Marconi Radar Systems

Air Defence Radar Systems

Radar Systems

Air defence radars provide the real-time accurate intelligence on which modern high performance aircraft and missile systems depend to maximize their first-time-interception capability.

Both strategic and tactical radars are essential to an air defence system, using large static sites hardened against attack and rapidly redeployable radar convoys with operations centres to process and use the raw data. These units must be capable of being called upon at any time to operate as a complete air defence complex.

Marconi Radar Systems Limited is the world leader in the design, manufacture, and installation of all types of radar for air defence purposes, having been involved in radar since its conception. The Company also has unique experience in programming for air defence due to their long involvement in data gathering and handling.

The S600 Series

The S600 Series radar systems meet any defence radar requirement. The modular design provides such flexibility and cost effectiveness, reliability, compactness, and ease of operation that these features characterize the equipment.

Modularity

A range of mobile surveillance and heightfinding radars for tactical air defence applications, together with display and data-handling elements, provide basic sub-systems that can either operate in complete isolation or supplement an air defence system. The basic facilities can be extended to form complex networks with no loss of compatibility.

Flexibility

Control facilities in a tactical situation can be built up without interruption from the simplest surveillance component to a full intercept and strike or control facility which is fully effective when supporting services and communications are completed.

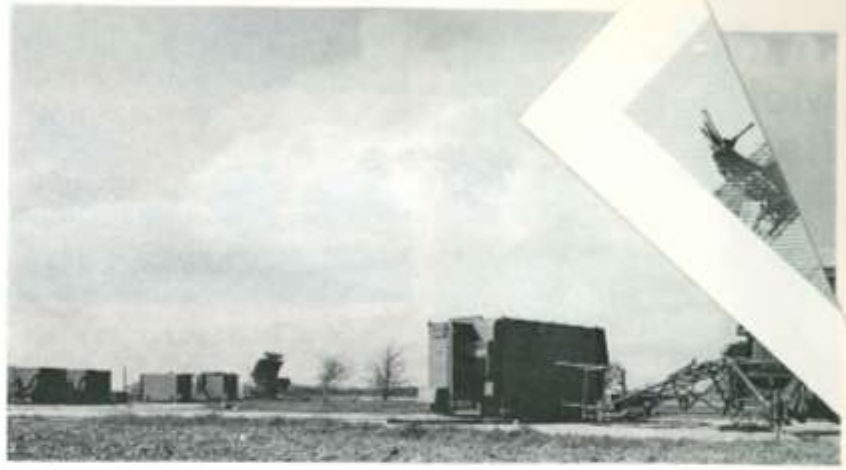
Cost effectiveness

Modular construction and standardization minimize the total capital cost incurred in establishing a radar system to meet individual requirements. Economies in running costs result from lower manning requirements, smaller spares holdings, simpler training, and reductions in back-up facilities. The S600 Series is unequalled for providing and sustaining a system to meet a particular requirement on a long-term basis.

Deployment

Surveillance and heightfinder aerials which fold easily and quickly for transportation, standard cabins housing transmitter/receivers, display and data handling and communications equipment, can be lifted by helicopter, carried in transport aircraft or fitted with running gear and towed over land. A surveillance radar system, consisting of an aerial, an electronics cabin, and a towing vehicle, make one load for a C130 aircraft and can be fully operational in 30 minutes from the time of arrival on site.

An S600 Series transportable surveillance aerial ready for the road . . .



A deployed S600 Series radar convoy

Reliability

Solid-state devices including integrated circuits, simplicity of circuit design, conservatively rated components, and a high standard of quality control provide maximum Mean Time Between Failure with minimum Mean Time To Repair. System failure due to accessory defects is minimized by matched reliability of auxillary machinery, such as driers, compressors, and air-conditioning equipment.

Clutter suppression

Performance figures in excess of 40dB are achieved by using robust magnetrons with special cooling techniques to reduce modulation of the output due to vibration. The receiver consists of a parametric amplifier followed by linear and logarithmic pulse length discrimination (log PLD) circuits. Signal processing facilities provide digital moving target indication, pulse recurrence frequency discrimination (PRFD), or stagger (PRFS) as required.

ECCM performance

Wavelength of 5·5cm (C), 10cm (S) and 23cm (L) Bands are used, with frequency diversity available in each band, to enable several transmitters to be operated into one aerial with sidelobes reduced to a minimum. The combination of frequency diversity special receivers and filters, PRFS, PRFD, and PLD provides a very high degree of resistance to jamming and interference.

Computer functions

Marconi automated air defence systems provide the means for virtually instantaneous assessment of air situations, methods of control, and advice on the most effective use of the defence resources. Controllers are left free to make vital decisions and the very necessary time advantage is gained to enable defence forces to be used with maximum efficiency against any threat. A single computer system provides display processing and interception calculations adequate for a typical GCI station, including automatic tracking of up to sixty aircraft, and interception control of up to six simultaneous engagements by manned interceptors or SAM batteries. With the adoption of program-controlled computer

being loaded into a Lockheed C130 Hercules . . .

and completing its journey by helicopter

systems, changes in weapons, tactical procedures, etc. can be accommodated by modifying the program.

Adaptive programs, in conjunction with rapid man/machine communication links via electronic tabular displays and data entry mechanisms, direct operators along a logical decision tree which minimizes operating time and reduces errors when under stress.

Communications

Comprehensive communications facilities covering v.h.f. and u.h.f. ground-to-air and h.f. point-to-point requirements are provided in communications cabins capable of deployment under the same conditions as the radar equipment.

Operational facilities

Display and data handling equipment, housed either in operations cabins for mobile applications or in operations rooms for static installations, provides facilities for manual operation, limited automation or comprehensive automatic systems.

Manual operations cabin S5013

Aerials

There are nine aerials in the S600 Series *(corresponding Marconi Radar Data Sheets are given in parenthesis)*.

TRANSPORTABLE AERIALS

10cm (S) Band surveillance *(Data Sheet A1)*
23cm (L) Band surveillance *(Data Sheet A2)*
5·5cm (C) Band heightfinder *(Data Sheet A3)*

STATIC AERIALS

10cm (S) Band Surveillance *(Data Sheet A4)*
23cm (L) Band Surveillance *(Data Sheet A5)*
10cm (S) Band heightfinder *(Data Sheet A7)*
23cm (L) Band surveillance *(Data Sheet A9)*
Back-to back surveillance *(Data Sheet A6)*

All the S600 Series aerials except the 10cm (S) Band static heightfinder are designed for multi-frequency operation.

