LUNAR LANDER

written by

CLARK A. CALKINS

for

DIGITAL GROUP SOFTWARE

the digital group
po box 6528 denver, colorado 80206 (303) 777-7133

296-010-A-6

LUNAR LANDER

1) INTRODUCTION

Lundar Lander is a real-time program that simulates the landing of a Lunar Excursion Module (LEM) on the surface of the moon. The visual display produced by the program shows the module moving against the lunar landscape as if the user were watching the actual landing (hence the term "real-time"). As the module approaches the lunar surface, the thrust from the rocket motors is used to slowdown the rate the descent such that a "soft" landing can be made. The user has complete control over these rocket motors. He can increase or decrease their thrust (either slowly for fine control or rapidly for emergency action). To control the horizontal motion of the module, the ship can be "tilted" either to the right or to the left. When the module is tilted to the left, for instance, the thrust from the rocket motors will make the module accelerate toward the left. If the module is moving to the right, it will appear to slow down, then finally move to the left. In actuality, the module does not tilt; however, the angle of the ship is displayed at the top of the screen.

2) VISUAL DISPLAY

For the purpose of providing a realistic display, the lunar landscape is shown in one of three background screens. First is the long range display which shows a 20,000X20,000 meter area containing mountains and several landing areas. This is the initial display when the program begins. When the altitude of the module falls belon 1500 meters, the background is switched to either of two close-up landing sites (each shows an area of 2000X1500 meters) depending on the modules horizontal position. If the module is located at a distance of]3,000 meters, the main landing site is displayed, showing an abundance of smooth landing area with only a few "rocks". One of the features of this program is that when the module moves off of the present screen (either left or right), the background displayed is automatically switched, showing the new location. If the module moves off of the top of the display, the long range screen is again shown.

Along with the background display, the top line of the screen is used to show the current instrument readings for the module. These include the modules altitude (ALT), the amount of fuel remaining (FUEL), the present distance (DIST), the time since the start (TIME), the horizontal velocity (HOR-VEL), the vertical velocity (VER-VEL), the attitude or angle of "tilt" in degrees (ATT), and the rocket motor power level or thrust (PWR). Not all of these parameters will fit on one line of the display, so the user can choose which of two sets of readings is desired. This choice can be made at any time by typing either a "1" or a "2" on the keyboard. To see all instruments, the user can switch back and forth at will.

The second line from the top is used for displaying warning messages (like OUT OF FUEL), or landing messages (like ROUGH LANDING - SHIP DAMAGED), or a crash message (like YOU CRASHED INTO THAT MOUNTAIN). All of these comments will flash for the user. For the special case when the remaining fuel is low, the digital fuel reading will start to blink.

3) KEYBOARD COMMANDS

To allow the user to control the module, the program checks the keyboard periodically to see if a key is pressed (this occurs about eight times per second). If the program finds that a key is pressed, it determines what action is required and then continues with the display. These commands either affect the thrust (magnitude or direction) or the instrument readings displayed. The following keys are the only ones that have any effect on the program (upper case only).

"1" - Select instrument reading set number one. This includes fuel, altitude, hosizontal and vertical velocities, the modules attitude, and the power.

"2" - Select the second set of instrument readings. These are the time, the distance, horizontal and vertical velocities, modules attitude, and power.

"D" - Decrease the power slowly. The power will be reduced by 5 units, but it will not fall below the minimum value of 10 units.

"F" - Set full throttle at once. The power will be increased to the maximum of 200 units.

"I" - Increase the power slowly. The power will be increased by 5 units up to its maximum value of 200 units.

"L" - Tilt the module more towards the left. The modules attitude will be decreased by 5 degrees. A negative angle indicates that the module is headed to the left and a positive angle means to the right. The attitude is not permitted to be more than 90 degrees off vertical.

"R" - Tilt the module more towards the right. The modules attitude will be increased by 5 degrees.

"Z" - Set the thrust to its minimum value of 10 units at once.

ESCAPE - This causes the program to return to the monitor (reset could also be used).

4) LOADING THE PROGRAM

Lunar Lander is loaded similar to the standard Digital Group operating systems. The EROM will read this program into the first 8K of memory. The regular operating system options are displayed along with the added (7 Lunar Lander) option. By typing a 7, the program will begin by displaying a greeting message, and after a pause, the lander will start.

5) USING THE PROGRAM

When Lunar Lander initially starts, the module is located at a distance of 0 meters (the left edge of the screen) and at an altitude of 20,000 meters (the top of the screen). The top line of the display will contain the instrument readings for option #1. The initial horizontal velocity is set to 1000 meters/second (to the right), the vertical velocity is set to -1000 meters/second (down), the module will be "tilted" 45 degrees to the left (ATT -45), and the power will be set to 75 units. If the user does not touch the keyboard, the module will descend to the lower right side of the screen before switching scales to one of the alternate landing sites; then it will finally crash.

