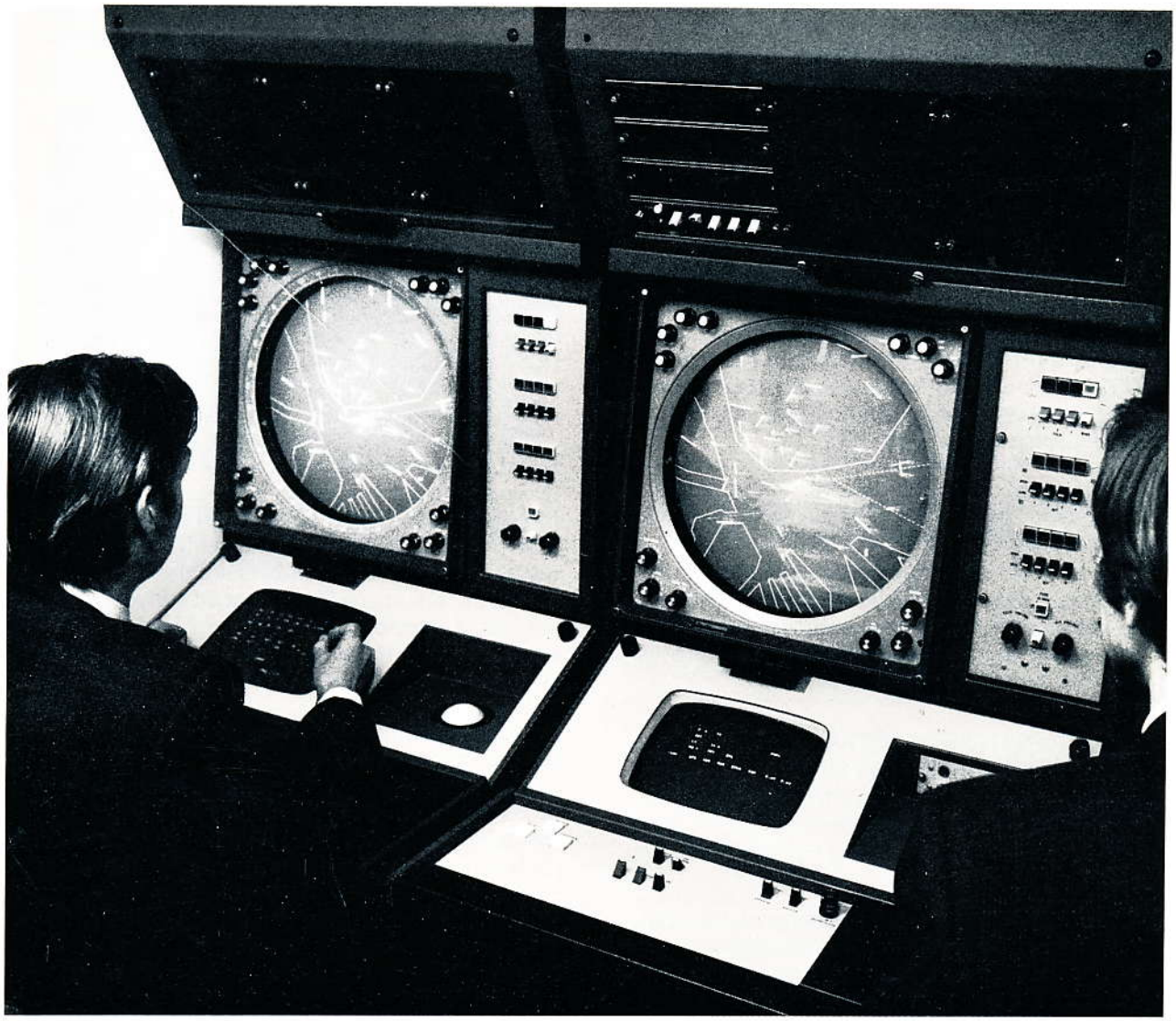
Marconi Radar Data Sheet H2

Operations Cabin Type S5014

S-00-5014-01 to 03



- Transportable
- Extendable system capability
- Automatic tracking and interception control
- Digital display techniques
- Rapid deployment
- Efficient man-machine communication

To meet the requirements of modern tactical air defence, a highly transportable radar system such as the Marconi S600 Series of radars demands an equally transportable, rapidly deployable yet powerful operations and data processing capability. This demand is met by the Operations Cabin, Type S5014 which houses not only three operators with their marked radar displays and communications services, but also a powerful data processing system based on the Marconi Locus 16. Thus a single S5014 Operations Cabin provides autonomously a display and data processing system of the most sophisticated kind with automatic tracking and intercept control. By associating S5014 Cabins in groups, the system capability can be expanded from the level of a Control and Reporting Station to a complete Air Defence Operations Centre. Typically, one or more S5014 cabins are co-sited with one or two surveillance radars and a heightfinder radar. Radar data from other sites is received over narrow band links, in the form of extracted plots or track messages. Command information is exchanged with other stations and with aircraft by a variety of voice and digital data channels.

