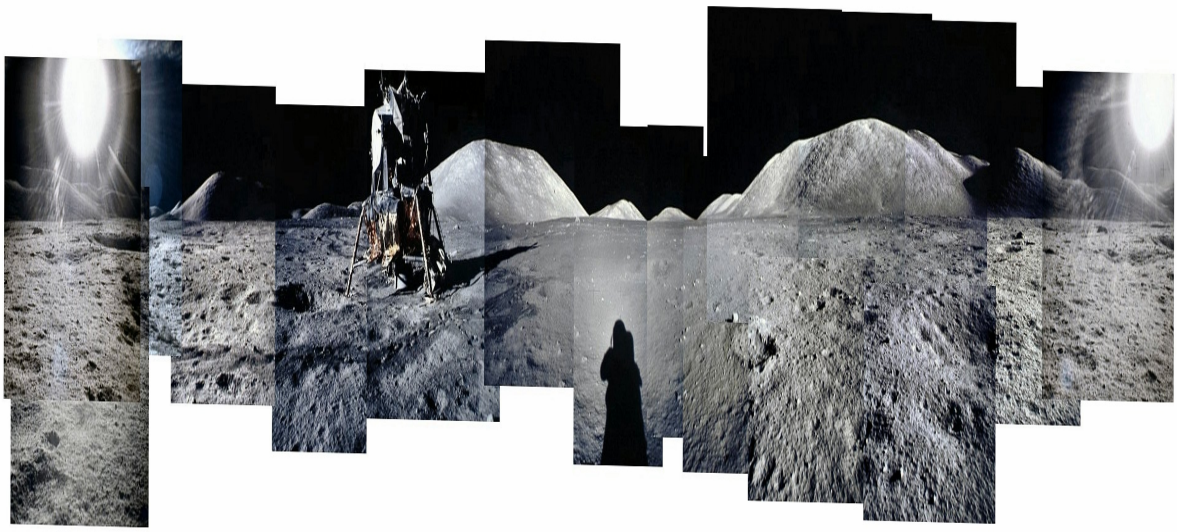
National Aeronautics and Space Administration

Return To The Moon Challenge

A Digital Learning Network Experience



Designed To Share

The Vision For Space Exploration

A Digital Learning Network (DLN) Challenge

A DLN Challenge is an in-depth research/design experience that allows students to propose solutions to Challenge criteria and present their solutions to NASA through a videoconferencing system. The educational criteria embedded in the Challenge draws from Inquiry-based and Problem Based Learning strategies. A DLN Challenge involves more than one DLN videoconferencing connection, in-depth student involvement through research and design activities, open-ended problem solving flexibility, and formal student presentations that demonstrate understanding and application.

Return To The Moon

A Digital Learning Network Experience

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The Vision For Space Exploration

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Space Administration

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Module Overview

Grade Level(s): 6-12

Focus Question:

The Apollo program was the focus of U.S. efforts in space for the years 1967-1972. During those years, six missions landed on the moon. Although landing on the moon looked effortless, many men and women worked for years on designing the spacecraft and choosing the appropriate landing site, among other things. We will be returning to the moon in the coming years, this time to stay. What are the design requirements and criteria needed for a 30-day Lunar Base Habitat? Where would be the safest yet best scientific location to establish a permanent presence on the Moon?

5 E model of Return to the Moon Challenge:

- **Engage-** The learner will share prior knowledge about the Constellation Program.
- **Explore-** The learner will examine all of the criteria, requirements, and challenges that engineers must consider in order to safely live on and explore the Moon.
- **Explain-** The learner will demonstrate their understanding of the lunar environment by determining what countermeasure must be used given the conditions found on the lunar surface.
- **Elaborate-** The learner will work in small groups to design and construct a model lunar base or landing site that will sustain a crew for 30 days.
- **Evaluate-** The learner will defend the design and purpose of their lunar base or landing site while connected to a DLN education specialist during an additional connection in the following weeks.

Sequence of Events

Pre-Conference Requirements

Online Assessment A brief pre-event online assessment tool is available to determine the students' level of understanding prior to the videoconference. Suggested answers are included.

Introduction to Challenge Videoconference (About 45-60 minutes)

With the Apollo era Moon landings as a reference point students will be given the Challenge to design and locate a new Lunar Base Habitat (LBH) that parallels NASA's vision and mission to return to the moon!

Videoconference outline

In-Class Research-Design Activities

Challenge criteria applied by students An inquiry-based activity that applies and extends the students' understandings in the area of lunar geology, geography, environmental conditions, and human habitat needs that will result in a Lunar Base Habitat design placed at the most optimal location on the moon.

Solutions discovered and summarized into Student Presentation

Content and Presentation Rubric Guidelines

Presentation of Student Solutions Videoconference (About 45-60 minutes)

This videoconference allows selected teams to demonstrate their LBH designs and verify their lunar geographic location in a timed presentation to NASA.

Videoconference outline

Post-Conference Requirements

Online Assessment

A post-event online assessment is available to determine changes in student levels of understanding.

Participation Certificate

National Standards

NATIONAL SCIENCE EDUCATION STANDARDS (NSES)

Science as Inquiry - Content Standard A: As a result of activities in grades 5-8 and 9-12, all students should develop:

Abilities necessary to do scientific inquiry

Understandings about scientific inquiry

Science and Technology - Content Standard E: As a result of activities in grades 5-8 and 9-12, all students should develop:

Abilities of technological design

Understandings about science and technology

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS (NCTM)

Standard 4 - Measurement

In all grades students should apply a variety of techniques, tools, and formulas for determining measurement

Standard 8 - Communication

In all grades students should organize and consolidate their mathematical thinking to communicate with others

Express mathematical ideas coherently and clearly to peers, teachers and others

INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION (ITEA)

Design: Students will develop an understanding of engineering design.

Design - Standard 10

Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving

The Designed World - Standard 17

Students will develop an understanding of and be able to select and use information and communication technologies

NATIONAL GEOGRAPHIC STANDARDS (NGS)

The world in spatial terms: How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information.

Environment and society: How human actions modify the physical environment.

The uses of geography: To apply geography to interpret the present and plan for the future

TEXAS ESSENTIAL KNOWLEDGE and SKILLS (TEKS):

(6.13) Science concepts. The student knows components of our solar system. The student is expected to:

(A) Identify characteristics of objects in our solar system including the Sun, planets, meteorites, comets, asteroids, and moons; and

(B) Describe types of equipment and transportation needed for space travel.

(8.5)Scientific processes. The student knows that relationships exist between science and technology. The student is expected to:

(A) Identify a design problem and propose a solution;

(B) Design and test a model to solve the problem; and

(C) Evaluate the model and make recommendations for improving the model.

(B) Describe types of equipment and transportation needed for space travel.

Sequence of Events

Pre-Conference Requirements

Online Pre-Assessment

A week before the event, students will need to take the online pre-conference assessment. This short assessment will provide useful background information for the presenters to prepare for the videoconference.

Pre-Conference Assessment Questions

1. **What did the Apollo program accomplish for lunar exploration?**
2. **What is the moon made of if it's not cheese?**
3. **What are some of the design issues and details that must be considered for an extended human presence on the moon?**
4. **What was the main function of the Apollo Command Service Module and the Lunar Module?**
5. **What are the environmental conditions on the surface of the moon?**
6. **Describe four major geographic features found on the moon.**
7. **Describe the major rock types that compose the moon's geology.**
8. **Identify some of the major metals and elements that can be used from the moon to sustain human habitation on the moon.**
9. **What Lunar feature is located at Lunar Longitude 20 degrees W, Latitude 10 degrees N?**

Teacher's Page with suggested answers:
What did the Apollo program accomplish for lunar exploration?

