*LEFT: OSCR on a Miami beach.*

*BELOW, LEFT: HF radar VTM (vessel traffic management) display.*

*RIGHT: Experimental HF radar antennas on the hull of* **HMS Londonderry.**

*BELOW, RIGHT: OSCR display.*

first time, mainly because we were using the ship's existing HF communications antenna which, we were assured, was omni-directional. In fact it radiated most of its power over the stern and we were doing our OTH trials on aircraft flying a long way ahead over the bows!

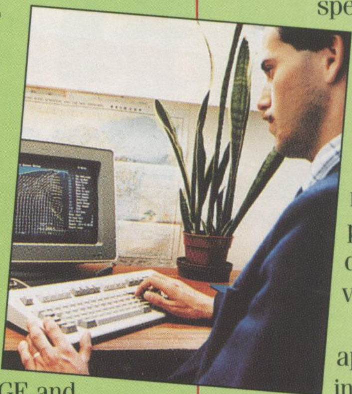
We put our own antenna on another ship and obtained superb results on a *Canberra* aircraft flying a few feet above the sea at OTH distances.

With the Falklands behind us, we led a UK-industry team studying Skywave radar operation from the UK, but more importantly for our future, in the mid-80s we initiated the PV core technology programme we called SWORD or Over-the-horizon Radar Defence — the SW standing for either Surfacewave or Skywave. This work was to have important implications when we went to Canberra in 1988 to register interest in a certain project called Jindalee.

Also in the mid-80s, we proposed LES-1 or Look-East-Skywave No. 1, using the BBC Overseas Broadcasts' Daventry transmitter with its antennas trained to the east, radar- modulated and synchronised with the HF receivers at Dengie to detect aircraft by Skywave over the Baltic, almost to St Petersburg. It was a good idea, but the Cold War was thawing, so LES-1 was never built. Now we travel to St Petersburg and Moscow to share our experiences with Russian HF radar engineers who had been similarly enjoying themselves inventing ways to look at us!

We successfully built a Surfacewave radar that tracked a missile skimming the sea over Cardigan Bay, and while the radar was measuring the missile's characteristic accelerations we realised that this would help to identify it.

Era 3 began in 1988 when, late one Friday evening, our first proposal for the Jindalee Operational Radar Network (JORN) was faxed to Australia and submitted to DOD in Canberra. We were one of 169 firms who had registered interest. Soon we were teamed with Telecom Australia and competing against GE and Raytheon in the JORN Project Definition Study.



We are now engaged in this massive Australian HF radar surveillance project, which will aid the stability and prosperity of the South Pacific Rim nations well into the next century. Apart from JORN, we are currently marketing new Surfacewave radars for tracking ships out to 200nm (370km) in the Economic Exclusion Zones, also for tracking sea-currents near oil-rigs, sewage outfalls etc.

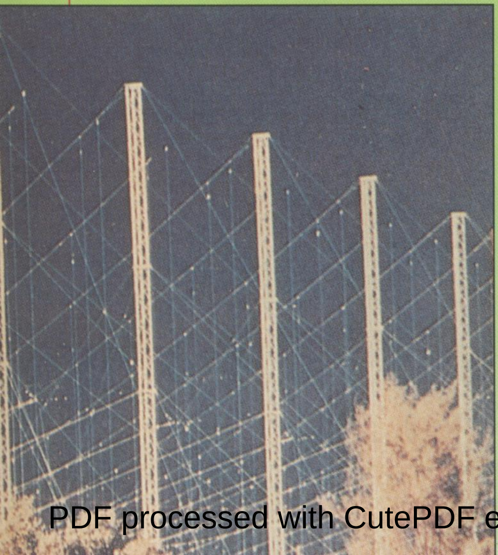
Over 60 nations in UNCLOS, the United Nations Convention on the Law of the Sea, have ratified the EEZ regulations, which not only confer benefits from fish, oil and mineral exploitation but also impose responsibilities for the protection of all those traversing the Zones and for search and rescue.

The Marconi S124 Surfacewave radar is purpose-designed to provide policing of the EEZ and to direct aircraft and ship patrols to investigate, intercept and expedite search and rescue.

HF radar transmissions react with sea waves to produce unique doppler-spectral returns that enable us to offer yet another product, OSCR, to the oceanographers. We are marketing OSCR in many countries for land reclamation, monitoring pollution and assisting the docking of very large vessels.