To land the module, the user must slow down the descent rate by increasing (use the "I" key) the thrust (around 100 will do for starters. It my be necessary to hold down the key for a short time to enable the program to read it. If the program does not respond well to the keyboard, refer to section #7 for ideas on how to modify the program). This will also decrease the horizontal velocity and halt the movement to the right. Now, before the horizontal velocity decreases all the way to zero, lessen the left "tilt" by hitting the "R" key until the attitude becomes zero (the module is straight up). Then as the vertical velocity approaches zero, decrease the throttle (use the "D" key) to prevent the module from going back up (and leaving lunar orbit). A descent rate of 100 meters/second when the altitude reaches the switching point (1500 meters) is about right. After the screen switches to the close-up landing site, the power can be increased, and the attitude adjusted, to balance the module. The actual balancing point for the module is with a power between 15 and 20 units. Once the user has the module well balanced (hovering), he can then search the lunar landscape(by moving left or right) for a good place to land. The main landing site is located at a distance of 13,000 meters. The user must watch his fuel supply carefully to be sure he can land before running out. Note that it is far easier to land the module by watching the digital readings than by watching the module itself. Once the module has reached the ground (altitude is 0), the program checks the landing velocities to see what condition the module is in. One of the following messages will be shown.

FANTASTIC LANDING - Both the vertical and horizontal velocities were less than 5 meters/second.

GOOD LANDING - The vertical velocity is between 5 and 15 meters/second and the horizontal velocity is less than 5 meters/second.

ROUGH LANDING - SHIP DAMAGED - The vertical velocity was between 15 and 30 meters/second or the horizontal velocity was between 5 and 15 meters/second.

YOU CRASHED - Either the vertical velocity was greater than 30 meters/second or the horizontal velocity was greater than 15 meters/second.

6) SIGN CONVENTIONS

For the purpose of computing the modules position, the following sign conventions have been chosen.

Horizontal Velocity - Negative indicates movement to the left and positive to the right.

Vertical Velocity - Negative indicates a downward movement and positive upward.

Attitude - A negative attitude (tilt) indicates the rocket motors are trying to move the module to the left and a positive attitude will move the module to the right.

7) KEYBOARD REQUIREMENTS

The keyboard imput routine (located between 030300 and 030335) tries to simulate an interupt driven keyboard. It does this by checking input port 0 for a valid character (it will wait no more than 6 milliseconds). If none is found, the program will just continue. If, however, a key is pressed, a second routine is entered that lets the data settle for 3 more milliseconds (or until the strobe goes off). This character is checked to see if it is recognized, and if it is, the requested action is taken (unknown characters are ignored).

Because different keyboards may act in different manners, the user may have to alter this routine. Basically, this routine checks for a valid character and continues (through location 030336) with the valid character in register " C" (the strobe bit does not have to be set). If there is no valid character, exit the routine with a RETURN instruction(the stack should be left intact, but registers may be altered). If it becomes necessary to use more core than this routine has provided, memory above 036000 may be used up to 037300 (the stack is set to start at 037377 but does not drop below 037300).

The routine, as written, is designed for a keyboard that generates a valid character when a key is pressed (because the strobe is sometimes so short, the program may not reliably find it). Furthermore, as long as the key is pressed, this character remains valid (this allows parameters to be changed in a fairly quick manner by just holding the key down for some time).

8) ERRORS

If, when computing the modules position, an arithmetic overflow is detected, a special message will appear in the upper left hand corner of the screen over-writing the instrument readings (ERR?). When this occurs, all other processing will stop until a key is pressed. At this time, all registers are restored to their conditions prior to the error and the standard operating routine (TY DUMP) is called. This condition is most probably caused by a bad read of the program tape. If, after re-reading the tape, the problem continues, the user can check the SIN-COS table for errors (this is the most sensitive data area). This table starts at 020000 and consists of the SIN of the angles from -90 to 180 degrees in two's compliment integers (four bytes long); these SIN's have been multiplied by 64 and rounded to integer numbers. If no errors can be located, please notify the Digital Group Software so that corrective action can be taken.

APPENDIX I

Here are a couple of keyboard input routines for Lunar Lander. The first will work with boards that:

a) have short strobes, but data is valid (but not latched) as long as a key is pressed.
b) generate random characters until a key is pressed.
c) latched output boards with a strobe that's on as long as a key is pressed (or at least 10ms).