The Apollo program was the focus of U.S. efforts in space for the years 1967-1972. The initial successful piloted mission of the series, Apollo 7, was launched in October 1968. During that mission, three astronauts orbited the Earth for eleven days. Two months later, the crew of Apollo 8 became the first humans to escape the Earth's gravitational field and orbit the moon. Apollo 11, the most famous Apollo flight, was launched on July 16th, 1969. Four days later astronauts Neil Armstrong and Buzz Aldrin climbed into the lunar module and landed on the moon. Over the next three years, five more Apollo missions landed ten more Americans on the moon. Moon rocks weighing 842 pounds were transported back to Earth by the Apollo missions.

What is the moon made of if it's not cheese?

The moon is covered with rocks, boulders, craters, and a layer of charcoal-colored soil from 5 to 20 feet (1.5 to 6.1 meters) deep. The soil consists of rock fragments, pulverized rock, and tiny pieces of glass. Two types of rocks are found on the moon: basalt, which is hardened lava; and breccia, which are soil and rock fragments that have melted together. Elements found in moon rocks include aluminum, calcium, iron, magnesium, titanium, potassium, and phosphorus.

What are some of the design issues and details that must be considered for an extended human presence on the moon?

The lunar environment includes no atmosphere, extreme temperatures, radiation, reduced gravity, and distance from earth. Designing a habitat for human use entails life support, recycling systems for air water and food, use of available lunar resources for processing as construction materials, air, water, and fuel. The need to reduce external supplies from the Earth and become a more self-sufficient and self-sustaining colony is very desirable.

What was the main function of the Apollo Command Service Module and the Lunar Module?

The Command Service Module (CSM) contained the Command Module that carried the three astronauts along with life support systems, environmental control, communication and computers. The Service Module contained oxygen tanks and rocket propellant and a rocket engine that provided the propulsion for orbit changes. The Command Module was the only section of the Apollo to return to Earth upon completion of the mission. The Lunar Module carried two astronauts to the surface of the moon. The LM provided a landing-launch platform and a temporary lunar habitat for the astronauts. The lower half, the decent stage, stayed on the moon while the upper half, the ascent stage, later returned to the CSM to dock and transfer the two astronauts and the lunar samples. The LM was then discarded to crash into the moon.

What are the environmental conditions on the surface of the moon?

The Moon is an airless and waterless place (except for small amounts of ice near its south pole) where no live has ever existed. At noon on the lunar equator the temperatures hover around 210 F, while the same spot at midnight could come in with a bone-chilling reading of -250 F. The Moon is 2,160 miles across, making it small enough to fit between the east and west coasts of the US. Because of its much smaller mass, the Moon has significantly less gravitational pull than the Earth resulting in a gravitation force of only one-sixth of the Earth.

Describe four major geographic features found on the moon.

Craters – Mostly created when asteroids, meteoroids, and comets crashed into the lunar surface.
Maria – "seas" dates back to the earlier days when the smooth dark appearance of these areas let some to speculate that they might actually be bodies of water. Actually they are large plains of solidified lava that welled up from deep inside the Moon during its early evolution and flooded lowland regions.
Highlands – The lighter areas are generally regions of higher elevation know as the lunar highlands. Much of this is mountainous or heavily cratered terrain.
Mountains – The Moon has several mountain ranges. Some of its peaks are higher than Mount Everest. The moon does not have plate tectonics, nor does it have erosion due to wind and rain, hence, there is little wearing away as with mountain ranges on Earth.
Rills – Sinuous valleys that may be places where subterranean tubes of lava collapsed just below the lunar surface.
Others may include: Plateau, Basin, Rays, and Ejecta Blanket

Describe the major rock types that compose the moon's geology.

Anorthosite: a rock made mostly of calcium, aluminum, silicon, and oxygen that is white to light gray. It formed the original crust of the moon.
Basalt: dark-colored rock rich in iron and magnesium, created by the solidification of lava. Lunar basalts are found in the maria.
Breccia: rock made of fragments of other rocks as a result of impacts.
Regolith: loose rock and mineral fragments created by impacts. The surface of the moon is covered with regolith.

Identify some of the major metals and elements that can be used from the moon to sustain human habitation on the moon.

Aluminum and silicon are found in anorthosite, which formed the original crust of the moon. Anorthosite is found in the highlands. Titanium and iron are ingredients of the lava that formed the Maria. These heavier elements are found in the black lunar rock called basalt. Breccias have melted bits of impact meteorites or comets as well as anorthosite and/or basalt. This lunar rock contains KREEP: potassium, rare earth elements, and phosphorus. About half of each lunar rock is oxygen but contains very little hydrogen.

What Lunar feature is located at Lunar Longitude 20 degrees W, Latitude 10 degrees N?

The crater Copernicus is located at these lunar coordinates.

Introduction to Challenge Videoconference Outline

Join NASA as we look back at America's national effort to land a man on the Moon. From this historical reference point you will be given a Challenge to design a new Lunar Base Habitat and justify the best geographic location for a permanent base on the moon that parallels NASA's vision and mission for a Return to the Moon Mission!

Video Conference Introduction to Challenge Outline

- Introduction to NASA
- Historical Reference – Mission objectives of Gemini and Apollo
- Traveling from the Earth to the Moon the CSM and LM
- Apollo 11 to 17 lunar location and scientific studies
- What's it like to live on the moon
- Stating the Challenge, criteria and constraints
- Team objectives and collaboration
- Clarification: Student questions, resources, research
- Student presentation expectations
- How to stay in contact
- Good bye to Chase the Problem…as only NASA can!

In-Class Research-Design Activities

RISKING FAILURE TO BE SUCCESSFUL
CHASE THE PROBLEM
TO MEET THE CHALLENGE
TO FLY THE DREAM

Here is your Challenge:

The Mission to Date:
Historical (Apollo) and current data (Lunar Surveyor) are being analyzed and a permanent Lunar Base site will soon be selected by your team. Robotic missions will then survey, deliver the base equipment package, and begin to prepare the selected site for the arrival of the lunar crew 6 months later.

Your task is to assemble two research teams. One will develop a Lunar Base Habitat and include the design details for a presentation back to NASA and the other will develop three potential lunar sites that will meet specific criteria and constraints but only choose and defend a final selection to NASA. This extended 30 day exploration and base assembly mission will be the first giant leap for Mankind in the building of a permanent human presence on the Moon!

Your Challenge is open-ended and involves a variety of collaborative and creative problem solving efforts!

- Research historical Apollo Command, Service, and Lunar Module.
- Design a LBH-30 and determine its architecture, gross weight, and size.
- Provide design details, systems, measurements, and capabilities
- Research past lunar landing sites, geology, and geography.
- Based on criteria – constraints, defend a lunar base location on the moon.
- Provide a visual and oral summary of your solutions.

Guidelines

Write the words “criteria and constraints” on the board. Ask students to define the terms. Explain that when designing any device, the inventor-engineer must consider criteria and constraints.

*The students should understand that **criteria** are standards or requirements that must be included. Examples of criteria are that the LBH-30 must utilize natural resources-geologic features on the moon, must house a crew of 2-5, and must be light and expandable for future mission use.*
***Constraints** are things that limit the design of the base. Examples of constraints are money, time, available materials, safe location, availability of lunar resource at the site, scientific interest for the site, and human capabilities.*

Design Team:

1. Under the title: “LBH-30 Criteria” write the following:
    a. The LBH-30 must house a 2-5 member crew on the moon for 30 days.
    b. The LBH-30 must demonstrate the beginnings of a permanent base that will be expandable at a later date.
    c. The LBH-30 must be as light (weight) and small (volume) as possible and still meet all the mission objectives.
    d. The LBH-30 team must provide detailed schematics or a 3-D model of the proposed LBH-30.
    e. The LBH-30 team must calculate, in general terms, the amount of food, air, water, waste, energy needs of the crew, and consider recyclable systems needed for 30 days on the moon.
    f. Teams will prepare a final presentation of results and understanding based on the scoring rubric.
2. Under the title: “LBH-30 Constraints” write the following:
    a. The materials used for the 3D model are only limited by team resources available to them.
    b. The LBH-30 solution must use as many natural lunar resources as possible.
    c. There will be a work-research-solution time limit set by the classroom teacher.
    d. Final team presentations will be limited by time, depending on the number of total presentations. Usually 5 to 6 minutes.
3. Using provided and additional resources students can now begin background research, gathering materials, design, and construct a model of the LBH-30.