For the future, the applications for HF radar include ballistic missile tracking; interdiction of aircraft ferrying drugs over jungle areas; protection of ships from sea-skimming missiles; beyond-the-horizon targeting of incoming attack vessels; detection of Stealthy aircraft and ships; tracking cyclones; remote measurement of wind, seawave height and direction; supervision of oil drilling operations at sea; protection of UK forces abroad with tactical HF radars.

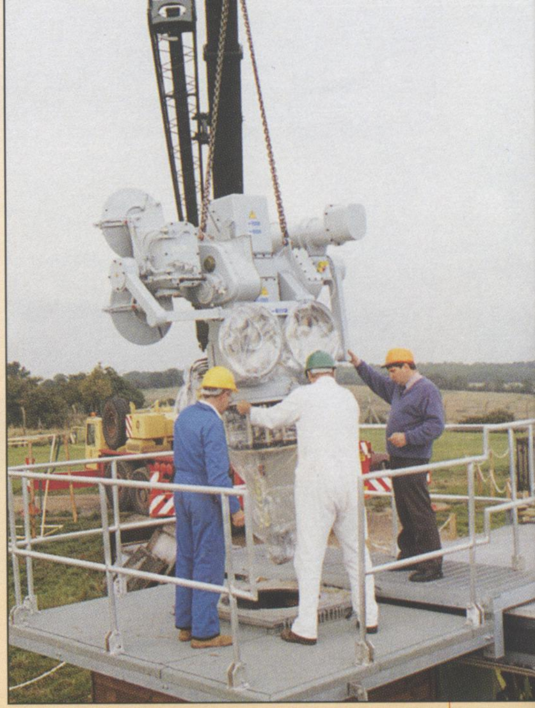
Sir Eric Eastwood was with us to encourage our aspirations 25 years ago; we have not failed him and we shall expand our HF radar business from the new workplace that bears his name.



*LEFT: Jindalee antenna at Alice Springs.*

*INSET LEFT: The Dengie HF radar.*

# Customer support



When our new company came into being in 1969, the radar support operation remained under the wing of Marconi's Central Division. On the retirement of the Division's manager, the legendary P.J. Donnelly, many months were spent deliberating on the way ahead: should the Division remain intact, as an independent, self accounting business? Should it continue as an independent business but release its profits to the appropriate new management companies — i.e. ourselves and Marconi Communications Systems? Should it be split between them? In the event the last-named course was taken.

Initially, the key functions of spares and repairs, technical information and technical services were located variously in Waterhouse Lane and Baddow but in 1976 they came together at Writtle Road, where they were joined by Field Services who had functioned as the Operations Group of the former Marconi Radar Division. Writtle Road remained the centre of our support organisation until, but a short while ago, it moved to ***Elettra House***.

**Spares and Repairs**

Over the years the spares and repairs business has changed dramatically: from supplying components we have advanced to supplying printed circuit boards and major sub-assemblies — generally referred to these days as LRUs (line replacement units).

The repair workshop — the first section to take up residence at Writtle Road, having moved from the 'Jam Factory' in Waterhouse Lane — has witnessed a tremendous increase of business over the years as GWS25 *Seawolf*, S600, UKADGE and *Martello* systems entered service.

An MoD Type 88/89 *Green Ginger* system, damaged in Germany; the S600 transmitters that were dropped during loading at Stansted Airport; the MoD Type 96 (S659 ) at Saxa Vord, which was severely damaged in gales exceeding 100 mph — all came our way for major repair.

Possibly the most demanding periods, and ones of which we are justly proud, were those covering the Falklands and Gulf campaigns, when we satisfied all the requirements placed on us — a task that imposed a 24-hour, 7-day working week on our workforce. During the Falklands conflict RAF staff were seconded to assist in packing containers with equipment and personal effects for the troops, and we built up a never-to-be-forgotten personal relationship with them.

**Technical Information**

The technical information facility has developed to a point where it can be classed as a centre of excellence. From the days of the manual typewriter we have moved with changing technology and now exploit sophisticated computer systems to fulfil our commitments.

We introduced desk top publishing, which, with electronic colour illustrations, constitutes a quantum leap in the quality of our handbooks.