A squintless linear feed is used with the surveillance aerials to provide accurate signal distribution over the reflector surface and enable any frequency to be used within the band. All surveillance aerials accept co-mounted secondary radar aerials.

The transportable surveillance aerials use a single curvature reflector. Sidelobe performance is better than −28dB. The transportable heightfinder uses a double curvature reflector, horn fed, and has a capacity for up to 22 heights per minute with computer controlled slewing. It is operable in modes of single-shot, automatic searchlight, burn through and continuous volumetric or sector scan. The static surveillance aerials have very long range capability and incorporate single-curvature reflectors. They can be used singly or in back-to-back configuration. For air traffic control duties at military airfields, a double-curvature aerial is available.

The 5·5cm (C) Band transportable heightfinder radar S613

The static heightfinder aerial has a single curvature reflector with a linear slotted waveguide feed. It is operable in modes of single-shot, automatic searchlight, burn through and continuous volumetric or sector scan. The data rate from the static heightfinder approaches that of the transportable version, as the same automatic height extraction facilities are used.

Transmitter/receivers

There are five transmitter/receivers in the S600 Series *(corresponding Marconi Radar Data Sheets are given in parenthesis)*.

10cm (S) Band *(Data Sheet B1)*
1 MW peak power, 3·5dB noise figure
10cm (S) Band *(Data Sheet B3)*
2·25MW peak power, 3·6dB noise figure
23cm (L) Band *(Data Sheet B2)*
2·3MW peak power, 2·5dB noise figure
800kW peak power, 2·5dB noise figure
5·5cm (C) Band *(Data Sheet B4)*
1 MW peak power, 4 dB noise figure.

The 10cm (S) Band static heightfinder radar S669

Each transmitter/receiver occupies less than 1·2m³ (12ft³) of floor space and is less than 1·67m (5·5ft) in height. Signal processing equipment is contained within a cabinet of similar height and requiring 0·46m² (5ft²). Except for the magnetron, modulator thyratron, and klystron pump for the parametric receiver, the transmitters use solid-state components.

The solid-state receiver uses a stabilized parametric input amplifier for consistent range performance. It provides either linear or logarithmic PLD output video with provision for ECCM.

The solid-state signal processing system incorporates double cancellation MTI, PRFS to raise the blind speeds above Mach 2 and PRFD to provide protection against impulsive interference.

Full details of signal processing facilities are given in Marconi Radar Data Sheets C3 and C7.

Displays

The S3000 Series of high definition, fixed-coil displays includes 305 mm and 400mm (12in and 16in) fluoride displays, a 280mm (11in) bright display and a distance from threshold indicator, both using direct view storage tubes suitable for daylight viewing, three-colour, rearport and autonomous displays.

Full details of these displays are given in the F series of Marconi Radar Data Sheets.

Computing equipment

The Locus 16 processor uses a network of distributed processing elements matched to individual communication, display, input/output and computing loads.

Full details of radar data processing equipment are given in the G series of Marconi Radar Data Sheets.

Plot extraction

To derive the full benefit of data processing, plot extractors are fitted to both primary radars and to the IFF system. These enable automatic following of tracks, automatic identification, flight plan correlation and remote linking by narrow band channel.

Automatic extraction of height data from nodding heightfinders is also used.

Full details of plot extraction equipment are given in Marconi Radar Data Sheets C4, C5, C6, D3, E4.

Operations cabin

Type S5013 (manual control) containing :
Three operational PPI displays
Three height read-out indicators
Optional IFF decoder equipment
Ground-to-air communications control
(Cabin interface designed for use singly or in pairs)

Type S5014 (automated) containing :
Three operational PPI displays
Three operational electronic tabular displays
Three man/machine communications systems
Ground-to-air communication control
Local processor
(Cabin interface designed for use singly, or for groups of up to six)

Full details of Marconi transportable operations cabins are given in Marconi Radar Data Sheets H1 and H2.

23cm (L) Band static surveillance radar S622H

Ancillary equipment

To give complete system capability a range of ancillary equipment is provided, including aerial turning controllers, pressurization and air conditioning systems, heat exchangers, equipment pallets, running gear and a primary power unit supplying 40 kVA.

Full details of these ancillaries are given in Marconi Radar Data Sheets E1, E3, E5.

Manual operations cabin S5014

Transportable/ Mobile Radar Systems

By selecting suitable elements from the S600 Series, control facilities may be built up in a tactical situation from the simplest surveillance component, provided at the earliest possible moment and withdrawn at the latest possible moment, up to the full strike and intercept control facility which operates when supporting services and communications have been built up.

These configurations offer systems performing operational roles of increasing complexity and are :

1. Early Warning Post
2. Track Reporting Station
3. Control and Reporting Station
4. Area Control Station (full computer control)

Early Warning Post

This provides low cover surveillance or gap filling in a more extensive system. The radar responses are displayed on a single 16in PPI display unit in the transmitter cabin. Track reporting from this position is carried out manually by voice communication over a v.h.f radio communication link. The PPI incorporates range expansion and off-centring facilities for detailed examination of areas of importance, range markers at 5 or 10 mile intervals and a range/bearing cursor line.

Track Reporting Station

A station of greater capacity is provided by the addition to an Early Warning Post of an operations cabin Type S5013.

IFF facilities for identification of aircraft responses may be fitted to all aerials.

