Radar Systems International

MARCONI

No. 28

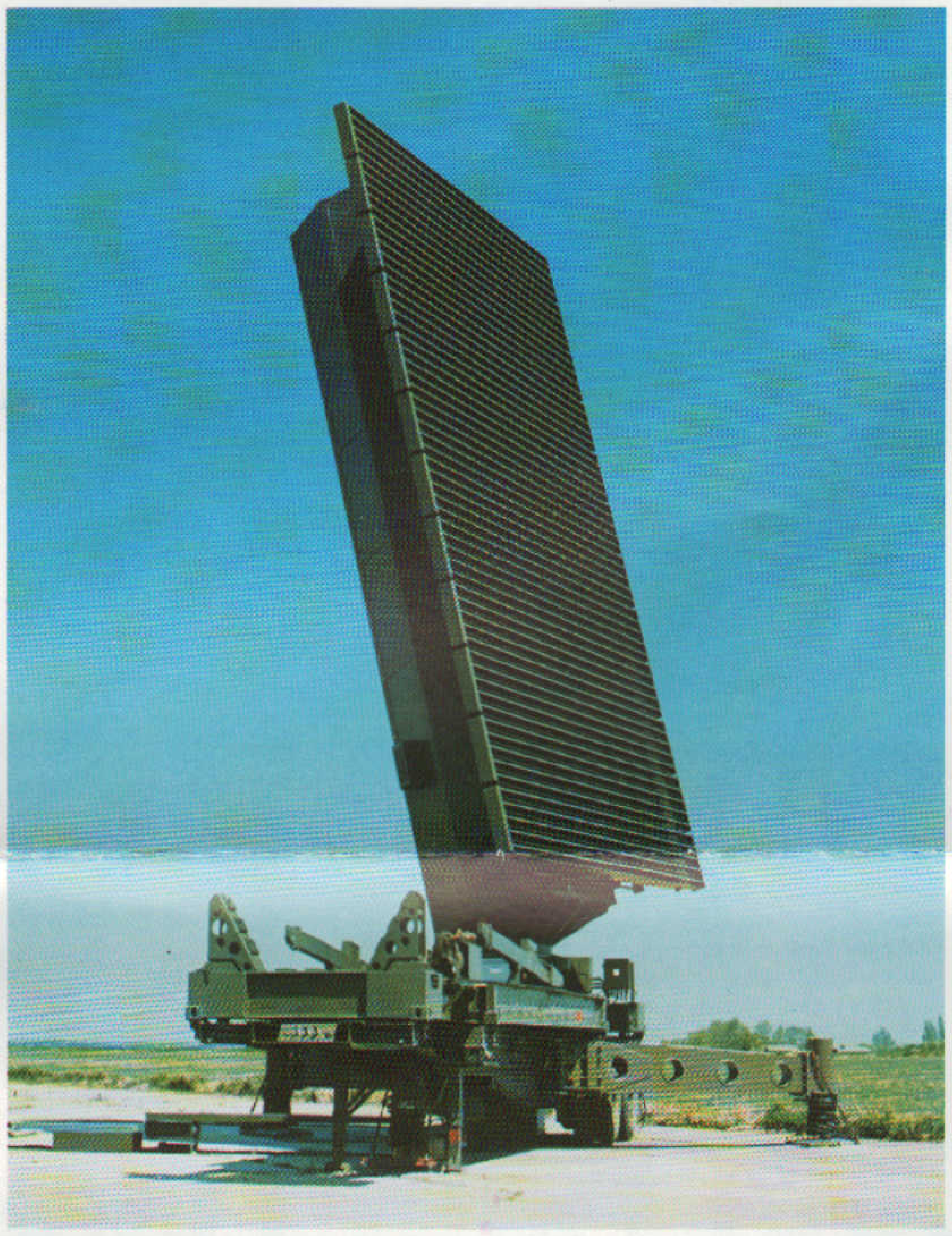
Martello, the Future Air Defence Radar!

On the airfield at Rivenhall in Essex stands today the world's most advanced air defence radar.

Martello, despite its futuristic appearance when deployed, is a highly reliable 3-D radar which provides complete long-range surveillance of tactical airspace.

Martello has the ability to detect small targets moving at high speed and is able to maintain detection even in a hostile ECM environment.

It is a truly transportable radar system of modular construction employing pulse compression and digital processing techniques under computer control.



The Martello 3-D Radar Antenna deployed at Rivenhall.

The Role of Air Defence Radar

The design concept throughout Martello is "tomorrow's air defence radar must have mobility!" The air forces of the future will be operating high performance aircraft with a capability in all the attack roles. The significant characteristics of the attacking aircraft will be high speed and high manoeuvrability in all three dimensions. As a result, it will be necessary to provide for the initial detection of attacking aircraft at long range in order to allow sufficient time for engagement by appropriate weapons, for accurate and continuous positional tracking and for frequent height measurement to ensure that tactical height changes can be detected in good time.

Most air forces operating modern attack aircraft will use electronic countermeasures (ECM). The opposing air defence system must be equipped with adequate electronic counter-countermeasures (ECCM). The design of new radars must include the application of techniques which reduce the effects of jamming. Also the ability to move a complete radar system and then redeploy it hours later, miles away from its original location. An effective air defence system will always become a priority target on the outbreak of hostilities. As a result it is necessary to consider the physical survival of all the elements of the air defence system, particularly the radars. Radars can be detected and located by enemy electronic intelligence systems and are vulnerable to physical attack. Future systems should have the maximum possible protection, including decoys, to divert direct attacks; guard systems, to control the switching of main radar and decoy transmissions; and transportability, allowing rapid dismantling and deployment at alternative sites to confuse the enemy.

Flexibility of Design

Automatic performance monitoring and fault location is a feature of Martello which is designed to meet all the foreseeable military requirements for an air defence radar. A typical Martello system consists of a basic group of four vehicles, but this can be varied to suit any specific requirements.

The basic vehicle group comprises standard ISO containers, the antenna is a planar array built onto a trailer which becomes the antenna gantry when the equipment is deployed.

The antenna is easily and quickly lowered, and after the removal of the array modules forms a neat compact transportable unit complying with ISO container standards. The array modules are carried on a separate ISO pallet.

A typical Martello radar system consists of the Antenna vehicles, the Radar container, and the Services container.

Other containers may be added according to the customer's requirements.

The Equipment

Martello is a stacked beam system. It uses eight beams formed electronically in the receive mode and a single composite pattern in the transmit mode. The eight receive signals relating to each of the eight beams are processed separately and in parallel. The number of pulses per target per scan is therefore comparable with 2-D systems allowing comprehensive signal processing to be applied to all beams out to the full range. A secondary radar system is included and forms an integrated part of the system package.

All radar information including height data is presented on a PPI display. Primary plots, secondary plots and combined primary and secondary plots can be displayed.

Monitoring of radar performance is an automatic process, radar status and performance data being displayed on a VDU. Radar control is carried out using this same VDU with a Digilux touch system and rolling-ball marker.

All plot data can be transmitted over a narrow band link, to a remote operations centre.

The system has been designed to be extremely reliable and very fault tolerant. Failure of up to four receive channels, loss of 50% of the total number of transmitter frequencies, failure of one channel within any of the processors, and failures within the Built-in Test Equipment (BITE) are examples of losses which will not cause a significant degradation of system performance. The mean time between significant failures, excluding the primary power generation, system cooling and SSR, is in excess of 1000hrs, so the system is more likely to be only degraded by failures, than it is to suffer a total loss of performance.