Our authors too have been affected by operational changes and these days carry out a multi-skilled function.

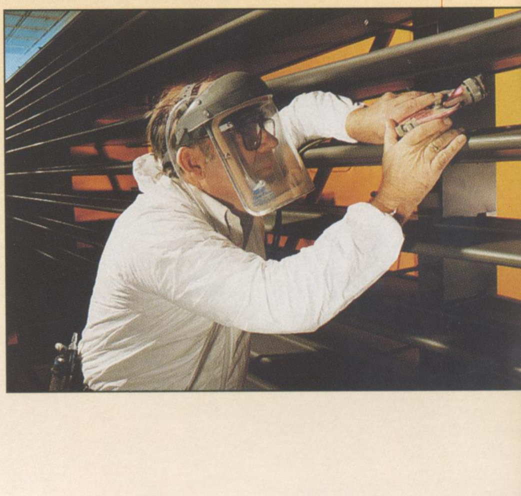
Not only does our technical information facility provide an internal service but it is also involved in direct business and sub-contracts, an example being the *Tornado* programme for GEC Avionics.

**Technical Services**

As with all our customer support operations, we have developed our technical services appreciably during the last 25 years.

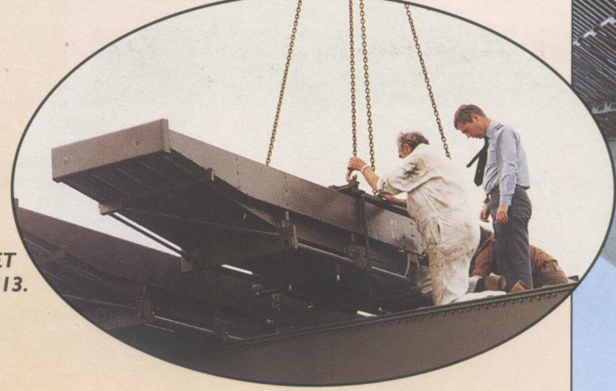
Customer requirements, from single items to multiple, complex systems,

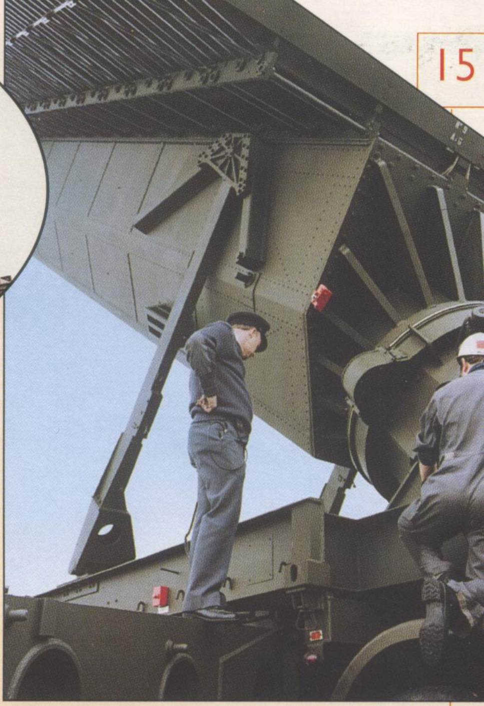
*LEFT: A Seawolf tracker type 910.*



*RIGHT: Paint spraying.*

LEFT: Prototype 1802SW at Bushy Hill





RIGHT AND INSET RIGHT: Martello S713.

are met at design level by a well-qualified, highly experienced team, whose expertise encompasses tracking and surveillance radars; secondary surveillance radars; display and data handling systems; electro-optics, including autotrack television and infrared sensors; mechanical structures; hydraulics; servos and computing.

We also develop software to meet specific needs, and provide world-wide diagnostic support for operational systems.

We survey, modify, refurbish, refit and repair both civil and military radars.

The front-line support we provided during the Falklands and Gulf conflicts takes a proud place in our annals. A more recent achievement that claims a place in our history was when our expertise in HF radars was exploited to predict sea surface movement following serious oil spillage from a wrecked tanker.

**Field Services**

Twenty-five years ago in 1969, our Field Services staff were deployed across a huge range of sites. In the UK they stretched from Hope Cove in Devon to Saxa Vord in the Shetlands. Mostly the staff working in this country were engaged on the east coast sites at Neatishead, Staxton Wold and Boulmer, while a large contingent were at West Drayton. GWS25 was then in its early stages.

