Lunar Command

Version 1.0

Instruction Manual

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Introduction by
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CHAPTER I

WELCOME TO LUNAR COMMAND!

Lunar Command (formerly **Moonbase**) is designed to give you a realistic idea of what it might be like to create and operate a colony on the Moon. The program was originally designed for the National Aeronautics and Space Administration (NASA) as a training tool, and was then made available as a simulation for the general public. We've provided structure and vehicle icons in accordance with NASA specifications, as well as economic models that take into account a broad variety of factors. But to prevent Lunar Command from becoming dry and monotonous, we've also taken a little programmer's license and added in a few "interesting" features. Sorry, you'll have to look for these yourself.

You Don't Do Manuals

Sure, we know. You never read manuals... just fire up the program and muddle on through from there. Well, by now you've probably noticed that this isn't your average, everyday manual. This one was designed to help you live the Lunar Command experience while you're learning it. So sit back, put your feet up, and enjoy yourself. So c'mon ... just do it.

Manual Conventions

In this manual, *italics* are used to indicate one-word commands or actions that you should type in or perform (ending it with the Enter key, of course), and key names will be boldfaced (like the reference to the Enter key above).

System Requirements

Lunar Command requires the following computer system:

- *An IBM PC or compatible 386 (or larger) computer* with one *floppy* and one *hard disk* drive, at least 2 megs memory, a *VGA* color graphics adapter card, and *IBM-DOS* or *MS-DOS* (version 3.3 or later).
- Joystick. (Optional for manually operating the lunar lander.)
- Sound Blaster sound card. (Optional)

Installing and Running Lunar Command

As with any new microcomputer product, you should first make a backup of the distribution diskette and then install the program and all its data files onto your system. Do this by copying all the files onto a newly-formatted floppy disk, or use the DISKCOPY program that comes with DOS. Your DOS manual describes how to make such copies.

Before even installing Lunar Command, you should read the file READ.ME from the distribution disk, if one is present. Like all microcomputer products, Lunar Command undergoes constant revision, and some things may have changed since this manual was printed, including the installation procedure. The READ.ME file documents these changes.

To see READ.ME on your screen, simply enter the command

***type* read.me**

at the DOS prompt (>) and watch the file scroll. Use **Ctrl-S** and **Ctrl-Q** to stop and restart the scrolling if it moves too fast. (**Ctrl-S** means to hold down the **Ctrl** key and press the **S** key at the same time.) To print the file, make sure your printer is connected and online, then enter

copy read.me prn

Installing To Hard Disk

To install Lunar Command on your hard drive:

1. Insert the Lunar Command Program disk into the appropriate floppy drive (A or B):
2. Log onto the floppy drive in which you inserted the disk.
3. Type Install and press Enter.

To run Lunar Command from your hard disk:

1. *Log onto* the hard disk Lunar Command directory.
2. *Type* **LC**, *then press* **Enter** and the program will run.

The Design Team

Lunar Command is the culmination of a joint venture between Wesson International and KDT Advanced Systems Group, both of Austin, Texas. Wesson has been a premier developer of simulation software, primarily for air traffic control, for several years. KDT has worked with the National Aeronautics and

Space Administration's Johnson Space Center on Planning and Logistics for Lunar Bases.

Original programming for Lunar Command is by Robert Green and Brett Adams of Wesson, and Brendan O'Connor of KDT. Many of the advanced, realistic features were suggested by NASA. The introduction was created through the combined talents of John Ryan and David Warner. The story, from a concept by Lisa Guerra, was written by Gareth dePutron. Instructional portions of the manual were compiled by dePutron, O'Connor and Elfego Pinon, III. Final editing was done by Gareth dePutron and Bob Wesson.

Special acknowledgement is given to Ken Klingensmith, Lisa Bell and Curt Bilby of KDT, as well as the entire staffs of KDT Industries, The Large Scale Programs Institute and Wesson International for their enormous contributions to the original programming.

Lunar Environment

The Moon, whose center is located approximately 384,400 kilometers from the center of the Earth, completes one revolution of the Earth every 27.3 days and makes one complete rotation about its axis (with respect to the Sun) every 29.5 days. As a result, the lunar day is actually 29.5 Earth days long. This means that points on the surface of the Moon are exposed to the Sun's heat for over 14 consecutive days and then plunged into darkness for over 14 consecutive days. These long light and dark periods lead to extreme temperatures. During the lunar day, the temperature can soar as high as 370K (206.3 F) while at night the temperature can drop to 125K (-234.7 F).

These temperature extremes are also made possible by the lack of an atmosphere on the Moon. The Moon lacks an atmosphere since its small mass (compared to the Earth) does not provide enough gravitational force to keep an atmosphere from escaping. The Moon's surface gravity is about one sixth that of the Earth's. Thus, a 180 pound weight on the Earth would only weigh 30 pounds on the Moon. A lunar atmosphere would help stabilize the temperature on the surface by trapping heat during the lunar night. As a result of these temperature variations, thermal control is a very important concern on the Moon. Also, the lack of an atmosphere makes radiation shielding a high priority concern, since the Moon is bombarded by both solar (ultraviolet or UV) and cosmic radiation. The ozone layer of the Earth's atmosphere helps shield the surface from UV radiation. The Moon's surface is unshielded from these deadly forms of radiation.

Selenography

Although some seismic activity has been detected on the Moon, all volcanic processes have ceased. As a result, the Moon has no internal heat source and the surface has remained relatively unchanged for billions of years. The most prominent features on the surface are the craters formed by meteoroid bombardment. The craters range in diameter from just under 1 meter to over 200 km. In addition to craters, the surface is covered with relatively smooth dark areas called maria (seas) which were formed billions

of years ago by flowing lava. Mountains, some of which rise to heights of 7 km, can also be found crossing the lunar surface.

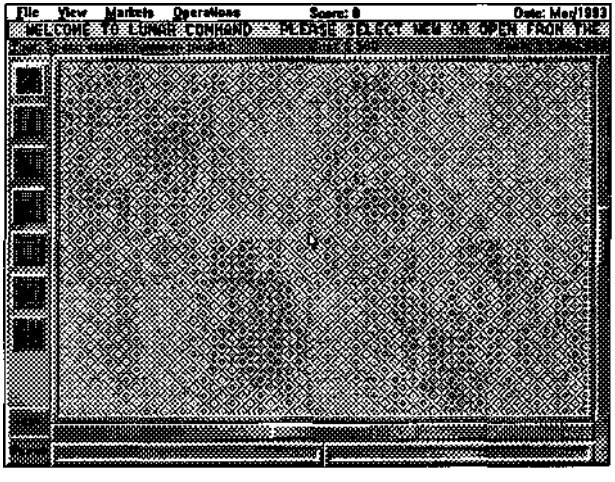
The surface of the Moon is covered with a mixture of fine particles and rock fragments, known as *regolith*. Based on analysis of the samples returned during the Apollo missions, scientists have determined that the rock material was formed by the solidification of lava. The regolith contains calcium and aluminum silicates, titanium, uranium, iron, magnesium, and oxygen. Unlike Earth rocks, the lunar rocks contain only small traces of volatile elements such as chlorine, copper, argon, sodium, potassium, and carbon compounds.

Solar Radiation

Without an atmosphere or magnetic field on the Moon, there is nothing to protect humans from solar or cosmic radiation. For this reason, most structures would have to be buried under up to 2 meters of regolith to provide adequate radiation shielding for the occupants. In order to make the Lunar Command simulation more interesting visually, we have taken the liberty of leaving them uncovered.

The Main Screen

The Lunar Command screen is comprised of four major areas, including the Working Screen, a white Top Level Menu bar, a yellow Information or Tickertape bar, a blue-green Status bar, and the various icons in the vertical Toolbox.



The Working Screen takes up most of your computer screen, and may be considered the view of the lunar surface as seen from your lander. This is where you will actually design and construct your base. Using the horizontal and vertical scroll bars (bottom and right of screen), you may view any portion of the displayed scenario.

The Top Level Menu bar is located at the top of the screen, and is divided into five headings: File, View, Markets, and Operations. Each Top Level Menu item may be accessed using an Alt-key command (e.g., Alt-F = File), or by pulling it down with the mouse.

Directly below the Top Level Menu bar is the yellow Information bar. This will operate automatically throughout your scenario providing valuable information dealing with population, production, supply and demand figures, and newsworthy events from Earth.

The Status bar tells you which icon menu item is currently selected, how much that item costs, and how much cash is currently available to cover the needs of your base. This figure will change automatically depending on profits, expenditures, or varying internal and external economic factors.

The various Toolbox icons are located to the left of the Working Screen. These include: Habitats, Science, Mining/Processing, Support Services, Thermal, Power, and Manufacturing, and may be accessed by using the Tab keys, or mouse. Selecting one will popup a menu of subitems for that icon.

Vertical and horizontal movement of the playing grid may be controlled using the scroll and elevator ban on the bottom and right sides of the screen. These function in the same manner as any scroll bars.

In the lower left corner of the screen are buttons marked Info and Pause. Information will pop up the Information library box, and may be accessed at any time. Pause, of course, will pause you scenario.

At the very bottom of the screen, below the scroll bar, are the Power and Thermal Meters. Red represents Power, and blue represents Thermal. The meters display the percentage of Power and Thermal demand versus base output, and will fluctuate as elements are added or removed from your base.

One final item is included on your Lunar Command screen. The date appears in the upper right corner on the Top Level Menu bar. At the beginning of each new scenario, the date matches that currently on your computer. As you play out your scenario, the date will change by month and year, and the speed with which it changes will depend on what speed you have set your scenario to play.

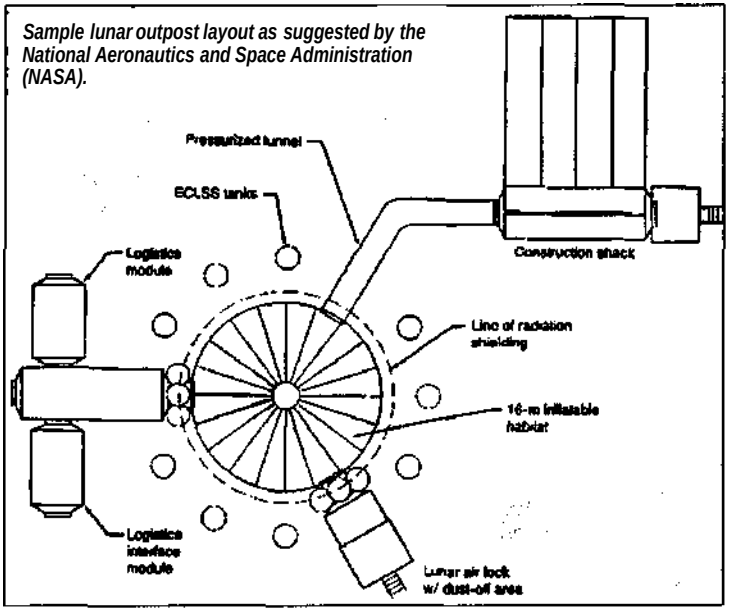
Your Objective

As Commander of the lunar colony, you must carefully decide how to spend the limited amount of money supplied by NASA. NASA will supply funds for base construction and operation for 10 years. After this time, the base must be self sustaining and will receive only minimal support from NASA. The cost to build the base components varies depending on the complexity of the structure and number of crew members required to complete construction. In addition, exploration missions to locate buried ice can become costly if an intelligent search strategy is not followed. The base can generate revenue in several ways. The first way is to mine, process, and sell LLOX. Another way to generate funds for construction and operation is mining and selling He3. In addition, materials processing plants can be built. Materials Processing Plants produce crystals for solar power cells by extracting the necessary compounds from the regolith. Lunar Command Electronics Plants produce low-gravity semi-conductor computer chips. The crystals and chips can be sold to Earth companies. The final way to generate funds is through tourism. Hotels can be built to house tourists who will pay large sums of money to spend time on the Moon and visit various historical sites and interesting surface features.

