ORBIT!

A Space Travel Simulation

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INTRODUCTION

"Orbit" is a detailed simulation of space travel from the Earth to the Moon. The simulation poses a series of orbital navigation and piloting challenges for you.

1) Intercept Target Drone. You must pass within 1,000 miles of the target drone and vaporize it with your laser.

2) Rendezvous with Space Station. Match orbits with the Space Station. Move within 300 miles for about 15 seconds to dock with the station. When you have docked, you will load fuel and life support for a trip to the Moon.

3) Travel to the Moon. Enter a transfer orbit which will carry your spacecraft to the vicinity of the Moon. Once you are near the Moon its gravity will draw you toward it. When you are within about 25,000 miles of the Moon, the Moon will appear at the center of the display.

4) Detach the Lander. Maneuver your ship to a low lunar orbit. When you are within 250 miles of the surface, detach the lander.

5) Land at Farside Station. Land at Farside Station which in the center of Daedalus Crater on the far side of the Moon. A soft landing completes the simulation.

OPERATING INSTRUCTIONS

1) Necessary Equipment.

Atari 800 with 48K RAM, Atari 1200 or Atari 800XL.
One disk drive.
One joystick.

2) Starting the Program.

Turn TV on.
Turn disk drive on.
Insert "Orbit" disk into disk drive.
Plug joystick into port number 1 (left socket)
Turn computer on. The program will take about 40 seconds to load. Leave the disk in the drive.

3) Use of the Joystick.

"Orbit" is controlled by the joystick. A diagram (called the "Stick Map") in the lower right corner of the screen shows the nine positions possible for the joystick. (see figure A) The following instructions refer to these positions by compass directions. Upper right becomes northeast ("NE"), lower left is southwest ("SW") and so on.

A cursor or moving light will illuminate the current position of the joystick on the stick map. In that position on the stick map is a letter or symbol which represents the function which will be performed if the trigger is pressed at that moment.

The trigger operates quite fast. A sharp fast punch on the trigger will execute the chosen function which will be signalled by a beep. If the trigger is depressed for too long, it will repeat the function. Sometimes this is desirable, sometimes not.

4) Controlling the Attitude of Your Spacecraft.

The direction your ship is pointing is called its "attitude." Your ship's attitude is shown by the green pointer in the circular dial in the lower left corner of the screen. By moving your joystick to the left or right (west or east) you will move the red/purple pointer. (When the red and green pointers are aligned and overlapping they are white.) When the red pointer is clockwise from the green (attitude) pointer, the east position in the stick map will light up. The west position will light if the red pointer is counterclockwise from the green pointer. Pressing the trigger will cause your spacecraft to rotate toward the red pointer until it lines up in the direction indicated by the red pointer.

5) Controlling Your Rocket Engine.

Set the throttle on your engine by moving the joystick north or south. The throttle setting is shown on the bar gauge (marked "THR") which is second from the left. The throttle gauge is calibrated in thousands of miles per hour. When the red and green attitude pointers are aligned, and the throttle is set above zero, the north and south positions on the stick map will light up. This shows that if the trigger is pressed, the engine will fire. The engine will fire long enough to accelerate your spacecraft by the amount shown on the throttle in the direction shown on the attitude indicator.

When your engine fires, it consumes fuel. Your fuel supply is measured by the bar gauge (marked "FUEL") at the left side of the screen. The fuel gauge is calibrated in metric tons of monopropellant. It takes 6.25 tons of fuel to accelerate the ship by 1,000 miles per hour.

6) Speed and Life Support.

When "Orbit" starts, it is operating at 94 times real time. In other words, one minute of simulation time represents 94 minutes in the real world. To double the speed of the simulation, move the stick map cursor to the northwest ("NW") to illuminate the "S" with the arrow above it and press the trigger. The speed can be doubled up to seven times to a maximum of about 12,000 times real time. At that speed a day of real time takes 7.2 seconds to simulate. Speed may be decreased by moving the stick map cursor SW and pressing the trigger.