Control and Reporting Station

This is the most representative of the S600 configurations. It provides ground control of interceptor aircraft and close support for strike aircraft in a tactical situation. The normal configuration is :

S604H or S605H (L) Band (23cm) surveillance radar, $cosec^2$ aerial

S613 (C) Band (5·5cm) heightfinder radar

S5013 Operations cabin — one or two

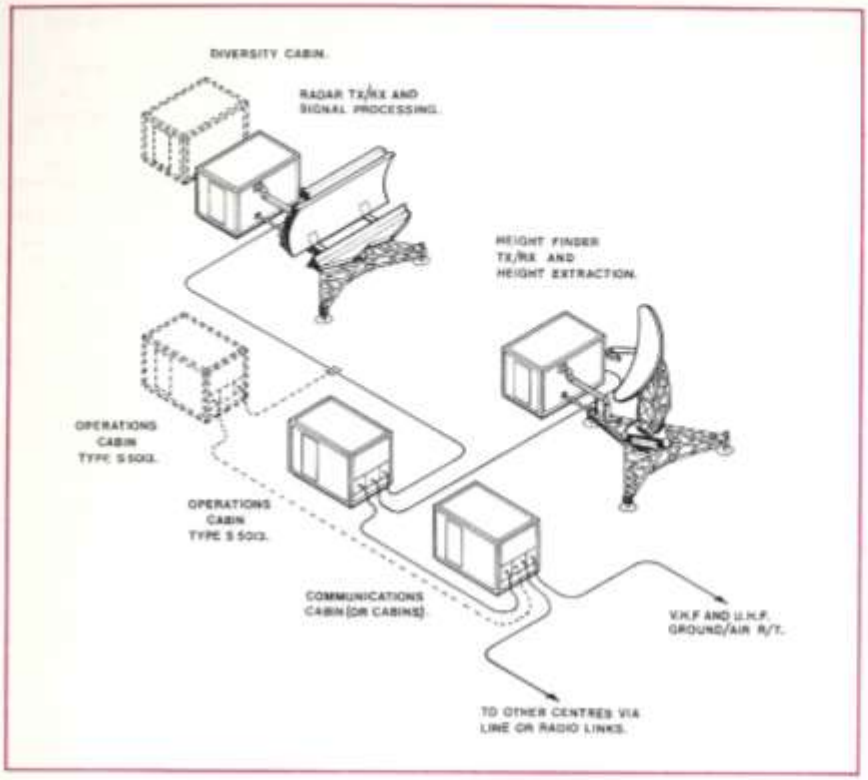
S5023 Communication cabin

Detection of fighter-bomber aircraft out to ranges of 120 miles and medium bomber aircraft up to a range of 160 miles is supplemented by accurate height information. The performance of the heightfinder radar is matched to that of the surveillance radars so that height information can be obtained on all aircraft detected. Furthermore, the heightfinder radar has a useful capability in a volumetric scanning role to maintain radar cover in the event of surveillance radar malfunction.

The operations cabin Type S5013 contains three 16in operational displays each incorporating semi-automatic track reporting by digital data link. Track positions are precisely marked by electronic markers superimposed on the radar responses using a tracker ball. The co-ordinate information, new track/old track entry, track quality, track identity, and raid strength form a digital data message. This is sent via data link to a remote operations centre. Each operator can maintain up to four tracks simultaneously, giving a total capacity of twelve tracks to the cabin.

If it is assumed that the threat only justifies deployment of a single operations cabin, then the operational functions may be used in any of the following roles :

1. In a reporting role, manned by a master tracker and two trackers, increasing under periods of peak activity to three trackers
2. As an early warning unit with a capability of handling two manual interceptions from one position, with track reporting from the two remaining positions
3. As an early warning unit with a capability of handling four manual interceptions from two positions with broad brush reporting from the remaining position



Control and reporting station

4. Solely as a control unit capable of handling six manual interceptions from three positions with no raid reporting

A station with dual operations cabins has six operational positions and its capability in terms of the possibilities described above is doubled.

Communication with aircraft requires a number of ground-to-air channels on u.h.f and/or v.h.f radio equipment. These facilities are provided either by fitting a limited amount of equipment in the transmitter equipment cabin or by a separate communications cabin S5023, for more extensive facilities.

Optional fitting of additional equipment gives the ability to extend this system in the following ways:

1. Addition of a second transmitter/receiver cabin for diversity operation to give increased range performance and greater capability against electronic counter measures (ECM). This is the S605H radar

2. Fitting of IFF equipment for the identification of co-operating aircraft

3. Inclusion of the display unit in a transmitter/receiver cabin for technical monitoring or additional reporting purposes

4. Inclusion of electronic counter counter measure (ECCM) features

5. Provision of an electronic repair cabin

Where a Control and Reporting Station is to be part of a major tactical air defence network, the introduction of automatic data processing techniques reduces reaction time and improves operational effectiveness. An expanded version is available, with extra features allowing integration directly with computerized systems or a retrospective up-grading of the station to a fully computer-aided intercept capability.

This version of the station consists of the same surveillance and heightfinding radars but incorporates the operations cabin Type S5014, which contains several additional display facilities of advanced design. These are, three display positions each with a 16in display Type S3015 and an 11in tabular data display which operates in conjunction with a data entry module to give program-directed communication with a computer. The method chosen represents an advance in man/machine communications of the order necessary to meet the rapidly changing demands of the present day air battle. Organization of the displayed data and interpretation of the entries from the operators' controls are effected by a processor contained within the cabin.

The inclusion of a processor in the operations cabin Type S5014, endows it with a considerable capability, the processing capacity being sufficient for the following functions:

1. Control of the heightfinder to obtain absolute and relative heights on selected targets

2. Inter-console marking

3. Track storage for up to 160 tracks including manual input of identity, strength and height data

4. Transmission of track data to remote sites via digital data link

5. Display of relative range and bearing between two designated responses or between aircraft response and base location

6. Labelled radar display with alpha-numeric character plaques alongside all targets being tracked

7. Automatic tracking with smoothing, hopping strobe and rapid selection facilities

8. Generation of area gate strobe for active SIF code on selected targets; validation of decoded returns and display of code information

Alternatively the Type S5014 cabin can communicate, interactively, with a remote central computer complex to form part of an integrated system.

Area Control Station

This configuration incorporates the maximum facilities for full control of the air battle in a tactical situation.