The Basics

There are three essential elements to running a lunar base — crew, power, and thermal control — and most of the base structures require all three. If something isn't working, it's probably because it lacks one of these three elements. There is a wide variety of structures that can be built and activities which can be carried out and you're limited only by your equipment and your knowledge of the lunar environment.

The Moon is a difficult place for humans to live—some things that can be taken for granted on Earth are very difficult to obtain there. Crew members require life-support, food and water to survive, yet none of these is readily available. Life-support for the colony is built in as part of the Habitation Modules (Habs). Food and water are part of the resupply costs which the base must pay for on a yearly basis. In Greenhouses, food can be grown on the Moon and since water might be found as well, it is possible to reduce the base's dependency on resupply (and its costs!) from Earth by making use of these factors.



Sample lunar outpost layout as suggested by the National Aeronautics and Space Administration (NASA).

The population of the base must be monitored carefully. You need enough workers to man the various production plants, but you must also insure there is enough space for them in the Habs. Without enough room, overcrowding will occur and crew morale will drop. In turn, productivity at the plants will go down. Construction accidents and other disasters may result in crew fatalities requiring you to bring in replacement workers. If there is a shortage of workers, the workers on hand will become overworked, which will also lead to a drop in morale and productivity. The cost of providing air, food, and water for the crew is computed as part of the annual resupply cost of running the base.

Construction

Construction is one of the primary activities which you will direct as Base Commander. When the simulation starts, there will be no buildings on the lunar surface. You must decide where to start building the main base complex. The building costs will be subtracted from your available funds each time you place a structure. The computer will prevent you from constructing buildings on top of each other or with overlapping areas.

Self-Sufficiency

One of the problems which will plague any lunar base will be the costs of getting supplies from the Earth to the Moon. The main one being the enormous cost of getting things from the Earth's surface into obit due to the magnitude of the Earth's gravity. Estimates have placed the cost at approximately $6600 per kilogram ($3000 per lb) placed in orbit. Since the Moon's gravity is much less than the Earth's, it would be far cheaper (in terms of rocket propellant) to transport goods from the Moon to Earth orbit This is the center of much of todays discussion of exploitation of the Moon's resources.

Resupply

The supplies needed by a lunar base from Earth include the food, water, and hardware needed to keep the men and women who make up the crew alive and well as well as the spare parts and replacements needed to keep the machines and structures functioning properly. There are three things that you as the Base Commander can do to reduce your base's dependence on supplies from Earth. You can grow your own food, mine your own water and do some of your own maintenance so that everything that breaks does not have to be scrapped and replaced from Earth. Food is grown in Greenhouses, each of which can grow enough food to feed 24 people. Water (if it exists, and if you can find it) can be extracted from the lunar regolith by Water Extraction Plants. The water needed to resupply the base is automatically subtracted from any water mined. Maintenance can be performed in Maintenance Facilities which, when hooked up to power, thermal control and sufficiently manned, can significantly reduce the amount of hardware which must be transported from Earth each month. The cost of resupply and the percentages of food, water and hardware which make up of this cost are reported each year in the annual report box.

Disasters

There are several types of disasters which will cause crew fatalities and slow the work rates at the production facilities. One type of disaster is a solar flare. Due to the distance between the Sun and Moon, astronomers can give the crew an 8 minute warning before the effects of the flare are felt on the lunar surface. Fatalities from solar flares can be avoided if telescopes are built which can give advanced warning of solar flares.

Another type of disaster is a lunar lander crash. The landers are used to transport materials and crew members to and from lunar orbit. Unfortunately, lander crashes are not preventable, but they can be greatly reduced by constructing landing pads. The landing pads make it easier for the pilots to home in on the base and help in judging the distances between the lander and the ground.

There are also inherent risks in operating nuclear (fission) plants on the Moon. Since mass is at a premium, the amount of shielding would be minimal. Nuclear plants on the Moon, if they get out of control, will be extremely dangerous. Placing these plants in craters will provide extra protection from radiation hazards.

CHAPTER II

GETTING STARTED

Top Level Menu Options

Notice the Top Level Menu bar across the upper part of the Lunar Colony display. This menu bar will remain throughout the simulation, and features the top-level menus File, View, Markets, and Operations. You may select these options by using either the keyboard or a mouse. Any option followed by '...' indicates that selecting that option will popup a dialog box.

With the keyboard, *select* a menu by using an Alt-key combination, such as Alt-F for File. Then use the Left/Right Arrow keys to move between headings. When you have selected your menu, use the Up/Dn Arrows to highlight the menu item, then *press* Enter.

If you are using a mouse, simply position the mouse pointer over the desired menu, *click* the left button, and the menu will drop down. Then *select* the item you want in the same way.

FILE

The File menu box contains the following options: New..., Open..., Save..., Save as..., Settings..., Print, Exit, and About Moonbase.

You will use the New... command to begin a new scenario. New... will ask you to enter a name under which you may want to save your scenario. Type in your file name, press Enter, and the program will generate the terrain for your scenario.

Use Open... to see previously saved scenarios. The Save... command lets you save a scenario that was previously saved to disk, and then continue playing. Use Save as... to save a scenario for the first time, or to save a new version of an existing scenario without losing the original.

The Settings... option allows you to set Sound Blaster and Printer parameters. This option is also where you will set the speed in which your scenario is played — Slow, Medium or Fast. The date and economic factors will change more rapidly in the faster modes. You may also toggle the Animation, Sound, and Voices options on or off, and determine whether landers will operate automatically or by manual control.

Select Print if you want to print out a copy of your lunar base. Exit will return you to the DOS prompt.

VIEW

View contains only four options, Zoom Out, Power & Thermal Grid, Information, and Redraw. After you have opened your New scenario, use Zoom Out to see the terrain in which you may build your base. If you are already working in a scenario, you may use the option as a tool for lunar exploration (see Tool Icons). Use the mouse or, with the keyboard, the direction keys to move around inside the dialog box. Your screen will shift behind the dialog box as you move the cursor around. When you have selected a site for your base, *press* Enter or *click* on the OK box to set the selected terrain on your screen.

The Power and Thermal Grid option allows you to view your entire base to see at a glance which structures are not connected to power or thermal. Those that aren't will flash slowly on the screen.

Information can also be accessed via the Info button in the lower left corner of the Lunar Command screen. This option provides access to an onscreen library of available tools, as well as details such as power, thermal, and crew requirements, and production figures.

Try the Redraw command if you encounter any technical problems with the screen.

MARKETS

You will use the Markets menu only after you have begun playing a scenario. This menu contains three of your economic options: Sell..., History... and Demand..., and are used to open dialog boxes that provide information on current markets and prices, what has been produced and sold over the previous five years, and what markets are currently available for each product.

OPERATIONS

Like Markets, Operations also deals with the economics of each Moonbase scenario. In this menu, use Population... to check the available population versus the demand, and then increase or decrease the number of people living and working at Project Moonbase. Select Productivity... to show the current percentage of production capability of your plant(s). Selecting Budget... will popup a large dialog box that contains information on available products, amount of money supplied by NASA, cash flow, salaries, etc. The only feature in this box that you may control is the amount of resupplies required from other sources. At the beginning of the scenario, Project Moonbase is automatically assumed to require 100% resupply. As your base begins to produce materials, you may choose to decrease the amount of resupply. To do this, simply use the Up/Dn Arrows, type in a percentage or click/hold on the arrow tabs until you reach the desired resupply percentage. The Budget dialog box will automatically popup at the end of each year throughout the scenario and will remain on the screen until you press Enter or click on OK.

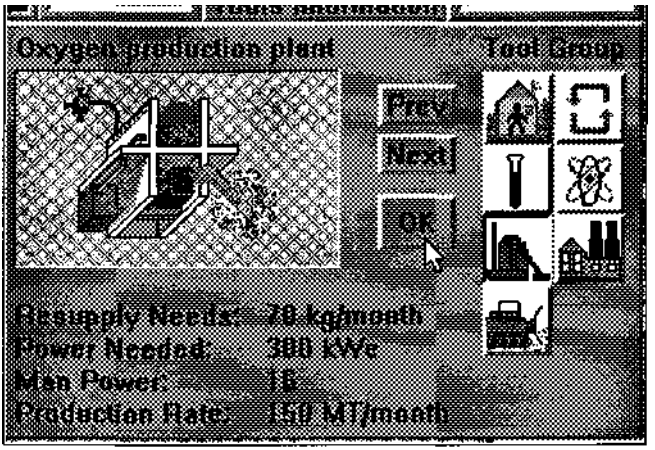
Dialog Boxes and Messages

Dialog boxes are those that require you to enter additional information before proceeding with other functions. You may move around to the various options in these boxes by clicking with the mouse, or by using the Tab, Shift-Tab and Space bar to select and/or change the required parameter. ESC will choose any Cancel button. All dialog boxes may be repositioned on your screen by *dragging* the dialog box name plate. *Press* Enter or *click* OK to exit the box.

Announcements regarding various factors that impact directly on the economic stability of your Colony will popup on the screen as Message boxes at seemingly random times throughout the simulation. As with the ticker tape information at the top of your screen, you *must* pay attention to these messages. A strike by your miners will cripple your productivity, while war on Earth will mean a significant, if not total, reduction of support from NASA and a loss of markets for your products. In some cases, such as the war scenario, there is nothing you can do but wait it out. However, in other cases it may simply be a matter of increasing population, improving living conditions, or providing fresh foods from a greenhouse. To acknowledge these messages, either *click* inside the message area with the mouse or *press* any key.

Information

Lunar Command allows you to access an onscreen library of information regarding the tools, structures, and vehicles available for constructing your base. This pop-up dialog box may be accessed via View Information, or by *clicking* the Information button in the lower left corner of the Lunar Command screen.