Geographic Site Team:

1. Under the title: “LBH-30 Criteria” write the following:
    a. Longitude, Latitude, and nearby identified lunar features must accompany the selected LHB-30 site.
    b. The site must have identified natural lunar resources that can be used in the construction of the LBH-30 and provide protection for the crew.
    c. The selected power source should help determine the site.
    d. The site must consider scientific investigations of the moon and its environment such as geology, geography, astronomy, etc.
    e. The site must consider all aspects that will allow the base, in the future, to become self-sufficient and self-supporting.
2. Under the title: “LBH-30 Constraints” write the following:
    a. The materials and resources used are only limited by the research abilities of the team.
    b. There will be a work-research-solution time limit set by the classroom teacher.
    c. Final team presentations will be limited by time, depending on the number of total presentations. Usually 5 to 6 minutes.

Peer Evaluations

1. After student teams have completed their research and tasks, have different groups switch designs or solutions and evaluate each other's proposals.
2. In this evaluation process, the groups should focus on whether the design or solution meets the criteria and constraints up to this point and to offer any constructive criticisms or suggestions that would lead to greater success.
3. Once the groups have shared their evaluations, discuss as a class what the students learned from this peer evaluation. Lead a discussion using the following questions:
   a. Did your LBH-30 design or Lunar landing site meet the criteria and constraints?
   b. What is needed to make your proposal better, stronger, more complete?
   c. What changes would you make and why?
   d. What helpful comments did you get from the other group?
4. Explain to the students that an important part of the peer review process is having outside reviewers provide input that allows you to revise the designs or solutions prior to the final presentation.

Discussion/Wrap-up and Team Presentations

1. Have the students explain the steps they went through to meet the constraints and criteria set out in the Challenge. Ask the students if they think scientists and engineers follow similar steps. After the students have shared their ideas, explain that the students followed a very similar process to that of design engineers.
2. Explain that the basic design process includes: defining a problem, specifying constraints, exploring possibilities, selecting an approach, developing a design proposal or solution, making a model or prototype, testing and evaluating the design-solution using specifications, refining the details, and communicating the process and results to others.
3. Using the scoring rubrics for "PowerPoint Visual Design" and "Final Student Presentation" as a guide. Select the best student teams to prepare a 5 to 6 minute visual-oral presentation for NASA that includes details that meet the criteria and constraints of the Challenge, and demonstrates why this design and site is the best solution to the problem.

Teams should refer to the **VOCABULARY**, **RESOURCES**, and **BACKGROUND INFORMATION** sections of this Challenge as starting points and then expand through traditional and non-traditional sources for further research and information.

Solutions discovered and summarized into Student Presentation

Students will prepare a short, timed presentation to demonstrate knowledge, understanding, and verification of their solutions. Lengths of each team presentation (Base and Site together) will depend upon the number of presenting teams within the total time set for the second videoconference. The format includes student team presentations plus time for a NASA-DLN host to provide follow-up questions to each team.

Content and Presentation Rubric

Student Team Presentations

Student teams are selected to present to NASA's DLN

- Classroom Teachers can use the provided Rubric to help determine which student teams will present their results during the second DLN connection.
- The remaining student teams will be passive participants.
- Each team has 5 to 6 minutes to present the following items and information:
  - The actual model of the LBH-30
  - Required measurements for the LBH-30
  - List and explain Lunar resources used for LBH-30
  - Provide Latitude and Longitude w/ geographic landmark of final landing site.
  - Justify Lunar landing site for safety, natural lunar resources, and scientific interest.
  - Provide visual of selected Lunar landing site
  - Teams should demonstrate examples of collaboration between themselves during the research process.
  - Description of problems and successes during process.

A. Lunar Base Habitat-30 Design Team

TOPIC	**POSSIBLE POINTS**	**EARNED POINTS**	**COMMENTS**
Number of crew stated Crew supplies estimated Recyclable Systems included	15		
Detailed schematics included 3D model provided Schematics match Model	30		
Earth based materials noted Moon based resources noted	10		
Gross weight of base estimated Total area of base calculated	10		
Power source selected Reason for source provided	10		
Provision for protection of crew from lunar environment provided	10		
Provision for expanding LBH-30 for later mission provided	10		
LBH-30 meets Geographic Site team's criteria	5		
Subtotal	**100**		

B. Lunar Geographic Site Team

TOPIC	POSSIBLE POINTS	EARNED POINTS	COMMENTS
Visual detail of lunar site provided Lat. and Long. Included Map of Moon provided	30		
Lunar resources identified at site For construction and life support For safety of crew from environ.	20		
Geographic and Geologic features are noted at site	20		
Scientific interest of site justified	10		
Power selection should match site location's environment	5		
Site safety issues addressed	10		
Geographic Site meets LBH-30 team's criteria	5		
Subtotal	**100**		

C. Power Point Visual and Content Design

TOPIC	POSSIBLE POINTS	EARNED POINTS	COMMENTS
Readability – size of fonts, color in back/foreground	10		
Visual Support – images, graphs, charts, model, maps,	10		
Documentation – team members, calculations, measurements, sources	10		
Graphic Design – clutter, clarity, and visual appeal	10		
Subtotal	**40**		

D. Student Team Presentation

TOPIC	POSSIBLE POINTS	EARNED POINTS	COMMENTS
Visual Support – PowerPoint, Video/MPEG Graphs/Charts BHL-30 model Lunar site map	20		
Voice Projection- Volume-speed Articulation Lack of filler words (um, uh)	10		
Speaker Stance- Look at audience Enthusiasm Confidence	10		
Body Gestures – Appropriate to presentation	10		
Time - Set by NASA Host – Usually 4-6 min.	0		Penalty, if any, is set by classroom teacher
Subtotal	**50**		

Presentation of Student Solutions Videoconference Outline

Your task was to assemble two research teams: one was to develop a Lunar Base Habitat and include the design details for life support, exploration, and safety for a 30 day mission on the moon, while the other team was to research, select and defend a potential lunar site that will meet the above mentioned mission criteria. Your Team presentation will determine how well you have met these mission objectives: the first steps in the building of a permanent human presence on the Moon!

Videoconference Presentation of Student Solutions Outline

- Introduction and welcome to NASA
- Brief overview of Challenge
- Student Team presentation expectations
- First Team (Design and Site) timed presentation
- NASA-DLN host follow up questions
- Second Team (Design and Site) timed presentation
- NASA-DLN host follow up questions
- Continuation of Team presentation and DLN follow up
- Final question and answer session with students
- NASA's Future Vision and Mission Plans
- Good-bye and Fly The Dream with NASA!

Post-Conference Requirements

Online Post-Assessment

After the conclusion of the event, students will need to take the online post-conference assessment. This short assessment will provide useful comparative learning information for teacher assessment.

