A2-FS1

FLIGHT SIMULATOR

APPLE II

ASSEMBLY LANGUAGE 16K

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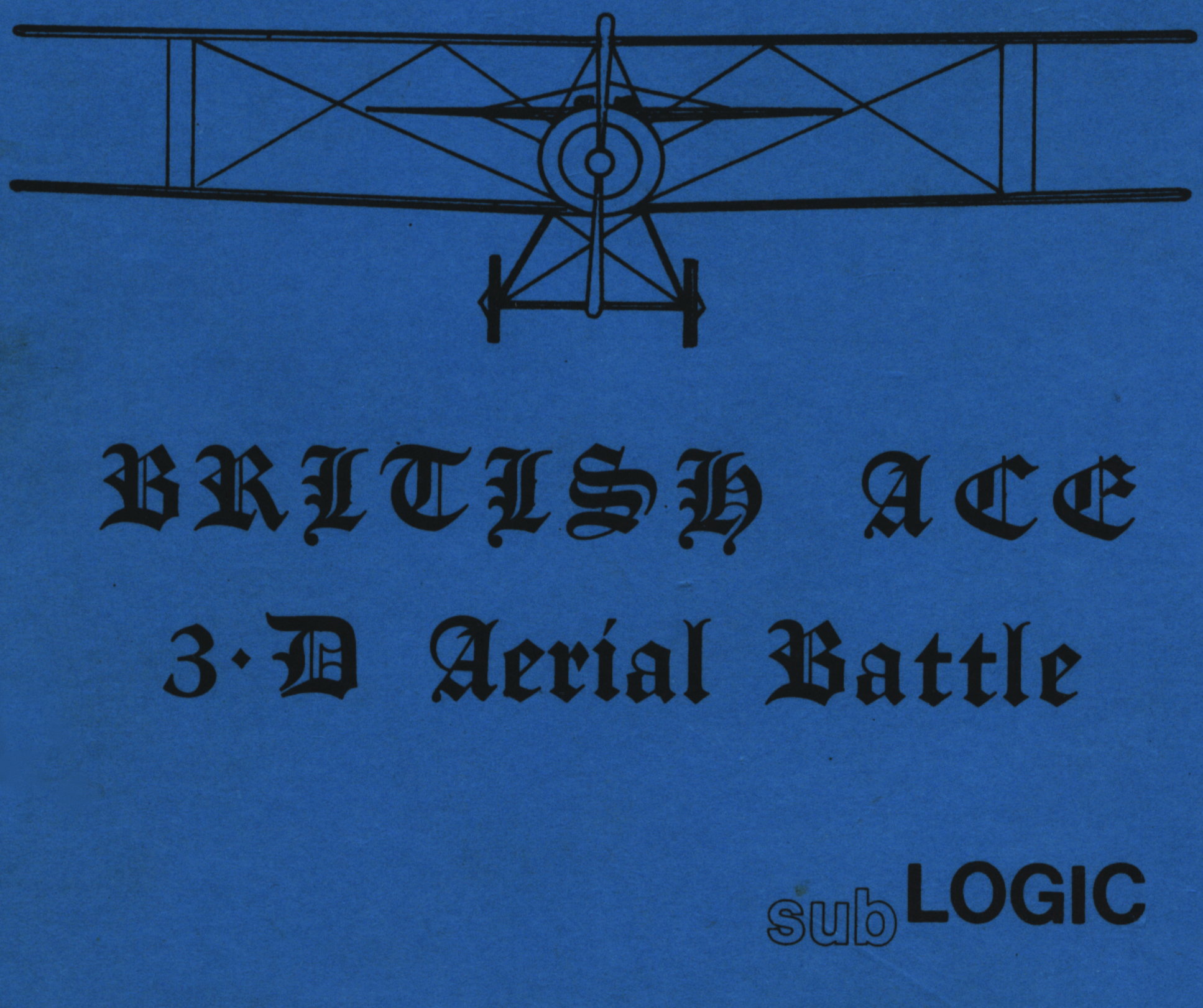
with ...



BRITISH ACE

3-D Aerial Battle

subLOGIC

A2-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 A2-FS1 Flight Simulator is a program designed to run on an Apple II 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 dual Vickers machine guns). The program is written in optimized assembly language and is capable of presenting 2 to 5 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 an A2-FS1 package.

The FS1 is Sublogic's first flight simulator, and the Apple II is Apple's first large-selling 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.

For the game "British Ace", the sopwith camel is certainly appropriate. The famous dog-fights of WW I were the real "man against man" aerial battles and were a lot more challenging and "fun" than today's push-button warfare.