Your simulation may continue only so long as you have life support supplies ("LS"). The amount of LS remaining is shown on the bar gauge which is the second from the right. The LS gauge is calibrated in days of remaining supplies. LS is consumed at a constant rate in real time. As a result, the apparent rate of LS consumption will vary as the speed of the simulation varies. When your LS falls to a one day supply, a warning message will scroll across the screen. When you run out of LS, the simulation is over.

7) <u>Magnification</u>

When "Orbit" starts, the display shows the Earth and a square area of surrounding space about 14,000 miles on a side. The magnification may be reduced by a factor of two by moving the stick map cursor to the SE to illuminate the "M" with the arrow below it and pressing the trigger. The magnification may be halved up to five times. At minimum magnification the display shows a dot representing the Earth at the center of the screen and an area of surrounding space over 460,000 miles on a side. This is large enough to show the Moon's orbit which has a radius of about 230,000 miles in this simulation.

When you are in orbit around the Moon, the magnification may range from displays showing 7,200 miles on a side to a maximum of 57,600 miles on a side.

8) <u>Change Stick Map Options</u>.

If the center "OPT" position in the stick map is illuminated, you may change the function options shown at the corners of the stick map by pressing the trigger. If the "OPT" position won't light up, either the attitude pointers aren't aligned or the throttle isn't set to zero. Be sure the throttle is set at zero and press the trigger to align the attitude pointers. The "OPT" position should then light up. Press the trigger again to change the corners of the stick map.

9) Trace Orbits.

The current position of your spacecraft is shown by a moving white blip. The target drone and the Space Station are shown by moving blips which periodically flash green. To trace your spacecraft's full orbital path move the stick map cursor to the NE to illuminate the circle with the "S" in it. The trigger will then trace the orbit. Using the "T" in the circle at the NE corner of the stick map will trace the orbit of the target drone or of the Space Station.

10) Radar Mode.

Move the stick cursor to the SE to illuminate the "R" and trigger to select radar mode. A radar screen will appear. The radar sweep will scan 1,800 miles in all directions from your spacecraft. If the target drone or Space Station is within 1,800 miles, it will appear on the radar screen as a white blip. The range to the target will periodically scroll across the top of the screen.

When you enter Radar mode, the stick map is replaced by a telescopic viewscreen. At the top of the viewscreen area is an indicator showing the laser and docking status. The attitude and throttle are controlled in the usual manner. To exit from Radar Mode move the stick "SE" to illuminate the "OPT" position and press the trigger.

i. Laser Control. Your first objective in the simulation is to intercept the target drone and destroy it with your laser.Turn the laser on or off by moving the stick to the "SW" to illuminate the "L" and pressing the trigger. This will cause the laser to start charging. The laser requires a few moments to charge. When fully charged and ready to fire, the status indicator shows "ARMED". The trigger will fire the laser. Note that charging the laser consumes fuel. The laser consumes fuel at a slower rate while it is armed. It is best not to arm the laser too early.

When the laser is armed, aim it at the target. The laser direction is shown by the red pointer in the attitude dial. Remember that your ship is at the center of the radar screen. Thus, if the target is northeast of you, you will set the laser direction pointer so that it points northeast toward the target. You must center the target in the viewscreen crosshairs by moving the joystick left or right. When the laser is on target, the flashing lights below the viewscreen will turn red. If you are in range, on target and armed, FIRE! If you hit the target, it will disappear in a cloud of incandescent vapor.

Your chances of hitting the target improve as you get closer. For practical purposes you must be within 1,000 miles to hit the target although longer shots may be possible.

ii. Docking. To dock with the Space Station you must move within 300 miles of the station and hold that range for about 15 seconds. When you get within 300 miles of the station, the status indicator will show "DOCKING". After about 15 seconds, the status indicator will show "DOCKED", and your ship's orbit will be matched to that of the station. A message signalling the docking will scroll across the screen, and your ship will be filled with fuel and life support supplies.

11) Navigation Mode.

