THE LUNAR HABITAT
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THE VISION

BACKGROUND

The background page describes the events that lead to the formulation of my thesis idea.

ABSTRACT

The abstract is a concise description of my thesis goals and process.
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During my internship at Ray & Hollington architects I worked under a Ball State Alumni. Over the course of my time working at that firm we occasionally discussed thesis projects and went over some ideas that I was considering. At this time in addition to working at Ray & Hollington Joe Meppelink was a professor at the University of Houston and a thesis advisor to several architecture students at Rice. During one of my discussions about my thesis ideas I mentioned my interest in design for extreme environments and the subsequent architecture’s impact on the occupant under stressful situations. In response Joe mentioned his involvement in the space architecture program at U. of H. and the students involvement in architecture that deals with the most extreme conditions possible. This sparked my interest in the idea of a sustainable habitat on a different planetary body to push my earlier idea to its absolute limits. After researching the current approaches to similar challenges and the discovery of NASA’s plan to build a basic habitat similar to the idea I had, my mind was made up. I decided I would take the plans NASA developed and explore one possible step further in this endeavor.
Abstract

Mankind is on the verge of a scientific achievement greater than any previously attempted. By the year 2018 N.A.S.A. plans on returning to the lunar surface. Initial voyages will consist of mostly research and manned moon walks reminiscent of the Apollo missions. After preliminary exploration is complete plans involve establishing a human habitat on the moon.

My goal is to be in the forefront of this monumental undertaking by examining current mission plans and advancing those ideas to more ambitious goals while applying an architect’s understanding of space and how it can be used to preserve physical and psychological health. As a parallel issue I will use the local environment to inspire a responsive design esthetically pleasing and virtually sustainable.

The question therefore becomes, can a habitat be designed that can sustain life in an alien environment and also address the mental clarity and well being of its residents through intelligent design. I believe it can, and it will lead to a new perception of the human interaction in the spatial and aesthetic construct of a sustainable habitat. Moreover the project will set the stage for further exploration of our solar system and more advanced human inhabitation of other planetary bodies.
THE ENVIRONMENT

General Facts

General facts about the moon and its influence on the earth show its importance for scientific and architectural discovery.

Soil Conditions

With the harvesting of minerals and water required to establish a sustainable habitat it was important that deposits are accessible.

Lighting Conditions

Using the environment to fuel the habitat required calculated responses to the sun patterns for power and thermal control.
Site Selection

With environmental responsive architecture it is paramount that an appropriate site is selected. This section gives some criteria for such a site.
**General Moon Facts**

**New Moon**

- **Distance from Earth:** 225,745 miles
- **Length of day:** 27.3 days
- **Radius:** 1,080 miles

**Full Moon**

- **Weight:** 81 quintillion tons
- **Surface temp. (day):** 273 F.
- **Surface temp. (night):** -244 F.

**Old Moon**

- **Gravity on surface:** 0.1667 g (1/6 Earth’s)
- **Estimated Age:** 4.5 billion years
- **Widest craters:** 140 miles (dia)
Moon’s Effects on Earth:

Shift in earth's tilts from moon’s gravity caused humans mass migration from Sub Saharan Desert.

Without the moon earth would wobble on axis like Mars.

Full moon causes 20% increase in crime and accident rate.

Full moon causes 15% increase in hospital activity.

Moon saved life on earth several times by absorbing meteors otherwise headed for earth.

Moon’s influence calmed earth's weather making it possible for life on land.

No Moon = No Humans

Orbital speed: 2,287
Driving time by car: 135 days
Flying time by rocket: 60 to 70 hrs.

# of humans on surface: 12

Deepest crater: 15,000 + (ft.)
Highest mountain: 16,000 + (ft.)
The South Pole Aiken region is a large crater that provides access to upper and lower mantle conditions. The map below shows the outline of this impact zone. This area is important for its scientific potential and the accessibility to minerals to support the habitat.

The topographical changes are represented below. Changes from positive to negative eight kilometers exist in the Aiken region.

This region contains high concentrations of iron. Many of these areas are within traveling distance from the South Pole.

The location of titanium deposits is similar to that of iron, mostly in close proximity to the South Pole.
Thorium

Geology

Albedo

The distribution of thorium is confined to an area near the south pole.

This map shows more clearly how the most diverse mineral concentrations are located in the Aiken crater basin near the south pole.

