MICRODEAL would like to thank Trago Mills for the use of the pictures of their SAH1 Light Trainer Aircraft on the cover of this box. The SAH1 is produced in Cornwall by Trago Mills, Liskeard, Cornwall.

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QL FLIGHT SIMULATOR

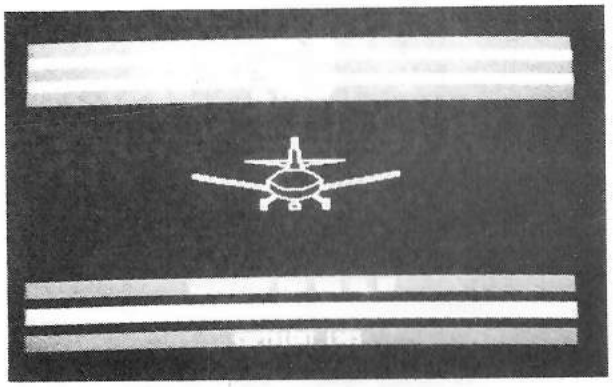
MANUAL

MICRODEAL

Q L FLIGHT
BY MICRODEAL

1.0 INTRODUCTION

WELCOME to Q L Flight if you are impatient to get flying then follow the loading instructions in chapter 2 then go immediately to chapter 7 where "CIRCUIT" flying is described.
Q L Flight is not a game and has not been written to be a game, it is a true representation of a light aircraft and has been written by a pilot, tested by a pilot and hopefully will be used by existing pilots and student pilots alike. You do not have to have knowledge of flying to use Q L Flight but for the novice the book outlined in the Hints and tips section would prove invaluable.



THE OPENING SCREEN

QL FLIGHT (QLF) is a "view" oriented flight simulation for the SINCLAIR QL Computer. "View" oriented means that the user (or pilot) may determine his or her position by actually viewing the surrounding landmarks as opposed to using instruments which sense navigational references. This is a major departure from "instrument only" simulations which can be achieved through BASIC programs.

The aircraft modelled is an experimental, sport-trainer type and thereby lacks most of the instruments necessary for purely instrument capability. However, most instrument manoeuvres and procedures may be practiced. The craft is a light-weight, single-wing aircraft with low wings and a "T" tail. A nose wheel which is both steerable and retractable is also modelled. The pilot is seated in the nose section and is surrounded by a high-visibility ("bubble") windshield. Some aerobatics are possible including sustained inverted flight, aileron rolls, spins and stalls.

Instruments indicate: wheel brakes, gear position, flap position, fuel, elevator trim, stall, altitude, heading, indicated velocity,

ground speed, rate of climb, engine speed, 2 Min.turn, sideslip and pitch and roll attitudes. The engine may be started and shutdown and there are re-fuelling stations at each airport which may be taxied to if re-fuelling is required.

In terms of visual effects QLF utilizes Hi-Res "wire" (or line) graphics to define landscape features. The pilot usually looks straight ahead; however, his or her viewing angle may be incremented in 90 degree increments in the horizontal plane and in 8 degree increments in the vertical plane. A unique "RADAR" or overhead view visually pinpoints your crafts exact position and direction of travel. This is essential to instrument manoeuvres or when flying above cloud ceiling.

QLF features HI-Res graphics, optional joystick control, realistic response, and sound. The pilot may fly into and out of nine different "worlds" and control the weather conditions in each of these worlds. All worlds are fully 3-D in nature and contain objects or scenery which must be avoided (e.g. towers, mountains etc.). Every effort was made to contain the technical "correctness" of the flight dynamics as well as the visual display out of the window. The result is a serious and challenging observation of one of the most fascinating experiences of modern man..... The Experience of Flight.

2.0 LOADING

Before running the game for the first time we strongly recommend that you make at least one backup copy of the cartridge. To do this press the reset button and then F1 or F2 as normal. Now place the original cartridge in drive 1 and a blank cartridge in drive 2. Note that the blank cartridge in drive 2 need not be formatted and that any files already on it will be destroyed. Type in LOAD MDV1_BACKUP and press the enter key. When the backup program has loaded type RUN and press ENTER. After about ten minutes you will have a complete backup cartridge in drive 2. You can make further backup copies in the same way either from the original cartridge or from any of your backup cartridges. The backup cartridge is then placed in drive 1 and the original cartridge in drive 2 whenever you wish to use the program. Note that the program will load from either the original or any backup in drive 1 but if you are using a backup the original cartridge must be placed in drive 2 or the program will not run. The protection method used is very reliable and and the above method will work even when the original cartridge is years old, damaged and unreadable!

3.0 GENERAL PROGRAM OPERATION

This section describes the operational "flow" of QLF in general. It details how the simulation sequences through its various phases and how it is intialized (setup) and reset.

3.1 INITIAL DISPLAY

Initially the program goes through an opening display featuring an aircraft aileron roll. After the engine sound stops, the display may be exited by pressing the [ENTER] key. This sequence is never repeated and is followed by the DEFINE WORLDS phase.

3.2. DEFINE WORLDS

This portion of the program is entered after the initial display and after a CRASH or RESET of the simulation. This is the part of the program which allows the user to change or control the weather conditions in each of the nine worlds. Control is initiated by pressing the first letter of the first word in each of the controllable parameters. An example would be "W" for World Select. After pressing the "W" a white square will appear over the position of the previous world number. This is your prompt to enter your selection which should be a number between "1" and "9", all others are ignored. Pressing a "3" will draw World No.3 and allow the weather conditions to be changed in that world. The world displayed is the world in which changes may be made. It is also the world in which the simulation will begin until the "B" key (Begin in world) has been pressed and a new world number is specified. Initially, the DEFINE WORLD sequence starts in the middle world (No.5 - the practice Field). After a CRASH or a RESET the world displayed is the one in which the CRASH or RESET occurred. The following is a description of the control keys in DEFINE WORLDS and the limits of their inputs:

KEY — DEFINE WORLDS CONTROL DESCRIPTION

S - Allows user to set the SPEED of the wind in knots.Two digits must be entered from 00 to 29 knots. All other keys or numerical values are ignored.

F - Allows user to set the direction in degrees FROM which the wind is blowing. Three digits must be entered from 000 to 359. All other keys or numerical values are ignored

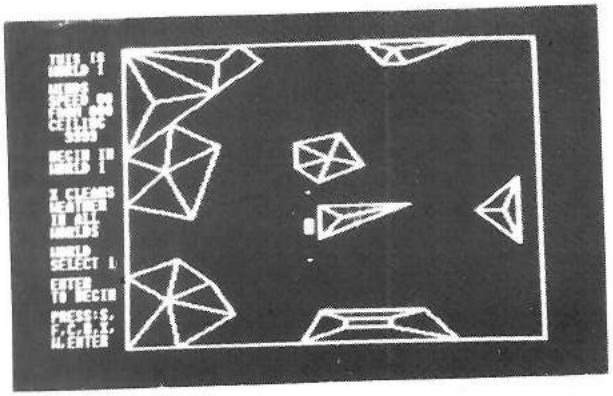
C - Allows the user to set the CEILING in feet below which the ground and other landmarks are visible through the aircraft windows. This parameter does not affect the RADAR view. Four digits must be entered from 0000 to 9999. All other keys or numerical values are ignored.

B - Allows the user to set the world in which the simulation will BEGIN. A single digit must be entred from 1 to 9. All other keys or numerical values are ignored. If unspecified, the simulation begins in the last displayed world before (ENTER) was pressed.

X - Allows the user to X-OUT or clear the weather conditions in all the worlds at once. A clear is sefined as; SPEED 00; FROM 00: CEILING 9999. These are also the default values if the weather in a particular world is never specified.

W - Allows the user to select any of the nine WORLDS for the purposes of view or specification of weather conditions. Value is initially "5" and thereafter takes on the value of the world in which a CRASH or RESET has just occurred.

ENTER - Pressing this key exits the DEFINE WORLDS phase and transfers control to the flight simulation with the parameters specified during the DEFINE WORLDS sequence. The (ENTER) key is the only exit.



