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Electronics in air defence

IT IS A FRUSTRATING TASK to survey the field of air defence electronics, since in spite of our hopes and predictions progress is extraordinarily slow. For example, in the Fifties one would scarcely have predicted that the main air defence threat through the Seventies would remain the manned aircraft in relatively small numbers, and that defence philosophy of the Western Alliance would be the containment of "conventional" war and the prevention of escalation.

As a result of this static situation, coupled with the lessening of Britain's fixed commitments overseas, progress in air defence at home has been unspectacular and advances in technique in ground applications have been limited. Indeed, it seems probable that many of the radar sensors manufactured and installed ten or 20 years ago will still be with us, perhaps with a modest face-lift, well into the Eighties.

There are, however, a number of new and exciting techniques currently in the embryonic state in which significant progress could be made in the next few years across the whole spectrum of sensors, data-handling and display, data utilisation and communication. It must be realised urgently that we cannot afford to neglect the research and development work necessary to bring along these techniques to the feasibility and prototype stage, even if money cannot be found immediately to put complete new schemes into the field.

In defence electronics generally, the real danger exists that failure to invest in forward-looking work, both by industry itself and by British Government sponsorship, will result in the permanent loss of the basic competence and experience in systems and techniques. Not only would this be fatal to our ability to compete in world markets, but when requirements eventually arise in the future the inevitable result would be overseas purchase of defence equipment, involving not only loss of foreign exchange and further damage to Britain's export potential, but also even further dependence on foreign suppliers for national defence.

Industry can only invest to the extent that it can plough back a pro-

portion of revenue and cannot bear the load unaided. It must be incumbent upon the Government to recognise these dangers and difficulties and to finance the work needed to preserve the best of the existing system and technique teams in Britain for the sake of export markets in the immediate future and the ability to defend this country in the long-term.

One can, fortunately, take a less gloomy view of air defence electronics as an earner of foreign currency. There is a steady world demand for such equipment and since the war Britain has obtained a large share of the market. Competition is undoubtedly fiercer and rougher than ever, but there is no reason why we should not continue to prosper in this particular activity. The ingredients of export selling vary enormously from case to case, but success must derive from the product itself. Cost effectiveness, flexibility of operational application, reliability and ease of maintenance are key factors. It has been a fact of life since the war that surprisingly few of the systems designed for British Service use, under Government sponsorship, have proved acceptable in the export market. Consequently it has been necessary, in order to remain competitive, to develop with private-venture money systems and equipment more suitable for world-wide exploitation. There has been more emphasis on simplicity and flexibility without loss of the ability to meet rigorous operational requirements.

A second and vitally important factor in selling overseas is the "total system" concept—the ability of the industrial organisation to participate with the customer in the formulation of his operational philosophy, and to plan a complete "ground environment" from first principles. This should include civil engineering, power generation, accommodation, etc., as well as all facets of the system itself, together with training, maintenance, documentation, spares and technical advisory services.

Thirdly, one must never underrate the commercial factors; the importance of good representation across the world, in the form of associated companies, agencies and resident staff. Where appropriate, the importance of vigorous support of the

Government at home and the Embassies abroad, cannot be over-stressed. The "ear to the ground" is vital, so that the market in a particular territory can be attacked the moment one gets a whisper of a requirement, or indeed so that where possible the requirement itself can be created and cultivated.

A retrospective examination of the problem and difficulties of air defence in the last decade may point to developments in the future. A lesson that has been learned the hard way is not to embark in a single step on vast, ambitious "all-singing all-dancing" schemes, based on extremely optimistic estimates of time-scale, cost and achievement. The inevitable result is over-run of time and money, a cut-back to a less ambitious scheme, and a final system which is obsolescent before it goes operational. How much better to plan a series of evolutionary steps, each one with a fairly high probability of success, and with a "rolling" five-year and ten-year forecast of financing and achievement. One particular European country, with a limited defence budget, but with a single authority for all aspects of air-defence procurement from operational requirements, technical specifications and finance, right through to final acceptance, has employed this technique for many years with great success, and has really got value for money in defence spending. The futility of authority split and dispersed across too many different departments, trying to achieve too great a single step, cannot be stressed too strongly. In the realisation of new systems, the customer must have undivided and decisive authority, the objectives must be clear and capable of achievement, and the contractor for his part must engage all the tools of modern management to perform the task within the limits of time and money.

