GOALS AND DESIGN PRINCIPLES

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In the development of the design program for lunar base habitats, the studio generated a comprehensive list of pertinent design criteria. This list, developed with input from Astronautics Corporation and other consultants, formed the basis for the studio's design scenarios. The 32 design solution characteristics that were developed were further grouped into five basic areas of concern. These five areas will be discussed in more detail. The studio decided that the success of each individual's or group's design would be based upon its adherence to these design criteria and the further exploration of an area or areas of particular interest to the designer.

As a result of the design enterprise, four major design principles emerged, together with a number of other design ideas. These four design principles will also be discussed below.

SAFETY

Of utmost importance to the survivability of a lunar colony is safety, necessitating an emphasis on safety throughout all aspects of design. Safety consciousness can range from the design of "soft" furnishings and equipment to avoid possible bodily injury, to base-wide concerns like power and environmental supply redundancy, fire and contamination protection systems, and "safe havens" or contained environmental systems for sustaining life in emergencies.

HUMAN FACTORS/ENVIRONMENT-BEHAVIOR DESIGN

The psychological and physiological well being of the inhabitants of a colony in a habitat as foreign as the moon was one of the primary goals of the design investigation. The severity of the lunar environment necessitates a closed base design with limited exposure to the surface. These restraints can result in a number of psychological problems including boredom, wayfinding difficulty, and the feeling of isolation (National Aeronautics and Space Administration, n.d.).

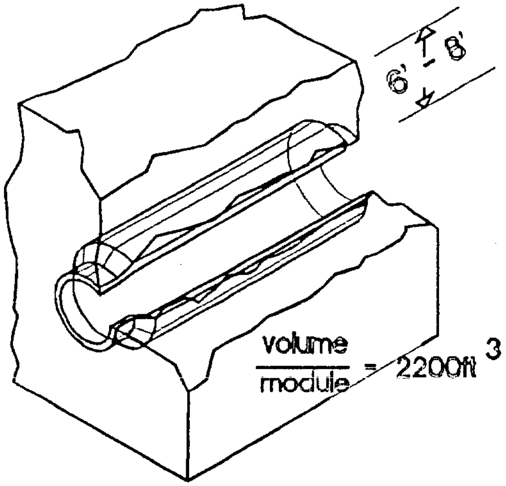
Economic and resource constraints dictate spaces which serve multiple functions. Multi-use programming could result in some loss of privacy and socialization, increasing tension among workers, and causing other secondary and tertiary problems, including loss of productivity. Maintaining a highly productive and interactive team is one of the most important concerns in both a safety and economic sense.

The maintenance of the health of the astronauts is also of vital concern. The moon's 1/6 earth gravity will, over time, weaken muscle tissue and bone structure. To combat the possible loss of strength, a vigorous exercise program is needed. Successful design solutions should allow space for exercise equipment and rigorous human workouts.

Finally, the design of spaces for basic health care must also be considered. The ability to perform emergency first aid, dental hygiene, and health maintenance will be required.

BASE PLANNING

The program developed for the design scenarios called for between four and six phases of construction taking up to 20 years to be completed. During this time, the base's primary role would evolve from simply a "safe haven" to an exploratory base camp, a scientific research center, and finally a lunar materials processing center. Base design and planning should address the evolving nature of the structure in allowing spaces to adapt easily to new functions. Early phase structures must integrate well with later phase construction to make the base economically feasable and safe. This will require long range planning and visionary designs early in the base's evolution.



Economic, modular design strategy

ENVIRONMENTALLY RESPONSIVE DESIGN

The extreme conditions of the lunar surface necessitate the development of a number of different environmental strategies. One of the most serious problems facing a lunar colony is protection from radiation. The lack of an atmospheric protective shield necessitates more complex radiation protection designs, including those which utilize the lunar surface's natural resources.

Another significant problem is the maintenance of a closed living environment. Designs must eliminate virtually all atmospheric leakage while still maintaining effective ventilation and filtering, sanitary upkeep and a constant supply of vital resources. Thermal control also poses a unique problem. Both heat retention and elimination in an environment lacking any atmosphere and having daily temperature swings from 134C (270 F) to -170 C (-270 F) require careful design consideration.

