Lunar Housing Simulator

Statement of Work

Prepared By

R. H. Hall

August 4, 1959

Table of Contents

Table of Contents (Con't) Page

I Introduction

This statement of work has been prepared to enable The Martin Company, Denver Division, Denver, Colorado to define the Architect-Engineering services adequately to obtain a preliminary Architect - Engineer bid for the design and supervision of construction of a Lunar Housing Simulator for the Seattle Exposition, Seattle, Washington.

No, not true

A Scope Criteria outlining the function of the project has been included as a supplement to this document. A detailed Design Criteria will be furnished to the Architect-Engineer subsequent to the award of the Architect-Engineering contract.

II Summary of Facilities

This work statement governs the design for the construction of a Lunar Housing Simulator and an associated Support Building and includes the following listed components:

1. The complete Lunar Housing Simulator Sphere.
2. An elevator in the Access Shaft.
3. An access air lock and utility corridor.
4. A water storage and distribution system for the process water, potable water, and fire protection.
5. An air conditioning system.
6. A vacuum system capable of reducing the air pressure in the Lunar Sphere to five (5) pounds per square inch absolute (psia).
7. A standard electrical system to supply required power for the equipment in the Lunar Simulator Sphere and for the equipment and lighting in the Support Building. A special high voltage, high frequency electrical system, including the motor-generators, to supply power for lighting in the Lunar Simulator Sphere.
8. A food preparation center.
9. Refrigerated storage.
10. A communications system and a closed circuit television system.
11. A Support Building and facilities.

III General Conditions

A. Responsibilities of the Architect-Engineer.

1. Prime Responsibilities

a. Preparation of design

The Architect-Engineer shall prepare complete design drawings, specifications, and bills of material necessary for the purchase of all equipment and the construction of the entire facilities

as tentatively described by the Scope Criteria, and which will be further defined by the Design Criteria. Design and construction of the Lunar Housing Simulator shall conform to the time schedule given in Section III C. (Generally True: Date of occupancy - firm.)

b. Supervision of bid letting for construction

(1) Letting of bids

The Architect-Engineer shall obtain bids from a minimum of three (3) construction contractors acceptable to The Martin Company.

ALTERNATE HERE → A-E-CONST. — ONE CONTRACT

(2) Analysis of bids

When the bid closing date has arrived, the Architect-Engineer shall analyze the bids within two (2) days time and obtain the approval of The Martin Company prior to making the final selection and awarding the contract.

c. Monitoring and inspection of construction

After awarding the contract the Architect-Engineer shall monitor and inspect the construction of the facility and the installation of the equipment. The Architect-Engineer shall ascertain that the construction and installation meet the requirements of the design specifications and applicable national and local codes.

d. Verification of Equipment operation

Upon completion of construction the Architect-Engineer shall verify the satisfactory operation of all equipment and systems prior to the final inspection.

e. Final inspection and approval

A representative of The Martin Company shall accompany the Architect-Engineer during the final inspection and shall verify the operation of all equipment and systems. The final inspection data shall be submitted to The Martin Company for approval prior to the acceptance of the project.

f. Providing of records

(1) Design drawings

The Architect-Engineer shall submit _____ complete sets of the final issue of the Design Drawings and one complete set of sepias to The Martin Company for retention.

(2) Specifications

The Architect-Engineer shall submit &____ copies of the construction specification to The Martin Company for retention.

(3) Bills of material

The Architect-Engineer shall submit _____ copies of the Bills of Material to The Martin Company for retention.

(4) Vendor Prints

The Architect-Engineer shall forward three (3) copies of each certified approved vendor prints to The Martin Company for retention.

(5) Reports

The Architect-Engineer shall submit _____ copies of each report to The Martin Company

(6) Operating procedures and schematic diagrams

The Architect-Engineer shall submit three (3) sets of equipment operating procedures and system schematic diagrams to The Martin Company for retention. The operating procedures shall include applicable spare parts lists.

2. Procedures

a. Design Drawings

Except as agreed otherwise, all drawings prepared by the Architect-Engineer shall be on 28" x 40" linen. The Architect-Engineer shall submit the original tracings and three (3) prints of each drawing to The Martin Company prior to final

issue for approval. The approved originals will be returned to The Architect-Engineer for his retention.

b. Specifications

Specifications shall be typewritten on 8½" x 11" multilith (or equal) mats. The Architect-Engineer shall submit the original multiliths and three (3) sets of specifications to The Martin Company for approval. The originals will be returned to the Architect-Engineer for his retention.

c. Bills of material

The Bills of material shall be typewritten on 8½" x 11" linen. The Architect-Engineer shall submit the originals and three (3) prints of each to The Martin Company for approval. The originals will be returned to the Architect-Engineer for his retention.

d. Vendor Prints

The Architect-Engineer shall be responsible for expediting the receipt of vendor drawings, specifications, and data pertaining to all major equipment, structural steel and shop fabricated piping.

e. Reports

The Architect-Engineer shall submit reports to The Martin Company as follows:

(1) Submit design and construction progress reports semi-monthly.