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 horizontally into two parts: the upper 3D out-the-window display and the lower instrument panel. The screen instrument functions will now be described in detail.

3D Out-The-Window Display

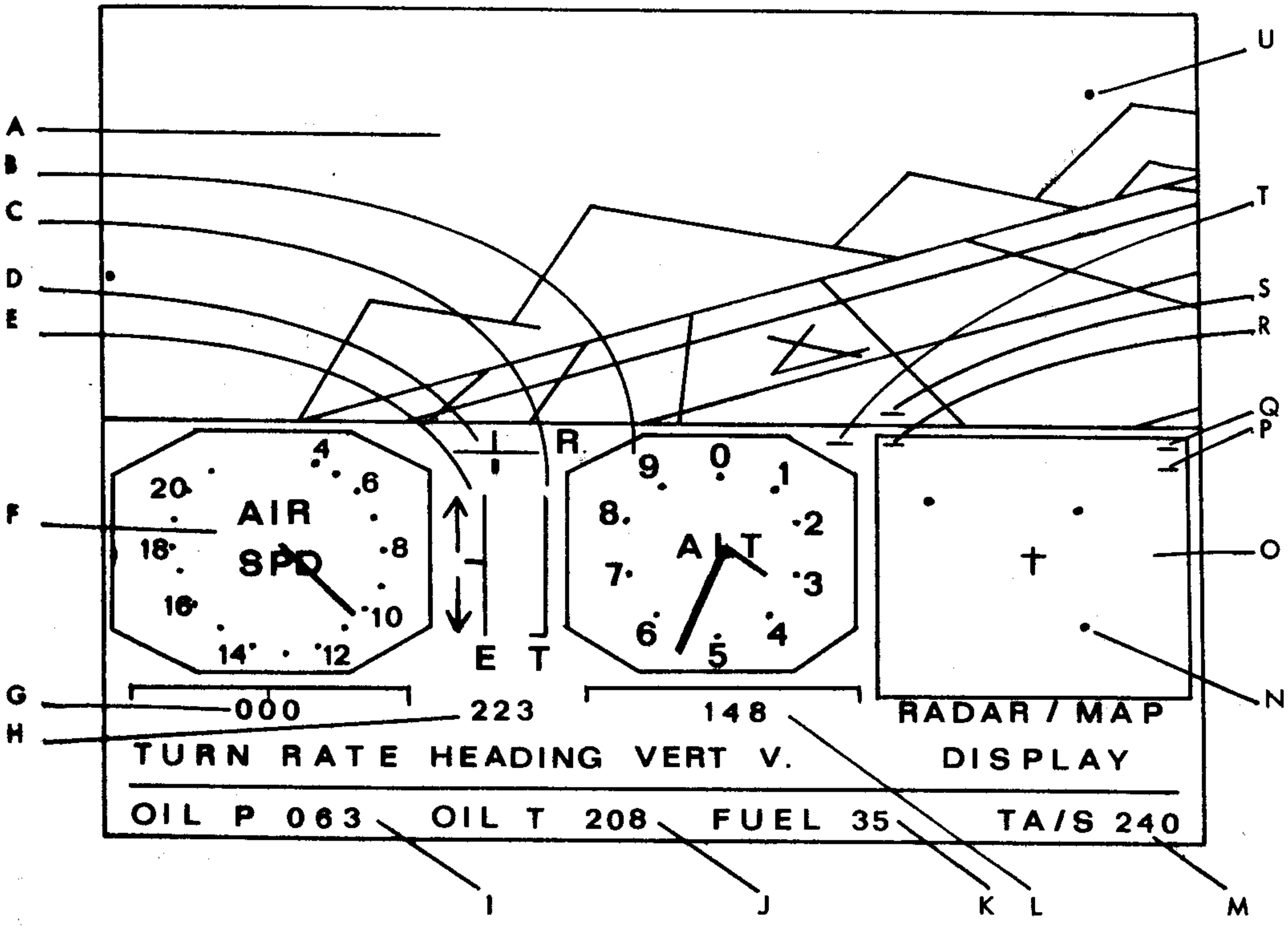
This is a view out the windshield of the aircraft. The view is oriented as if the pilot were leaning foreward slightly to get a better downward view. This view was chosen because it gives better airborne visibility, especially when climbing or flying at high altitudes. When flying, there will usually 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.

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 guage, oil temperature guage, compass, and fuel guage to qualify for legal VFR flight. The FS1 has these guages and more.

Airspeed Indicator -- This guage (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 40 mph until that speed is passed. Readings under 40 are not of great use because this is an air pressure activated guage.