THE DEFINE WORLDS SCREEN

3.3. FLIGHT SIMULATION

This is the heart of WORLDS OF FLIGHT and can only be entered from the DEFINE WORLDS phase. Ths initial starting position is always at the south end of the runway within the runway scene. In order to provide a much more realistic and detailed take-off and landing simulation, a separate runway scene has been provided. Although the locations of the runways are different in each world, the runway scenes are the same and oriented on a north-south heading. Shortly after take-off the scene transitions from the runway graphics to the appropriate world scene. As your flight path crosses the boundaries of your current world, a transition takes place into an adjacent world. The layout of the nine worlds is given by the following diagram:

WORLD LAYOUT

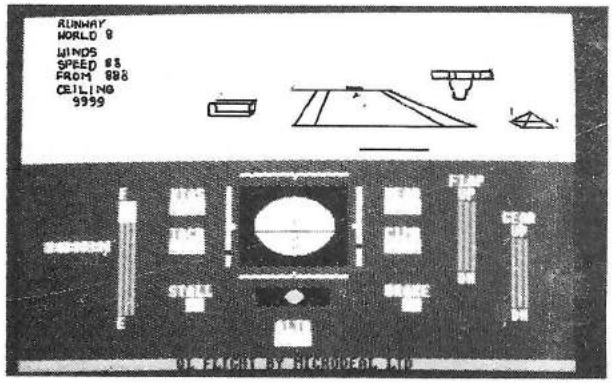
NO. MOUNTAIN WORLD NO.1	NO.2 ARABIAN GULF	NO.3 PANAMA CITY
NO.4 DAHLGREN VA.	NO.5 PRACTICE FIELD	NO.6 MOUNTAIN WORLD NO.2
NO.7 ISLAND BAY	NO.8 MOUNTAIN WORLD NO.3	NO.9 POWER LINE RIVER

As the aircraft approaches the runway, the graphics will once again transition to the runway scene. The requirements for a transition to the runway scene are as follows:

* Altitude - Below the CEILING or 400 feet whichever is less
* Range-to-Runway Threshhold: 3888-4401 feet

* East-West Drift - +-864-978 feet off runway centreline

It should be noted that the representation of the runway or airport before the transition to the runway scene is very simple, (two reference marks to aid the final approach and an elongated rectangle as the runway itself). Its sole purpose is to provide a "target" to the pilot relative to which he or she may make manoeuvres leading to final approach.



APPROACHING THE RUNWAY PRIOR TO LANDING

As with real aircraft, control inputs have been simulated not to cause instantaneous responses. Characteristic of all aircraft is a slowly oscillating but damped pitching motion called PHUGOID which occurs in response to an elevator or throttle control command. For instance. suppose you are flying along straight and level, then pull the elevator stick back. Assuming that you don't stall, the aircraft will first overshoot your new pitch attitude then undershoot it! This may continue for another cycle or so but it will eventually stop or "damp". You will see this happen in intervals, which is the update rate of the simulation.

3.4. FLIGHT TERMINATION

The simulation is running continuously unless the [P] or [ESC] keys are pressed. The [P] key completely "freezes" the entire simulation including the engine sound. Pressing the [P] key again, immediately causes resumption of the simulation. This feature may be used as many times as necessary. The [ESC] key totally RESETS the simulation and goes back to the DEFINE WORLDS sequence. A CRASH also causes a termination of the simulation preceeded by a violent explosion, a colour-filled screen and a data block in the upper left-hand corner indicating your impact coordinates, and the world in which you CRASHED. If you CRASHED in the runway scene, your coordinates may have negative values (see 8.0 MAPS). A CRASH is caused by:

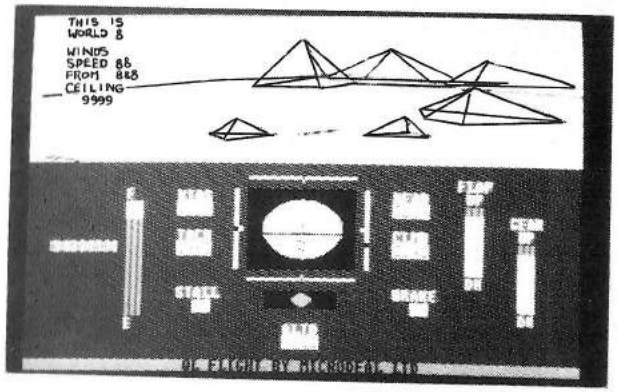
* AN OUT-OF-TOLERANCE LANDING

* A LANDING OR TAKE-OFF, OFF THE RUNWAY
* IMPACT WITH THE SCENERY (MOUNTAINS, TOWERS, ETC)

As before, pressing the [ESC] key causes a RESET from the CRASHED condition to the DEFINE WORLDS sequence where the worlds may be respecified and the FLIGHT SIMULATION re-entered.

4.0 UNDERSTANDING AND CONTROLLING THE GRAPHIC VIEWS

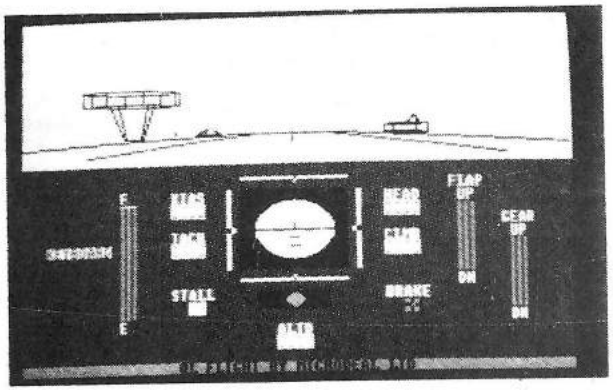
QLF uses "wire" (or line) graphics to represent the various worlds. This method minimizes the memory required for each world and maximizes the speed at which the 3-D scenes can be drawn. As a result of some of the techniques used, QLF also provides "flicker-free" animation of the graphic scenes. For a more detailed discussion of "wire graphics", the user is encouraged to refer to the Appendix under the title "Representation of Graphic Scenes".



SCENERY AS WIRE GRAPHICS

4.1 WIRE GRAPHICS

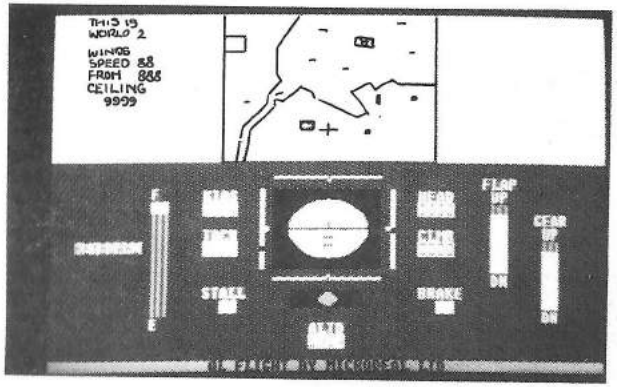
Wire graphics define only the outlines or contours of the objects they portray. To some, the "phantom" appearance of the objects represented in this fashion causes some visual difficulty in actually interpreting what they are supposed to be seeing. Yet, to others, the objects are obvious. All this is to say, that it may take some "getting used to" before some users begin to visually intepret the significance of every detail "seen" out of the windows. For these reasons, a significant help has been installed into the simulation which should substantially aid in determining one's position and understanding of his or her surroundings. This is the ability to change ones viewing angle relative to the aircraft's orientation, or a PANORAMIC VIEW capability.