In Martello, fault finding and repair is a simple procedure due to the modular construction and comprehensive built-in test equipment. The Mean Time to Repair is one hour and all preventative and corrective actions can be carried out using site personnel.

Deployment and recovery of the whole system can be achieved in less than five hours by a practical team of four men.

Operation of the system can be maintained by three men, only one of whom would need to be a skilled technician.

The Martello Radar System in action.

The Antenna Vehicle en-route to another site.

LOOKING INTO MARTELLO

Inside the Radar Container showing the Transmitter on the right and the Signal Processing Panels and Plot-forming Cabinets opposite.

Martello introduces new concepts in both electronic and mechanical design and combines high power with transportability. Some of the new techniques are reviewed briefly here.

The transmitter comprises a frequency synthesizer and r.f. amplifiers, and produces a high-power pulse at a low p.r.f. The system employs pulse compression techniques, the swept i.f. signal being generated in the signal processor and then passed to the frequency synthesiser where it modulates the r.f. signal. The synthesizer can generate a number of predetermined frequencies which are selected either singly in a programmed sequence, or randomly under the control of the system computer. The r.f. pulse is fed from the frequency synthesizer to a TWT intermediate amplifier which raises the pulse from 100mW to about 4kW peak, before being passed onto the hybrid power amplifier which amplifies it up to 3.3MW.

The high power pulses are passed to the antenna and through the power divider to each of the radiating elements. The receive signals are fed from each element to a double superhet receiver which feeds into the beam forming network (BFN).

The eight i.f. signals from the BFN go to eight adaptive processors in the signal processor unit, each i.f. being processed separately. The processors apply pulse compression to the incoming signals then converts them to digital signals before further processing. After A to D conversion, the signals pass into two channels; an MTI channel and a non-coherent channel. The MTI employs a vector processor with a triple canceller.

Both the MTI and non-coherent channels are followed by threshold circuits which are adaptive and are applied selectively according to the prevailing conditions. The combined outputs of the processors taken from both the MTI and the non-coherent channels are then fed to the Plot Forming Unit.

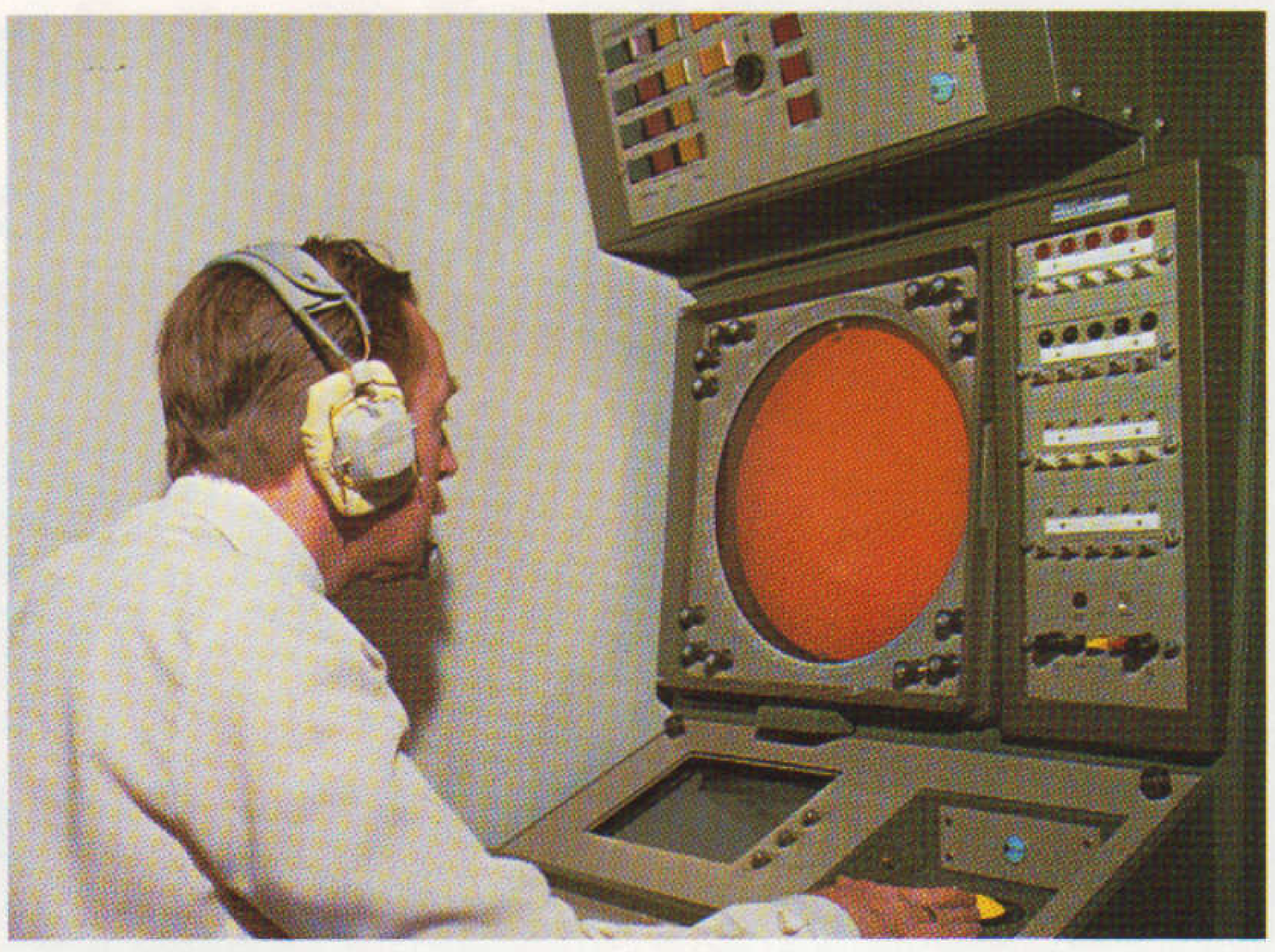
The Plot Forming Unit carries out, first of all, a prefiltering process to eliminate random threshold crossings and then assembles likely target signals for further processing. These potential targets are called Partial Plots and are assembled together with information on the target elevation. Each of these Partial Plots is then processed by applying certain criteria, which if satisfied, allows them to be passed as Intermediate Plots to the Locus 16 Data Processor. Decoded and validated returns from secondary radar interrogations are also passed to the Data Processor as secondary plots.

The Data Processor then takes each of these Intermediate Plots, calculates the target height from the elevation data, taking into account site height, vertical reference and refractive index and produces a plot symbol on the display.

The Data Processing system also performs other functions:

It correlates primary and secondary plots and then displays these as combined plots.

It is used for system control and status monitoring. Extensive self checking and monitoring is built into the various units and should faults occur, the Data Processor alerts the Radar Manager.