(2) Submit drawing and specifications reports semi-monthly.

(3) Submit vendor print status semi-monthly.

(4) Submit current time schedule monthly.

f. Operating Procedures and Schematic Diagrams

The Architect-Engineer shall furnish schematic diagrams which will fully describe the process requirements, piping and duct flow, the electrical system, and instrumentation. These drawings shall include an index sheet. A start-up and checkout procedure shall be included. Operating instructions, supplementing those received from vendors of major equipment, shall be included where applicable.

B. Change Orders

The Architect-Engineer shall evaluate all construction and equipment changes that affect engineering or design in terms of their effect on cost and time schedules. Changes which will adversely affect the cost of the project, the overall time schedule, or the performance of the equipment shall not be accepted or implemented by the Architect-Engineer without first obtaining the approval of The Martin Company.

C. Time Schedules

1. Design Schedules

The Architect-Engineer shall submit a schedule of design activities showing estimated performance on the following:

a. Flow Diagrams

b. Procurement Specifications

c. Design Drawings

(1) Architectural

(2) Electrical

(3) Piping, heating, ventilating, air-conditioning

(4) Instrumentation

(5) Mechanical

(6) Structural

2. Overall Schedule

The overall schedule for the Architect-Engineer's services

shall be approximately as indicated in the accompanying schedule diagram.

D. Conflicts in Documents

Where there is a conflict between the Scope Criteria, the Design Criteria, and the drawings therein, The Martin Company shall interpret and decide which shall govern.

LUNAR HOUSING SIMULATOR

ARCHITECT-ENGINEERING SERVICE

SCHEDULE

Design Criteria

Customer Approval & A & E Selection

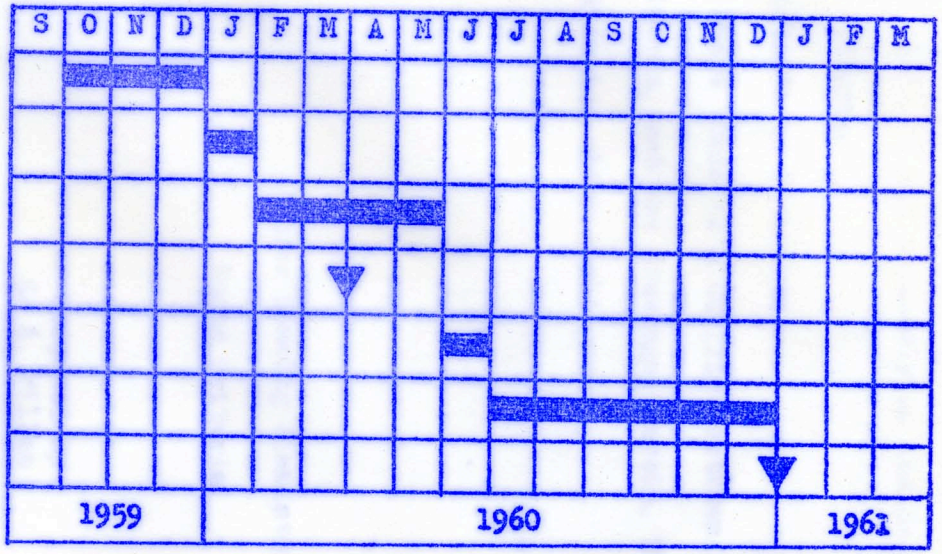
A & E Design

Advance Procurement Start

Bid Letting

Construction

Occupancy



WORKING PAPERS

Lunar Housing Simulator

Scope Criteria

Prepared by
R. A. Willes

August 4, 1959

LUNAR HOUSING SIMULATOR

SCOPE CRITERIA

I. GENERAL CONDITIONS

A. Scope

This document contains a technical description of the Lunar Housing Simulator for installation at the Seattle Exposition in 1961 and a brief outline of the functional purpose of the facility. The major facilities necessary for this program consist of the following structures:

The Lunar Housing Simulator

The Access Tunnel

The Test Support Building

B. Introduction

When man personnally leaves the earth to embark on an exploration of outer space, it will soon become necessary to establish an operational base from which he can conduct long term studies of his new environment. The base must contain the basic elements required to support human life such as a pressurized environment, oxygen, food and water. To avoid a constant and costly resupply of the life supporting essentials as they are consumed by the personnel manning the base, the Martin Company proposes that a minimum self-sustaining environment be developed.