Post-Conference Assessment Questions

1. **What did the Apollo program accomplish for lunar exploration?**

2. **What is the moon made of if it's not cheese?**

3. **What are some of the design issues and details that must be considered for an extended human presence on the moon?**

4. **What was the main function of the Apollo Command/ Service Module and the Lunar Module?**

5. **What are the environmental conditions on the surface of the moon?**

6. **Describe four major geographic features found on the moon.**

7. **Describe the major rock types that compose the moon's geology.**

8. **Identify some of the major metals and elements that can be used from the moon to sustain human habitation on the moon.**

9. **What Lunar feature is located at Lunar Longitude 20 degrees W, Latitude 10 degrees N?**

Digital Learning Network

Certificate of Completion

This certifies that

Has completed NASA's

Return to the Moon Challenge

____

Instructor

Vocabulary

Anorthosite – rock made mostly of calcium, aluminum, silicon, and oxygen that is white to light gray. It formed the original crust of the moon.
Apollo – a project of the US that took men to the moon between 1968 and 1972. Apollo was the Greek god of light, truth, and healing.
Basalt – dark-colored rock rich in iron and magnesium, created by the solidification of lava. Lunar basalts are located in the maria.
Breccia – rock made of fragments of other rocks as the result of impacts.
Command Module (CM) – an Apollo spacecraft that took men from Earth orbit to lunar orbit and brought them back to Earth.
Dayspan – daytime on the moon. A dayspan lasts two Earth weeks.
Electrolysis – the use of electric current to separate a compound into its chemical parts, such as water into hydrogen and oxygen.
Far side – the side of the moon that faces away from Earth at all times. It is not dark, It receives as much sunlight as the near side.
Fuel cells – rechargeable batteries that combine hydrogen and oxygen to make electricity and water. Fuel cells may be used as a power source for rovers and to store solar power for use during the night span.
Galactic cosmic rays – charged particles of radiation from outside the solar system. Water and lunar regolith both block these rays.
Hydrogen reduction – a method of removing oxygen from lunar rocks using hydrogen gas.
Ilmenite – an iron-titanium mineral found in mare basalts that can be used as a source of oxygen.
KREEP – an acronym for potassium (K), rare earth elements (REE), and phosphorus (P). The Apollo 14 area has the most KREEP.
Lox – an acronym for liquid oxygen that is made by chilling oxygen gas. Lox is used in rocket engines, fuel cells, and for making air.
Lunar Module (LM) – an Apollo spacecraft that landed on the moon. After each mission, these modules were discarded and crashed on the moon.
Magma electrolysis – a method of removing oxygen from rocks that requires melting the rock at high temperatures.
Mare (maria plural) - the Latin word for sea. Maria formed when dark lava flowed into deep craters.
Near side – the side of the moon that always faces Earth.
Nightspan – nighttime on the moon. A nightspan is two Earth weeks long.
Regolith – loose rock and mineral fragments created by impacts. The surface of the moon is covered with regolith.
Saturn V Rocket – a rocket used by the Apollo program to launch men to the moon.
Service Module (SM) – an Apollo spacecraft that carried astronauts to moon and back.
Titanium – a metal used in aircraft and spacecraft because it remains strong at high temperatures.

Resources

The following represent a few selected internet resources that would be helpful for research:

Astromaterials Curation Office
Small samples of representative lunar rocks and soils, embedded in rugged acrylic disks suitable for classroom use, are made available for short-term loan to qualified school teachers. Request lunar samples at:
http://www-curator.jsc.nasa.gov/lunar/index.cfm

USGS Astrogeology Research Program
This site allows the user to move around, zoom in and out for detailed topographic views of the moon, provides latitude-longitude, and lunar nomenclature.
Home site at:
http://planetarynames.wr.usgs.gov/

Topographic map of moon at:
http://planetarynames.wr.usgs.gov/luna_ccsr.html

Goddard Space Flight Center Lunar facts, images, history resource site
http://nssdc.gsfc.nasa.gov/planetary/planets/moonpage.html

Johnson Space Center, Human Space Flight for Shuttle and ISS
This site will allow you to look at all aspect, past and present, of NASA's human space flight efforts. Living and working in space programs from eating to research, daily routines to problem solving.
http://spaceflight.nasa.gov/home/index.html

The NASA Portal
Student, teacher, and public resource sites on everything NASA.
www.nasa.gov

Vision for Space Exploration – Exploring the Solar System
NASA is charting a bold new course into the cosmos, a journey that will take humans back to the Moon, and eventually to Mars and beyond.
http://www.nasa.gov/missions/solarsystem/explore_main.html

NASA Event Guidelines

1. Audience Guidelines

Educators, please review the following points with your students prior to the event:

- Videoconference is a two-way event. Students and NASA presenters can see and hear one another.
- Students are sometimes initially shy about responding to questions during a distance learning session. Explain to the students that this is an interactive medium and we encourage questions.
- Students should speak in a loud, clear voice. If a microphone is placed in a central location, instruct the students to walk up and speak into the microphone.
- Educator(s) should moderate students' questions and answers.
- Students should remain quiet while others are talking. The microphones pick up background noise, and this can be very distracting.
- Students are representing their school; they should be on their best behavior.
- Students should be prepared to give brief presentations (depending upon challenge selected), ask questions, and respond to NASA presenters.

2. Educator Event Checklists

Date Completed	**Introduction to Challenge Pre-Conference Requirements**
	1. Print a copy of the challenge.
	2. Have the students complete the online pre-assessment.
	3. Email questions for the presenter. This will help focus the presentation on the groups' specific needs.
	4. Review the Audience Guidelines, which can be found in the previous section.
	Day of the Event Requirements
	1. The students are encouraged to ask the NASA presenter qualifying questions about the Challenge.
	2. Follow up questions can be continued after the conference through e-mail.
	Introduction to Challenge Post-Conference Requirements
	1. Have the students begin their research, construction, and testing phases of the Challenge.
	2. Use the provided rubric as guidelines for content and presentation criteria.
	3. Students can continue to e-mail questions to the NASA presenters about the Challenge and its criteria as they arise.

Date Completed	Presentation of Student Solutions Pre-Conference Requirements
	1. Review the Audience Guidelines, which can be found in the previous section.
	2. Students may use the content and presentation rubric as guidelines for final presentations to the NASA presenters.
	3. Students should have their final solutions prepared for a timed formal presentation.
	5. Using a variety of presentation methods (oral, visual, PowerPoint, mpeg, video, charts, etc) students should practice and time their presentations.
	Day of the Event Requirements
	3. The students will be asked to share their results from their pre-conference lesson with the NASA presenters.
	4. Bring any materials to help support the student presentations.
	Presentation of Student Solutions Post-Conference Requirements
	4. Have the students take the online Post-Assessment to demonstrate their knowledge of the subject.
	5. Educator(s) and students fill out the event feedback.

Background Information

Summary of Moon Facts

Regolith composition:
45% oxygen, 21% silicon, 12% aluminum, 9% calcium, 7% iron, 6% magnesium, and less than 1% of rare elements such as titanium, potassium, and phosphorus.
Moon Surface Area:
14,600,000 sq. miles (37,900,000 sq. km). About the land area on Earth of Africa plus Australia.
Lunar Temperature:
Coldest, south pole at -387 degrees F (-233 degrees C)
Warmest, far side equator at noon, 253 degrees F (123 degrees C)
Warmest, near side, 243 degrees F (117 degrees C)
Average dayspan, 225 degrees F (107 degrees C)
Average nightspan, -243 degrees F (-153 degrees C)
Moon Revolution:
Time to orbit Earth, 27 days 8 hours (656 hours)
Moon Rotation:
Time between full moons, 29 days 13 hours (709 hours)

Apollo Mission	Launch Date	Landing Date	Landing Site	Latitude	Longitude	EVA time (hours)	Traverse (km)	Sample Return (kg)
11	16 Jul 1969	20 Jul 1969	Mare Tranquilitatis	0.674 N	23.473 E	2.53	0.25	21.7
12	14 Nov 1969	19 Nov 1969	Oceanus Procellarum	3.014 S	23.419 W	7.75	1.35	34.4
14	31 Jan 1971	05 Feb 1971	Fra Mauro	3.645 S	17.471 W	9.38	3.45	42.9
15	26 Jul 1971	30 Jul 1971	Hadley Rille	26.132 N	3.634 E	19.13	27.9	76.8
16	16 Apr 1972	20 Apr 1972	Descartes	8.973 S	15.499 E	20.23	27.	94.7
17	07 Dec 1972	11 Dec 1972	Taurus-Littrow	20.188 N	30.775 E	22.07	35.	110.5

