New Data Handling Technology in Air Defence

*by J. W. Sutherland, Chelmsford**

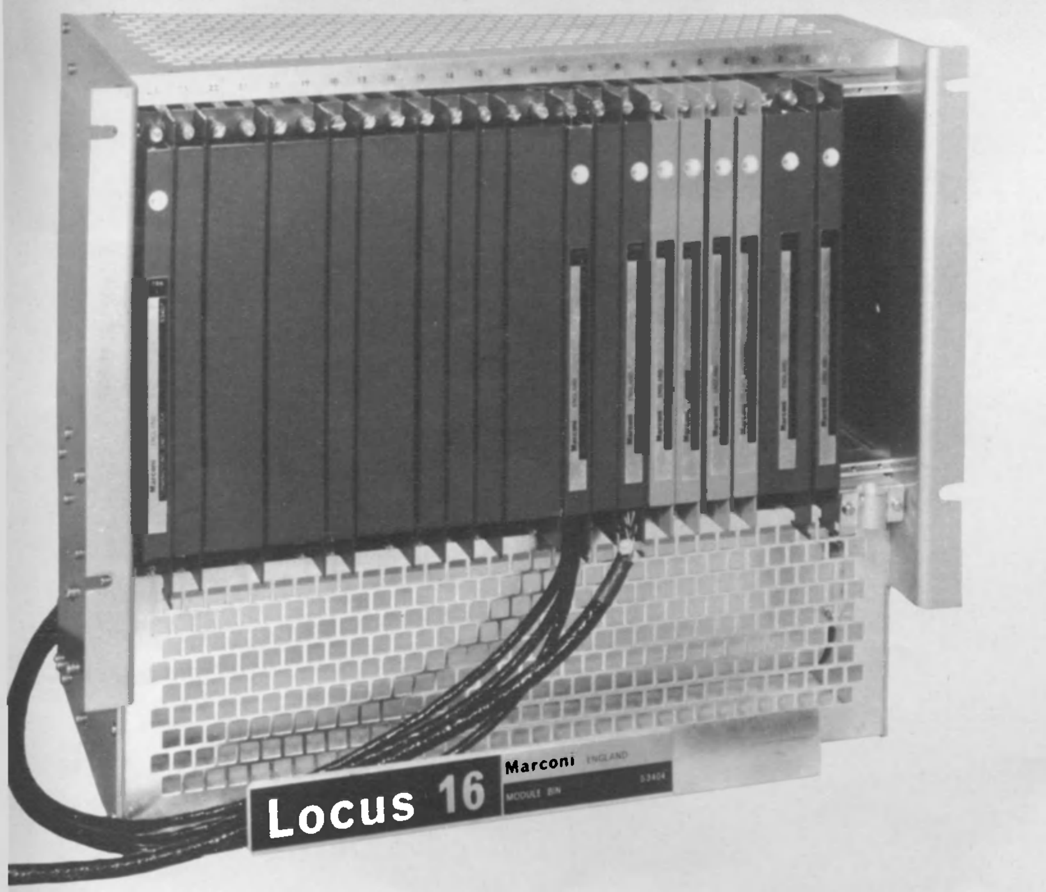
Recent advances in air defence technology have a significant impact on the overall effectiveness of total systems, and what is even more important, can be applied retrospectively to many existing defence environments. There have been notable developments in signal processing, aimed at the production of 'clean' radar signals from an environment of clutter of all kinds, and the constant electronic battle between the jammer and the defence against jamming has become ever more sophisticated. This article however concentrates on distributed data processing, an advance which has had a remarkable effect on air defence philosophy and which brings new freedom in system analysis and programming to the air defence scene.

In major systems to date, be they warships, sector operations centres or major air defence operations centres, data processing has been based on the concept of the central processor. Indeed the general purpose digital computer in the central function has evolved from the late fifties through at least three generations of machine, and has given sterling service. A typical example is the STRIL 60 system in Sweden, designed and built by Marconi in the early 1960s, which was the first fully automated air defence system in Europe, paving the way for many further systems by the same company. The earliest systems operated with germanium transistors and bulky storage, to be followed by much faster silicon transistors, leading to the last generation of very high powered central processors using integrated circuit logic.