The Operations Cabin Type S5014 contains three display positions, each of which is furnished with a 400mm (16in) marked radar plan position indicator (PPI) and an electronic data display (EDD) with a tracker ball and touch mask to enable the display operator to communicate with the the data processing equipment.

A remote labelled keyboard or light-pen may be specified as alternatives to the touch mask.

Data processing capability is provided by two sets of Marconi Locus 16 distributed data processing equipment incorporating the necessary communications to serve the digital data links.

Each display position has comprehensive voice communication facilities for both operational and administrative services A fourth operator position accommodates a liaison officer who has full voice communication facilities but no display.

The interior layout and furnishings of the cabin have been carefully designed to give the operators a compact but comfortable working environment and hence to minimize operator fatigue.

The cabin is 2·26m (7ft 5in) high by 3·55m (11ft 8in) wide by 2·26m (7ft 5in) deep. It weighs 2700kg (6000lb) without the running gear and can be transported by air, road, rail or lifted by helicopter. Standard detachable running gear for road transport includes built-in jacks for deployment. For full details see Marconi Radar Data Sheet E5.

The equipment contained in the S5014 cabin is suitable also for use in static installations and as a result of the self-contained modular design adopted both for the display positions and data processing elements, can be expanded to meet a wide variety of operational requirements.

Operational Features

All display positions have an identical equipment fit. Either the full range of facilities or a subset, defined by the software, is available to the operator.

PPI Display Facilities

Both broad band (video) and narrow band (extracted) radar data can be displayed.

Broadband data is independent of the Locus 16 processing system.

Video selection
A selection of linear, log PLD or fully processed video is available at each position. IFF video can be mixed in with any of these and the relative levels adjusted as desired.

Expansion and off-centring
The displayed picture can be expanded in the ratios 1 :2 :4 :8 :16 of the maximum display range, which is normally 256 nautical miles but may be specified. Off-centring in any direction by an amount equal to the maximum range is achieved by using a tracker ball to position the operator's personal mark over the required display centre position and operating a key to bring the selected point to the centre of the display tube.

Head selection
If two co-sited surveillance radars are in use, the PPI system can display either video from each by selection or video from alternate p.r.f. periods from each, irrespective of whether or not the heads are locked in azimuth, giving enhanced performance in areas of overlapping radar cover. This facility is a consequence of the digital display deflection system.

Range marks
A selection of coarse or fine with brightness control is available at each position. Ranges are marked at 10 and 50-mile intervals on the three longer ranges, and at 2 and 10-mile intervals on the most expanded ranges.

Personal mark
Each position is provided with a personal mark controlled through software by a high precision tracker ball. This mark is used for defining the positions of plots for the following functions :

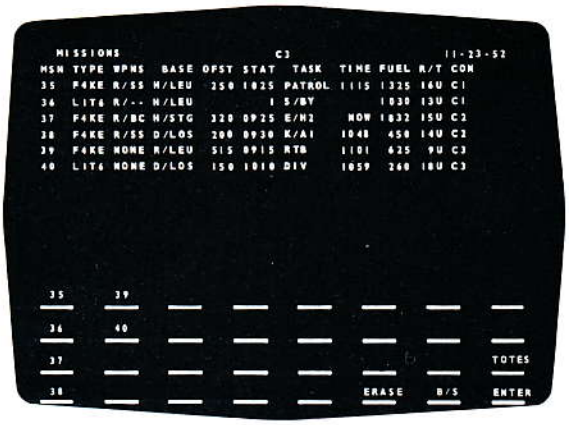
Pointing to another display
Heightfinder sector scan
Off-centring
Tracking
Personal height request
Active SIF decode.
Range and bearing measurement

Synthetic marks
The PPI can show either labelled radar or a fully synthetic display. Marking capability includes plot symbols, track labels with speed and heading vectors, intercept profiles, reference points, digital maps and tabulated data. Up to 160 track labels are displayed at any position. Size and brightness of marks can be selected.