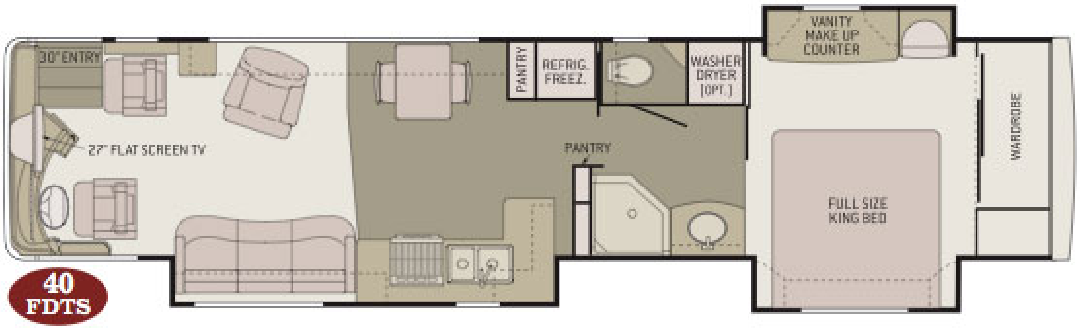
EARTH Based RVs as Reference for Initial Design Considerations of Lunar Base Habitat (LBH-30)

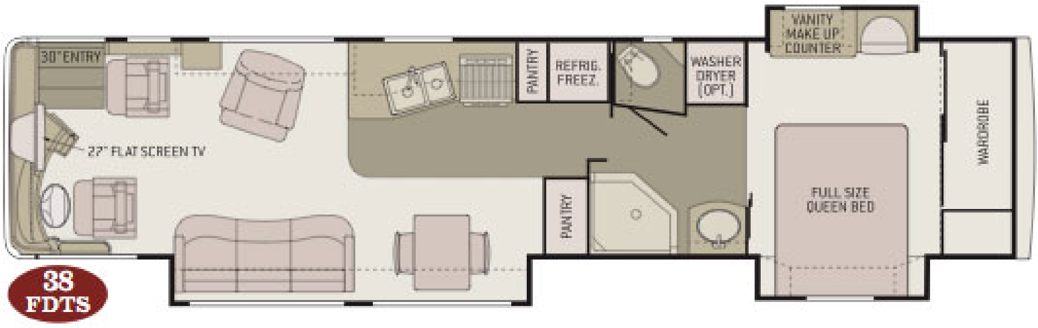
The following Recreational Vehicle information is designed for reference and comparison purposes as the LBH-30 teams begin to develop their designs. The Apollo illustrations will provide direct historical reference points to design elements that resulted in short-term visits to the moon from 1969 to 1972 by NASA.

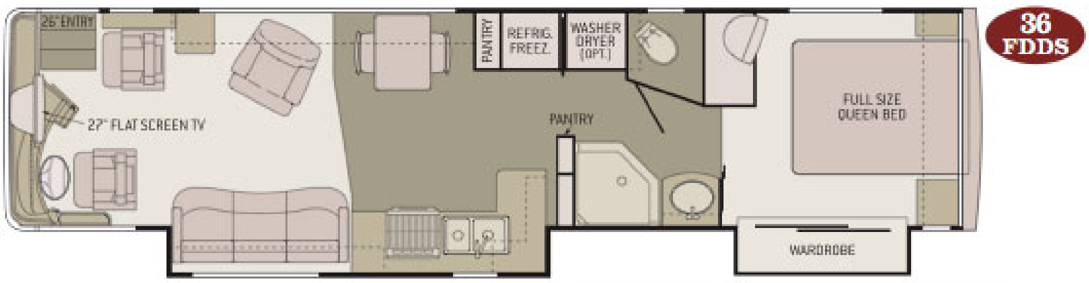
ALPINE COACH LIMITED SERIES WEIGHTS AND MEASURES

	36FDDS	36FDDS	38FDTS	40FDTS	40FDTS
Interior height	6'7"	6'7"	6'7"	6'7"	6'7"
Exterior height	11'11"	11'11"	11'11"	11'11"	11'11"
Exterior width	102"	102"	102"	102"	102"
Length overall	37'	37'	38'6"	40'	40'
Unloaded Vehicle Weight with fuel - UVW lbs.**+**	N/A	24,863	26,528	26,680	26,520
Cargo Carrying Capacity - CCC lbs	N/A	6,419	4,754	3,602	4,762
Gross Vehicle Weight Rating - GVWR lbs.	33,000	33,000	33,000	33,000	33,000
Fuel tank - gallons	115	115	115	115	115
Gross Combined Weight Rating - GCWR lbs.*	43,000	43,000	43,000	43,000	43,000
LPG tank - gallons	42	42	42	42	42
Fresh water - gallons	100	100	100	100	100
Combined waste tank capacity - gallons	178 (100 Grey 78 Black)	178 (100 Grey 78 Black)	178 (100 Grey 78 Black)	178 (100 Grey 78 Black)	178 (100 Grey 78 Black)