A drawback to the central processor' philosophy was its lack of flexibility. Software consisted of virtually one single package for the whole system, and therefore had to be put together as a totality with all the problems of interaction from one operation to another. Systems analysis and programming were unduly complicated, such that even the most simple modifications to the program became difficult to implement.

Since every computer aided or controlled function at any operational position required input to and output from the central processor, the physical interconnections became very large, prone to error and vulnerable to damage. Commissioning and proving of the software was also a massive task, since the whole system was necessarily involved, if the programs were to be properly checked out and 'debugged'. This weighed heavily on time and skilled manpower.

▼ The LOCUS 16 processor, developed by Marconi, is essentially a high-speed 'highway' into which are plugged different p.c. boards to perform various functions.



Distributed data processing

A completely new 'breed' of distributed processing equipment provides the freedom to put the required processing power and storage precisely where it is needed. Thus each operational position, or input and output point, can, if appropriate have a co-located sub-system to carry out the necessary processing functions to enable that position to operate to its full potential, to communicate with the rest of the system and with the outside world, and yet remain autonomous. The advantages are manifold, with the task of programming and software proving greatly simplified, since in both conception and the commissioning stages the position can be specified, fragmented, set up, tested and operated in its own right. Each position can be planned so that interconnections with other parts of the system are generalised, and in physical terms consist of a single pair of wires.

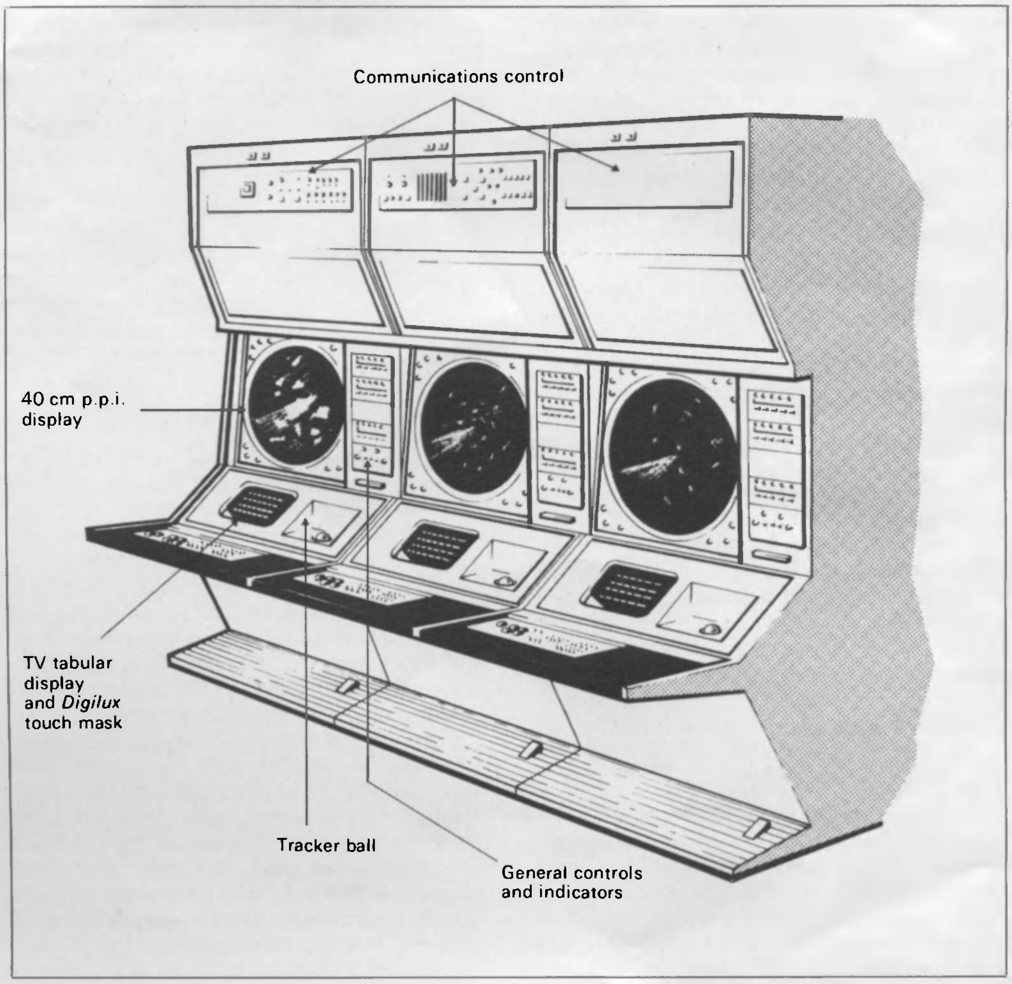
In equipment terms Marconi's LOCUS 16 processor has been designed and engineered to meet this specific need. It consists essentially of a short high-speed 'highway' into which can be plugged directly a series of boards performing the function of arithmetic unit, storage, input/output devices, drives for different types of display and other peripherals, etc. The boards themselves have multiple connectors on either edge, one edge providing a direct plug-in to the highway, and the other performing a dual function: firstly, through a connector, a means of cabling to peripherals; and secondly, by prewiring within the connector, a means of providing varied operation from the same basic board—which has very obvious advantages. Logistically very few varieties of spare elements can serve a multiplicity of applications. For example, the same basic store board can be adapted to fulfil different addressing requirements, merely by connections on the front edge.

