ENTERPRISE

PROGRAMS

HEATHROW A.T.C.

SIMULATION

INSTRUCTION MANUAL

1. INTRODUCTION

Congratulations! You are the proud owner of Heathrow Air Traffic Control for the Enterprise, written entirely in machine code for maximum enjoyment.

Your purchase will provide you with hours of fun because it simulates as closely as possible the real-life operation of the Air Traffic Control Centre at London Heathrow Airport. You should not expect to understand all the operations immediately — you must first learn the meanings of special words and phrases like localiser, expedition, glide slope and fully established.

To make the most of your cassette as soon as possible you are advised to:

(a) read all the instructions, particularly sections 3 and 4:
(b) load the cassette and watch the demonstration (level 5):
(c) re-read sections 3 and 4:
(d) re-run level 5 and follow the description of it in section 4.

You should then be ready to progress through the various levels. Eventually you will become fully capable of dealing with any situation and will be able to take charge of Heathrow Air Traffic Control.

The program is designed to simulate the functions of Heathrow Airport air traffic control. The objective is to land 10 aircraft (or as many as possible within the time limit of 30 minutes) as safely as you can. The task is a complex one and has been broken down into a number of levels to enable you to develop your expertise gradually.

2. LOADING THE PROGRAM

Set up your Enterprise 64 as explained in the Setting Up Guide.

Load the program by pressing FUNCTION KEY 1 'START' on your Enterprise.

Start the tape at the beginning and wait until you are offered a menu of options on the TV screen, then switch off the tape. The menu consists of a choice of several levels.

3. SYSTEM DESCRIPTION

In order to understand the Air Traffic Control problem, run the demonstration exercise by either pressing 5 or leaving the computer for 40 seconds, after which time the demonstration is selected automatically.

Once into the demonstration, the radar screen is displayed together with information on the aircraft. The aircraft arrive at four holding stacks. These are radio beacons around which the aircraft fly in a racetrack pattern. Air Traffic Control (ATC) then gives instructions to position the aircraft onto a pair of radio beams, called the ILS (Instrument Landing System) with which the aircraft can complete the landing at Heathrow airport.

3.1 RADAR SCREEN

The radar screen is the dark rectangle, with the four holding stacks shown as small white plus signs around which the aircraft (shown as white blocks with a trail of white dots) circle. The stacks represent Bovingdon (BNN) on the top left. Lambourne (LAM) on the top right, Ockham (OCK) on the bottom left and Biggin (BIG) on the bottom right. The rectangle at the top represents Luton airport.

In the centre of the screen are two small rectangles representing Heathrow and on either side are shown the extended centrelines of the double runways at Heathrow. The small dots on the centrelines are range marks located every two miles. The total length of the centreline is 10 miles either side. Heathrow has two parallel runways, one for landing and one for take off. We are concerned only with the landing runway, which is the top line. The centreline to the right of centre is the westerly landing direction because aircraft are landing into a westerly wind and flying from right to left. Conversely aircraft landing from left to right use the easterly landing direction on the left of centre. In the demonstration, a westerly landing direction is used.

Whichever level you choose to play, you will be given the choice of landing from the west or from the east. Press W to select a westerly landing or E for an easterly landing.

As the demonstration progresses, the aircraft circle around the stacks. Near each aircraft is a label produced by the Secondary Surveillance Radar (SSR). This label consists of a one letter call sign of the aircraft and one digit showing the altitude of the aircraft in thousands of feet, rounded down to the nearest thousand feet: for example A6 means aircraft A at an altitude between 6000 and 6999 feet. Labels are only displayed on aircraft below 8000 feet and only inbound aircraft are controlled and labelled. Outbound aircraft are marked with the altitude only.

3.II STACK DISPLAY

To the right of the radar screen is the stack display. This shows information about each aircraft from the time it first appears on the radar until it lands. It is divided into four sections (one on top of the other), one for each of the four holding stacks (the appropriate 3 letter designator being printed beside each section). It is also divided into three vertical columns. The left-hand section contains aircraft identity (one capital letter), followed by the aircraft type (one small letter), followed by the altitude to which it has been cleared by ATC. The aircraft type can be one of five types:– c for a Concorde, h for heavy jet (such as Boeing 747), m for medium jet (such as Trident), s for small propellor-driven airliner (such as Herald and l for light aircraft (such as Navajo).