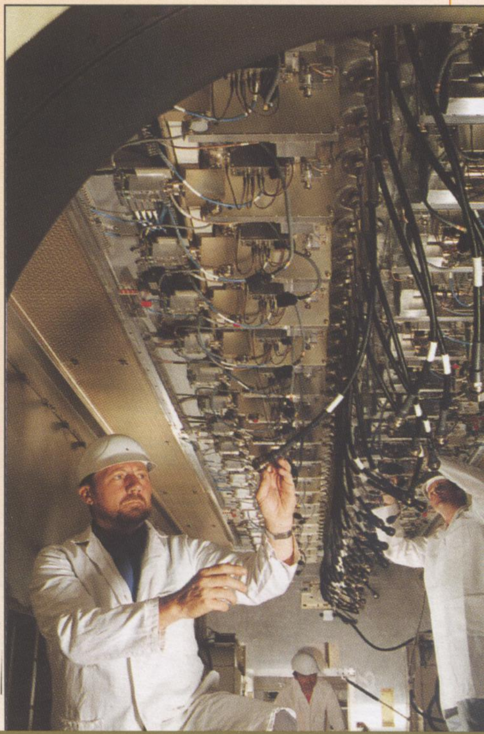
Overseas activities extended across Western Europe and the Middle East to Singapore, Australia and New Zealand. The Saudi Arabia defence system alone was occupying about 50 people.

To list all the sites would be a formidable task, since that year Field Services were also in Iran, Turkey, Greece, Italy, Kenya, Norway, West Germany, South Africa and Australia. Most of these countries, plus others that have been added to the list, are still being visited and in some, residential maintenance staff are employed.

A major involvement in later years has been the ship installation of the GWS25 *Seawolf* system. A Field Services specialist team was selected, which, starting as a customer liaison group, has developed into a strong sales and marketing team, responsible for our support business.

The years have seen a dedicated effort to expand the traditional support business by promoting, for example, equipment improvements, enhancements, mid-life updates and new ventures such as flight plan processing systems, workshops and, currently, contractorisation. It has not been an easy road to follow but sheer hard work and determination have borne fruit, as exemplified by contracts in Turkey and Saudi Arabia for mid-life updates and enhancements and in Oman for contractorisation in respect of *Rapier* weapon and *Martello* systems.

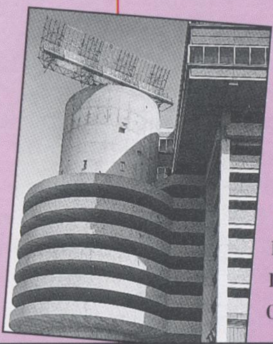
The 25 years that we are celebrating have undoubtedly witnessed significant advances in our support activities, which have always figured largely in our successful operations — indeed some equipment supplied before Marconi Radar's independence is still being supported!

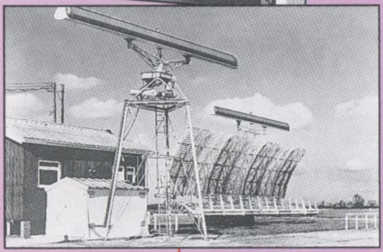


RIGHT: Inside the spine of Martello 743D

# Safety in the air

In the decade before the formation of Marconi Radar Systems, The Marconi Company was a major force in the ATC market. It was unique in its expertise in the design and operation of radars working at the long wavelength of 50cm, which provided accurate position information on aircraft, despite heavy competing rain and clutter signals. Avoiding the need for a tall, strong antenna support tower also made for cheaper and easier installation.





Being Corporate Members of the UK Guild of Air Traffic Controllers and the International Federation of Air Traffic Control Associations kept us closely in touch with air traffic controllers' needs and ways of working, and led to a recognition that the radar was only a part — albeit a large one —- of a total requirement, embracing navigation aids and operator working environments. This in turn resulted in our total system approach.

**CHANGE AND GROWTH**

The 1970s unfolded a number of significant factors that led us to develop new products. Prominent among these factors were:

**a)** More and more of the 600MHz (50cm) band of frequencies available for radar was being allocated for the sole use of broadcasting.

