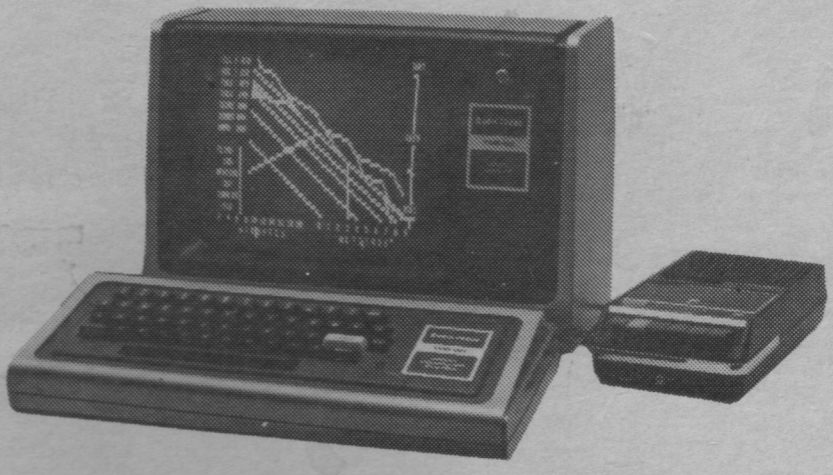
T80-FS1
Flight Simulator

for the

TRS-80

Level I or Level II, 16K



with

"British Ace"
3D Aerial Battle Game

subLOGIC

T80-FS1 FLIGHT SIMULATOR

WITH

BRITISH ACE - 3D AERIAL BATTLE

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INTRODUCTION

Nearly everyone, at times, wants to go flying, and many of us would actually enjoy spinning toward the ground at 180 mph or being involved in an aerial battle. A few of us actually follow up on our interests and become private, commercial, or military pilots, and a small percentage actually end up doing aerobatics and participating in dog-fights. The three things that stop many potential pilots and limit the active ones are time, danger, and of course money. The aviation community has a solution to these problems known as the "flight simulator". A flight simulator simulates the flight of a real aircraft and is initially quite expensive, but simulators cost little per hour to operate.

Flight simulators costing less than a few hundred thousand dollars usually include no visual display and are of limited use in training visual flight rule (VFR) pilots. Without an out-the-window display, the thrill of watching the world from five-thousand feet is gone (unless you have a vivid imagination). The most exciting simulators are undoubtedly the military ones with out-the-window displays, armament, and aerobatic capabilities. These simulators cost millions of dollars.

The Sublogic T80-FS1 Flight simulator is a program designed to run on a Radio Shack TRS-80 microcomputer with at least 16K of memory. It offers aircraft simulation that considers 23 important aircraft characteristics, an out-the-window 3D dynamic flight display, extensive flight controls, minimum VFR instrumentation plus additional instruments (18 in all), a radar display, and full armament (bombs and machine guns). The program is written in optimized assembly language and is capable of presenting 3 to 6 frames per second. In addition, "British Ace", an aerial battle game is included.

Finally, anyone can beat the three limitations of flying for the price of a

microcomputer and a T80-FS1 package.

The FS1 is Sublogic's first flight simulator, and the TRS-80 is Radio Shack's first microcomputer. Microcomputing and microcomputer flight simulation are in their early stages, and over the next few years improvements will be astounding. Our choice of aircraft for the simulation was thus an early, first generation aircraft - the Sopwith F.1 Camel of WW I. This aircraft offered room for refinement (witnessed by today's "Phantom Fighters") as does our simulation. This aircraft's characteristics (weight, length, ceiling, horsepower, top speed), incidentally, are nearly identical to those of a Piper Super Cub 150 making it an ideal light aircraft for training.

Improvement of the FS1 is already underway. The T80-FS1 is the second version of the FS1 program. Feedback from users of our initial Apple II version of FS1 has been used extensively in the TRS-80 version. Selectable downward view, bomb sights, visible enemy gun blasts, and a "simulation reset" command were all added to the FS1 since the introduction of the Apple II FS1. The T80-FS1 also has a slightly higher frame projection rate than the Apple version.

The FS1 has not been tested for pilot training effectiveness, and we aren't sure if it will make you a better pilot. The Sublogic staff members, however, are pilots and agree that the FS1 flies surprisingly like a real airplane; so much so in fact, that no special routines to accomodate aerobatics were needed. They worked well with the straight simulation.

The simulator and the aerial battle game will now be described. A note of caution is in order first. You must be familiar with the control functions, instrumentation, guages, aerial maps, taxi charts, and aircraft behavior before taking off. You must, in other words, "attend ground school" by carefully reading this manual. This is especially true if you are not already a pilot. Aircraft act in

unexpected ways. If you fly along at a constant speed and altitude and decrease the throttle, the aircraft speeds up for example. If you would like to know more about the reasons for this behavior, a book such as "The Student Pilot's Flight Manual" by William K. Kershner should be read.

Also, don't try and fight the enemy if you are not familiar with your aircraft and have not logged enough flight training hours. The German pilots you are up against are very formitable and will shoot a beginner out of the sky!

COCKPIT INSTRUMENTATION AND SYSTEMS

Figure 1 defines the FS1 screen instrumentation. The screen is split into two functional parts: a centered 3D out-the-window display, and a wrap-around (left, bottom, and right) instrument panel. The screen instrument functions will now be described in detail.

3D Out-The Window Display

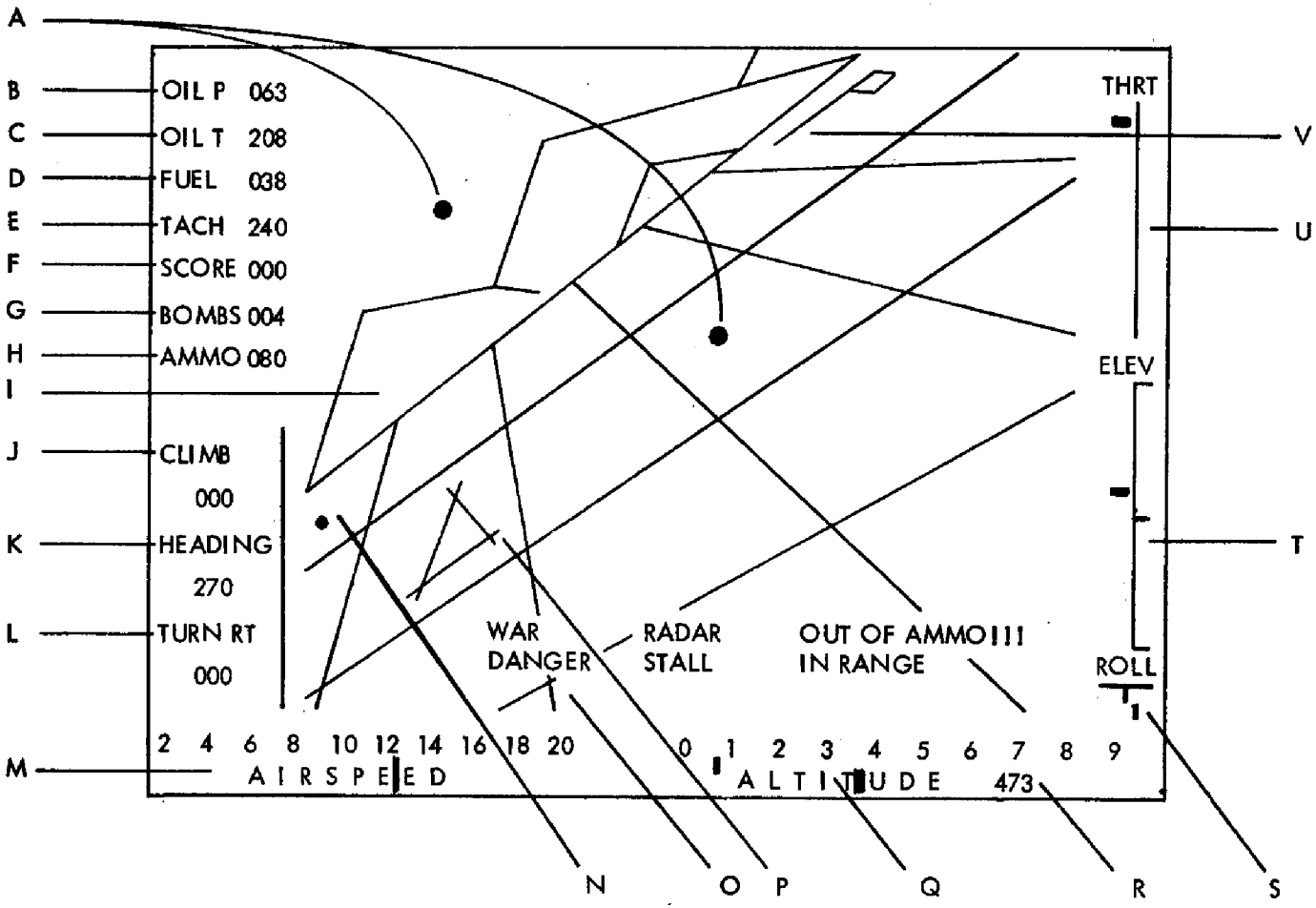
This is a view out the windshield of the aircraft. The view is oriented as if the pilot were leaning foreward slightly to get a better downward view. This view was chosen because it gives better airborne visibility, especially when climbing or flying at high altitudes. When flying, there will usually be something on the 3D display, but occasionally the display will be blank (when climbing at steep angles, looking at the sky for instance). Under these conditions you must "fly blind" and use instruments until something again comes into view.

