

# L.E.M Simulator 1.0f

i

We choose to go the moon in this decade and do the other things, not because they are easy but because they are hard.

J.F.Kennedy



## Contents

- I- Introduction
- II- Controls/instruments
- III- Quick Start Guide
- IV- Game Levels and Missions
- V- The Apollo Lunar Landing
- VI- LEM Sim Sub-Systems Description
- VII- Frequently Asked Questions
- VIII- Registration and Support Information

## **I- Introduction**

### **Lunar Excursion Module Simulator**

Welcome to the LEM Simulator, the most advanced lunar lander simulator for Palm/Treo devices!

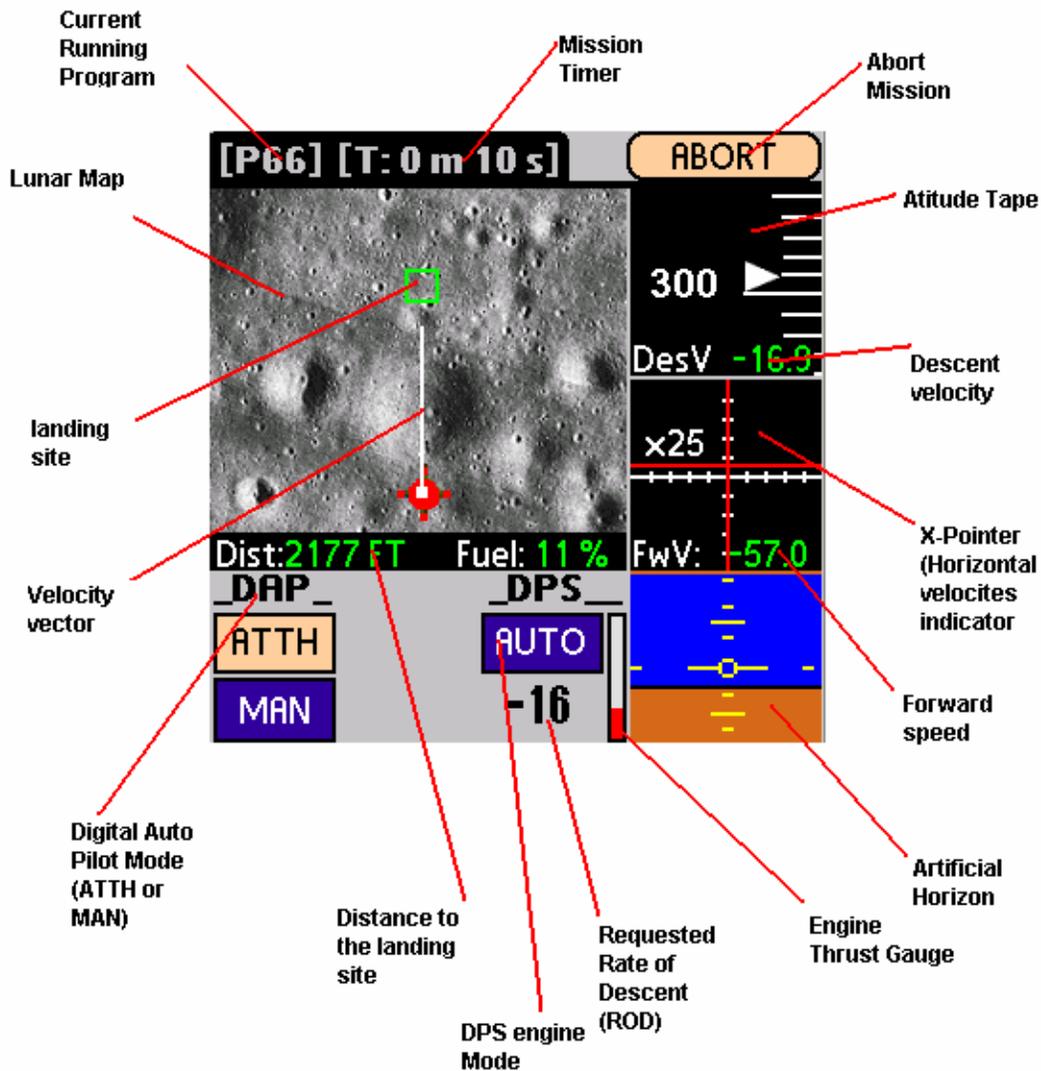
Unlike older versions of lunar lander game, this is NOT an arcade game. Extensive research has been employed to provide you with the most realistic simulation of a moon landing on PDA. As with other sophisticated flight simulators the challenge will be in perfecting your skill. Remember, astronauts didn't learn to land on the moon in a day and neither can you.

We hope this user manual will help you make the most of your gaming experience.

## II- LEM controls/instruments description

Before you can attempt your first landing, let's review your LEM Sim controls and instruments. If you need more detailed descriptions of the lander controls/instruments, please see section VI of this guide.

Here the LEM cockpit display:



## LEM Sim instruments and indicators

### 1) **Current running computer program**

- a. **P64:** is one of the on-board computer (DAP) program. "P64" will be displayed on top left of the screen during the approach phase to the moon. P64 starts at about 8000 feet. During P64, the on-board computer controls the rate of descent
- b. **P66:** is the DAP program used during the final landing phase (below 500 feet). The computer basically gives up control of the rate of descent but keeps the direct control of the engine thrust.

2) **Event Timer:** Shows time from start of the mission.