VIEW OF THE RUNWAY WITH 8 DEGREE DOWNWARD PITCH

4.2 PANORAMIC VIEWS

The ability to "Pan-around" is the equivalent of rotating your head (your viewing angle) left to right and up and down. This feature is controlled by the arrow keys. The [ALT/UP ARROW] key rotates your view to straight ahead again, just in case you get disorientated. Your view is normally depressed (pitched down) 8 degrees relative to the aircraft's pitch attitude. This is the natural look-down of the pilot's line of sight over the instrument panel. After the aircraft's altitude (climb angle + angle of attack) exceeds an 8 degree pitch up, the forward looking view becomes AUTO-LEVELLING. This is the equivalent of pitching the pilot's head one degree downward for each degree the aircraft pitches upward past 8 degrees. Consequently the centre of the elevation view is never above the horizon. While this may be somewhat unrealistic (although there is a natural tendency to do it), the feature allows the pilot to view at least some of the horizon even in a steep climb rather than just sky. Once the craft pitches below 8 degrees, the "pitching motion" of the scenery will return. Above 1500 feet at a maximum climb, even auto-levelling does not insure a horizon as you fly to the "edge" of a world; use the [DOWN ARROW] to get it back. The cross-hair in the centre of the straight ahead view indicates where the aircraft is headed. The cross-hair can be used to determine if the aircraft is above or below an object by incrementing the view UPWARD [UP ARROW] until the view stops moving downward in response to the key. This is where the AUTO-LEVELLING feature takes over and the resulting view represents a true elevation view relative to the scenery. Press the [ALT/UP ARROW] key to re-establish the normal 8 degree depression.



RADAR VIEW OF MOUNTAIN WORLD NO 2

4.3 RADAR VIEWS

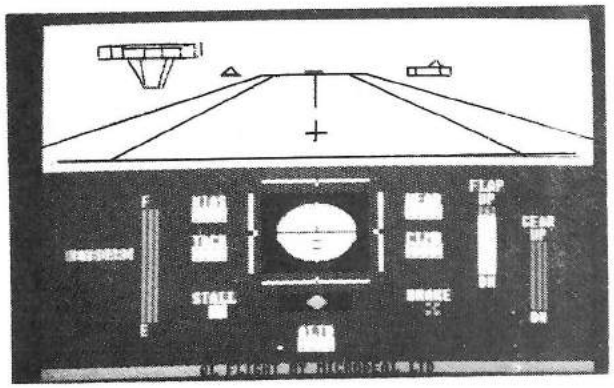
Another related feature is the "RADAR" which can be thought of as an overhead or "birds-eye" view (downward looking) of your world with a cross-hair at your exact position. In this view, the top portion of the "+" is pointing in your direction of travel or heading. The RADAR view is toggled (both entered and exited by [TABULATE]). It also has a variable magnification [ZOOM] feature which is controlled by the [Z] and [X] keys. Both the PANORAMIC and RADAR views are available at any time during the simulation. Liberal use of these features is recommended, especially the RADAR feature. When flying instrument practice or above the cloud ceiling the RADAR view is the only precise check available on position (the clouds obscure the ground features out of the aircraft windows).

The following is a summary of the VIEW CONTROL functions:

UP ARROW	Elevate the vertical viewing angle 8 degrees
DOWN ARROW	Depress the vertical viewing angle 8 degrees
RIGHT ARROW	Move the horizontal viewing angle 90 degrees to the right
LEFT ARROW	Move the horizontal viewing angle 90 degrees to the left
ALT/UP ARROW	Set the horizontal view straight ahead with an 8 degree depressed vertical viewing angle
TABULATE	Toggles the RADAR or overhead view. To exit press TABULATE again
[Z]	Enlarges (ZOOMS) the RADAR view by a factor of 2
[X]	Reduces the RADAR view by a factor of 2
[8]	"Inverts" the video of all graphic views Press 8 to return to the original format.

NOTE: PANORAMIC views are relative to aircraft attitude.

5.0 THE INSTRUMENT PANEL AND FLIGHT CONTROLS



THE INSTRUMENT PANEL

5.1 INSTRUMENTS

In order to describe the instrument display, it is best that the instrument panel be visible. If it is not at this time, go through the loading process and exit the initial display. When world No.5 appears press the "S" key followed by a "05". Then press the "C" key and enter 5000. You have just set the wind speed at 5 knots and the ceiling to 5000 feet in World No.5. Now press [ENTER]. The instrument panel should appear. The instrument displays will now be discussed starting from left to right.

5.1.1 ELEVATOR TRIM INDICATOR

This display indicates the position of the elevator trim. Trim initially being in the centre (0) position. Trim position is controlled by the buttons. [V] - Trim UP. [R]- Trim DOWN.

5.1.2.FUEL GAUGE (FUEL)

This bar gauge indicates how much fuel you have. The rate of fuel loss is proportional to throttle position. At full throttle you have approximately 50 minutes of fuel in a full tank, when you run out, your engine will shut down, if you're on the ground then you're stuck without the ability to move your aircraft, so you will have to RESET [ESC] the simulation unless you can coast to the re-fuelling area. If you run out of fuel in the air you'll have to perform a power-off landing and then roll to the re-fuel area (a next to impossible task!!!).

5.1.3 KNOTS OF INDICATED AIR SPEED (KIAS)

This instrument measures the speed of the wind flowing over the aircraft. This is a RELATIVE or INDICATED wind velocity NOT GROUND SPEED. If you have followed the suggested setup, this display should read 0005 knots because of the 5 knot wind that we previously set in. Now press the [A] key once and the digital display will "invert". This is your ground speed - 0000. All aerodynamic forces on the aircraft depend on the INDICATED or RELATIVE velocity, NOT ground speed. This feature is purely a navigational aid. Don't ever fly by the white-on-black ("inverted") numbers! Press the [A] key again and the display will return to its normal black-on-white format.

5.1.4 ENGINE SPEED (TACH)

This is the engine tachometer. It measures engine speed in 80 rpm intervals. A different engine sound is heard every 320 rpm. Wide open throttle is 2560; idle is 640. The pressing of the [+] and [-] keys on the top row controls the throttle. The engine is STARTED by pressing the [I]for ignition key. The engine is SHUTDOWN when on the ground by pressing the [S] key. The engine can't be shutdown in flight (why should you want to?) Try it now. Make sure the brake is set (black cross in a small box below CLMB readout), set it by pressing the [ENTER] key until the cross appears. Then start and shutdown the engine a few times and play with the throttle.

5.1.5 STALL INDICATOR (STALL)

This little square indicates that a stall is occurring. A black cross appears along with a raspy, stall-warning tone. This tone occurs whenever the angle-of-attack builds up to 16 degrees. (See section 7.2.1. Stalls). When a stall occurs the yoke centres itself.

5.1.6. ARTIFICIAL HORIZON (Centre Instrument)

This is the instrument most familiar even to non-pilots. It visually conveys aircraft pitch and roll attitude. Your aircraft is represented by a coloured "W" which does not move. Your horizon is represented by a dark line. This line translates up and down indicating changes in pitch attitude and rotates about the horizontal centreline of the instrument to indicate roll attitude. Note that although the representation of the aircraft does not move, the instrument nonetheless is attempting to portray your aircraft's attitude relative to the horizon as if you were actually inside the aircraft and looking out of the window. The short tick marks on the horizontal centre of the instrument but just below the horizon line are spaced every 10 degrees of pitch attitude and move with the horizon. They also indicate where the "ground" is relative to the horizon. When flying level but inverted for example, these marks appear in the upper portion of the instrument indicating that you are indeed upside down. The small tick marks located along the circumference of the instrument are also placed at every 10 degrees of pitch attitude, thus helping to determine a quantitative measure of your craft's pitch attitude.

5.1.7 SIDESLIP INDICATOR (Ball-Below Artificial Horizon)
This instrument indicates whether or not your aircraft's turns are coordinated. It has been added for the sake of functional "correctness", however in a banked turn it has little or no dynamic effect on the turn itself. Since the consequences of uncoordinated turns (side forces on the pilot) cannot be simulated, you will probably find little need to coordinate your turns (centre the ball), but if you would be perfect, apply rudder in the direction of the ball. In non-banking flight, the rudder may be used to skid-turn but this is not a standard producedure. For this very reason rudder "power" has been purposely made rather weak (can only produce a maximum of 2 deg/sec).

5.1.8 ALTIMETER (ALT)
Just below the sideslip indicator is the ALTIMETER. It always reads altitude above the ground or above ZERO absolute altitude. The runway is always at "0" altitude and all the various world features are also referenced to a "0" altitude base.