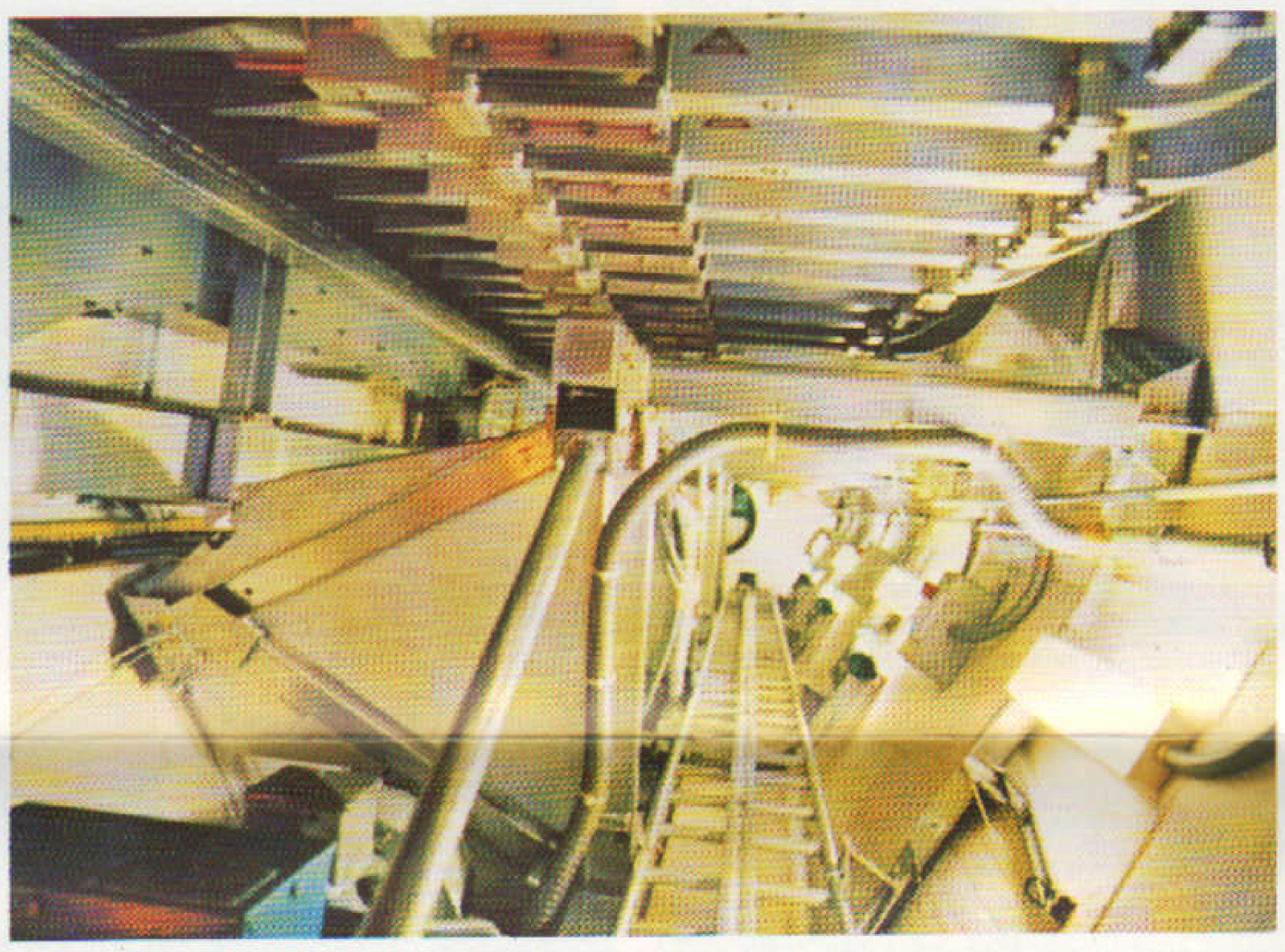
An operator at the Radar Manager's Display Console.

Finally the Data Processor sends plot data out via the modems to a remote operations centre.

Control of the system is exercised by the Radar Manager from the Radar Manager's Position. He has a PPI, a VDU with a Digilux and a rolling-ball marker to help him in this task.

The antenna is driven by the Antenna AC Control Unit which also sends antenna position data to the rest of the system.

All these equipments (other than the antenna) are housed in one container, the radar container.



Vertical view inside the antenna spine showing waveguide assemblies opposite the ladder. The circular opening visible at the head of the ladder is an exit hatch.

Radar Display and Data Handling

Marconi Radar display and data handling systems incorporate the wide experience gained by the Company over many years. The systems make use of the latest electronic and manufacturing techniques and are based upon modular formats. This allows requirements of all degrees of complexity to be readily incorporated. Marconi systems are available in static and mobile versions, engineered where necessary to a customer's specific requirements. The basic display and data handling modules include a full range of monochrome and colour displays controlled by Locus 16, the Marconi Radar distributed data processor designed for real-time data handling situations. All systems are backed by an extensive library of supporting software. Both these elements, hardware and software, are the subject of a continuous improvement programme aimed at the goal of improved reliability and efficiency.

Marconi Radar data handling systems form the ideal basis for Military Control, Command and Communication facilities. The data handling systems provide real-time assembly and display of all available data together with the categorising and assessment programs essential to command and control decision making in modern defence situations. Marconi Radar data handling system modules integrate into defence systems of all degrees of complexity from the very small to the very large. The modules are used as Control and Reporting Posts, Missile Control Centres, Sector Operations Centres and other related functions. Minimal conversion is necessary, the modules incorporating the ability to change the functions of individual positions by program replacement, resulting in common hardware and in real savings in spares, training, maintenance and support costs.

Marconi Radar Locus 16 processors are designed specifically to utilize cost-effective distributed data processing principles. Employing high speed parallel highways and plug-in card units such as arithmetic processors, RAM and ROM stores, Small Devices Processors, Display Processors and all other necessary devices, the Locus 16 processors interface readily with all associated equipments and are easily and speedily extended and re-configured. Maintenance is simple, aided by the plug-in modular system and by built-in and add-on test units and programs. All system connections are by edge connector modules at the front of the processor.