The second vertical column contains the aircraft heading or other direction information eg 'H' = Holding at stack, 'loc' = localiser established, 'EST' = fully established. Aircraft heading is the direction in which an aircraft is flying measured in compass degrees; ie 360 degrees = North, 270 degrees = West, 130 degrees = South East etc. (Direction on the radar screen is aligned such that North points straight up.) The third vertical column contains the aircraft speed in nautical miles per hour. To assist in identifying items in the stack display, the columns are headed with the stack name. 'A' for altitude, 'T' for aircraft type, 'L' for Altitude (Level), 'Hdg' for heading and 'Sp' for speed. Above the stack display, wind information is given measured in compass degrees (the direction from which the wind is blowing), followed by the speed in knots; eg wind 240/20 means a wind from the South-West at 20 knots.

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The speed and direction of the wind affect the aircraft in two ways. First, the aircraft heading is the direction in which it is pointing, and therefore the direction in which it will fly through the air. If however that air is moving (that is, there is a wind) the path of the aircraft will be a combination of the two movements. If the aircraft is heading 270 (due West) and the wind is from 360 (due North), the resulting path of the aircraft on the radar will be South of West (260 or 250, depending on the wind strength).

Secondly, the speed of the aircraft is its speed through the air, so if it is heading into the wind, the movement on the radar will be slower than if the aircraft is flying with the wind.

3.III RADIO COMMUNICATION

On the left-hand side, above the radar screen in the box marked RT, is the equivalent to the radio communication at Heathrow. You can send instructions to aircraft using the keyboard. As you press each key, the appropriate symbol will appear. Instructions have the format:– aircraft identity (1 letter), instruction type (input the first letter and the whole word will be printed), appropriate parameter (letter or numbers).

THE INSTRUCTIONS ACCEPTED ARE:–

Altitude — When followed by one number (RETURN), this will instruct the aircraft to climb or descend to the altitude entered. (The number is the number of thousands of feet; eg A (Altitude) > 3 means aircraft A climb or descend to 3000 feet.) You may only input altitudes 2 - 9. The lowest safe altitude is 2000 feet and 9000 feet is the top of your airspace. Any error in this will give the response "Bad Alt" (Bad Altitude). The rate at which an

aircraft will climb or descend depends upon the aircraft type; ie l/s aircraft climb and descend slower than m/h/c aircraft.

Once an instruction has been typed in, press ENTER. If the instruction is acceptable, it will move down one line and the word **"Roger"** will appear after it, meaning "message received and understood". If you make a mistake and wish to retype the instruction prior to entering, press the ERASE key to delete the instruction.

Left — This is a heading change instruction telling an aircraft to turn left to the heading designated after the word Left: For example, A Left > 240 means aircraft A to turn from its present heading onto heading 240 degrees with a left turn. It takes some practice to visualise whether a turn is to the left or right, especially when aircraft are not flying "up" the radar screen. Any value of heading input will be rounded down to the nearest 10 degrees.
Note: Headings must be input using three digits; eg 090, not 90, etc.

Right — A heading change instruction telling an aircraft top turn left to the heading

Speed — This tells an aircraft to adjust speed to the specified speed;
eg C Speed > 200 means aircraft C adjust speed to 200 knots.

The different types of aircraft have different speed ranges over which they may fly. If you input a speed not possible for that particular aircraft or make some other error on entry, you will get the response "Bad Spd" (bad speed).

aircraft type	maximum speed	minimum speed	ILS max speed
l	180 kts	120 kts	160 kts
s	210 kts	140 kts	180 kts
m	250 kts	160 kts	200 kts
h	250 kts	160 kts	200 kts
c	300 kts	190 kts	230 kts

Speeds when input are rounded down to the nearest 10 kts.

Quote — This is an enquiry to an aircraft followed by one letter which specifies the information required. The information appears in the space normally occupied by the message "Roger". The letter 'A' returns a value of the aircraft altitude in thousands of feet; eg A Quote > A might return a value 3.8, meaning aircraft A altitude = 3,800 feet. The letter 'H' returns the aircraft heading, and 'S' the speed. If a letter is input which is not recognised, you will get the response "repeat", inviting you to re-input the enquiry with the correct letter.