Downward View Display

At the touch of a button (see Aircraft Controls section), the 3D display turns into a downward view/radar display. The view is always from a constant altitude thereby giving it a radar characteristic (the range of objects on the ground does not change as you change altitude). This capability is extremely useful when taxiing, fighting enemies, or making an approach. Downward view also compensates for the TRS-80's lack of vertical graphic resolution. In many situations simply switching to downward view will clear up questions about where you are.

Required VFR Instrumentation

The FAA, under Part 91 of Federal Aviation Regulations, requires that an aircraft be equipped with an altimeter, airspeed indicator, tachometer, oil pressure gauge, oil temperature gauge, compass, and fuel gauge to qualify for legal VFR flight. The FS1 has these gauges and more.



A Enemies on 3D screen
B Oil pressure (psi)
C Oil temperature (degrees F)
D Fuel (gallons)
E Tachometer (rpm)
F Score (1 per fighter, 1 per bomb hit)
G Bombs remaining
H Ammunition remaining
I 3D out-the-windshield display
J Climb rate (feet per minute)
K Compass heading (degrees true)
L Turn rate (degrees per minute)
M Airspeed (mph)
N Enemy fuel depot
O Status messages (6 in all)
P Enemy airbase (three runways)
Q Altimeter (feet)
R Micro-altimeter (feet) when below 700 feet only.
S Roll rate indicator (rudder position)
T Elevator position indicator
U Throttle position indicator
V British airbase

Figure 1. T80-FS1 Cockpit instrumentation.

Airspeed Indicator -- This gauge (see figure 1) reflects the trajectory velocity of the aircraft. It is read as a car speedometer is read, but is pinned at its low reading of 20 mph until that speed is passed. Readings under 20 are not of great use because this is an air pressure activated gauge. This gauge indicates true airspeed (your speed along the trajectory) and does not give low readings at high altitudes as most real altimeters do.

Altimeter -- This instrument measures altitude in feet. It is operated by atmospheric pressure which decreases as altitude increases. This gauge is read like an "unfolded clock face". Two needles move horizontally across the face instead of around it. The short, bottom needle represent thousands of feet, and the larger top needle represents hundreds. The FS1 altimeter is not continuous but rather indicates to the nearest 50 feet. Fifty foot increments are adequate for all situations except landing.

Micro Altimeter -- This new addition to the FS1 will assist you on landings. A digital readout of your altitude to the nearest foot is presented to the right of the altitude legend whenever you are below 700 feet (ground elevation is 400 feet). This gauge, and a lot of practice, will allow you to skim-along a few feet above the runway with hairline accuracy.

Oil Pressure Gauge -- The oil pressure gauge (Oil P) indicates oil pressure in PSI. It should be noted that the FS1 has very simple engine functions at this time due to memory size and time constraints. Oil pressure, temperature and other engine functions are very simple-minded.

Oil Temperature -- This gauge indicates oil temperature in degrees F.

Fuel Guage -- A fuel gauge indicates the number of gallons of fuel in your tanks.

Tachometer -- This gauge indicates engine RPM x 10.

Score -- In British Ace mode, this indicator tallies your game score.

Bombs -- This gauge tells how many bombs you have left.

Ammo -- This gauge tells how much ammunition you currently have.

Compass -- The compass (Heading) indicates true heading in degrees thus making it correspond more to a gyrocompass (at a 0 degree isogonic line) than a magnetic compass. Its smooth operation is also typical of a gyrocompass. You never have to wait for the compass to stabilize. Unlike a gyrocompass, it is always correct and never needs to be caged or adjusted. Its a great compass!

Additional Instruments

These instruments will be invaluable as you fly the FS1. They are more useful in the FS1 than in a real aircraft because a real plane has side windows for you to get a better idea of headings, turn rates, and climb velocities. Using thes instruments will give you good instrument use experience.

Turn Rate Indicator -- This instrument tells you how fast you are turning in degrees per minute. A positive reading is a turn to the right. A standard rate turn (a 2 min. 360 degree turn - a standard flying maneuver) is thus registered as 180 or 180 degrees per minute. You will quickly find that this gauge helps you set up a straight line of flight. With the limited 3D capabilities of the FS1 it is sometimes hard to tell if you are in a very slow turn that drifts you off course. A 000 indication on this instrument guarantees straight flight.

Vertical Velocity -- This instrument (Climb) indicates your rate of climb in feet per minute. A positive reading indicates an upward climb. This gauge is good for helping you maintain level flight and will help get you down to desired

altitudes in desired distances. Non pilots are cautioned against chasing this gauge in an attempt to get a desired rate. Slow changes and waiting for stabilization ar required.

Roll Rate Indicator -- This sliding bar type indicator corresponds directly with aileron/rudder position and indicates that the plane is either being steered (on the ground) or is rolling into or out of a bank in flight. Right movements indicate right banks or steering. Center indicates that the plane is going straight on the ground using ground steering, or that it is in a steady bank if flying. Note that a centered needle does not mean that you are flying straight. Non pilots should note that you must roll out of a turn by giving opposite aileron/rudder. Airplanes do not straighten out by themselves (if they are neutrally stable like the FS1.) The roll rate indicator is nonlinear. The gauge is narrow to avoid using valuable 3D graphics screen space and does not have much "swing" to it. It is intentionally very sensitive to small roll rates, and less sensitive to changes in high roll rates.

Elevator Indicator -- This gauge indicates the position of the elevators. Up and down elevators don't necessarily mean climb and dive, however, because aircraft climb is also dependent on airspeed, turn rate, and air density (altitude). Up movement of this gauge simply means "up elevator".

Throttle -- This indicator reflects the position of your throttle lever. Full back (toward the bottom of the screen) means engine idle.