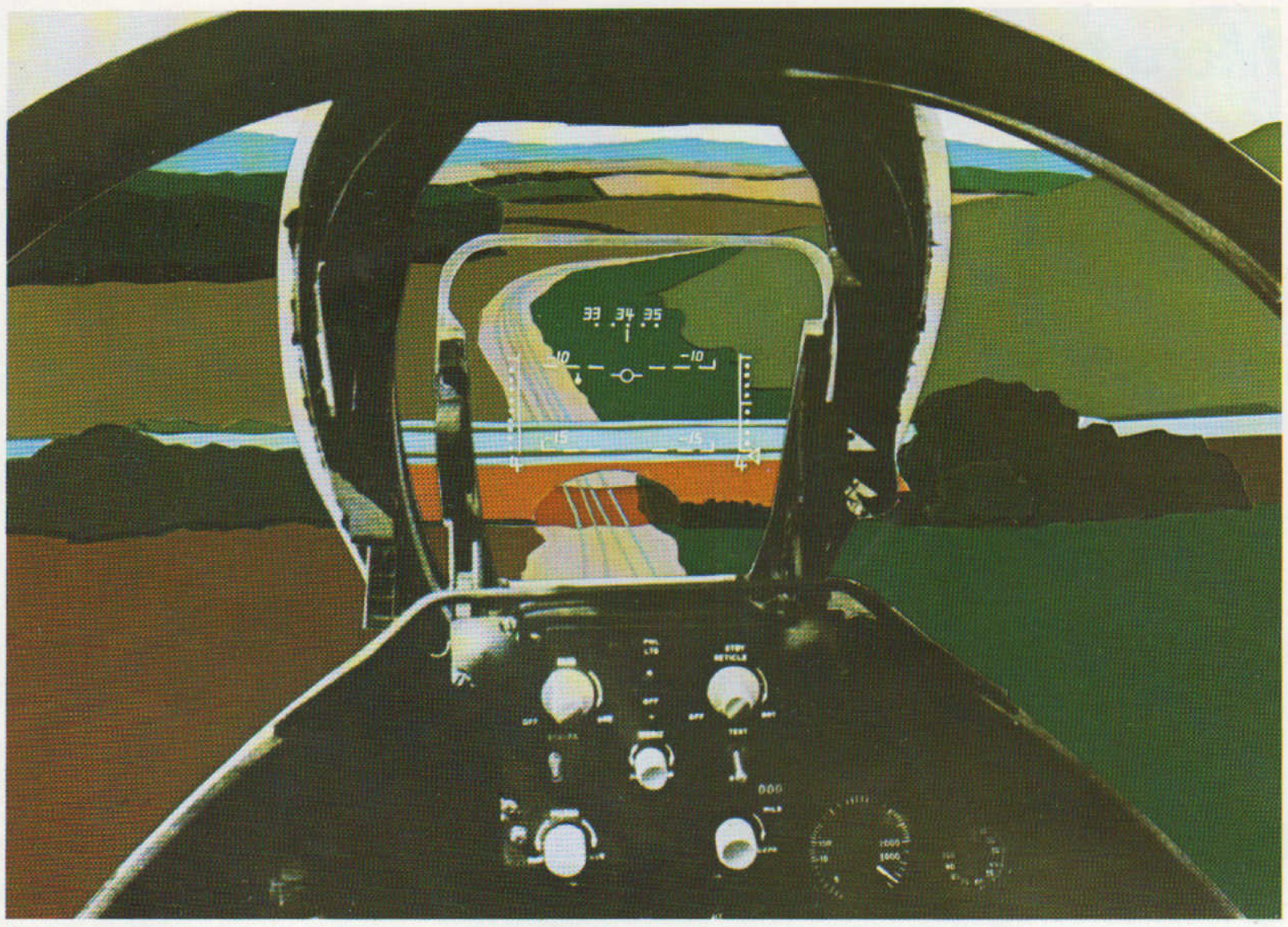
A recently exported Air Defence Display and Data Handling Cabin Installation.

The data processing display consoles are ergonomically engineered to fulfil all necessary technical and physical parameters. The consoles, based upon a modular format, enable single or multiple configurations to be readily assembled. The consoles house the radar displays, in 16″ and 23″ sizes, interface devices such as keyboards, touchmasks, rolling balls, etc, together with all necessary communications facilities.

Marconi display units are available in monochrome and in colour versions, with various tube type permutations, to suit the required application.

The data processing and display software programs conform to the overall system principles of modularity and extendibility. Software packages are available for numerous air defence applications such as Control and Reporting Centres, Sector Operation Centres, Air Defence Operations Centres, Surface-to-air Missile Control Centres, etc. The packages are identical in terms of the operating, data management, display support, inter-site digital communications and entry of weapon and logistic systems. All necessary facilities, typically: primary and secondary radar automatic tracking; automatic track cross-tell; trial interception; executive weapons systems control; automatic weapon assignment, etc, are provided.

A New Visual System for Aircraft Simulators



A typical TEPIGEN initiated scenic display for use with an aircraft simulator.

TEPIGEN the Marconi Computer Generated Imagery equipment has been combined with the latest computer techniques to provide a very advanced visual system for a military flight simulator. Computer generated imagery (CGI) is an established technique producing life-like scenes entirely from a computer. The scenic imagery produced this way can be made to change in aspect as the pilot alters course or climbs or dives during the simulation.

Whilst a great deal of first class training was possible on many flight simulators those manoeuvres relying on visual judgement were least well catered for. The impressive reproduction of 'feel', instrumentation and motion in modern flight simulators was not matched by visual systems of equivalent excellence. Indeed, many simulator operators managed without a visual system of any sort. These flight simulators contributed little to those areas of flight, often the most critical, involving the pilot in external judgement, — take-off and landing, formation flying, combat, ground attack and so forth.

The introduction of computer generated imagery (CGI) into flight simulation was a determined effort to overcome this deficiency. Initially restricted to dusk or night scenes, recent advances in simulation techniques and in the availability of high speed microprocessors has enabled CGI to take the major step into full colour and daylight operation.

In the forefront of the progress into such advanced CGI visual systems is TEPIGEN, the product of a continuous programme of development started in 1972 by Marconi Radar's Control and Simulation Division.

Computer generated imagery, where pictures are wholly synthesized within the computer, is a technique that overcomes many of the limitations of the earlier visuals. In particular, the inherent flexibility of digital systems and the capability of accurately reproducing the realistic interaction between the high-speed movement of a modern aircraft and the view of a dynamic outside world from the cockpit, give CGI a powerful advantage.

The advanced TEPIGEN system builds on the success of versions already in service at home and abroad for training weapon operators. Particular attention has been paid to ensuring that the visual cues important to the pilot are present in the scene whilst at the same time avoiding the over-extravagant provision of equipment. Systems of varying size and capacity can be configured by Marconi Radar to meet a very wide range of flight simulator requirements.

The TEPIGEN Visual System for a Strike Aircraft Simulator

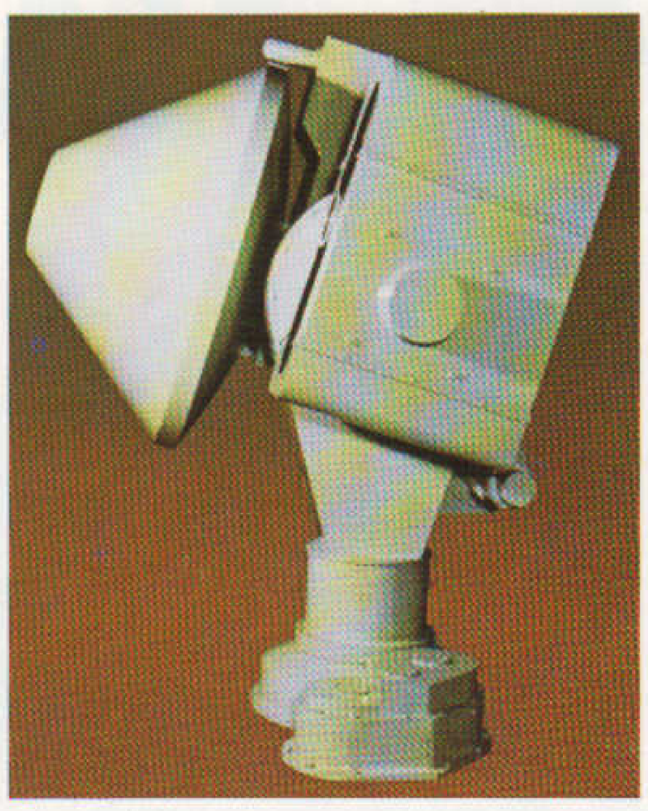
A particular visual system that Marconi Radar is currently developing is the TEPIGEN Visual System for a Strike Aircraft Simulator for full mission training or research. The system may be applied to either a fixed wing or helicopter simulator. The Visual System is intended to provide imagery for pilot and co-pilot/gunner crews. Low detail background and high detail target imagery channels are combined to provide realistic target engagement training with a range of missile and gunnery effects. The configuration also allows for in-cockpit head-down displays and helmet mounted displays employing imagery from a range of sensors. There exists a numerous range of capabilities in the TEPIGEN Visual System for this type of application. These capabilities may be selected or enhanced for any other particular application, as required by the user.