3) **Altitude Tape:** Display your current altitude.

4) **Descent Velocity:** or DesV, shows how fast the LEM is dropping toward the moon surface. Negative number means you are going down; positive number you are going up.

5) **X-Pointer:** Displays your horizontal velocities. The red horizontal line shows your forward speed. Your forward speed is also displayed at the bottom of the X-Pointer indicator (FwV). A negative value means you are traveling forward toward the landing site. The vertical red line shows your lateral (left/right) velocity.

6) **Artificial Horizon:** Shows the LEM current attitude angles (pitch/roll)

7) **Engine Thrust Gauge:** Displays current engine thrust (0-100%).

8) **DPS:** Stands for Descent Propulsion System. Essentially the main descent rocket engine. The DPS mode is normally set to AUTO during the all flight.

9) **Digital AutoPilot :** Or DAP is the LEM on-board computer. You can toggle between two DAP modes:

- i. **ATTH – (or Attitude Hold)** In this mode, the pilot controls the attitude (pitch/roll) and the computer controls the rate of descent (DesV). This is the normal mode during the approach phase or P64.

- ii. MAN - Pilot controls both the lander attitude and rate of descent. This is the normal mode during the final landing phase or P66.

10) **Digital Map:** Shows the LEM position on moon surface. The red circle with 4 feet represents the lander and the white line coming out of it represents your velocity vector (basically where the LEM is heading). The end of the white line represents where you will be in the next 30 seconds if you keep the same horizontal velocities. The landing site is somewhere inside the grey box on the moon picture. This landing site (represented by a green box) will be shown to you only when you are less than 10000 feet distance from the landing area.

11) **Master Alarm:** This button appears to alert you to a LEM malfunction. The sound can be turned off by pressing this button once (the malfunction will continue of course)

## **LEM Sim main engine and thrusters controls**

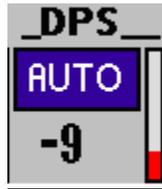
### **Thrusters controls (RCS):**

RCS stands for Reaction Control System and it is basically your attitude thrusters. You control your lander attitude (pitch and roll) using Palm/Treo 5-ways navigator pad as a joystick.



Note: If your device does not have a 5-ways navigator pad then use the UP/DOWN buttons to pitch up/down your lander. Then use Hard Key 2-3 to roll left/right. Hard Key 2-3 are usually located on both side of the center UP/DOWN buttons.

### **Main Engine controls (DPS):**



The lander engine thrust (or rate of descent) is controlled by the Hard Key 1 and 4. Hard Key 1-4 actions will depend on the DPS engine mode.

#### **If DPS mode is set to AUTO (normal mode):**

Then you are requesting a rate of descent (ROD) change.

Hard key 1: Increases your descent velocity by 1 feet/sec (you drop faster)

Hard key 4: Slows your descent velocity by 1 feet/sec (you slow down)

#### **If DPS mode is set to MAN:**

Then you are requesting an engine thrust change.

Hard key 1: Reduce your engine thrust by 3%

Hard key 4: Increases your engine thrust by 3%

Unfortunately hard keys location is devices depended. Usually hard key 1 is located on the bottom left side of the device and hard key 4 on the right of the device. For instance:

Palm TREO 650:

Hard key 1= Red ON/OFF button

Hard Key 4= Phone dial green button

Palm Tungsten C:

Hard Key1= Calendar button

Hard key 4= Web button

Palm LifeDrive:

Hard key 1= Home button

Hard Key 4= Files button

**Requested ROD:** requested Rate of Descent. If you are below 500 feet altitude (P66 phase) or if you switch the DAP to manual mode, a number indicating the current requested descent rate will appear under the DPS mode button. For instance the “-9” in the figure below means you are requesting a rate of descent of -9 feet/sec. You can adjust that number by pressing on the hard key 1 or hard key 4.



Please note that the requested rate of descent (ROD) is different from the displayed DesV which is the actual lander current descent rate. The computer will try to match those two numbers by automatically adjusting the engine thrust for you.

If there is a malfunction of the DAP then the DPS will be switch to MAN(manual). In that case you will have no other solution but to control the main engine DIRECTLY (also with hard keys 1-4). Be aware that in this mode, the lander is very difficult to fly and so you will get extra bonus points for that.

### III- Quick Start Guide

Now that you familiarized yourself with your lander controls and instruments, it is time to take the LEM for a ride!

The goal of the game is to:

- land on the surface of the moon as softly as possible,
- as close to the landing site as possible
- with the LEM upright, and
- with as much fuel as possible in the tank.

1- Launch the application which will bring the following main screen:



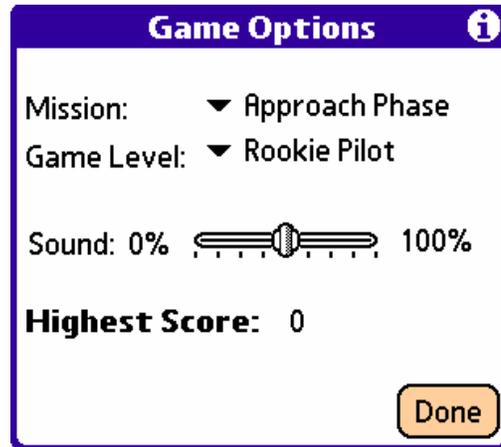
**Note:** You can access a much shorter version of this user manual directly on your Palm by tapping on the **i** icon on the top right of the main screen.