A second routine is for boards that just don't work with the above routine (latched output with short strobe, etc.). The problem with this routine is that it slows down Lunar Lander quite a bit. Try different loop counter values for the DGS keyboard to see what works the best.

KEYBOARD INPUT ROUTINE (I)

```
Ø3Ø3ØØ   KEY IN  333 ØØØ        IN A,Ø          GET CHARACTER
Ø3Ø3Ø2           247            AND A           CHECK FOR STROBE BIT
Ø3Ø3Ø3           ØØØ            NOP             THIS SHOULD BE A "RET P" FOR
                                                KEYBOARDS THAT "LATCH" THE
                                                OUTPUT (WITH LONG STROBES)
Ø3Ø3Ø4           117            LD C,A          SAVE CHARACTER IN "C"
Ø3Ø3Ø5           Ø21 ØØØ ØØ1    LD DE,ØØ1 ØØØ   SET LOOP CONSTANT, THIS CAN BE
                                                VARIED FROM Ø TO 377377
                                                TO SET THE DELAY FROM Ø TO 64Øms
Ø3Ø31Ø   LOOP    172            LD A,D          THIS LOOP
Ø3Ø311           263            OR E            WILL WAIT
Ø3Ø312           Ø33            DEC DE          FOR DE TO
Ø3Ø313           3Ø2 31Ø Ø3Ø    JP NZ,LOOP      EQUAL Ø
Ø3Ø316           333 ØØØ        IN A,Ø          GET CHARACTER AGAIN
Ø3Ø32Ø           247            AND A           JUST RETURN IF ZERO
Ø3Ø321           31Ø            RET Z           (NULLS NOT ALLOWED)
Ø3Ø322           271            CP C            IS THIS CHARACTER THE
Ø3Ø323           3ØØ            RET NZ          SAME AS BEFORE?
Ø3Ø324           366 2ØØ        OR 2ØØ          SET STROBE BIT
Ø3Ø326 - Ø3Ø34Ø ZERO                            SPARE WORK AREA IF REQUIRED
```

KEYBOARD INPUT ROUTINE (II)

FOR LATCHED OUTPUT BOARDS WITH SHORT STROBES (<10ms)

```
Ø3Ø3ØØ   KEY IN  Ø21 ØØØ Ø22    LD DE, Ø22 ØØØ  SET LOOP COUNT
Ø3Ø3Ø3   LP      333 ØØØ        IN A,Ø          CHECK KEYBOARD
Ø3Ø3Ø5           247            AND A           FOR STROBE
Ø3Ø3Ø6           372 32Ø Ø3Ø    JP M,FND        BIT HIGH
Ø3Ø311           Ø33            DEC DE          REPEAT
Ø3Ø312           172            LD A,D          UNTIL
Ø3Ø313           2Ø3            OR E            DE=Ø
Ø3Ø314           3Ø2 3Ø3 Ø3Ø    JP NZ,LP
Ø3Ø317           311            RET             NO KEY, RETURN
Ø3Ø32Ø   FND     117            LD C,A          STROBE BIT
Ø3Ø321           333 ØØØ        IN A,Ø          FOUND, WAIT
Ø3Ø323           271            CP C            FOR IT TO
Ø3Ø324           3Ø2 32Ø Ø3Ø    JP NZ, FND      GO OFF
Ø3Ø327           171            LD A,C
Ø3Ø33Ø - Ø3Ø34Ø ZERO                            ROOM FOR EXPANSION
```

APPENDIX II

The Lunar Lander was written to use the Z-8Ø operating system that goes with the system. Lunar Lander is written in 8Ø8Ø code but references the operating system as follows:

```
Ø2Ø 362      CALL TVEDIT
Ø2Ø 367      CALL WAIT (1/10 seconds)
Ø31 364      CALL TVEDIT
Ø31 367      CALL KEYBOARD
Ø31 374      JUMP STORAGE DUMP
```

The section #7 of the documentation, "Keyboard Requirements", may be changed to reflect the revised input routine. The new routine:

1) checks for a character.
2) for "latched" output boards; also, checks for a strobe bit by making location Ø3Ø 3ØØ contain 36Ø (RET P).
3) enter a delay loop. Decrement DE down to ZERO. Increase or decrease the initial value of DE to suit your needs.
4) checks keyboard again. If the same character is found, call it valid. If not,just return.

Program requires:

1) 64 character TV display (64 TVC)
2) 8K minimum memory
3) ASCII keyboard

Program features:

1) real-time response
2) complete instrument readings
3) two-dimensional display including module against lunar landscape
4) complete user control

For those hard to land spots, try increasing the fuel available. The location is Ø17 ØØØ, 4 byte signed integer.