The albedo is the reflectivity of the lunar surface. As you can see, the high mineral content of the south pole region is highly reflective.
The images to the right are cumulative compositions formed from overlays of one lunar day. They were created by the Clementine Mission.

At first glance the north pole appears to have superior lighting conditions than the south. Under deeper investigation this is not so. Although the north pole does have a larger area that experiences solar saturation, the duration is far less than the south pole. As a matter of fact, the south pole contains three locations with sun for more than 60% of the lunar cycle. The entire north pole region doesn’t have any areas with greater than 40% illumination. This makes for worse conditions than the equatorial region that experiences 50% illumination.
Just like on Earth, the sun conditions change drastically between the poles and the equator. Unlike the Earth, the polar conditions on the Moon experience similar light conditions all year long due to the Moon’s 2% of tilt on its axis. On the equator, the sun rises and sets in equal day intervals.
The yellow dots on the model represent the habitat location.

In order to get a first hand understanding of the south pole lighting conditions I extruded a 3D projection of the south pole. I then used the roughter to make a accurate scale model of the landscape. That model was then tested on the hilodron under calculated light angles to understand the exact light patterns for my site. You can see a few examples of the outcome in the above images.
The chart to the upper right traces out the lighting patterns I gathered from my experiment. This chart traces out the angles of influence from natural light in yellow and reflected light from solar stations (see next capture) in orange.
Site Selection

With a good understanding of general environmental conditions I was able to choose the most appropriate location for the habitat. Initially my research lead me in two different directions at this point. One stance on the location of a lunar habitat is that it should be located near the equator. The second idea is a south pole habitat.

Strong arguments can be made for locating this habitat at either site. The equator site is fortunate that it has continuous sun for fourteen continuous days. This would provide a consistent source of power. The equatorial region also has a forgiving site. The Apollo missions provided extensive information on this area and there is relatively minor topographic changes, providing a tried and true landing procedure.

Unfortunately several limitations hinder the equatorial site. First and foremost is the disconnect between it and water deposits. This would make a sustainable habitat much more difficult, not to mention negating the possibility of harvesting fuel from the water sources for resupply on the way to Mars. On top of that there is the light condition. Although I mentioned it as a positive, there is a duality making it a challenge because the light is on 14 day cycles, darkness is also. Long spans of power draw without any way of replenishment would require a small nuclear power supply. As you can imagine this would present many problems, from delivery, to maintenance, to a divergence from the sustainable ideal.
The South pole region has advantages of its own. The South pole’s low angle of incline from the sun creates a point of near eternal light in three positions. Each location is on the side of a crater wall high enough to overcome the slight tilt on the moon’s axis. As a group these points would provide a uninterrupted source of solar energy. On the inside of the South pole crater basin two very important condition exists. First is the access to lower mantle conditions that would help explain the moon and earth’s formation. This could also hold the answer to the formation of life on Earth which is believed to have occurred after the moon broke off our planet in a collision with a asteroid. More important than that, the crater basins contain frozen water deposits in places of eternal darkness. The water would fuel the inhabitants and future fuel needs as we branch out in our solar system.

With these positive qualities there are also inherent challenges. The South pole regions intrigue and opportunities from its crater sites are also its biggest setback. The harsh terrain makes landing much more complicated. It also presents interesting challenges for crew and machines as they explore the depths of this region.

With positive and negative qualities of both sites analyzed I feel the South pole is the clear choice.
# THE CONCEPT

## Expectations

This section describes the way ideas are represented in the early design stage and how they will effect the occupants.

## Spacial Requirements

Early studies led to an understanding of spaces and functions needed to support a habitat on the Moon.

## Spacial Layouts

Initial layouts of space focused on the required size and connection between interrelated functions.
<table>
<thead>
<tr>
<th>Options</th>
<th>Final Idea</th>
</tr>
</thead>
<tbody>
<tr>
<td>This section represents several ideas that were explored in model form.</td>
<td>From the options in the preceding pages a decision was made determining the best choice. This section shows that choice.</td>
</tr>
</tbody>
</table>
### Expectations

The lunar habitat will begin to explore the social and physical impacts of long term stays on an alien land and the architectural significance of the relationship between the crew, the environment, and the structure. To accomplish this the interior layout, organization, and interaction with the crew and environment were main focus points of early design responses. With these guiding ideas in mind a study of the space requirement and interconnections was carried out and translated into conceptual designs.
Phase One

The initial installment of the lunar habitat will be focused on the preparation of the site for future long term missions. This initiative will deal with the establishment of a power source, a means of resource extraction for fuel, water, building materials, and a basic life support system to maintain a crew of four for one lunar cycle (28 Earth days).