Electronic Data Display Facilities

These provide the principal form of data input and output. A plain language tabular display in preset formats and a touch mask are used to select both data and the action to be applied to it. The results of the action are displayed in the original or a new format indicating further consequent actions, thus creating a dialogue between the operator and the system. The dialogue may take the form of a programmed routine which guides the operator through a logical operational sequence.

The tabular data is displayed on an EDD unit. Where a limited amount of display marking is required, the tabular data can be displayed on a reserved area on the PPI unit.



Tabular display format showing a mission tote and a touch area, defining missions for which data input can be made and a reversion selection.

In either case the display area is divided into four fields.

1) The read-out area consisting of legends and data.
2) The touch area consisting of functions available for selection.
3) The scribble area in which selections are assembled prior to entry.
4) The reply area in which replies to requests are made.

The exact content of each area is dependent on the role of the cabin and the operational function of the display position.

Dialogues are normally initiated from a primary selection format containing all the functions available for use. Selection of an item causes a mnemonic to appear on the scribble line and the touch area format to change to a list of active track references, a display selection or other appropriate format. This choice of action within defined limits provides a flexible approach with reduced chance of error.

Heightfinder Facilities

Normal control

The heightfinder is normally controlled by program to measure sequentially and automatically the heights of selected tracks. Measured heights are held in the track store for play-out as required. The automatic sequence can be interrupted by the operators using an EDD/touch dialogue to obtain personal height and personal relative height read-outs on demand.

Volumetric and sector scan

The centre display position of one cabin is designated as a master position and the operator can command the heightfinder to function in a surveillance role. Hence the C-band system can be used as a standby in the event of failure of the surveillance system, or to combat electronic counter measures.

In each case all the PPI displays receive log PLD video and turning data from the heightfinder. If there are two surveillance radars in the system then display of signals from the second head is not affected by use of the heightfinder in surveillance mode.

Height-range display

One PPI display can be switched to operate as a simple height-range display to enable the operator to resolve any ambiguities in height measurement resulting from jamming or unusual propagation conditions.

IFF

Under normal circumstances inputs from a secondary radar plot extractor are processed to display SIF codes as labels on the appropriate tracks on the PPI or as data on the tabular display. Active and passive decoding are provided.

Track Handling

The track handling facilities provided are :

Automatic initiation and continuity tracking for up to 60 aircraft tracks.
Reception of plots and tracks from remote reporting posts.
Exchange of selected track information with other sites.

Track initiation may be either automatic or manual. The system may be constrained to initiate tracks automatically in designated areas if required.

The number of tracks in the system is operator limited. Each track supervisor can cope with 20, thus a single cabin can handle 60 tracks.

When ambiguities arise in the automatic tracking process, the system indicates to the operator that track repair is necessary by displaying a special symbol with the track. Track repair is achieved when the operator injects track position using the tracker ball and control keys.

Track data can be output automatically over narrow band serial data links at a preferred rate of 1200 bauds. Track data received over data links from the remote sites is stored and displayed in the same way as locally generated tracks.

Interception control

When all display positions in the cabin are being used for interception control the cabin handles up to six simultaneous interceptions, this limit being imposed more by the abilities of the human controllers in communicating with the aircraft rather than by equipment limitations.

The calculations for the interception profile are performed using the following system facilities :

Weapon assignment
Trial interception
System interception control
Recovery control
System weapons definition.

The system interception control facilities are designed as an aid to the interception controller rather than a replacement. He may accept a high degree of computer decision, ignore the orders or override them. In the latter case the computer continually revises the interception geometry on the premise that the override is about to be removed.

Communications

Voice communications

Each of the display operators has a head-set with two earphones and one microphone. One earphone is connected to the radio-telephone (R/T) system and the other to the telephone system. The microphone is normally connected to the telephone system but is transferred to the radio telephone system when the operator desires to transmit. Each display position has two head-set telephone jacks wired in parallel, one of which may be used for monitoring or training purposes.

Each operator position has a set of keys to the right of the PPI display. These keys are mounted in three groups of five keys for R/T and telephone control, each group being mounted on a removable module.

In this way various communications options may be employed and an operator may have a maximum of ten channels of R/T and five of telephones.