In the sphere of new techniques and system concepts currently in the research or experimental phases, there are some exciting possibilities. During the past 15 years air defence has been increasingly dependent on high-speed on-line computers, and modern data-handling systems have performances and speeds of reaction which would be unthinkable in manual systems. The flexibility and storage capacity of modern machines enables a large amount of rapidly updated data to be acquired from a variety of sensors, together with background information on performance of interceptors and weapons, airfield states, meteorological conditions and other relevant data. This is collated, stored and presented in the appropriate form to the user. The latter is backed in all his functions by a variety of computing processes to enable weapon allocation, interceptions, recovery and other procedures to be carried out rapidly and effectively.

This leads us to the more philosophical concepts; in particular the

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key aspect of communication and relationship between the human and the computer. The latter can only in the limit be an aid to the man, extending his capacities and capabilities, but never replacing him. There must always be the ability in the system for man to over-ride, to make decisions, to take over. Indeed much work has been done, and even more remains to be done, on the means by which the human operator exchanges data with the data-processing system; how he observes what the computer is doing, how he injects data and instructions, how he steers the progress of the air battle. This so-called "man-machine interface" is an area to which a great deal of attention must be paid in future. Work on new types of data presentation and data exchange is looking very promising, but regrettably it does not appear that sufficient resources are being applied in Britain to make the rapid progress necessary to remain competitive.

There are some new trends in data-processing for air defence which are worth exploring. The massive central processor in defence or air traffic control systems has become so complicated, and requires such a great volume of data flow, that it is becoming very troublesome to commission. Programming, with hundreds of thousands of interdependences, becomes extremely difficult and lengthy, with unreliability of software becoming more significant than that of the hard-

ware. The rate and volume of data distributed to and from the central processor to a wide variety of sensors, display positions, keyboards and other peripherals, poses difficult problems of interference, earthing and physical cabling.

The answer lies in distributed data-processing power. Each operating position or group of positions will have its own special-purpose computing and storage capability, tailored to the requirement. In small and medium systems there may be no need at all for a central processor, and even in the larger systems the data flow is minimised, since each semi-autonomous position is independent for the generation of symbols, driving of input-output devices, local data storage and computer assistance of operating functions. Equipment based on this concept is in production now in Britain.

This makes the system engineering and the programming tasks substantially easier. The local data processor can be a fairly simple engineer-programmed device, and the "distributed" processor concept opens up the possibility of a much more flexible system which can be modular, and can evolve and develop as the operational requirements change, without scrapping a major investment in software and hardware.

The performance parameters of radar sensors for air defence must inevitably be a compromise weighted

by the relative importance to the user of such factors as resistance to electronic countermeasures, resistance to clutter of various types, positional discrimination, range of detection and data rate among other factors. But it is in the area of producing a "clean" signal from a small, high-velocity target in the presence of both ECM and clutter that recent progress has been made. New forms of modulation, coupled with sophisticated receiver and signal-processing techniques, can be made to produce remarkable results under difficult conditions. It is only with such clean signals and low false alarm rates that one can make the most of automatic processing of radar data.

The other aspects of radar sensors in which development is emerging is the physical configuration of the radar head itself. The big, static equipment, even with expensive "hardening," may well be too vulnerable and inflexible in the future. Mobile and transportable equipment, which is capable of very rapid redeployment to give whatever cover is dictated by the tactical needs of the moment, in many circumstances can provide a much more cost-effective solution to the air defence problem.

All the trends for the future are away from large "set-piece" systems towards flexible and adaptable concepts of air defence which can readily adjust to changing threats and requirements. ■