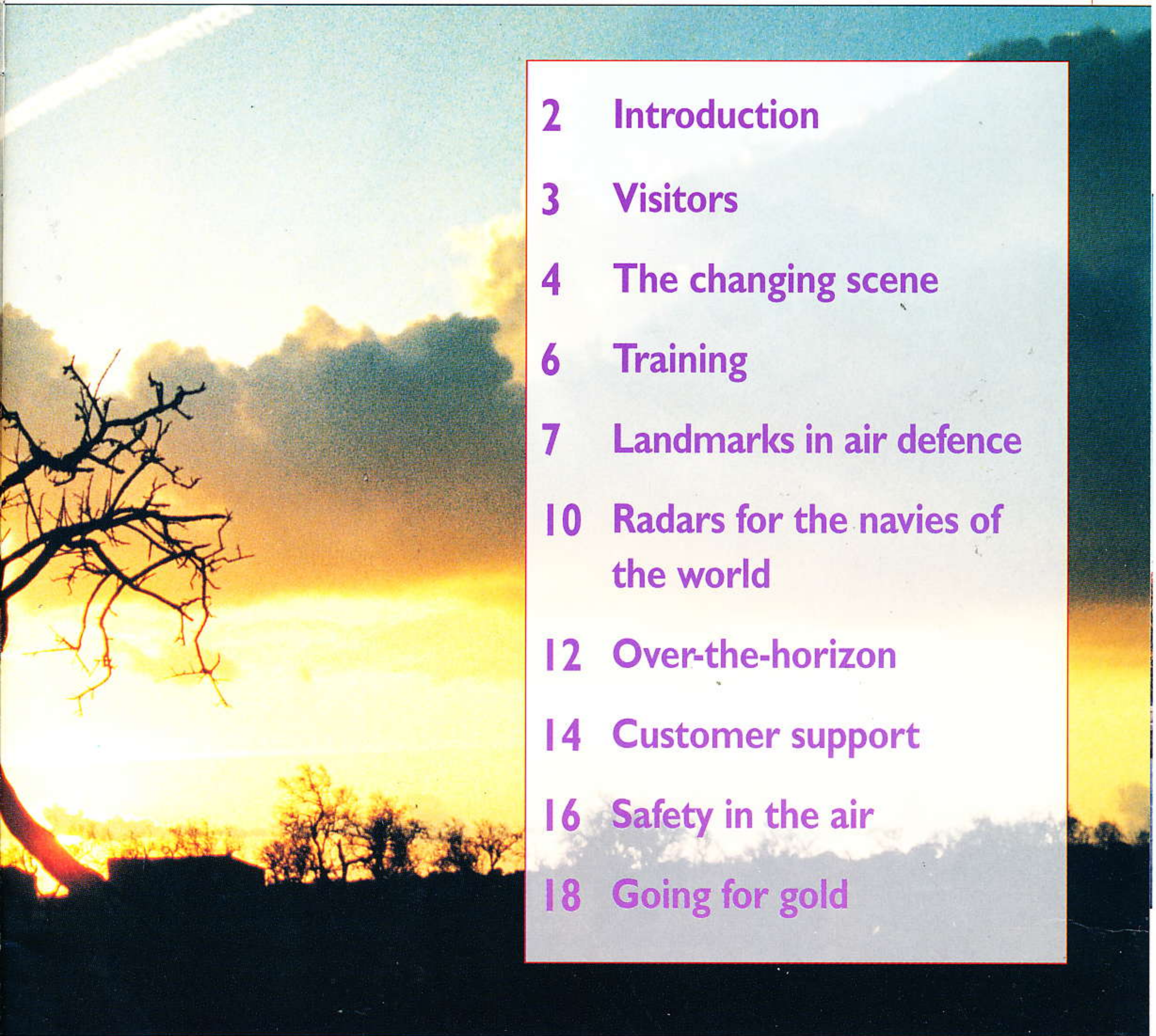
SILVER JUBILEE

Marconi
Radar Systems

GOING FOR GOLD

contents



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Introduction

1969 signalled a milestone in the history of three of the most powerful radar organisations in the UK. That year, following the merger of GEC and English Electric, Marconi Radar Systems Limited was formed, bringing together the elements within both GEC and EE that were engaged in ground radar: the Radar Division of the Marconi Company, the Airspace Control Division of Elliott Space and Weapon Automation and AEI's Naval Aerospace and Defence Division. The new company, under the leadership of managing director John W Sutherland, provided a total capability in ground air defence, shipborne defence and air traffic control radar.

Although the launching of Marconi Radar Systems hit the headlines in the trade press, it was not so much a revolution as a natural but significant stage in the evolution of its constituent parts.

Because of the bricks from which it was built, the new company could claim an association with radar that began long before radar emerged from the laboratory benches to take its place as a major contributor to victory in the Second World War: its experience could not be surpassed.

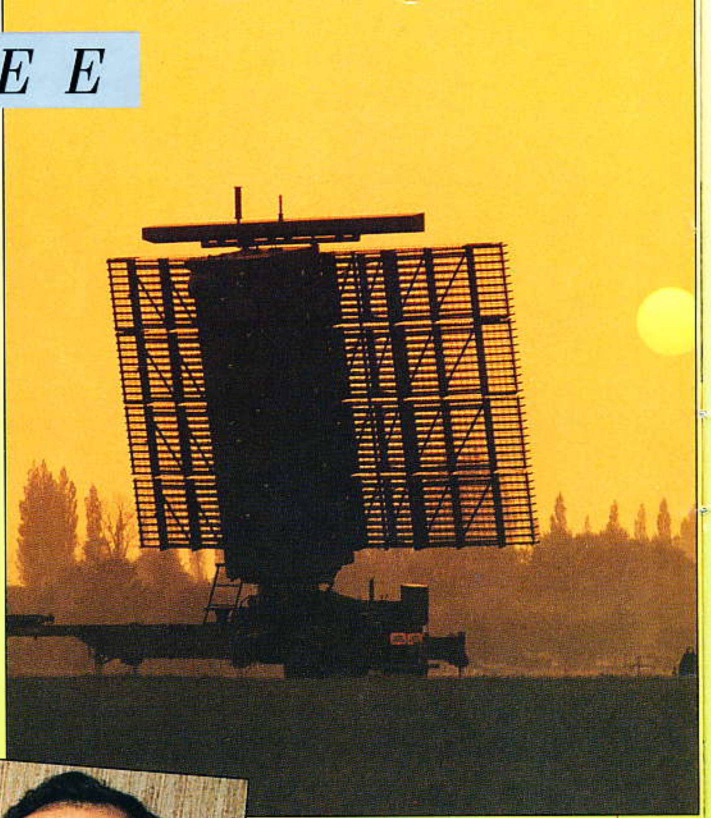
Because it emerged on the scene fully staffed by dedicated teams of men and women, many of them internationally recognised as leading authorities in scientific and engineering fields, its expertise could not be challenged.

Because of the combined reputation of its constituent parts it was assured of a place at the leading edge of the radar world. And last but by no means least, it was starting life with an order book worth £70,000,000!

Welding together three formerly independent — and sometimes competing — organisations took time. But geographical difficulties were overcome, overlapping activities rationalised and Marconi Radar embarked on the future with confidence.