In its fullest configuration the area control station uses:

1. Two surveillance radars, typically one S600, an S Band (10cm) radar using a parabolic reflector thus obtaining maximum range cover at low elevation angles, and one S605H, an L Band (23cm) radar using a cosec^2 reflector, for general surveillance and higher cover

2. Two heightfinding radars S613 giving a data rate of 40 heights/minute

3. Six operations cabins Type S5014, providing eighteen display positions with increased processing power

4. Up to eight digital data link terminals for the automatic transfer of data

5. Ground-to-ground communication equipment

A system of this magnitude embodies facilities at a level previously found only in complex fixed installations with specialized display positions for individual functions. The computer, operated with an adaptive program, and the universal display positions allow

changes in operational functions to meet differing requirements in a tactical situation. The following services are available to meet the demands for tactical air control :

1. Tracking capacity of 160 tracks, using either manual or automatic initiation with subsequent automatic track following on data from a plot extractor. All tracks are presented on marked radar displays

2. Automatic correlation of secondary radar with tracks for identification purposes

3. Flight plan storage for information received from movement control centres

4. Display of stored flight plans

5. Control of heightfinder sequence and correlation of extracted heights with track stores

6. Trial intercept calculations and control of fighter aircraft for up to six simultaneous engagements per cabin

7. Calculations for recovery of up to six aircraft simultaneously per cabin

8. Calculations for planning and controlling aircraft on strike missions

9. Data recording for assessment of operational efficiency

10. Video indication of selected airfields and beacons

Each display position may be programmed to perform any of the designated operational functions and the system may be restructured by program change to overcome the loss of service from any position. Inter-communication equipment is provided to link all positions for voice contact. Also, each position is connected by an electronic pointer facility for hand-over of positional data observed on the PPI displays. Both voice and digital ground-to-air and ground-to-ground communication connections are available in each cabin and can be selected by operators and controllers as required.

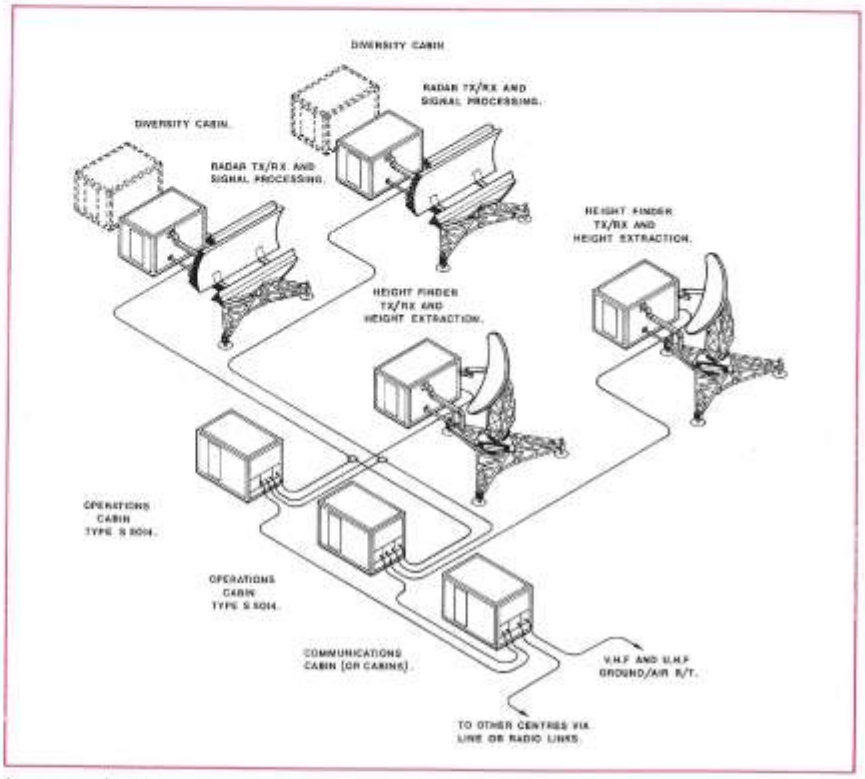
Integrated Tactical Control System

For overall cover of a forward battle area an entire air support control complex is necessary. A number of stations are required, deployed at points of vantage giving maximum radar cover, and all the data gathered must be integrated into a complete system. The various individual stations are designed to work together in a complete system.

The air defence centre is the section of field headquarters responsible for overall command of the air battle. The centre must be in constant communication with the area control station from which executive control of all aircraft is exercised.

The area control station is the main control centre of co-ordination of aerial activity within the command sector. Its functions include :

1. Co-ordination of the individual air support control elements within the system



Area control station

2. Assembly, correlation and distribution of data relating to aircraft movements, status of air defence elements and tactical allocations

3. Assessment of hostile air activity and allocation of defence elements

4. Control of aircraft on interception and strike missions

5. Integration of manned interceptors and surface-to-air weapons defence systems

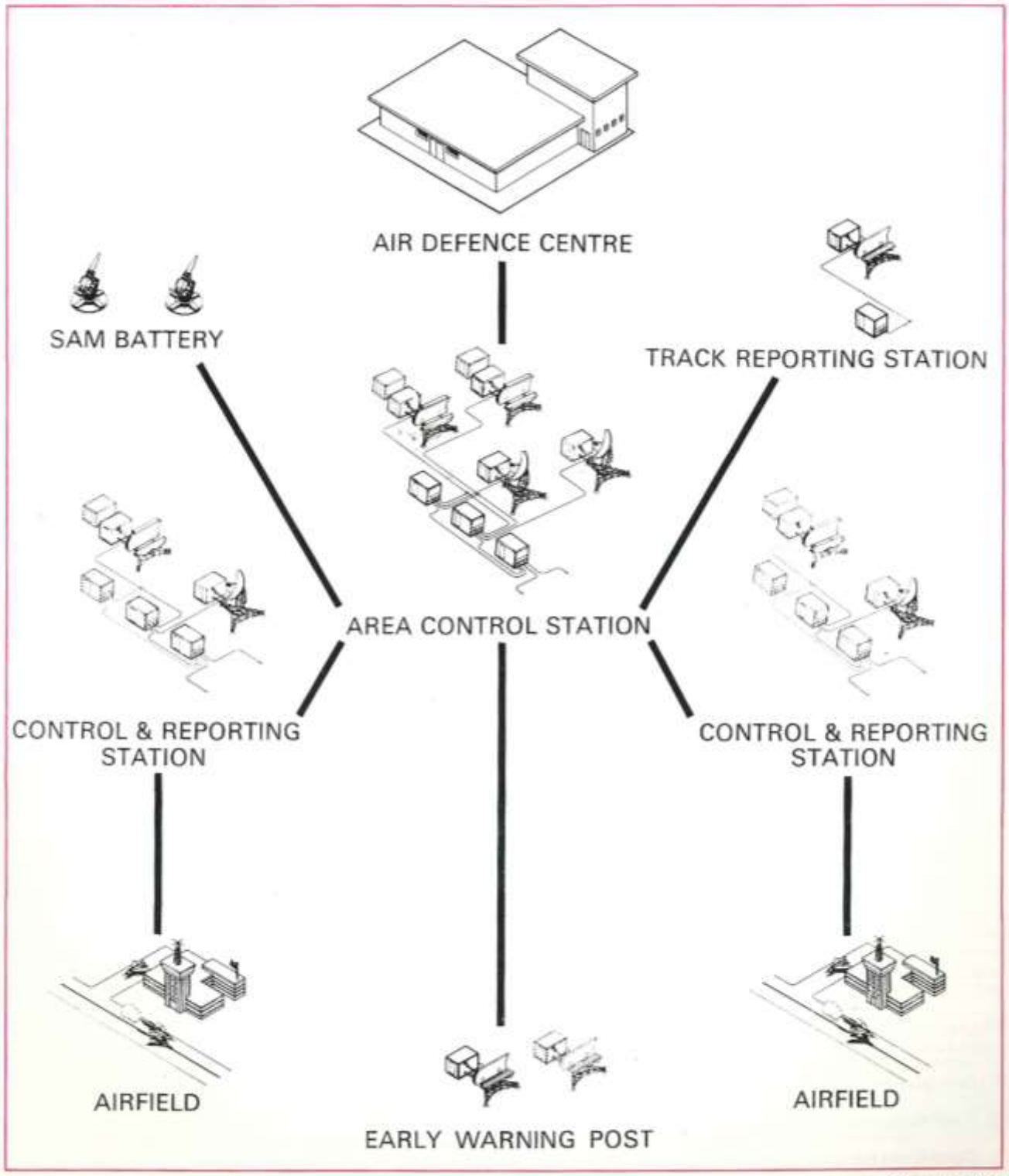
6. Feedback of information to the air defence centre