Status Messages -- Six self-explanitory messages appear at various times during the flight. These messages are arranged as follows, and are either on or off:

WAR	RADAR	OUT OF AMMO!!!
DANGER	STALL	IN RANGE

Danger and In Range are described in greater detail in the British Ace instructions.

AIRCRAFT CONTROLS

The TRS-80 microcomputer does not include a control yoke, rudder pedals, and a throttle lever as standard equipment so an alternate means of controlling the flight simulator is needed. Keyboard controls are used, but the keyboard layout and "touch" are different than the typical typing arrangement. Instead of using key letters for references (such as R for right and L for left), a "control diamond" pattern was set up. Figure 2 illustrates the keyboard control scheme.

The solidly outlined keys in Figure 2 are primary aircraft controls (elevator, aileron/rudder, and throttle). The dashed outlined keys are less-often-used functions.

In addition to nonstandard key references, nonstandard "touch" is used. Holding a key down for a short time has a small control effect while a long press has a large effect.

Using the Control Diamond Keys

Normal typewriter hand positioning is not used in any way in the control diamond scheme. Rather, you put your middle finger of your right hand (or left hand if desired) on the G key and your index and ring fingers on the appropriate keys to either side (keys F and H). To turn the rudder right, press the right key (H key). A short press gives a little bit of right rudder. You may straighten the rudder or make it go left by pressing the left key (F). It is time consuming to manually center the rudder by small right and left movements, so for convenience, you may press the middle G key to automatically straighten the rudder. For rudder control, your hand rocks from right to left in joystick fashion.

The FS1 has linked rudder and ailerons for self-coordinated flight. You can determine the position of the rudder by watching the roll rate indicator on the

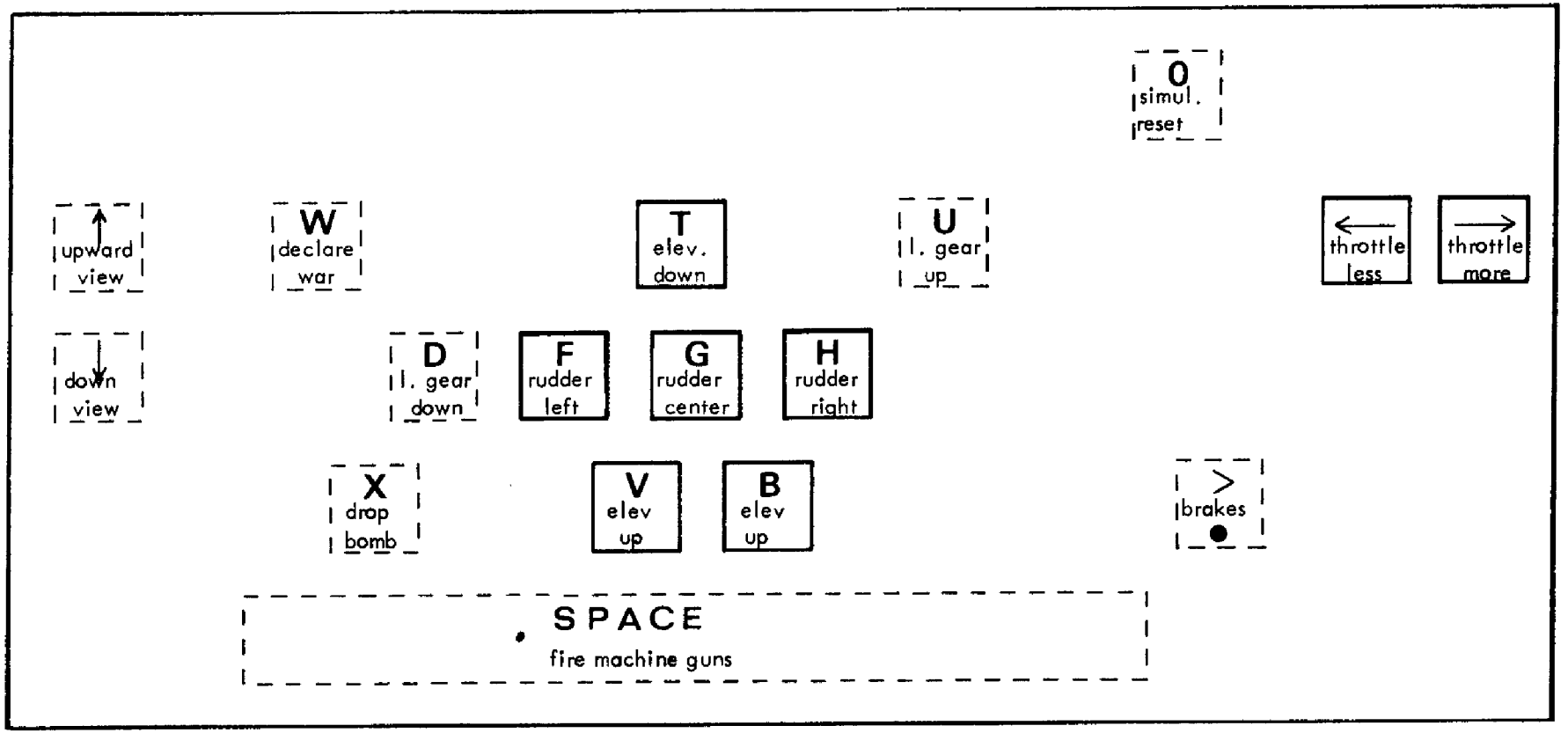


Figure 2. FS1 control system.

instrument panel (see figure 1). It will move from side to side as you turn the rudder right and left. Seven notches of rudder to either side are available. The more notches you use, the faster you will either ground steer or roll into a bank.

Elevator Control -- To lower the elevators, simply reach your middle finger up to the T key and press it to activate down elevator. Rocking your hand back for up elevator sometimes results in hitting the B and sometimes the V key due to the keyboard used on the computer, so both keys were set up for the same function; elevators up. You can watch the elevator position on the E indicator on the instrument panel.

It may seem strange that you go down on the keyboard for up elevator and up for down, but this method was chosen to correspond to a real airplane. Think of the control diamond as the control yoke. Pulling back raises the aircraft's nose (and the elevators) and pushing foreward lowers the nose. Think as a pilot does- pull the nose up, and push the nose down.

Throttle -- The throttle controls use key markings as a guide. Right arrow means more throttle while left arrow means less. You have 16 notches of throttle. The T indicator shows throttle position.

Secondary Controls

There are a few keys that you will seldom use. These keys were chosen for position as well as letter legend sake.

Landing Gear -- Assuming you are not playing British Ace, the landing gear keys will be the most-often-used secondary controls. These keys are lettered U for up and D for down. They are in a convenient position off the control diamond. After a bit of practice you will know to press the key to the left for

down landing gear and the key up and to the right for up landing gear.

The landing gear on the FS1 is not really a landing gear (Sopwith Camels don't have retractable gear) but are rather a low/high database selection control. The keys were initially called hi/lo database selector keys, but after extensive flying we noticed that they were used in nearly the same sequence as the landing gear on the airplane. Read the section describing the world for more details on the high and low altitude databases.

Downward View Select -- The up arrow and down arrow keys correspond to out the windshield and downward-looking views respectively. The downward view is also called "RADAR" because it is designed to serve a radar function as well as a visual one. The view is always from the same altitude (for each data base), and objects that are above you are projected as if they were at their current North and East position but on the ground.

You will quickly get familiar with the downward view feature and know the best times to use it (taxiing, final approach, navigating, etc...)

Armament Control Keys -- Briefly, the W key declares war and puts the FS1 into aerial battle mode. Once you declare war, there's no turning back. You will not be attacked by the enemy even during wartime as long as you stay out of his territory. The X key drops the bombs on the enemy fuel depot, and the space bar fires your machine guns. See the British Ace section of this manual for more details concerning armament control.