Inter position telephone

Each operator can communicate with all other display operators in up to four cabins. In addition, he can communicate with the administrative position provided in each cabin.

External telephone communications

Each cabin is fitted with ten telephone connections. These lines are taken to a plug for connection to a communications cabin. In a dual operations cabin role, with one communications cabin, the total number of available telephone lines is twenty. The lines can be wired internally in the cabin to give various options, depending on equipment fit.

Maintenance telephones

Ten pairs of lines pass through the cabin with a polypole connector at each end. Ten telephone jacks on a panel are connected to these lines inside the cabin.

All the S600 cabins are fitted with a similar arrangement and may be connected in series to provide a ten-line maintenance telephone circuit. Each hand-set has its own self-contained power source which causes a remote hand-set to emit a loud tone when a button on the local hand-set is depressed. One of these hand-sets is permanently wired to the line associated with the cabin to act as an alarm on incoming calls, whilst the other may be jacked into any other line to call other cabins.

Radio telephone – V.H.F. and U.H.F.

The radio telephone system allows for the simultaneous monitoring of up to ten channels of v.h.f. or u.h.f. at each display position. Selection is by means of a three-position 'Channel Select' key, the normal off position being in the centre.

To monitor a channel, the key is operated upwards to the 'Monitor' position. In this position the R/T earpiece of the headset is connected through to the receiver of the selected channel. In this way any number of channels can be selected for monitoring from any position. If it is then required to transmit on any one channel, the key for that channel is depressed to the 'Speak' position. This action releases all other channels being monitored at that position and switches the the transmit channel through under control of the 'Transmit' key.

When the 'Transmit' key is operated, the microphone is switched to the transmitter line and the 'Channel Selected' lamp for that channel flashes on all positions. When the transmission is completed, the 'Channel Select' key is returned to the 'Monitor' position and all channels previously selected are restored to 'Monitor'.

Two emergency channels may be monitored at once by means of a small loudspeaker. Selection of these channels is by means of two fifteen-position switches.

Electrical Features

The widespread use of micro-electronics techniques has brought substantial advantages in the cost, weight, volume and reliability of electronic equipment. In this system several additional benefits have been achieved. All of these stem, essentially, from the decentralization of signal generation equipment which micro-electronic techniques have made possible.

In radar display systems, in the past, it has been customary for such services as display deflection waveforms and display marks to be generated in central drive units and for each waveform to be distributed to all displays. This has made necessary many interconnections carrying high-speed signals. The high-speed, high-level cable driving and receiving circuits are expensive, have high power consumption, restrict separation between cabins and are susceptible to crosstalk. These features are particularly undesirable in a transportable system, in which inter-cabin cables have to be disconnected and reconnected every time the system is moved, and in which the relative configuration of cabins can never be specified precisely.

The Locus 16 distributed data processing system housed within the S5014 cabin provides all the computing power required by the operators in that cabin. Care has been taken throughout the design of the S5014 to define the intercabin interfaces in such a way as to minimize the rate of data transfer between cabins. All data (with the exception of video and voice communications)is transmitted between cabins in digital form and, in the majority of cases, in serial form to reduce the number of connections and hence the size and weight of inter-cabin cables. Aerial azimuth data is transmitted as a binary angle, resolution and timebase generation being performed within the display cabins.

Decentralization of signal generation has been continued down to the level of the individual display position. Each display position generates its own timebases and makes its own selection of incoming signals. This policy leads to a very high degree of system integrity in that, in a system based on two surveillance heads, no single fault condition leads to the loss of radar signals at all display positions. This resilience is inherent in the system configuration and does not depend on the provision of automatic fault detection techniques or main/standby changeover mechanisms, which themselves have been a limiting factor in the achievement of high reliability in some earlier systems. By making all display positions effectively identical, any position can take over the functions of another merely by requesting the display data required by that position in its new role.

Digital techniques are used extensively in the display drive equipment with the primary aim of eliminating time-consuming setting-up routines, as well as increasing reliability and reducing cost. This is particularly important for transportable operations where rapid deployment is required and transportation is likely to disturb the setting of high-accuracy linear circuits. In the display deflection circuits all time-base generation, radar/marks mixing, off-centring and range expansion are performed digitally, with a single high-speed digital-to-analogue converter to produce the final deflection waveform. This technique ensures accurate registration between radar and synthetic marks and allows full advantage to be taken of the high definition of the displays even on expanded ranges.