Altimeter -- This instrument measures altitude in feet. It is operated by atmospheric pressure which decreases as altitude increases. This guage is read like a clock. The small hand indicates thousands of feet, and the large hand indicates hundreds. The FS1 altimeter is not continuous but rather indicates to the nearest



A Three-dimensional out-the-windshield display.
B Altimeter (feet)
C Throttle indicator
D Roll Rate indicator
E Elevator position
F Airspeed indicator (mph)
G Turn Rate indicator (degrees per minute)
H Heading indicator Gyro-Compass (degrees)
I Oil Pressure (psi)
J Oil Temp (degrees F)
K Fuel (gallons)
L Vertical Velocity (feet per minute)
M Tachometer (rpm x 10) or Score during game
N Enemy aircraft on radar
O Radar Display
P Bomb Hit Target indicator
Q Bomb Dropped indicator
R Enemy in Gun Range indicator
S Enemy is Firing Guns indicator
T Stall indicator
U Enemy Aircraft on 3D display

Figure 1. A2-FS1 Cockpit Instrumentation.

50 feet. Due to "exclusive ored line generation", the overlapping portions of the altimeter hands tend to disappear when the needles overlap. The guage can be easily read by seeing the remaining portion of the hands, but you should be aware that this is normal.

Tachometer -- When in flight simulation mode (not British Ace mode) the display in the lower right hand corner (TA/S) indicates engine rpm x 10. TA/S stands for Tachometer/Score. The game score is tallied on this guage when in game mode.

Oil Pressure Guage -- The oil pressure guage (Oil P) indicates oil pressure in PSI. It should be noted that the FS1 has a very simple engine due to memory size limitations. Oil pressure, temperature and other engine functions are very simple-minded.

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

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. It's a great compass!

Fuel Guage -- A fuel guage indicates the number of gallons of fuel in your tank. A full tank is 38 gallons.

Additional Instruments

These instruments will be invaluable to you 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 these 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 clockwise turn. A standard rate turn (a 2 minute 360 degree turn- a standard flying maneuver) is thus registered as 180 or 180 degrees per minute. You will quickly find that this guage helps you set up a straight line of flight. With the limited 3D capability 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 indicates your rate of climb in feet per minute. A positive reading indicates an upward climb. This guage is good for helping you maintain level flight and will help get you down to desired altitudes in desired distances. Non pilots are cautioned not to "chase" this indicator in an attempt to get a desired rate. Slow changes and waiting for stabilization are 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).

Elevator Indicator -- This guage 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 guage 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.

Stall Indicator -- This little bar of light will come on when you stall the aircraft (put too great an angle of attack on the wings by trying to climb or pull out of a dive too fast). The bar goes off when the aircraft recovers from the stall.

Armament Indicators -- The radar display, bomb hit, bomb dropped, enemy in gun range, and enemy firing indicators are described later in the British Ace instruction section.

AIRCRAFT CONTROLS

The Apple II 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. In early experiments, keyboard keys were used as elevator and aileron/rudder controls with the intention of switching to paddle controls later on. Upon switching we found the keyboard controls more to our liking. The FS1 is therefore supplied with both capabilities. You can use the method of your choice or even use a joystick that plugs into the paddle ports.

The main reason for our liking the keyboard method was the nice layout of the control keys. 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 are primary aircraft controls (elevator, aileron/rudder, and throttle). The dashed outlined keys are less often used functions.

Using the Control Diamond Keys

Normal typwriter hand positioning is not used in any way in the control diamond control 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) one or more times. Three presses gives 3 notches of right rudder. You may straighten the rudder by pressing the left key (F key) 3 times. For convenience, you may press the middle G key to straighten the rudder. For rudder control, your hand will rock 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