The Information box contains a window for viewing each available element, controls for selecting elements, and information about the selected element. To access information in this box,

- *Click* once on the Tool Icon containing the desired element. Then,
- *Click* on the NEXT button.

This will let you scroll through the available elements in that tool classification until the element that you wish to see appears in the window. The pertinent information below the window will change automatically. *Clicking* PREV will let you scroll backward to view previous elements.

To view elements under other tool classifications, simply *click* on another Tool Icon.

Using Zoom Out

Zoom Out displays the entire terrain area upon which you build your colony, as well as your current location. The colors displayed in the Zoom Out view correspond to the colors of the icon tools, so that at a glance you can tell what type of structure is located where.

To view a different part of the lunar base:

- With a mouse, *move* the rectangular cursor around inside the Zoom Out box and *click* with the left mouse button.
- With the keyboard, *press* the Tab key to select the Zoom Out view, then *press* the Arrow keys to move the rectangular cursor.

With both methods, the terrain area behind the Zoom Out dialog box will change to show the new view of the lunar base.

- To exit Zoom Out, *select* OK to accept the new location, or Cancel to abort the selection.

Selecting Icon Tools

When the terrain is displayed and you've selected a suitable site for your base, you're ready to begin construction. As stated previously, the Icon Tools are located on the vertical menu bar to the left of the Main Screen. At the start of each new scenario, the Habitat icon at the top of the bar is automatically selected (defaulted). This is followed by Science, Mining, Support Services, Thermal, Power, and Manufacturing. Use the Tab and Shift-Tab keys, or *click* with the mouse to move up and down between Icons to make your selection. Remember that you may preview each tool, structure, and vehicle by opening the Information box.

To open the selected Icon, *press* the Space Bar, or *click/drag* with the mouse. This will open the Icon's menu, giving you access to a set of tool options. Use the Up/Dn Arrows or your mouse to select an option. Remember to *press* Enter following each keypad command. When you have made your selection, the cursor or mouse pointer will become a box the size

of the tool that you are using. Your selection will appear on the Status Line below the Top Level Menu bar. Each tool costs the player a preset amount that will be automatically deducted from the budget. These costs will be displayed on the Status Line.

Placing Icons with the Keyboard

With the Arrow keys:
Striking an Arrow key will move the icon cursor up, down, left and right while selecting a sight for placement. When you have decided on the desired location, *press* Enter or Shift/Arrow. For continuous drawing of cables, pipes or roads, or for multiple structure placement, hold down Shift/ Arrow.

With the Keypad (Number Lock On):
Use the Number keys to move the entire terrain grid. Use Shift/Arrow to place individual structures or segments of cable, pipes and roads. For continuous drawing of cables, pipes or roads, or for multiple structure placement, hold down Shift/Arrow.

With the Keypad (Number Lock Off*):*
The Arrow keys will move the icon cursor, while Shift/Number will move the entire terrain grid. *Press* Enter to place structures.

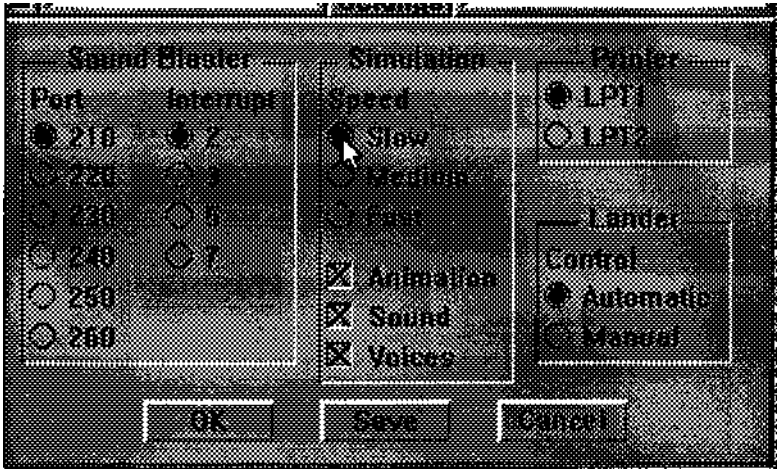
Changing Laboratory Module Aspect:
The Laboratory is the only structure that may be turned. To change the placement aspect of the Lab module by 90 degrees, *press* Ctrl-R, then press Enter to place the unit.

Starting From Scratch

Each time you start Lunar Command, you're presented with the main playing screen on which nothing is functioning. To start a new scenario, *pull down* the File Menu and *select* Settings...

In the dialog box,

- *Select* the Sound Blaster Port and Interrupt. Then,
- *Select* the speed - Slow, Medium, Fast - at which you wish the scenario to operate. Next,
- *Enable/Disable* Animation, Sound, and Voice by *clicking* in their respective boxes. Doing so allows you to toggle these elements on or off. If you will be printing out a copy of your base,
- *Select* the port to which your printer is connected. Finally,
- *Select* Automatic or Manual to determine whether the computer or you will operate the landers, and
- *Select* OK or Save.



Now, *pull down* the **File Menu** again,

- *Select* New...,
- *Enter* a **name** in the popup dialog box, and
- *Click* **OK.** The program will generate a randomly selected lunar landscape.

Once the lunar landscape has been created, use the **Zoom Out** feature to choose an appropriate site for your base. It might be a good idea to use the Exploration tool from the Science Tool Icon to examine the selected area first.

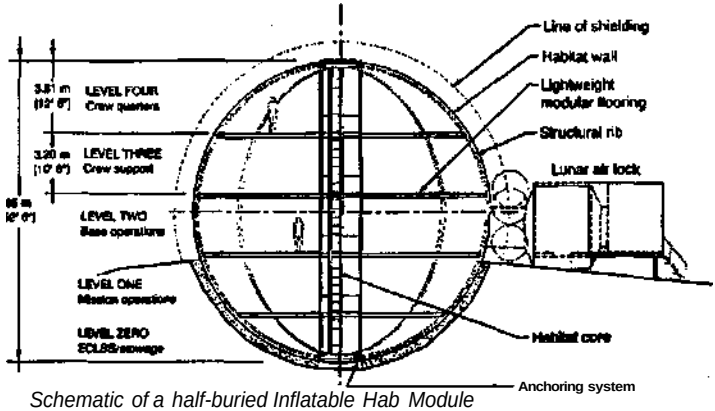
When you begin each new scenario, your base crew consists of YOU — period. So once you've made your site selection, start simple. After all, NASA has only given you a limited amount of cash to get started. Place an **SSCM**, one **Radiator,** and one **Photovoltaic array.** This will be more than adequate to get things moving, and you will add to this basic setup as you progress. Next, check your population needs and refer to the **Information** library for **SSCM** capacity and crew requirements for the **SSCM,** power, and thermal units. Finally, construct a **Landing Pad and a Maintenance** facility. You'll need the **Landing Pad** to allow safe lander operations (either automatic or manual), and you must have a **Maintenance** facility before starting any *extended* exploration missions (see **Chapter 5**, **Extended Exploration Missions**).

With a small base of operations in place, your next task is to start producing something that can be sold - oxygen is the most abundant, and will be found in concentrations up to 40 percent, so the higher the concentration, the better your productivity. Use the **Exploration** tool to locate a suitable mining site, then build a **LLOX Plant** and give it at least *three* **LLOX Miners. The LLOX Plant** must be supplied with power and thermal. If you do not want the facilities close to your main base, and therefore attached to the base power/thermal grid, you may connect the **LLOX**

Plant to a single Photovoltaic Array and Radiator. Now, quickly check the crew requirements for the total facility - Plant, Miner, Power and Radiator - and increase your crew and housing accordingly. You do not need to place housing at the facility site.

With these elements in place, check your **Productivity** box under **Operations.** You should see the level of LLOX productivity rising from zero, which means that you now have products to sell (check the Sell box under the **Markets** menu).

Now, you need to keep your miners happy. If you don't have enough cash to build the structures you need, sell some of your Oxygen inventory. And be sure to watch your Resupply at the start of each new year. You *must* resupply your base. If you fail to resupply, your mining and processing facilities will breakdown and your productivity will drop — which leaves you with no inventory to sell when you need it. You'll notice more often than not that resupply will destroy your cash balance. This is when you need to sell your inventory, and then add to your base. Check the Demand chart under **Markets** to see what is needed, then select an appropriate facility and place it in the same manner as previous units.



Schematic of a half-buried Inflatable Hab Module

When resupplying at the start of the year, follow a three-step procedure. First, accept the resupply percentage listed in the Resupply box. Next, *pull down* the Markets menu, *select* Sell, and sell half or all of your inventory. You'll need to use your judgement based on what the current demand and prices are to determine how much to sell, but it's usually best to keep something in inventory against possible emergencies. After selling your inventory, *pull down* the **Operations** menu, *select* Budget, and *raise* the resupply percentage as high as it will let you (maybe 100%, maybe less). *Click* **OK** to complete the process. In effect, what you have done is sell products for cash in order to purchase spare parts from Earth. Without spare parts, your facilities will begin to break down, productivity will fall off, and your base will fail. *(Note:* Maintenance facilities can't create spare parts.)

The next facility that you should construct is Communications. Up to this point in the scenario, your yellow Information bar has remained inoperative. Placing a Communications facility will get your market information flowing so you can keep a constant eye on prices without accessing the Sell or Demand boxes. The Information bar also warns you of some elements that will affect your productivity or market, as well as emergency situations such as solar flares.

Printing Your Base

If you want a printout of your base, you must have an Epson-compatible printer. (Support for other printers may be added in the future.) You may print the entire grid, or just part of it. First make sure that you've checked the appropriate box (LPT1 or LPT2) in the FILE Settings box.

Next, *select* FILE Print. In the dialog box, select the area of the base that you want to print by positioning the cursor box and *clicking* on the Print Enclosed Base box. If you want a printout of the entire playing grid, leave the Print Enclosed Base box empty. When you're ready, *click* Print. Your base will be printed while you continue play. If, after clicking the Print button, you want to halt the printing, *click* Abort.

You may prefer to save the base and print it later. To do this, simply *enter* a file name in the appropriate box *and press* Enter. Later on, when you're ready to print it, *select* FILE Print, then *select* the file name, *and press* Enter.

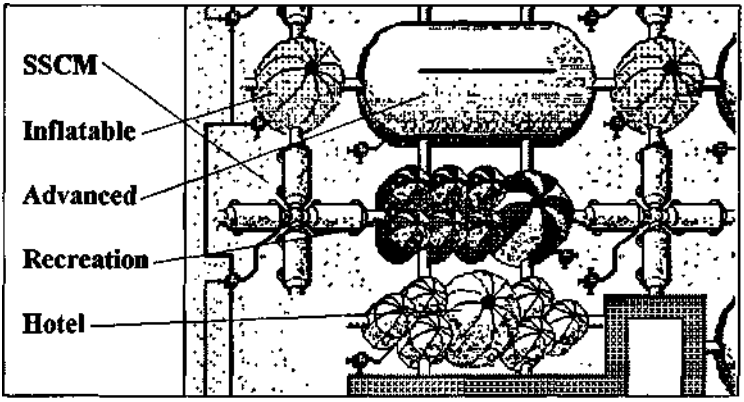
CHAPTER III

TOOLS, STRUCTURES, & VEHICLES

As stated in the previous Chapter, you may choose any of several missions when creating your lunar colony. To facilitate this, you are given an icon bar to the left of the main screen from which you will select any or all of the required housing, scientific, mining, support, thermal, power, and manufacturing options.