#### Here are your starting conditions

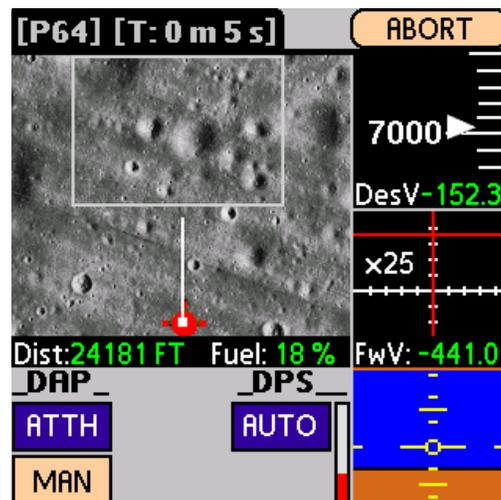
The default mission is the “Approach Phase”. You can change LEM Sim game options like mission type, game and sound levels by using the drop down menu on the main screen. The game starts with the following initial conditions:

- game level: Rookie Pilot
- Sound Level: 50%
- Altitude: 8,000 ft
- Rate of descent: -160 ft/s
- Forward velocity: - 470 ft/s

- Lateral velocity: 0 ft/s
- DAP mode = ATTH
- Program running : P64 (approach phase)
- DPS engine mode= AUTO
- Fuel level: 18%



2- Press the “GO!” button



- 3- The LEM cockpit above will be displayed and you will hear CapCom ( the **Capsule Communication** officer in Houston) say “**You are go for landing, over**”
- 4- At any time during the descent, you can abort the mission and come back to the main screen by pressing the **ABORT** button on the top right of the screen. You have to abort the mission before you can exit the application.

- 5- The DAP mode will be “ATTH” which means that the computer controls your descent rate following its own internal program. You do not have to worry about your rate of descent at this time.



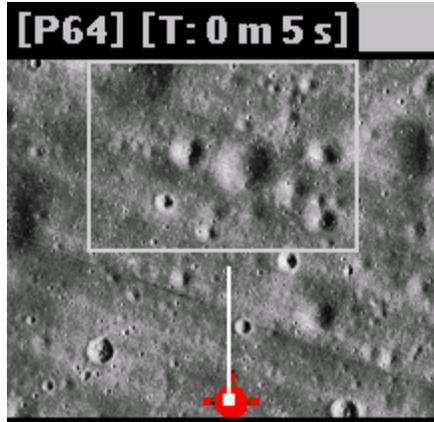
**Digital AutoPilot (DAP)**

- 6- Your job is to reduce your forward speed to about -80 feet/sec when you reach 500 feet altitude. To change your forward velocity, you will need to pitch your lander up or down. You do this by using the 5-ways rocker on your device. Pitching up will reduce your forward speed, pitching down will increase it. Each click on the pad will change the lander attitude about 5 degrees. During this the P64 phase, the LEM computer will limit your pitch and roll angles to +/- 45 degrees (+/- 30 degrees during P66). Use the X-pointer instrument to judge your forward (and lateral) velocities. Since your initial lateral velocity is zero, there is no need to worry about lander roll angle at this time (a different story when in Pilot or Commander game level modes!).



**X-pointer**

- 7- Try to reach 500 ft with a forward velocity  $FwV = -80$  ft/sec. DO NOT reduce your forward velocity to -80 ft/s too fast or you will take too long to make it to the landing site risking a crash for lack of fuel. Use your initial forward velocity (-450 ft/s) to your advantage and adjust your pitch to arrive at 500 feet with a velocity of about -80 ft/s.
- 8- Aim for the outlined gray box shown below. Your landing site will only be visible (green box) once you are less than 10,000 feet from the site.



- 9- At any time during the flight, you can access your flight plan by tapping your finger on the moon picture (tap again to turn off). The flight plan shows you a realistic descent and forward velocities for specific altitudes. Apollo astronauts used a similar table to judge whether or not they were following the nominal descent trajectory. You can leave the table displayed during the all flight if you wish.

| Alt  | DesV | fwV | Dist  |
|------|------|-----|-------|
| 7000 | 151  | 440 | 24000 |
| 6000 | 134  | 410 | 21000 |
| 5000 | 113  | 380 | 19000 |
| 4000 | 93   | 340 | 16000 |
| 3000 | 71   | 300 | 12000 |
| 2000 | 48   | 250 | 9000  |
| 1000 | 27   | 150 | 4000  |
| 500  | 17   | 80  | 2000  |
| 400  | 14   | 67  | 1800  |
| 300  | 12   | 50  | 1000  |

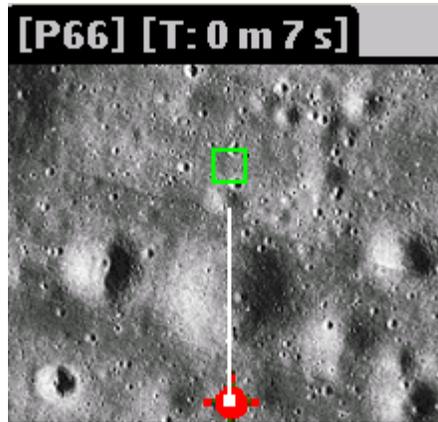
- 10-Once you reach 500 feet altitude CapCom will announce that the computer has automatically switched to mode “P66” which is the final landing phase. Once in P66, the DAP computer mode is switched automatically to MAN (manual) . You are now responsible for both rate of descent and forward velocity!