Brakes -- There are brakes to stop the aircraft while on the ground. Press the period for brakes. They will keep slowing you for as long as you keep the key pressed.

Simulation Reset -- This new feature restarts the simulation. You are placed back on the runway at ground level, given a full load of fuel, ammo, and bombs and the war mode is turned off(unfortunately your score is also set to zero !)

Keyboard Usage

The simulation program runs in a loop that executes from 3 to 5 times per second. It can only sample one time per loop so there must be about one fifth to one half of a second press time per key (minimum). After some practice you will find the most effective press times. If you press a key for too short a period it may not register at all. If you hit more than one key at a time, one key will take priority over the other in an arbitrary manner. The only time key press times will be annoying is when you want to go to a zero turn rate by making small changes. Again, practice will make this easier.

Absolute and Rate Control

Aircraft controls are not like those of an automobile. Pilots know this, but non-pilots often assume that controls will work a certain way based on the way other vehicle controls respond. Automobile controls (steering and throttle) are absolute controls. Give an automobile half throttle and it cruises at 60 mph, and turn the steering wheel 90 degrees and it enters a 100 foot radius turn. Straightening the steering wheel makes the car go straight again.

Aircraft controls are pressure and rate oriented. The aileron/rudder position determines how a plane turns, but only indirectly An airplane turns by banking and the aileron/rudder puts the plane into a bank The amount of aileron/rudder determines how fast the plane will roll into a bank, not how much of a bank one will ultimately end up with

Once a turn is complete, the plane must be rolled out of the bank, back to straight and level flight. You must therefore use right aileron/rudder to get into a right turn and left to get out of it An automobile with this setup would remain in a right turn after you straightened the steering wheel and would require a left turn (beyond the straight position) to come out of a right turn

The elevators indirectly control a number of items Up elevators cause the aircraft to climb if there is enough throttle dialed-in, but the plane may loose altitude with up elevators if there is too little throttle. Elevators mainly control

aircraft pitch with respect to the air flowing past the airplane.

You will get familiar with the ways these controls operate with experience. Non-pilots may initially have trouble flying the plane as they would in normal life. If you fall into this category, you will need a lot of practice at operating the aircraft's controls, but practice, after all, is what a training flight simulator is for.

AIRCRAFT BEHAVIOR

The FS1 flight simulator is designed to simulate light aircraft with top level cruising speeds of about 120 mph. In order to make flight easier for non-experienced pilots, turns are automatically coordinated by the simulation software. Slips and skids and certain aerobatic maneuvers therefore are not possible. Calm air is assumed as crosswind landings are difficult with coordinated rudder and aileron control. The FS1 makes use of double and triple precision arithmetic and internally performs all calculations in metric (MKS) units. The simulation module is broken into navigation and kinematics simulator sections. The kinematic simulator considers:

Aircraft attitude
Lift (Bernoulli)
Lift (angle of attack)
Foreward push due to prop thrust
Foreward or rearward pull of gravity
Downward pull of gravity
Drag (induced)
Drag (parasitic)
Lift loss in turns
Aircraft momentum (linear)
Aircraft momentum (polar)
Derated lift and drag due to altitude
Side forces due to bank
Stalls due to high attack angle
Fixed pitch prop thrust efficiency and prop stalling
Structural failure due to excessive G forces
Ground steering (by aircraft wheels)

The navigation simulator considers the following:

Aircraft position (North, East, Up) to the nearest tenth of an inch (approx)
Aircraft velocity (North, East, Up) to nearest .006 mph
Aircraft heading to nearest .2 degrees

FS1 Simulation Structure

The total FS1 simulation consists of 16 major software modules including a stripped-down version of Sublogic's Z80 3D graphics driver and high performance line generator. Figure 3 illustrates the program's overall design.

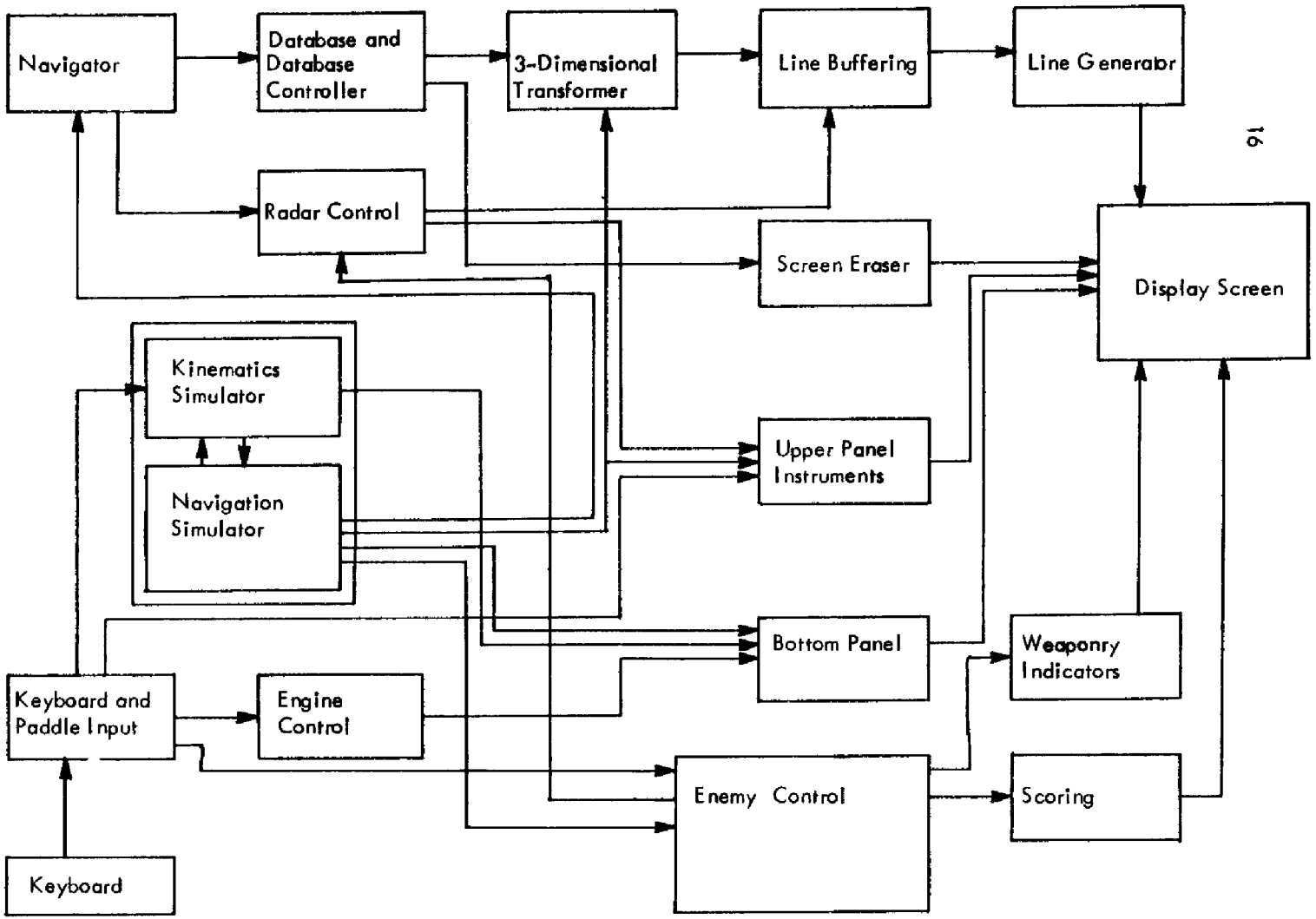


Figure 3. FS1 simulation structure.