To enter Navigation Mode move the stick map cursor SW to the "N" symbol and trigger. As you enter Navigation Mode, the screen colors will change and the orbits of your spacecraft and the target or station will be traced. The current positions of your ship and the target will be shown by closely spaced pairs of dots. These position markers can be difficult to make out so try to notice the positions before you enter Navigation Mode.

While you are in Navigation Mode, the game is frozen. Although the delay will reduce your score, the simulation is otherwise frozen. This allows you to plan your course of answer the phone at your leisure. Navigation Mode allows you to analyze and test. In particular it allows you to do four things:

i. Orbit Constants. When you enter Navigation Mode, the orbit constants for your orbit and that of the target will scroll across the top of the screen.

Three constants are displayed: eccentricity, apogee and perigee. The eccentricity is a measure of the shape of an orbit. A circular orbit has an eccentricity of zero. As an orbit becomes more egg shaped and elongated, its eccentricity increases. When the eccentricity is greater than or equal to one, the orbit is no longer closed. The spacecraft will not loop around the orbit. Rather, the spacecraft will leave the planet and never return. The eccentricity ("E") determines the type of orbit:

E equals 0	Circular Orbit
E less than 1	Elliptical Orbit
E equals 1	Parabolic Orbit
E more than 1	Hyperbolic Orbit

The apogee is the high point on an orbit or its furthest distance from the center of the planet being orbited. For orbits which aren't closed (parabolic and hyperbolic orbits) the apogee is infinite. If the apogee exceeds about 300,000 miles it is beyond the range of the simulator to display. Therefore, no apogee will be given.

The perigee is the lowest point on the orbit. Remember that the perigee is also measured from the center of the planet. Since the Earth's surface is 4,000 miles from its center, a perigee of 3,900 miles would lead to a nasty crash. The Moon's surface is 1,020 miles from its center. The perigee and apogee are always on opposite sides of the orbit.

ii. <u>Moving the Nav. Cursor/ Velocities</u>. The Navigation Cursor is a red or green cross which is located somewhere on the tracing of your ship's orbit in Navigation Mode. When the Nav. Cursor is red, you may move it to any place on your orbit by moving the joystick left or right. When the Nav. Cursor is located where you want, you may freeze it at that location by pressing the trigger. The Nav. Cursor will turn green to show that it is frozen. To thaw the Nav. Cursor move the Stick Map Cursor SW to "P" (for "position") and press the trigger. The Nav. Cursor will turn red again and may be moved to a new place on the orbit. If you select "P" while the Nav Cursor is already red, you will exit from Navigation Mode.

When you freeze the Nav. Cursor at a position, the tangential and radial velocities of your ship at that place in the orbit will scroll across the top of the screen. In addition, the distance of that position from the center of the planet will be displayed. Tangential velocity is the speed horizontal to the ground. Radial velocity is the speed away from the surface, or, if negative, toward the surface. The bar gauge at the far right of the screen gives a running measure of your ship's radial velocity ("VR"). The "VR" gauge is calibrated in thousands of miles per hour. Zero is at the center of the "VR" gauge. Positive radial velocities (away from the planet) are shown above zero and negative (toward the planet) below.

As you become more expert in space navigation, you will find these velocity figures useful. Some observations may help get you started. For a circular orbit (E=0) the radius of the orbit is constant. Therefore, the radial velocity is always zero. In any orbit the radial velocity equals zero at the apogee and perigee. The tangential velocity is greatest at the perigee (low point) and smallest at the apogee (high point). You will be able to see this as you watch the simulation. The spacecraft will slow as they pull away from the planet they orbit and speed up again as they fall back toward the surface.

iii. Testing Course Changes. Once you have chosen a position on your orbit and frozen the Nav. Cursor at that position, you may test various course changes. Set the test attitude (direction) of your ship by moving the blue needle in the attitude dial with your joystick. Set the throttle in the usual way. Press the trigger to trace the orbit which would result from an engine burn of the magnitude shown on the throttle, at the position shown by the Nav. Cursor and in the direction shown by the blue attitude pointer. As the test orbit is traced, the orbit constants for the test orbit will scroll across the screen. You may change the throttle setting or attitude and repeat the test as often as you please.