A Great Day For Marconi Radar

Marconi Radar's managing director John Sutherland formally accepts the 1980 Queen's Award for Export Achievement, from Admiral Sir Andrew Lewis KCB the Lord Lieutenant of Essex. Mr Sutherland expressed his pride in all those people in the Company, throughout the country and overseas, whose determined and persistent efforts had obtained the coveted Queen's Award for Marconi Radar.

The Lightweight Sea Dart for Small Craft

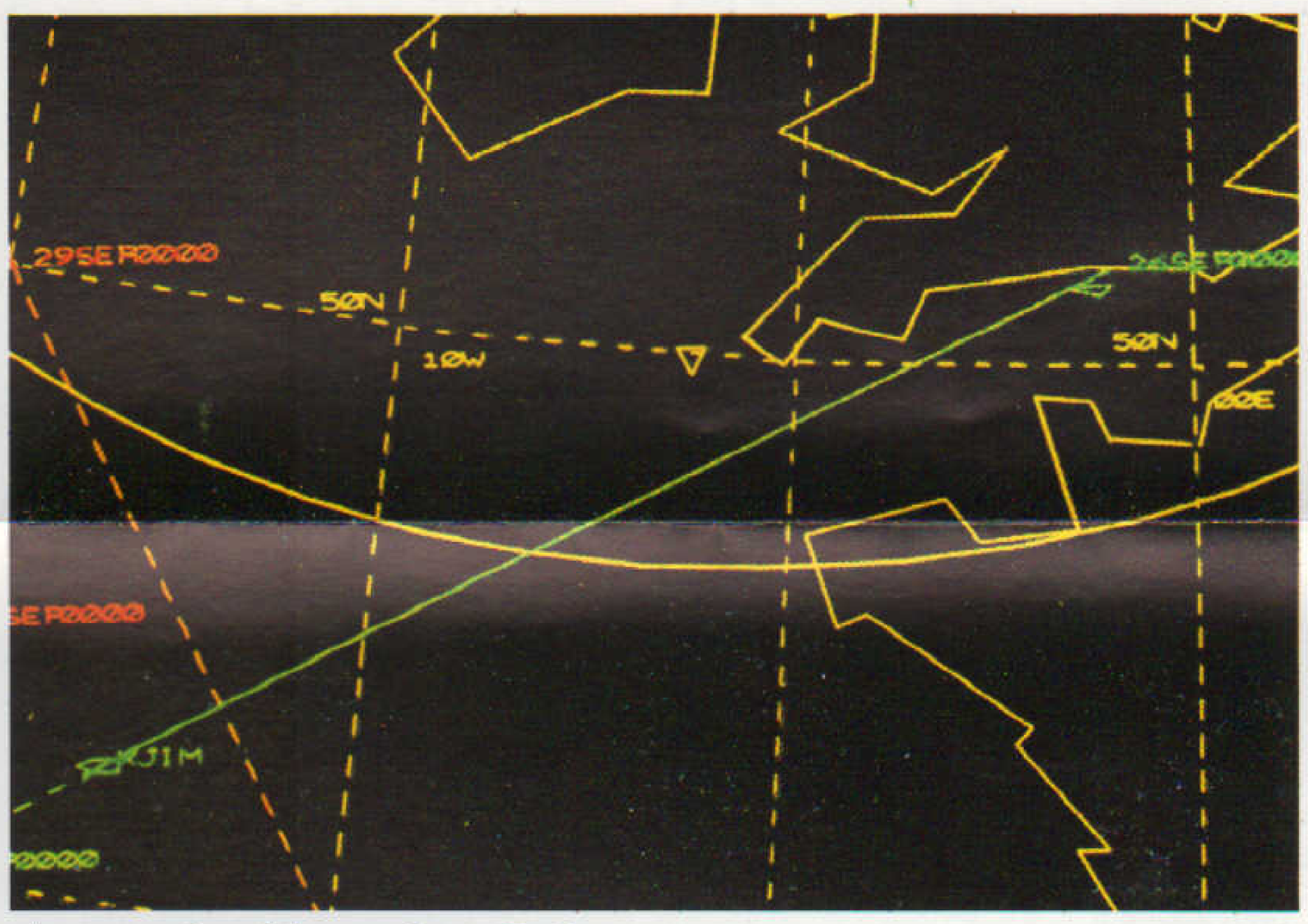
Much emphasis has been placed by Marconi Radar on the provision of a lightweight Sea Dart system suitable for small craft. The radars for this much needed role are part of the Marconi X band S800 Series. A new system (ST805) has been evolved from proven components of the GWS 30 system at present fitted to larger frigates. ST804 is suitable for craft down to about 300 tons, whilst the new ST805 is for the small frigate. Lightweight Sea Dart uses Marconi radar control with the British Aerospace, Sea Dart missile and a lightweight missile launcher plus all the necessary support electronics. Lightweight Sea Dart has a complete capability to meet surface threats as far as the radar horizon with a kill range of more than 20km against air targets. The system provides a sophisticated defence against sea skimming targets and can operate, largely unaffected, in the presence of heavy electronic countermeasures.



The ST805 Lightweight Sea Dart Antenna.

Marconi Radar, the United Kingdom's leading supplier of naval radar, have developed a new range of advanced radars for use in the 1980s. An established supplier of early warning and target indicating radars to the Royal Navy, the Company has in recent years developed the Seawolf as well as the Sea Dart. These radars, designed for larger fighting units of the RN, are complemented by the series of lightweight radars, the 800 series, which form the basis of a range of modern weapon systems for the smaller craft. This range of modern lightweight radars uses the latest technology and Marconi naval design experience to provide control of guns and missiles in anti-aircraft and anti-ship roles. Their modular construction gives flexibility of layout where space is limited and built-in monitors permit rapid servicing. Operating in X-band, these radars combine high performance and light weight.

There's Safety in Colours!



An operational four colour display.

Four colour displays help to avoid ambiguity in the interpretation of data, which could lead to danger in certain situations. Marconi Radar have been working for many years on further improvements in the presentation of radar data on a c.r.t.

The application of this work to military requirements is well appreciated. Marconi Radar have now produced a new 22-inch colour display which is a considerable improvement over the earlier model. The colours can provide a clear separation and distinction between functions. For example, the map information may be outlined on one colour while the remaining colours are used for specific information. A typical arrangement of colours is red, yellow, orange and green.

The latest Marconi colour displays are based upon a range of high definition penetron tubes and are available with various colour and persistence permutations. Typical examples are a four colour short persistence version giving red, orange, yellow and green and a three colour unit giving orange, yellow and green, the orange being long persistence. A particularly useful feature is the high brightness level of the displays enabling satisfactory viewing in conditions of high ambient light.

The colour tints are independently variable to suit the operator and all colours have independent brightness control.

The Need for Multi-Colour Displays

From the inception of radar, well over 45 years ago, the monochrome cathode ray tube has been a primary medium for the presentation of radar derived information. Over this long span of time, aircraft performance, size and traffic density have increased dramatically; this trend has, of necessity, considerably increased the problems of the civil and military air traffic controllers.

Over the years, numerous improvements have been introduced into the control centres to help cope with this increased traffic pattern and to improve operational working conditions. The latest such improvement and perhaps one of the most significant is the introduction of the high definition, high light level, multicolour radar display. This modern device backed by sophisticated electronic techniques adds the impact of colour to the observer's vision, and hence, to his understanding.

