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Integrated communication systems for naval ships (ICS3)

Summary

This article discusses the philosophy behind the design of the Royal Navy's third and latest communication system, ICS3. Marconi Communications Systems was chosen by the Ministry of Defence (Navy) to undertake the overall design and development of the system. The Company worked closely with the Admiralty Surface Weapons Establishment in the development to achieve the most advanced naval communications system in the world. The system's advanced modular design gives it great flexibility and already keen interest is being shown by overseas navies in this remarkable system.

Introduction

In the last few years, great strides have been made in overcoming the many technical problems which have long stood in the way when the adoption of modern communication practices have been considered for naval ships. Progress in this field has been made more difficult by the revolution that has recently taken place in the use of electronics aboard ships for more and more functions which had previously been performed by mechanical devices with or without the assistance of manpower.

Unlike the designer of weapon systems, which are physically limited to the parameters of each ship, the communications engineer has a much wider requirement to satisfy as the radio system must be designed to ensure that the ship cannot only operate as an independent unit, but also it must be able to operate effectively with other ships and aircraft which may be part of a task force. In addition, the radio communications system must be capable of operating with other armed services, other national forces and with ships which may only be fitted with existing equipment and facilities. A high degree of reliability in operation has also to be achieved.

System requirements

It is no longer sufficient to determine the number of

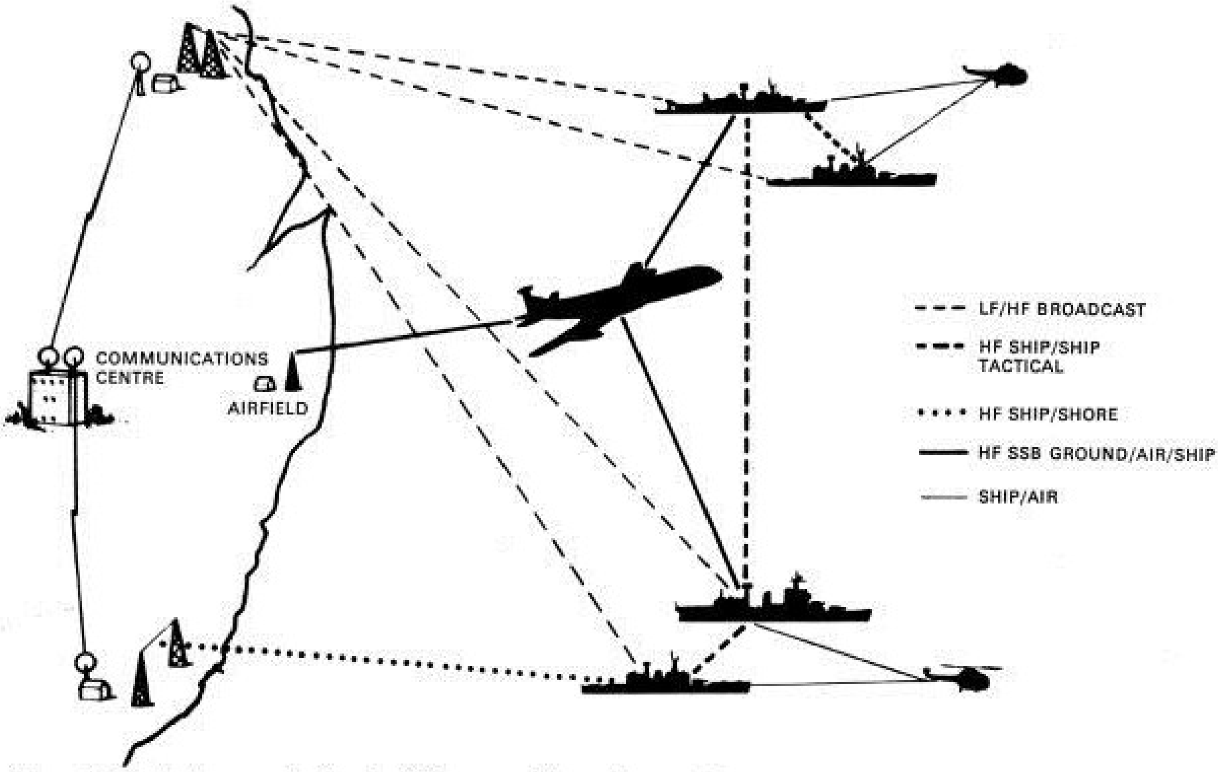

Figure 1. Typical communication facilities covered in an integrated system

radio communications lines required and then to fit the appropriate number of receivers and transmitters chosen at random.