5.1.9 COMPASS (HEAD)
This compass reads relative to true North. It has one special feature. When banking to turn the heading readout goes to an "inverse" video display whenever the aircraft is in a 2 MINUTE TURN (3 deg/sec turn rate)

5.1.10 RATE-OF-CLIMB INDICATOR (CLMB)
This readout displays the aircraft's rate-of-climb or rate of descent in feet per minute. Descents are indicated by a minus sign. The readout has a dynamic range of -9999 feet per minute.

5.1.11 BRAKE INDICATOR (BRKE)
Just below the rate-of-climb indicator is a small square indicating whether the wheel brakes are set. If set, a black cross appears in the box. Brakes are toggled on and off by the [ENTER] key while on the ground but may not be set while flying. These brakes are strong enough to hold against a maximum throttle "run-up" and are the only positive way of completely stopping the aircraft once it is rolling.

5.1.12 FLAP INDICATOR (FLAP)
The flaps may be lowered to 60 degrees in 10 degree increments. This is denoted by an incremental lengthening of the bar gauge. The flaps are fully down when no white is showing. The [N] key lowers the flaps; the [Y] key raises them again.

5.1.13 GEAR INDICATOR (GEAR)
This bar gauge is very similar to the flap gauge. It indicates the gear position. The minimum length with a single block showing indicates gear up, the maximum with no white showing - gear down. The [U] key raises the gear.The [D] lowers the gear. Gear may not be raised while on the ground.

5.1.14 RUDDER INDICATOR (Below the atrificial horizon)
This indicator is set at the central position on initial startup and will move 2 places to the right or left by pressing the keys [C] or [M].

5.1.15 AILERON INDICATOR (Above artificial horizon)
This indicator shows the position of the yoke. Moving the yoke (one press of the [H] or [F] keys or one movement of joystick to the left or right) will put the aircraft into a banked turn. To centre the ailerons once the required amount of bank has been reached press the joystick fire button or press the [G] key.

5.1.16 ELEVATOR INDICATOR (To the right of the artificial horizon)
This indicator shows the position of the elevators which are controlled by forward and backward movement of the joystick or by the [T] and [B] keys.

5.1.17 KEYBOARD/JOYSTICK INDICATOR
To the left of the fuel gauge the word JOYSTK or KEYBRD appears to tell you whether you are in joystick or keyboard mode. The simulation always starts in keyboard mode. Pressing either the [J] or [K] keys will switch you from one mode to the other.

5.2 FLIGHT CONTROLS
Real aircraft are flown by stick or yoke back pressure. The motion of the aircraft and back pressures that the pilot feels on his controls (elevator, ailerons and rudders) communicate what additional control inputs, if any, are needed. Without some elaborate and expensive control simulator to hook up to your home computer, stick feedback pressure is impossible to simulate. And as for the motion of the aircraft - FORGET IT! (Now you're talking millions of pounds). However, model aircraft enthusiasts fly without these feedbacks, although they can view the aircraft's altitude and usually have self-centering springs on their controls. So there is hope for joystick control even though some loss of realism is unavoidable.

5.2.1 KEYBOARD/JOYSTICK CONTROL
QLF was designed to offer the option of keyboard or joystick control of the elevator and ailerons. The [K] key selects the keyboard (QLF always starts in this mode) whilst the [J] key selects the joystick. The joystick should be plugged into the CTRL2 socket.

5.2.2. THROTTLE
The [+] and [-] keys produce THROTTLE changes in small increments of 80 RPM. The [+] key opens the throttle, the [-] key closes it. Additional controls have been provided to give immediate full throttle and a cut of the throttle to idling speed. the full throttle control is provided by the [] key and the cut of the throttle by the [[] key. Since this control provides well defined thrust characteristics, THROTTLE can and should be used to make SMALL ADJUSTMENTS in the RATE-OF-CLIMB of the aircraft. For example, suppose you are flying at 70 knots and climbing at 120 fpm and you want to level your flight at 70. You could - a) push the elevator stick forward but you may speed up since this is a course attitude control; b) trim down. This may work since the trim control is much finer elevator control but you may

still speed up; c) REDUCE THROTTLE (probably 160 rpm) and presto! - straight and level at 70 knots without ever touching the trim or the elevator. Want to climb at 70 knots?..... Throttle up. Want to dive at 70 knots? .....throttle back.

5.2.3. ELEVATORS
These are controlled by forward and backward movement of the joystick or by the [T] and [B] keys. The degree of elevator movement is displayed on the small vertical bar gauge to the right of the artificial horizon. Extreme backward movement will almost always result in a stall whilst extreme forward movement results in heavy loss of height.The throttle should be used to control the rate of descent or climb at a constant speed, however the combination of elevator and elevator trim (V _R keys) controls the equilibrium velocity of the aircraft at a constant throttle setting. For example, assuming a wide-open throttle, the elevator stick would need to be nearly centred (trim at 0) with the aircraft "clean" (gear up - flaps up) to cruise straight and level at 90 knots (104 mph). Pushing the stick slightly forward will cause a dive but no longer at 90 knots. As a result the engine may overspeed and the airspeed increase to over 100 knots. Pulling back on the stick will cause a climb but once again not at 90 knots; maybe 80, 70, 60 or even as slow as 50 knots. Since almost all manoeuvres are specified at a particular indicated velocity (KIAS), the elevator/trim combination becomes the primary control of airspeed at a constant throttle setting. For instance, suppose you are level at a 60 knot cruise, but would like to be straight and level at 90 knots. You must do two things at once; open the throttle (cause a climb) and slowly push the stick forward (cancels the climb caused by throttle). Small adjustments can be made by the elevator trim to maintain level flight. When this is done, look at your airspeed....88 to 92 knots in level flight.

5.2.4. AILERONS
The indicator above the artificial horizon shows the position of the yoke.Moving the yoke to the right (one press of the H key or one right movement of joystick) will move the ailerons and put the aircraft into a banked turn, once the correct turning rate has been reached centre the stick immediately (Joystick fire button or G key).The left right motion of the joystick or the [F] and [H] keys cause a roll rate that is proportional to the degree of movement shown on the horizontal bar gauge. The extreme settings of this control should only be used when a large roll correction is necessary, for normal flight especially landings these extreme control zones should be avoided.

5.2.5. RUDDER
The [C] and [M] keys control the aircrafts rudder and nose wheel. The degree of movement is displayed on the bar guage below the artificial horizon.When on the ground these keys control the nose wheel. In the air it controls the rudder. It has 2 large control zones to either side. While on the ground the nose wheel gives a 4 deg/sec turning rate in zone 1 and 8 deg/sec in the extreme zone. In the air the turning rates due to rudder are 1 and 2 deg/sec, respectively. Note that the rudder is the only way to steer the aircraft on the ground. The [G] key centres the rudder as well as the ailerons both on the ground and in the air.

5.2.6. ELEVATOR TRIM
The ELEVATOR TRIM is controlled by the [R] and [V] keys. The [V] key trims up 1 degree and the [R] key trims down 1 degree of elevator. An elevator trim range of +/- 4 degrees is available.

5.2.7. ENGINE START
Pressing [I] starts the aircraft's ENGINE whilst on the ground. (You are not allowed to shut-down the engine in flight, so you won't need to restart it!)

5.2.8.FLAPS
The [N] key LOWERS the FLAPS in 10 degree increments, press and hold the [N] key until the bar gauge shows no white if you require full flaps. The [Y] key RAISES the FLAPS 10 degrees. Flaps affect aircraft trim.

5.2.9. GEAR
The [U] key starts to raise the landing gear. The [D] key starts to lower the gear. Gear position like the flaps affect the aircraft's trim. Press and hold the key to fully raise or lower the gear.