You should notice that when you test a course change the Stick Map Cursor changes from red to green. This means that an automatic course change has been programmed. This discussed below in detail.

As you test several course changes, the screen will become cluttered with the tracings of test orbits. To erase the test orbits move the Stick Map Cursor NW to the "E" symbol and trigger. This clears the screen and also cancels the automatic course change. (The Stick Map Cursor will turn red again.) If you test a number of course changes in quick succession, you may overflow the the storage area for the messages that scroll across the screen. If there is such an overflow, all the stored messages will be erased. Don't worry about this. Just test your most recent course change again to display the test orbit constants.

iv. Automatic Course Changes. As described above, the most recent course change tested is stored as an automatic course change. If you exit Navigation Mode while the Stick Map Cursor is green, the last tested course change will be executed automatically. After you exit Navigation Mode, you will find that your attitude and throttle are frozen at the programmed settings and that you cannot fire the engine. The engine will ignite when your ship reaches the position on your orbit where the burn was tested. After the engine burn, the Stick Map Cursor will turn red again and you will again have control of the throttle and attitude of your ship.

a. Cancelling Automatic Course Change. If you wish to cancel an auto course change, you may return to Navigation Mode in the usual way, select "E" (Erase) and trigger. This will cancel auto mode. You may then exit Navigation Mode by moving the Stick Map Cursor SW to the "P" symbol and pressing the trigger.

b. Problems With Auto Course Changes. There are three things to watch for in using automatic course changes. First, when you return to the simulation, don't use high display speeds when you approach the position where the course change is set to occur. At high speeds your spacecraft can skip over the the place where the course change is programmed. Unless you cancel the programmed auto course change, the computer will wait while the ship circles the orbit and comes back to the proper position again. Second, your automatic course change may require more fuel than you have. When you reach the programmed execution point, the engine won't start and a message will explain the problem. This will cancel the auto course change. Third, you may accidentally program an execution point which is behind your current position. If you do this on an open orbit (E greater than 1), your ship will never return to the execution point. You must cancel the automatic course change as described above.

12. Travel to the Moon.

You may travel to the Moon at any time in the simulation. You will have enough fuel and life support to make it to the Moon if you leave as soon as the simulation starts. In the alternative you may wish to rendezvous with the Space Station for a full load of fuel and life support supplies before starting the long trip to the Moon.

At minimum magnification the Moon's orbit is traced around the edge of the display. The Moon moves at about 2,000 miles per hour around its orbit. You will see the Moon as a blip moving slowly in a counter-clockwise direction. Use high display speeds to see the motion more clearly.

As you approach the Moon, its gravity will draw your ship toward it. Trace your orbit as you head toward the Moon. You may notice that the Moon pulls you off your orbit. Indeed your orbit is being gradually changed or perturbed by the influence of the Moon's gravity. If you maneuver within about 25,000 miles of the Moon, and you are not moving past the moon at too high a speed, then the display will shift to show the Moon at the center of the screen at a higher magnification. You may then trace your orbit around the Moon just as you did for orbits around the Earth.

The mass of the Moon is about 1/81 of the Earth's mass. Therefore, the Moon's gravity is far weaker than the Earth's. Orbital speeds around the Moon are thus much slower than for the Earth. For example, near the Earth the orbital speed is about 17,500 m.p.h. while near the Moon the orbital speed is about 4,400 m.p.h.

13) Detach the Lander.

Your objective is to enter a near circular orbit around the Moon at an altitude of less than 250 miles. Since the Moon has a radius of 1,020 miles, the radius of your orbit should not exceed 1,270 miles. If you are in a proper orbit, you may detach your landing module for the decent to the surface of the Moon. This is done by moving the stick NE to the "D" symbol and pressing the trigger. (Note that the "D" appears in place of the "T" in a circle when you are in lunar orbit.) You may not detach your lander unless you leave the rest of your ship in a safe parking orbit. You cannot detach if your orbit has a perigee of 1,020 miles or less since that would lead to a crash.

When your lander detaches, you will see this on the screen. After this there will be a delay of about 30 seconds while the landing program loads from the disk.