**AT THIS POINT YOU WILL NEED TO SLOW YOUR RATE OF DESCENT!**

The current requested Rate of Descent (ROD) will be displayed under the DPS mode. You may adjust your rate of descent by pressing Hard Key 1 and Hard Key 4.. Hard key 4 slows your descent velocity by 1 feet/sec and Hard key 1 Increases your descent velocity by 1 feet/sec.

11-The digital moon map will zoom in to show a closer view of the landing site (green box).



12- Again you can adjust your rate of descent during P66 anyway you want but your chance of landing softly will greatly depend on how much fuel you have left (critical while in Pilot or Commander game level). If you have plenty, you can afford to go down slowly most of the way. If on the other end the fuel is short then you better increase your rate of descent to conserve fuel and only at the last minute slow your lander rate of descent.

13-You can land anywhere but of course the closer your are to the planned landing site indicated by the green box the better. If you land more than 3,000 feet from the landing site (see your radar distance indicator on the bottom left of the moon map **Dist:2813 FT** ) then you will not receive points for accuracy. If you do not crash, you will still get points for touchdown velocities, fuel left and so on. Just not for accuracy. Of course it is better to land far away from the landing site than to crash. So if you do not have enough fuel to reach the landing site then by all means just land where you can. Also watch your attitude (pitch/roll angles) at touchdown.

14-When your altitude is below 6 feet, the contact light will turn on indicating that you are very close to the surface and you will hear CapCom say “**contact light!**” The engine will automatically shut off once your are below 1 feet from the moon surface. That’s will be the end of your mission.

15- At touchdown, You will make a successful landing if:

- all your velocities are below **+/- 10 feet/sec**
- and your attitude (pitch/roll angles) are below **+/- 15 degrees**

Anything else will be considered a fatal crash. Of course the softer you land the higher your score will be.

16- If you successfully landed, you will be presented with your score. Which also displays the highest score achieved to date:

| <b>Highest Score: 5445 points</b> |       |                                     |
|-----------------------------------|-------|-------------------------------------|
| <b>Flight Data</b>                |       | <b>Score</b>                        |
| Distance(ft):                     | 779.7 | 2220                                |
| Descent Vel(ft/s):                | -1.3  | 2373                                |
| Forward Vel(ft/s):                | 2.3   | 42                                  |
| Lateral Vel(ft/s):                | 0.1   | 250                                 |
| Fuel Left(%):                     | 8.8   | 439                                 |
| Pitch (degree):                   | -0.5  | 21                                  |
| Roll(degree):                     | 0.1   | 100                                 |
| Manual DPS Bonus:                 |       | 0                                   |
| <b>Your Score: 5445</b>           |       |                                     |
|                                   |       | <input type="button" value="Done"/> |

If you unfortunately crashed then a “crash data” window will be displayed providing you information on what went wrong!

| <b>Crash Data</b>    |       |                                     |
|----------------------|-------|-------------------------------------|
| <b>Flight Data</b>   |       | <b>Status</b>                       |
| Distance(ft):        | 1,466 | OK                                  |
| Descent Vel(ft/s):   | -17.6 | FAIL                                |
| Forward Vel(ft/s):   | -23.5 | FAIL                                |
| Lateral Vel(ft/s):   | 0.0   | OK                                  |
| Pitch (degree):      | 20.0  | FAIL                                |
| Roll(degree):        | 0.0   | OK                                  |
| Fuel Left(%):        | 11.1  |                                     |
| <b>Your Score: 0</b> |       |                                     |
|                      |       | <input type="button" value="Done"/> |

## **IV- Game Levels and missions**

Currently in LEM Sim, you have a choice of three game levels:

### Rookie Pilot Mode

In this first level:

1. The LEM sub-systems failures are disabled
2. The landing site location is always the same
3. Initial conditions are always the same for each mission, altitude, velocities, etc.
4. the fuel depletes more slowly than at other levels

This level was specifically designed to allow you the time to concentrate on developing your skills with the lunar lander controls and indicators rather than focusing on fuel level or LEM malfunctions.

### LM Pilot Mode

This intermediate level feels more like the real thing. All initial conditions are different on each mission. This includes:

1. fuel level
2. landing site location
3. initial velocities and altitude

In addition, there is a likelihood that some of your lander subsystems would fail during the descent to the moon. Some of those failures are recoverable. One example is a leak in the fuel tank developed during the descent. This will of course reduce the amount of fuel available for landing requiring you to land quickly.

Other failures may be fatal. For instance, if the main descent engine shuts down for too long then NASA may as well name a new crater after you! Please note that most sub-system failures last only for a few seconds but some can last up to a minute or more (especially in game level three). LEM sub-system failures will happen randomly during your descent while in game level 2 or 3 realistically providing you with a new mission each time.

### LM Commander Mode

This level is not for the faint of heart. Initial conditions can vary much more and failures will happen much more frequently and last longer. To add to an already difficult level, the fuel will deplete faster than in the two first levels which will force you to watch that fuel gauge more closely. While you may want to start with this level we strongly suggest you master the lower levels of this game first.