An exception to the general adoption of digital techniques occurs in the character generation equipment. The stroke-writing method of writing characters is still unmatched for legibility, particularly when very small characters are required, as they are when data plaques are displayed on the PPI in dense traffic situations. Character generation by stroke writing requires the use of simple analogue integration methods backed by digital decoding techniques to control them. A new character generation module has been developed which makes full use of both digital and linear integrated circuits to write characters in 5 microseconds. It offers a choice of two character sizes on the PPI displays.

The raw data generated by the radar heads is fed to the three PPI displays. The processed or synthetic data for marking the displays is stored by the processor. This data is then played out repetitively to the displays at 25Hz.

Processor Sub-system

Data processing capability is provided by two Locus 16 bins, (Marconi Radar Data Sheet G7) housed in standard 19in cabinets in the cabin. Each bin is fitted with the following modules :

- Systems control
- Termination and clock
- Arithmetic processor
- Diagnostic module
- Random access store
- Small devices processor
- Display processor
- TV processor

In addition, particular communications processors are fitted to enable the Locus 16's to exchange data between themselves and with the outside world and to interface with the displays and other equipment in the cabin.

Two flexible disc drive units provide bulk storage to back up the semi-conductor stores in the Locus bins. Each disc holds approximately 130,000 Locus words.

Display Sub-system

The PPI display uses a Type S3015 display unit (Marconi Radar Data Sheet F12). This incorporates a 400mm (16in) diameter cathode ray tube and a single-coil fast deflection system. The digital timebase and marks position unit built into the display provides all the deflection functions with the exception of off-centring and off-set, which come from the processor, and character generation.

The character generator produces up to sixty-four characters or symbols from a 6-bit version of the International Standards Organization (ISO) code. Its output consists of six sets of stroke-writing deflection waveforms in the X and Y axes, together with bright-up for those strokes which should be visible. Up to sixteen connected strokes on a basic 5 × 5 matrix are possible, modifiable by a 'half-rate' facility. Two more strokes are available at the start of the character for traversing from the centre of the matrix to a suitable starting point. The complete cycle of the character generator occupies 5 microseconds. Any arrangement or grouping of characters is possible, but playout time is saved by using a set of preferred plaque formats pre-wired into the hardware.

The electronic data display uses a standard television monitor. It has an 11 in diagonal tube and works on the 625 line standard. Alphanumeric data is played out to it by the Locus 16 TV processor, which also provides the control system for the touch wire mask.

Display input devices including the touchwire system and tracker ball controller are fully described in Marconi Radar Data Sheet F9.

Raw Radar Signal Buffering and Distribution

Video, azimuth and sync. from all heads are received into the cabin by special noise immune balanced differential receiving elements.

The production of 13-bit sin θ and cos θ from the 13-bit binary code or incremental input is performed by a reversible digital resolver, using the digital differential analyser technique with reset points every 5·625 degrees.

Under normal operation the heightfinder is under direct control of the data processor and the heightfinder azimuth information is not required by the display operator.

All videos enter the PPI and are selectively mixed under remote d.c. control from the PPI front panel. Remote gain control of each group of videos is also effected by d.c. control lines from the PPI front panel prior to final mixing.

Software

A range of software modules is available for the Locus 16 system, taking full advantage of the company's long experience in automated air defence systems.

Real Time Operating System

This consists of a loader, an interrupt handling mechanism, and an executive suite which embodies a time scheduler and an input/output suite.

Display Marking

This controls the format of display information for the tabular displays and PPIs in the system. It is designed such that formats can be easily modified by simply changing module parameters.

Touch Wire/Keyboard

This deals with all operator inputs from touch wires, keyboards and tracker balls and provides tell-back in the form of scribble information and dialogues. On completion of input the module performs the appropriate actions for processing or storing the information. The module is re-entrant to allow simultaneous data entry from all positions.