HABITATION

Habitation modules are perhaps the most important type of buildings to construct on the Moon. The purpose of a hab module is to house the crew and any visitors when they are not at work at the various mines and processing plants. There are three types of hab modules that can be built to house the crew and one type that can be used by tourists in later stages of the simulation. The first type of crew hab module is

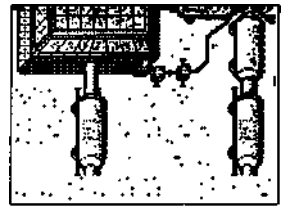


the Space Station Common Module (SSCM) designed to house 16 crew members and originally designed for use aboard Space Station Freedom. These modules can be easily adapted for use on the lunar surface. The second type of crew hab module is the Inflatable hab module. These modules are designed to house 50 people under very comfortable conditions. The third type of habitation module is the apartment complex (Adv. Hab) which is designed to house 150 people. Recreation Centers (Rec. Center) are required to maintain crew morale, and should be constructed fairly early in the scenario. Without one, the miners will start complaining about conditions and productivity will suffer. Hotels can be constructed to house tourists. All of these habitation modules must be hooked up to a power plant and a thermal control system before they can be used. The final option available under Habitation is Air Locks. These are actually tunnel segments used to connect structure air locks when you want more space between them, or whenever they are offset for any reason.

SCIENTIFIC

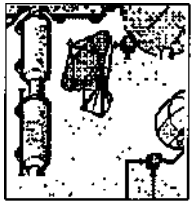
NASA's primary interest in the lunar base is for its scientific value. NASA's continued interest in the base and its level of support is largely dependent on science. There are three science missions which can be carried out in Moonbase, they are explorations, astronomy, and laboratory experiments. Explorations are carried out by selecting Exploration from the tool box and then clicking the left mouse button on the spot on the lunar surface that you wish to explore. A crew is dispatched to explore the site and when they arrive you may request a report by clicking on the site. The reports contain information on the mineral content of the Regolith and on any features that might be of interest to scientists or tourists from Earth. Astronomy missions are carried out by building a telescope and they are important for providing early warnings of dangerous solar flares which can be fatal to anyone caught out in the open. Laboratory missions are initiated by building and manning laboratory units. The experiments carried out in the labs relate to nuclear fusion, low-gravity electronics and lunar materials processing. Discoveries in any of these fields are important factors for the base Commander to consider in planning base growth strategies.

Laboratory



Although the module might not look like much, the **Laboratory** serves the function of initiating scientific missions. If your primary mission is exploration or mining, you probably won't require labs. They are, however, essential for other missions. The development of fusion as a power source requires a lab, as do some of the manufacturing missions. One lab will sometimes be sufficient, particularly if you have a single mission base, but multiple labs will greatly increase scientific development. Labs may be standalone units or may connected via airlock tunnels to any existing module.

Astronomy

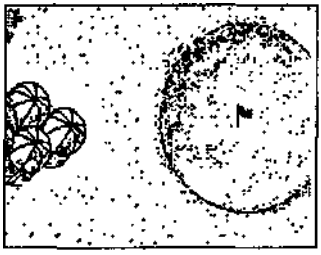


In addition to the production facilities and buildings mentioned throughout this manual, Astronomy facilities can also be built near the base. These facilities will mostly be used during the lunar night as astronomers try to learn more about our universe. With these astronomy facilities, new discoveries may be made which will convince NASA to continue funding or may provide incentive for tourists to visit the Moon. The astronomy facilities do not require power or thermal control hookups.

Exploration

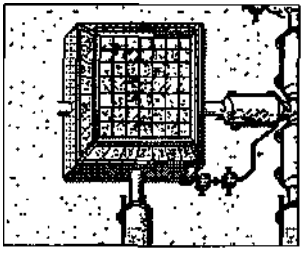
Exploration of the lunar surface in search of deposits of oxygen-rich soil, hydrogen, helium 3, and water, is one activity over which the base Commander has complete control. With the exception of water, all of these are found in varying concentrations in your scenario terrain. Finding them is the trick. Since water in the form of ice *may* be hidden somewhere on the Moon, it *is* possible that you might just locate some. The most likely place to find water is in a craters. The concentration of oxygen in the lunar regolith

varies from 28% to 45%. Other materials are found in lower concentrations.



Although the search for mineable elements is the primary function of Exploration, from time to time your crews will stumble across a variety of other "items." Some of these, like Alan Shephard's golf ball and dilythium crystals, are in there for fun and serve no useful purpose in your simulation. Others, such as alien ruins and cave formations, will increase the interest in tourism. This would be a good time to place a hotel at your base.

Greenhouse



As your base grows, you'll quickly find the need to construct at least one Greenhouse. This will be your base's primary source of fresh food, and the base crew will let you know when a Greenhouse is needed. Failure to provide one will result in a drop in productivity. Likewise, aphids in your Greenhouse will affect productivity. Getting rid of them is a matter of buldozing and replacing the Greenhouse... expensive, but necessary. It's a lot worse if you have several Greenhouses, as an aphid infestation will affect all of them and can't be localized.

MINING

The Moon offers several possible resources which can be mined and extracted for use by future explorers to make lunar colonization easier and more profitable. These include oxygen, helium-3, and water, although the existence of the latter is mostly speculative and will depend on the availability of ice trapped in the lunar regolith.

Oxygen/LLOX

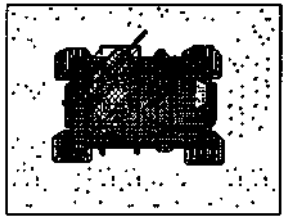
Perhaps the most important of the lunar resources, and certainly the necessary for maintaining life, Oxygen can be used for both life support and as an oxidizer for rocket propellants such as hydrogen. Oxygen stored in liquid form, LOX (Liquid OXygen), can be transported to lunar orbit where it can then be used to refuel Earth-to-Moon transfer vehicles, and eventually Earth-to-Mars and other exploration vehicles. The oxygen is found in varying concentrations (28% to 45%) in the regolith from which it can be extracted. Oxygen derived from the lunar regolith is called LLOX, short for Lunar-derived Liquid OXygen. The Oxygen Extraction Plant can produce up to 150

Metric Tons per month, but it requires Oxygen Miners to dig up the regolith and feed it to the Plant. The Plant should be located in an area of high oxygen concentration, and at least three Miners should be placed with it. As with most mining and materials operations, your base will automatically deduct its needs from your inventory, so keep that in mind as you increase the size of your base complex.

You will not need to place your main base close to the oxygen mining operation, nor will you need to make special housing arrangements for the mine crews. You may elect, however, to give your Plant its own power and thermal facilities; one Photovoltaic Array and one Radiator will be sufficient.

Helium-3

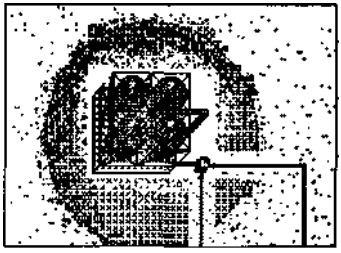
Another valuable resource found on the Moon is helium-3 (He-3), a very rare light isotope of helium. The most important use of HE-3 is as a fuel for nuclear fusion power plants. Currently, all nuclear power plants on Earth utilize nuclear fission to generate heat, which is used to boil water to produce steam that turns turbines, and generates electricity. Fusion is a safer form of nuclear reaction, wherein atoms are fused to release heat. If He-3 is used as the fuel for a fusion reaction, the resulting waste from the reaction would be low enough in radiation that is could be safely buried near the Earth's surface. Helium-3 is very rare on Earth, but can be found everywhere on the Moon in equal concentrations. Current estimates are that approximately 1 million tons of He-3 exist in the lunar soil. The lunar HE-3 mobile Extraction Plant can produce only 3 kg of helium-3 per month, but since it is so rare on Earth, it could become extremely valuable once fusion is perfected (see Laboratory).



The mobile He-3 plants can be located anywhere, since the concentrations of He-3 in the soil are uniform across the lunar surface. These plants are placed like the other options. They contain their own mining equipment, and are essentially self-sufficient, requiring no power or thermal connections. If you plan to mine He-3, it may be a good idea to place two or three mobile Miners as soon as you have the money to do so. Then, let them operate and build up an inventory until fusion is discovered. Within a short period following that discovery, the He-3 price on the commodities exchange will begin to rise, giving you a strong source of income. Remember, however, that if you place a Fusion Reactor at your base, it will use everything your initial miners produce, and you must place additional miners in order to build inventory.

Lunar Water

Water, in the form of ice, is another possible resource that can be found on the Moon. The most obvious use of water is for life support purposes. Water can also be broken down into its basic elements, hydrogen and oxygen through electrolysis, a process which uses electricity to break apart water molecules. It is then used as a rocket propellant. Although no ice was found in the samples returned by the Apollo astronauts, scientists speculate that ice may be present deep under the regolith lining select craters. One theory is that the ice was deposited by meteoroids or comets impacting the Moon. If found, water could be easily extracted from the regolith using current technology. The Moonbase Water Extraction Plant can produce up to 50 Metric Tons (a metric ton is 1000 kg) of water per month.



The water extraction plants are used to extract water from regolith containing ice, assuming ice has been found by exploration missions. These facilities require power and thermal control like most buildings. Each water extraction plant can produce up to 50 MT of water per month. The procedure for selling the water is similar to that for He-3 except the water option is chosen. Mining and selling water is a good way to support the cost of operating the main base.

NASA theorizes that if water does exist in any extractable quantities, it will most likely be found below the lunar surface. Therefore, the most probable and economically feasible sites for locating ice deposits would be in craters, where meteoric impacts may have uncovered them. Since the existence of lunar ice *is* theoretical, look for deposits in the *largest* craters.

SUPPORT SERVICES

Support Services includes facilities that are not considered essential for successfully *building* a lunar base. Communications, Maintenance, and Landing Pads will, however, certainly make things a lot easier as you strive for self-sufficiency. Support Services also includes the Bulldozer and Roads commands.

Bulldozer and Roads

Although you may place structures almost anywhere on the lunar surface, you may not do so if it overlaps a crater. Use Bulldozer to remove elements that you wish to place elsewhere, or that stand in the way of other facilities.