In the 25 years that have passed between 1969 and the present day, there have been changes in personnel, locations, organisational structure and market focus, mostly inspired by the need to meet new challenges in technology, greater and more informed requirements from customers, a shrinking market, increasingly fierce competition and the effects of a long-lasting, world-wide recession. The ability to adapt to changing circumstances is essential not only to success but also to survival.

A history of those 25 years is beyond the scope of this booklet: that can be left to the archivists. Here we attempt no more than a brief broadbrush picture to mark and celebrate our Silver Jubilee, and to broadcast the message, **"Now go for Gold."**



ABOVE: Martello, winner of the Queen's Award to Industry for outstanding technological achievement, 1986.

INSET LEFT: Managing director, Roger Mathias.

RIGHT: S600 radar convoy at Bushy Hill test site.

INSET ABOVE: Founder managing director, John W Sutherland.

Visitors

In 25 years, we have played host to thousands of visitors to our headquarters, demonstration sites and exhibitions.

No one would pretend that the bricks, mortar and portakabins of Writtle Road helped us to project ourselves in our true light — as leaders in high technology and a formidable force to be reckoned with in the radar world. But what went on within those walls attracted reigning monarchs, heads of state, government ministers, commanders-in-chief of the armed forces and many other important visitors.

Now, 25 years on, we look forward to receiving our illustrious guests in the impressive environs of our new headquarters.

***TOP:* HRH The Prince Michael of Kent.**

***ABOVE:* The Rt Hon Michael Heseltine, PC, MP.**

***ABOVE, RIGHT:* Managing director of GEC, Lord Weinstock.**

***RIGHT:* Admiral Sir Anthony Griffin, GCB, Controller of the Navy at the time of his visit.**

***LEFT:* HRH The Duke of Edinburgh.**

***BELOW, LEFT:* HRH The Prince of Wales.**

***BELOW, RIGHT:* Rear Admiral Dato Khalid, deputy chief of the Royal Malaysian Navy, our first important visitor to Eastwood House.**

***BOTTOM:* The Marchese Maria Cristina Marconi and The Princess Elettra Giovanelli Marconi.**

The changing scene...

Of our staff of 1,300, 150 have been with us since Marconi Radar Systems was formed. Four of them look back on the changing scene.

ALAN CUSHING

In 1969 I was part of the System Development group, designing and implementing air defence systems. Although my role is the same today, techniques and equipment have changed.

In 1973, *Linesman*, which updated the UK air defences, was handed over: the remainder of the 70s was devoted to modifying the initial design.

The original concept was to base all operational facilities at West Drayton. Later it was decided that the radar sites should also have some operational facilities. Money was short, and at Staxton Wold we were asked to provide adequate facilities with virtually no money at all. We therefore cobbled together a display facility from surplus equipment as a temporary measure that lasted into the early 90s!

In the late 70s the equipment at Watton and North Luffenham became part of military air traffic control, and we were asked to improve the stability of the old valved displays. But we finished up replacing all the displays and the back-up with transistorised equipment!

Also in the 70s, the company, along with US General Electric and Plessey, was responsible for the next generation of radars for the UK defences: it also formed a consortium with Hughes and Plessey to supply the display complexes. We were given a small contract to prepare the sites for, and then look after, the integration of the new radars and displays. However, due to slippages of the radar programmes, we were asked to modify the existing radars to provide an input to the new, non-compatible display system. Just as production was about to start on the modifications it was revealed that the programme for the new displays was also slipping, so a new task arose to integrate the new radars with the existing non-compatible displays!

Changes? Yes, lots of them over the years, mostly concerning customer requirements to meet changing conditions.

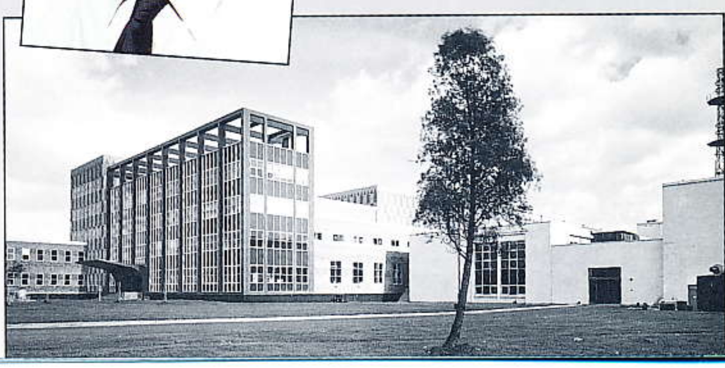
JOHN PARR

When Marconi Radar was formed I was a section leader working on the contract for the RAF *Linesman* control complex at West Drayton. September 1969 heralded the beginning of a period of change of occupation for me, from that of systems engineer at Baddow to publicity work.

The new company embodied GEC's recently acquired radar interests, which included the ex-AEI establishments in Leicester. A management team, headed by Peter Way, was despatched up the M1 to Leicester. One of that team was Max Stothard — my boss since 1957. Because of my involvement in project management systems he asked me to join him to head a small project management support team.

Part of our function was to produce management reports of high visual, as well as technical, quality. In the process of tarting-up these documents we became involved in all forms of presentation media, and I became the local "expert". Over the years the need for a separate support section waned as each project team began to use the special control techniques for itself, but by then I had become almost fully involved in presentation systems. Print, brochures, in-house newspapers, 35mm and overhead slides, film and all their complexities became second nature to me. So in 1974, after 17 years with Max, I left him and moved into sales and marketing. This team operated as Leicester's publicity department until the 1976 management rationalisation when I was shipped back down the M1 to become the company's chief publicity officer and subsequently publicity manager.

So in these 25 years I have made a complete switch in occupation, but my peers still speak to me!



BRIAN PARTRIDGE

Over the last 25 years I've seen enormous advances in computers and many changes in industrial working practices as their use spread. In 1969, one of our products was the *Myriad* real-time, high-capacity computer, which we brought into our own workplaces, where we had formerly used hand calculators and the Baddow main frame.

Some interesting leading-edge technology arose from its use, not least when we coupled a simulator with the automatic test programs that we were running on *Myriad* to test digital PCBs.

In the 1980s we were still relying mainly on the main frame computer for mathematical analysis. However, desk calculators were becoming increasingly sophisticated and included programming facilities and complex mathematical functions. From these, the desktop computer was developed — changing our lives at a stroke !

We were fortunate when Marconi Radar took the enlightened decision to provide its staff with a low-cost way of owning a BBC micro. Furthermore, it purchased a number of them for the engineering departments.

The desktop revolution enabled us to use computers for all sorts of routine processes. But a milestone was reached in 1982 when we, along with GEC Computers and Marconi Research, developed printed circuits design software, which ran on the GPT 4,000 computer and marked the first major step in design automation.

In 1988 we started investment in bought-in computer-aided design facilities, which have been continually extended to cover all engineering disciplines. Our achievements in the early days were ahead of current thinking but I feel they were never fully exploited outside GEC.

KATH ROBERTS

When I joined Marconi in 1967 as a copying assistant in the Reprographics Group, the state-of-the-art equipment was Roneo and Banda, manually operated. High on Banda spirit and with muscles like an all-in-wrestler, I progressed to running the off-set litho section.