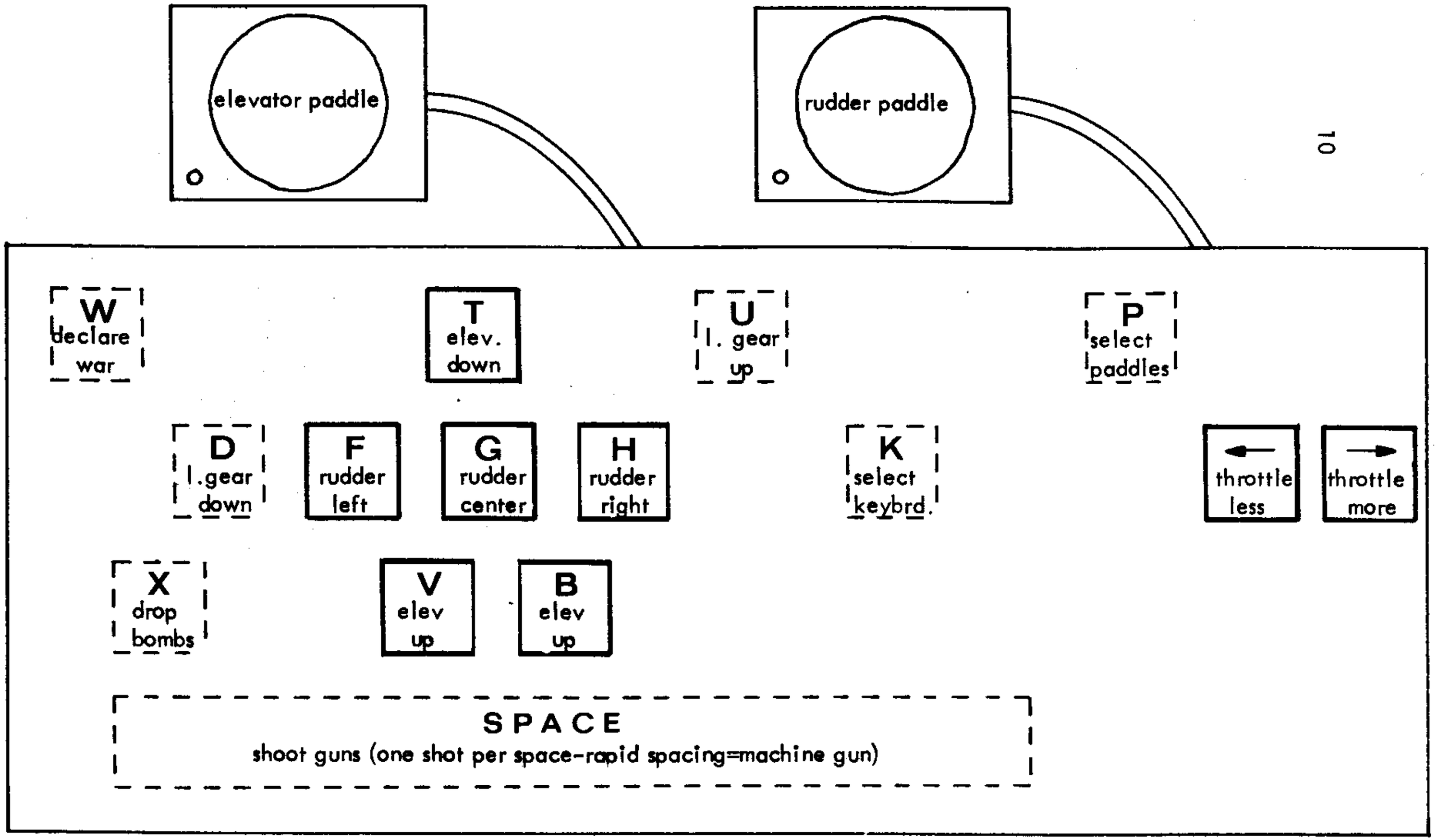


Figure 2. FS1 control system.

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-in one notch of down elevator. Rocking your hand back for up elevator sometimes results in hitti ng 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 altitude data-base selection control . The keys were initially called hi-low 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 databases.

Paddle and Keyboard Select Keys -- Pressing the P key switches control diamond control over to the paddles. One paddle is the rudder/aileron and the other is the elevator. You can center the controls by watching the E and R indicators on the instrument panel.

If you find the paddles inferior to the control diamond, press K to return to keyboard control.

Throttle, landing gear, and all armament controls are not affected by the P and K keys and always remain as keyboard controls.

Armament Control Keys -- Briefly, the W key is pressed to declare war and put the FS1 into its 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's fuel depot, and the space bar fires a burst from your machine guns. These guns fire in small bursts with each space bar press. See the British Ace section of this manual for more details concerning armament control.

Keyboard Usage

The simulation program runs in a loop that executes from 3 to 5 times per second. It can only sample one key press per loop, so there must be about one fifth to one half a second between control key pressings. After some

practice you will find the most effective repetative press rate. If you hit more than one key in a short time, the last-pressed key will be the one that is read by the computer.

The only time this wait between keys is somewhat annoying is when you want to rapidly make large throttle changes or when you want to go to a zero turn rate by making small corrections.

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 way these controls operate with experience. Non-pilots may initially have trouble flying the plane as they would in normal life. If you fall into the student pilot 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 A2-3D1 graphics driver and high performance line generator. Figure 3 illustrates the program's overall design.