There are also two missions you can choose from. Here a quick description of each mission:

#### Approach Phase Mission

This is the default mission. In this mission, your LEM initial conditions are:

- game level: Rookie Pilot
- Sound Level: 50%
- Altitude: 8,000 ft
- Rate of descent: -160 ft/s
- Forward velocity: - 470 ft/s
- Lateral velocity: 0 ft/s
- DAP mode = ATTH
- Program running : P64 (approach phase)
- DPS engine mode= AUTO
- Fuel level: 18%

If you only wish to practice your final landing, then you may switch to the “final landing phase” mission using the “Game Options” screen.

#### Final landing Phase Mission

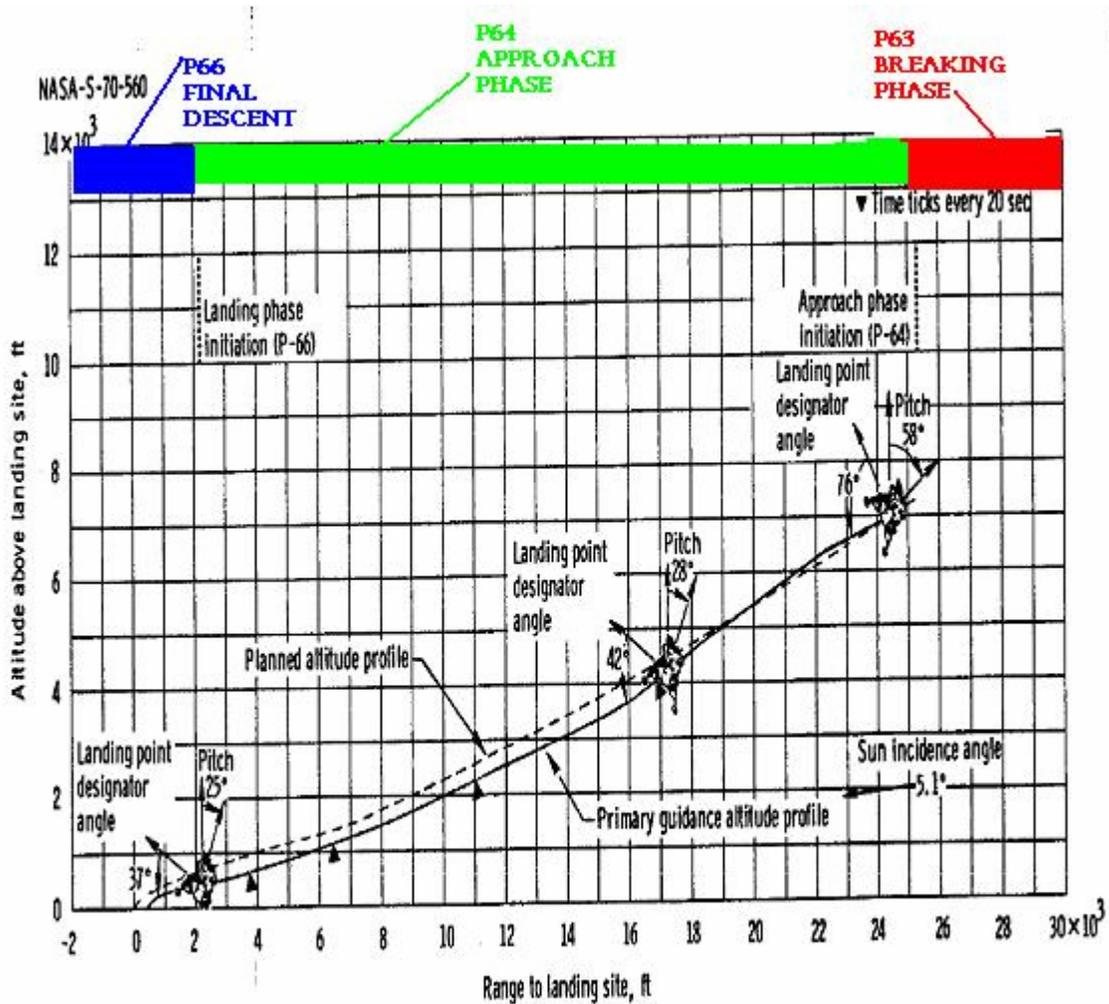
This mission simulate the last few minutes of moon landing. In this mission, your LEM initial conditions are:

- game level: Rookie Pilot
- Sound Level: 50%
- Altitude: 500 ft
- Rate of descent: -17 ft/s
- Forward velocity: - 80 ft/s
- Lateral velocity: 0 ft/s
- DAP mode = MAN
- Program running : P66 (final landing phase)
- DPS engine mode= AUTO
- Fuel level: 12%

## V- The Apollo lunar landing

To better understand what a moon landing really entails you will find here a description of a typical Apollo mission and how it relates to the LEM Sim game.

The moon landing was indeed the most demanding step of a moon mission. The landing was accomplished in three distinct phases as shown on the figure below taken directly from NASA documents. P63, P64 and P66 refer to internal computer programs which the on-board computer (DAP) followed in order to assist the astronauts land on the moon surface. Some programs like P63 were entirely automatic but others (P64 and P66) allowed the astronaut to have some or complete control of the LEM. Here is a description of the different phases:



(a) 26 000 feet to landing.

**The breaking phase (P63):** This first phase (not modeled here) starts with the LEM orbiting around the moon at an altitude of 50,000 feet and a forward velocity of about 5,500 feet/sec. The LEM is first pitched up 90 degrees so the main engine nozzle is facing forward in preparation for the breaking burn. During this phase which lasts approximately 9 minutes, the main descent engine is fired up at maximum thrust to slow down the LEM to about 400 feet/sec after the 9 minute engine firing. This breaking phase also lowers the LEM altitude to around 8000 feet. These become the initial conditions for the next phase of the landing. It is important to note that this phase is entirely automatic and under the control of the on-board computer (DAP). For this reason, the LEM Sim will not simulate this phase. This is suppose to be a fun game and so there is no much fun to stare at the PDA screen for 9 minutes while the on-board computer is doing its thing!

