, the Department of Architecture offered its first studio in "Space Architecture: Lunar Base Scenarios," resulting in the the first in our Space Architecture Report Series (Schnarsky, Cordes, Crabb, & Jacobs, 1988). Simultaneously, the School and its Center for Architecture and Urban Planning Research hosted a series of workshops by leading members of the aerospace industry and visiting lectures by nationally recognized experts, made slide and video presentations at national meedtings including the 3rd, 4th, and 5th Annual Summer Conferences of NASA/USRA (e.g., Cordes, Moore, & Hansmann, 1989), and wrote a series of articles for architects and academics about space research and design opportunities (e.g., Schnarsky, 1988).

NASA/USRA Lunar Outpost Project

Design and development of this lunar facility was initiated in 1989 by the University of Wisconsin-Milwaukee's Center for Architecture and Urban Planning Research (UWM/CAUPR) and Department of Architecture (UWM/DAR) in cooperation with the College of Engineering and Applied Science (UWM/CEAS). It was supported by the first year of a three-year grant from NASA/Universities Space Research Association (NASA/USRA) University Advanced Design Program. UWM/Architecture is one of 44 universities in the NASA/USRA University Advanced Design Program, and one of only three architecture schools in the program. The program stresses the systems approach to design in which the class works together on a major "real world" project.

The project was completed over the course of two academic semesters. In the fall of 1989, an information seminar was conducted (Architecture 392/792, 3 credits) in which interested students received lectures, read extensively, and conducted simple sketch designs to "come up to speed" on information needed to design a lunar habitat. The product was a program requirements document available in the Space Architecture Series (Baschiera, et al., 1989).

In the spring of 1990, a space architecture design studio was conducted (Architecture 690, 3 or 6 credits) in which the actual designs were developed. The results are reported in this document.

The seminar was run by Mr. Edwin Cordes, a recent graduate of our Master of Architecture prgram and mnow a design engineer for Space Station Freedom at the McDonnel Douglas Space Systems Company, and myself. I ran the studio with significant input from a cast of visiting faculty and national critics from NASA Johnson Space Center and elsewhere. Our chief consultant through the year was Mr. Thomas Crabb, an astronautical engineer and Vice President of Orbital Technologies Corporation in Madison, Wisconsin. The NASA/USRA teaching assistant was Mr. Timothy Hansmann, who had been a summer intern in the Advanced Programs Department of the Engineering Directorate at NASA/JSC. Three extra-credit students - Messrs. Dino Baschiera and Joseph Fieber and Ms. Janis Huebner Moths - served as team leaders for the various analysis and design teams; together with Ms. Kerry Paruleski, all are now employed in the aerospace industry.

During the design phase of the project, three different design scenarios were explored based on differing sets of engineering and architectural assumptions: (1) use of prefabricated Space Station Freedom-type hard modules and other earth-based construction technology; (2) use of the lunar surface craters and lava tubes; and (3) use of inflatable structures. Results of these scenarios were presented to and reviewed by NASA, USRA, industry, and university personnel. The best of each scenario was then combined into a final integrative design.

This report summarizes the main performance requirements for a lunar outpost (cf. Baschiera et al., 1989 for greater detail), discusses the advantages and limitations of the three preliminary scenarios explored, and presents the final integrated design solution.

Since drafting this report, and as a deirct outgrowth of the first year of our NASA/USRA grant, we were invited to be the lead unit on what evolved into a $3.4 million grant proposal to the University of California Lawrence Livermore National Laboratory to research, design, fabricate, and test a new concept for a second US space station. The proposal involves a consortium of academic departments (architecture, chemistry, engineering, and materials science) at two major universities together with four industrial partners. The Proposal is under review and pending.

Gary T. Moore, Ph.D.
Professor of Architecture
Project Director and Faculty Advisor

3. ACKNOWLEDGEMENTS

The team members would like to thank the National Aeronautics and Space Administration (NASA) and the Universities Space Research Association (USRA) for sponsoring the project, and Celeste Sychterz-Wilson from the Lyndon B. Johnson Space Center who was our NASA/JSC liason. Special thanks to Dr. Gary T. Moore, our faculty advisor, and Mr. Tom Crabb of Astronautics Corporation of America for their support and assistance with human factors and technical information, and for their confidence in the team's capabilities throughout the academic year.

Thanks also to Kriss Kennedy, Mike Roberts, and John Connolly of the Johnson Space Center for technical and program assistance, and in helping define the requirements of the project.

The team is also grateful to Dr. John Alred, Program Manager at USRA , Deborah Neubek of the University of Houston's Sasakawa International Design Program in Space Architecture , and Professor Aurio Andino of the University of Puerto Rico's Space Architecture Program for taking the time to visit and add their valuable input during the course of the project.

Thanks to Mr. Ed Cordes, now at McDonnell-Douglas Corporation, Houston, without whom the program would not exist at the University of Wisconsin-Milwaukee.

We also owe our thanks to the following: to our Visiting Faculty, Profs. Ryoichi S. Amano, Department of Mechanical Engineering; Al Ghorbanpoor, Department of Civil Engineering; Robert Greenstreet and Anthony J. Schnarsky, Department of Architecture; Umesh Saxena, Department of Industrial and Systems Engineering; and to our Visiting Critics, Michael Kalil, Architect, Kalil Studios, New York; Jason Lorandos, Sasakawa Internationl Design Program in Space Architecture, University of Houston; Ronald R. Teeter, Orbital Technologies Corp., Madison; and Claudio Veliz, Architect, New York.

Timothy Hansmann
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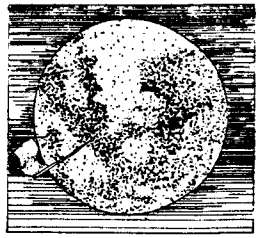

TABLE OF CONTENTS

4. LIST OF FIGURES

4. LIST OF FIGURES (Cont.)