The control and reporting stations extend the radar cover over wider areas and in addition to feeding information back to the main centre provide a facility for local control of limited forces engaged in interception and strike functions. If situated adjacent to support bases, the control and reporting stations can also perform a military air traffic control role for all arriving and departing aircraft.

The track reporting stations and early warning posts are deployed in forward areas, charged with detection of enemy movements and with passing this information up the chain of command for action.

By combining stations in this manner the maximum advantage is gained in terms of radar coverage at lower level, adequate overlap to make good losses due to equipment malfunction or damage, and a wider frequency spectrum to combat electronic counter measures. To be effective a system of this type must be established rapidly ; with the S600 Series, all the components of the stations are small enough to be transported swiftly, and any of the smaller stations can be brought into operation within 30 minutes of arrival on site.

Integrated tactical control system



Static Radar Systems

Air defence of sovereign territory and installations of strategic importance depend upon a full knowledge of the current air situation. Adequate warning of hostile movements can only be obtained by provision of full radar cover. The Marconi range of equipment for static installations providing such radar cover contains more powerful radars with greater range capability on small aircraft, greater flexibility in operating characteristics, and more refined processing to combat enemy electronic counter measures activity.

To provide the greatest possible measure of continuity of service, it is normal to house all vital equipment and operating personnel in hardened concrete bunkers where adequate stand-by equipment may be fitted to ensure a high level of operational availability. The above ground elements are still vulnerable, but if affected by hostilities can be replaced by mobile sensors and/or data from other centres providing overlapping cover, thus maintaining operational effectiveness.

Electronic units used in the static installations are the same as those used for the transportable systems and their compactness leads to great space savings.

Standardization of the main components in the series greatly simplifies the problem of maintenance and spares holdings.

System philosophy

The choice of the main parameters of static radar air defence systems is governed by consideration of the operational environment and total air defence organization within which the radar system is to function.

Such considerations include the magnitude and nature of the threat, the defensive weapons available, the size and physical nature of the territory, the radar counter measures likely to be employed, and the nature and location of the areas to be defended.

The basic configuration for the most usual operational roles are :

1. Early Warning Post
2. Track Reporting Station
3. Control and Reporting Station
4. Area Control Station
5. Air Defence Operations Centre

Early Warning Post

This provides a low cover, gap filling, range surveillance or coast watching role.

The radar responses are displayed on a single 400mm (16in) PPI display unit. Track reporting from this position is carried out manually by voice communication over a v.h.f radio communications link. The PPI incorporates range expansion and off-centring facilities for detailed examination of areas of importance, range markers at 5 or 10 mile intervals, and a range-bearing cursor line. The standard layout provides space for the installation of a second transmitter for use either as a standby or in a frequency diversity role.

Track Reporting Station

A station of greater capacity is provided by the addition of a three-display console suite to an early warning post.

The console suite contains three 400mm (16in) operational PPI displays each incorporating semi-automatic track reporting by digital data link. Track positions are precisely marked by electronic markers superimposed on the radar responses, the markers being controlled by tracker ball. The co-ordinate information, new track/old track entry, track quality, track identity and raid strength form a digital data message, sent via data link to a remote operations centre. Each operator can maintain up to four tracks simultaneously, giving a total capacity of twelve tracks to the station.

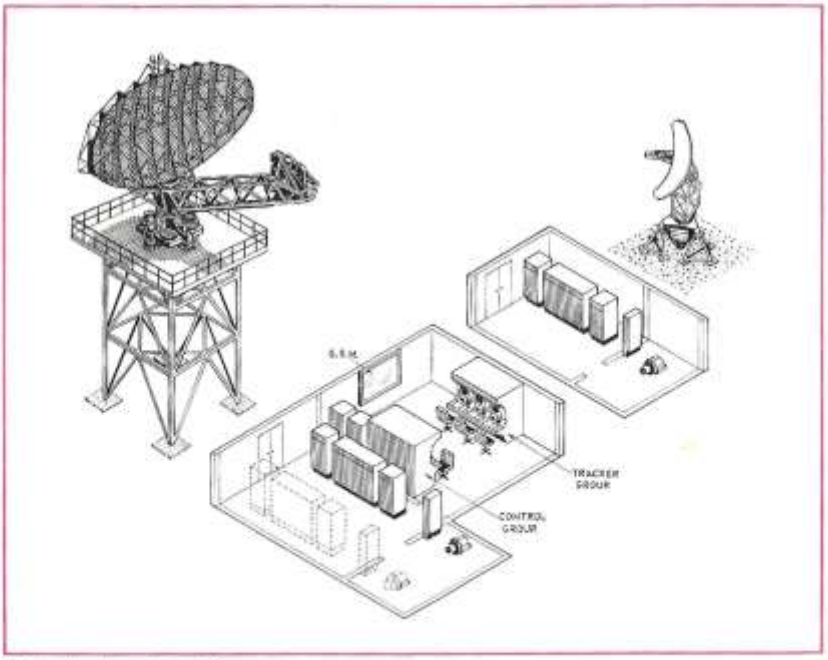
The addition of a primary/secondary radar plot extractor enables full data to be transmitted to the remote operations centre.