**The approach phase (P64):** This is where LEM Sim game begins. At about 8000 feet altitude, the LEM will pitch over to about 30 degree angle from vertical which allows the crew to see the moon surface and especially the landing site. The goal of this phase is to slow down the LEM even more (80 feet/sec forward velocity) and bring down the LEM to about 500 feet above the moon surface. Unlike the breaking phase (P63), P64 is semi-automatic phase. To assist you the on-board computer (DAP) will control the descent rate following its internal program. During this phase, which normally lasts around 2 minutes, the only manual control you will have is pitch and roll. The computer will automatically throttle up or down the main engine so that you reach 500 feet with a descent velocity of about -17 feet/sec. At least that's what the DAP will attempt to do. If you feel that the DAP is bringing you down too fast (or too slow), you can switch the DAP to manual mode. In that mode you can adjust the descent rate with the hard key 1-4 buttons. As soon as the LEM altitude is lower than 500 feet, the on-board computer will automatically switch to the final phase P66 (DAP mode=MAN).

**The Landing phase (P66):** This final phase should last about 2 minutes and is entirely done in manual mode. Below an altitude of about 500 feet, DAP will switch to manual mode and keep the last rate of descent you had at the end of P64 (which was about -17 feet/sec). It is your job now to slow your descent rate and horizontal velocities (forward and lateral). The mechanical limit at touchdown of the LEM dictates that you need to slow all velocities (ROD, forward and lateral) below +/-10 feet/sec at touch down. A landing with any velocity higher than +/-10 feet/sec would be considered a fatal crash. Any landing with a pitch or roll angle at touchdown higher than +/-15 degrees will also be considered a crash since you will not be able to take off with the lander at high degree of tilt.

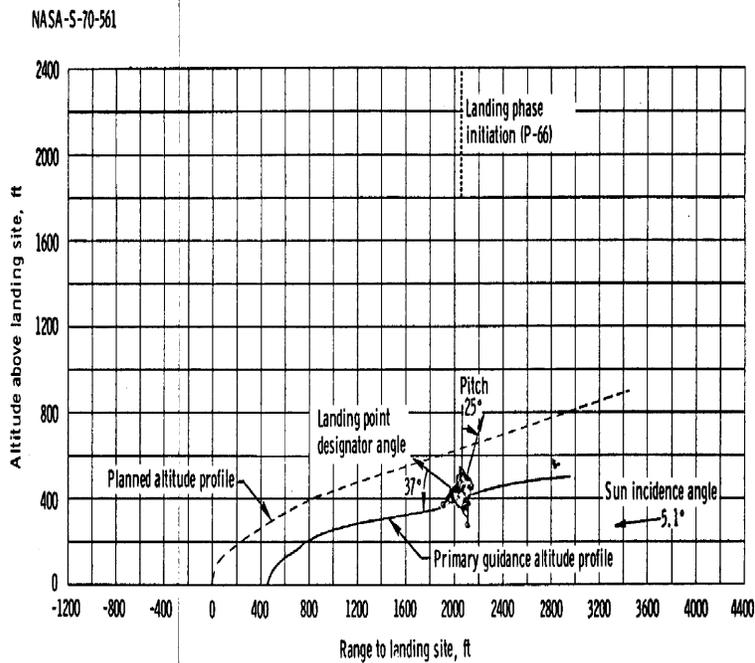
Of course the softer the landing the bigger the score will be. Once you reach about 6 feet of altitude, the contact light will illuminate indicating that you are very close to the surface (the Apollo LEM used probes wires that dangled under the lunar module feet). The engine will be cut off shortly after the contact light turns on.

Obviously, the goal of the game is to:

1. land on the surface of the moon as softly as possible,
2. as close to the landing site as possible
3. with the LEM upright, and
4. with as much fuel as possible in the tank.

All these variables will be taken into account in the calculation of your final score. The game also keeps track of your main engine (DPS) throttle mode (AUTO versus MAN mode) and awards you bonus points for your time in manual mode.

Here is a graph (again from NASA) showing the final descent P66 phase:



(b) 4200 feet to landing.

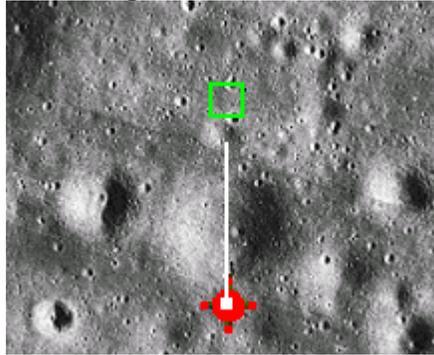
## VI- LEM Sim Sub-Systems Description

To help you land safely on the moon, you will need instruments to monitor your flight, a propulsion system to slow your descent and control your attitude, and as in the real thing, an on-board computer to help during the most demanding phase of a moon mission.

Here is a more complete description of instruments, controls and systems that you have at your disposal in LEM Sim.