5.3 AIRCRAFT PERFORMANCE
The following is a summary of the simulated aircraft's performance characteristics:

MAXIMUM CROSS WEIGHT	600 LBS
ENGINE HORSEPOWER	40 H.P.
FUEL CAPACITY	17.5 GALLON
BEST RATE OF CLIMB	1020 FPM @ 60 KTS
BEST CLIMB ANGLE	900 FPM @ 50 KTS
MAXIMUM CRUISE SPEED (CLEAN)	90 KNOTS
MAXIMUM DIVE SPEED (CLEAN)	120 KNOTS (SIMULATION LIMITS THE ALLOWABLE DIVE ANGLE SO THAT AIRCRAFT STRUCTURAL LIMITS ARE NEVER EXCEEDED)
SERVICE CEILING	8960 FEET
STALL SPEED (CLEAN)	46 KNOTS
STALL SPEED (GEAR AND FLAPS)	42 KNOTS
MINIMUM TAKEOFF ROLL	864 FEET
MINIMUM LANDING GROUND ROLL	506 FEET
FUEL CONSUMPTION RATE	21 GAL/HR MAX.THROTTLE
MAXIMUM RANGE _ENDURANCE	109 MI IN 1.9 HRS @ 50 KTS @ LESS THAN 1500 FEET @ 960 RPM
MAXIMUM ROLL RATE	20 DEG/SEC (AILERON POWER LIMITED BY SIMULATION FOR BETTER "FAST--ROLL" CONTROL)
INVERTED FLIGHT TIME	SAME AS NORMAL FLIGHT (FUEL AND OIL SYSTEM IS PRESSURIZED)

5.4 SPECIAL FEATURE CONTROLS
The following controls do not directly affect the flight of the aircraft. They are, however, special aids which are available to the pilot.

5.4.1 TWO MINUTE TURN
Although a standard 2 min. turn undicator is not present on the instrument panel, an indication of this standard turn is available by way of the compass (HEAD) readout. Whenever the aircraft is in a 2 min. turn the head readout will go into inverse video format.

5.4.2.THE "A" KEY - GROUND SPEED INDICATOR
GROUND SPEED (previously mentioned in 5.1.3) is not usually available on demand to small aircraft pilots, but since it is calculated by the simulation it has been made available. To obtain your ground speed in knots, press the [A] key and the KIAS readout will go to an inverse video format. The inverse video indicates that the speed reading is GROUND speed. Press the [A] key to return to the normal display format and Knots of Indicated Air Speed (KIAS).

5.4.2 THE [W] KEY - WEATHER INFORMATION
Pressing the [W] key will cause a data block to appear in the upper left of the aircraft window. This data block identifies the current world and its WEATHER CONDITIONS. This display automatically disappears after five seconds. World identification and weather information will also appear during a transition to another world or any transition to the runway scene. The data block accompanying the runway scene will identify itself as "RUNWAY" WORLD No.1 to 9. So if you are confused as to which world you are in, or you have forgotten the weather info, just press the [W] key.

5.4.4. THE TAXI FEATURE
In order to provide for stable and controllable manoeuvres off the runway, a taxi feature has been added. It provides a steady 10 knot GROUND speed TAXI and allows the aircraft to move off the runway for the purposes of re-fuelling or just taxiing around. This is how TAXI is performed:

* Set the brakes so that the GROUND SPEED is 0000
* Throttle back and maintain an idle of 640 rpm
* Release the brake
* Steer with the rudder

As soon as the throttle is moved above 640 (dead idle) the simulation will assume that you are throttling up for takeoff and your craft MUST BE ON THE RUNWAY to avoid a CRASH.

5.4.5. THE [S] KEY - ENGINE SHUTDOWN
The [S] key shuts down your engine whilst on the ground. The key is ignored in flight.

5.4.6 THE [SPACEBAR] - REFUELING
Both ends of the runway have a refueling station. Each station consists of three refueling locator marks and an adjacent fuel storage pyramid. To refuel, establish a TAXI and switch to the overhead or RADAR view (this is not required, it just makes it easier). Then manoeuvre with the rudder control (nose wheel) until your position cross-hair is heading inside of the three marks. Set the brakes so that your aircraft stops inside of the three locator marks. Now shut down your engine. When this is complete, press the [SPACEBAR] key and the refueling sound will be heard. If you are really low, it will take a while. Leave the other controls alone while refueling. Once you are full, restart your engine and be on your way.

6.0 NAVIGATION AND COLLISION AVOIDANCE
This section assumes that some pilots would like to know how the simulation handles navigation and that you would like to know what situations cause a CRASH.
6.1.1 LANDING REQUIREMENTS
The following conditions must exist at touchdown (ALT=000) in order to produce a successful landing which is accompanied by "WHEEL NOISE"; otherwise a CRASH will result.

POSITION: Completely ON THE RUNWAY at touchdown and DURING ROLL-OUT. In other words, stay on the runway until you have stopped.

GEAR POSITION: Completely DOWN and locked.

DESCENT RATE: Less than or equal to 360 feet per minute. 360 fpm is a HARD landing but survivable. HARDER landings are assumed to cause aircraft damage or a CRASH.

ROLL ALTITUDE: Less than or equal to 16 degrees either way.

HEADING: NOT restricted but remember when your nose wheel touches - you begin to turn on the nose wheel if your heading is not 0 or 180. Generally a few degrees either way is NOT critical.

6.1.2 TAXI-ING AROUND THE AIRPORT
After establishing a TAXI you may use the rudder to steer about within the runway scene. You must avoid running into objects with height such as fuel tanks or the tower. The runway layout is detailed by MAP 8.10. The locator marks are labelled "NO CRASH" and will NOT cause a CRASH. This is a good time to practice using the various views so that you will become accustomed to how things appear as you pass them, (taking off while looking backwards is interesting!). For example, taxi straight up the runway and switch to RADAR view [TABULATE]. Note the cross-hair, it helps you determine when objects are directly ahead, directly beside or directly behind you. As the tower approaches directly to your left, switch back to the window view [TABULATE] and increment your view to the left once (90 degrees) [LEFT ARROW]. The tower should be going by. As it passes, increment to the left one more time (180 degrees) [LEFT ARROW] to see it as it moves behind you.

A side note here. It is possible to taxi right out of the runway scene into the world scenes, although at 10 knots it wouldn't be fast. You must still avoid obstacles. Turning around and heading back to the runway will eventually get you back.

6.2 WITHIN A WORLD
Objects and scenery must always be avoided except in WORLD NO.5 (The Practice Field). The MAPS in Section 8.0 are accurate enough to navigate by with a high degree of precision. Remember to compensate for the wind if you are really serious about flying over a particular point at a particular time.

6.3 WORLD TO WORLD
When a WORLD boundary is crossed, a transition to another WORLD occurs. The outside boundaries wrap-around NORTH to SOUTH and EAST to WEST as described by Section 3.3. Navigation across multiple worlds is precise and repeatable since the worlds have truly common boundaries. So one may fly diagonally across World No.9, No.5 and No.1 (fuel permitting) and eventually end up on the same heading back at your initial starting position in World No.9. This assumes of course that you did NOT set the winds in these worlds, (see figure below).

EXAMPLE TRANSWORLD FLIGHT PATH

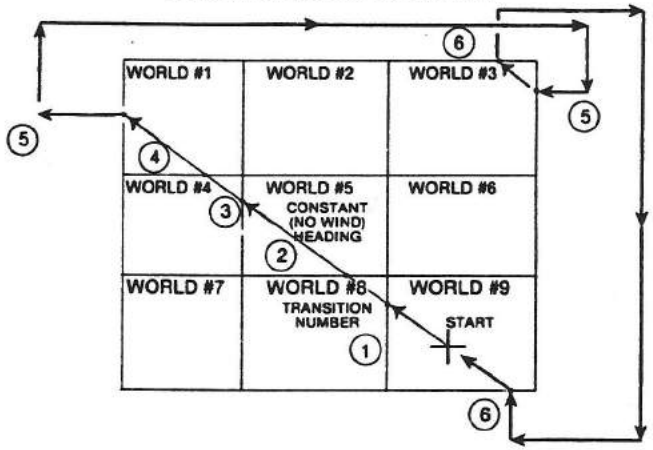


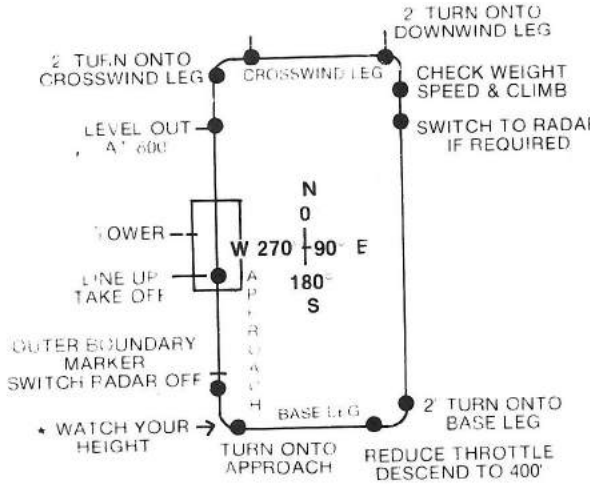
DIAGRAM: TRANSWORLD FLIGHT PATH

If the weather conditions are different in the world you are transitioning to, you will instantaneously (upon transition) be flying in the new set of weather. This could greatly upset the trim of your aircraft, so be forwarned. Also, when approaching "transition", check closely the "lay of the land" in the world you will be entering; there may be mountains of significant height on the borders. Without adequate altitude, you may transition SMACK INTO A MOUNTAIN. To be sure, once again, consult your MAPS (Section 8.0)