IFF facilities for identification of aircraft responses may be fitted to all the variants of the S600 range.

Control and Reporting Station

A control and reporting station for ground control of interception aircraft is provided by combining a heightfinder radar with one or two surveillance radars. A powerful combination comprises :

S654 – 23cm (L) Band, 2MW peak transmitter, dual-beam aerial high cover surveillance



Control and reporting station

S637 – 5·5cm (C) Band, 1MW peak transmitter – nodding heightfinder

Detection of fighter-bomber aircraft out to ranges of 150 miles and medium bomber aircraft up to ranges of 200 miles is supplemented by accurate height information. The performance of the heightfinder radar is matched to that of the surveillance radar so that height information can be obtained on all aircraft detected. Furthermore, the heightfinder radar has a useful capability in a volumetric scanning role to maintain radar cover in the event of surveillance radar malfunction.

The electronic counter counter measures (ECCM) capability of the station is high by virtue of the use of two separate frequency bands, the low sidelobe level of the surveillance aerial, the use of anti-jamming receivers and signal processing.

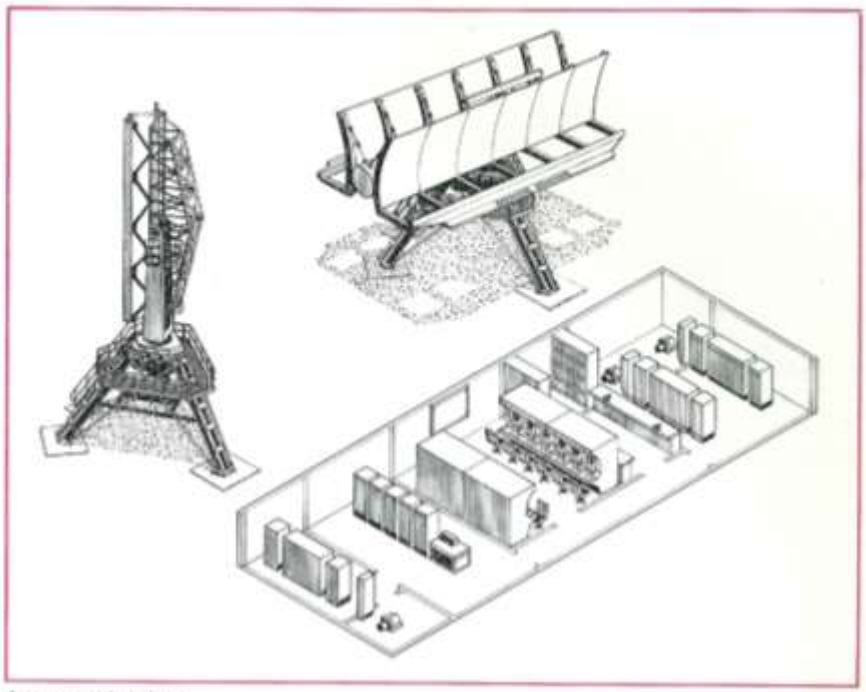
This configuration is effective where the threat is limited and the defence budget restricted. In this situation it is capable of a stand-alone role and for this purpose is equipped with two three-display console suites. General situation assessment is achieved by plotting onto a vertical edge lit Perspex general situation map (GSM) from track data supplied by two trackers, with the third position on the console suite allocated to a master tracker who is also responsible for the identification of tracks.

The other three-display suite is manned by a chief controller and two interception controllers who direct the interception and recovery of the fighters to base through u.h.f or v.h.f ground-to-air radio links. A communication system also links the operator positions together and to fighter bases and other remote units of the defence organization.

All positions obtain height data through demands made by a tracker ball control which actuates the automatic height extraction equipment. The same marking system is also used to obtain relative range and bearing information and to 'point' between operational positions.

Area Control Station

In situations where it is desirable to exploit the full long-range high cover capability of large static aerial systems and in order to provide a pivot for a complex air defence system extending over a large geographical area, a more complex configuration of equipment is appropriate.



Area control station

The processed signals from the surveillance radar system are fed into primary and secondary radar plot extractors, whereby all valid plots are expressed as digital quantities and correlated with secondary plots from the same target. Secondary radar signals are decoded at this stage.

The heightfinder radars respond to demands from the display and data processing system, the signals received from the selected targets are analysed in the automatic plot extraction equipment and the height values computed.

As control signals to the radar aerial equipment and the data therefrom can be expressed in a form suitable for transmission over narrow bandwidth data links, it is possible to locate the aerials for optimum radar cover at sites remote from the display and data processing systems.

A typical configuration uses the S631 'S' and 'L' Band high power static surveillance radar in combination with one or two heightfinder radars, type S669, to provide primary radar data. Secondary surveillance radar is achieved by installing an interrogator/responser, and by co-mounting an IFF aerial on the primary radar aerial.

The main features of the system are :

1. Simple, effective design, proved in service
2. Optimized frequencies for both surveillance and height finding
3. Increased data rate
4. High ECM resistance
5. Excellent clutter suppression
6. Low running costs and simple maintenance
7. Automatic tracking and narrow band data transmission
8. 3D data on all tracks

Additional features are the high performance of the squintless linear feed, the exceptionally low sidelobes, circular polarization, multiple frequency diversity in 'S' and 'L' Bands, high power high stability magnetron transmitters and the matching of the primary and secondary plot extractors to the digital MTI system.

Mechanical features are the multi-speed turning gear and the honeycomb construction of the reflector, which allows rapid on-site repair. The equipment is suitable for operation in most climates, with special versions available for extreme conditions. The range capability of this combination is such that, in general, the detection of high altitude attacking aircraft is limited only by the earth's curvature.

This system embodies the following features, which are fundamental in countering ECM in general and jamming in particular :

1. Two widely spaced frequency bands
2. High power transmitters in multiple diversity
3. Extremely low sidelobes over the whole band of the surveillance radars

. Operation of the heightfinders in olumetric or sector search modes and urn-through capability

The effect of the foregoing is to force the attacker to spread his jamming power over two wide frequency bands, and at the same time to improve the ratio between jamming and wanted signals. Thereafter, anti-jamming receivers and advanced signal processing techniques discriminate between natural and man-made clutter and provide additional ECCM.