### Instruments and indicators

#### Digital Lunar Map



The digital lunar map shows your location and direction above the moon surface. The green box is where your landing site is located. It will be revealed to you only when your distance to the site goes below 10,000 feet. The white line coming out from your red lander is a velocity vector. This line basically shows your lander direction and speed. The end of the line tells you approximately where you are going to be in the next 30 seconds if you keep the same velocities.

#### Program and Event Timer

**[P66] [T: 0 m 11 s]**

The number on the top left of the screen indicates the current computer program running, ie. P64=Approach phase, P66=Final landing phase

The event timer is basically a clock which starts at zero at the start of a new landing. You can use this timer to compare your landings or compete against yourself for least amount time.

### Altimeter Tape:



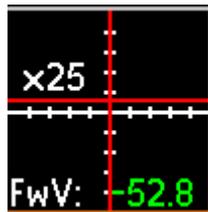
Located on the top right side of the screen, this instrument relays your altitude from the descent radar. It is called a tape because originally it was basically a long piece of tape with markings scrolling up or down. The white arrow indicates your current altitude as measured by landing radar.

The number in green on the bottom right shows your rate of descent velocity or DesV (vertical speed). It is negative when you are going down and positive when are going up.

### Contact Light indicator

This indicator, also located on the altitude tape screen, illuminates when you reach 6 feet from the lunar surface. The real LEM had contact sensors hanging down from its feet in order to detect contact with the lunar surface. The sensors signaled the commander to shutdown the main engine before touching the ground. This prevented the descent engine nozzle from being damaged by the engine's flames.

### X-Pointer:

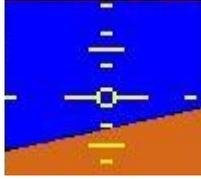


Located just below the altitude tape is the X-pointer. This instrument graphically displays your forward and lateral velocities. This data is also coming from your landing radar. The red horizontal line is your forward velocity. The line is above zero when you are going forward and below zero when going backward. You can also read your forward velocity at the bottom of the screen. FwV (forward velocity) is negative when going forward.

The vertical red line is your lateral velocity (left or right speed). So for instance, if you are drifting right then the vertical red line will be shown to the right of the white center line.

To help you better judge your velocity close to the surface (when your speed is low), the X-pointer has two scales (X1 and X25). The scale will automatically switch from X1 to X25 if any of your velocity becomes higher than +/- 25 feet/sec.

### Artificial Horizon:



At the bottom right of the screen, you will find the artificial horizon display. This instrument shows you your attitude in relation to the moon surface (pitch and roll angles). The two longer yellow lines at the mid-bottom/mid-top of the indicator indicate +/-45 degree pitch angle. Remember to watch this indicator when you about to land because a touchdown any pitch/roll angles higher than +/- 15 degree will be considered a crash.

### Fuel Level indicator:

**Fuel:22%**

This number of course shows you the amount fuel left in your tank (in percentage of maximum fuel). Please note that you never start a mission with 100% fuel level but more likely around 15-20% (depends on the game level). The reason is simple. LEM Sim game starts few seconds after the end of the breaking P63 program. This means that the engine has been firing for almost 9 minutes and went through about 80% of the fuel in order to slow you down. That's before you even take over the LEM controls for P64 phase of the landing.

When the fuel tank level goes below 5%, the color of the fuel-level number will change from green to red and you will hear CapCom saying "**low level**". This means that you have only few minutes of fuel left and you should start thinking about landing or risk crashing because of a lack of fuel.

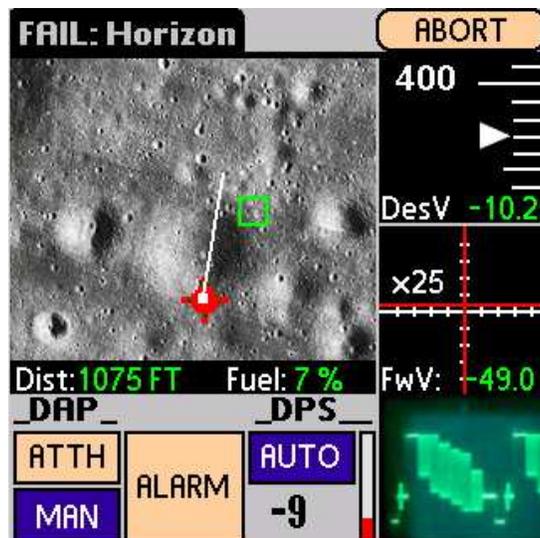
### Master Alarm indicator:



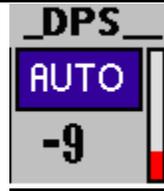
Yet another invisible indicator, this audio warning will indicate that the DAP (digital auto pilot) has detected an anomaly with one of the LEM sub-systems (fuel tank, main engine, RCS thrusters and so on). The Dap will also display a short description of the failure such as "**FAIL:Thrusters**" or "**FAIL:fuel tank leak**". To stop the loud siren sound just press the "Master Alarm" button once. The button will turn blue. Of course this action will not stop the failure which you will still need to cope with. Here are some of the failures you may encounter and what you can do about them:

- **Fuel leak:** Every second that this alarm is on, the fuel will deplete a little faster than normal. Hope it won't happen while you are low on fuel and very close to the surface!
- **Main engine:** This alarm indicates that there is something wrong with the descent engine (DPS). This failure will bring the engine down to 0% for a short period of time (engine shutdown). You can compensate by going in manual mode (DPS=MAN) and increasing the engine thrust yourself after the malfunction stops.
- **Thruster failures:** Pitch or/and roll RCS thrusters may get stuck and will change the attitude of the LEM. You can compensate for this effect by using the opposite thruster. So for instance, if the LEM seems to pitch up, you can try to pitch down. Same for the roll angle
- **DPS auto mode failure:** The DAP main engine throttling routine (ROD) is no longer working. The DPS mode is switched to MAN. This means that you need to take DIRECT control of the main engine until the alarm goes off. The ROD number will become engine thrust percentage number (% of max thrust)
- **False alarm:** No need for explanation!