**b)** The superior performance of 50cm radar was gradually being matched by systems operating at 23cm and 10cm — the result of much improved transmitters, with very high stability, and highly reliable signal processors of increasing performance.

Consequently, in the early 70s we completed development of a new 23cm radar system, the S654, which incorporated the world's first double-curvature two-beam antenna, especially designed for ATC.

We also exploited the small size, reliability and flexibility of the latest transistor technology to produce signal processing that gave the S654 the same excellent performance as its 50cm equivalents, but with the added advantage of a narrow beam to assist controllers in discriminating two aircraft flying in close proximity.


In parallel with primary radar development, the ATC world was increasingly looking to secondary surveillance radar (SSR) as a more sophisticated air traffic control tool, because it gives not only aircraft position but also the aircraft's coded identity and altitude. Thus the controller has, effectively, three-dimensional data on known aircraft. We responded to this new emphasis by producing the S464 - a much cheaper and more modern system than the SSR developed by Marconi's in the early 60s.

The combined effectiveness of the S654 and S464, together with our powerful expertise in system design and project management, resulted in our winning one of the biggest contracts of the day for a country-wide ATC System in Saudi Arabia. The sale of these systems into Germany and Canada bore testimony to their excellence as pan-climatic designs.

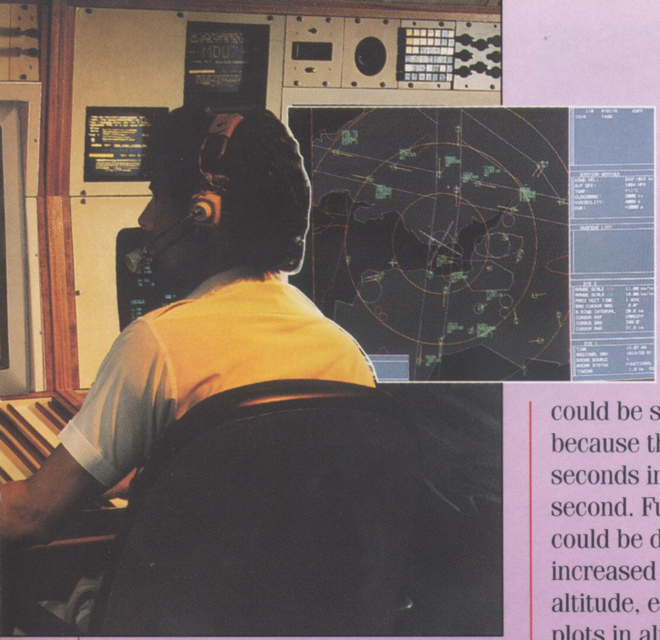
**DATA HANDLING AND DISPLAY**

In the early '70s the flight plan processing system (FPPS) at the

*ABOVE, LEFT (top) S264 at Heathrow Airport and (bottom) S264 with* **Challenger** *antennas.*

*LEFT:* **Surveyor** *(S511 airfield surveillance radar) and* **Messenger** *antenna.*

*ABOVE CENTRE:* **Mainstay** *en route air traffic control radar.*



LEFT: *The Civil Aviation Authority's evaluation unit at Hurn Airport and, inset, a display of data from the S511 radar at Cardiff Airport.*

London Air Traffic Control Centre was brought into service. Using three Marconi *Myriad* computers operating in parallel, it produced and up-dated all the flight plans and flight progress strips for the busy airspace of the UK's southern area. The use of three computers ensured extremely high reliability. The system was de-commissioned in 1991, after over 17 years of continuous service.

*Myriad* was the world's fastest, real-time computer on the market at its inception. Subsequent updates led to the highly successful *Locus* architecture, using the highway principle of interconnecting a multiplicity of processors — a precursor of today's ethernet. Because of the flexibility of the *Locus* architecture it was able to exploit over 150 different plug-in processors, allowing computer and data processing systems of great complexity to be implemented.

Displays of many types were developed, the accent being on improving operator facilities. Direct view storage tube displays allowed the ephemeral real-time signals to be stored and viewed in full daylight conditions. Advances in signal processing enabled the radar signals' position to be measured and stored ('plot extraction'). Thus, radar pictures could be sent over telephone lines, because the data now lasted for many seconds instead of only millionths of a second. Furthermore, radar displays could be designed that enabled much-increased amounts of data (identity, altitude, etc) to be written alongside plots in alpha-numeric characters.

