T H E M A R C O N I C O M P A N Y L I M I T E D

RADAR DIVISION – SYSTEMS 'A'

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OPERATIONAL REQUIREMENTS FOR DISPLAY AND DATA HANDLING- SYSTEMS

At a time when product appraisal studies are being made to assess the technical problems and costs involved in the development of a new generation of' radar display equipment it is felt that these should be closely allied to a consideration of the operational requirements which call for such displays. The following notes have been prepared in an attempt to list possible areas in which new display equipment could be required, especially those likely to make use of S600 series radars.

The impact of the operational environment, especially in terms of communications facilities which have to be integrated into the operator's furniture and equipment cabins, can be considerable and this should be taken into account from inception of the design.

1. AIRFIELD CONTROL RADARS (TERMINAL AREA SURVEILLANCE)

1.1 Permanent Installations

One application which may be met by S600 radars is that of terminal area surveillance at either military or civil airports. For this purpose two to four displays may be required for direct use by controllers in the airfield control tower. Limited facilities such as video map, range arid bearing lines and A.D.F. lines are the only features likely to be requested. Generally the display equipment must be accommodated alongside the control room furniture in a specially darkened area. Bright displays, either D.V.S.T. or scan conversion are regarded as preferable. Control facilities for ground-air and ground-ground communications are required,

1 .2 Transportable Installations

For military use transportable installations suitable for use at forward air strips or temporary take-off pads for V.T.O.L. aircraft may be required. In such an application two displays in a transportable cabin would be adequate but ground-air and ground-ground signals facilities would have to be included to make an effective package.

It is highly unlikely that this application would involve any form of height finding equipment, because co-operating aircraft only are considered and they can report their own heights more accurately than this can be measured.

2. COAST WATCHING RADARS

Simple low cost installations may be required for coast watching radars. No height finding is involved and a simple display system with, say, two displays would be a typical installation. Ground-ground communications, possibly including a digital data link for semiautomatic transfer of information, would be essential. Any semiautomatic extraction of data will add to the diisplay equipment content.

In the past some requirements have included the automatic transfer of full radar information and called for proposals for broad-band video linking. In general broad-band links have proved too expensive; local plot extractors feeding a narrow band link may be an acceptable alternative.

3. MISSILE OR ARMAMENTS RANGE SURVEILLANCE RADARS

Radar Surveillance for safety purposes and for the control of target drones at firing ranges is another possible requirement. For this purpose relatively simple display equipment with two to four displays would be adequate. Height finding may be required and the control of this radar from a simple display system would then become necessary. The simplest approach is by means of range and bearing controls which allow the angular information to be controlled directly by manually operated hand wheels. If X,Y controlled strobes, using joystick or rolling ball, are considered essential then the complexity of the electronic equipment is increased considerably.

The height data may be extracted either by a conventional height range display or by an automatic height extractor. Either of these devices must include compensation to give height above sea level, i.e. allowance must be made for site height, earth curvature and the refractive index of the atmosphere. In a digital system the function of co-ordinate conversion for laying on the height finder and the height calculation may be combined in one unit. To meet the requirements for more extensive ranges it becomes necessary to integrate the surveillance radar with T.I.R. systems used for missile control. In this event the amount of equipment increases and the system becomes similar to that for Tactical Control Radars described in one of the following sections. The main difference which will arise is that the range equipment nay be deployed as a fixed installation.

4. EARLY WARNING REPORTING POSTS

In this category we can include the requirements of early warning in forward areas, gap filling for main surveillance elements over arcs obscured by topographical features and stations specially arranged for detection of low fliers. Height finding radars may or may not be required depending upon the particular role. The tracking capacity for such systems is generally limited to something in the order of ten to twenty aircraft and since the radars form part of an overall defence plan it is necessary to transmit the data gathered to a main centre where it can be utilised.

An essential element of the system is therefore an adequate ground to ground communications network for inter-unit linking. Track telling by manual means is slow and laborious, incurring significant time delay before reaction to a threat is possible. Automatic methods using plot extraction would be ideal, but probably not acceptable economically, but at least semi- automatic transfer ought to be available. This would allow operators at the early warning stations to mark targets, obtain heights on such targets and have the data transferred over narrow band data links. In such an arrangement one operator may be expected to handle four to six tracks. Thus a minimum solution might be provided by a small system with three or four PPI displays.