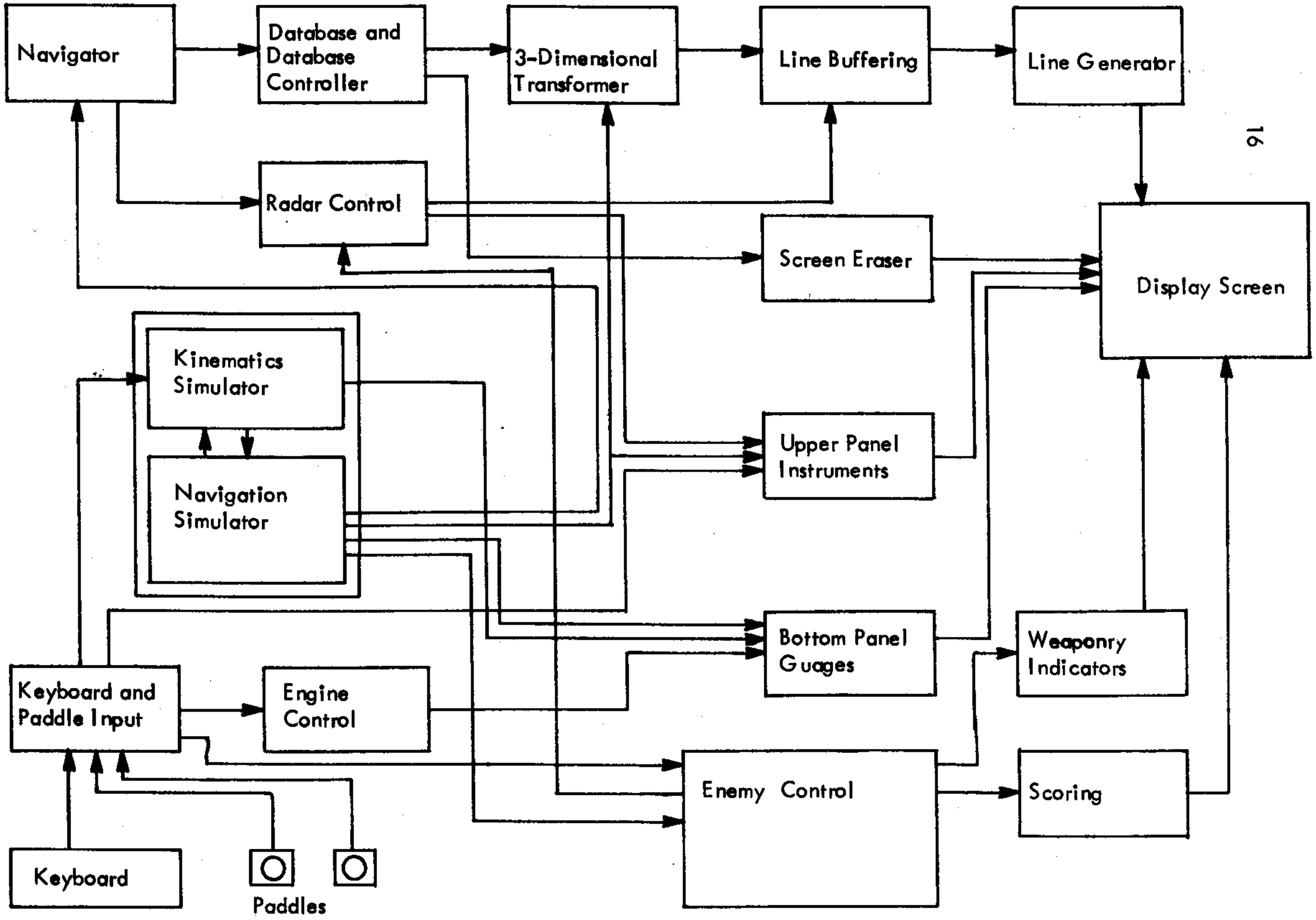


Figure 3. A2-FS1 simulation structure.

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.

AIRCRAFT SPECIFICATIONS

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	500 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 graound 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).