14) Piloting the Lander.

i. Navigation Aids. The control screen for the lander is specialized for the purpose of navigating over the Moon's surface. The top section of the screen shows a profile of the terrain passing beneath the lander. The three horizontal slashes above the terrain mark altitudes of 5, 10, and 15 miles. When the altitude of the lander falls below 20 miles, a marker appears to show the lander as it approaches the surface.

The green area below the terrain profile is a map of the Moon's surface. The lander's position is shown on the map by a red box. The box is directly beneath the altitude marks on the terrain profile section of the screen. The scale of the terrain profile is 16 times as large as the scale of the map. The terrain profile shows about 125 miles of the Moon's surface on the screen at a time. The map shows an area of about 2,000 by 400 miles.

The last navigation aid is the round position dial located at the lower right corner of the screen. The circle at the center of the dial represents the Moon. The vertical arrow shows the position of Farside Base while the lander's position is shown by the white "needle" that moves around the dial.

Farside Base is an as yet imaginary facility located on the far side of the Moon. It is located in Daedalus Crater, almost at the center of the hemisphere of the Moon which is hidden from the Earth. Farside Base is marked on the map by a cross. The names of Daedalus Crater and other prominent map features are displayed above the map on the screen. When the name of the feature is centered on the screen, the map position box will be in the correct place on the map.

ii. Maneuvering Controls. The lander controls are more simple than those of the orbiter. Moving the joystick left or right starts the lander rotating in the direction chosen. Once the ship starts to turn it will continue for some time unless you move the stick in the opposite direction to stop it. The lander's attitude (orientation) is shown by the red/purple pointer in the center dial.

The throttle is set by moving the joystick north and south. The throttle setting is shown at the right end of the blue stripe which runs across the screen just above the position dial. The throttle is calibrated in "gee's". One gee (1 G) equals the acceleration due to gravity at the surface of the Earth. At the surface of the Moon the acceleration due to gravity is about .15 G.

You may fire the lander's engine by setting the throttle at a desired acceleration and pressing the trigger on the joystick. The engine will burn as long as you hold the trigger and the fuel lasts. Fuel is measured by the dial which is second from the left. Firing the engine changes your vertical and horizontal speed depending on the attitude of the lander. Vertical and horizontal speed is printed in the blue stripe above the five dials. The speed numbers are in miles per hour. The small arrows show the direction.

iii. Altitude. Altitude is shown on the second gauge from the right. The gauge is calibrated in miles above the surface of the Moon's maria or large flat planes. The large red number at the center of the gauge shows the number of hundreds of miles from zero to nine. If the altitude is 1,000 miles or more, the center digit will read "E". The short "hand" of the altimeter reads tens of miles while the "big hand" reads single miles. The gauge operates like a clock. When the big hand goes around the dial once, it measures a change of altitude of ten miles. At the same time the small hand will move one mark. When the small hand goes entirely around the dial the center digit will change by one.

Remember that the altimeter measures the distance above lunar "sea level". Since some mountains and crater walls exceed 25,000 feet in height, you must watch the terrain when you are close to the surface.