Opportunity came to join TID, and I embarked on a long and varied career in Publications, cutting m,y teeth on the very large NATO Air Defence Ground Environment contract.

The then Department bosses had the radical idea that women could do the same work as men. This, at a time when women were separately graded, proved to be very unpopular with the resident males, but that is another story.

We had all the high-tech equipment you could wish for: manual typewriters, scissors, paste ... that sort of thing. Producing a manual took forever. Corrections/changes had to be pasted onto the camera copy, some of which would peel off during printing; drawings were produced by hand; printing was usually done by the Marconi Printing Department and delivery could take up to 10 months; so many people tasked, and sometimes not knowing why or what happened next.

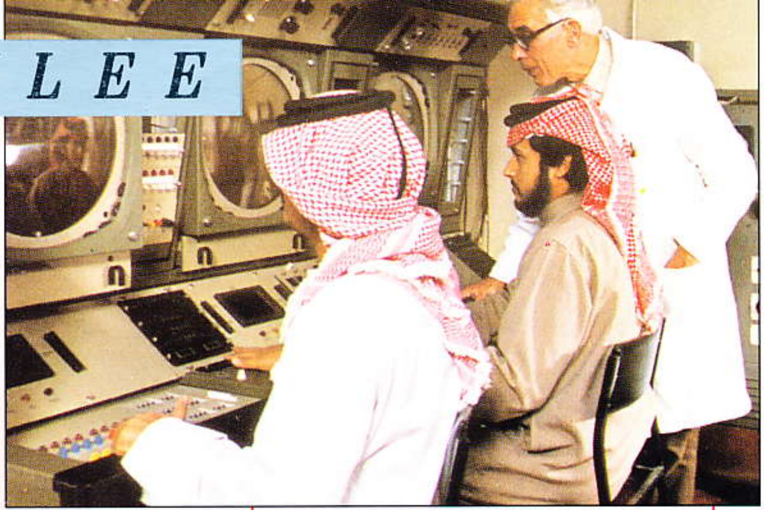
I went on to run the Production Unit, which later included the IBM Typesetter Unit, and then became part of the team evaluating the first dedicated wordprocessor (Wordplex).

We installed the company's first desk-top publisher. Then came personal computers, Volkswriter, Venture and currently, Wordperfect, together with various graphics packages, databases, scanners and OCR.

Twenty-seven years on, I'm still with TID, now a senior project controller, designing departmental databases, co-ordinating resources, controlling budgets and producing estimates.

Much has changed. We have all become multi-skilled. There are fewer of us but we now have the opportunity to get involved with everything. Particularly things have changed for women. Yes, I still hear the odd remarks about Old Dragons but they can't mean me — can they ?

Training



The face of training has changed considerably over the past 25 years at Marconi Radar. There has been a move away from apprentice training to an emphasis on updating and developing the skills of the existing staff to meet the needs of an ever changing and more demanding technical and business environment.

In 1969 apprentice training was organised by The Marconi Company with something like 500-600 on the books at any one time. In those days an apprenticeship lasted for five years with people being taken on at 16 and gaining their indenture at 21. The time was spent in the Marconi Training Centre, lovingly referred to by apprentices as The Pit, at New Street, where skills such as instrument making, sheet metal working and lathe operating were taught under the watchful eye of Jack Carr. Trainee draughtsmen attended the DO School in the more grandiose setting of Springfield Hall. Time was also spent at college — Dovedale's or Braintree — and doing work-based placements around this company and other GEC-Marconi units in Essex to gain practical experience.

During the 1970s the situation changed with the establishment of a training centre at Writtle Road. This initially provided manufacturing training through a three-year craft apprenticeship, and developed into the wider provision of technician apprenticeships, both mechanical and electrical, and a clerical training scheme. There was also student sponsorship and graduate training, involving project work and placements around the company for the new graduates to learn the company organisation. In the 1970s and early-

to mid-1980s the training centre always had about 280-300 trainees on the books, with an intake of approximately 80 a year!

During this period we ran a number of conversion courses. These converted the skills of existing staff from, for example, craft-skilled to draughtsman, and planners to estimators. Management and skill development training was provided at Marconi College, which continues to this day to provide technical training for our staff.

Over the past ten years the situation has altered drastically, with the number of apprentices and graduates falling to 15 a year by the early 1990s. The reduction in the numbers reflects our changing business circumstances and the fact that we now sub-contract our manufacturing to Leicester.

Greater emphasis is now placed on the development of core skills required by staff, and the use of external bodies to help achieve this end. Training is carried out in-house, either by external agencies running customised courses to meet our needs or by the Training Department. Current major training initiatives include the First Line Management programme, the Project Management programme at Dunchurch, the Managing People programme, Risk Assessment and the Graduate Development programme.

When talking of training, we cannot omit the important supporting role played by Marconi College when it comes to listing our capability to our customers. In close liaison with ourselves, the College plans and implements intensive courses for our customers' engineers anywhere in the world on our own and other manufacturers' equipments and systems.

TOP: Customer personnel in training at Chelmsford.

CENTRE: Apprentices with the replica they have made of an early spark-gap transmitter.

LEFT: Apprentices raise money for **Children in Need.**

Landmarks in air defence

In 1969, the three organisations that formed Marconi Radar were committed to major air defence programmes.

Marconi was supplying long-range surveillance radars for the RAF and providing the tactical surveillance and height finding radars for the army *Thunderbird* surface-to-air missile batteries. Long-range surveillance radar and heightfinders were being delivered to NATO countries as part of the NATO Air Defence Ground Environment system (NADGE). Other export ventures kept Marconi engineers busy in four continents.

● continued overleaf →

Landmarks in air defence

AEI were providing the UK defences with high power stacked beam 3-D radars, whose smaller brother was going to the Saudi Arabian Ground Environment, where the signals were displayed in centres designed and equipped by Marconi.

The Elliott Airspace Control Division had contracts with the RAF to supply computers and software for interception control and SAM allocation at overseas bases. They also produced simulation packages for the RAF and NADGE.

The new company was thus assured of a strong base, especially as development of a new range of equipment, the S600 series, was already well advanced.

S600 SERIES

At that time, the rapid deployment of forces was becoming an operational requirement, and the S600 series was designed as a family of compatible modules that could be put together in various combinations to meet almost any air defence or air traffic control requirement. All were readily transportable by helicopter, transport aircraft or by towing with light vehicles.

This concept proved popular and over 30 systems were supplied to Malaysia, Turkey, Kenya, Yugoslavia, Saudi Arabia, Jordan, Abu Dhabi, and Oman. Similar equipment was deployed by the RAF during the Falklands campaign. Thus, the S600 series was severely tested in pan-climatic conditions. Other modules were supplied to Norway, Canada and the UK Civil Aviation Authority.

S700 SERIES

Martello — By the mid-70s, advances in the electronic counter measures armoury of hostile aircraft, coupled with the ability to accurately locate and target sensors with air-to-ground radar attack missiles, called for new ideas in designing air surveillance radar. Our answer was the 3-D radar known as the S700 series *Martello*, which is currently in service in NATO, the Middle East and Asia.

Martello is now in its third generation, having taken advantage of technological developments over the past 15 years to progressively improve its performance.