The FS1's flight parameters are set to correspond to the performance of a 1917 Sopwith F.1 Camel - one of the best and most popular British fighters of WW I. Note the specifications of Figure 4. The characteristics of a Piper Supercub 150 are also shown. It's hard to say what the exact handling characteristics of the Camel were, but from our investigations we found that Camels were quite difficult to fly for novice pilots due to their nose-heaviness (the result of the large Clerget or Bently engine and twin Vickers machine guns up front). On the other hand, the Sopwith Camel was known as the most maneuverable aircraft of its type and was an excellent aircraft in the hands of a skilled pilot.

The FS1 is probably much easier to fly than a Camel, and probably flies more like the Supercub. Also, with the FS1's slightly pitched foreward view and its inability to nose - over (nose over onto its prop), it can hardly be considered a tail-dragger. If you can rationalize a tricycle-geared, good handling Sopwith Camel with a radar screen, you are ready to fly the FS1.

Some general flight techniques and how they apply to the FS1 will be presented shortly, but first, it is important to get familiar with the "world" in which you fly.

Characteristic	Sublogic FS1	Sopwith F.1 Camel	Piper Supercub 150
Type	Single engine - land	Single engine - land	Single engine - land
Power	130 HP	130 HP	150 HP
Wingspan	28 Ft	28 Ft	35 Ft
Length	18.9 Ft.	18.9 Ft.	22.7 Ft.
Height	8.6 Ft.	8.6 Ft.	6.8 Ft.
Weight (empty)	929 Lb.	929 Lb.	930 Lb.
Weight (gross)	1453 Lb.	1453 Lb.	1750 Lb.
Top speed at sea level	113 MPH	113 MPH	115 MPH
Effective Ceiling	19000 Ft.	19000 Ft.	19000 Ft.
Stall Speed (0 Flaps)	50 MPH		
Never Exceed Speed	150 MPH		
Fuel Capacity	38 Gal.		
Wing Loading	4.2 Lb/Sq. Ft.		
Power Loading	11.2 Lb/HP		
Prop Fixed Pitch Diameter	2.6 M x 2.12 M pitch		
Engine	130 HP Clerget		
Rate of Climb at sea level	650 Ft/min		
Take off			
Ground run	1100 Ft.		
Total Dist. 50 Ft. Obst.	1800 Ft.		
Landing			
Landing Roll	500 Ft.		
Total Dist. 50 Ft. Obst.	1200 Ft.		

NOTE: Climb rates, landing and takeoff distances are approximations.

Figure 4. Aircraft specifications for FS1.

THE WORLD

Figure 5 illustrates a map of the "world". This is a 36 square mile area containing a British airbase, a German airbase, a civilian airport, an enemy fuel depot, a mountain range, and an enemy territory. You can fly off this grid for many miles in any direction with no bad effects. If you fly too far, however, strange things start happening as you "fall off the edge of the world". The mountain range is really flat (like a cardboard cut-out) but looks good from almost anywhere and serves as a valuable reference point.

In normal, high altitude flight, the full world is shown on the 3D display at about 2.5 frames per second. Objects are simplified considerably to increase projection rate.

Slow frame rates and complex scenes are fine for high altitude flying, but on takeoff or final approach, higher frame rates are desirable. Features not important in high altitude flying take-on importance when landing (runway lines, taxiways, etc.). For this reason, a low altitude data base for airport details is provided. The taxi chart of figure 6 illustrates the low altitude data base for the British airbase. This data base can be switched on by lowering the landing gear. Raising the gear switches to the high altitude data base. The gear, as mentioned before, are not really landing gear, and you may be on the ground and switch between data bases if you wish.

Your flight operations on the FS1 are out of the British airbase. At this time only the British airbase has a low altitude database due to the 16K memory limitation.

CAUTION: You must be close to the airbase to view it correctly using a low altitude data base. Looking at a low altitude data base from more than a couple of miles away gives strange graphics results (although flight and the flight instruments aren't affected).

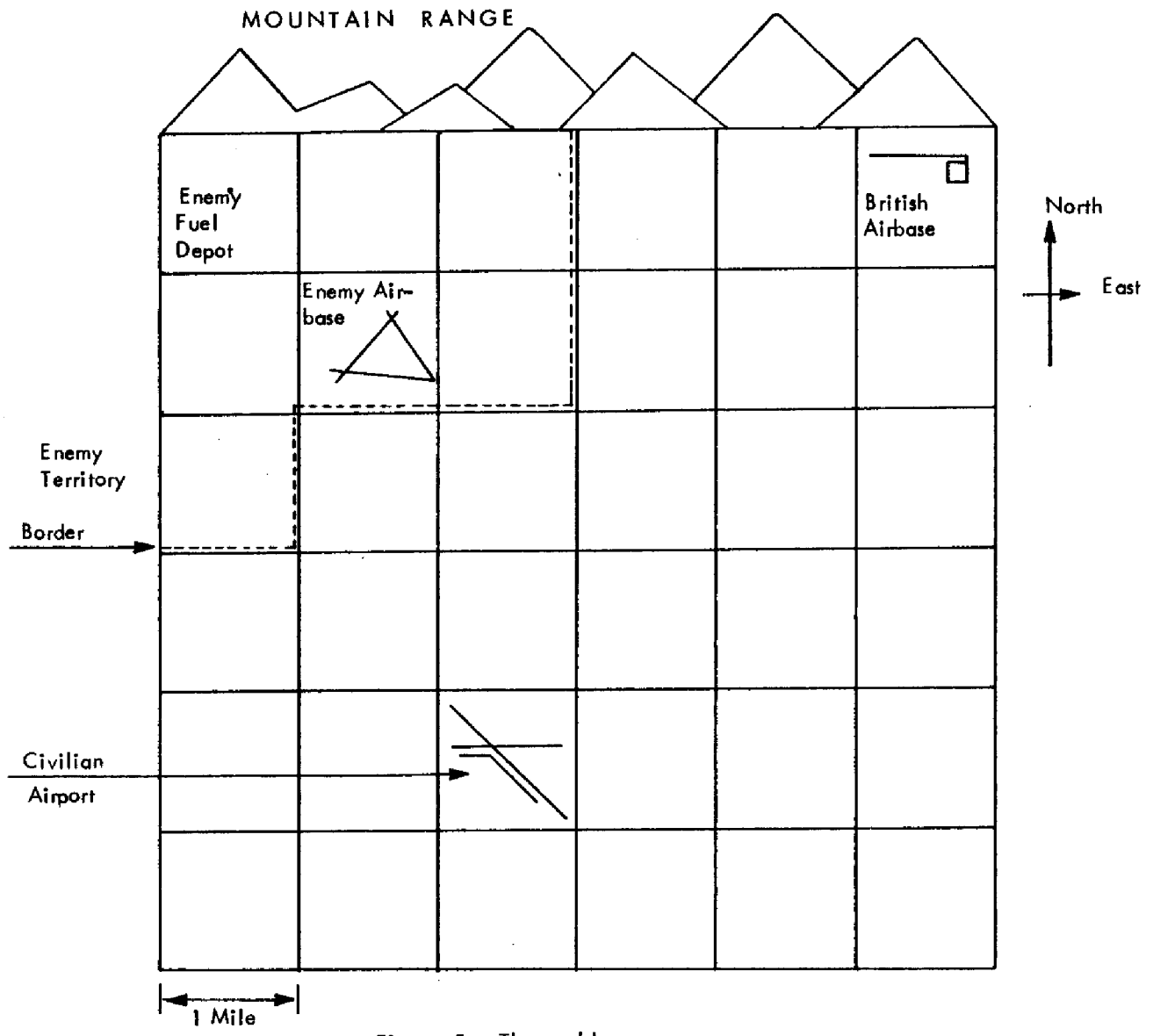


Figure 5. The world.