If autonomous operation with limited control facilities for manned aircraft interception is required then one of the displays may be used for manual control action. The communications facilities must then be extended to provide ground to air radio links with the appropriate transmit/receive and frequency channel controls, and additional ground to ground communications to the fighter base or bases.

5. TACTICAL CONTROL RADARS

Another specific requirement is the provision of Tactical Control Radar Systems providing the surveillance element in a surface to Air Weapons Complex. In this case long range detection of aircraft and provision of information for laying on the Target Illumination Radars is necessary. Conversion of data gathered as X,Y geographical co-ordinates of plan position and height into range, bearing and elevation angle relative to the surface to air missile launch posts and its transmission to the appropriate site is the operational requirement. The data rate of the radars, the frequency at which co-ordinate calculations are required and the data link message rate are all dependent upon the S.A.M. system parameters including the minimum acquisition range,

maximum closing rates and maximum crossing angular velocity. Various systems may therefore have very different arrangements of control organisation. Typically six to eight operator positions may be required to cater for a S.A.M. battery command post. A digital computer is almost essential for weapons systems which require the acquisition data to be predicted and up-dated several times per second. In this case the computer will control the organisation of display operations, height data extraction, track forming and smoothing and formation of digital data link messages as well as the spherical co-ordinate transformations.

For data display in this application a conventional PPI display with electronic track markers is adequate because, after allocated, the computer output is fed out directly to the S.A.M. site. Specialised control desks are required to permit entry of allocation and control instructions into the computer and there will almost certainly be some tell back of S.A.M. site status into the T.C.R. For validation checks on the input data and a flexible method of displaying the signals from the S.A.M. site it may be convenient to have an electronic data display in addition to the PPI display. Alternatively part of the PPI display area could be reserved for this function.

In addition to the outgoing digital data other communication channels complete with P.B.X. facilities are necessary for inter-unit speech channels for command and administration purposes. These will include the return link, automatic or semi-automatic, to relay information on the weapon status at the S.A.M. site.

This type of system must be transportable, either in the form of mobile vehicles, or transportable cabins if the Army authorities have yet accepted that their survival can be entrusted to movement of equipment by air.

6. TACTICAL AIR DEFENCE SYSTEMS

For the ground environment necessary to support air defence in a tactical role or in territories with a limited threat a small defence scheme consisting of a surveillance radar, either 3D or combination of search and height finding radars as in the S600 Series, is adequate. These systems may be in transportable cabins for tactical role, or in fixed buildings for smaller territories with limited capability to respond to a threat. Equipment designed to the constraints imposed by the need of transportability should be adequate to meet both requirements except for the possible use of larger aerial arrays.

To minimise time delays through the data handling system and secure effective reaction the maximum amount of automation must be introduced. Automatic tracking, under manual supervision, and automatic height extraction would be highly desirable. Economic factors may dictate that, manual track initiation with automatic correction against output from a plot extractor has to be accepted.

Typically, systems of this type may be required to follow 40-50 tracks and allow for control of 6-10 simultaneous interceptions. If plot extraction with automatic correction is available an operationally viable system can be achieved with about twelve PPI displays.

The whole of the display and data handling should be based on a computer organisation; within a transportable system the conventional PPI display with electronic marking must be considered adequate and the low level of lighting an accepted feature of the environment. Since the control operation will be performed by relaying computer generated instructions to the aircraft an efficient dynamic readout is essential and the electronic data display appears to be the best solution.

To perform its function the tactical air defence system must have extensive communications links, both ground-ground and ground-air. These include:-

a. Local P.B.X. facilities.

b. Local maintenance telephone circuits for inter-cabin communication.

c. Local control intercommunication with tied lines for vital functions.

d. External tied lines to airfields for scramble purposes.

e. External switched lines for administration purposes.

f. Teleprinter services to civil airfields, meteorological services,, etc.

g. External tied lines to Air Defence Headquarters for executive command and air situation reporting.

h. External lines to local defence organisations, anti-aircraft batteries, armed services, etc.

i. External lines to local civil organisations, e.g. hospitals, fire services, etc.

j. Multi-channel ground-air speech communication for aircraft control and direction.