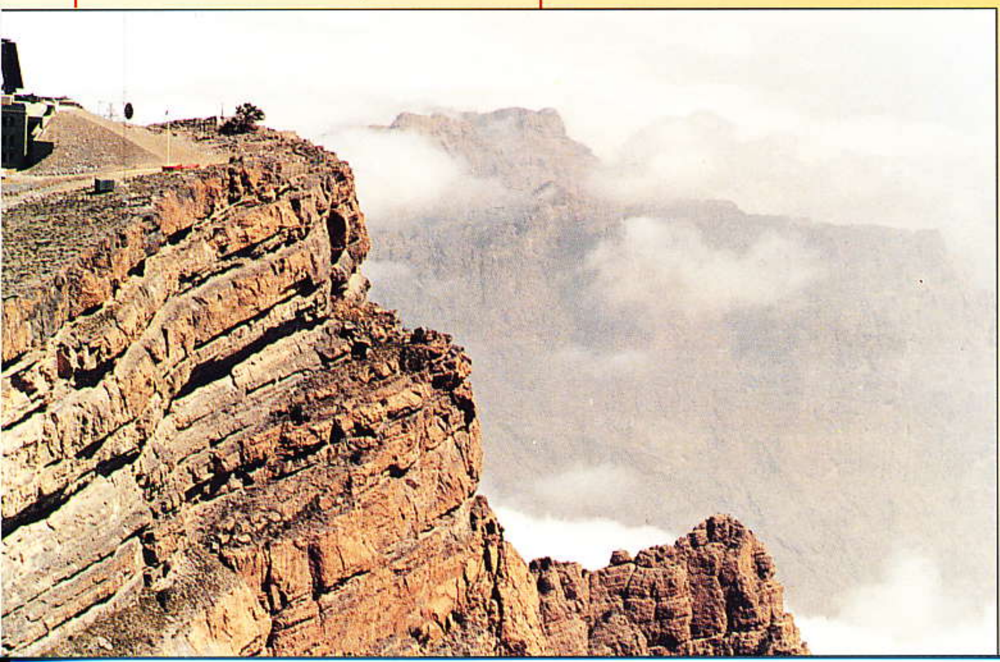
Low Level Radars. — To counter the possibility of hostile aircraft penetrating the defences by flying at very low level to escape detection by major strategic radars, we introduced a tactical radar into the S700 series, the S711. This is for application in terrain with mountainous, forested or urban areas and can also provide a powerful capability in the coast-watching role.

The S711 is operating in Europe and Asia where contracts have been won against many of the world's leading manufacturers.

Signal Processing. — It is in signal and data processing that spectacular advances have been made in the past 25 years.

Computer processing power has increased dramatically, along with impressive reductions in size and cost: *Myriad* occupied a full-sized rack; five years later *Locus* was contained on printed circuit boards, and now a whole signalling processing capability can be provided by a single chip.

Storage capacity has increased equally rapidly, and processing power is further enhanced by using parallel processing techniques as in our current designs.



LEFT: Martello *S713B in Oman.*

LEFT: Executive operations cabin.

SIMULATION

Training radar operators and air defence controllers can be carried out and tactics honed by the use of simulated signals. Such arrangements allow for maximum concentration of the threat and electronic counter measures in a way neither available nor allowed in live exercises in peace-time conditions.

In the 70s, independent simulators, originally developed by Elliott Airspace, were employed by the RAF, the Royal Australian Air Force and NADGE. This expertise was carried on into systems marketed as part of our radar system range.

Later advances and more powerful computing have enabled extensive radar simulator facilities to be incorporated in *Martello*, and air defence simulators are available with C² systems, as in the case of the UK Ground Defence Environment (UKADGE).

LEFT: S711 radar.

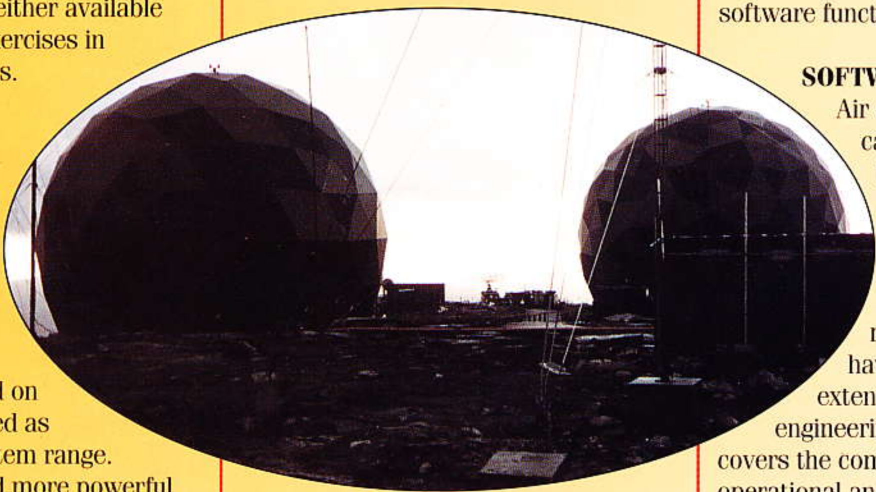
BELOW: S259 radar.

COMMAND AND CONTROL (C²)

C² facilities are necessary if radar surveillance data is to be exploited effectively. The raw radar display of early days has given way to data that is now processed and used to produce a recognised air picture (RAP), available for presentation on workstations to air defence controllers. Extensive computing facilities are used to analyse threats and assist controllers in the direction of available weapons.

System technology has advanced enormously since the days of the operational cabins supporting the S600 series and the C² centres in the Saudi Arabian Ground Environment. Throughout the 1980s, our *Locus 16* computer systems were used to provide the C² systems in such programmes as TOR, the fully-mobile Swedish air defence system, and UKADGE.

Today, modern, high-performance, commercial off-the-shelf (COTS) technology is available, and provides the platform for our sophisticated air defence software function.

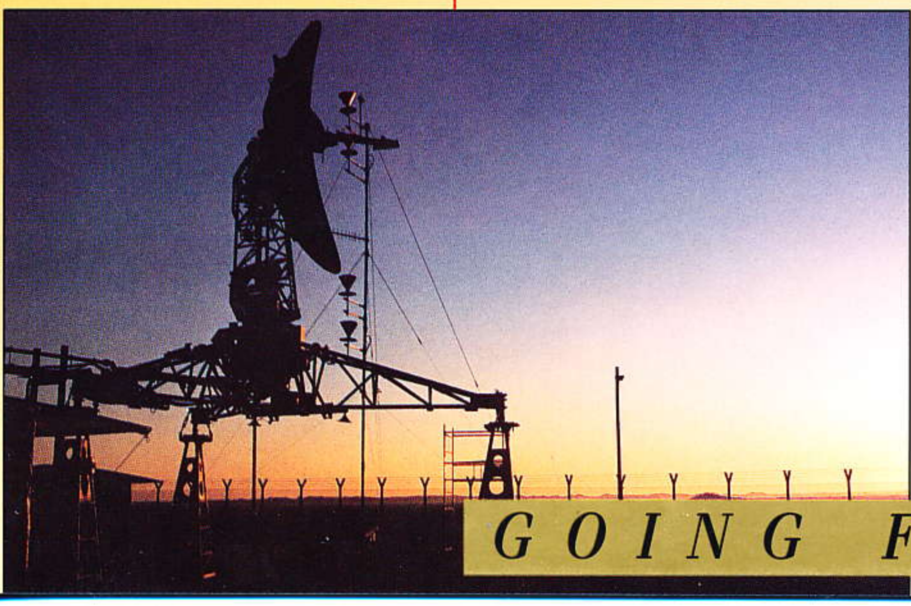


SOFTWARE

Air defence programmes carried out since 1969 have become increasingly dependent on comprehensive, error-free software. To generate the required software, we have developed an extensive in-house software engineering expertise, which covers the complete life-cycle, from operational analysis, through development and on to customer support.