Components:

- Three linked solar arrays located at points of maximum illumination provide a constant power supply 98% of the time.
- A soil extraction and refinement plant will produce a lunar brick and oxygen as a by product to be used for life support and fuel.
- A limited human habitat will support a crew of four for one lunar cycle.
- Two ground support vehicles will be deployed to gather resources and transport crew members to research sites.
- An off site communication relay station will transmit any signals back to Earth during times of radio blackout.

Overview

Overall the initial work is intended to be a stepping stone for future developments. Many of the ideas I listed above are included in the plans NASA has for the 2018 mission. My focus for this project is on Phase two which I will get to next.
Phase Two

This step in the project is the primary area of investigation. Secondary construction on the lunar site will focus on the human physical and physiological support systems. Points of interest will include the creation of a landing and takeoff site, regenerative life support system, and an evolved living space with an environmental derived form.

Components:

- The landing site will consist of a level surface of lunar bricks created during the production of oxygen in phase one, with a support building for fuel storage and landing module repair.
- The regenerative life support system will incorporate biological components in the synthesis, purification, and regeneration of basic life support commodities.
- Human living space will consist of a permanent habitat focused on the mental stability of its residents. Spaces will be designed to stimulate human interaction balanced by areas of varying degrees of privacy.

Overview

The final site development will lead to extended stays on the lunar surface under sustainable conditions. It will become a ever expanding living environment for human habitation, creating a stepping stone for future human exploration. Many solutions that will make this habitat sustainable can be directly applied to the expanding importance of making human life on earth sustainable.
**HABITAT REQUIREMENTS**
- Capability to monitor crew health
- Crew sleeping accommodations
- Capability of the crew to maintain habitat

**HYGIENE**
- Capability for the crew to maintain personal hygiene
- Capability for food preparation

**REGENERATIVE LIFE SUPPORT FACILITY**
- Recycle air and water, produce food, and process waste
- Combination of higher plant life, microorganisms, and physiochemical processes
- Biological components are used in synthesis, purification, and regeneration of basic life support commodities
- Higher plant life will be used for food production, CO2 uptake, and O2 release and in combination with microbial systems, will support water purification

**SCIENCE AND ENGINEERING WING**
- Capability to perform engineering demonstration stations on the lunar surface
- Capability to perform research activities on the lunar surface
- A pressurized laboratory provided for scientific activities

**EMU ELEMENT**
- Capability for frequent EVAs
- Capability to support a two-person EVA crew for a lunar day and transport them over a distance of at least 100 kilometers
- Ability to clean and repair spacesuits and portable life support equipment

**CON STAT**
- Provide continuous communication relay to earth
- Provide a staging point for mission and activity briefing

**MED FACILITY**
- Crew health maintenance and medical care

*Early investigation into habitat requirements focused on the understanding of all the support systems needed for a project of this type. The ideas to the left are early thoughts that later evolved into more detailed understandings of the facility breakdown.*
My first layout was purely functional. I wanted to take my understanding of the required spaces and see how they should relate to each other.

Air locks are placed in areas that require isolated atmospheric conditions. Their interference with traffic patterns is minimized to cut down on transition time from space to space.

The crew support wing that N.A.S.A. plans on completing by 2018 will be converted from full life support to lunar brick and oxygen production after phase two is completed.