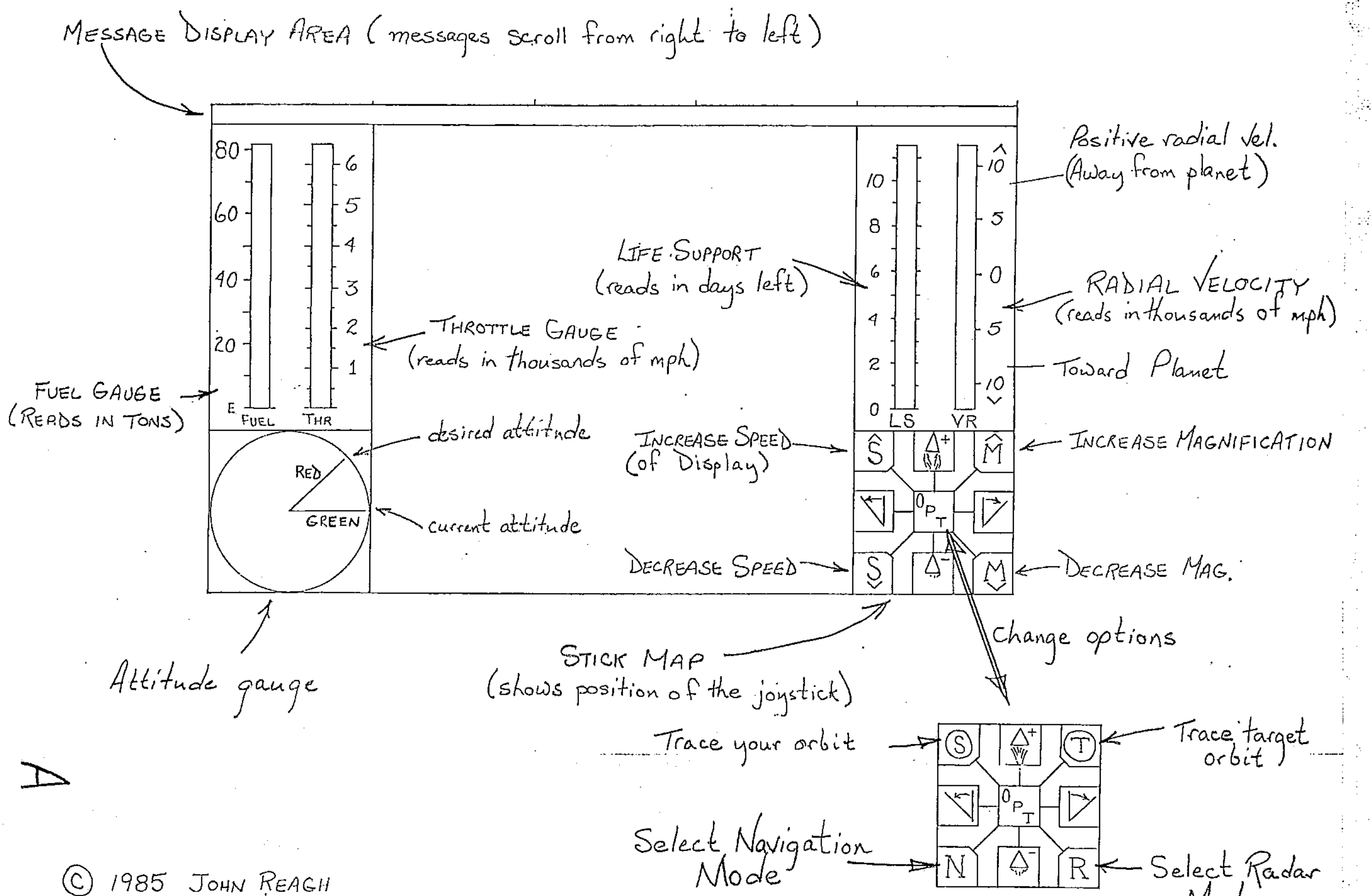
iv. Oxygen / Time. When you detach the lander, you have enough oxygen for about one orbit of the Moon but not much more. This places a time limit on you. The landing section of the simulation operates at about 16 times real time. Since a full orbit of the Moon would take about 87 minutes at low altitude, the simulator takes about 5.5 minutes for such a trip. Also, since it takes about three minutes and twenty seconds in real time to decelerate from lunar orbital speed (about 4,400 m.p.h.) at 2 G's, it will take the simulation about 12 seconds at maximum thrust. During that time the lander will travel about 125 miles. You must plan ahead!

v. Landing. The object is to land in the center of Daedalus Crater at as low a vertical and horizontal speed as you can manage. In addition you should conserve as much fuel and oxygen as you can. When you are near the surface, you may find it helpful to reduce the throttle to about .3 G. This is about twice the lunar gravity but low enough to allow you to control the landing with some delicacy. Note that the landing area is at zero altitude.

15) Restarting the Simulation.