It should be noted that some of these services may require radio equipment whilst others may depend on land lines.

7. AIRWAYS SURVEILLANCE (AIR TRAFFIC CONTROL)

For area surveillance of airspace within the jurisdiction of national Air Traffic Control organisations long range primary and secondary surveillance radars are employed. These are generally fixed installations sited at points from which the air lanes in use can be covered to the greatest advantage. If the physical location of the site is not coincident with the site of the Air Traffic Control Centre then radio links or short coaxial cable runs are used to pass the radar data to the centre.

For the display of the information thus gathered there is considerable pressure to use large screen p.p.i, displays which can be viewed in a high level of ambient lighting. Scan-conversion equipment converting radial scan information into T.V. scan is now being used in many installations to give displays of 19" and 22" in diameter. This type of equipment suffers from a number of system problems, e.g. expansion can only be achieved at a loss in resolution if a single converter channel is used. Similarly each set of radar information to be selected must have its own converter. Alternatively full flexibility may be obtained by using one converter with each display position. In addition character writing brings additional problems. The Marconi approach has been leaning towards the use of the D.V.S.T. as a bright display unit compatible with the conventional PPI waveform generation equipment, but at present we are limited to 11″ diameter displays with no markers.

So far as data handling is concerned it would appear that although automation of the flight planning processes is now becoming established there will be little movement towards correlation between active radar information and the flight planning until satisfactory automatic tracking is proven. A plot extractor capable of operation from both primary and secondary radar inputs is an essential step in this direction. The output from this device might then interface with a central computer complex covering all the data handling in the system.

Another part of this type of system is the updating and display of flight planning information. The paper strip has long been acceptable as the main reference but electronic data displays are now being used to supplement the flight strips and it is expected that these will play an even bigger role as more computer facilities become available.

The Air Traffic Control Centre must be supported by a vast amount of communications equipment and the user's console design is usually a special arrangement to suit his own particular situation. Generally the radar viewing unit and the electronic data display have to be fitted into the customer's consoles, To minimise the effect of maintenance staff working on equipment there is usually a desire to have a viewing unit which can be removed for servicing

and all possible supporting equipment located outside the equipment room, or at least behind the consoles where technicians do not interfere with controllers at work.

8. I1AJ0R AIR. DEFENCE SYSTEMS

Major air defence schemes, such as N.A.D.G.E., "Fur Hat", Linesman, etc., normally arrange for the collection of radar data from several radar heads and provide for the exchange of data between centres. Each is usually a specialised project so that the display and data handling system becomes a major development task. As a result special purpose equipment is specified and it is not uneconomic because of the considerable production quantities which are involved. Also the time scale for the whole project is usually adequate to allow for the development and manufacture of equipment to meet the specific requirements.

9. CONCLUSIONS

9.1 Display and Data Handling Systems

Whereas in the past a common PPI unit was capable of meeting the requirements of a wide range of radar applications the advent of new techniques and more sophisticated systems makes this almost impossible. From the foregoing it would appear that the requirements may now be divided into three main categories.

a. Simple PPI displays, either fluoride phosphors or D.V.S.T. without character writing or intertrace marking facilities,

b. Conventional PPI and electronic data displays in a compact integrated console or cabin framework including computer desk and communications facilities, etc., suitable for mounting in transportable cabins. Electronic track markers and display of instructions in alpha numeric characters are essential. Automatic data transfer over narrow band data channel is desirable.

c. Brighter, larger screen viewing units containing limited electronic circuitry suitable for mounting into or alongside the customer's furniture in fixed installations. The remaining electronics can be housed in any convenient form of rack; this does not have to withstand severe shock or wide range of ambient temperature:;,

9.2 Engineering Considerations

If the approaches recommended above are adopted it is essential, that the engineering design should extend to modules giving a complete operational function, e.g. character generator, and hence cut down on the amount of special engineering required on every job as at present. Furthermore, an attempt should be made to obtain a system using several identical major units driven from a simple computer peripheral cabinet, rather than one special purpose back-up which will only suit one particular customer. This approach would cut down the large central core where one failure can put the whole system out of service.

The use of multiple identical units would also reduce the spares holding which can become almost the same cost as the main equipment if one-off special boards are used extensively, as they must be with integrated circuits.

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