Maintain — This instructs an aircraft to continue flying on whatever heading the aircraft is on or passing at the time.

Orbit — A heading change instruction telling an aircraft to turn right to the designated heading.

If you get the response of "No Reply", this means that you have addressed an aircraft not under your control (either not yet on the radar, already landed or overshooting).

Above the radar is a line marked EV (Event) awaiting any relevant incoming messages. When messages come in, you will hear a rising "beep" each cycle. Acknowledge the

message by pressing the Space Bar.

Certain of the keys have special functions.

Space — acknowledges incoming messages (you will get no further messages until each message is acknowledged, in turn).

Enter — used for evaluating instructions.

Erase — deletes the line of instruction currently being typed.

Stop — freezes the exercise and waits until Enter is pressed to restart.

CTRL + F — accelerates the update rate to a rate faster than real time (you can switch between the two rates using keys CTRL + and CTRL + S.

CTRL + S — decelerates the update rate.

CTRL + A — holds the exercise and displays a page of information containing an assessment of your performance to date (based on average landing interval, expedition, safety and, if applicable, emergency handling). (You need 70% to pass.)

CTRL + X — abandons the exercise and returns to the menu.

CTRL + R — puts RMA lines on the screen for 12 seconds.

CTRL+ H — gives a set of Help pages.

Function 7 — switches speaker on/off.

Expedition marks are dependent upon

1) the time it takes to land the first aircraft (the sooner the better);

2) the average landing interval (the smaller the better);

3) the number of aircraft landed (the more the better).

Beneath the assessment is a series of pages of significant event. Key 'M' gives a new page of events. At the end of all events, you are given the prompt "Press Enter to return" which is the key to return you to the exercise.

4. DEMONSTRATION EXERCISE IN DETAIL

Re-run the demonstration level and try to follow the detailed instructions appearing on the screen. These given an insight into the ATC techniques employed. To help you follow the techniques you may use any of the special function keys.

The exercise starts with empty radar screen and stack display. Aircraft are introduced one at a time at altitudes 7 and 8, (7,000 and 8,000 feet) at each individual stack in turn (these altitudes are used so that the aircraft are safely above any outbound aircraft, which only climb to 6,000 feet). Before they appear on the radar, they are controlled by an en route controller, who also controls the outbound traffic, until such time as they can safely be put into the holding stacks at least 1,000 feet above the next lowest aircraft.

The exercise ceases at 15 mins and reverts to the menu of options.

5. BASIC VECTORING, SLOW TRAFFIC — LEVEL 1

In this exercise you are given all light aircraft and the objective is to establish them on the ILS and get them to land.

There are two stages to establishing an aircraft (a/c) on the ILS. First, you must

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establish on the ILS centreline (called the localiser). To do this, the a/c must have a heading of plus or minus 40 degrees from the runway heading (ie on westerlies runway ILS closing headings lie between 240 degrees and 320 degrees. On easterlies, ILS closing headings lie between 060–140 degrees. If the a/c actual heading is not within these limits, the a/c will not establish. To get an a/c to establish, you **must** append the letter 'E' to the end of the heading instruction; eg "A Right > 240E". When the a/c is established on the localiser, the letters 'loc' appear in the appropriate place in the stack display, and the a/c will turn to fly down the centreline.

The second stage of the approach is to establish the a/c on a sloping radio beam (called the glide slope) down which an a/c will fly to get to the runway. To establish on this beam you must be established on the localiser and at the same altitude as the beam at the point that you establish (as a guide the glide slope uses 300 feet for every mile from touchdown — thus at 10 miles you must be at or below 3000 feet.

The safest way to ensure that you establish an aircraft on the glide slope is to reduce the altitude to a level below the glide slope and fly along until the glide slope coincides with the a/c altitude. When established on the localiser and the glide slope, the letters EST will appear on the stack display.