The lunar housing simulator is planned to develop and verify the requirements for a self-sustaining environment for outer space, in as nearly identical conditions as are practicable to obtain here on the earth. The lunar housing simulator will contain crew housing quarters for five men and a system capable of reconverting their waste products back into the organic forms useful to support human life.

The access tunnel permits passage through an air-lock from the outside into the lunar house. The test support building contains electrical power

equipment for transmission and generation of the lunar house power requirements, air conditioning equipment for removal of excess heat from the ecology laboratory, vacuum pumps to maintain the reduced atmosphere status within the simulator and an administrative office.

C. Development Plan

The scope criteria, this document, and the design criteria will be developed by ABSD of Martin-Denver. Facilities Design will be by an acceptable Architect-Engineering Firm under the supervision of the Martin Company. Facilities construction will be monitored & inspected by the Architect-Engineer. The final operational verification of the facilities will be supervised by the A & E & in the presence of the Martin Company. Equipment installation and plant operation will be by the Martin Company.

D. Reference Document

The following documents and drawing further describe the development plan and functions of the Lunar Housing Simulator project.

1. Proposal For Lunar Housing Simulator: March 59
2. Drawings as follows:
   a. Lunar Housing Simulator
      SK-0000753 - Structural Layout
   b. Lunar Housing Simulator
      SK-0000754 - Floor Layouts
   c. Lunar Housing Simulator Support Building
   d. Preliminary Flow Diagram Lunar Housing Simulator
      June 19, 1959

E. Operational Requirements

Design of the Lunar Housing Simulator shall conform to the following operational requirements:

1. The Lunar House shall be capable of maintaining a reduced air pressure of 5.0 psi (equivalent to a terrestrial altitude of 27,000 feet under an external ambient pressure of 14.7 psi.

2. The lunar house shall be capable of complete isolation from the outside environment except for electrical power and chilled water systems during test periods.

3. Aocess to the lunar house shall be through the air lock access tunnel.

4. The lunar ecology system shall be capable of being operated by five men.

II. Facilities

A. The Lunar House

The simulated lunar house is a three story laboratory located within an air-tight steel sphere 32 feet in diameter. Figure 1 shows an artist conception of this laboratory. For the Seattle Exposition air sealed windows are provided to permit circumferential surveillance of the second and third floors from a promenade platform. In addition, four port-hole type windows are available for general observation of the first floor living quarters from the outside.

1. Structural Description

The lunar simulator sphere is an air-tight steel and glass enclosure that is supported from a central shaft and by four vertical posts attached to an equatorial ring, drawing SK-0000753 shows the conceptual details of this facility. The upper shell is a ribbed steel dome with circumferencially interspaced steel panels and air sealed windows. The lower half of the shell is sheet steel with four portal window. Around the windows the steel shell is reinforced to maintain the structural integrity of the shell and to secure the installation of air tight windows.

The central support shaft is large enough to contain an elevator for the transport of personnel and small equipment from the air lock entry to any floor. A pressure sealed plate at the top of the shaft may be removed to permit installation of heavy equipment from the out-

rubber tile covering ?

side. The floors are metal decking supported on radial beams extending between the box guides at the central shaft and the outer shell.

2. Architectural Description

The second and third floors contain the ecology laboratory with facilities for growing algae, small edible plants and some animals. Artificial lights of high intensity furnish the radiant energy used in the plant processes to change organic waste into plant tissue useful to man. During the photosynthetic process associated with plant growth, carbon dioxide is absorbed from the surrounding atmosphere & oxygen is released.

Acoustical insulation located at intermittent points in the walls and ceiling serve to reduce sound reverberations to an acceptable level.

A laboratory work bench is located at the central core on the second floor for the preparation of plant samples for installation in the growth section & for sample testing of the hydroponic system.

The first floor serves as living quarters for up to five men, and is partitioned into a living room, a kitchen, a shower room, and sleeping quarters. To make the first floor habitable for long periods, the floors are covered with asphalt tile and the ceilings and outer walls acoustically insulated against excessive sound transmission from the upper laboratories.

The kitchen contains a galley for food preparation, refrigerated storage, electrical cooking equipment, a double basin sink, a metal dining table and folding chairs. The bedroom is furnished with a double bunk bed, three wall beds, and metal clothing closets. The bathroom contains a shower, a wash basin, a water closet, and a medicine chest and mirror. The living room is furnished with an executive chair, an easy chair, an end table, a desk, book shelves, a radio, and a television set.