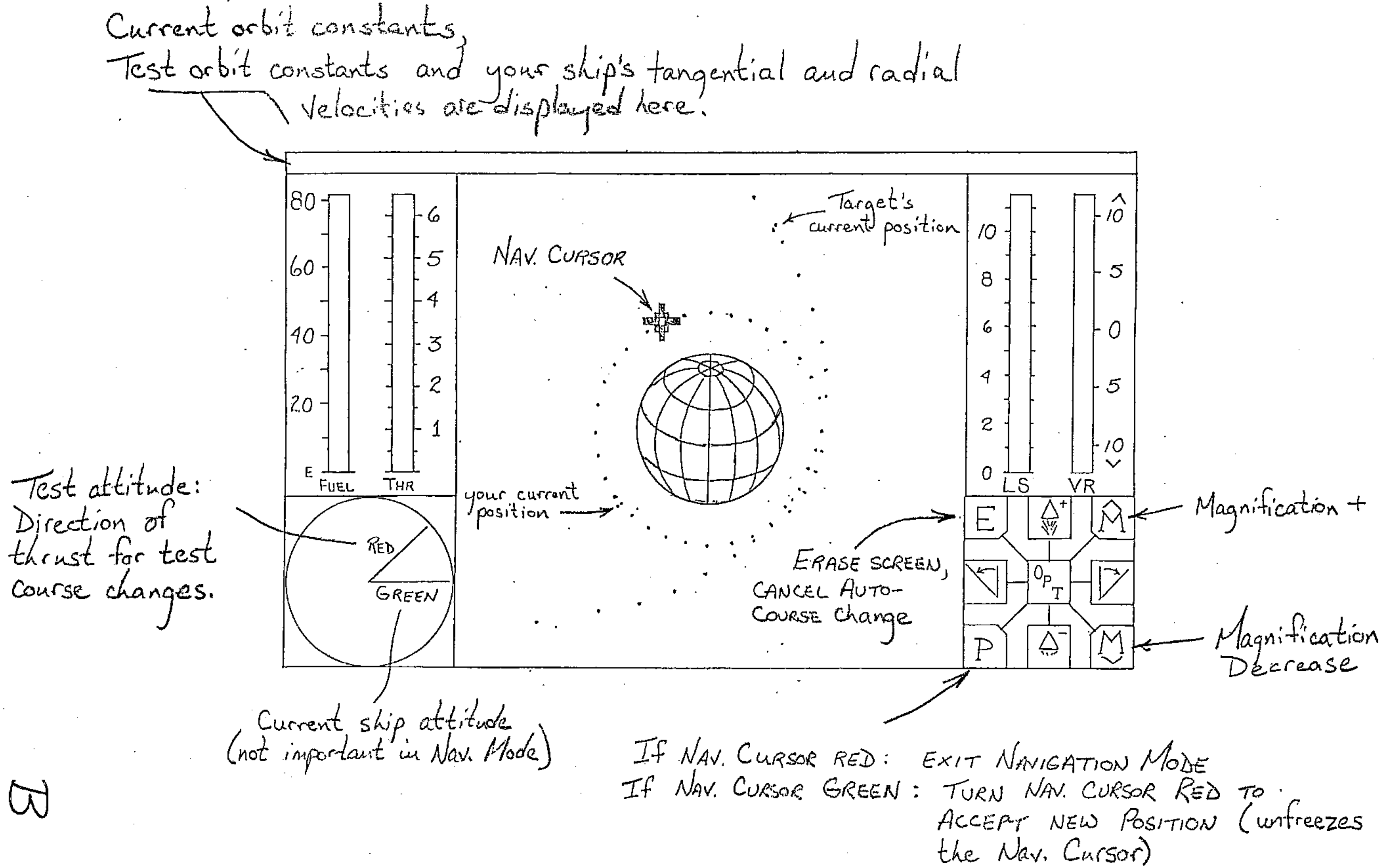
If the simulation ends before you have detached the lander, press the "START" button on the computer and then the trigger on the joystick. This starts the program from the start. Otherwise the simulation may be reloaded and run by pressing the "RESET" button.