If the aircraft establishes on the localiser but not on the glide slope, you may break off the approach once you have decided that it is too high by simply inputting a heading instruction. If you do not break off the approach, the a/c will "Go Around" when it is overhead Heathrow. This means the a/c will

turn back to be repositioned (and climb to 3000 feet if it is below that).

On westerlies, an a/c which carries out a "Go Around" makes a right turn on to a heading of 090 degrees and on easterlies a left turn on to a heading of 270 degrees. During the "Go Around", you do not have control of the a/c until it is steady on the heading. You will be informed in the EV box "– Go Around (too high)" (remember to acknowledge using the space bar) and the word "Go Around" will appear on the stack display.

NB When on this ILS all a/c like to reduce speed, and will not accept a speed above the maximum ILS speed. When the a/c gets to 4 miles fully established, the a/c enters the "final approach" stage and will reduce speed. It ceases to be under your control at this point. After 30 minutes or landing 10 a/c, the exercise will cease and after reviewing the assessment, you are given the option to start a new exercise or continue your present one for a further 30 minutes.

6. MIXED TRAFFIC WITH AIRSPACE RESTRICTIONS — LEVEL 2

In this level you have to deal with a mixture of aircraft types. This affects you in several ways.

First there is a speed differential between the various types and you must adjust the speeds accordingly to help your vectoring. Secondly, the different types have different rates of descent. This affects the distances required to descend to a suitable glide slope

altitude. Lastly a/c will not establish on the localiser at more than their ILS maximum speed, which is 40 knots above their minimum. Thus you must reduce a/c speed to at or below the ILS maximum speed before they cross the centreline (like all other variables, speed changes are not instantaneous and you must allow good time for them).

The other concept introduced in this level is that of airspace restrictions. As the Heathrow radar controller you are only entitled to use certain areas. You must keep your a/c on the radar at all times. Failure to do this will result in the message "–OUT OF RADAR COVER"

Also you may only descend the aircraft below 7,000 feet when they are in an area called the Radar Manoeuvering Area (RMA). This is an area which changes depending on the landing runway — on westerlies it is a box whose top edge is a line East/West through LAM, bottom edge is a line E/W through BIG, left-hand edge is North/South through the centre of Heathrow and right-hand edge is N/S through BIG. On Easterlies the box has the top edge E/W through BNN, bottom edge East/West through OCK, left-hand edge is the left edge of the radar, right-hand edge is North/South through Heathrow. Descent below 7,000 feet outside the appropriate RMA will result in the message "–Outside Airspace". To illuminate the RMA boxes press keys CTRL + R.

Finally, the minimum safe level is 2,000 feet (to ensure at least 1,000 feet above the highest obstacles in this area). However, you can only descend below 3,000 feet inside a line 12 miles east or west of Heathrow. Descent below 3,000 feet outside 12 miles will

result in the message "LOW BELOW AIRSPACE".

Any airspace infringement will result in the loss of safety percentage points in accordance with how long the relevant aircraft was outside the allowed airspace.

7. LANDING INTERVAL AND SEPARATION — LEVEL 3

Up to this stage the only criteria for landing safely has been safe establishment on the localiser and glide slope. However to ensure that each a/c remains safe, only one a/c is normally allowed on the runway at a time. Hence the minimum time allowed between landing a/c is 1.5 mins. This equates to about 4 miles distance between a/c on the ILS but will vary with wind speed, direction and a/c type.

To achieve the optimum landing interval, experiment with different successive landing a/c and refer to the events page to see the result in the landing times. If the interval between landing a/c is less than 1.5 minutes, the a/c will Go Around (as per Level 2) with the message "Go Around (spacing)" meaning the spacing on final approach is insufficient.

The other concept introduced here is perhaps the most fundamental and important part of air traffic control; that of the method of keeping a/c safely apart. At Heathrow, there are two basic types of separation — vertical and radar. An a/c is vertically separated when it is at least 1,000 feet above or below all other a/c in its vicinity. An a/c is radar separated when it is 3 miles or more from any other a/c.

You must ensure at all times that all a/c under your control are either vertically separated or radar separated. If two a/c under your control are less than 1,000 feet vertically separated and less than 3 miles horizontally apart, you will get the message "– No separation with –" and the separation hooter will sound for three seconds. If the distance apart gets down to 1 mile or less you will get the message "– Collision risk with –" and the separation hooter will sound continuously.