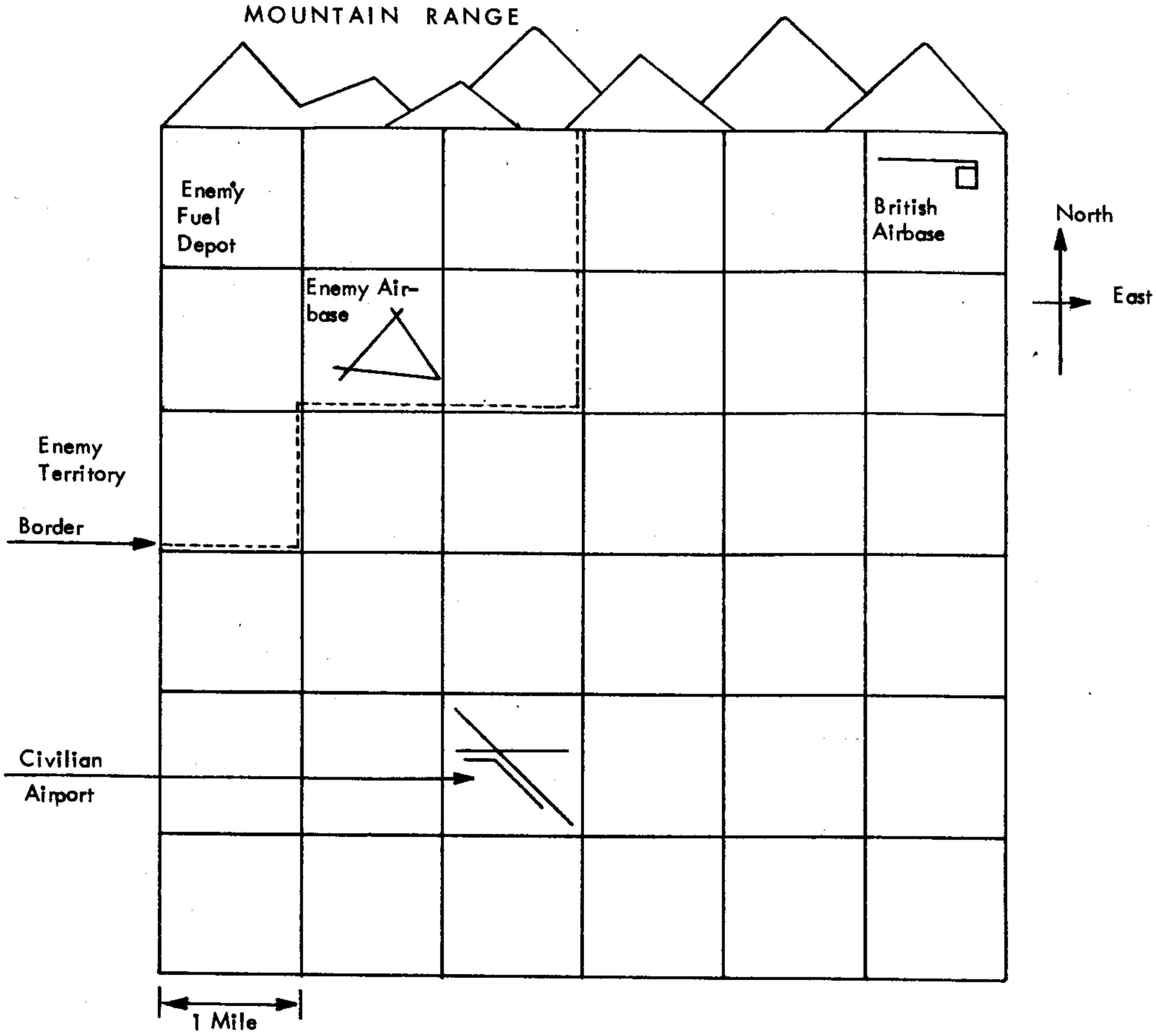


Figure 5. The world.