Similar to Bulldozer in the way it works, the Roads command allows you to lay down bermed roadbed to connect your base facilities. Roads may cross power cables and thermal pipes, both of which will appear as zigzag lines at each crossing. They may not, however, pass lengthwise beneath a road.

Roads, Pipes and Cables must run in horizontal or vertical lines, and will automatically make right-angle turns when you change direction. These elements may cross each other, but may not cross facilities. With the keyboard, position the cursor over the desired spot and *press* Enter to place each segment. Alternately, *hold down* the Shift key and *press* one of the Arrow keys. With the mouse, place the pointer at the starting point and *click* the left button once for each segment. For continuous sections, hold the button down and *drag* the pointer to the desired terminus. If you *hold down* the Shift key while *dragging* the mouse pointer, continuous horizontal or vertical segments are created.

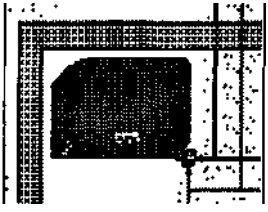
If you want to remove any element on your base, use the Bulldozer command in the Support Services menu. Place the cursor box at the desired starting point *and press* Enter or *click once* with the mouse. If you are removing terrain, roads, pipes or cables, only the area directly under the cursor will be bulldozed, leaving a cleared square of terrain. To remove a structure, simply bulldoze any one

point on it and the entire structure will be reduced to rubble. This rubble must be bulldozed before construction on that site can begin. [Note: Be careful! If you accidentally nick a structure with the bulldozer, the structure will be destroyed.]

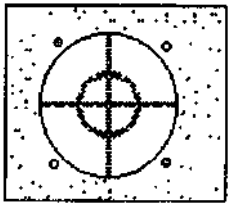
All structures for placement on the lunar terrain are pre-set in a specific aspect, and may not be turned to face another direction. This does not apply to Laboratory modules, which may be turned 90 degrees to attach to other structures. To change the aspect of a Laboratory module, *select* the Laboratory tool *and press* Ctrl-R.

You may notice occasionally that one or more of the tool icons are blocked-out and will not function. This indicates that you do not have sufficient funds to use those tools. To gain access to them, you must sell products using the Sell box in the Markets menu. [Hint: It's recommended that you build a LLOX facility at the start of your simulation to provide products for sale immediately.]

Maintenance



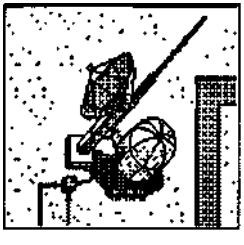
Another way of working towards self-sufficiency is through maintenance. By constructing maintenance facilities at your base your crew can begin fixing parts that break instead of replacing them with new parts from Earth. This will help reduce your hardware resupply costs which are calculated automatically and reported in the annual report box. Remember that this element also controls exploration missions and rovers.



Landing Pads

Landing Pads are needed to allow lunar landers to ferry supplies to and from the base more safely. Although landers can touch down safely under many conditions, lack of landing facilities is the prime reason for lander crashes. Landing Pads do not require any power or thermal connections.

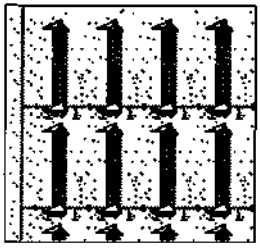
Communications



Although you will have limited communications capabilities with Earth throughout the simulation, a Communications facility will greatly enhance the amount of communications traffic, and therefore information, that reaches your base. The Communications facility requires both power and thermal connections. At the start of each simulation, your ticker tape line (yellow bar) is inactive, showing only a dashed line. This will remain inactive until you place and activate a Communications facility at your base. This element is located in the Support Services tool icon menu.

THERMAL CONTROL

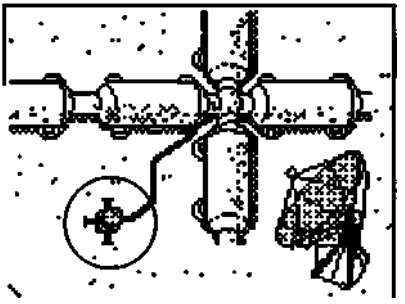
In order for most buildings to be usable, you must provide some sort of Thermal control for them. Since the Moon has no atmosphere, heat cannot be carried away from hot objects by convection (like a breeze cooling you off on a hot day). On the Moon, heat must be removed using conduction (a hot object touching a cold object passes some heat to the cold object) or radiation (the way you feel the heat from the Sun).



Unfortunately, the lunar regolith makes a very poor heat conductor. Therefore, radiation is the primary method used to cool hot substances, and is achieved through the use of a simple Radiator. These are constructed just like the other buildings. In addition, these systems must also be hooked up to the buildings they are meant to cool.

Power and Thermal Control Hook-ups

Most, but not all, base components must be hooked up to both power and thermal control in order to function properly. It's easy to tell which base components need these hook-ups... they all have a connector unit on them with connection indicator lights. Connections are made by attaching power cables and thermal control pipes to these units. Connections are also made through adjacent buildings by the connecting tubes which also contain power and thermal control hook-ups. Connector units on base components that require power and thermal control have green indicator lights to signify a proper thermal control connection and red indicator lights to signify a proper power connection. All power plants are equipped with their own thermal control to radiate their waste heat, so they don't have to be hooked up to thermal control but any base components which use power also require thermal control.



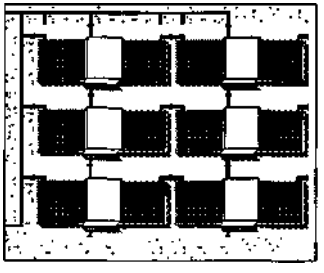
Power and thermal control connector

POWER

Power plants are the second most important type of building to construct. There are 3 types of power plants which can be constructed. The first type, which is also the simplest and cheapest, is the solar power plant (Photovoltaic Array). This power plant consists of solar panels arranged to capture the Sun's energy and convert it to usable electricity. Solar power plants are of course useless during the lunar night so the ones used in Moonbase include batteries to store up power during the day. The second type of power plant is the nuclear Fission Reactor. This type of plant can operate during the night or day, and is more useful

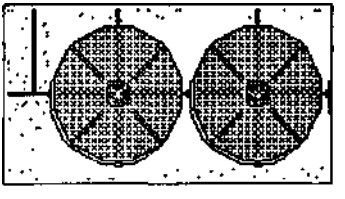
in the long run. The third type of power plant is the nuclear fusion power plant (Fusion Reactor) which is the most efficient of all the plants. When the simulation starts, this type of power plant is not available since nuclear fusion has not been perfected. By building science labs, however, you can increase the chance that nuclear fusion technology will be mastered. *If* this technology is mastered, you will be allowed to construct fusion plants. All of these power plants include their own thermal control systems.

Photovoltaic Array



Photovoltaic Arrays, or solar panels, are the base's primary source of power, and you should always have 2 or 3 on line, if only as backup for other power sources. Photovoltaics are the least expensive sources of power for the base, and should always be used for smaller complexes. As your base grows, you may choose to add more arrays, or switch to another power source.

Fission Reactor



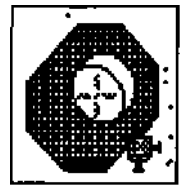
Earth politics aside, Fission Reactors are normally reliable sources of power for your base, and will handle the needs of a much larger complex. They do, however, have the rather nasty, though infrequent, tendency to go critical and melt down. Aside from the loss of power, the resulting explosion will be disastrous to your base, destroying part or all of it. A message box will pop up advising you that your reactor is overheating. The only way to prevent meltdown is to bulldoze the reactor. In order to provide uninterrupted power to the rest of your base, place a new reactor in another location and connect it to your power grid before removing the old one. But you'll have to be quick. If you delay, the reactor will go critical and meltdown will occur within a month.

As a safeguard, place your **Fission Reactor** in one of the largest craters, or as far from your base as possible, connecting it to the complex with additional cable. This will provide your base with a margin of safety by containing the effects of the meltdown and allowing you more time to deal with it. But before you get carried away, check crater locations for ice concentrations. Water is hard enough to find on the Moon without dropping a reactor on the only source. You may *not* rebuilt on a contaminated meltdown site.

Fusion Reactors

Fusion Reactors are the safest, but most expensive sources of lunar power, and also the hardest to get. You cannot build a Fusion Reactor until fusion has been discovered, which may not happen at all no matter

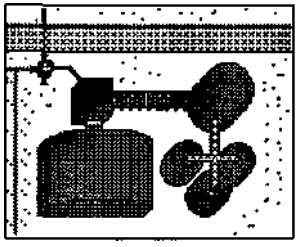
how many labs you build. You do not need to worry about meltdowns, and one Fusion Reactor will supply the power needs of even the largest base. One thing you must keep in mind, however, particularly if you are mining and processing helium-3, is that your Fusion Reactor will automatically deduct its fuel needs from what your mines produce. This may leave you with nothing to sell for profit. If you've got a Fusion Reactor, you'll need additional miners to counter the inventory drain.



MANUFACTURING

Exploitation of the Moon's resources is the surest way of generating revenues to run the base. Manufacturing plants which make use of the Moon's environment and resources and mining activities are by far the most promising. There are five commodities which can be manufactured or mined. They are: Electronics, Materials, Oxygen, Water and Helium-3. The finished products produced on the Moon can be sold as rocket propellant in space or be transported back to Earth to be sold for the cash needed to resupply and run the base.

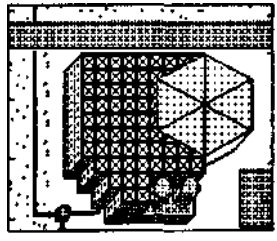
Materials Manufacturing



Since the Moon's gravity is only one sixth that of the Earth's, many products can be manufactured more easily on the Moon. Defects, which are often caused by gravitational distortion, in products such as crystals, semi-conductors, and Pharmaceuticals can nearly be eliminated by producing them on the Moon. Materials processing plants can be constructed to produce crystals for use in solar power systems. These plants require power and thermal control hookups and each can produce up to 500 kg of crystals per month. The Sell option allows you to sell processed materials produced at these plants.

Electronics Manufacturing

Electronics plants can be built to produce semi-conductors formed under low-gravity conditions. Each of these plants can produce up to 1000 units per month for sale to Earth companies. Like all the other commodities lunar electronics can be sold by choosing the Sell option from the drop down menus.