Return To The Moon





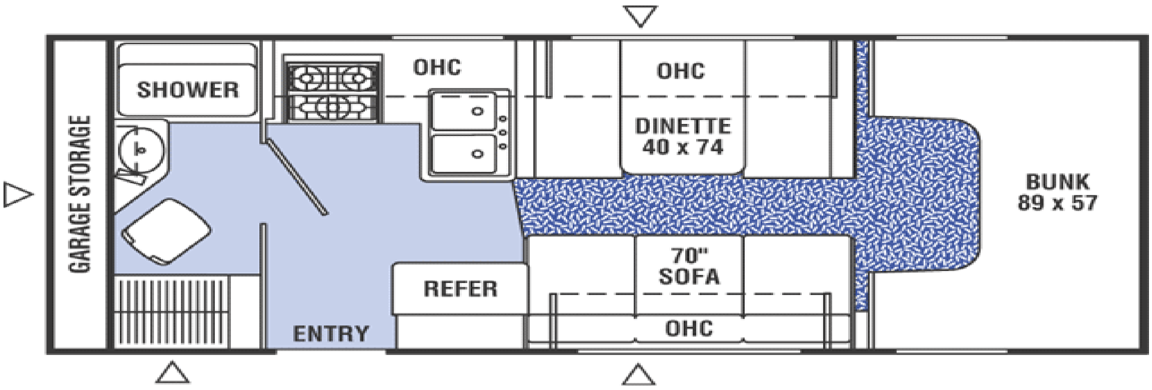


Used with permission from Washington RV – Alpine Coach Limited Series

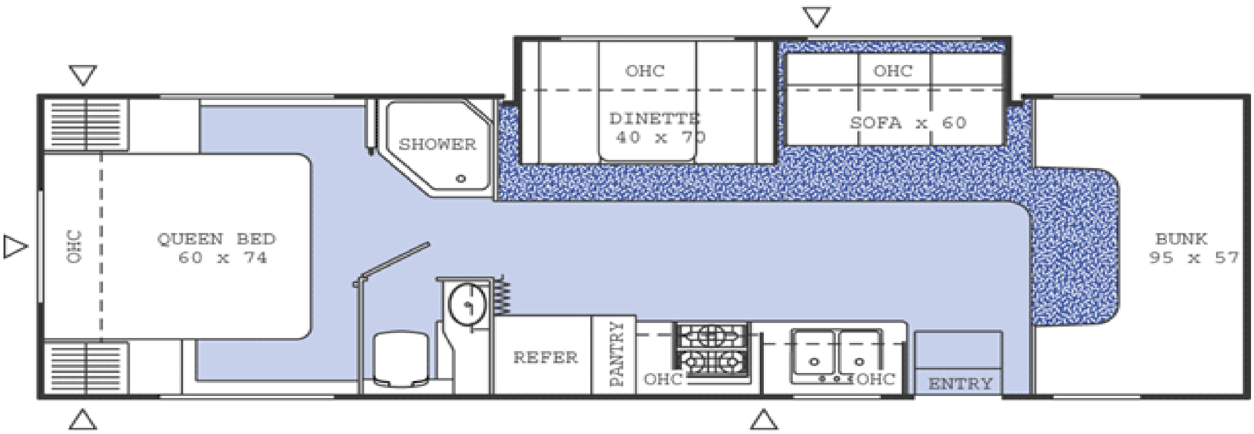
Return To The Moon

Coachmen Freedom Weights and Measures

	200 RB	314 SO
Gross Vehicle Weight Rating GVWR (lbs.)	12,300	14,050
CW (lbs.)	8,395	10,868
Gross Combined Weight Rating GCWR (lbs.)	16,000	20,000
Exterior Length	23'7"	30'6"
Exterior Height	10' 11"	11' 2"
Exterior Width	7' 9"	8' 3"
Sleeping Capacity	4	6
Interior Width	7' 6"	8'
Interior Height	6' 8"	6' 6"/6' 11"
Fuel Capacity (gal.)	35	55
Fresh Water Capacity (gal.)	32	54
Grey/Waste Water Capacity (gal.)	28/28	27/28
Water Heater Capacity (gal.)	6	6
LP Gas Capacity (lbs.)	68	68