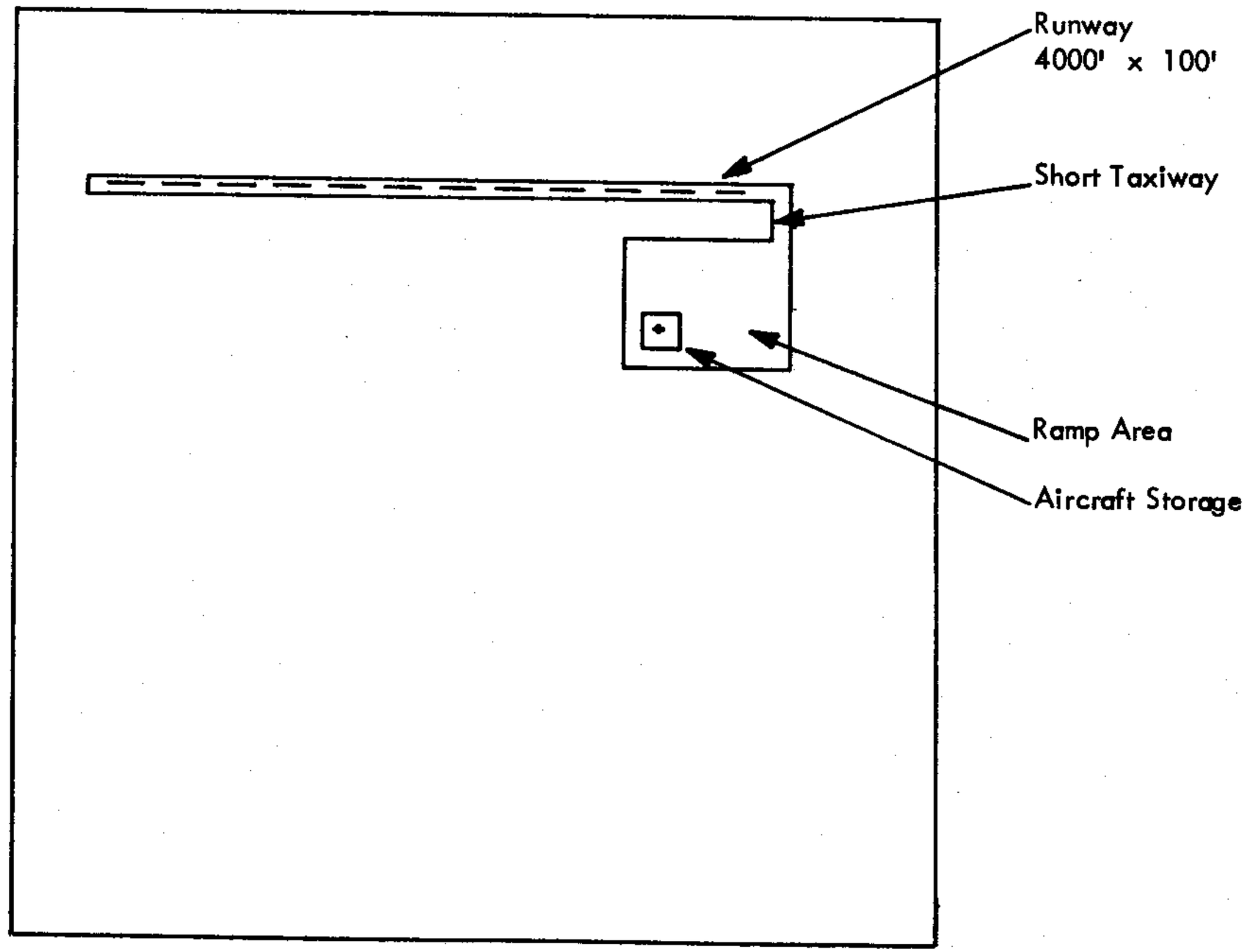


Figure 6. British airbase taxi chart.

FLYING THE AIRCRAFT

The first step in using the FS1 is loading the program.

Tape Loading

The FS1 is loaded in a slightly different way than most Apple II tapes. First, a loader is loaded, then the loader loads the rest of the program. Use the following procedure, and refer to Appendix 1 for tape use suggestions.

1. Get into the system monitor (* prompt) mode. Normal Apple IIs power-up in this mode. If you own an Apple Plus, type CALL -151 followed by a return to get into this mode.

2. Set the volume on your cassette recorder so it sounds about the same for the Sublogic tape as for other Apple tapes you are used to loading.

3. Type the following after the monitor prompt:
   3000.3200R 3000G
   followed by a return. Make sure to leave a space after the R.

4. Play the cassette.

5.* After a short time, a buzzing will come from the Apple II speaker. This is the calibration tone. The calibration signal on the tape which is playing while this buzzing is occurring is available to help set your cassette player for the optimum volume level. You have about 15 seconds to do this once the tone starts. Find the upper and lower volume settings where the buzzing stops or gets erratic, then set the volume level right in the middle of these two settings. Remember, you only have about 15 seconds to do this once the tone starts.

6. From here on everything is automatic. After a short load-in time the flight simulator will start running. You will then be ready to fly.

* Note: This step should only be taken if the level set in 2 causes problems. When performing step 5, don't go too high on the volume (as APPLE recommends).

Setting TV or Monitor

Black and white TVs or monitors don't require any special adjustments. Set them to a setting that you like. On color TVs or monitors you will notice that the instrument panel is green and purple. To make the simulation more realistic, adjust the monitor to make the instrument cluster orange and blue. The orange color should be the same shade that aviation instruments are normally illuminated (redish orange).

Getting Familiar With the Airplane

You start out in the aircraft storage area 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 guages. Notice the compass indicates a heading of west(270 degrees), the airspeed is 0 (or at least below 40) and your altitude is 400 (this airbase is at 400 ft. above sea level).