Track Handling

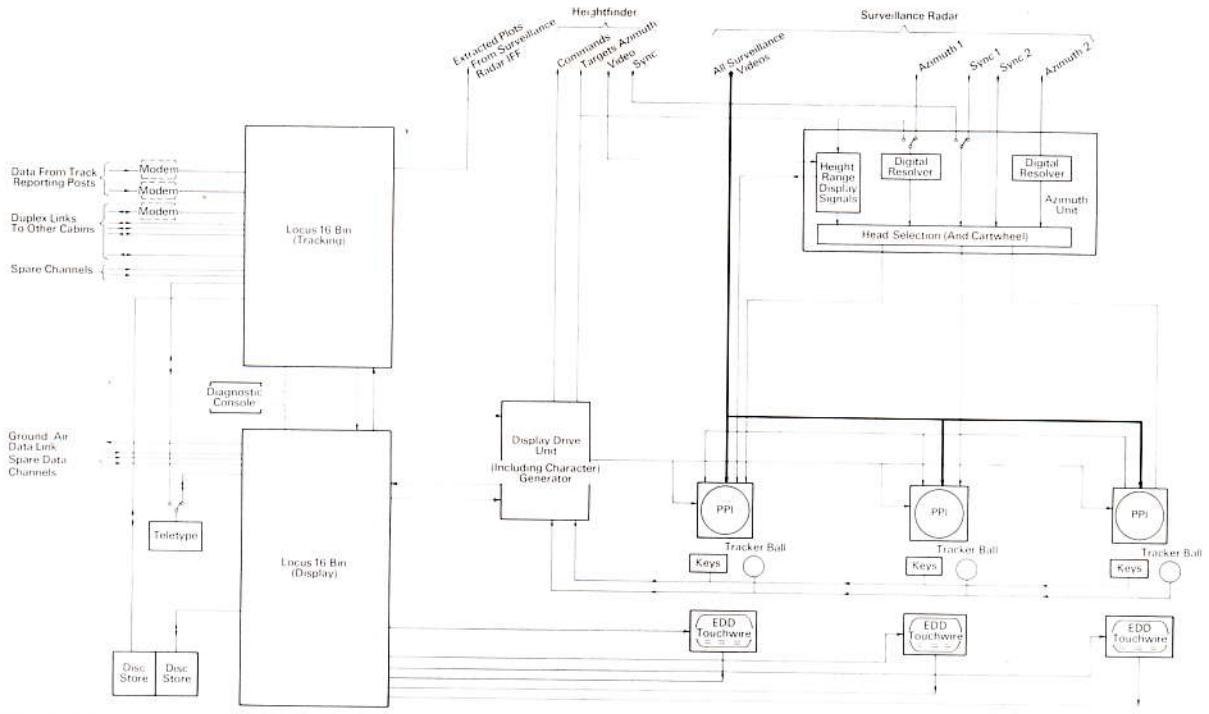
This updates the track store using data from all inputs.

Automatic Tracking

Data is presented to this module from the primary and secondary plot extractors. Track positions are predicted and an association formed between existing tracks and the incoming plot-data. Plots fitting within the allowed tolerance are smoothed and new track information is generated. Deviations from predicted positions produce possible forking tracks, which remain as such until the situation has resolved into a turn or two tracks are identifiable.

When ambiguities arise manual intervention may be necessary to resolve the difficulties. This is achieved by injecting a track position at the operator's display.

This module also correlates free plots which have not been associated with existing tracks to decide if these are new tracks and automatically initiates them into the system if this is so.



Block diagram of Operations Cabin Type S5014, excluding voice communications.

Manual Tracking
This allows tracks to be initiated into the system and updated manually. Positional data is input from PPIs using tracker-balls and keys. Position, velocity and height data may also be input via a touch wire dialogue to update data on voice-told tracks or to override data input from PPI displays.

Track/Plot Input/Output
This is responsible for transferring track and plot data to and from remote sites via digital data links.

Heightfinder Control
This allocates heightfinders to tracks and maintains a priority heightfinding system, taking into account rules specified according to the particular operational requirement. Tracks are selected in azimuth order to minimize slew time and thereby maintain the highest possible data rate. The module also allows personal and relative personal heights to be provided to operators on request.

Simulation
This causes simulated video targets to be generated and perform manoeuvres on demand from operator positions being used as simulator pilots. The targets are flown according to aircraft performance data extracted from the weapon system module. Background tracks can be specified by data tape, allowing them to follow pre-specified manoeuvres. The simulated video plots can be extracted by the primary plot extractor and fed back to the data processing.

Interception Control, Recovery Control and Trial Interception
This performs calculations required to fly a mission aircraft along the best path to follow to intercept a target, directing the fighter through a series of manoeuvres along this path designed to bring it to an 'offset point' at which the normal interception calculations are terminated and the attack stage commences.