Freedom 200 RB



Freedom 314 SO

Used with permission from the Coachmen RV Company – Freedom Series

Apollo Mission Lunar Hardware Illustrations

Fig. 1 Command and Lunar Module Comparison

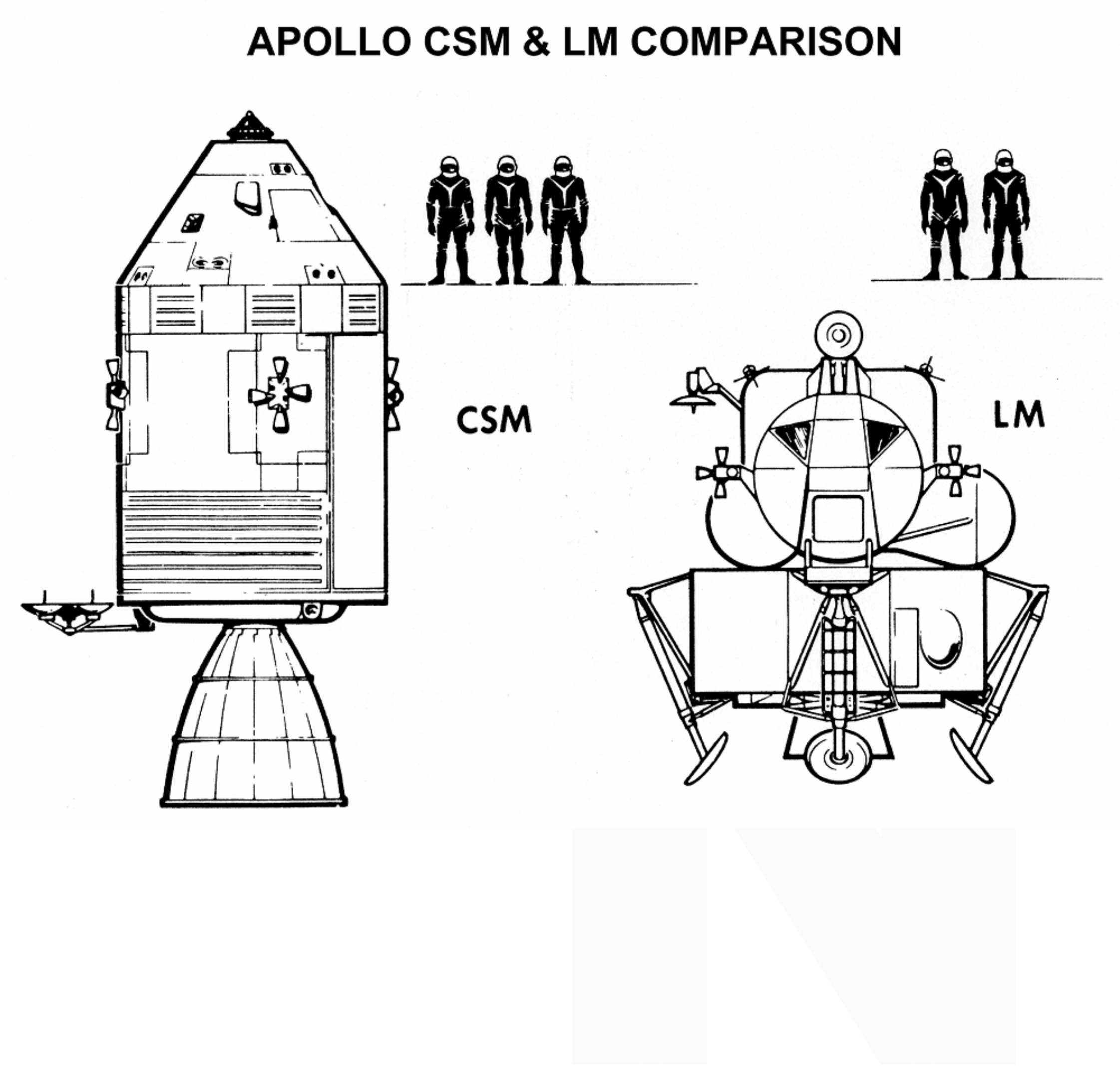


Fig. 2 Apollo Lunar Module

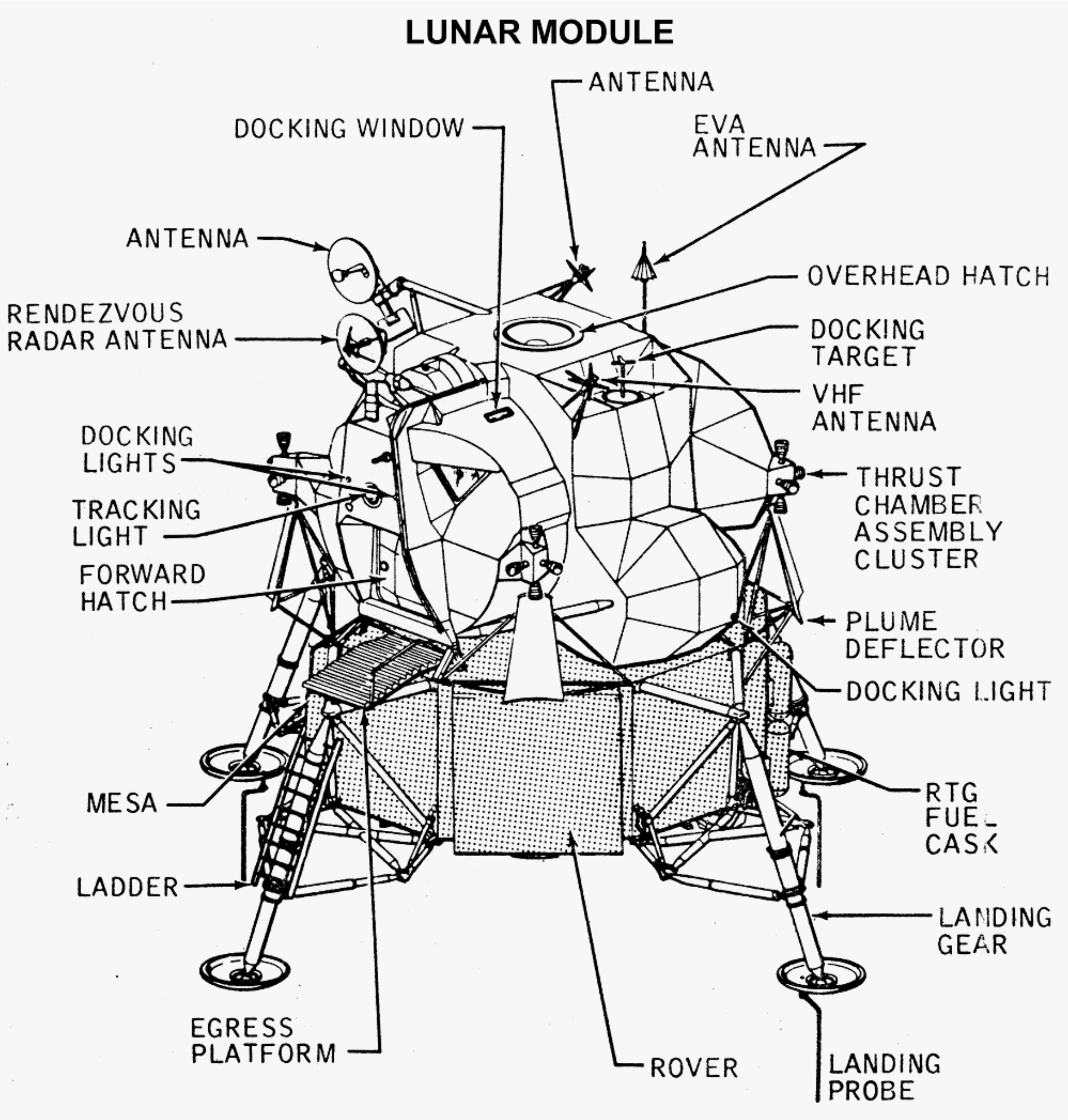
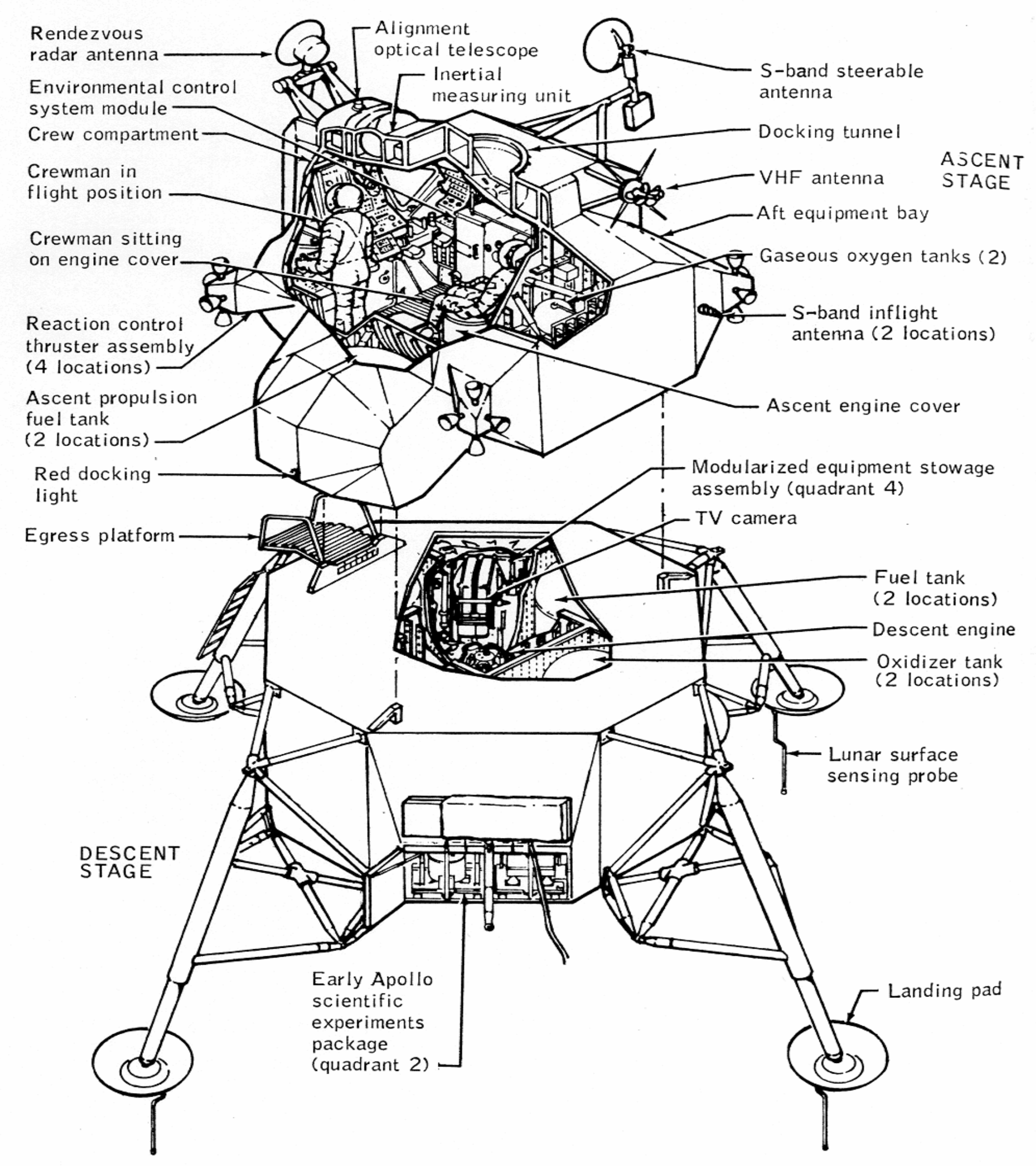


Fig. 3 Accent and Decent Lunar Stages



LUNAR MODULE CONFIGURATION FOR INITIAL LUNAR LANDING

Brief Lunar Background Readings

Today we live in a tremendously fragmented world. As Margaret Mead observed, mankind needs a mutually shared body of materials, events and efforts that gives everyone, whether from a technologically advanced society or a primitive one a basis for communication and understanding. To date the unifying force is weak. The conquest of space, of which a lunar colony or observatory is but a small first step, could be the beginning of the development of important elements of a shared culture. Much of mythology deals with humanity's battle with nature. Science fiction deals with man's use of technology in this effort. Creation of a lunar base would be but one more step by man to bring to reality positive elements of mythology and science fiction. Perhaps the establishment of a lunar base could be an element in the dawning of a bright new age for mankind – the age of space exploration. (From: Lunar Bases and Space Activities of the 21st Century, 1985, p55)

Lunar Base Concepts

The selection of the location for the first base on the Moon will be heavily influenced by programmatic priorities. Some argue that a return to one of the Apollo landing sites will suffice. The geology and the environment of a landing site are well known, obviating the need for any expense of delay associated with precursor survey missions. If scientific investigations have the highest priorities, then the major questions in lunar science would drive the selection process. Since radio astronomy from the farside of the Moon has long been a prime candidate for a surface investigation, a good location might be somewhere on the limb, where communication with the Earth can be maintained while the radio telescope is still nearby. On the other hand, the long-term strategy for building the surface infrastructure might require the early exploitation of local resources. An unmanned polar orbiting satellite would make sense as a precursor resource survey mission.

Some scientists have advocated a base at the lunar pole. The nearly perpendicular orientation of the lunar rotation axis to its orbital plane results in a continual twilight at the poles and, consequently, constant access to solar energy. A polar base would reside on the limb and would be continuously accessible from a station in lunar polar orbit. Unfortunately, the polar regions are the least known either in terms of geology or resources.