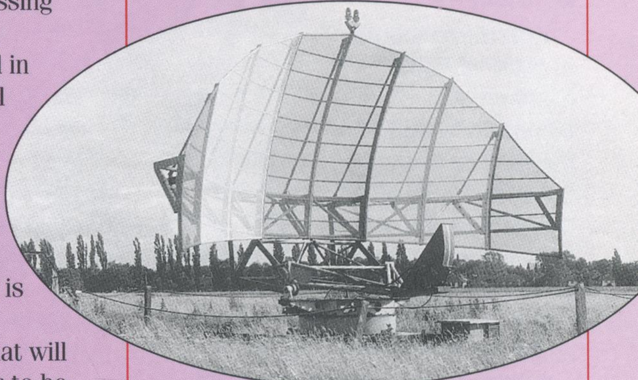
The *Locus* architecture allowed for the first time a low-cost computer to be associated with each display, thereby distributing the processing and increasing overall system availability. This is exemplified in the Scottish Air Traffic Control System (ScATCC) where, for over 15 years, over 30 *Locus* computers and displays have been in use without an operational system failure. A further upgrade to the system is now under way to provide additional radar processing that will allow conflicting aircraft paths to be identified to the controller, well in time to allow safe avoiding action to be initiated. This will allow the ScATCC system to continue its safe operation into the next century.

In recent times, we developed and switched to the MITRE data processing architecture, which is able to utilise readily available commercial off-the-shelf (COTS) components.

**MODERNISING THE RADARS**

In the late 70s it became clear that a market existed for a smaller-scale primary radar and a companion long-range SSR of improved performance. Together these would meet most ATC requirements — the universal carriage of SSR transponders by air traffic giving long-range 3-D data, and shorter ranges, 60 nmiles down to touch-down, being covered by primary radar, which, with modern signal processing, would out-perform its predecessors.

With this in mind, in the early '80s we produced the S511 airfield surveillance radar (ASR), which has since been in world-wide service, from Bombay to Northern Canada.



In 1985 we produced the Marconi *Messenger* monopulse SSR. It broke new ground in its engineering form and established new benchmarks in accuracy and the ability to unscramble garbled messages.

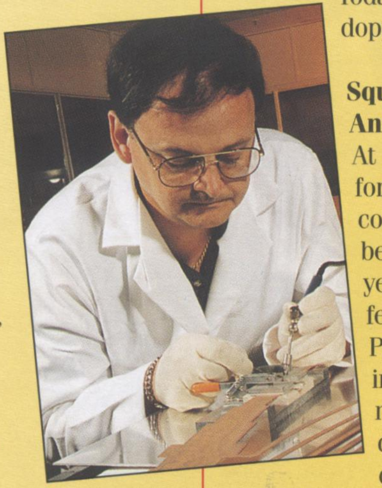
The S511 primary radar is a system of great simplicity — easy to understand, reliable and having high performance. The latest version, the S511H *Surveyor,* incorporates a very long-life transmitter tube with a stability that matches its more complex rivals. The S511 and its SSR companion form the heart of the ATC system installed at Jordan's Queen Alia Airport in 1985. Our most recent successes have been the sale of the S511H and *Messenger* into Poland and Africa.

ABOVE: *S232 at Farnborough.*

LEFT: *Air traffic control at RNAS Yeovilton (HMS Heron).*

# Going for gold

The GEC-Marconi Research Centre at Great Baddow is one of Europe's largest research organisations. Among its many laboratories, each one dedicated to a specific area of activity, is the Radar Research Laboratory, the source of innovative techniques that have influenced the course of radar throughout the world.



With the formation of Marconi Radar Systems, the laboratory's workbase, formerly designed to serve the interests of the Marconi Radar Division, broadened to include the whole spectrum of activities embraced by the new company.

Dominant among the subjects to which it has addressed itself during the past two-and-a-half decades are:

**Doppler Radar**

By 1969 a great deal of work had already been carried out on doppler radar as part of a programme on point defence for the Royal Navy ships. This continued into the early 70s and resulted in the *Seawolf* 967 D-band surveillance radar, and 910 and 911 tracking radars.