7.00 AIRCRAFT MANOEVRES
This section describes some suggested techniques for performing some rather basic aircraft manoeuvres and a few aerobatics. These are by no means the only way to do things nor are they necessarily the accepted ways, but they do work.

7.1 FLYING A CIRCUIT THEN LANDING:
The student pilot, when learning to fly, must first fly between 8 and 10 hours of practice "circuits" to learn the basics of flying e.g. direction, stability, landing etc. As, with this simulation you can't have a qualified pilot instructor sitting next to you, by following the basics below you will be able to take off, fly a circuit then land again. It must be noted that many of the neccesities of real flying have been omitted such as pre-flight checks, pre-landing checks, radio information, raising of flaps/nosewheel etc.,

7.1.1.DEFINE WORLDS
From Loading Screen press [ENTER] or from any other screen press [ESC], select WORLD 5 and ensure wind is 0 ceiling is 9999 by pressing [X] then press [ENTER] to go to runway scene.



THE TRAINING CIRCUIT

7.1.2.STARTING AND ROLLING
Press the [UP ARROW] key if you prefer a view straight down the runway (Press Alt/up Arrow once up in the air to reset the display), now press the following keys:

[J] JOYSTICK	:	if you are using a joystick in port CTL2
[I] IGNITION	:	to start engine and bring revs up to 640
[L] SOUND	:	to switch off sound if required.
[ ] FULL THROTTLE	:	to bring engine to full throttle (2560 rpm)
[N] FLAPS DOWN	:	press hold down until flaps are fully down
[ENTER] BRAKE	:	to release brakes

7.1.3. TAKEOFF
The aircraft will now be moving down the runway, watch the airspeed indicator "KIAS" as soon as it reaches 60 pull back on the YOKE by either pulling back on the joystick or by pressing and holding down the [B] key. The gauge to the right of the artificial horizon should move down. Once the gauge is approx. midway between the centre position and the bottom of the gauge the aircraft should have lifted off and the ALTITUDE GAUGE "ALTD" should be above 0. Adjust your rate of climb by moving the yoke forward or back (Joystick or B/T keys) so that your airspeed is approximately 60.

7.1.4.LEVELLING OUT
Once you are near 800 feet on the ALTITUDE METER, reduce throttle by pressing and holding the [-] key until the rate of climb "CLMB" is reading 0. You are now in straight and level flight.

7.1.5.CROSSWIND LEG
You must now turn very gently onto the CROSSWIND LEG which is a heading of 90 degree's. To do this move the YOKE (joystick to the right or H key pressed just once) and watch the heading "HEAD" indicator the moment this goes into inverse video (indicating a 2 minute turn) centre the YOKE with the joystick fire button or [G] key, wait until heading "HEAD" reads approx 80 degree's then move the YOKE in the opposite direction by pressing the [F] key once or moving the joystick to the left once. The moment the centre black line in the artificial horizon is straight, centre the YOKE again by pressing [G] key or pressing the joystick fire button. The heading should read approx. 90 degree's. The above procedure should be practised to enable you to get the feel of turning the aircraft. You should also watch the aileron indicator above the artificial horizon which will show you the amount of response to your key/joystick movements.

7.1.6.DOWNWIND LEG
Check your HEIGHT (approx 800) SPEED (approx 60) and CLIMB (0) press the [TABULATE] key to determine your position by RADAR, press again if you wish to return to normal vision or leave on radar if required. (You will find it easier during training to switch back to normal vision when at the outer boundary marker). Now turn onto the DOWNWIND LEG (180 degree's approx.) by using the same procedure as in 5 above. Then check HEIGHT, SPEED and CLIMB.

7.1.7.BASE LEG
By using RADAR you should be able to see the runway passing on your right. The DOWNWIND LEG gives you plenty of time to adjust your SPEED, HEIGHT and DIRECTION. Once past the southern end of the runway turn onto the BASE LEG (270 degree's Approx) by using turning procedure in 5 above. Then reduce throttle to give a CLIMB of -180, return to level flight at approx 400 feet.

7.1.8.APPROACH
BEFORE You are at right angles to the runway, turn to the approach (0 degree's) and ensure the aircraft is heading directly for the outer BOUNDARY MARKER. RUDDER - left or right - can help to straighten the flight path ([C] or [M] keys).

7.1.9.LANDING
Try to be at approx 200 feet at the OUTER BOUNDARY MARKER and your "CLIMB" should be -180 approx, this with a heading of 0 will bring you down onto the runway. Adjust your height when approaching the runway by slight adjustments to THROTTLE ([+] or [-] key) or slight adjustments to YOKE ([T] or [B] key or joystick forward/back). As soon as the sound of the wheels touching the runway is heard apply the BRAKES [ENTER] and wait for the aircraft to stop.

7.1.10.HINTS AND TIPS
A).Take the aircraft up into the air and practice the 2 minute turn.
B).Use RADAR regularly until you are orientated and familiar with the surroundings.
C).Remember that turning reduces height, increase throttle slightly to retain height.
D).If you misjudge the approach hit full throttle []] and circuit again, this is normal pilot procedure.
E).Don't expect to be able to land the aircraft on it's first attempt, it will probably take 3/4 hours practice, a trained pilot would require this amount of time for familiarisation with a new aircraft.
F).The above circuit instructions do not follow closely the regular rules of circuit flying but are aimed at giving the novice easy familarisation. Normal circuit flying rules inlude the following:

* Raise flaps and nosewheel after take-off
* Reduce revs after take-off to give a steady climb
* Climbing - turn into crosswind leg at 500'
* Nosewheel down towards end of downwind leg
* Close throttle on base leg, lower part flap and re-trim
* Gliding turn onto approach.

G).Use PAUSE [P] OFTEN

H.)Recommended reading is the book FLIGHT BRIEFING FOR PILOTS by N.H.BIRCH and A.E.BRAMSON published by PITMAN. This book explains the basics of flying together with setting many excercises for the student pilot. This flight simulator reacts in a very simular fashion to the aircraft described in the book. Reading the book together with flying this simulator and performing the excercises outlined in the book would bring the student pilot to "solo flight" at a very early stage and would certainly improve flying skills and competence.

7.2 AEROBATICS
All aerobatics should be performed with at least 1500 feet of altitude, 70 knots of airspeed and in a "cleared" portion of a world. The PRACTICE FIELD (WORLD NO.5) is a good place to try these because there is absolutely nothing to run into save the ground itself.

7.2.1 STALL.
Stalls are caused by angles of attack at or above 16 degrees (plus or minus). Angle of attack is caused by ELEVATOR STICK and ELEVATOR TRIM Controls. When these two control inputs combine to give a +/- 18 degree deflection or more a STALL will eventually develop. The reason a stall does not occur immediately, is because there is a RESPONSE LAG in both the control input and the aircraft's flight path turning rate, (the latter caused by inertia). A STALL will cause a counter-clockwise roling motion of the aircraft (due to engine torque) along with a rapid drop of the nose. As with most light aircraft, stall recovery is almost automatic assuming that adequate altitude exists. You may stall "proof" your aircraft by trimming down 2 degrees. In this way, extreme backward stick will not develop more than 16 degrees of elevator and thereby limit the angle of attack to less than its critical value. Take heed, however this condition could "bite" you if you fly inverted as forward stick will now stall EARLIER.