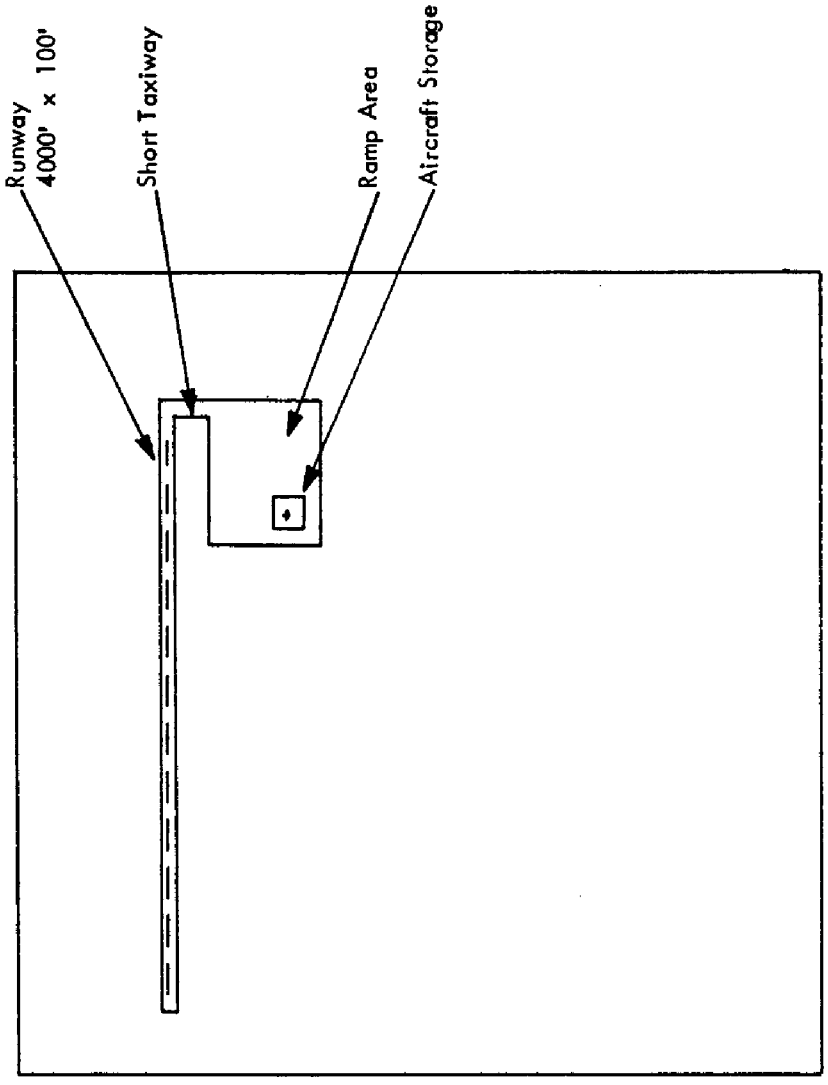


Figure 6. British airbase taxi chart.

FLYING THE AIRCRAFT

The first step in using the FS1 is program loading.

Tape Loading

We have tried to make the FS1 as easy to load as possible. TRS-80 cassette interfaces can be a bit touchy at times, but the interactive loader will help you rapidly find the best volume setting for your recorder.

The T80-FS1 tape is a Sublogic Universal Level I and Level II cassette. Note that there are not two seperate programs for levels I and II, but rather that the same tape is compatible with both. Both level I and II first load a "preloader", then they execute the preloader to read in the rest of the tape. Here's the method:

Level I

1. Set your cassette to the standard level I load-in level (maybe the slightest bit softer)

2. Rewind the FS1 cassette, put it in the tape player and hit the play button (the mic on/off should be connected)

3. Type CLOAD (return). Watch the flashing "*" on the screen's upper left.

4. Go to step 6 below.

Level II

1. Set your cassette to the standard level II load-in level. If you run multiple cassettes, you must use tape drive #0.
2. Rewind the cassette, put it in the tape player and press the play button (the mic on/off should be connected).

3. Type SYSTEM (return). After the *? appears type FS1 (return).

4. A short program should load (watch the cursors in the upper right corner) The tape will stop when the load is done (the preloader load).

5. After the machine comes back with a *? type / (return)

6. Watch the upper right corner of the screen. There are two cursors. The right one shows the actual data as it is read in (it should be flashing very fast). The left one changes at a slow, steady rate (one change per 256 bytes). Each 256 bytes is checked for accuracy (checksummed) and an ER message will appear to the left of the 2 cursors if an error in that block was detected. The left cursor goes through the following sequence:

   4 3 2 1 0 / . - ' + *) (' & % $ # " W V U T S R Q P O N M L K J I H G F E D C

7. After this sequence, the program starts running all by itself.

8. If problems arise, adjust volume levels. You know you are going in the right direction if you can load more of the sequence each time.

See appendix 1 for tape suggestions.

Getting Familiar With the Airplane

You start out sitting at the end of the runway (east end) on the British airbase, facing west. If this is your first time in the airplane, it is time to get familiar with it. First, observe the positions of the gauges. Notice the compass indicates a heading of west (270 degrees), the airspeed is 0 (or at least below 20) and your altitude is field elevation (400 ft. above sea level for this airbase).

Taxiing

You are, unfortunately, now at the point of the flight where the 3D out-the-windshield display is at its worst - sitting on the ground. This is due to the limited vertical resolution of the screen. You can get a better idea of where you are by switching to the downward view (down arrow). Compare your position with the airbase taxi chart of Figure 6.

Try turning the rudder from right to left (see controls section). Notice how the R indicator on the screen moves. The rudder controls ailirons and rudder in the air and ground steering when on the ground. On the ground, the airplane steers just like a car. The reason you didn't start turning around when you turned the rudder was because you were not moving. You must be moving to steer the airplane on the ground. To get moving, give the plane one notch of throttle (right arrow). Watch out the windshield (or downward view) and use the rudder controls to steer the plane. Go around in a few circles and get to know the airbase. Learn how to taxi your plane in a straight line down the runway and down the taxiways without rolling off the runway onto the grass.

Pre-Takeoff Check

Once you are familiar with the airport it is time to go for your first flight. But first, you must do your pre-takeoff check Go the east end of the runway,

point west and line yourself up with the center line, reduce throttle to zero and coast to a stop. Use brakes to completely stop. Now, go through this checklist:

PRETAKE-OFF CHECK

1. Check for proper elevator operation. Move them up and down and finally center them.

2. Check the rudder in the same way. Center it.

3. Check your gauges. Check your compass. You should be heading due west (270 degrees). Anything close to 270 is fine as you can correct your heading as you roll down the runway on take-off.

Take-Off

Make sure you have read the section on turns, climbs, and glides before taking off. Once you are in the air its good to know how to do these things.

If you are ready, here goes. Get ready to steer the plane as it rolls down the runway. Small adjustments in steering are preferable to wild zig-zagging. Now - FULL THROTTLE. Keep the plane on the runway. Keep half-an-eye on the airspeed indicator. It will start to rise. The Camel has fairly quick acceleration. When you reach about 50 MPH you can begin your takeoff roll (the point where you start to pull back the yoke and raise the nose to get off the ground). About 2 notches of nose up (elevator up, pull back on the yoke) is about right. You will notice the runway drop away as you lift off. You will see the nose pitch up and the vertical velocity indicator start to show a positive reading.

You are airborne, and you can put up your landing gear (press u for up). The full mountain range will come into view. Check your heading. If you are heading more than 270 degrees at this point, watch out. You are heading for the mountains!