Taxiing

You are, unfortunately, now at the point of the flight where the 3D out-the-window display is at its worst - sitting on the ground. This is due to the limited resolution of the Apple II screen. While sitting on the ground, everything gets cluttered-up on the horizon because most objects are viewed edge-on. It's often hard to make out taxiways until you are close to them. Taxi around a bit to find your way around the airbase.

Try turning the rudder from left to right (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 standing still. You must be moving to turn the airplane. To get moving, give the plane one notch of throttle (right arrow). Watch out the windshield, and use your rudder controls to steer the plane. Go around in a few circles and then get to know the airbase. Refer to the taxi chart (figure 6) to help find your way. Taxi over to the runway and taxi up and down it. Learn how to guide the plane down the runway, and keep your wheel on the center line.

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 to 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. Now, go through the pretake-off check

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 guages. 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 guage 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.

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.

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 "light bar" indicators indicate attack status. (see Figure 1.). An "enemy in gun range" indicator in the upper left of the radar screen indicates that the enemy is within your gun's range. An "enemy is firing guns" indicator just above the "enemy in gun range" indicator (on the 3D display) starts flashing when an enemy is firing at you.

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

radar screen has you in the middle, and picks-up other aircraft in front, back and beside you. This radar has approximately 1 mile radius on the screen. You will quickly get used to its capabilities.

Bombing

The fuel depot is the target, and the X key is the bomb release button. There is only one load of bombs, so you get only one shot at the target. You must be within 100 feet (horizontal distance) of the target to get a hit. No parabolic trajectory for the bombs are calculated - they drop straight down. You must be right over the target for a hit.

Figure 1 depicts the two bomb indicator lights. One lights when you drop the bomb, and the other indicates that the bomb scored a hit.

You should consider different bombing techniques. It is a lot easier to hit a target from a low altitude than a high one.

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 doesn't necessarily mean an enemy scoring. His hits depend on his skill level.

If your aircraft starts acting strangely or you start to loose fuel and are under attack, you know you have been hit. You should try to make it back to your territory and preferably the airbase. You don't want to be captured by the enemy!

Enemy Appearance

Due to the limited memory size and resolution of the Apple II, the enemy appears as just a dot on the screen. You must judge his position by radar and

his movements on the 3D screen. The "enemy in firing range" indicator also gives positional information.

Point Scoring

In the game mode, the TA/S indicator keeps the score. Points are as follows:

2 points - fuel depot bombed, minimal damage

3 points - fuel depot bombed, extensive damage

1 point - enemy shot down

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.

APPENDIX 1

TAPE USE SUGGESTIONS

Here are a few suggestions to help in using the A2-FS1 tape.

1. Step 5 in the loading procedures on page 22 says to listen for a continuous tone that is not erratic. The speaker in the Apple II, when operated at the low frequency generated by the sync stream, tends to sound slightly erratic even when it is totally stable. These slight variations are to be ignored.

2. Two copies of the A2-FS1 program are provided on the program tape. The second copy is the backup copy and should be used upon failure of the first copy.

3. It is important to keep the tape in good condition for repeated use. This can be done by following these guidelines:

   a) Always rewind the tape after a load. Don't leave it sitting at the end of the program with tape exposed to outside conditions.

   b) Don't stop the tape in the middle of a load. Always stop or start the tape in a blank section or on the pure-tone leader at the beginning of the 3000.3200 load-in section. Starting or stopping the tape can apply severe compressive forces to the tape (the capstan pressure against the pinch roller) that can leave a slight bend in the tape which may affect loading.

   c) Don't foreward or reverse cue or review the tape (quickly making it slide by the heads by releasing the pinch roller). The stopping motion when the cue or review is finished can put bends in the tape (caused by pinch roller action on the quickly moving tape).

   d) don't let the tape get dusty, and keep the tape away from magnetic (especially electromagnetic) fields.

   e) Don't use the pause control or "Mic On/Off" control on any data portion of the tape. Stopping the tape (especially with the Mic switch) can put bends in it.

Also see: Page 22 - Tape Loading
Page 36 - Error Messages

APPENDIX 2

ERROR MESSAGES

If the message "STOLEN AIRCRAFT" appears on the screen, it means that you have a bad tape. Under rare circumstances (never experienced at subLOGIC but conceivably possible) a bad load could cause this message. If you get this message, try and load the tape again. Make sure that you are following the loading procedure TO-THE-LETTER.

If the STOLEN AIRCRAFT message keeps appearing, please send the tape to subLOGIC for replacement.

The engineering and graphics experts.

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