7.2.2. AILERON ROLLS.
Aileron rolls make use of the extreme limits of the AILERON yoke. Raise the nose a touch and then move the AILERON yoke to one of it's extreme limits. Try not to give elevator. When the altitude indicator is within 20 degrees of wings level, centre the yoke IMMEDIATELY. Now give gentle roll yoke until the wings are level. Re-adjust your trim if necessary.

7.2.3 INVERTED FLIGHT.
Raise the nose slightly, then give extreme AILERON yoke. When your altitude indicator is within 20 degrees of upside down, centre the yoke IMMEDIATELY and push the elevator yoke forward slightly to maintain level flight. Now make gentle rolls until your wings are level. Re-adjust your trim if necessary. Remember that elevator and rudder respond in a "BACKWARDS" fashion now, and of course your window views will also be inverted.

APPENDIX

1.REPRESENTATION OF GRAPHIC VIEWS
The graphic representation of scenery is obviously an important part of any flight simulation which professses to be "view-orientated". True 3-Dimensionalism requires that these scenes "grow" or expand as they are approached and that they appear in the proper perspectives from ALL aspects. The mathematics involved with this capability, coupled with the flight dynamics equations of motion, combine to produce a complex set of computional requirements. These computional restraints impact the simulation's speed.
The technique selected for this program was one which creates the scenic views by way of "wire" (or line) graphics. Each world is defined as a series of points. These points are transformed into the aircraft's frame of reference and projected into the 2-dimensional plane of the craft's windows. The resulting points are then connected by lines and the lines limited or "clipped" to lie on the 2 hi-res graphic pages which make up the upper half of the TV screen. The main advantage of these methods is that they are MEMORY EFFICIENT and allow the potential for multiple worlds.

2. CONVERSION FACTORS

1 NAUTICAL MILE (NM) = 6076 FEET
1 STATUTE MILE (M1) = 5280 FEET

GIVEN	MULTIPLY BY	TO OBTAIN
NAUTICAL MILES (NM)	1.51	STATUTE MILES (M1)
STATUTE MILES (M1)	.869	NAUTICAL MILES (NM)
KNOTS (NM/HOUR)	1.688	FEET PER SECOND (FT/SEC)
FEET PER SECOND	.592	KNOTS
KNOTS	1.151	M1/HOUR - M.P.H.
M.P.H.	.869	KNOTS

3. SUMMARY OF CONTROL COMMANDS

*** DEFINE WORLDS CONTROL ***

[S]	SET WIND SPEED	[F]	SET WIND DIRECTION
[C]	SET CLOUD CEILING	[B]	SET BEGINNING WORLD
[X]	CLEAR WEATHER IN WORLD	[W]	WORLD SELECT
[ENTER]	EXIT TO SIMULATION		

*** FLIGHT CONTROLS ***

[+]	INCREASE THROTTLE 1 NOTCH
[-]	DECREASE THROTTLE 1 NOTCH
[[]	MINIMUM THROTTLE(TICK OVER)
[]]	MAXIMUM THROTTLE
[C]	RUDDER LEFT
[M]	RUDDER RIGHT
[T]	*ELEVATOR FORWARD
[JOYSTICK FORWARD]	ELEVATOR FORWARD
[B]	*ELEVATOR BACK
[JOYSTICK BACK]	ELEVATOR BACK
[F]	*AILERON TO LEFT
[JOYSTICK LEFT]	AILERON TO LEFT
[H]	*AILERON TO RIGHT
[JOYSTICK RIGHT]	AILERON TO RIGHT
[G]	*AILERON + RUDDER CENTRED
[JOYSTICK FIRE]	AILERON + RUDDER CENTRED

*=OPTINAL JOYSTICK CONTROL

[V]	TRIM UP	[R]	TRIM DOWN
[I]	IGNITION	[S]	STOP ENGINE
[N]	LOWER FLAPS	[Y]	RAISE FLAPS
[U]	RAISE GEAR (PRESS _HOLD)		
[D]	LOWER GEAR (PRESS _HOLD)		
[ENTER]	TOGGLES BRAKES ON/OFF		

*** VIEW CONTROLS ***

[UP ARROW]	ELEVATE VIEW UP 8 DEGREE
[DOWN ARROW]	DEPRESS VIEW DOWN 8 DEGREE
[RIGHT ARROW]	ROTATE VIEW TO RIGHT 8 DEGREE
[LEFT ARROW]	ROTATE VIEW TO LEFT 8 DEGREE
[ALT + UP ARROW]	CLEARS WINDOW VIEW TO STRAIGHT AHEAD
[TABULATE]	TOGGLES RADAR VIEW
[Z]	ENLARGES (ZOOMS) RADAR VIEW

[X]	REDUCES RADAR VIEW
[8]	TOGGLES THE INVERSE GRAPHIC VIEW
	*** SPECIAL CONTROLS ***
[A]	TOGGLE TO GROUND SPEED
[L]	TOGGLE SOUND ON/OFF
[W]	WEATHER INFO
[SPACEBAR]	REFUEL
	*** PROGRAM CONTROLS ***
[P]	TOGGLES PAUSE SIMULATION
[ESC]	RESET SIMULATION

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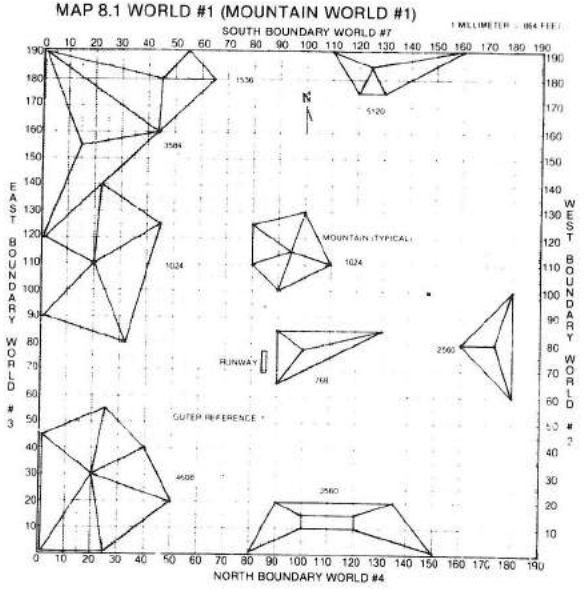
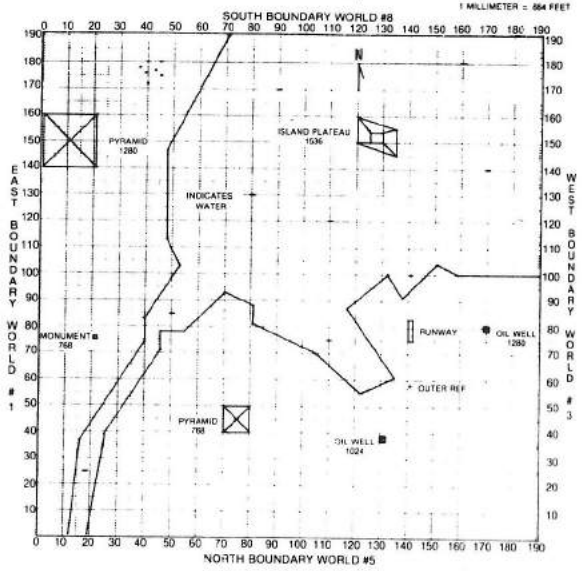
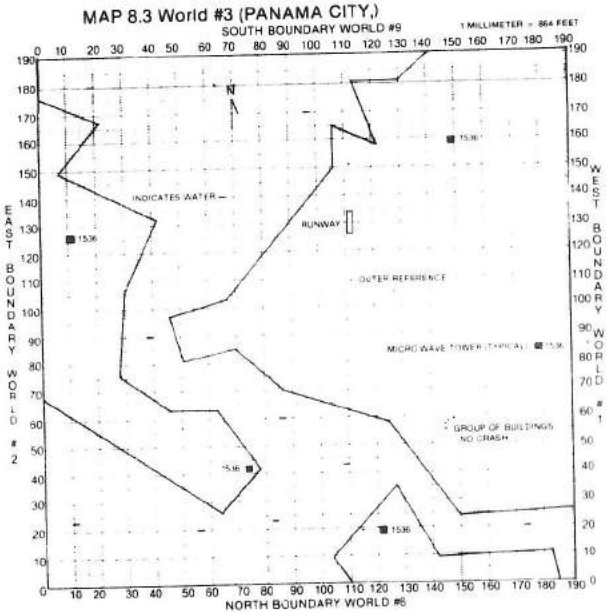
MAP 8.1 WORLD #1 (MOUNTAIN WORLD #1)