Air Defence Operations Centre (ADOC)

Up-to-date information on deployment of forces, availability of resources and the extent of engagement is essential to the higher command executive responsible for strategic battle decisions. Display and data handling equipment from the Marconi range provides the means by which this information can be collected, correlated, and presented automatically on electronic displays.

In an air defence operations centre, a computer accepts data from remote control centres via narrow band digital data links. Co-ordinate conversion is carried out to allow the positional information to be referred to a common reference for presentation purposes. The extent of the equipment in the centre is determined by the assessment of the threat in terms of tracks to be handled and the extent of the defensive structure in terms of hostile engagements. A large screen projector or rapid processing photographic machine provides conference facilities. Individual user displays from the S3000 range provide information in both graphical and tabular form allowing the higher command staff to call down further information on any aspect of the defence situation such as availability of transport, logistics, data on maintenance, reserves and effects of force re-configuration. Gathering of data and exercising the system under practice conditions is an important feature and these systems may be programmed for simulation studies to establish effective co-ordination of the entire defence organization.

The computer complex is based on Locus 16. Display requirements are met by adopting a modular approach.

The displays themselves employ digital techniques throughout to improve stability and minimize setting-up procedures. All display positions use identical equipment, their operational role being determined by the computer program which selects the relevant portion of its adaptive routine to meet the desired role. Operational organizations may be altered with minimum disturbance when new facilities are required.

The total display content for a particular system is provided by

An operational suite of Marconi radar displays

assembling the appropriate quota of display modules. This design philosophy ensures that malfunction in a module affects a limited part of the system and realizes a high level of operational reliability.

The computer complex automatically services digital data links feeding data to adjacent sector operations centres, surface-to-air missile sites and air defence headquarters.

Without the restrictions imposed by considerations of transportability, the system can be extended to meet virtually any level in capacity, but the operational facilities available are generally as for the S600 Series transportable Area Control Stations. The computer programs incorporates the same software packages, so that operational procedures can be similar throughout defence organizations where static and mobile installations co-exist.

10cm (S) Band and 23cm (L) Band static back-to-back surveillance radar S631

An operations room equipped with Marconi radar displays

Digital Radar Simulation Systems for Air Defence Training

More than twelve years ago the Company undertook the pioneer work that led to the production of the world's first digital radar simulator. This early success has been followed by a large number of orders for radar-based simulator training systems including equipment to meet the requirements of the UK Civil Aviation Authority, Eurocontrol, the Royal Air Force and NATO.

Equipment has ranged from site-based training aids, fully integrated with operational facilities, to large autonomous systems for use in training establishments.

The Company's experience of digital radar simulation is backed by more than £2 million of research and development work, and standard packages can be supplied for both hardware and software to produce a system tailored to specific requirements.

Digital simulation offers very much more than just a replacement for earlier analogue training schemes and cannot therefore be directly related to initial cost. The role of the digital simulator is 'environmental', in that it creates realistic working situations for training staff, under essentially operational conditions. In these days of optimum airspace utilization, it is particularly important that operators are fully conditioned to working under pressure before this occurs in 'live' operations. The scope of digital simulation is not, however, merely limited to individual controller training, but enables exercises to be conducted at system level with all control elements working together. It is now quite practical and economical to plan for simulation to cover at least 80% of training to qualification standard, with the remaining 20% carried out under operational supervision at the control centre. This presents a complete reversal of formerly accepted proportions.

Unlike other training methods, which to varying degrees require manual intervention, digital systems allow precise exercise 'specification' (which may be exactly repeated if required) in order to obtain assessment of results. Not only can standards be set and maintained for individual performance and team efficiency, but also the techniques employed can be effectively evaluated and improvements made in operational procedures.

System realization

The system is driven by a high-speed general-purpose computer with a store configuration to suit the particular requirement. This processor interfaces with simulation peripheral hardware of which the major units are the Radar Signal Generator (RSG) and the Aircraft Control Unit (ACU).

The RSG interfaces with the control displays which may be operational equipment as used in a control centre or similar in character if specially supplied for a school.

The ACU positions are linked by simulated radio telephone (R/T) circuits to associated control/training positions. The input and output facilities of each ACU allow the operator to deal with all the traffic a controller can handle on one R/T channel. In fully developed training systems, a supervisory position should be incorporated to give full control over the exercise in progress.

Additional facilities such as automatic direction finding (ADF), active SSR decode, flight plan and radar data processing, can be incorporated either initially or as extension packages later.

Simulator output is program-controlled to be consistent with system requirements and operating characteristics. Software packages are designed to deal with exercise preparation, running and recording, replay and analyses.

Simplicity

With any training system, exercises must be simple both to produce and to run. Marconi Radar Systems provides a method of exercise data specification which can be carried out by operationally competent training staff, without the need for specialized technical knowledge. Exercise writing consists of inserting the operational parameters onto special proformas, which are then transcribed onto paper tape and processed by the computer as an off line activity. The output tape is used to run and control the exercise and may be re-run as often as required without further processing. An exercise may last two hours or more, depending upon its complexity and the configuration of processing equipment supplied.

Flexibility

Flexibility is built into Marconi simulator systems, so that changes to operational procedures or equipment can be accommodated without expensive hardware replacement. Normally, it is necessary simply to vary the data produced in the exercise specification and only in exceptional circumstances is a change required in the simulator software. Such changes may be economically carried out as part of the Company's post delivery service.

Modularity in design means that expansion requiring additional hardware is achieved simply by 'plugging-in' additional units.

Reliability

Reliability in Marconi simulator systems is achieved by using fully proved processing equipment and special-to-purpose peripheral units, employing advanced technology and manufacturing methods. This in-built reliability avoids costly equipment redundancy in systems which are not required to provide completely 'no break' services.

Simulator systems have been developed and supplied for severe climatic conditions and for mobile installation where high reliability must be achieved with minimum maintenance. Maintenance procedures make the maximum use of

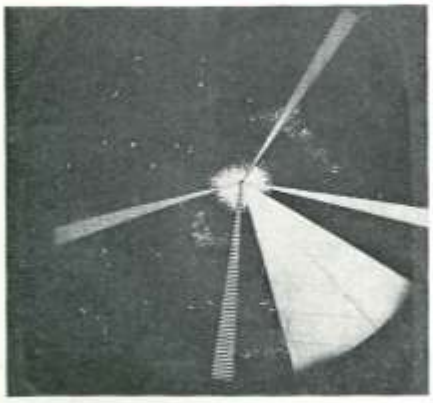
test equipment which does not require highly specialized technical staff on site. The Company offers whatever technical training or backing in the field may be needed to ensure that the simulator is fully utilized, maintained and developed alongside the operational system.