The 967 provided clutter improvement ratios of 90-100 dB, which were the world's best at that time. Since then, the technique has been modified to achieve better frequency-agility, and to take advantage of the improved signal processing that is available with current computing devices.

Today we lead the field in doppler signal processing.

**Squintless Feed Antennas**

At the time of the formation of the new company, research had been in train for some years into the squintless feed principle. Progressive improvements were made possible by the development of computer analysis and synthesis programmes until, by the early 1980s, ultra-low sidelobe waveguide antennas could be designed by computer, drawn, and milled under computer control to provide within-specification performance.

The squintless feed techniques developed by the lab received their final seal of approval when they were applied in the antennas of the highly successful S600 series radars, and their inclusion in the antenna for the Royal Navy STIR radar enabled us to win this contract in the face of severe competition.

The techniques were further developed and extended to cover stripline networks and are the basis of the design of all the *Martello* arrays and of the current LANZA antenna.

**Tracking Radars**

As with doppler surveillance radar, it was the Royal Navy's requirement for ship defence that triggered the lab's work on tracker radars, resulting in an expertise that is reflected in our *Seawolf* 910 and 911 X-band trackers, and the ST 1802 and ST 1803 radars.

The 910 tracker provided state-of-the-art differential tracking accuracies for the *Seawolf* MoD 0 equipments. To achieve this performance, new ground was broken in the design and evaluation of antenna components, such as twist reflector antennas, waveguide comparators and overmoded feed horns, and in signal processing techniques for low-angle tracking (electronic angle tracking).

We then developed the lighter, cheaper, frequency-agile radars, the 911 and then the ST 1802 and ST 1803, which form part of today's product range.

**Bistatic Radar**

During the 1970s the MoD and Marconi Radar Systems funded research to provide the receive station for a bistatic radar, with a view to setting up a chain of transmit and receive stations around the UK coastline to detect enemy aircraft. The aim was to protect the expensive, non-radiating, covert receive stations from enemy attack, and to make lower-cost transmit stations with a number of back-up stations that could be switched on when required.

This led to the highly successful BEARS (bistatic experimental antenna receive system) demonstrator, which was the vehicle for demonstrating not only


***ABOVE, LEFT:*** *Working on stripline antennas.*

***ABOVE, CENTRE:*** *Experimental planar array device.*

***LEFT:*** *S511 antenna in the anechoic chamber.*

LEFT: Experimental HF antenna.

LEFT: Near-field test site and (below) the antenna tower at Rivenhall.

bistatic radar operation, passive detection and signal processing but also techniques for more general application such as IF and digital beamforming.

Subsequently, military tactics changed in favour of highly mobile radars in order to increase survivability against enemy attack. However, much of the work carried out on bistatic radar principles has now been applied to our HF radar systems.

**IF and Baseline Beamforming**

In the mid-1970s the Radar Research Lab invented and undertook the successful design and manufacture of the resistive matrix that provides the IF beamformer for the elevation beams in the *Martello* family of radars. It extended the technique to higher IF frequencies: a 60MHz beamformer was used in the BEARS demonstrator at the GEC-Marconi Research Centre.

During this period, a digital beamformer, using a novel IF-to-baseband down-conversion technique was also produced and evaluated on the BEARS demonstrator.

These latter techniques have not yet been exploited in our products.

**HF Radar**

During the mid 70s the Radar Research Lab carried out a feasibility study into the use of land- and ship-based HF radar to detect aircraft that were below the horizon of microwave radars.

The key innovations, introduced during this and later studies, funded by ourselves and HM Government, led to the production of the *Heartbreak* HF radar demonstrator.