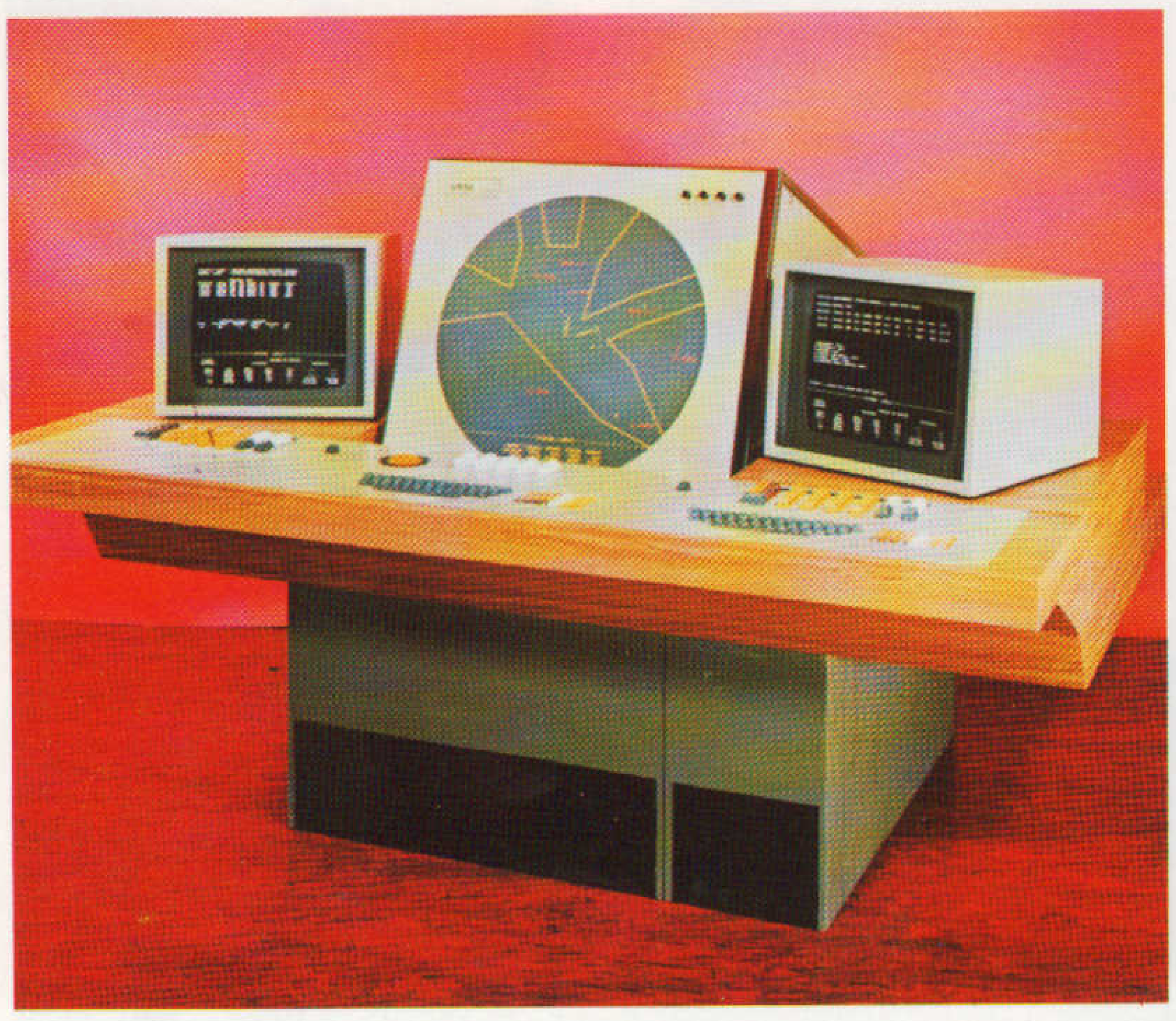
The multi-colour display is expected to have a great and increasing role in the operations rooms of the future.

Colour coding is suitable for many roles in air defence, naval defence and air traffic control. In air and naval defence applications the codings are obvious and traditional, deriving basically from the plotting boards and tables used in defence operations rooms for many years. Typical such codings are: hostile, friendly, unknown, and neutral, the definitive colours adding unambiguous identities to such critical plots.

In air traffic control, certain other uses readily suggest themselves. Typical applications are fixed locations such as beacons and airfields, the background map incoming/outgoing flights, height bands or even the controller's own tracks.

It is apparent that the introduction of the multi-colour display, points the way to safer, unambiguous, operational techniques.