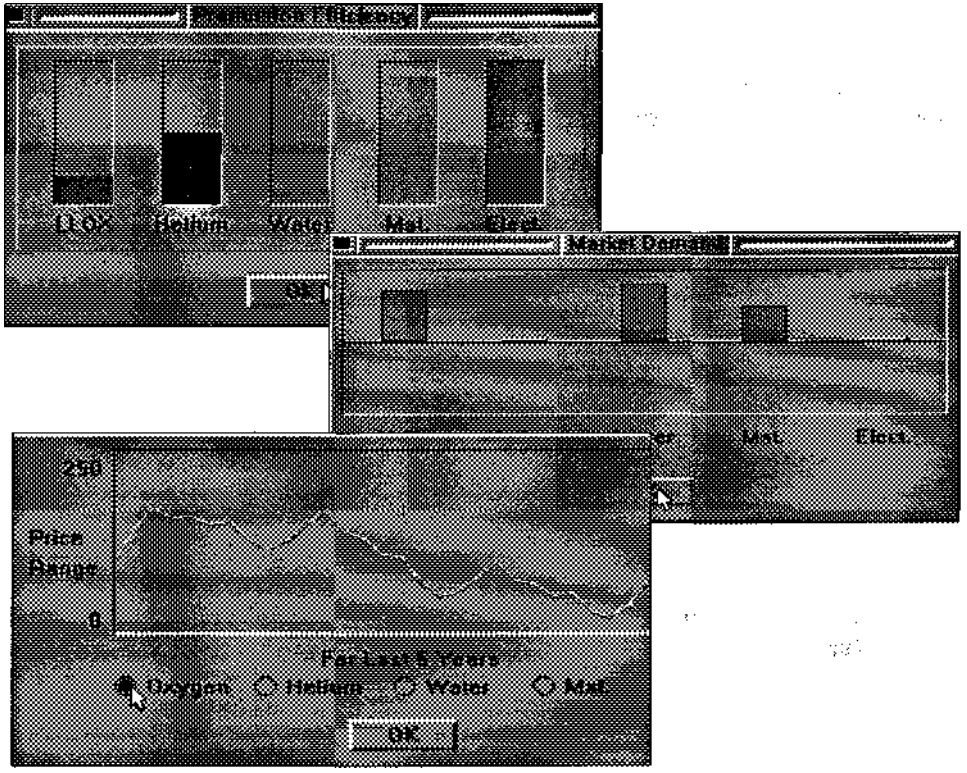


CHAPTER IV

ECONOMICS AND RESUPPLY

Monitoring Manufacturing and Mining Activities

Three graphs are provided which will allow you **to monitor** the status of your base's manufacturing and mining activities. These are the **Marketing Productivity, Demand/Supply, and Selling Price History** graphs. The **Marketing Productivity** graph under the **Operations** menu shows the percentage of the production capability that is being used at present for each of the five manufacturing and mining activities. Obviously it is best to keep productivity as close to 100% as possible. The **Demand/Supply** graph tells you what products and materials are in demand versus the current supply. **Selling Price History** gives you the price range fluctuations over the preceding five years, from which you may **form** a marketing strategy. **Demand/Supply and Selling Price History** are accessed via the **Sell menu.**



Supply and Demand

In the initial stage of the simulation, all of your funding comes from NASA. However, since your goal is to become self-sufficient, you can raise money by trading in any of five commodities that may be found or produced on the Moon. Just invest in a plant that produces one of these commodities, supply it with crew, power, thermal control and resupply, and sell the goods you produce on the open market.

The five commodities sold on the Lunar Commodities Exchange are Oxygen, Water, Helium-3, Electronics, and Materials. Current prices on the Exchange are listed continuously on the yellow Tickertape bar that scrolls across the top of your screen.

Oxygen, which is cheap on Earth but expensive to lift into orbit, is needed for life support and as a primary component in rocket propellant. Rocket traffic between the Earth, Moon, and space stations is high, and the market for oxygen will depend on the number of rocket resupply trips to and from your base. Other space missions will also require oxygen, as will the stations.

Water is also required for life support, but is used primarily for the oxygen and hydrogen that can be released through electrolysis. These are used for rocket propellant, the hydrogen as the fuel and the oxygen as the oxidizer. Water is therefore affected by the same things that affect the oxygen market.

Helium-3 is used in fusion research, and eventually as fuel for fusion reactors. A light isotope of helium, helium-3 is rare on Earth but can be commonly found on the Moon, though not in high concentrations. Large amounts of regolith must be processed to get helium 3 in any quantity. The demand is low at the outset of the simulation, but will rise rapidly if fusion generation is perfected.

Low gravity and extreme conditions allow the production of very high quality electronic components, such as crystals and semi-conductors, which are in strong demand on Earth. Continued research and development will improve the quality, and consequently the market demand.

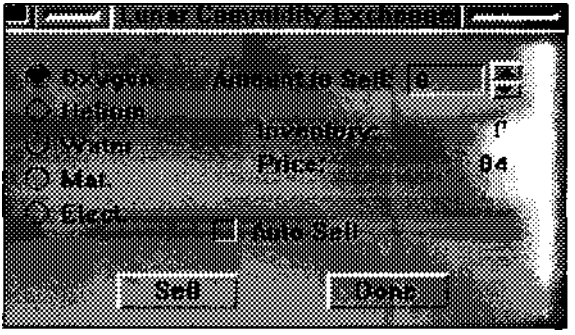
Space stations and exploration missions will be the most likely markets for materials processed on the Moon. It is far cheaper to ship materials from the Moon than it is to lift them from Earth. Solar power cells (photovoltaics) are in demand for stations and ion rockets.

Cash Flow

At the very bottom of the Annual Report box is a figure denoting your cash flow. This number is simply the sum of your income minus the sum of your operating expenses. These expenses do not include any money that was paid for base components such as power plants and habs, but only covers operating expenses. A positive cash flow means that you made more money than you spent. An efficiently operating base will have expenses cut to a minimum, while sale of inventory keeps the profits rolling in.

Working The Economic Boxes

Keep an eye on the amount of cash listed on the Tickertape bar. This amount reflects how much yon have in the bank, and will change according to how much funding is provided by NASA, which in turn will depend on what the economic climate is on Earth. As your simulation progresses, the only way to increase this amount is by selling products to Earth or other space missions. This function is handled by the Sell box in the Markets menu. You may check your inventory in all production areas with the Tab or Arrow keys, or with your mouse. Each category will display total inventory and current market value. With the inventory box highlighted, you may choose to sell some or all of that product. Simply enter the amount(s) you wish to sell, then *select* Sell and *press* Enter. The generated income will automatically be added to your bank balance.

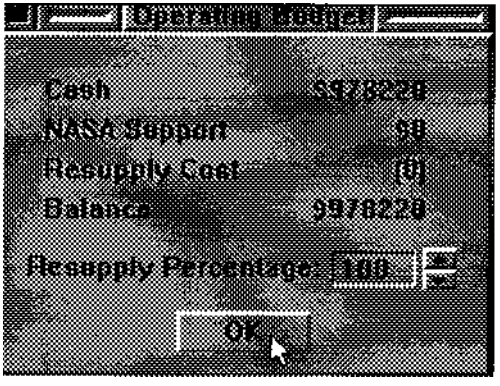


You may also choose to select Auto Sell. This option will automatically sell all of the selected inventory, and will continue to do so until you deselect the option.

Operating Budget

The Operating Budget box pops up automatically at the first of each new year, or may be accessed via the Operations menu at anytime. In the latter case, the information in the box reflects the proposed figures for the next year. You may elect to change your amount of resupply at any time.

This dialog box contains information pertaining to the financial status of your base. Line One - *Cash* - indicates the total amount of cash at your disposal including *NASA Support.* Line Two shows the current amount of that support, and will vary according to economic factors on



Earth. Line Three lists the *Resupply Cost* - always shown in () because it is an expense - which will also change according to economic factors. Resupply includes the necessary oxygen, water, food, and spare parts needed to keep your base running, and represents supplies both from

Earth and from lunar-produced materials. *Balance* is *Cash* plus *NASA Support* minus *Resupply Cost.* This number also appears on the right end of the Tickertape

bar at the top of your screen. You may elect to accept 100% resupply, or you may prefer to set your own *Resupply Percentage* in the box. The cash amount of the selected resupply percentage will be deducted from your *Cash,* and will be reflected on the Tickertape bar.

Example:	Cash	$100000
	NASA Support	$ 5000
	Resupply Cost	($25000)
	Balance	$ 80000

At 100% resupply, *Resupply Cost* ($25000) is deducted from the total of *Cash* ($100000) plus *NASA Support* ($5000) for a *Balance* of $80000. The figure shown on your Tickertape bar is the *Balance.*

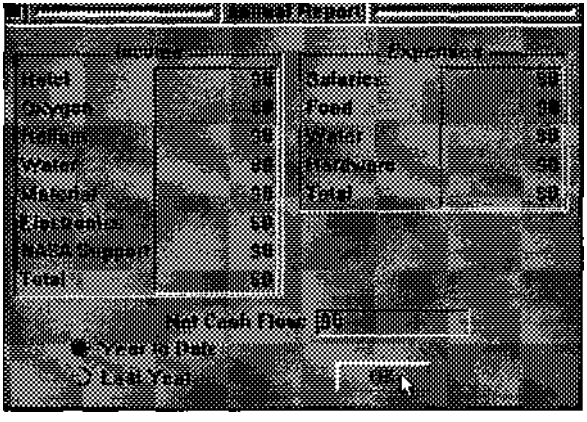
NASA Support will be shown in the Operating Budget only when the box appears at the start of each new year. As it represents a yearly figure, it is added in only once, and will appear as $0 whenever you access the Budget from the Operations menu.

If you *Resupply Cost* is listed as $0, your productivity levels will also be zero. This indicates that your base is understaffed, or that the mining and processing crews are unhappy about some elements) of the living conditions. To increase your productivity and inventory of products for sale, you must find a way to solve the problem by satisfying their requests.

Resupply Percentage will be suggested each year by the simulation, and the cost of resupply at that level will be shown on the *Resupply Cost* line. This figure will never be greater than the amount of cash available to your base, and will be adjustable only to a lower percentage (and therefore a lower cost). This will be useful in the event that you have little or no inventory to sell at that time. However, as your inventory grows, the *Resupply Percentage* (and cost) will also increase. The higher the level you select for resupply, the happier your crew will be and productivity will increase accordingly.

Annual Report

The Annual Report Box maybe accessed from the Operations menu at any time, and is used to check current and previous financial figures. You may toggle between *Year to Date* and *Last Year* figures to compare income and expenses.



Figures listed in the *Income* column provide a breakdown by product or service category, and will change automatically to reflect increased or decreased productivity. A zero balance in any category may simply mean that you have not begun operations in that area, but it may also

mean that your crews are dissatisfied and that production is falling off because of it. The *Expenses* column lists a dollar breakdown *of Salaries,* and what you are paying for resupply *of Food, Water* and *Hardware*.

Income minus Expenses equals your Net Cash Flow. If this figure is negative, then your *Expenses* are still higher than the *Income* your base is generating, and you need to increase your productivity. A positive *Net Cash Flow* indicates that you are making a profit, so the higher the better.