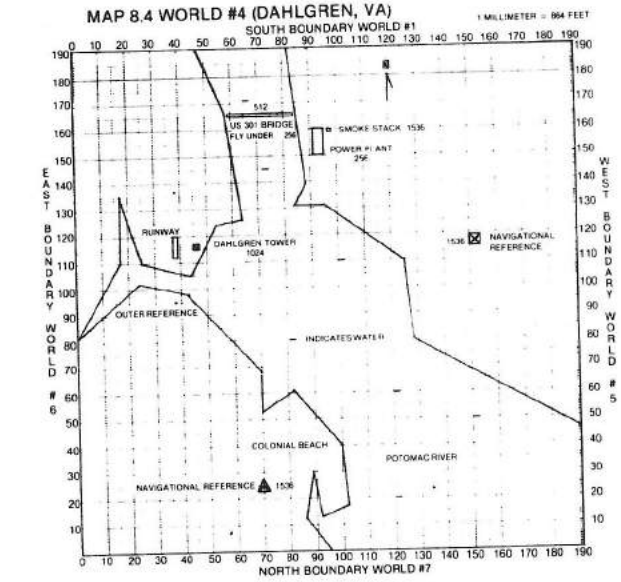
MAP 8.2 WORLD #2 (ARABIAN GULF)



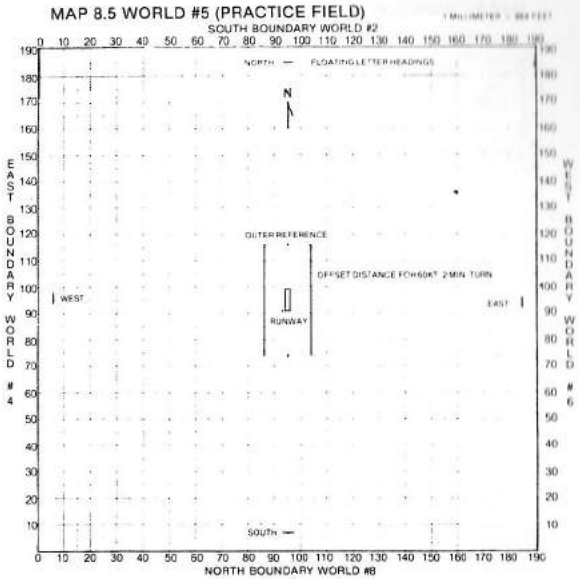
MAP 8.3 World #3 (PANAMA CITY,)



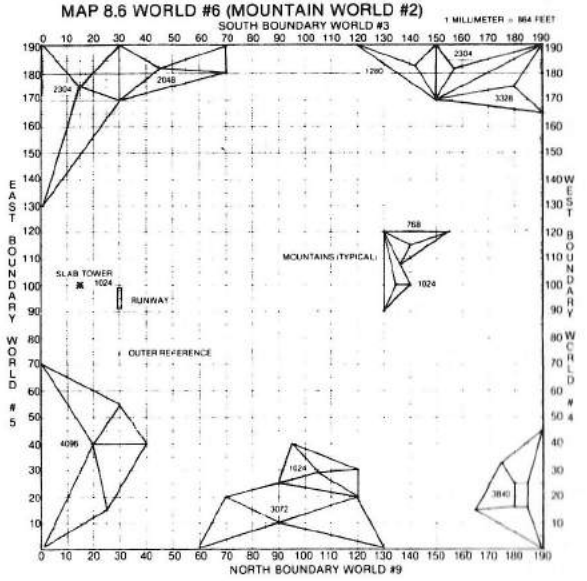
MAP 8.4 WORLD #4 (DAHLGREN, VA)



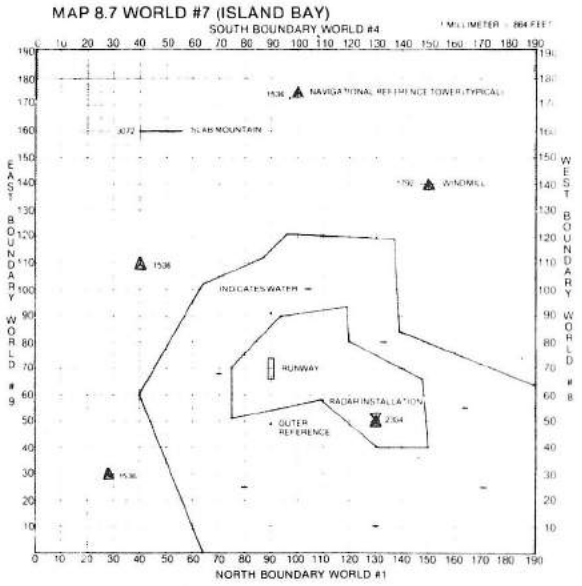
MAP 8.5 WORLD #5 (PRACTICE FIELD)



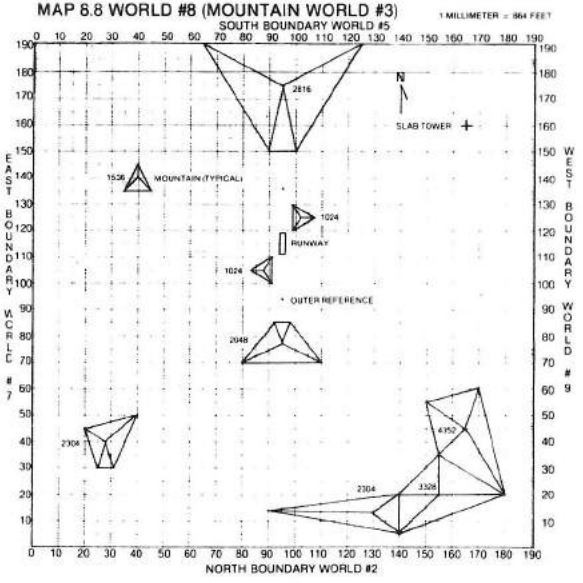
MAP 8.6 WORLD #6 (MOUNTAIN WORLD #2)



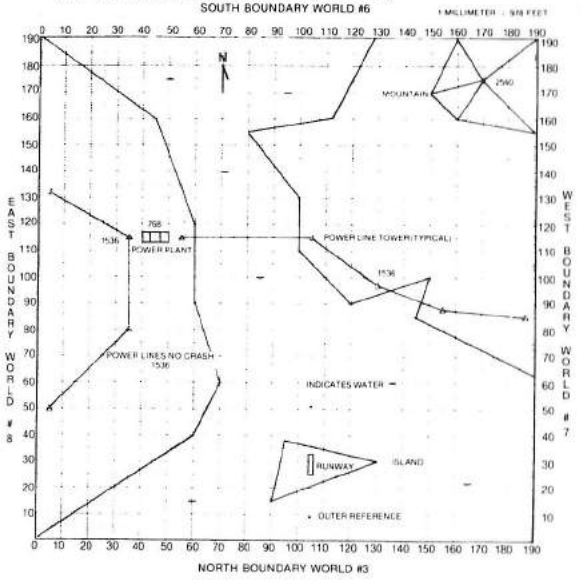
MAP 8.7 WORLD #7 (ISLAND BAY)



MAP 8.8 WORLD #8 (MOUNTAIN WORLD #3)



MAP 8.9 WORLD #9 (POWER LINE RIVER)



MAP 8.10 RUNWAY SCENE