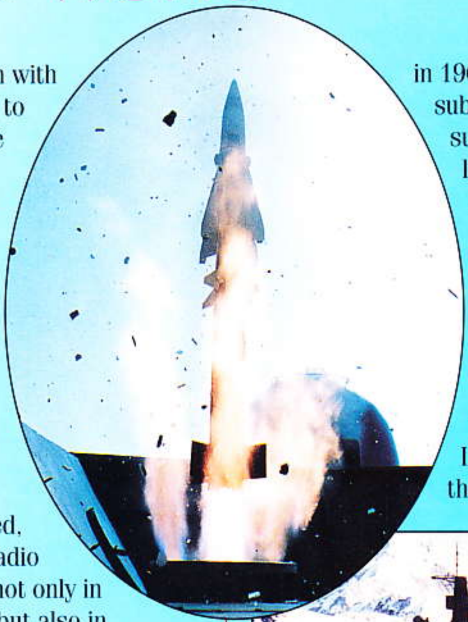
The need for effective quality control of software has resulted in increased disciplines in the use of procedures and tools; international requirements demand the use of standard methods, tools and languages. Undoubtedly, further advances in technology and tools will make the next 25 years equally demanding, and the role of the software engineers even more important.

ABOVE: Radomes in Mt Kent in the Falklands.



LEFT: Heightfinder S613 radar in the desert.

Radars for the navies of the world



Marconi's association with the sea reaches back to the latter years of the last century, when Guglielmo Marconi's first priority was to use his newly harnessed radio waves to benefit those who sailed in ships.

In the years that followed, concepts broadened and technologies advanced, so that those same radio waves were applied not only in telecommunications but also in broadcasting and, in the decade leading up to the Second World War, in radar.

The Marconi Company was in on the ground floor of this dramatic new development and, inevitably drawing on its traditional interest in serving the world's mariners, it directed much of its effort to applying the principles of radar to produce shipborne equipment and systems.

The expertise gained over the lifetime of radar was inherited by the newly formed Marconi Radar Systems Company when it was created in 1969 — and was substantially supplemented by the long experience of AEI, whose naval radar capability, based in Leicester, was absorbed into the new organisation.

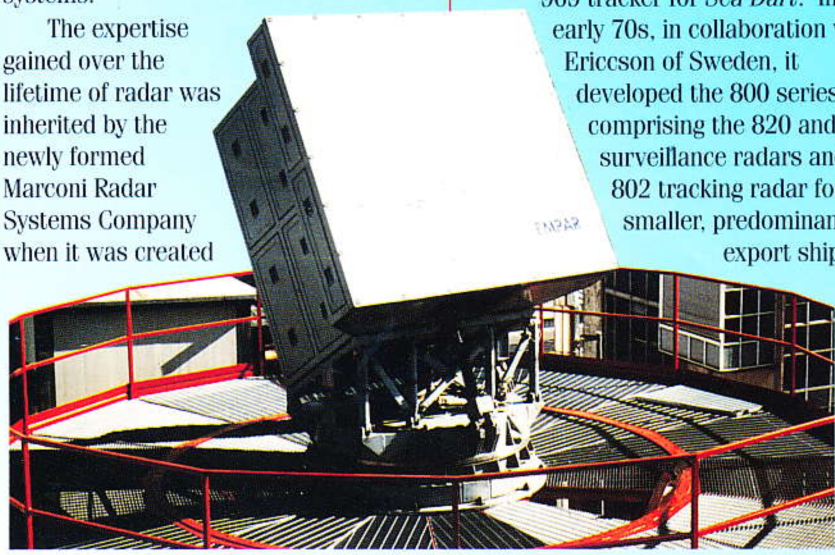
1970s

In the early days, the Leicester arm of Marconi Radar had the dominant share of the business with STIR, the 965 and the 1022 surveillance radars and the 909 tracker for *Sea Dart*. In the early 70s, in collaboration with Ericcson of Sweden, it developed the 800 series, comprising the 820 and 810 surveillance radars and the 802 tracking radar for smaller, predominantly export ships — a number of them were sold into the export market through UK shipbuilders. In the mid-seventies, responsibility for the 800 series passed from Leicester to Chelmsford.

At Chelmsford in 1969 a feasibility study was running in conjunction with the Marconi Research Laboratories on a project called PX430. This was later known as GWS25/*Seawolf*, the new RN point defence system, and was to lead to projects that have dominated our naval involvement for the past 25 years. During the 70s various improvements to the GWS/25 system were proposed in order to keep pace with the threats developing in the Cold War. These were to become the basis of the new systems for the 80s.

1980s

At the beginning of the 80s, a major defence review caused certain changes of emphasis in our planned operations.



ABOVE, TOP: **Seawolf.**

ABOVE: **HMS Brilliant, *South Georgia.***

LEFT: EMPAR at Alenia Works, Italy.

LEFT: *Type 23 frigate,* **HMS Norfolk.**

BELOW, CENTRE: *County class destroyer* **HMS Antrim,** *carrying* **Seaslug** *missile and 965 radar.*

RIGHT: *Egyptian Ramadan class fast patrol boat.*

The STIR project at Leicester was cancelled and significant changes in the future of *Seawolf* trackers became necessary.

On the positive side, in 1982 we were awarded one of the first fixed-price competitive contracts for the 805SW (RN Type 911[1]), a lightweight dual radar tracker. It augured well, ultimately resulting in over 50 radars of that type entering RN service, mainly on Type 22 and Type 23 ships, over the next 12 years.

On the *Seawolf* front, further contracts awarded during the 80s, formed the core of our naval business, and developments were put in train for the vertical-launch version of the system, which is now operational on RN Type 23 frigates.

Meanwhile, in order to meet export demand in the mid-80s, we developed the 1800 series, consisting of the 1802 trackers and 1810 surveillance radars. These were based on the 802 and 810 but were more versatile and achieved higher performance. The 1800 series was sold into Korea in 1986.

Two entirely new products were added to our portfolio in the 80s — Vessel Tracking Management (VTM) and *Sea Cobra*.

VTM is a management tool used to assist the entry, exit and docking of ships in harbours. Two systems were sold and still operate at Harwich and the Medway ports.

Sea Cobra, a wideband tracker on a gun mounting, did not go into production but the investment provided the basis for the *Marksman* anti-aircraft turret.

The path along which naval radar was to advance in the future became apparent as the result of sponsored research work into planar array antennas and electronically steerable beams. This made multi-function facilities a practicable proposition — i.e. the combining of surveillance and tracking.