Here is a screen shot of a failure: In this example we have lost the artificial horizon indicator so it impossible to know the lander attitude during the malfunction.



## Propulsion/Attitude Control



To slow down your descent to the moon, your LEM is equipped with a rocket descent engine also called DPS (descent propulsion system). The DPS can be throttled between 10% and 90% of maximum thrust. The DPS cannot be shutdown during flight (unless there is an engine failure)

The red gauge at the bottom right of the screen is your engine thrust indicator (0-100%). The hard key 1 and hard key 4 are your engine controls. The large number under DPS mode button is your requested rate of descent or ROD. If the DPS mode is set to MAN then that the ROD will switch to a engine thrust number (10%-90% max thrust).

The DPS has two modes of control:

Normal mode (AUTO): In normal situations, the autopilot (DAP) actually controls the engine thrust through a computer routine called ROD which stands for Rate Of Descent. So when you press hard-key 1 or hard-key 4, you are actually requesting a LEM rate of descent change. The DAP in return will control the engine thrust trying to match your request. Please note that to save fuel, you cannot in this mode request a positive rate of descent (make the LEM go upward) but you can request the LEM to hover (zero rate of descent). This hover can help you “bleed” some large horizontal velocities before going down again. Of course hovering is very costly in term of fuel usage and should be used sparingly.

Manual mode: As described above, the DPS in AUTO mode is the normal mode used by all Apollo astronauts. If you wish to make a landing more difficult, and get bonus points in the process, or if there is an autopilot malfunction, you will have to switch the DPS to manual mode (press the DPS mode button). In this mode a click on Hard Key 1- 4 will directly affect the engine thrust. Since the DPS engine minimum throttle thrust change is 3%, this mode is very difficult to use, especially close to the moon surface. This is why you will get extra points on using the manual DPS mode.

## The LEM on-board computer (DAP)



The LEM is also equipped with a Digital AutoPilot also known as DAP. DAP is an on-board computer designed to assist you during the landing. The DAP has many functions:

- Monitor the status of the LEM sub-systems
- Gather altitude and velocities from radar, attitude from gyro platform and fuel level from the fuel tank sensor
- Display all this info in the cockpit
- Control the LEM descent engine during the automatic (P63) and semi-automatic (P64) phases of the descent
- Throttling the main engine to try to match the pilot rate of descent request (ROD function)

DAP has essentially two operational modes:

### Semi-automatic mode (Attitude Hold or simply ATTH)

In this mode, the computer controls the descent rate following its internal program P64. You control the LEM attitude. Below 500 feet the DAP mode will automatically switch to manual mode.

Manual Mode: In this mode, in addition to the RCS controls, you will need to control the main descent engine (DPS). The type of control you will have over the DPS will depend on the status of the DPS mode button. In the manual mode the DAP will still monitor the health of your lunar and display important information like your altitude or rate of descent.

## VII- Frequently Asked Questions

Here some answers to questions you may have about the game.

**Q:** Can I pause the game?

**A:** Yes. During the descent, just click on the top of the screen. The game will be paused and a menu will drop. At this time, you will be able to start a new mission, change game settings or simply exit the application.

**Q:** Why are my Palm keys disabled during game play?

**A:** This is needed to keep the device from exiting the game while you are playing. If you need to exit the application, first press the ABORT button.

**Q:** Why does the descent rate indicator become positive, i.e going up, when I request a rate change?

**A:** If you are at a low descent velocity and you request a change, the on-board routine is so realistic that it may overshoot while its adjusting the engine thrust to match your requested rate of descent change.

**Q:** How often do the malfunctions happen during a game?

**A:** In the Pilot mode they are not frequent but occur from time to time. In the Commander level, you may experience multiple failures during a single mission.

**Q:** Can I switch to manual DAP mode during the Approach phase?

**A:** Yes you can. You will need to adjust your descent rate manually.

**Q:** Why can't I change the DPS mode to manual while the DAP is in ATTH mode?

**A:** When the DAP is in the ATTH mode, the computer controls the engine using its internal ROD routine. If at any time you wish to switch the DPS engine mode, first set the DAP mode to MAN.

**Q:** Why do I crash sometimes without any apparent reason even when my descent and horizontal velocities are below the crash limits?

**A:** The most likely problem is that you touched down with the LEM tilted. NASA forbids astronauts from landing with a pitch or roll angle higher than +/- 15 degrees. The bottom part of the lander is used as a launch platform and you want the LEM to land as upright as possible. Use the "Crash Data" screen to find out why you crashed.

## **VIII- Registration and Support Information**

If you need assistance with the game registration or have any comments/suggestions about this application, please do not hesitate to contact us at:

[lemsim@gmail.com](mailto:lemsim@gmail.com)

With the LEM Simulator loaded on your Palm/Treo device, you are ready to have fun landing on the moon anywhere and anytime.

**Houston, you are go for landing...!**