LOCUS 16 is much more adaptable than a general purpose 'mini' computer, since it can be assembled, off the shelf, into hundreds of different configurations with a high degree of commonality of basic elements. On the other hand, the mini' may only exist in a few variants, and will require to be backed-up with a miscellany of drives and input/output devices before it can be a full processing system. Furthermore, LOCUS 16 is very simply extended or reconfigured by the addition or substitution of boards. As technology advances the system can be simply up-dated by replacement units, thus keeping the system, as a whole, abreast of device development.

The choice of whether a central processor is necessary at all, rests with the system designer. In smaller systems it may well be

* Mr. J.W. Sutherland is associated with Marconi Radar Systems Ltd. in Chelmsford, England.

► A schematic representation of the basic unit of Marconi's modular distributed data processing system. It consists of a three position console, with an ancillary position for a video data terminal and keyboard. In this versatile concept, each console can be configured to an appropriate function almost instantaneously by software means.



superfluous while in larger systems there are probably two reasons for retaining a central processor: first, quite a simple processor to maintain a system data-base holding a general assembly of key information, gathered and updated from various locations in the system; and second, for the occasional major calculation ('number crunching'). The key feature of such a 'database' in a central processor is that the information contained is of course also fully preserved elsewhere in the system.

Consider this concept of distributed processing in the context of air defence. In the majority of air defence systems, the data handling tasks to be performed are:

1. the collection, correlation, sorting, storage and distribution of data;
2. the building-up of both an overall picture of the air battle situation for Command use, and detailed pictures of each sector, or function, of the battle area to enable a variety of control operations to be performed;
3. the basic 'command' functions, such as interception control, weapon control, recovery etc, each with subsidiary functions, involving threat assessments, identification etc.

New requirements

Recent experience has reflected some degree of change in operational philosophy, in particular to deal with a very large volume of activity at very short notice — e.g the necessity to deploy virtually one's total resources of weapons and interceptors at the very outset of an engagement as a counter to an attempted pre-emptive strike. Therefore the control functions must be relatively simple, totally reliable and extremely flexible. What does this mean in system philosophy? One would suggest that it needs a high degree of automation of the functions mentioned whilst retaining the option of manual intervention should the need arise both in 'command', where decisions of a strategic and very broad tactical nature are made, and in 'control' where intervention in detailed tactics is appropriate. Thus, the human operator must still be at the heart of the system, even though the whole of the air battle may be automated to the extent that it could be conducted in a 'hands off' mode. Manual intervention must also be possible at all stages and in all levels of seniority from the Air Defence Commander down to the track supervisor. Therefore, when a completely new concept is being developed, the most important factor is the direct relationship between the person and equipment. How can each operator in the system best exercise his functions (which increasingly become those of supervision and discretion