KEY TO BASIC SCREEN FUNCTIONS



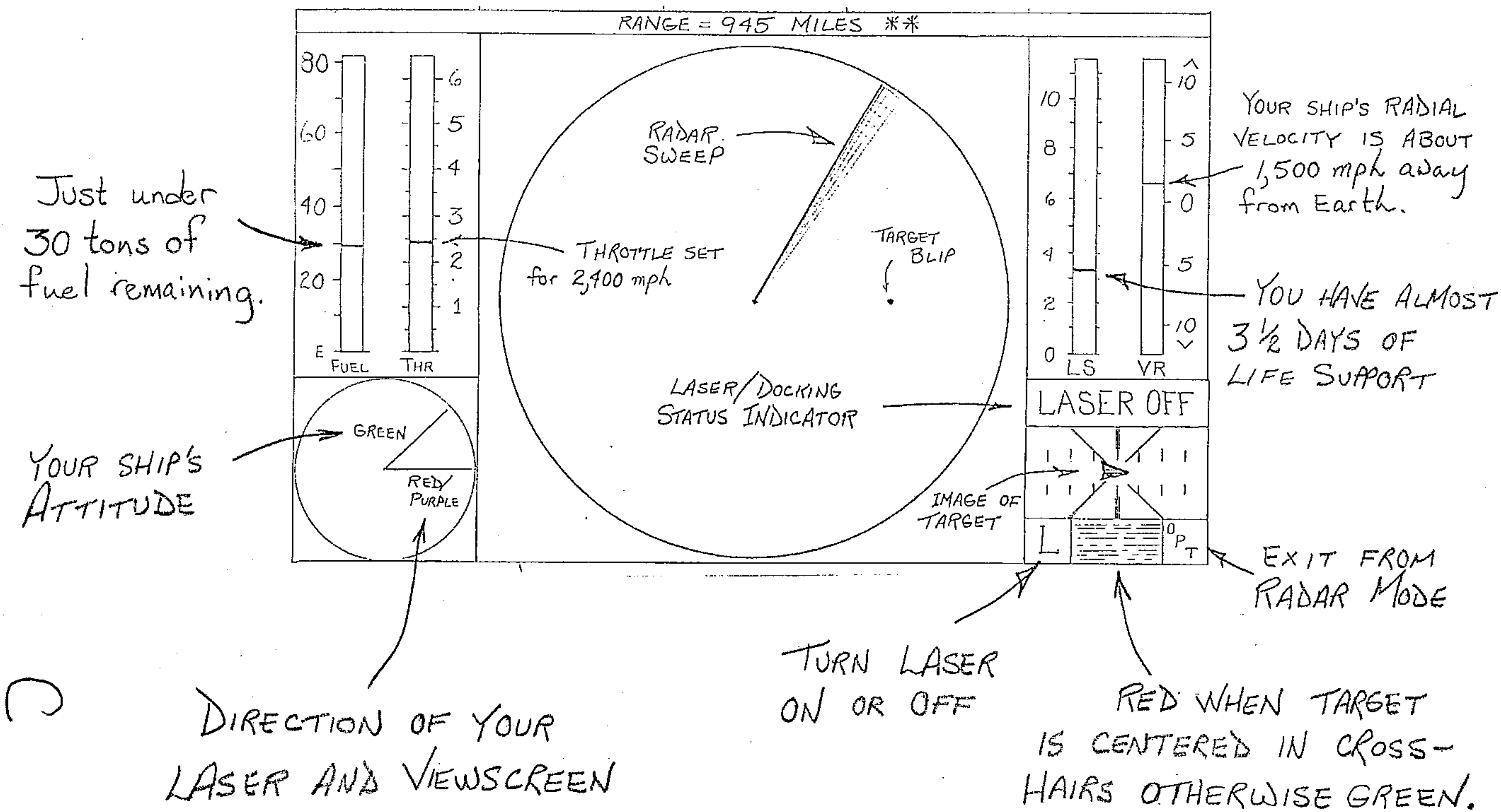
A

KEY TO NAVIGATION MODE



B

KEY TO RADAR MODE



KEY TO LANDER MODE