DESIGN ECONOMY

The extreme cost and risk of delivering payloads to the moon's surface necessitates the exploration of economically feasible construction methods and materials. Design strategies developed in this study included tension structures, inflatable membranes, pressure vessel units, and the use of the lunar regolith for shielding and construction.

Also inherent in the development of economic design strategies was the investigation of labor efficient construction sequences and unit designs. Design strategies included the study of symmetrical units, repetition, and multiple building blocks. The use of robotic construction machinery, even in prehabitation phases, figured prominently in many of the solutions. It was the opinion that these machines could complete difficult, dangerous or mundane tasks without endangering the astronauts lives.

Details on these design principles and a number of other design criteria are given in the accompanying matrix. The circles represent those design principles and criteria that figured importantly in each of the student design scenarios.

TABLE OF SOLUTION CHARACTERISTICS BY DESIGNER

types of concepts	● Ahmad Hamzah	● Ed Cordes	● Hairuddin Munip	● Michael Bahr	● Nnamdi Elleh	● Norshamsiah Abdhamid	● Steve Frahm	● Tim Luettgen
BIOLOGICAL ANALOGY					O			O
LUNAR (LAND) SCAPE UTILIZATION			O	O			O	
HIGH EARLY CROSS OVER TECHNOLOGY	O	O		O		O	O	
THE MOST EXPENSIVE CAMPING TRIP IN THE WORLD		O		O			O	

particular response to deterministic force system	● Ahmad Hamzah	● Ed Cordes	● Hairuddin Munip	● Michael Bahr	● Nnamdi Elleh	● Norshamsiah Abdhamid	● Steve Frahm	● Tim Luettgen
RADIATION	O	O	O	O	O	O	O	O
LEAST WEIGHT DESIGN	O	O		O		O	O	O
VISUAL ACCESS TO LUNAR SURFACE			O	O	O		O	O
ADAPTABLE STRUCTURE	O					O		O
MODULAR CONSTRUCTION	O	O	O	O		O	O	
PACKAGING FOR TRANSPORT FROM EARTH		O		O			O	O
ROBOTIC CONSTRUCTION	O	O		O			O	
ACCESS AND REPLACEABILITY	O					O	O	
CONSTRUCTION SEQUENCE		O		O			O	O
INTERIOR SYSTEMS			O	O	O	O		O
INTERIOR DURATION STRESS (BOREDOM)				O	O	O		
SAFETY AND REDUNDANCY		O	O			O	O	
CIRCULATION LOGIC	O		O			O		
VERTICAL GRADIATION OF ACTIVITIES			O	O	O	O	O	
UTILIZATION OF EARLY EARTH BUILT MODULES AS BACK-UPS	O	O	O	O	O	O	O	
EARLIER STRUCTURES BECOME PART OF CROSS-OVER HYBRID		O	O	O	O	O	O	

kinds of construction strategies used	● Ahmad Hamzah	● Ed Cordes	● Hairuddin Munip	● Michael Bahr	● Nnamdi Elleh	● Norshamsiah Abdhamid	● Steve Frahm	● Tim Luettgen
ALUMINUM BALOON	O	O	O	O	O	O	O	O
CABLE STRUCTURE			O					O
NET STRUCTURE			O					O
LUNAR CONCRETE	O			O	O			
SPACE FRAME	O	O	O			O	O	
ISOLATION OF REGOLITH STRUCTURE FROM ATOMOSPHERIC	O	O	O	O			O	
BAGGED REGOLITH PROTECTION							O	
MELTED REGOLITH GLASS PROTECTION				O				
LUNAR MATERIALS IN COMPRESSION		O		O	O			
BERM CONSTRUCTION	O			O		O	O	O
FLAT MARE CONSTRUCTION	O	O	O	O		O	O	
HARD ROCK OR CRATER CONSTRUCTION					O			O
HABITATION THAT CAN MOVE TO ANOTHER SITE	O				O			