The system should be planned and designed to achieve the desired performance in both electrical terms and manpower requirements as well as lower capital and running costs. Full consideration must be given to the provision of the following basic design:

(1) Simple and accurate means of setting the r.f equipment to any required frequency with a high order of stability.
(2) Reception and transmission of signals on different bearings and elevations over the whole frequency band.
(3) Simplification or preferably elimination of time-consuming tuning arrangements when frequency channels are switched.
(4) Satisfactory operation with a wide range of modes of emission.
(5) Operation in the presence of other weapons systems.
(6) Effective use of equipment provided.
(7) Simple operational methods.
(8) Simple and minimized maintenance.
(9) Efficient message-handling facilities.
(10) Simultaneous operation of co-sited receivers and transmitters.

A few words about item (10) will be of interest. The equipment arrangement and performance must be such that automatic telegraphy, data and voice signals may be received while transmissions, some of which may be high power, take place simultaneously. The high r.f potentials generated by a ship's own transmitters, or from a ship in close proximity, make stringent demands on the dynamic range of the receivers and their associated equipment over both h.f and u.h.f ranges. This situation is common to practically all military operations, but nowhere is it as difficult as in a warship. Some idea of this problem can be obtained by comparing the normal receiver threshold to the voltage induced from a 1kW h.f transmitter. A typical receiver threshold is about 1 μV while the induced voltage (using a 30ft receiving whip antenna) is in the region of tens of volts and can on some existing ships be as high as 100V. (This is equivalent to looking for and at a pinhead in the presence of Mount Everest.)

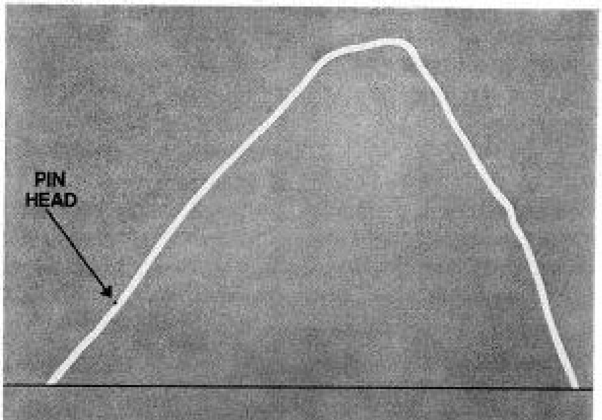

Figure 2. Graphical illustration of the relative levels of wanted and unwanted signals

Future systems capabilities

During the past two decades the Ministry of Defence (Navy) in conjunction with British industry has expended much effort in a programme of changes in equipment designs to provide the Royal Navy with continuous improvements in their communications capabilities.

The latest and most major improvement is the Integrated Communication System Stage 3 (short-title ICS3) which will provide for the transmission and reception of signals with speed and reliability in all types of ship-to-ship, ship-to-air and ship-to-shore, tactical and strategic communications in the l.f/m.f/h.f frequency bands. It also provides the operators' equipment and system interface for communications in the v.h.f and u.h.f bands via satellites.

Included in the system is a comprehensive switching and distribution arrangement which will allow any user to be rapidly switched to any equipment. Also included is an efficient Automatic Telegraph Message Handling system providing electronic storing and sorting of messages, together with visual display and editing facilities.

To produce an efficient system it is obviously necessary for all parties to have a thorough understanding of how the ship is going to be used. Also, it is necessary for a close dialogue to be maintained between industry, The Admiralty Surface Weapons Establishment and other departments of the Ministry of Defence (Navy) in order that new systems are related to modern 'state of the art' techniques rather than past equipment techniques. This dialogue has been vigorously pursued on ICS3 and, in fact, the great majority of the equipment is being designed specifically for the purpose.

The shipborne earth terminal, known as SCOT, which provides the Navy with long-range communications via satellites has been recently introduced to provide high quality, fade-free telegraph, speech and data circuits which are not always possible over long distances using the h.f band.