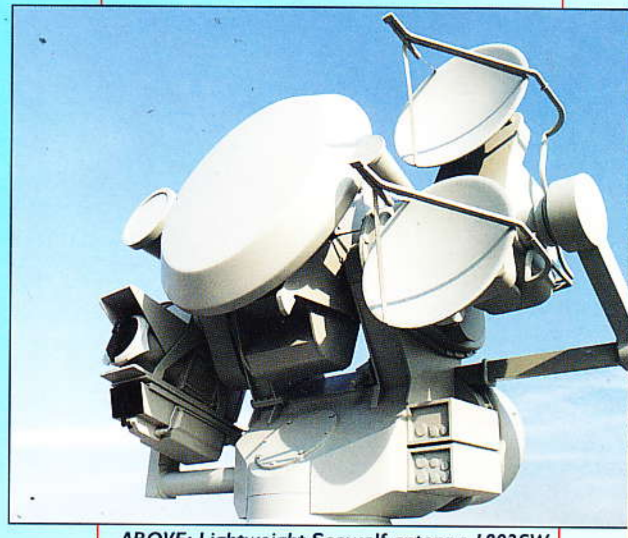
Capitalising on this innovative concept, we, in collaboration with Alenia (AESN), designed and developed EMPAR (the European multi-function phased array radar). The signal processing technology is a derivative of the transputer array (parallel processing) that we developed for the *Martello* 743-D programme in the latter part of the 80s.

Sea trials for the first EMPAR are due to take place on an Italian Navy frigate in early 1995.

1990s

Seawolf still forms a major part of our naval business today, and a mid-life update programme is planned.

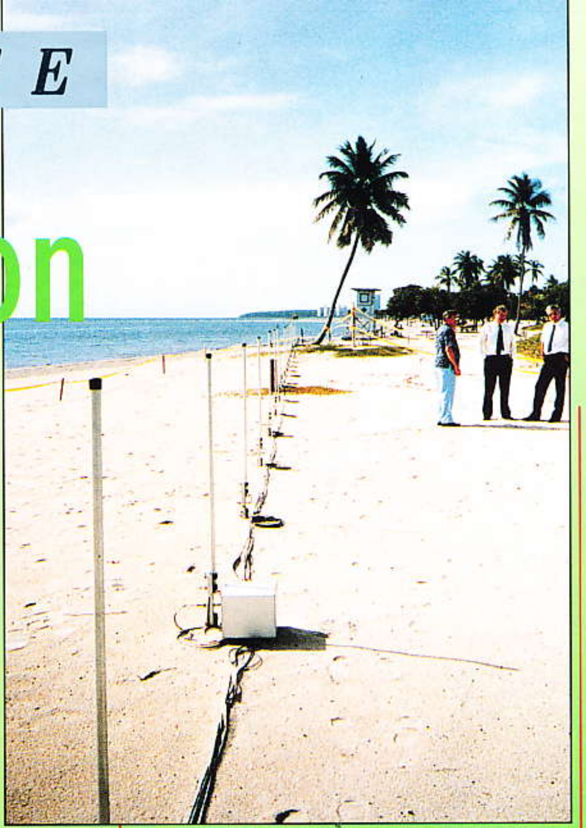
The 1800 series is being improved and forms the basis of the first *Seawolf* export order, which comes from Malaysia, whose new ships will undergo sea trials during 1995.



ABOVE: *Lightweight* **Seawolf** *antenna 1802SW.*

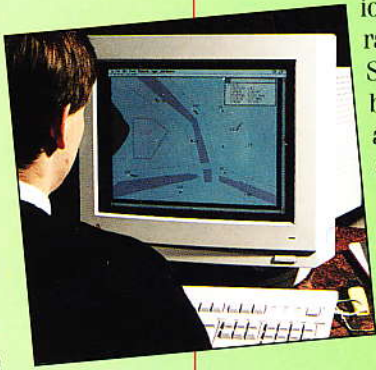
LEFT: *4.7m surveillance antenna S1830.*

Over-the-horizon



It may come as a surprise that Marconi has been involved in HF radar for more than 25 years: very hush-hush designs were being hatched in the Marconi Research Laboratories in the early 60s, under the supervision of Sir Eric Eastwood.

The HF (or shortwave) band is usually disparaged as congested and interference limited, but the HF radar engineer must work in it without affecting communications and shortwave broadcasts and not be affected by them. HF may be the only available, cost-effective way for radar or communications to reach beyond line-of-sight.



During the Cold War, when the USA and the USSR confronted each other from land-masses thousands of kms apart, and mutual surveillance was necessary, HF Skywave radar was developed to detect aircraft and ascending ballistic missiles in a way impossible for observation satellites and reconnaissance aircraft. In 1969 the USSR HF Skywave radar in the Ukraine actually watched the *Apollo* spacecraft ascending from Cape Canaveral, 10,000km away.

In the UK, the threat was a lot closer, and furthermore intruding aircraft could fly just a few feet above the sea in their final approach to the shoreline,below the cover of our coastal microwave defence radars. A second type of sensor, the Surfacewave radar, was developed to track this threat approaching *below* the horizon.

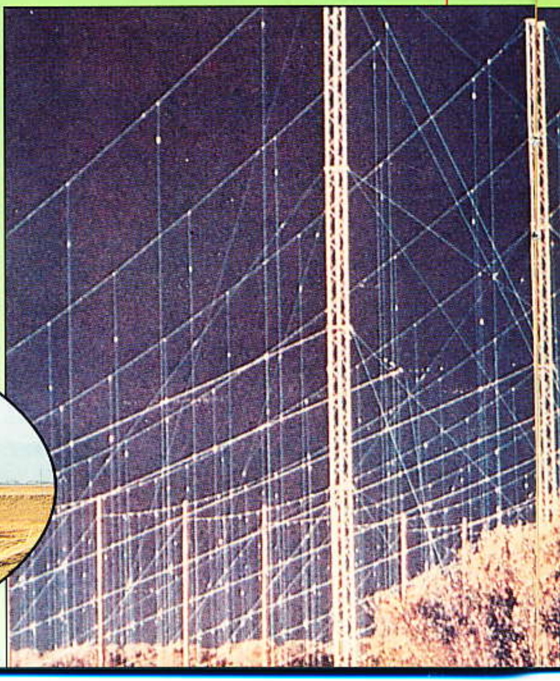
The first Marconi Radar era of HF radar began in the 70s, when we undertook very sensitive design work on military HF surveillance radars for the protection of the UK by both Skywave and Surfacewave techniques. In Skywave, the HF beam slants up to the ionospheric layers about 200 km above us to be refracted down to the target region, where aircraft and ships return the back-scattered signal via a similar ionospheric path to the radar station. In Surfacewave, the HF beam must be launched at the sea edge into the saltwater, over which it travels around the earth's curvature to detect ships or aircraft. Skywave sees targets out to 3,500km range (or even to 10,000km with a double ionospheric hop), whereas Surfacewave sees targets well beyond the horizon out to 400km (further for high altitude targets).

Our first era concluded with the defining of practical, operational radars. The new AP120B array processor enabled us to demonstrate the efficient digital filtering of vast quantities of received HF data in real time and showed that the tiny target signals could be separated from the environmental HF noise and clutter.

