The new Marconi Radar, the S600, made its civil debut at Farnborough this year. Its advanced modular and mobile form sets the trend of design for the future

GROUND RADAR IN THE

SEVENTIES

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MONTHS OF careful study have deen devoted to finding out what the demands of ground radar will be, and what 'shape' it should take for air defence and air traffic control in the seventies.

All the known market information, trends in operational philosophy, and current techniques have been investigated to arrive at a plan for a range of equipment which will be the best world-wide proposition.

Product planning is essential for a profitable business; only too frequently in the past the development engineer has said to the marketing man 'look what a clever piece of equipment I have produced, now go out and see if you can sell it,' with commercially disastrous results. It is most necessary to balance carefully the known techniques against the market requirements in terms of development cost, production cost, time scale and maximum return on investment, and to maintain a lively forward-looking policy for exploiting the market, particularly overseas.

Market requirements

Predictions of what the potential buyer of radar systems for the seventies would require led to four prime features: *cost effectiveness* in the widest sense; *technical performance; reliability* and all that this implies; and *clutter suppression.*

Examining each of these features in turn led us to set down a complete specification for an overall range of equipment to meet all markets.

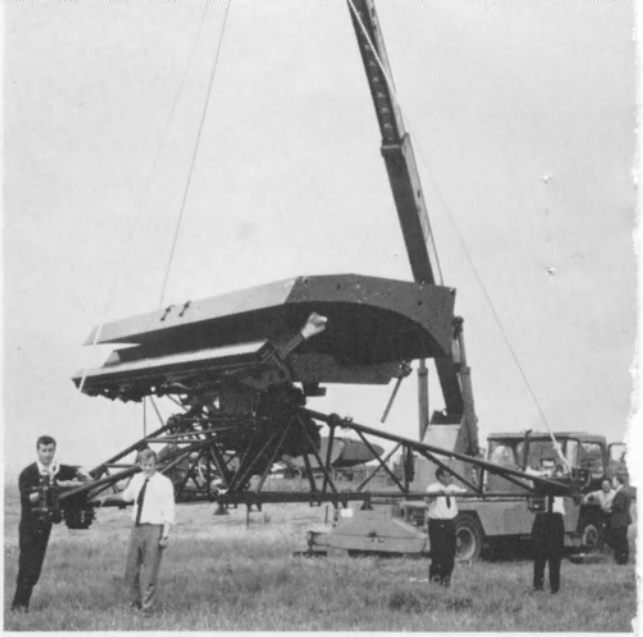
Considering first cost effectiveness; this means that in achieving the required technical performance everything which goes to make up the initial capital cost must be minimised and at the same time equipment must be adaptable and flexible in application to fulfil as many operational roles as possible. Cost effectiveness runs through every stage of design, production and implementation in the field, and must invoke detailed attention to the ease of operation and maintenance, with the utmost use of automation so that manpower requirements are reduced, together with concentration on economical power consumption, standardization of spares and replacements.

Considering reliability, users are demanding a higher order of reliability than has ever been possible in the past. This means conservative rating of components, simplicity of circuit design, total use of solid state and integrated circuit devices, meticulous attention to reliability in all the design stages and provision of standby circuits or units in critical areas. One is confident that this approach, based on many years of experience in the assessment and measurement of reliability, will lead to new standards of excellence in the seventies.

As we consider targets of smaller echoing area travelling at higher speeds, frequently at low level, the subject of clutter suppression achieves much greater significance and importance than it has done in the past. 'Clutter' is the unwanted reflection from the ground, fixed objects, precipitation which impairs the radar 'view' of wanted targets. The necessity for clean signals for automatic plot extraction

LEFT: *The new mobile modular radar S600 made its civil debut at Farnborough this year*

ABOVE: *On the move. Aerials and associated equipment cabins are quickly mounted on bogies for transport*



and automatic track forming makes vigorous attacks on this subject absolutely vital.

In determining a new product range of equipment to meet these essential requirements, one must obviously be aware of world trends, but only be prepared to adapt one's own ideas to these trends if they have real significance to the market. Certainly world trends until recently have been for big complicated 'all singing all dancing' systems designed very specifically for each individual requirement and involving very substantial development expenditure for a relatively small number of outlets. Furthermore, by pushing too early into production techniques very near to the threshold of new research, one invites trouble from a cost and reliability point of view.

The Solution

The optimum solution lies in a complete range of equipment in modular form, i.e. a number of transmitter/receivers, aerial systems, signal processing arrangements, display and data handling elements, data processing elements, which can be put together in a very wide variety of combinations to meet virtually any military or civil need for ground radar. This gives a simple and effective solution for any requirement which is easy to deploy, easy to operate and easy to maintain. It gives the client a freedom and operational flexibility which he has never enjoyed before. By rearranging his system elements he can build up from a simple environment to a very much more comprehensive and extensive capability at will.