For each infringement of the separation rules, you will lose safety marks for as long as the infringement exists. If two a/c collide you will fail the level!

8. VORTEX SPACING WITH OUTBOUND AIRCRAFT — LEVEL 4

In this level you will see outbound and other traffic not under your control. They climb to a maximum of 6,000 feet. You can identify this traffic by the SSR label displaying the a/c altitude only. You will see that some of the routes which the outbounds take, cut into or go very close to, the RMA. It is still your responsibility to ensure that your a/c remain separated from the other traffic. Failure to do so will result in the message "–No separation with ?".

When an a/c flies through the air, it creates a disturbance in the air similar to the wake of a boat in water. This is referred to as a Vortex wake. A Vortex wake affects a following a/c in proportion to the difference in size between the two a/c. It presents a hazard to the

following a/c, especially at the latter stages of its approach and landing.

To mitigate this hazard, minimum distances must be maintained as shown in the table below.

	Following aircraft				
Leading a/c	c	h	m	s	l
c	4 mi	4 mi	5 mi	6 mi	8 mi
h	4 mi	4 mi	5 mi	6 mi	8 mi
m	3 mi	3 mi	3 mi	4 mi	6 mi
s	3 mi	3 mi	3 mi	3 mi	4 mi
l	3 mi	3 mi	3 mi	3 mi	3 mi

Remember that depending on the order in which you select a/c, it is possible to change the average landing interval radically.

Failure to give enough spacing will result in a Go Around as in levels 2 and 3 and the message "Go Around (Vortex)".

9. EMERGENCY TRAFFIC — LEVEL 6

In this level, one of your a/c will declare an emergency. You must land the a/c as soon as is possible. You are marked on the speed with which you land the a/c.

10. ADDITIONAL PROBLEM — LEVEL 7

In this level not only do you have to contend with all the features of level 6, but also some other event will happen which may delay your traffic.

The possible events are:

1) An unknown a/c will fly through your airspace. You must apply the normal rules of separation or you will lose safety marks.

2) One of your aircraft may lose contact with you (radiofail). You will only know that a radio failure has occurred if you try to send an instruction and get the response "RT FAIL". The a/c will return into communication with you before very long.

3) Heathrow may lose a runway and you may have to go into Single Runway Operations. This means that the runway is being used for takeoffs as well as landings and therefore the minimum landing interval will increase to 3 minutes (to allow one a/c to take off in between a/c which are landing).

4) Your SSR may fail, leaving you with the a/c blips only. All other equipment remains serviceable.

11. RANDOM PROBLEM WITH EXTRA OUTBOUNDS — LEVEL 8

As exercise 7, with extra outbound traffic to avoid.

12. SUMMARY SHEET

Abbreviations

ATC	Aircraft Traffic Control
ILS	Instrument Landing System
BNN	Bovingdon Holding Stack
LAM	Lambourne Holding Stack
OCK	Ockham Holding Stack
BIG	Biggin Holding Stack
SSR	Secondary Surveillance Radar
a/c	Aircraft

Radio Communication

A — Altitude, S — Speed, L — Left,
R — Right, Q — Quote, M — Maintain,
O — Orbit.

Aircraft Types and Speed Ranges

	(knots)
c — Concorde	190–300
h — heavy jet (Boeing 747)	160–250
m — medium jet (Trident)	160–250
s — small prop (Herald)	140–210
l — light aircraft (Navajo)	120–180

Aircraft Heading and Direction Information

H	— Holding in stack
loc	— Localiser established
EST	— Fully established

Special Function Keys

Space Bar	— Acknowledges incoming messages
Enter	— Evaluates instruction
Erase	— Deletes line of instruction
Stop	— Freezes exercise
Enter	Resumes exercise
CTRL + F	— Speeds up exercise
CTRL + S	— Slows down exercise
CTRL + A	— Holds exercise and displays a page of information on performance
CTRL + X	— abandons the exercise
CTRL + R	— puts RMA on the screen for 12 seconds
CTRL + H	— displays the Help pages.
Function Key 7	— switches speaker on/off.