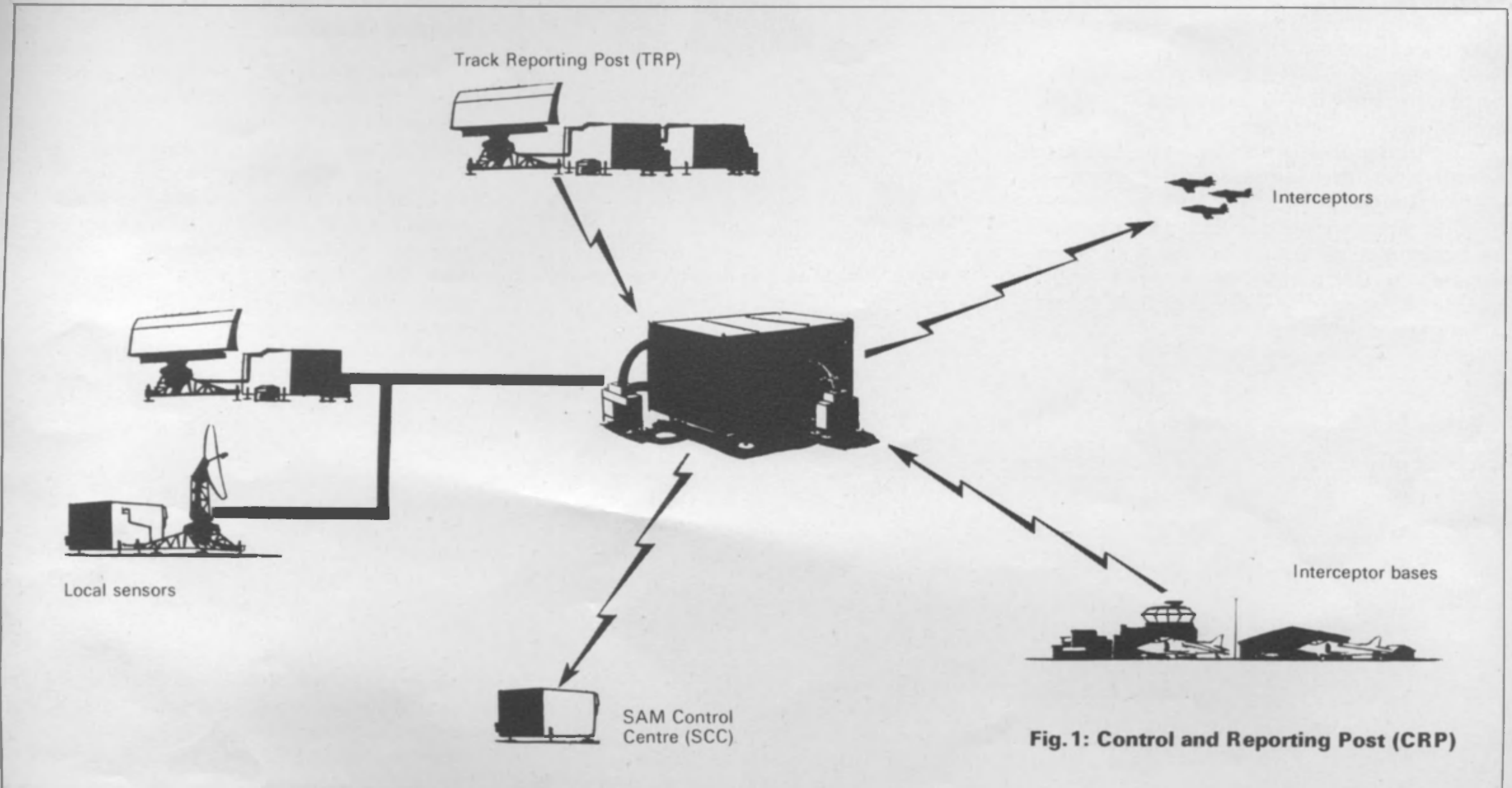


Fig. 1: Control and Reporting Post (CRP)

rather than direct operations) with least fatigue, with the most efficient mental grasp of available data and with the most effective means of conveying his instructions to the system? In short, the over-worked but nonetheless descriptive phrase the 'man-machine interface' is vital. This implies a number of requirements on the system to provide the operator with optimum facilities:

1. rapid access to a wide variety of data, in as much or as little detail as the occasion demands;
2. easy and foolproof facilities for injecting data, instructions, questions etc, into the system;
3. ability to convert a standard layout of operational positions rapidly from one function to another in case of damage or overloading;
4. a fundamentally simple approach to the software which enables individual positions to be highly autonomous from the point of view of design proving, system testing and commissioning, maintenance and up-dating;
5. the facility to include simulation in various degrees of sophistication for various levels of operational training, system evaluation etc.

Examination of a practical working system shows how these criteria can best be realised. The Marconi approach has been the concept of a modular arrangement from which one can build many varieties of air defence environment. The basic 'brick' is a three position console, with an ancillary position for a video data terminal and keyboard. The virtue of this concept is that with distributed processing, each group of consoles or indeed each console, can be configured to an appropriate function virtually instantaneously by software means, rather than consisting of dedicated equipment tailored to, say, track supervision, interception control, recovery etc. A simple section enables any console to take up any function in the system. The design and arrangement of aids to the operator are very significant and derive from many years experience, both in development and operationally in the field, of devices to optimize the operator's performance.

The operator faces a 40 cm p.p.i. display, on which may be displayed raw radar, with a superimposed synthetic picture, track labels, interconsole pointers, map data etc, or which in other situations may be completely synthetic. The operator has a rolling ball for 'pointing' out particular locations, a keyboard for communications and for a variety of other operational functions, and a tabular data display with a *Digilux* touch mask. This device has given a new degree of operational flexibility, for it guides the operator through predetermined but reprogrammable dialogue routines to achieve a desired action, and also provides an efficient and rapid means of data retrieval. Each basic group is then equipped with a full complex of communications — ground-to ground linkage with a variety of other local and remote posts and centres; ground-to-air communication for control and recovery; remote connections to video data terminals for such information as airfield state, meteorological state, civil flight plans etc.

Air defence organizations

There are many possible variants of air defence organization, but for the present purpose consideration is given to three examples of system components which are in line with current strategic thinking in many countries. Control and Reporting Post (CRP), Sector Operations Centre (SOC) and Surface-to-air Missile Control Centre (SCC) are examined to show how they might be interconnected and built up to form a complete national air defence scheme.

Control and Reporting Post — The CRP is normally associated with local radar sensors, but will also take track reports, either manually or automatically extracted from remote radar. The displays in the CRP will probably show local raw radar data, but overlaid with a synthetic picture giving track labels, interconsole pointer, map or geo-grid data etc. The tabular display and touch mask provide the operator with all the facilities needed to call up the types of display required, and to call up stored data on his tabular display. The basic module of the CRP will store target data — position, speed, heading, height, identity etc. — on typically 84 tracks. Some 60 of these will have been locally generated from automatic track-extraction computations with the remainder fed in from associated early warning or gap filling track reporting posts, which may rely on either manual or automatic tracking. The track data stored in the CRP, in most applications, will be filtered and passed to both SOC's and SCC's as appropriate. The CRP is directly linked to video data terminals at interceptor bases, meteorological centres etc, so that information can be directly entered into the CRP data store. There is also a video data terminal within the CRP to enter information, such as that which may be locally derived by voice communication. All data is available to any position; intercept controllers will have the normal facilities plus the ability to rapidly execute trial interceptions to assess the optimum attack. Recovery control and track supervision will be located in the most appropriate way. To increase capacity for intercept, recovery or tracking, a single CRP can be built up of modules to four times the volume mentioned.