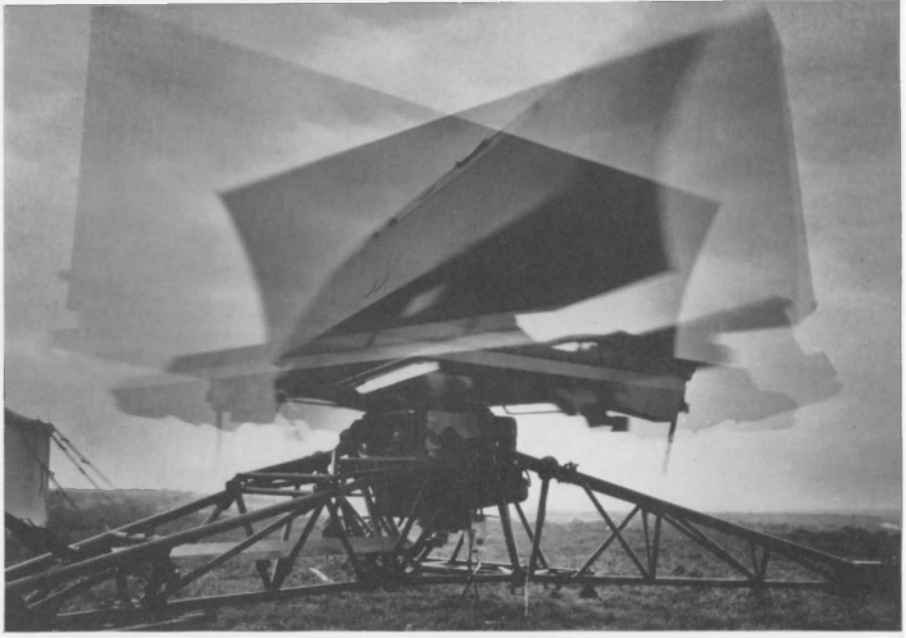
Having established a philosophy for this comprehensive range of ground radar equipment to meet the requirements of the seventies, the task of planning and engineering in detail the modern equipments which go to make up the range, was

Members of Mechanical Engineering Group, Radar 'A', Drawing Office, and Aerial Research Group who were engaged on the development of the S600, with the search head behind them at Bushey Hill. Back row, left to right: Jim McKean, Colin Lax, Eddie Crooks, Dick Rowe, Roy Frost, John Dearsley, John Davidson, Barry Peters, John Brewer, Mick Healey, Harry Jowers, Dennis Lloyd, Roy Garwood, Peter Davis, Norman Mapes, Tom Monk, Geoff Edwards. Front row: Cliff Warman, Alex Paton, John Brooks, Pat O'Donnel, Chris Brownless, Smudge Smith, Bill Macey, Cyril Slade, Len Gould, Harold Suckling, Ray Brown

FAR LEFT: *At the first demonstration at Bushey of the S600 in operation, J. W. Sutherland, Manager, Radar Division, left, and N. H. Ellis-Robinson, Engineering Manager, Radar Division, foreground*

LEFT: *The S600 search head undergoing lift trials by crane—tests for transport by helicopter*

RIGHT: *The search head rotating. The aerial mounting and the reflector were built at Gateshead*



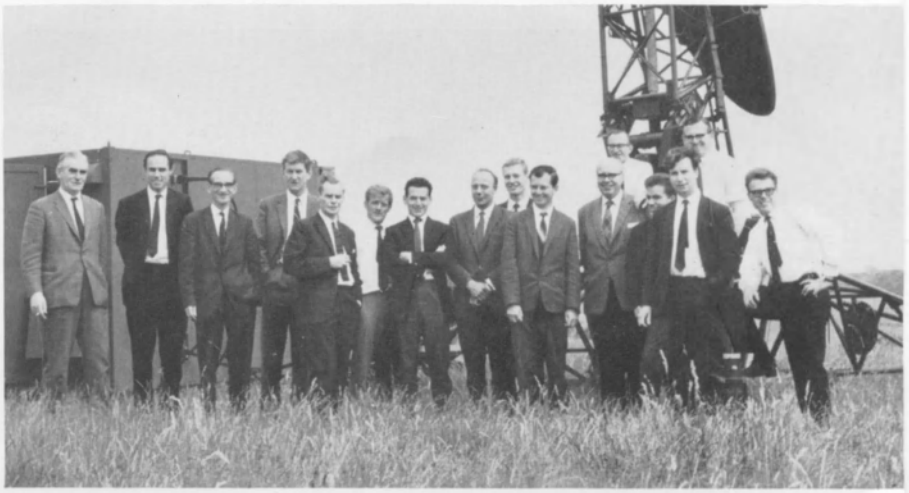
started. The basis is four transmitter/receivers: 1 Megawatt in the 10-centimetre band; 2 Megawatts in the 23-centimetre band; 1 Megawatt in the 5½-centimetre band; and 2¼ Megawatts in the 10-centimetre band. These transmitters, whilst employing the latest microelectronic and solid state circuitry are extensions of past experience, using the great deal of practical information gathered over many years of world-wide experience on the performance and reliability of radar equipments in the field. The aim throughout has been simplicity, reliability and cost effectiveness, coupled with an extremely high degree of stability which is the heart of an effective clutter-suppression system.