The second era began in 1980 with the challenge of packaging an HF antenna array onto a frigate to provide HF radar detection of aircraft and ships approaching from distances well beyond the range of the captain's telescope or indeed of his microwave radar.

Before going to sea, our new kit was tried out at the Explosives Proof Establishment at Foulness. The RAF provided a *Vulcan* bomber, which dodged the red flags and over-flew us at 500ft, continuing over the sea towards Rotterdam. We processed the first data from our embryonic radar and were stunned that it was immediately seeing the *Vulcan* flying very low almost to Holland.

By the start of the Falklands conflict we had strengthened our HF radar activity, and two radars were quickly built: one, land-based, was constructed in record time and works to this day on the Dengie peninsula in Essex; the other was a shipborne version that appeared not to work the



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!

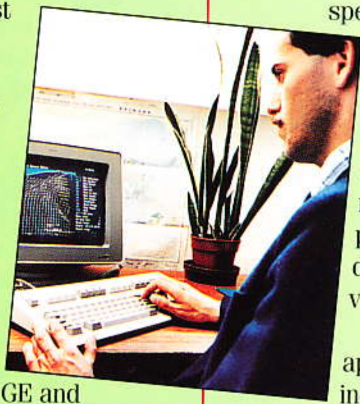
We put our own antenna on another ship and obtained superb results on a *Canberra* aircraft flying a few feet above the sea at OTH distances.

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.

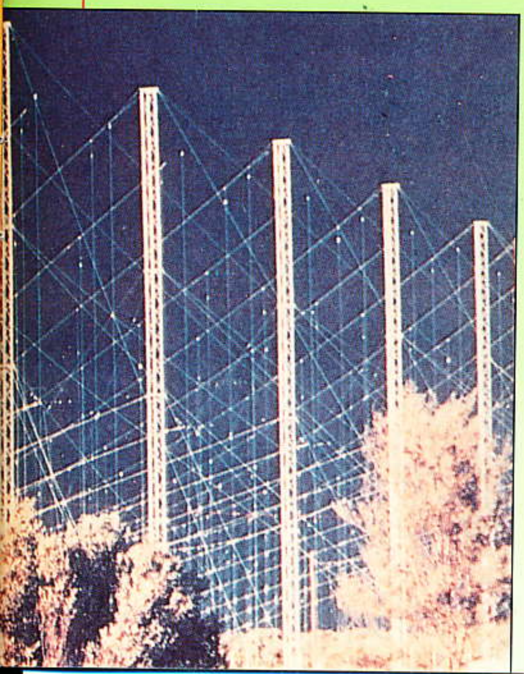
Over 60 nations in UNCLOS, the United Nations Convention on the Law of the Sea, have ratified the EEZ regulations, which not only confer benefits from fish, oil and mineral exploitation but also impose responsibilities for the protection of all those traversing the Zones and for search and rescue.

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***.

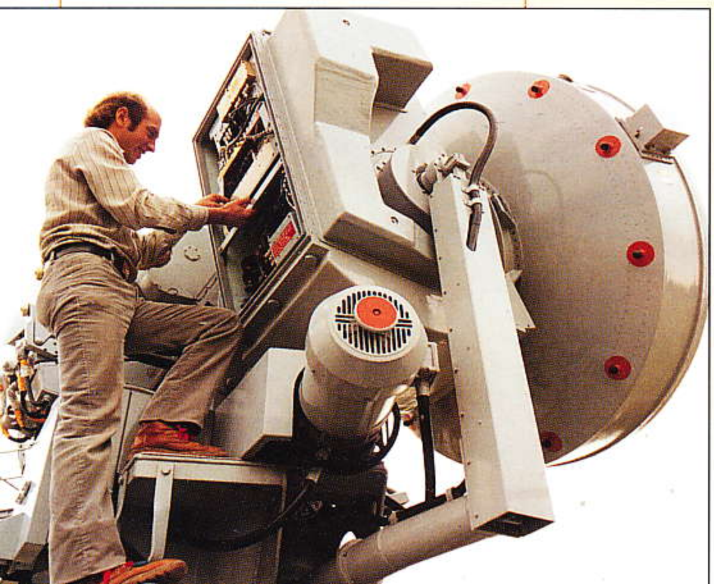
Spares and Repairs

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

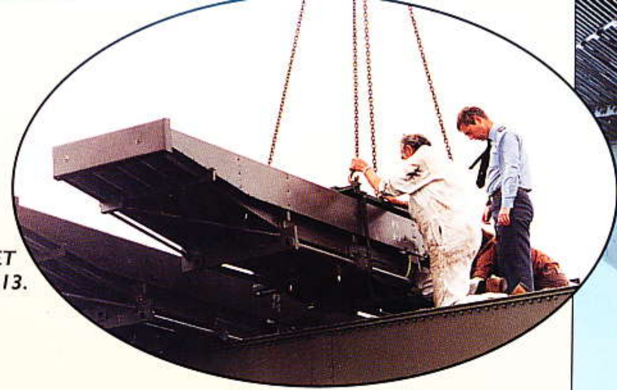
As with all our customer support operations, we have developed our technical services appreciably during the last 25 years.

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

LEFT: A Seawolf tracker type 910.

RIGHT: Paint spraying.

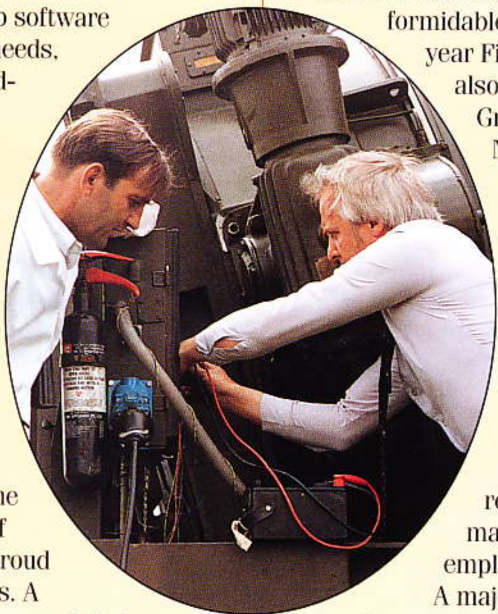
LEFT: Prototype 1802SW at Bushy Hill



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.

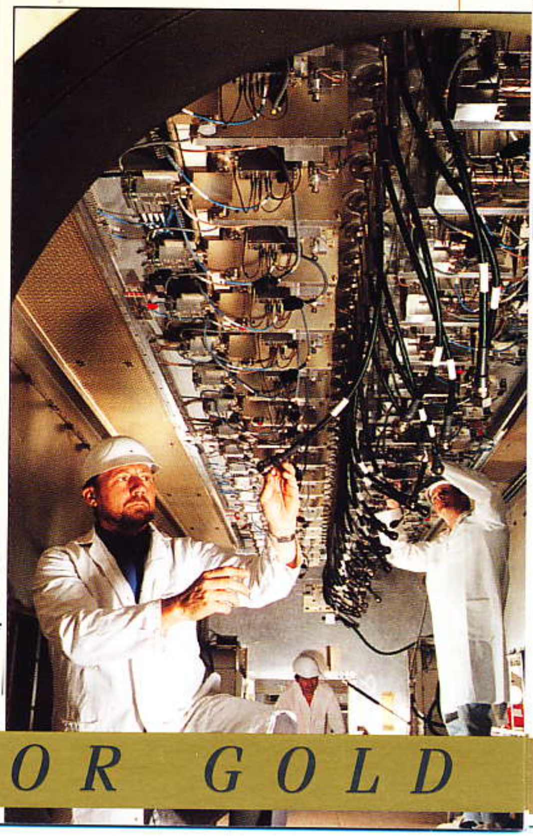
Overseas activities extended across Western Europe and the Middle East to Singapore, Australia and New Zealand. The Saudi Arabia defence system alone was occupying about 50 people.