The lunar habitat is broken down into three main areas. Regenerative life support for water and air recycling, medical space for mental and physical checkups, and living quarters for the crew.
<table>
<thead>
<tr>
<th>Phase One</th>
<th>Phase Two</th>
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<tr>
<td><strong>SPACE</strong></td>
<td><strong>AREA</strong></td>
</tr>
<tr>
<td>Solar array</td>
<td>- 50 x 100 M. = 500 M. sq.</td>
</tr>
<tr>
<td>Three integrated</td>
<td>- 3 x 10 M. = 30 M. sq.</td>
</tr>
<tr>
<td>1.7 MW of electricity</td>
<td>- 30 x 30 M. = 900 M. sq.</td>
</tr>
<tr>
<td><strong>RESOURCE UTILIZATION</strong></td>
<td><strong>LIFE SUPPORT SYSTEM</strong></td>
</tr>
<tr>
<td>Brick production</td>
<td>- 3 x 8 M. = 24 M. sq.</td>
</tr>
<tr>
<td>Oxygen production</td>
<td>- 3 x 12 M. = 36 M. sq.</td>
</tr>
<tr>
<td>Fuel</td>
<td>- 3 x 12 M. = 36 M. sq.</td>
</tr>
<tr>
<td>Atmosphere</td>
<td>- 3 x 6 M. = 36 M. sq.</td>
</tr>
<tr>
<td><strong>FOUR PERSON HABITAT</strong></td>
<td><strong>RESEARCH FACILITY</strong></td>
</tr>
<tr>
<td>Shared living space</td>
<td>- 3 x 8 M. = 24 M. sq.</td>
</tr>
<tr>
<td>Communication relay</td>
<td>- 3 x 10 M. = 30 M. sq.</td>
</tr>
<tr>
<td>Mechanical</td>
<td>- 3 x 3 M. = 9 M. sq.</td>
</tr>
<tr>
<td><strong>FINANCIAL SUPPORT</strong></td>
<td><strong>LIVING SPACE</strong></td>
</tr>
<tr>
<td>Airlock to support spaces</td>
<td>- 3 x 10 M. = 30 M. sq.</td>
</tr>
<tr>
<td>Airlock to support spaces</td>
<td>- 1 x 3 M. = 3 M. sq.</td>
</tr>
<tr>
<td><strong>A. RESOURCE UTILIZATION</strong></td>
<td><strong>B. FOUR PERSON HABITAT</strong></td>
</tr>
<tr>
<td><strong>C. LANDING SUPPORT</strong></td>
<td><strong>D. LANDING SURFACE</strong></td>
</tr>
<tr>
<td><strong>E. LIFE SUPPORT</strong></td>
<td><strong>F. RESEARCH FACILITY</strong></td>
</tr>
<tr>
<td><strong>G. SLEEPING SPACE</strong></td>
<td><strong>H. PUBLIC SPACE</strong></td>
</tr>
<tr>
<td><strong>I. MEDICAL SUPPORT</strong></td>
<td><strong>J. PUBLIC SPACE</strong></td>
</tr>
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The conceptual development of my project evolved through multiple steps. Each step had one underlining feature. That feature was the sun. It not only powers the habitat but also controls thermal gain.

My first concept was inspired by the local topography. Each individual component engages the sun as it circles the horizon.

The second concept responds to the sun with a central thermal mass that captures heat and distributes it through the design.

The final concept traced the pattern of the sun as it is blocked and then exposed from the surrounding crater walls.

All three concepts were studied on the hillock to test their engagement of the solar cycle. From the information I gathered in this process I was able to determine which ideas worked and which didn’t.
# The Personalization

## Crew Composition

This section is an investigation into the crew members at an individual level.

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## Expectations

This section explores the driving forces behind the interaction between the inhabitants, the structure, and the environment.

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## Crew Tasks

Crew tasks explores the work schedule of individual crew members through a typical week in the habitat.
Crew Schedule

The crew schedule highlights the daily movement patterns of crew members as they complete their work. Emphasis is placed on times when multiple crew members utilize the same space.

pg. 35-38
CREW CONSIDERATIONS

CREW SIZE / COMPOSITION (SIX MEMBER CREW)

- CREW LEADER
  In charge of organizing E.V.A. mission and the distribution of assignments.
- BIOLOGIST
  In charge of research and maintenance on the regenerative life support’s biological systems.
- GEOLOGIST
  In charge of discovery and research and mapping of lunar rocks and water deposits.
- PSYCHOLOGIST
  In charge of routine mental evaluation research into mental stability of crew members.
- ASTRONOMER
  In charge of utilizing the moon’s lack of atmospheric disturbance to observe our galaxy.
- PHYSICIAN
  In charge of health check ups and research into the health effects of a lower gravity environment.

CREW GENDER

- MALE
  Research has shown that groups respond better to men in leadership roles.
- FEMALE
  This position was decided on the basis of a balanced gender split.
- MALE
  This position was decided on the basis of a balanced gender split.
- FEMALE
  The average women’s stronger connection to emotional understanding led to this decision.
- MALE
  This position was decided on the basis of a balanced gender split.
- FEMALE
  This position was decided to support N.A.S.A’s aim for research into the effects of low gravity on the human reproduction system.