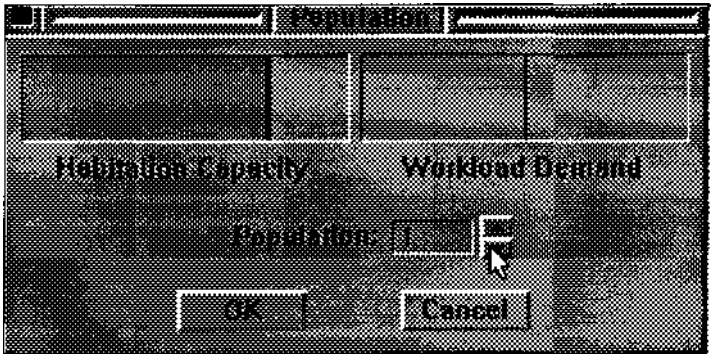
Reaching Self-Sufficiency

Since the entire point to this simulation is to become totally independent of Earth support, you must start generating a profit as quickly as possible. **Lunar Command** gives you an unlimited time frame in which to accomplish self-sufficiency, as well as all the tools and economic factors to do it. Remember that in real life self-sufficiency is not a permanent condition, so for the purposes of this simulation you may consider yourself to be self-sufficient when you have generated a profit with zero NASA support for five or more years. This means that each year a 100% resupply leaves you with cash left over and productivity levels sufficient to maintain the base and its standard of living.

Other Operations Menu Options

Population

You may check your current population **Percent of Capacity** and **Demand** vs. **Population** with this option. Under **Percent** of **Capacity,** green indicates the current population, and red indicates any over population. On the **Demand** vs. **Population** graph, you'll see the crew requirements as opposed to availability. By *clicking* on the **arrows,** you can increase or decrease your population to meet your base's needs. You may also *highlight* the Population **number** and *type* in a **change.** Both graphs will change automatically, and it's usually best to balance them equally on each graph's dividing line.



CHAPTER V

PLAYING TIPS & OTHER STUFF

Productivity -- Raising It and Keeping It There

For each module or facility placed, you must take into account crew, housing, power and thermal requirements. Each additional unit placed in support of the original also has these requirements. The key to creating and maintaining productivity is in balancing all of these factors.

> *Example:* One SSCM can house 16 people, but requires one crew member and 20kWe of power. One Radiator rejects 5000 kWe of heat, and is sufficient to cool a single SSCM (and a lot more). One Photovoltaic array produces 400 kWe, so again one is all that's needed. However, each of these units requires one crew member to operate properly, making a total crew requirement of three for this initial base, which leaves you with housing capacity for 13 more. The more modules and facilities you add, the more crew, housing, power and thermal are required.

When you're selling inventory, it's always a good idea to first check market demand and history. This allows you to sell at the highest price and the most favorable times. And watch the messages that pop up from time to time — they *will* affect your markets.

What To Do When the Bottom Drops Out

If your across-the-board productivity drops to zero, the most likely cause is failure to Resupply at the beginning of the year. If this is the case, you may perform a mid-year resupply via the Operating Budget box under Operations, but it *will* affect your cash balance in the same manner as new-year resupply. So make sure you've got something to sell from inventory. If not, simply wait until January and then resupply as usual (you can speed things up by toggling the Speed option under Setup).

If neither of these helps, check to see if your production facilities are top-heavy in hardware, or below suggested staffing requirements.

When to Resupply and How Much

Always resupply at the beginning of a new year when the Resupply box pops up. Early in each new scenario, you should accept the recommended Resupply Percentage. Keep an eye on the dollar amounts involved, especially NASA Support and Cost of Resupply. You'll gain money at first, but the amount of NASA Support will begin to drop as your base grows, and will be affected by events on Earth. This can be offset to some extent by building Maintenance facilities, but these alone can't supply all of the spare parts needed to keep the base going.

How to Handle an Emergency

Fission Reactor meltdowns will be disastrous. A message box will pop up advising you that your reactor is overheating. The only way to prevent meltdown is to bulldoze the reactor. In order to provide uninterrupted power to the rest of your base, however, place a new reactor in another location and connect it to your power grid before removing the old one. But you'll have to be quick. If you delay, the reactor will go critical and meltdown will occur within a month.

As a safeguard, you might place your Fission Reactor in one of the largest craters. This will provide your base with a margin of safety by containing some of the effects of the meltdown and allowing you more time to deal with it. This doesn't always save your base, so it's probably best to place your reactor as far from the base as possible in the first place.

Another emergency situation that may arise is an explosion in your LLOX Plant, usually attributed to sabotage. Locate the plant site, and simply build a new one. But keep in mind that the loss of the original plant will result in the total loss of LLOX productivity until the new plant is built. If you elect not to rebuild, you'll need to change crew and housing figures, as well.

Solar flares can be sneaky. If you don't have an Astronomy or Communications facility in place, you won't get any advance warning. Although a flare will have little effect on the physical part of the base, it can be disastrous to unprotected personnel. With warning, your personnel will automatically seek shelter.

Landers can crash anywhere and anytime (see Flying The Lander), and will cost you $10,000 when they do, provided they don't hit anything else. If they go down away from the base, you're only out the cost of replacement - which is automatic. But they might crash into a structure, resulting in the loss of personnel and facilities, and a corresponding drop in productivity. Building Landing **Pads** will make lander operations safer, reducing the chances of a crash. It's also a good idea to build the pads so that the Lander's flight path doesn't cross over elements of your base.

Rogue Miners

Every once in awhile, a miner may go Rogue if conditions aren't perfectly to his liking (overworked, not enough fresh food, etc.). This applies to both LLOX and He-3 miners. Whenever this happens, they lose all normal restraints and may destroy any base elements that they happen to run into. You'll be notified via tickertape message, sound, or both, and you must seek out the offending miner and destroy it before it takes out a portion of your base. Then, you must take steps to rectify the conditions that created the problem.

Destruction caused by Rogue miners will cost you in both money and points.

"Negotiating" a Strike

If you don't keep your miners happy, they'll start complaining ... and a miner strike can ruin everything. Placing a Greenhouse and a Recreation Center at your base to provide the crew with fresh food and something to do when they aren't working. Make sure you check the crew, housing, power and thermal requirements for each module, and increase them as needed. You *must* balance these factors each time you enlarge your base, or productivity will start to slip.

Tourism - When and Where to Build Hotels

Tourism may become a necessary evil at an otherwise scientific base, and at some point, you may decide to start up a tourist trade. Placing a Hotel works the same way as any other structure, and requires attention to crew, power and thermal control. You can place a Hotel anywhere on the playing grid, but it is probably best to select a site close to some interesting selenographic feature — a cluster of craters, for instance. This placement will not affect your tourist income, but this income •*will* rise if you locate one or more of the special "features" while you're exploring the lunar surface.

Hotels, like Mines, do not need to be placed close to your base. A single Photovoltaic Array and Radiator are sufficient to run the facility, which eliminates the need for proximity to the base. Nor is it necessary to place a Landing Pad in the vicinity of the Hotel. It may, however, be detrimental to your tourism operations if you place your Hotel close to mines, processing plants and power facilities, if only from an aesthetic point of view.

Flying The Lander

When you begin a new scenario, use the Settings box (FILE Settings...) to determine whether the landers will be handled automatically by the computer or manually by you, the player. Either way, landers will not start entering your base environs until you have constructed at least one landing pad. You may control the lander using either the keyboard or a joystick.

On the keyboard, Arrow keys control the X and Y position of the lander in relation to the lunar surface, while the Enter key provides vertical thrust to control the ascent/descent rate.

With a joystick, X and Y control is handled by the yoke, and vertical thrust by the Fire button.

In the manual control mode, the object is to land your lander on the assigned landing zone in the shortest time possible, using the least amount of fuel. Failure to land under manual control will result in loss of points, and possibly a lander crash as well.

Extended Exploration Missions

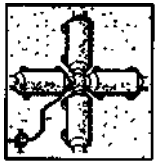
In previous versions of Moonbase, the Exploration tool immediately informed you of what was available on the site where it was placed. Likewise, if there happened to be a special "find" at that site it would appear instantly with information as to its identity. In Lunar Command, percentages of usable elements in the lunar regolith will still popup whenever you place a flag. However, if your exploration locates something more interesting, you must dispatch rovers to the selected site. You will then be notified via tickertape message or sound, and points may be assigned according to what has been found.

Since Exploration Rovers originate from Maintenance facilities, you must construct one before beginning your exploration of the lunar surface. The rovers will travel out to the exploration flags, then return to the Maintenance facility.

CHAPTER VI

BASE ELEMENTS QUICK REFERENCE

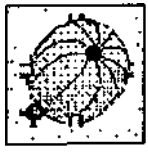
The following section describes the major components that you can use to build your base and provides some technical details.



Habitation Facilities

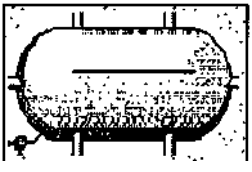
Hab Module: This is the primary habitation module designed for use on SSF or lunar base. The habitation module is a complex of four Space Station Common Modules connected by a node. The quarters provided by the basic hab are relatively cramped and uncomfortable.

Resupply Needs:	400 kg/month
Power Needed:	20kWe
Man Power:	1
Crew Capacity:	16 crew members



Inflatable Habitat: Inflatable medium-sized habitation module which provides more comfortable crew accommodations than the basic hab.

Resupply Needs:	1600 kg/month
Power Needed:	80kWe
Man Power:	2
Crew Capacity:	50 crew members



Advanced Habitat: Largest habitation module available, provides the most comfortable crew quarters as well as extensive common areas which help crew morale.

Resupply Needs:	4800 kg/month
Power Needed:	400 kWe
Man Power:	7
Crew Capacity:	150 crew members

Recreation Habitat: Habitation module designed for recreational facilities these are needed to help keep the crew's morale high.

Resupply Needs:	200 kg/month
Power Needed:	80 kWe
Man Power:	3

Hotel: Hotel for tourists visiting the Moon. Tourists from Earth are interested in visiting interesting surface features on the moon and historic sites.

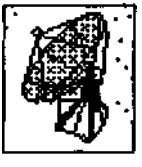
Resupply Needs:	2500 kg/month
Power Needed:	200 kWe
Man Power	10
Tourist capacity.	20 tourists

Science Facilities

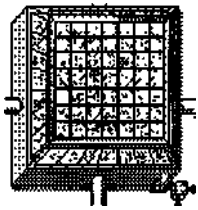
Science Lab: Module dedicated to scientific research and experimentation. Research carried out in the Moonbase Science Labs can lead to discoveries in nuclear fusion as well as processes to produce improved electronics in the Moonbase Electronics Plants and improved solar power cells in the Moonbase Materials Plants.

Resupply Needs:	300 kg/month
Power Needed:	30 kWe
Man Power:	4

Astronomy: Module designed to house astronomy equipment and crew. The astronomy facilities are self-contained and do not require power and thermal control.