New Console for NATO

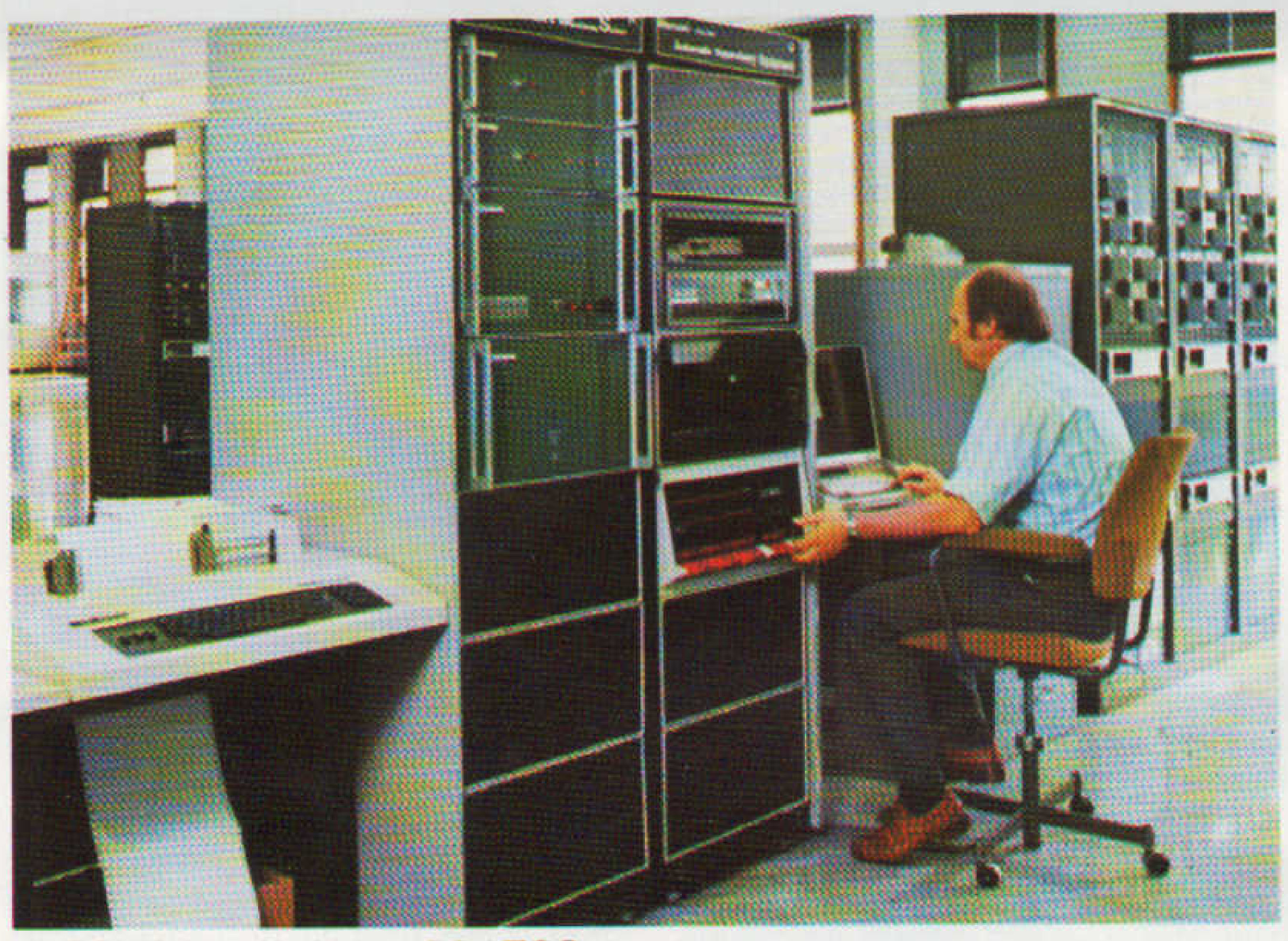


A typical UKSL Universal Console configuration.

Exhibited at Farnborough 1980 is the new UKSL Universal Display Console illustrated above.

UKSL is a British company created to implement the United Kingdom Air Defence Ground Environment system for the British Ministry of Defence on behalf of NATO. The Marconi Company with Hughes Aircraft Corporation and The Plessey Company Limited are the three companies forming United Kingdom Systems Limited. The UKSL Universal Console is specifically designed to meet UKADGE requirements and provides each operator with a bright flicker free colour display and VDU's. The console is designed in a table top configuration, suitable for one or two operators, with a low profile to provide maximum visibility. Flexibility of all functions and procedures is a feature of the console. The equipment also has integrated display and voice communication multi-processing. Reliability and ease of maintenance is assured by the extensive BITE, (Built-in Test Equipment).

Marconi Radar Supplies CAA with more CMM



A CCMS installation at SCATCC.

Following the successful operation of CMM installed at SCATCC over the past two years, the CAA have ordered more CMM equipment.

A unique new radar control system, playing a vital part in air safety in Southern England, is to be supplied by Marconi Radar Systems Limited.

In a contract valued at over £1¼ million, the Civil Aviation Authority (CAA) has placed an order for the supply and installation of a Radar Station Control and Monitoring System (RSCMS) which will improve the operating efficiency of air traffic control radars.

RSCMS will enable the CAA to centralise the control and supervision of ten en-route and terminal radars on the London Air Traffic Control Centre (LATCC) at West Drayton.

Mr John Sutherland, managing director of Marconi Radar, explaining the new system said "At present, London air traffic controllers rely on rapid communication with monitoring staff located at the radar sites to establish the integrity of the radar pictures. This means, say in the case of partial failure of the radar, for example, vital minutes may be lost in adapting traffic control procedures correctly to the new situation. The new RSCMS will allow West Drayton to check each radar's operational status continuously and give the same control facilities as are available at the radar site itself."

"A further benefit of the new system is that technical people at the radar sites can use RSCMS's monitoring facilities as the basis of maintenance."

At the heart of RSCMS is a system called CMM (Computerised Modular Monitoring) developed by Marconi Radar to improve and simplify the maintenance and management of complex electronic and electromechanical installations. In RSCMS its function is automatically to gather data from a large number of points in each of the radars and after processing in the computer, to display them in plain language to the equipment controllers and maintenance personnel both at the radar sites and at LATCC.

The CAA is probably the first civil authority in the world to commit itself to such a high level of remote control and monitoring, all three armed services in the UK are investigating Marconi CMM for the supervision of complex military systems.

ATC in the Eighties

More Marconi Data Processing for SCATCC

The new ATC Centre at Prestwick became operational early in 1980. Since opening, the Scottish Air Traffic Control Centre, which monitors aircraft in Northern England, the Atlantic Approaches and the North Sea including Scotland, has operated the most advanced radar data processing and display system supplied by Marconi Radar.

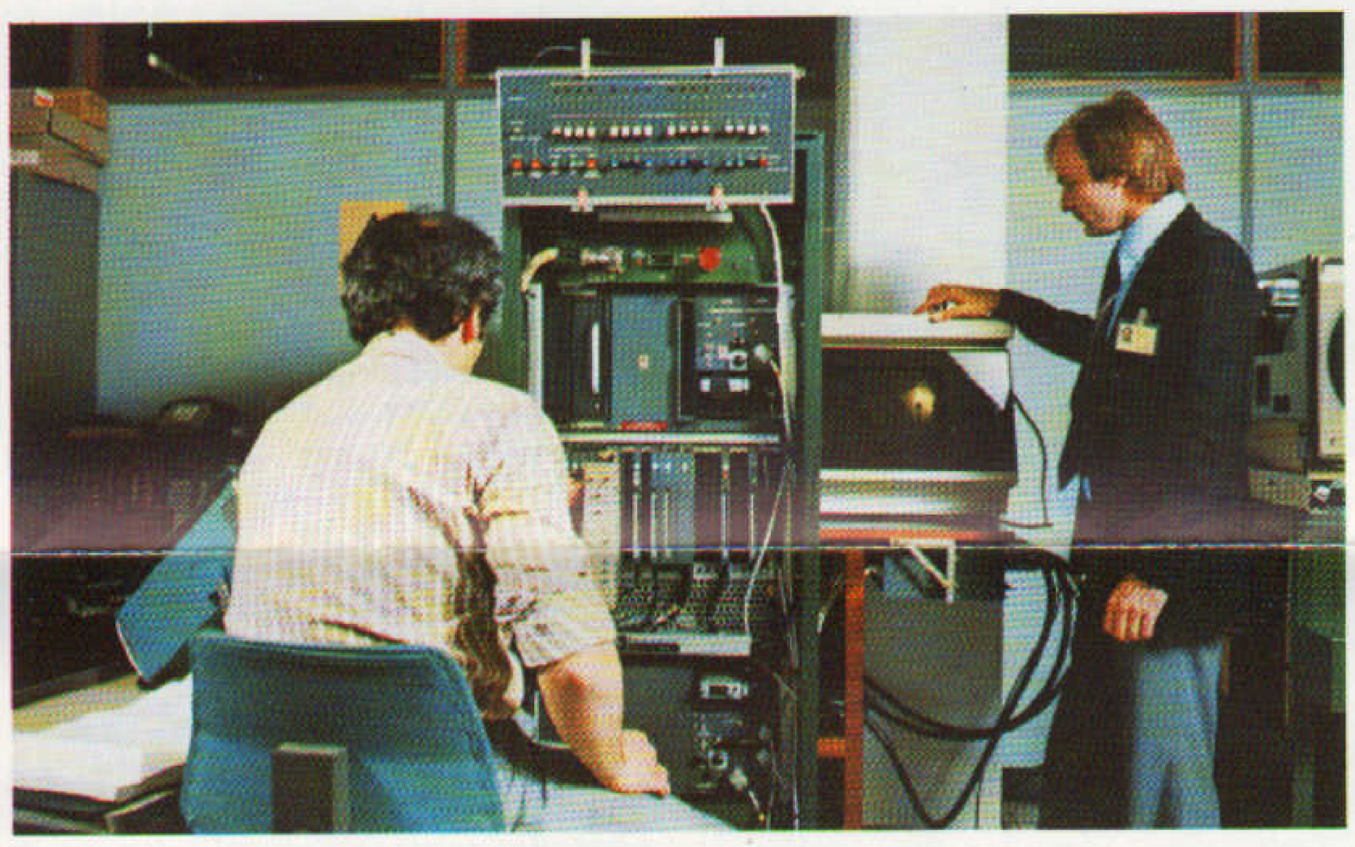
The Scottish Air Traffic Control Centre based on Marconi distributed data processors is about to be extended by the CAA with more Marconi data processors and displays.