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.

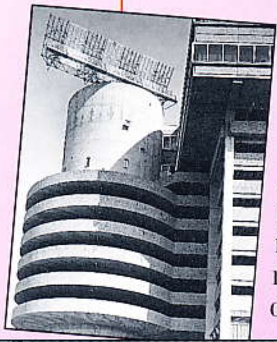
The 25 years that we are celebrating have undoubtedly witnessed significant advances in our support activities, which have always figured largely in our successful operations — indeed some equipment supplied before Marconi Radar's independence is still being supported!

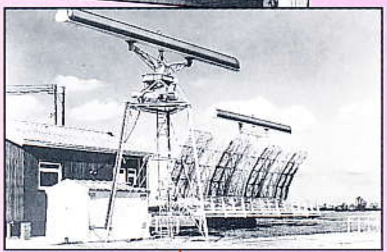


RIGHT: Inside the spine of Martello 743D

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.

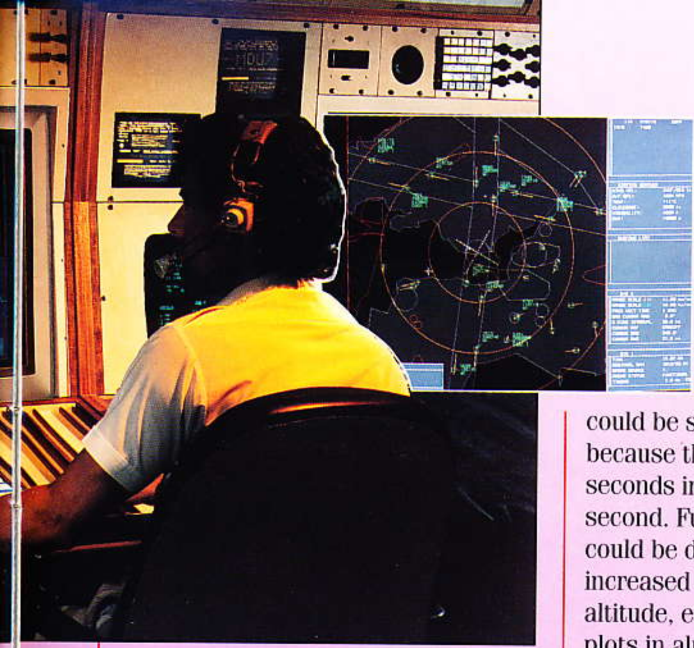
DATA HANDLING AND DISPLAY

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.

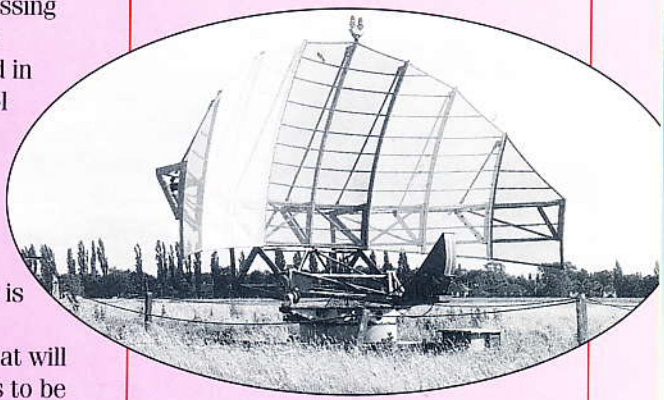
The *Locus* architecture allowed for the first time a low-cost computer to be associated with each display, thereby distributing the processing and increasing overall system availability. This is exemplified in the Scottish Air Traffic Control System (ScATCC) where, for over 15 years, over 30 *Locus* 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.

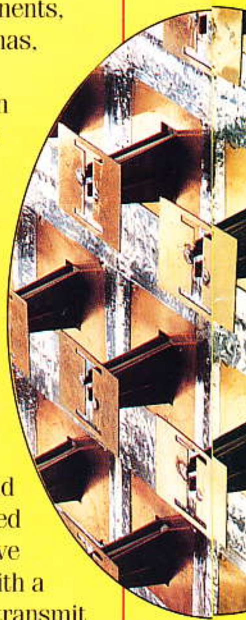
The squintless feed techniques developed by the lab received their final seal of approval when they were applied in the antennas of the highly successful S600 series radars, and their inclusion in the antenna for the Royal Navy STIR radar enabled us to win this contract in the face of severe competition.

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.

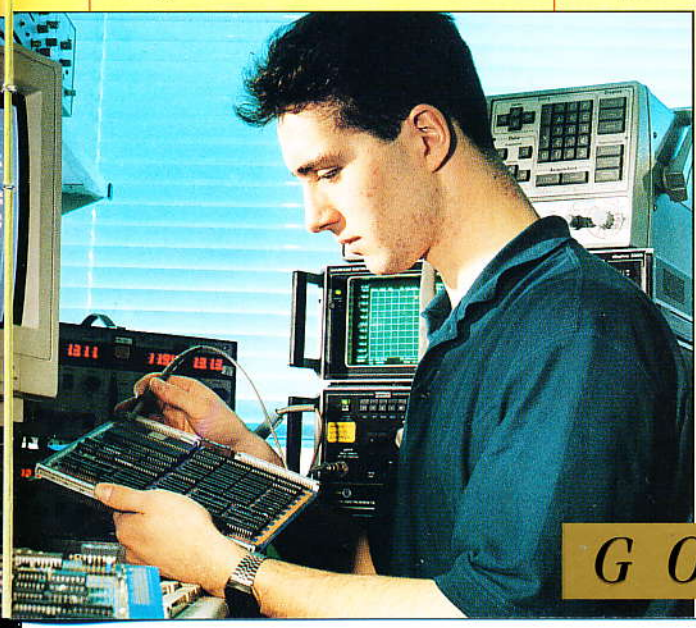
This key work and our continuing funding of HF radar research gave us the credibility and capability to bid for and win our current pivotal role in the JORN contract for Skywave HF radar in Australia. It is also reflected in our current work on a family of land-based Surfacewave HF radars for aircraft, 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 multi-function 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.

Publication number DS/10. Published by Marconi Radar Systems, Eastwood House, Glebe Road, Chelmsford, CM1 1QW. Telephone: 01245 702702. Edited by the Publicity Department
Designer: Colin Gurney. Produced by AB Consultants Ltd – *Publishers to industry*, 120 Wootton Street, London, SW1 8LY. Tel: 0171-928 1424