Wastes from the first floor level are macerated into small particles and stored in the cellar space, between the first floor and the bottom of the structural shell, until they are ready to be pumped into the plant ecology system. This small cellar also contains other liquid storage, pumps, and various items of mechanical equipment requiring infrequent direct access.

Trap doors and a steel ladder are provided at all floor levels to allow exit from the Lunar House in case of an elevator breakdown or power failure.

B. The Access Tunnel

An air-tight tunnel with sealed doors at each end is provided to obtain access to the lunar house with a minimum of air exchange. The interior portion consists of a metal grating walkway and a waiting bench. The doors are pressure locked to prevent opening of any door until the pressure within the tunnel is equal to the pressure on the opposite side of the door. Emergency operations however will permit the direct passage of air from the outside in case of an equipment failure.

C. Test Support Building

Successful operation of the lunar simulator is dependent upon a continuous supply of electrical power to stimulate plant growth and chilled water for removal of the resultant heat energy. Equipment to furnish these services and others essential to the preparation and support of the lunar simulator are located in a conventional type structure adjacent to the vacuum sphere. This test support building, see drawing _____ will be designed to conform to the prevailing architecture of the surrounding structures.

In addition to the electrical power generating and air conditioning control equipment essential to the daily operation of the lunar simulator, the support building contains vacuum pumps for the initial

reduction and maintenance of the interior air pressures. It also contains a receiving and storage area for incoming supplies, a small shop for minor equipment modifications or repairs and a conventional toilet and shower, and a support laboratory and office for conducting related tests and for supervising operation of the experiment.

III Major Systems

Operation of a self sustaining ecology system is dependent upon an outside source for a continous supply of electrical power for equipment operation and radiant light energy to stimulate plant growth, and chilled water to remove the resultant heat energy. In addition, an outside vacuum system is required to prepare and maintain the simulated air pressure anticipated at a lunar base. Inside the Lunar House, the air and water supply must be cycled through the plant and animal areas. This section contains a brief description of each of the systems proposed for this project.

1. Electrical Systems

Approximately 300KVA of electrical power is required for the operation of the Lunar simulator support building and functions.

a. Support Building

The Support Building houses the main power substation which transforms the local commercial power to 480 volts, 3 phase, 60 cycles. The 480 volt system will supply power to operate the various building systems as well as special support equipment. A 480 volt to 120/208 volts, 3 phase, 60 cycle transformer will supply power for lighting and appliances.

b. Lunar House

Three types of power will be supplied to the Lunar House from the Support Building.

(a) 480 volts, 3 phase, 60 cycle power for motor operation.

(b) 120/208 volts, 3 phase, 60 cycle power for appliances and laboratory apparatus.

(c) 600 volts, 840 cycle power for lighting.

2. Air Conditioning System

All of the energy which is continually supplied to the Lunar House ultimately degrades to heat. It is assumed that the net heat transfer through the shell of the sphere is zero. Therefore a means must be provided to remove heat from the sphere at a substantially constant rate equivalent to the energy input.

A supply of chilled water developed by equipment located in the test support building is considered the most practical means of heat removal from the sphere. Only the chilled water supply and return line are required for external connection. There will be no transfer of matter since the chilled water will be circulated through a sealed system within the lunar house.

The chilled water circulating pump(s) are external to the sphere, but the heat transfer surface and fans for air circulation are located within the sphere.

3. Vacuum System

In order to reduce the potential air losses and containment shell strength at an actual lunar base, the simulator test will be operated in ½ an atmosphere. A vacuum air pump system located in the test support building will serve to achieve the initial air pressures and maintain the system against air leaks. During the passage of personnel through the air lock access tunnel, the air pressure in the access tunnel will be adjusted to conform to the air pressure in the space to be entered.

4. Water Supply System

Three water systems service the lunar simulator. They are as follows:

a. Water for domestic consumption and general usage is supplied from the purified water tank located in the ceiling of the lunar house third floor area. As this water is used, the tank is refilled with moisture condensed out of the interior air in the dehumidifier & through a water purifier.

b. Water is used to convey human, animal and plant waste product through the ecological system. This water is processed and stored in a waste storage tank until required for recycling through the plant nutrient system.

c. The capability to supply water & remove waste from the lunar house between test operation are included in the facilities design plan. During test operations, however, usage of this water system will be limited to emergency situations such as a fire fighting or failure of the internal system.