Customer requirements

Although their existing training facilities may be inadequate, customers are often concerned by the possibility that the modernization of radars, aircraft and ground control systems would render newly acquired training equipment obsolete or inefficient. This is not the case with digital simulation training equipment. The hardware is of a general purpose nature and special effects are produced by program control, varied to suit changing conditions, thus maintaining the training system at its maximum effectiveness.

This situation can be fully exploited by the acquisition of a digital simulator before proceeding with a costly replacement of operational equipment. New types of radar can be simulated and their operational effectiveness fully evaluated before cost is incurred. New types of aircraft can be simulated and control techniques perfected in anticipation of the requirement. Control teams can be trained in advance in the use of both new equipment and control procedures, resulting in a much shorter and smoother transition period, providing improved air safety and substantially reducing the cost of training. In activity of this type, and in the course of normal training, provision can be made for voice and digital data recording which may be analysed immediately afterwards.

The essential feature of Marconi digital simulation systems is cost effectiveness with a high level of classroom training, an inherent capability for equipment evaluation and analyses, and a long in-service life.



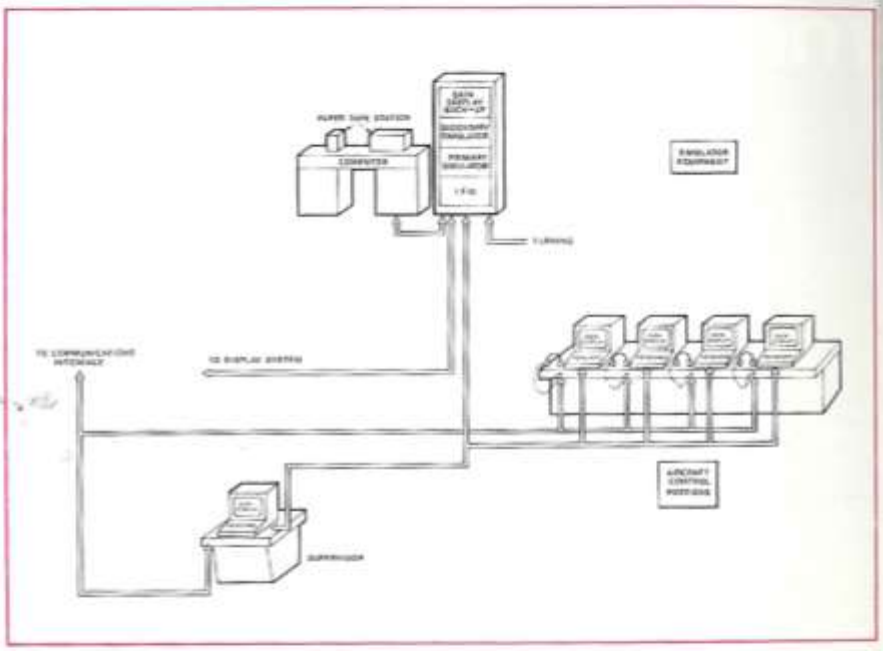
Hypothetical air situation to illustrate readily achievable track activity and special effects which are fully specifiable by the user

Further details of Digital Radar Simulation Systems are given in Marconi Radar Data Sheets N1 and H5

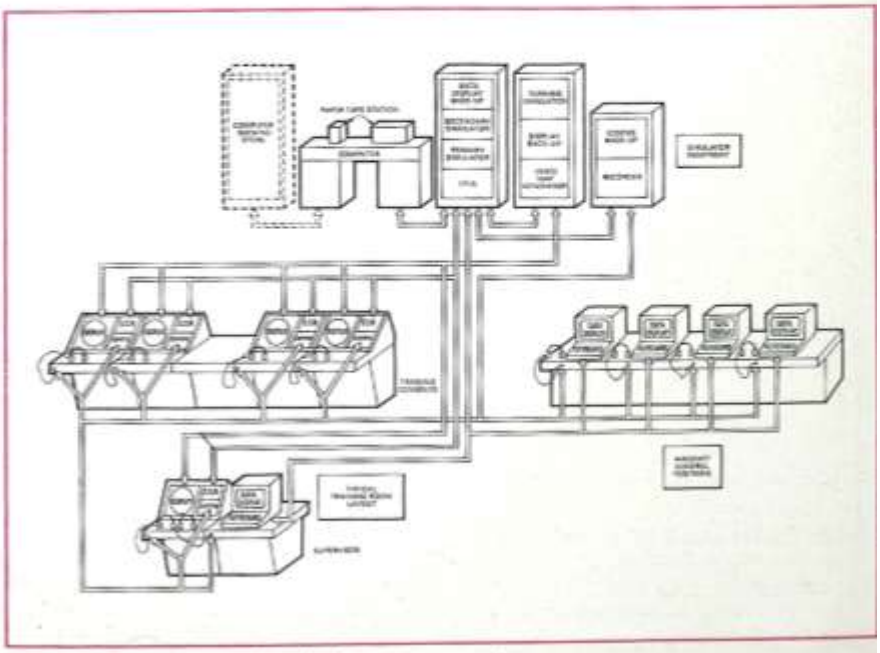
System capability

System capability provides for simulation of :

Primary radar :	2D, 3D, video, extracted plots
Secondary radar facilities :	Passive/active, video, synthetic
Heightfinder :	Demand, readout
Site characteristics :	Elevation cut off, permanent echoes, altitude
Meteorological conditions :	Wind, air temperature, cloud effects
Aircraft performance :	Interceptors, other aircraft types
Aircraft tracks :	Controllable, target, background
Airfield activity :	Weapon control operating status
Surface-to-air missile operation :	Manual, automatic
ECM/ECCM :	R/T, radar
Height finding :	Manual, automatic
Communications network :	R/T, landline
Data link :	Ground/air, ground/ground
Radar data processing systems :	Automatic, semi-automatic



Simplified system diagram of a typical add-on sub-system



Simplified system diagram of a typical autonomous system