I believe it is important to use a mixed gender crew on long term group missions. Studies sponsored by N.A.S.A. into the dynamics of mixed gender crews is a recent development that is still under way. My assumptions are based on figures from research already completed. I assume this reasoning way change as the research becomes more in depth.
With crew interactions being a primary area of focus for my plan layout, great care was taken to ensure that facility locations are organized in a way conducive to that ideal. Under normal circumstances crew members will be assigned tasks that require more than one member to complete. E.V.A. missions for example will always involve two crew members. The schedule of E.V.A.’s will circulate through a weekly cycle providing every crew member the opportunity to get outside of the habitat every week.

Multiple gathering spaces will be strategically placed throughout main circulation route. They will provide a calming environment for crew members to sit and relax as the transition from task to task. The location of these escapes will often cross paths of more than two crew members to provide a multi-disciplined environment to spark idea sharing and if nothing more, an opportunity to vent frustration with other people.

The location of food prep and dining space along with sleeping quarters are laid out in accordance with the schedule to provide a daily interaction of the entire crew. This will make dining activities something to look forward to each day. It will also provide a think tank type of environment for formulation of advanced thought in a relaxed environment.
CREW CONSIDERATIONS

A Typical Week

Crew Leader
- (routine) fourteen hours
- (maintenance) twelve hours
- (E.V.A.) twenty four hours
- (communication) six hours

Total = 56 hours

Physician
- (routine) fourteen hours
- (maintenance) twelve hours
- (E.V.A.) eight hours
- (research) sixteen hours
- (daily visits) three hours
- (monthly check up) three hours

Total = 56 hours

Biologist
- (health) fourteen hours
- (maintenance) twelve hours
- (E.V.A.) sixteen hours
- (research) fourteen hours

Total = 56 hours

Psychologist
- (routine) fourteen hours
- (maintenance) twelve hours
- (daily visits) six hours
- (E.V.A.) eight hours
- (research) ten hours

Total = 56 hours

Astronomer
- (routine) fourteen hours
- (maintenance) twelve hours
- (E.V.A.) eight hours
- (research) twenty two

Total = 56 hours

Geologist
- (routine) fourteen hours
- (maintenance) twelve hours
- (E.V.A.) twenty hours
- (research) ten hours

Total = 56 hours

Crew schedule follows a regular earth circadian rhythm. Each day has three one hour meal periods. The work week will circulate so three crew members have their day off at the same time. Each week is based on a six day week, nine hours of work a day.
Crew schedule

The crew follows a regular Earth circadian rhythm following fifty-six hour week work, three one-hour meal periods per day with exceptions do to daily tasks.

Sleep schedule

Crew sleep periods last eight hours with a hour assigned for pre and post sleep activities
Each crew member receives one day off out of seven mission days
Each day off coincides with two other crew members day off
Nine hour work days
Three hours a day for leisure activities

Crew health care

Exercise
Two hr/day, six days/wk for crew members not performing E.V.A. missions

Private medical conference
One fifteen minute call per day rotating among crew members

Physical exam
Two hr exam once a month for duration of stay with a half hr exam prior to returning to Earth.
CREW CONSIDERATIONS

CREW MENTAL HEALTH
Routine psychological analysis
One hr visit per day rotating among crew members
Full psychological analysis
Four hr exam once a month for duration of stay

CREW RESEARCH
Geological studies
E.V.A. periods last no more than ten hours
Geological analysis
Estimated at sixty man hours a week based on three eight hour E.V.A. mission times

SCIENTIFIC STUDIES
Estimated at twenty man hours a week

ASTRONOMY
Estimated at twenty man hours a week

CREW MAINTENANCE
E.V.A. maintenance
Estimated at thirty man hours a week
I.V.A. maintenance
Estimated at sixty man hours a week.
Crew Communications
Mission briefing
TBD
Overall crew and habitat report
TBD

Total crew work hours available
Based on a fifty six hour week
Three hundred and thirty three

Weekly work hours are evenly distributed among crew members

Definition of hours
Health is the sum of time spent weekly in physical and psychological check ups.
Maintenance is the sum of hours spent weekly of interior cleaning and repair.
E.V.A. is the sum of hours spent weekly on outside missions and repair.
Research is the sum of hours spent weekly of data analysis related to that crew members field of expertise.
Three or more chronometers

Two or more chronometers

Astronomer

Biolologist

Geologist

Physician

Psychologist

Crew leader

8:00 A.M. - 9:00 A.M.

10:00 A.M. - 11:00 A.M.

1:00 P.M. - 2:00 P.M.

9:00 A.M. - 10:00 A.M.

11:00 A.M. - 12:00 A.M.