Lunar bases at any other latitude will suffer through the diurnal cycle of two weeks of daylight followed by two weeks of night. A power system based entirely on solar energy will require massive energy storage facilities for night-time usage and must be oversized to generate the stored energy during the daytime operation. Principally for this reason, nuclear energy appears to be the best solution for early stage lunar bases.
(From: Lunar Bases and Space Activities of the 21st Century, 1985, p33-34)

Uses of the Moon

A manned lunar base can be discussed in terms of three distinct functions. The first involves the scientific investigation of the Moon and its environment and the application of special properties of the Moon to research problems. The second produces the capability to utilize the materials of the Moon for beneficial purposes throughout the Earth-Moon system. The last is to conduct research and development leading to a self-sufficient and self-supporting lunar base, the first extraterrestrial human colony. Although these activities take place on the Moon, the developed technology and the established capability will benefit society on Earth as well as the growing industrialization of near-Earth space. (From: Lunar Bases and Space Activities of the 21st Century, 1985, p58-59)

Why is ice on the Moon important?

The ice could represent relatively pristine comet or asteroid material which has existed on the Moon for millions or billions of years. A robotic sample return mission could bring ice back to Earth for study, perhaps followed by a human mission for more detailed sampling. The simple fact that the ice is there will help scientists constrain models of impacts on the lunar surface and the effects of meteorite gardening, photo dissociation, and solar wind sputtering on the Moon. Beyond the scientifically intriguing aspects, deposits of ice on the Moon would have many practical aspects for future manned lunar exploration. There is no other source of water on the Moon, and shipping water to the Moon for use by humans would be extremely expensive ($2,000 to $20,000 per kg). The lunar water could also serve as a source of oxygen, another vital material not readily found on the Moon, and hydrogen, which could be used as rocket fuel. Paul Spudis, one of the scientists who took part in the Clementine study, referred to the lunar ice deposit as possibly "the most valuable piece of real estate in the solar system". It appears that in addition to the permanently shadowed areas there are some higher areas such as crater rims which are permanently exposed to sunlight and could serve as a source of power for future missions.
http://nssdc.gsfc.nasa.gov/planetary/ice/ice_moon.html

Lunar Surface Conditions

The lunar surface is a source of high and unavoidable vacuum, both an inconvenience and a potential aid to manufacture. The acceleration of gravity is only one sixth that of Earth, which makes strengths of materials less of a problem for lifting and supporting, although not for withstanding changes in momentum. Also, the microgravity of orbiting factories can be used for processing lunar material, where appropriate. Half the time, the lunar surface is bathed in sunlight, without uncertainties from clouds; each day and night is about 328 hours long. Surface temperatures range from roughly -170 degrees C in the shade to +120 degrees C in direct sunlight. There is no medium for heat exchange as on Earth where abundant water and air are available, so waste heat must be dissipated by radiators. Sunlight is available nearly full time in orbit, and lunar bases at polar locations might also achieve full-time use of solar energy. The lunar surface abounds in find dust, a convenient form of rock fro some uses but a potentially serious problem for operation of equipment and for personnel comfort and health. (From: Lunar Bases and Space Activities of the 21st Century, 1985, p437)

Readily Available Materials

Unprocessed Regolith. The material most readily available is unprocessed lunar soil. This consists mainly of fine rock flour, produced by past impacts of meteorites on the atmosphereless lunar surface. As encountered, this rock flour contains fragments ranging in size from clay to boulders. Fragments in mare soils are rich in the minerals plagioclase feldspar and pyroxene with ilmenite an important minor component. From an elemental point of view, these soils are rich in oxygen (41%) and silicon (19%), and in iron (13%), magnesium (6%), and, relatively, titanium (up to 6%). Soils derived from highland rocks have lower abundances of iron and magnesium, but tend to be rich in aluminum (14%) and calcium (11%).

Minimally Processed Regolith. There is some metallic iron, commonly about a tenth of a percent, in lunar soils. It is mainly present as fragments from meteorites that broke apart during crater-forming explosions and became mechanically mixed with lunar rock debris. It consists of alloys of iron that contain up to several percent nickel and some cobalt. This metal can be high graded by simply drawing a magnet through the soil. The principal product would be high purity iron, and a secondary product would be high purity nickel. In such high purity, iron metal may attain remarkably high strength.

Melting of common lunar silicates can produce a variety of glasses with different properties. These can be cast or drawn, and under water-free lunar conditions may have great tensile strengths.

Thermal Release of Gases. The simplest scheme for production of gases involves heating of lunar soil to release trapped solar wind. The most abundant implanted elements that can be extracted in this way are hydrogen, helium, nitrogen, and carbon. Since concentrations of these elements are low, large volumes of soil must be heated for a reasonable yield. The elements are tightly bound within surfaces of soil grains; soils must be heated to temperatures of 700 – 1100 degrees C to release them. The products of heating the materials from indigenous and solar-wind sources would include water, hydrogen sulfide, carbon monoxide and dioxide, ammonia, and hydrogen cyanide, among others. For efficient handling, these gases may require oxidation (with lunar derived oxygen) to produce three readily separable fractions: water, carbon dioxide, and nitrogen plus noble gases. The gaseous product that has received the most consideration so far is oxygen. Extraction of oxygen requires oxidation of that element from an oxide (*e.*g., ilmenite) or from silicates (*e.*g., mare basalt).

Conclusions. Unprocessed lunar soil can be used for radiation shielding both on the Moon and in space. Numerous glass products can be made, perhaps with special properties resulting from the dry lunar and space environment; these may become the principal structural materials for space. Iron and nickel can provide steel products, including electrical conductors. Ultra-pure iron may be as good as steel for many purposes. Oxygen and perhaps hydrogen gases can be produced for propellant and life support. This is a very good list of potential early raw materials for use on the Moon or in Space. (From: Lunar Bases and Space Activities of the 21st Century, 1985, p437-441)

Metabolic Support for a Lunar Base

The objective is to impart a general understanding of the metabolic support requirements of a manned lunar base and how these needs might be provided. Metabolic support includes the oxygen, water, and nutrition intake and waste output (feces, urine, insensible water, and carbon dioxide output) of man in space. Economic considerations quickly lead to the need to consider the recycling of metabolic materials, i.e., water, oxygen, and food, in order to reduce resupply costs.

Metabolic Requirements (6 Persons for 1 Year)

Item	Weight (kg)
Food	1404
Water	7043
Oxygen	1765
Total	10212

Estimated cost: $13,000/kg

(From: Lunar Bases and Space Activities of the 21st Century, 1985, p647-648)

Radiation

Permanent residents on the Moon can spend about 20% of the time without significant shielding from radiation. This equals about 40% of the two-week lunar dayspan. Most of the time should be spent in shelters that have about two meters of densely packed lunar soil, either below the surface or on the surface beneath a shielding mound. At the time of rare gigantic solar flares, shelters with about four meters of packed lunar soil would be required for adequate protection. (From: Lunar Bases and Space Activities of the 21st Century, 1985, p668)

A Final Thought

Establishing a permanently manned base on the Moon is a large and visible exercise of engineering and technology. A lunar settlement continues humanity's movement to accessible frontiers. It may start as a statement of national resolve or as a monument to international cooperation. It could be an heroic enterprise of epic dimensions or the stimulus for democratization of space through economic growth. One thing is clear – the Moon sits on the lip of the confining terrestrial gravity well and thus is the stepping stone to the solar system. (From: Lunar Bases and Space Activities of the 21st Century, 1985, p669)

The space program blends a curious mixture of romance and reality. Goals are set by dreamers and implemented by people like you.

RISKING FAILURE TO BE SUCCESSFUL
CHASE THE PROBLEM
TO MEET THE CHALLENGE
TO FLY THE DREAM

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