Climbing

The FS1 has the stability of a real aircraft when it comes to climbs. It essentially climbs by itself without the need for constant adjustments. After takeoff with full throttle and a notch or two of up elevators, the plane should be in a steady climb. You can increase your rate of climb by increasing the throttle setting while holding a constant airspeed with the elevators. The elevators controlling the airspeed may seem strange, but in a sense, that is what they are doing. If you increase the throttle without raising the nose, your velocity instead of your rate of climb increases. By raising the elevators, you essentially turn what would have become extra speed into vertical velocity.

The relationship between speed, vertical velocity, elevators and throttle is complex. Practice flights will get you familiar with the characteristics.

Non-pilots should be cautioned against trying to attain an increased or decreased rate of climb by pulling back or pushing in the yoke (raising or lowering the nose) without adjusting throttle appropriately to keep airspeed steady. Raising the elevators alone will indeed increase your rate of climb for a few seconds, but soon your airspeed will start to drop as you loose momentum, and you will either stall or drop to a dangerously low airspeed. Down elevators alone will put you into a screaming dive.

Straight and Level, Constant Altitude Flight

Again, the FS1 acts as a real aircraft when in straight and level flight. The most common problem in holding a constant altitude is slowly drifting from your desired altitude by getting careless and not checking the altimeter once in a while.

Initially, the transition from a climb or glide to straight and level flight should be gradual. Use elevators and throttle to gradually get desired speed with no climb or drop. Don't chase the vertical velocity indicator. This can get you into trouble. After making small corrections using the altimeter and airspeed

indicators as guides , you will find that your vertical velocity settles down nicely to nearly zero.

Glides

In a climb, you increase throttle and raise the elevators to increase altitude, so it seems logical that you would want to lower the elevators and decrease throttle for a glide. This will not work. By decreasing throttle the plane naturally tends to drop its nose - - too far. Airspeed will start to rise if you hold a straight and level elevator position (or lower the elevators) and decrease throttle. Again, your elevators should be used to hold your airspeed constant at the desired glide speed. A bit of back pressure on the yoke (up elevators) should be used to keep the nose from dropping.

Judging how much up elevator to use takes experience. You have to learn to watch the world outside when you decrease throttle. Get to know your pitch attitudes in a glide.

To get familiar with glides, go up to 2 or 3 thousand feet, get straight and level, cut throttle to zero, and see what happens. If your airspeed gets dangerously high (over 140 MPH or so) give a notch of up elevator. Raise the nose to get out of the dive you are entering.

Turns

The FS1 has coordinated aileron/rudder controls which make turns simpler than in most real aircraft. The thing to remember about turns is that banking causes the turn. The aileron/rudder controls cause the plane to go into a bank.

The best way to learn about turns is by trying them. Get into straight and level flight . Give one notch of left rudder. You will start to bank. Wait until the horizon appears to be banked 10 or 20 degrees. Now center the rudder/aileron. You are now in a turn. You will remain in the turn until you "roll-out" of it.

If you want to get on a heading of 180 degrees, you must start to roll out of the turn (giving right rudder) about 10 degrees before 180 degrees is reached. It takes time to get level again, and in the process of levelling off you are still turning.

A 10 or 20 degree bank is a shallow turn. After the turn, look at your altimeter. You may have lost a bit of altitude. In turns, planes tend to loose altitude, and the steeper the bank, the worse it gets. A bit of up elevator is wise in a turn.

Landing

The hardest part of flying is landing safely and correctly. The idea of landing is to fly the plane a foot or two above the runway's surface and slow down until the plane stalls and stops flying. As the plane slows down, the nose will want to drop and the plane will try to fly itself onto the ground, but you must compensate with elevators to keep the plane at the one or two foot level until it stalls. If you fly the plane onto the ground above stall speed, you may bounce.

As you pull back the yoke, the plane will take a higher and higher nose-up attitude. This is good. When you finally touch-down, your elevators will be nearly all the way up.

You will know when you touch the ground. The scenery outside will level-out and stabilize as you land.

The process of getting to level flight above and aligned with the runway takes some practice. Steep glides are preferred as you come in for a landing. An engine failure while in a steep glide will have little effect on where you land whereas an engine failure on a long, shallow glide at treetop level will drop you into the field half a mile from the airport. The idea is to align yourself with the runway and glide toward it in a steep glide at approach speed (about 70 mph). You must then break the glide and transition into straight and level, power off flight a few feet above the runway. This transition is known as the flare.

You will usually approach the airport using the high altitude data base (gear up). When you get close, lower the gear to switch to the low altitude data base.

You will use the rudder to align yourself with the runway as you come in for a landing, but make sure that the rudder is straight when you touch down. If it is not, ground steering will whip you off the runway because your wheels aren't aligned to make the plane go straight. An abrupt turning of the airplane on the ground is known as a ground loop and could damage a real aircraft.

With the throttle turned completely off, you will shortly roll to a stop. You will know when you are stopped by the stopping of scenery motion and the inability to ground-steer the airplane. You will then be ready for your next flight. You may wish to taxi to the ramp area to top-off the tanks and turn around.

Before take-off, make sure to do your pretake-off check. You will usually find that you have to center the elevators which are nearly all the way up from the last landing. Taking off with full up elevators and full throttle can be disasterous.

The airbase has no traffic pattern rules, but if you want to use good landing techniques, use a standard left hand pattern, 800 feet above the airbase. Land west to avoid the mountains. Optionally, you can use a right hand pattern and land east. Remember, the airbase elevation is 400 ft. Pattern altitude is 1200 ft (indicated).

Fuel Management

You start your flight with 38 gallons of fuel. Keep an eye on the fuel gauge to make sure you don't run out. If you are low, land and taxi back to the aircraft storage area. You will be refueled if you stop within this area. If you run out of fuel in the air, the engine will stop. It's then time to think about an emergency landing. Actually, the engine does not stop, but is limited to 1 notch of throttle. Once on the ground you can slowly taxi back to the base for more fuel. This

could take some time, but thats what you deserve for running out of gas!

Overstressing the Aircraft

The "never exceed velocity" of the FS1 is 150 MPH. At this point, the aircraft is moving so fast that wing lift can tear the wings off if you try to climb too fast. If this happens on the FS1, you loose all lift as the wings break off. The wings are repaired when the speed gets down to a reasonable level (usually after you crash).

Flying Blind

At some times the 3D display will be blank. This sometimes happens when in a steep climb where the nose is pointed more toward the sky than the ground, and can also happen when flying off the grid area. Under these conditions you must fly "on instruments".

You must mentally keep track of where you are by keeping tabs on your heading and airspeed. Keep the aircraft under control by watching the turn rate indicator, vertical velocity indicator, and altimeter.

The most common mistake in flying blind is setting the aileron/rudder for a roll into a bank to turn around and forgetting to reset it when the desired bank is reached. You quickly find that you have made this mistake when the world comes into 3D view with about 60 or 70 degrees of bank and the airspeed is rapidly increasing. When flying blind, make sure to keep track of your rate of turn (which is indicative of your bank angle on the FS1) . Try to avoid the "graveyard spiral" condition just described.

If you get into one, first level the aircraft, then apply up elevator slowly. You will have a very high airspeed, and too much backpressure on the yoke could damage the aircraft.

Maneuvers, Advanced Maneuvers, and Flying in General

The descriptions given for how to fly the FS1 are by no means complete. A good student flight manual should be consulted for detailed instructions on flight techniques. Here are a few things to watch casually in normal flight, and closely in aerobatic flight:

1. Watch your airspeed. You can damage the aircraft if you go too fast and try to climb too fast.
2. Watch your fuel supply
3. Watch your altitude loss in turns.