Resupply Needs:	10 kg/month
Power Needed:	0 kWe
Man Power:	3

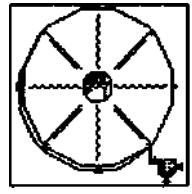


Greenhouse: Greenhouses are facilities for growing food which can help reduce the annual resupply costs and help make the base self-sufficient.

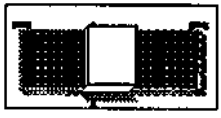
Resupply Needs:	2500 kg/mo
Power Needed:	200 kWe
Man Power:	8
Production Rate:	5000 kg of food/month

Power Generation Facilities

Nuclear power plant: Power plant that uses nuclear fission reactions to generate power.



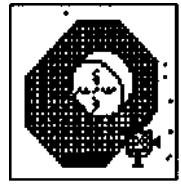
Resupply Needs:	100 kg/month
Power Needed:	0 kWe
Man Power:	4
Output Power:	1500 kWe



Solar: Power system that converts solar energy to electrical power.

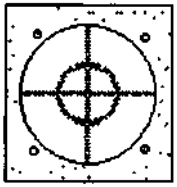
Resupply Needs:	10 kg/month
Power Needed:	0 kWe
Man Power:	1
Output Power:	400 kWe

Fusion: Nuclear power plant using fusion reactions to generate power. This is a cleaner, safer way to generate power than nuclear fission.



Resupply Needs:	100 kg/month
Power Needed:	0 kWe
Man Power:	25
Output Power:	10000 kWe

Maintenance and Operations Facilities

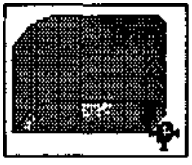


Landing Pad: Landing pad for lunar landers. Landing pads make it safer for lander operations and reduce the odds of landers crashing. As your base grows large the number of lander flights increases so the need for landing pads grows.

Resupply Needs:	100 kg/month
Power Needed:	0 kWe
Man Power:	2

Communication: Communication equipment for contacting Earth.

Resupply Needs:	1 kg/month
Power Needed:	5 kWe
Man Power:	2



Maintenance: Maintenance/repair facilities for base hardware. Building maintenance facilities helps to reduce the annual hardware resupply costs.

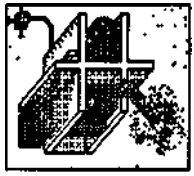
Resupply Needs:	500 kg/month
Power Needed:	100 kWe
Man Power:	4

Mining and Manufacturing Facilities

Water Processing Plant: Water mining/processing facility. Water Processing Plants must be placed at a site that contains water. Water can be located by explorations.

Resupply Needs:	80 kg/month
Power Needed:	800 kWe
Man Power:	35
Production Rate:	50 MT/month

LLOX Processing Plant: Lunar-derived Liquid OXygen production plant. LLOX plants extract oxygen by a reduction process from lunar regolith. Each facility requires a Mobil Oxygen Miner to supply it with raw material.

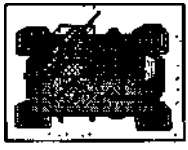


Resupply Needs:	70 kg/month
Power Needed:	300 kWe
Man Power:	16
Production Rate:	150 MT/month

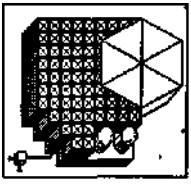
Mobile Oxygen Miner: The Mobile Oxygen Miner digs up Regolith and transports it to the Oxygen Processing Plant. Three Miners are needed to supply each LLOX Processing Plant.

Resupply Needs:	10 kg/month
Power Needed:	50 kWe
Man Power;	16
Mining Rate:	45000 MT of regolith/month

Helium-3 Processing Plant: Helium-3 mining/processing facility. This is a mobile miner and processor. Helium-3 is available in such small quantities that the volume of Regolith that must be processed is extremely large.



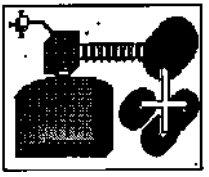
Resupply Needs:	100 kg/month
Power Needed:	200 kWe
Man Power:	20
Production Rate:	3 kg/month



Electronics Manufacturing Plant: Plant for producing electronic components from lunar materials. Electronics produced on the Moon have to compete with those produced at the space stations and at other lunar bases.

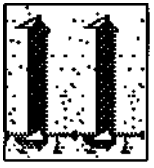
Resupply Needs:	5000 kg/month
Power Needed:	1000 kWe
Man Power:	80
Unit Production:	1000 units/month

Materials Processing Plant: Plant for producing solar cells from lunar materials.



Resupply Needs:	1000 kg/month
Power Needed:	200 kWe
Man Power:	40
Production Rate:	500 solar cells/month

Thermal Control Facilities



Radiator: The radiators are the primary component of the base thermal control system. A heat exchange fluid is circulated through the buildings on the base and then piped to the radiators where the heat is exchanged and radiated into space.

Resupply Needs:	10 kg/month
Power Needed:	0 kWe
Man Power:	1
Heat Rejected:	5000 kWe

Glossary

AI - Artificial Intelligence - computer systems designed to imitate intelligent behavior such as understanding languages, solving problems, and learning; also used in reference to certain elected officials

ALS - Advanced Launch System - launch vehicle being designed by the Air Force to carry 50 metric ton payloads to LEO

Alien Ruins - anything's possible; could boost your lunar tourism industry

Apollo - U.S. manned Lunar missions flown in the late 1960's and early 1970's; led to first Lunar landings

Base - a permanently occupied set of buildings or shelters that provide life support and work facilities

Biosphere - a closed-ecology system in which biological systems provide mutual support and recycling of water, air, and food; works best when it doesn't have a back door

CELSS - Closed-Ecology Life Support System - a mechanical or biological system that recycles the water, air, and food needed to support a human crew on a spacecraft, space station, or lunar base

Crater - deep depressions formed by meteor impacts

Dilithium Crystals - a crystaline power source used on Star Fleet Command vessels, but of no useful purpose in Lunar Command

ECLSS - Environmental Control and Life Support Systems - mechanical system that maintains climate, oxygen levels, and usable water levels for life suppor

ELV - Expendable Launch Vehicle - a non-reusable rocket

ESA - European Space Agency

EVA - Extra-Vehicular Activity - a spacewalk

Elvis - Hey, he's been sighted everywhere else; why not here?

Far Side - the side of the Moon which does not face the Earth; also a comic strip of the late 20th century

G Force - the unit offeree equal to the force exerted by gravity on a resting body; Earth gravity is measured as 1 G, while lunar gravity is 1/6 G, or one sixth of Earth gravity

Gamma Rays - electromagnetic radiation emitted by radioactive decay, more deadly than X-rays

GEO - Geostationary Earth Orbit - a circular orbit (altitude of about 22300 miles above the Earth's surface and inclination near 0 degrees) in which an object moves around the planet at the same rate as the Earth rotates, thus making it appear stationary with respect to points on the planet's surface

Green Monkeys - Hallucination brought on by oxygen deprivation. Just inhale deeply and stop worrying about them.

GTO - Geosynchronous Transfer Orbit - orbit designed to take a satellite from LEO to GEO; a last sports car popular among teenagers in the 1960s and 70s

Heat Pipes - sealed pipes filled with a fluid that can be vaporized and later condensed to carry heat away from vital hardware

Heliosphere - region of space in which the effects of the Sun's solar wind and interplanetary magnetic field can be felt

HeIium-3 - helium compound used as a safer fuel for fusion reactors; found in the Lunar regolith

HLLV - Heavy Lift Launch Vehicle - launch vehicle designed to carry 100 metric tons to LEO

IUS - Inertial Upper Stage - upper rocket stage designed to propel payloads from LEO to higher orbits

JPL - Jet Propulsion Laboratories - a division of NASA, located at the California Institute of Technology; primary mission is the unmanned exploration of the solar system

LEM - Lunar Excursion Module - name for the landing vehicles with ascent stages used in the Apollo missions

LEO - Low Earth Orbit - Earth orbit with a maximum altitude of about 1000 kilometers; born between July 23 and August 22

Libration Points - points in space at which the gravitational forces of attracting bodies balance, allowing an object to remain at the point if placed there with the correct velocity (also called Lagrange points)

LLOX - Lunar-derived Liquid OXygen; goes great with onion bagels

Luna Probes - series of Moon reconnaissance probes launched by the U.S.S.R. between 1959 and 1976

Lunar Day - amount of time it takes for the Moon to rotate once with respect to the Sun; 27.3 Earth days

MTV - Mars Transfer Vehicle - proposed vehicle for transfer of cargo or personnel from main Mars vehicle to Martian surface; a great place to watch music videos

Mass-Driver - an electromagnetic accelerating device used to propel material into orbit from a planet's (or moon's) surface; a Catholic Priest

Microgravity - extremely low level of gravity (near zero-g)

Mir - third-generation Soviet space station

MT- metric ton (1000 kg)

Moon - any large, natural satellite orbiting a planetary body; a favorite fraternity activity, often performed in moving vehicles

NASA - National Aeronautics and Space Administration

NASDA - Japanese space agency

OMV - Orbital Maneuvering Vehicle - a spacecraft designed to move other spacecraft in orbit and handle refueling operations

OTV - Orbital Transfer Vehicle - a space "tug" used for cargo or personnel transfer in Earth orbit

Outpost - an initial shelter erected on a planet's surface to provide temporary shelter for a crew

PAM - Payload Assist Module - small upper stage rocket used to boost satellites from LEO to higher orbits; a spray-on lubricant used in cooking

Ranger Probes - series of U.S. photo-reconaissance probes sent to the Moon in the early 1960's

Regolith - mixture of soil and rock fragments found on the surface of the Moon

SEI- Space Exploration Initiative - plan proposed by President Bush to establish a manned space station, a manned lunar base, and a manned mission to Mars

Spaceport - orbiting transportation center that provides facilities for transferring crew between spacecraft and provides repair and refueling services for spacecraft

Specific Impulse - a measure of engine performance calculated by dividing the engine's thrust by the product of the fuel mass flow rate and the gravitational acceleration constant

SSCM - Space Station Common Module - habitation module designed for use on the Space Station Freedom; can be used as a habitation module on the Moon

SSF - Space Station Freedom - the amazing shrinking U.S. space station to be launched in the mid-1990's

Shuttle - reusable orbiting vehicle which is launched with the help of two solid rocket boosters and a main fuel tank that feeds fuel to the orbiter's engines; also known as the STS - Space Transportation System

Space Clipper - one of several privately-funded, reusable options to the shuttle

Surveyor Probes - early U.S. lunar probes launched in the mid-1960's to analyze possible landing sites for the Apollo missions; performed soil analysis

TDA - Touchdown Attitude - the final positioning of the lunar landing vehicle immediately prior to touchdown on the lunar surface; a ritual display in the End Zone

TMIS - Trans-Mars Injection Vehicle - reusable propulsion vehicle used to place the main Mars vehicle in the proper trajectory for the transit from Earth to Mars orbit

Tele-operated - a system, such as a drill or cargo arm, that can be remotely operated

Index