In association with English Electric Valve Company new magnetrons have been produced which are unique in their robustness and stability. All forms of vibration and electrical or magnetic interference within the transmitter have been cut down to a negligible level and, by using vapour cooling in the magnetron, the turbulence associated with the more usual water-cooling (which has been proved to contribute to instability in earlier designs) was eliminated.

Aerial configurations have been developed for the tactical military application, that is to say, systems which have got cross-country mobility associated with the ability to be lifted by helicopter or stowed in most varieties of transport aircraft. This envisages an extremely rapid deployment of an effective radar system by the minimum number of operators in an extremely short time. For the static application we have a number of larger aerials which can be applied to both military and air traffic control functions.

The tactical deployment may be built up starting from a single 23 cm. surveillance radar which can be deployed rapidly to give early warning cover or be used as a gap filler or simple reporting post. To

Mechanical Engineers of Radar Group 'A' with the heightfinder and its cabin. Left to right: Alex Paton, Senior Project Engineer; Roy Frost; 'Smudge' Smith; Geoff Edwards; Cyril Slade, Chief of the Group; Jim McKean; Eddie Crooks; Mick Healey; John Dearsley; John Brewer; Norman Mapes, with Harry Jowers behind him; Mick Donnelly; John Davidson; Peter Robinson; Barry Peters

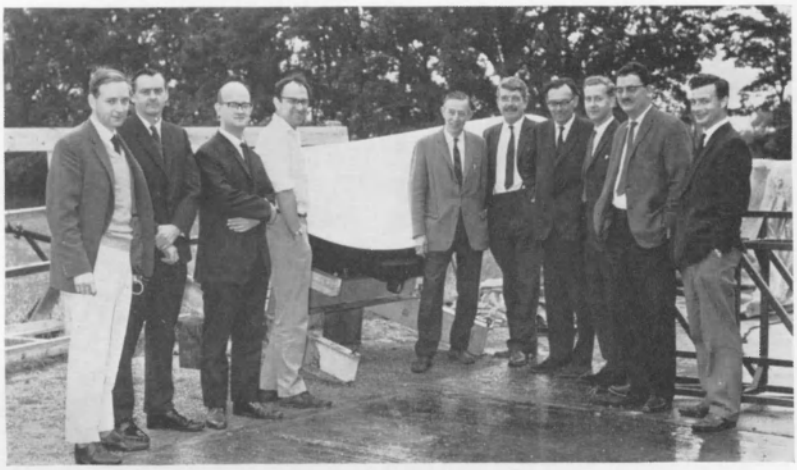


With a heightfinder dish are engineers of Aerial Department, Baddow, responsible for the design and development of the S600 reflectors and feeds. From front to back, five rows, left to right, LEFT GROUP: *Terry Roper; Trevor Gears, Bill Macey; Mike Webber, John Brain; Peter Storey Jamie Hird; 'Mac' MacLeod, Peter Humphrey, Ken Walker, Len Gill.* RIGHT GROUP: *Ken Clements, Colin Lax Tom Goolding; Jeff Masters, Mike Haley; Dick Cresswell, Neil Sellens; Arthur Rogers, Geoff Ironmonger, John Vince; Ken Jolly, Brian Kelly, Les Cooper. Chris Brownless, who was away on this occasion, appears in another picture. He was responsible for the mechanical development of the heightfinder dish, and led the construction team at Gateshead*

extend the capacity of such a station one may add display and data-handling cabins. Further, to extend the performance of the installation one can add a nodding heightfinder which gives accurate height determination and high data rate. It is worth pointing out at this stage that in operational studies leading to the definition of this range of equipment, all the available equipments and known techniques for providing height information were studied in great detail. The studies included stacked-beam radars, V-beam radars, interferometers, phase and frequency scanning and the separate plan radar with nodding heightfinder. Without doubt, from consideration of accuracy and overall cost effectiveness to meet specific applications, the plan radar plus nodding heightfinder provides the optimum solution.