We, at Sublogic, are not experienced aerobatic pilots, so we have not tried many maneuvers, and have crashed during others. We have performed a couple of reasonable barrel rolls however. You may wish to try maneuvers with the FS1. We believe it is capable of quite a lot.

Getting Better Views

Due to the poor vertical resolution of the screen, objects do not always appear as clearly as you would like them to. Switching to a downward view is one way to get a clearer view, and here is another: go into a very sharp bank and scan the area.

It turns out that 3D flight displays require good vertical but medium horizontal resolution (due to all the horizontal lines in the display). Its simply amazing how much better the view is in a steep bank (it appears almost as well as the 280 x 192 resolution APPLE II). By doing steep, sweeping turns you can take advantage of these nice viewing capabilities. You can think of these as "clearing turns" (a series of steep turns performed by pilots before practicing maneuvers to make sure that the airspace is clear of other traffic).

PLAYING BRITISH ACE

British Ace is a 3D aerial battle game that involves bombing runs and dog-fights with the computer-controlled enemy.

Starting the Game

The game begins when you declare war on the enemy by pressing the W key. You needn't be at your airbase to declare war, and you may find it more strategic to be somewhere else when you declare war.

Goal

The Germans have just established an airbase (with 3 runways in a triangular formation) and are occupying a territory in the north-west corner of the map. They have set up a fuel depot in the far NW mile square. Your RFC (Royal Flying Corp) commander has instructed you to bomb the fuel depot.

Your mission, however, is complicated by the fact that the Germans have 5 fighters stationed at their airbase. These fighters will protect the fuel depot and enemy territory. Your mission, therefore, is to shoot down as many fighters as you can, and bomb the fuel depot.

Fighting the Fighters

The basic way of fighting a fighter is to get close to him, point straight at him, and fire your guns. The space bar is the gun control and rapid bursts of many spaces are needed to be effective. You have a probabilistic chance of hitting the enemy if he is anywhere on your 3D screen (within gun range), but the distance you must be from the enemy to be in your gun's range decreases drastically as the enemy moves to the sides of the screen. Your gun has good straight range, but poor side range. The guns are only effective when aiming out the windshield (RADAR must be off). Use ammo carefully; you have only 80 rounds.

Every enemy fighter has a different fighing technique. The German pilots have orders to intercept any invader, but each fighter pilot has different instructions concerning when to launch and when to return back to base.* The pilots are of different skill levels. Some pilots take a long time to successfully hit you,while the German Aces are very proficient and score very quickly.

Fighters as well as pilots are different from one another. The Germans have two Hansa-Brandenburg D1s (fast, rugged, but with unreliable guns), one Fokker-DR1 (good speed and maneuverability), one Albatros D II (a normal plane with fair speed, maneuverability and guns), and one Fokker D VII (a super fighter). These planes all have different speed and climb rates. Count on the Aces to be in the best planes.

Armament Indicators

Two screen messages on the lower part of the 3D display (or RADAR) indicate attack status. An "IN RANGE" message goes on when an enemy is within your gun's range. A "DANGER" message starts flashing when the enemy is firing at you. You will see the shots on the 3D display if bullets start striking your plane and cause damage.

If an enemy is firing at you, you better shoot him down, or get out of there fast. Your evasive tactics will depend on the enemy fighter's characteristics. You might find that a power dive will get you away from an Albatros, while a quick turn will elude a Hansa-Brandenburg.

Enemy aircraft can come up from behind you and chase you. You may be in their firing range while they're not in yours.

Using Radar

World War I aircraft had no Radar, but the FS1 does. This radar is available primarily to compensate for your lack of "out-the-side" views from the cockpit. The

*HINT: This is the key to the game. You cann't expect to become an ACE if you try to take-on five fighters all at once! Lure them out, and pick them off.

radar screen has you in the middle, and picks up other aircraft and ground scenery in front, back and beside you. This radar has approximately 1 mile radius on the screen. You will quickly get used to its capabilities. Note that guns can not damage the enemy when your RADAR is turned on. You must have him in view on your 3D screen.

Bombing

The fuel depot is the target, and the X key is the bomb release button. You have 4 bombs that you can drop one at a time (short press of X) or in rapid succession (long press). You must be within 100 feet of the target (horizontal distance) to get hits. No special trajectories for the bombs are calculated - they drop straight down. You must be right over the target.

Use the downward view feature as a bomb sight. When a hit is scored you will see a large blast on the screen and the score will be incremented.

You should consider different bombing techniques. You may be able to get four hits in rapid succession, but a bomb or two may miss if you are flying too fast. It may be wiser to take a couple of passes.

Getting Shot Down

The enemy can shoot you down. Every hit that the enemy gets degrades the performance of your aircraft (as holes are shot in your wings, fuel tank, engine, etc.). Note that an enemy shooting (indicated by the DANGER message) doesn't mean an enemy hitting. Hits depend on his skill level (different for each German pilot). Blasts on the screen indicate valid enemy hits.

In a marginal situation you may sustain one or two hits and still be able to fly, but if the enemy has you in a bad position and gets 4 or 5 hits you will crash.

Enemy Appearance

Due to the limited memory size and resolution of the screen, the enemy appears as just a dot on the screen. You must judge his position by radar and the 3D screen. Remember, radar is not really a downward view - things above you are projected on the radar screen too. Don't make the false assumption that the enemy is below you. The "IN RANGE" indicator also gives positional information.

Point Scoring

In the game mode points are scored as one point for a fighter and one point for a bomb blast.

Becoming an ACE

It takes at least 20 points in one game to become an ACE. There are only 5 fighters at the enemy airbase at one time. If you get them all, you can land and refuel. The enemy will replace their aircraft while you are at your base.

Restarting

If you crash, get shot down, or want to start a new game simply hit the 0 key (zero key). This will put you back on the runway and refuel your plane. This command does not interfere with the kinematics simulator so you will not necessarily be standing still when you restart. If you want to be stationary, stop your plane before hitting the zero key.

APPENDIX 1 - TAPE USE TIPS

Here are a few suggestions to help in using the T80-FS1 tape.

1. The FS1 program is about 13000 bytes long so you must have your cassette player set to optimum settings for a good load. The cursors in the upper right corner are designed to help you find these settings. Watch the left cursor's sequence and if you get an error note where the load stopped and write it down. Adjust volume and try again. If you still get errors consider the following points:
    a. if you got further in the load than last time, the setting is probably better than before. You are going in the right direction.
    b. if the tape consistantly stops at the same point with exactly the same left and right cursor, the tape is probably bad at that point. NOTE: THERE ARE 2 FULL COPIES OF THE PROGRAM ON THE CASSETTE. Use the second copy. (find the second copy by listening to the tape. There is about a 12 second gap between copies with nothing on the tape.)

2. If you cann't even get the first part of the tape (the preloader) to load, listen to the tape (the preloader portion) and compare it to a tape that you are used to loading. If the volume is different, adjust the recorder's volume level so the Sublogic tape, when played, sounds like the good tape played at its good load volume level. Then load the tape.

3. LEVEL I USERS: The second portion of the tape (after the preloader) is similar in format to a LEVEL II tape and thus requires a slightly lower volume level. If the preloader loads OK (indicated by the 2 Sublogic cursors appearing in the upper right, but the sublogic portion has problems, do the following: Load the tape again and note when the cursor first appears after the CLOAD command (the CLOAD cursor in the upper left). Exactly 18 seconds after the cursor appears turn the volume down a little bit. This may help. When loading you will notice that the cassette player stops momentarily at about the 15 second from CLOAD cursor point. Adjusting volume immediately after this point is an alternative to timing out 18 seconds.