2:00 P.M. - 3:00 P.M.
5:00 P.M. - 6:00 P.M.  
7:00 P.M. - 8:00 P.M.  
Crew sleeping quarters

Three or more chronometers
Two or more chronometers
Astronomer
Biologist
Geologist
Physician
Psychologist
Crew leader

6:00 P.M. - 7:00 P.M.

Sleeping quarters are laid out in a way that matches the view with personality of the occupant of the room.
The crew leader has a view of all three solar arrays so he will be first to know about a problem.

The astronomer has the view with the least light pollution so he has a better view of the sky.

The physician has the view with the most natural light to study the health benefits of this condition.

The geologist's view looks out into the crater basin where he will do most of his research.

The psychologist has the view of Earth to help her mental state because she must be able to control her mental wellbeing along with everyone else’s.

The biologist has the most consistent light source from the solar array A, allowing her to study plant growth in her room.
The airlock system extends to connect sections similar to an airline terminal.

The rolling structure is supported with hydraulic actuators that adjust for ground irregularities.

The structural truss system allows infrastructure to be channeled through it while ceilings suspend below.

The structure is designed on a radial pattern that allows it to be delivered in a compressed form then expanded similar to an accordion. After the individual components are delivered, they are slid together via a wheeled connection to the ground.
**Space Planning**

**Resource Utilization**

- **Brick Production**
  - 3 x 8 M. = 24 M. sq.

- **Oxygen Production**
  - 3 x 10 M. = 30 M. sq.

- **Fuel Production**
  - 3 x 8 M. = 24 M. sq.

**Four Person Habitat**

**Shared Living Space**
- 3 x 18 M. = 56 M. sq.
Space Planning

- Crew Leaders Quarters
- Geologist's Quarters
- Biologist's Quarters
- Physician's Quarters
- Astronomer's Quarters
- Psychologist's Quarters
- Observatory
- Restroom
Two major factors were considered in the placement and orientation of the habitat on the site. The first requirement was a centered position between the solar arrays. This cut down on the required amount of infrastructure to connect the power supplies to the habitat. The determining factor for the orientation was the location of the Earth in the horizon. I wanted to optimize the visual connect to the Earth as a beacon of familiarity that helps the crew feel less isolated.
The north elevation shows how the solar array reflects light to the habitat.
From the west elevation you can see the second solar array reflecting light onto the habitat. You can also see the sun which at this point is around four days from passing behind the crater wall, not emerging for twelve days.
The east elevation shows the effects of the final solar array.
The south elevation clearly shows the view of the Earth that has been celebrated throughout the design.
This section is looking north east into the medical wing.

This section is looking south west into the life support systems.
This section is looking south west into the research wing and E.V.A. support space.

This section looks north east into the suit maintenance and gathering space.
This section looks north into the conference room and medical wing.

This section looks south into the control room and exercise room.
This section looks west into the science lab and life support wing.

This section looks east into the science lab and dining space.
Each crew quarter has a extending workspace that allows the occupant to customize their living space.

The second story ceiling drop makes the space more intimate and also shield against solar radiation.

The rolling connection to the ground adjusts height and insulates from the terminal variation of the ground.

The air locks snap into breaks in the structural grid.
Tinted glass panels in the research and exercise areas make for a more personal scale and shields from solar radiation.

Sliding wood and aluminum panels in the medical wing allow the space to be adjusted for changing light conditions and personal preference.

An aluminum drop down ceiling in the transition space traces out the circulations paths.

Wood panels in the dining area define each individual dining space and create a warm and inviting feel.
Exterior louver systems adjust to follow the pattern of the sun. This allows the habitat to capitalize as much as possible on the limited supply of now reflected light.

The louvers connect to a pivot joint the in conjunction with hydraulic actuators makes them fully adjustable.

A mesh shading device attaches to rollers in the front of the structure allowing the occupants to block the sun whenever need be.
The diagram above traces out the direction the sun will strike the habitat.

The section below shows how the lighting is reflected deep into the habitat by the louver system.
These interior perspectives show the layout of the dining space. In the image to the right you can see through the habitat to the Earth over the horizon.
The image to the left shows the drop down ceiling and reflected floor change that traces out the main circulation path. The image below shows the observatory. This room is oriented so it is in darkness most of the time.
The image to the right shows the research wing and the view of the Earth. The image below shows the exercise bay.
The interior of the psychiatric wing to the left uses wood accents and an adjustable light screen to make the space more personal. The crew quarters shown below use similar principles.
BIBLIOGRAPHY

The Moon


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