It provides full recovery of a mission aircraft to a nominated recovery position or 'gate' calculating the optimum path for the mission aircraft to follow, allowing for any constraints of prohibited airspace or fuel consumption.

It also provides manually selected trial interceptions for a particular hostile with a given weapon system, with predicted kill time and kill point and, if the mission is not already airborne, time boundaries for scrambling.

Weapons System
This is used to predict the detailed performance for the various phases of interceptions and recoveries. It defines the tactics to be employed by each type of aircraft/weapon system combination during the interception including the attack stage for each type of interception profile available.

Weapons Assignment
This is used to determine the optimum weapon systems to be used against a given hostile, according to a pre-defined set of rules, and if possible provides an intercept summary of the form given by the Trial module.

IFF/SSR Decoding
This is responsible for providing the IFF/SSR decoding facilities. It correlates secondary plot data with track stores so that replying modes and codes are held for display; it provides active decoding whereby secondary plots are correlated with track positions indicated by system operators and displays corresponding modes and codes on the operators' tabular display; it also checks plot data for emergency indications and displays 'emergency readouts'.

Common Subroutines
This contains all the mathematical, trigonometrical and other common routines and subroutines used by the modules in the system.

Mechanical Features

Construction

The cabin which has a flat roof, is formed by a welded framework construction of square steel tubes, clad internally and externally with 1·25mm (0·048in) thick aluminium alloy sheet riveted to the frame and forming a screened display housing. Spaces between the cladding are filled with polyurethane foam to provide insulation.

A steel lifting eye is secured at each corner of the cabin, the upper set fixing the centre of gravity below the lift attachment points, therefore providing stability in lifting by crane or helicopter. Four adjustable deployment pads are fitted and are used to level the cabin before the running gear is completely removed. Each pad shaft moves in a sleeve, which is positioned and held at the desired height by a locking pin. Using this method, the cabin can be levelled to within 3·2mm (⅛in) on a ground slope not exceeding 1 in 20.

For the attachment of running gear, two tine tunnels are fixed to the underside of the cabin. To minimize the effects of solar radiation, an overhanging canvas canopy can be fitted to the cabin roof. The cabin, which is undersealed, is finished in a coating of olive-green drab-matt and conforms to protective requirements specified by Defence Ministries.

Access is through an r.f. screened door 1·83mm (6ft) high by 762mm (2ft 6in) wide in the side of the cabin. A quick release escape hatch 762mm (2ft 6in) square is situated opposite the door.

Connection of all services to the cabin is made externally at a services panel which is located at the console end of the cabin. An associated input filter panel compartment houses r.f. filters on all inputs other than radar video signals.

Air Conditioning

Two air-conditioning units for each cabin provide air conditioning for the comfort of personnel and for temperature control of equipment within the

display console. For full details see Marconi Radar Data Sheet E5.

Display Removal

Secured to the cabin ceiling are three tracks which, with a hand winch, are used to assist removal of each 400mm (16in) display without disturbing the operation of the other display positions. The winch is located on the track of the display to be removed and guided to the display position. The display is withdrawn on its runners, nylon lifting ropes secured to it and the winch operated to take the full display weight. The display runners are pushed back into the console leaving the display suspended and free to be drawn clear of the console where it can be lowered to the floor and separated from the winch tackle.

Mains Power Distribution

Full power control facilities are provided at a master power control panel at the top left hand side of the display console.

Fire Precautions

An equipment BCF chemical fire extinguisher system is housed on the outside wall of the cabin. In the event of a fire within the console the lever on the fire extinguisher is pulled, which initiates the fire fighting system at several points throughout the console. A BCF chemical extinguisher for hand use is mounted on a quick release clip at the left hand side of the cabin door. The extinguishing agent is non-toxic and non-corrosive.

Lighting

Operational lighting is provided by fluorescent strip lights situated above each operator position. The lamp housings are designed to direct the light onto the operator's working surface and controls.

For maintenance purposes, two ceiling mounted 20W strip lights illuminate the whole of the cabin interior. Emergency lighting for use in the event of a total power supply failure is provided by a small light fitted above the cabin door, powered by a trickle-charged 6V battery.

Marconi Radar Systems Limited
A GEC-Marconi Electronics Company
Crompton Works, Chelmsford, England CM1 3BN
Telephone: Chelmsford (0245) 67111. Telegrams: Marstor Chelmsford Telex.
Telex: 99108 and 99449.

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