Royal Air Force Air Traffic controllers at Prestwick.

The Locus 16 System Can Cope!

The advent of the Locus 16 distributed processing technique by Marconi Radar has enabled many diverse and difficult applications to be brought under efficient control. This concept has proved itself eminently suitable for air traffic control and many other complex civil and military data handling systems.

This now well established and versatile data processing system offers a compact and robust assembly and uses highly reliable, yet advanced, parallel processing methods.



A Locus 16 test station at Prestwick.

Computing facilities in Locus 16 utilize a parallel multi-processor organization. Digital processors run concurrently within each module bin assembly, some controlling external devices while others are arithmetic and logic processors. All plug-in to the rear data bus, through which all internal communications and store access take place.

The Locus 16 programs are permanently held in an equipment configuration or loaded from a variety of devices and communications channels. The software deals with many aspects of radar data handling applications so that for some usages complete facilities may be provided from existing material.

The Locus 16 computing performance is very powerful, with parallel processing in conjunction with a unique memory management system.

Software and Locus 16 Systems

Locus 16 applications software employs a real-time executive program to schedule the use of processors in carrying out the work load. Rescheduling is initiated at program determined time intervals and by interrupt signalled events or calls occuring within the system. The methods closely reflect the 'MASCOT' philosophy adopted by the British Ministry of Defence. The Coral 66 language is used extensively.

A number of demanding and complex applications have been implemented, using Locus 16 connected into networks and intercommunicating locally using a high integrity data channel of capacity up to one million bits per second.

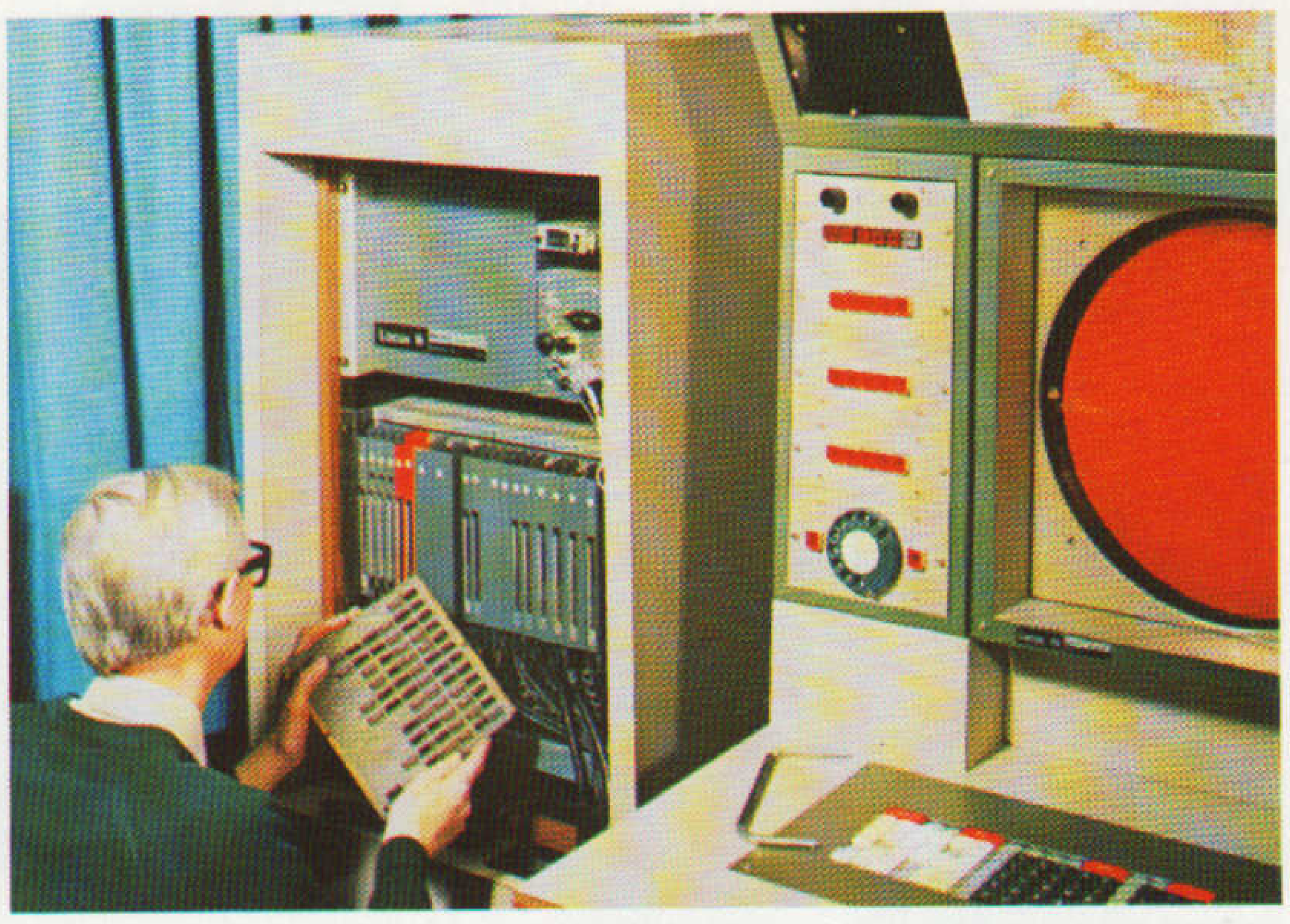
In particular cases these networks have been designed to provide continuity of service and protection of the data base despite failures of hardware or of a communications channel, data bases being held in RAM store and in large capacity disc storage units.

Within this framework, existing programs can be applied relating to the establishment of air situation data bases to the automatic tracking of aircraft, to fighter interception and weapons control and to a wide variety of requirements arising in civil, military and naval applications.

Locus 16 Reliability

The Locus 16 system provides high standards of reliability and is designed to enable rapid restoration of service following failure. This is normally done by module replacement, each module comprising one or two printed circuit cards accessible from the front of the unit. No special setting up is required as the environment dictates the operating parameters to be adopted. Subsequent repair can be carried out in the user's workshop or by Marconi Radar a diagnostic processor and console and a range of simple test jigs for use with test software packages being available. Training is also available.

In networks of Locus 16 configurations uniformity of the components parts contributes to the reduction in necessary spares holdings.



Replacing a module in the Locus 16 enables immediate restoration of service.

STOP PRESS

The 500th Marconi Radar Beacon sold!

The Compagnie Radio Maritime has just bought the 500th Sea-Watch 300 radar beacon. Throughout the world over 35 countries are using Marconi Racons to increase safety at sea.

Radar Systems International

the journal of
MARCONI RADAR SYSTEMS LIMITED
A GEC-Marconi Electronics Company
Writtle Road, Chelmsford, England CM1 3BN
Telephone: Chelmsford (STD 0245) 67111. Telex: 99108