Finally, the full capability of, for example, a high capacity ground control of interception stations can be built up. One has search radars in the 10-centimetre and 23-centimetre bands, including I.F.F. Each will have transmitters in diversity and the full gamut of anti-jamming equipment. Two or more nodding heightfinders in the 5½-centimetre band provide accurate determination of height; by automatic extraction of height, thus eliminating the height operator, and by computer-controlled 'putting on', each can contribute a data rate in excess of 20 heights a minute.

On the data-handling side, display cabins and computer cabins are built up to give the full complement of master control positions, track positions, intercept positions, recovery positions, computer capacity and data storage for any requirement of tracking and interception. A communications complex to integrate such a station into an overall defence scheme can be built up from standard modules.



Engineers of Radar Engineering Group 'A' responsible for electronic aspects of the project. Left to right: Barry Dennis, John Palmer, Malcolm Austin, Roger Kennett, Jim Brazendale, Eric Cable, Colin Latham, Assistant Engineering Manager; Denis Thorn, Bruce Neale, Assistant Engineering Manager; Dick Greenwood

Project Management

It is essential to back a range of equipment such as the one described above with a system engineering and project management capability which can give the client the full support and service that he needs, starting from his first definition of an operational requirement and working right through to the deployment, operation and support of his equipment in the field. It is here that the vast background and experience of The Marconi Company has proved so vital in obtaining very substantial new business in world markets over a prolonged period.

In the area of the management of major projects, there have been very substantial advances in the last year or two. British Industry must ask itself 'Has the performance on cost and delivery of major projects been entirely satisfactory in the past?' 'Can we continue to win in world markets, against international competitors who have embraced fully the most sophisticated management methods?' 'Will the British management technique of the last ten years be adequate for the next ten years?'

The answers clearly point to the absolute necessity drastically to revise our ideas. In particular, in the introduction of modern data processing techniques and the use of computers to enable us to run major tasks more effectively. In Marconi Radar Division these already cover such functions as computer-controlled preparation of production schedules, of wiring information within racks and units, of wiring information for overall installations, and the control of provisioning activities. In project control we have embraced fully the critical path analysis methods based largely on PERT techniques and have advanced with this to a high degree of sophistication. These techniques enable one to state completion dates with a high degree of confidence, to allocate resources both human and material for optimum effect, and to anticipate at the earliest possible moment those factors which may contribute to a setback in progress.

Conclusion

The author has tried to sketch within the confines of a necessarily brief article, not only a positive plan for ground radar in the seventies, but also a philosophy for the radar industry, which has been a good performer in the export field for many years, and which we hope will do even better in the future.

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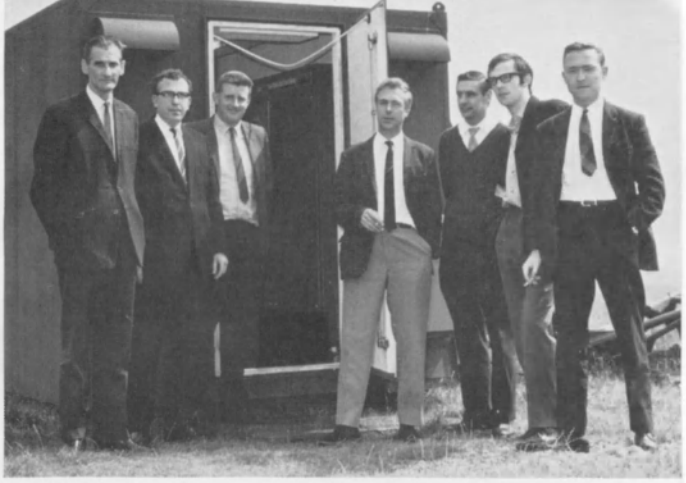

TOP: *Radar Group 'A' engineers and designers responsible for the mechanical aspects of the S600 transmitters and cabins. Left to right: Dennis Lloyd, Roy Garwood, Dick Rowe, Len Gould, Tom Monk, Peter Davis, Ray Brown*

ABOVE: *Here, in the heightfinder transmitter cabin, are Chris Arnold and Ken Smith, responsible for the design of the automatic height extractor, and to the right is Denis Thorn responsible for transmitter modulator design*

BELOW: *Radar 'A' engineers on the search head. Left to right, Bill Thornhill, Barry Wabling, Frank Giorgi, John Ellis, and, above, Jim Brazendale, Section Leader Technical Services*