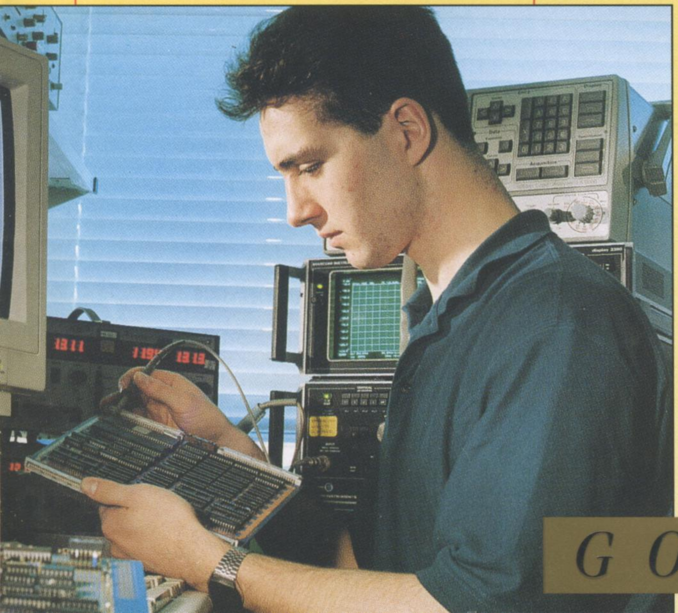
This key work and our continuing funding of HF radar research gave us the credibility and capability to bid for and win our current pivotal role in the JORN contract for Skywave HF radar in Australia. It is also reflected in our current work on a family of land-based Surfacewave HF radars for aircraft, ship and surface current detections, which have an important civil application in the surveillance of Economic Exclusion Zones to protect fishing and other natural resources in nationally owned waters.

**Phased Arrays**

Marconi Radar funded research into phased array antennas over a number of years during the 1970s and 80s and established the Baddow Research Labs as leaders in the field. The design of antenna radiators, taking full account of the mutual coupling which occurs between the closely spaced radiators in an antenna aperture, can now be extensively supported by validated computer software. This capability has also been extended to the waveguide and stripline networks that feed the radiators so that coupling via these feeding networks can be taken into account. The control of mutual coupling is the key to achieving good sidelobe control in the antenna radiation patterns. This capability enabled us to define and demonstrate key elements of an X-band phased array (S1805) aimed at providing an improved capability for the *Seawolf* ship defence system. Although the project was terminated, it was a prime factor enabling us to enter into collaboration on the European multifunction phased array radar, EMPAR, and many of the design principles incorporated in the EMPAR antenna resulted from our early research.

This research also underpinned the development of the *Martello* antenna, particularly for the generation of the set of overlapping elevation beams, and more recently of LANZA, which scans a beam over the elevation surveillance sector.

The phased array capability at the Baddow Laboratories is also supporting the GEC-Avionics research into airborne multimode solid state active array radar (AMSAR) for future airborne active phased arrays — work that will augment our own continuing research into both antenna systems at the Baddow Labs and basic GaAs technology and "chip-sets" at the GEC-Marconi Materials Technology labs at Caswell. The work at Caswell will provide active transmit/receive modules over a wide range of frequencies and lays down the capability for a range of future hi-tech, cost effective products for Marconi Radar. ➡



LEFT: At work at the GEC-Marconi Research Centre.

# Going for gold

**➡ THE FUTURE**
Clearly, our future depends on our ability to anticipate and meet our customers' future requirements, which include a better surveillance capability at a cost similar to today's, faster reaction time from our weapon control radars, and improved reliability with reduced life-cycle costs.

To meet such requirements, continuing research is being carried out into signal processing architecture and algorithms including, for example:

Non-cooperative target recognition;
Agile beam radars using solid state transmit/receive modules within the antenna aperture;
More extensive and capable sub-system emulation software, including models of the radar environment.

We are fortunate in that not only are our plans for the future firmly supported by well-directed research in our own laboratory, but also we shall reap the benefits of the research activities of our sister companies within GEC, as they too look to the future. For example, solid-state transmit/receive modules, being researched for satellite and airborne radar application, are of great interest to us too. Our ground radars will benefit when ways and means have been found to reduce the weight, size and power consumption of satellite and airborne equipment. Research into virtual reality could well lead to improvements in man-machine interfaces in our radar systems. Improvements in optical components in communications will enable us to make wider use of low-cost optical data highways in our radars.

We shall also look for applications for technologies being researched that are not obviously related to any specific areas in our business but that will help to give us the technological or cost advantage that wins us the future market.

These elements of uncertainty add excitement, greater challenge and increased opportunities in our determination to ***Go for Gold***.

*Eastwood House...It is apposite that in the year marking the twenty-fifth anniversary of the formation of Marconi Radar Systems we should move into our brand-new, architect-designed headquarters, named after the radar pioneer Sir Eric Eastwood.*

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