The Surface-to-air missile Control Centre — The SCC has virtually the same display facilities and automatic tracking capacity as a CRP but will normally operate on entirely synthetic data generated in linked CRP's or SOC's. Weapon data will be fed in via narrow band links and stored, available for presentation on the tabular displays. A missile assessment program, using track and weapon data, is used to assess the threat and allocate weapons. Constant interchange of data between SOC's, CRP's and SCC's ensures an integrated approach to threat assessment, weapon allocation and target engagement.

Sector Operations Centre — The prime function of the SOC is co-ordination aimed at the most effective utilization of weapons and interceptors. Track and mission data from CRP's, SCC's and other SOC's is semi-automatically filtered and correlated and then displayed for executive control. Up to four modular groups can be associated in an SOC, giving 12 executive positions.

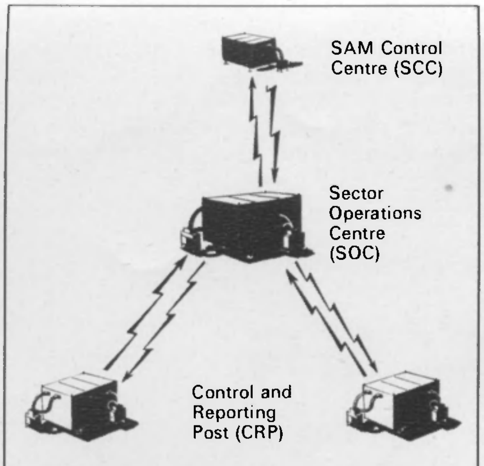


Fig. 2: Single sector operations centre

System Structure

Premutations and variations of system structure are almost infinite but for purpose of illustration three system configurations of increasing complexity are illustrated. Figure 1 shows a small system based on a single CRP, obtaining data from local sensors, one remote track reporting post in an early warning mode and controlling interceptors and SAM's. A medium power system is shown in figure 2. It is based on one SOC, associated with, say, two CRP's and an SCC. Finally, a full system with appropriate communication networks which could be built up into an effective command structure is shown on figure 3. A number of SOC's are grouped to give national coverage, exercised at the highest level through an air defence operations centre. Each SOC could co-ordinate data from up to five CRP's and each CRP could be associated with an SCC, controlling up to eight SAM sites and two Track Reporting Posts (TRP).

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This article has set out to describe, necessarily briefly, how the concept of distributed processing can bring new standards of operational flexibility and cost effectiveness to air defence. ✦✦

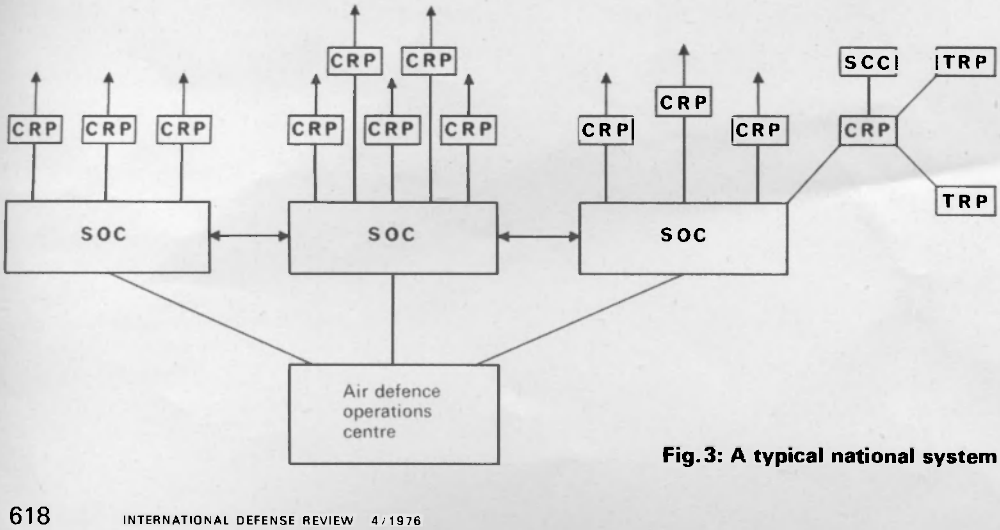

Fig. 3: A typical national system