The new generation of v.h.f and u.h.f equipments including multicouplers and antennas incorporate the latest design techniques to achieve simplicity of operation and maintenance, remote channel selection, high reliability and rapid repair. These objectives have been achieved by the extensive use of silicon integrated circuits, electronic tuning and plug-in modular construction. The multicouplers and antennas have been designed to achieve a high level of linearity to enable up to 12 transmitters (or 12 receivers) to be connected to a single antenna. These equipments are suitable for amplitude or frequency modulation for voice, teletype or data circuits.

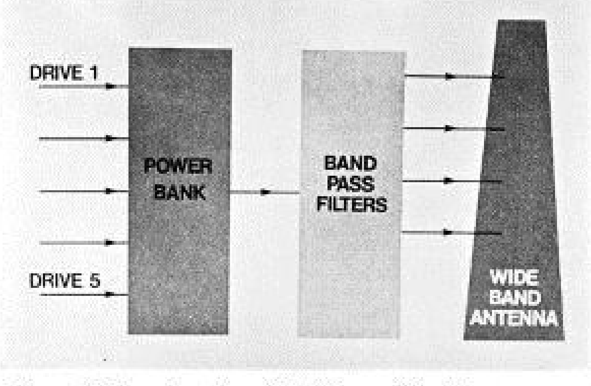

Figure 3. Broad outline of the 'Power Bank' arrangement

Integrated Communications System, Stage 3

Consideration of the Royal Navy's requirements has provided the objectives, and lead to the solutions described in this section. It should be noted that although the total ICS3 system may not be exactly applicable to other navies' requirements, many of the principles and much of the equipment will be directly applicable. The objectives of ICS3 are as follows:

(1) Reduction in initial costs.
(2) Reduced operational costs.
(3) Minimized training, planning and documentation.
(4) Improved performance.
(5) Reduced channel spacing.
(6) Improved distribution and supervisory facilities.
(7) Improved message-handling facilities.

Taking these one by one, the more important aspects of each item are given in the following explanatory notes.

REDUCTION IN INITIAL COSTS

Microminiaturization and other advanced design techniques have been used to provide smaller and more cost-effective equipment.

Radio equipment quantities have been reduced by the use of a flexible switching arrangement which allows any user to be quickly and easily connected to an appropriate radio line, thus permitting a degree of equipment sharing.

The use of amplifiers arranged in a 'power bank' feeding into wideband antennas via bandpass filters provides for varying combinations of high- and low-power channels, and requires no tuning or antenna-exchange facilities. If the channels required are mainly low-power channels, the number available can considerably exceed the number of amplifiers in the 'power bank'.

REDUCED OPERATING COSTS

Operator and maintenance manpower requirements are reduced by:

(a) Equipment design principles such as the 'Power Bank', good receiver automatic gain control and automatic drive level setting arrangements, which eliminate the need for variable controls and permit fast channel switching.
(b) Reduction of operator controls to the bare minimum, centralizing these controls and making them self-evident.

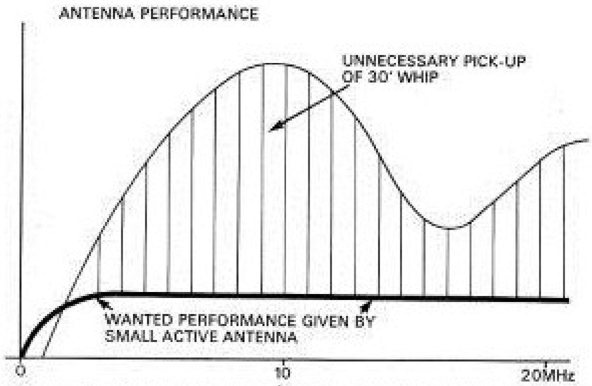

Figure 4. Performance comparison between a 30ft whip antenna and a small active antenna system

(c) Simple operational test and checking facilities.
(d) Simple equipment test procedures.
(e) Repair by replacement of easily interchangeable sub-assemblies.
(f) The use of an efficient message-handling system.

MINIMIZED TRAINING, PLANNING AND DOCUMENTATION

A close 'family likeness' between ship fits is achieved by a limited number of system packages each of which comprise a varying number of identical common equipments. This, together with the simplicity in operator controls, operation and equipment testing and repair previously mentioned, will enable major reductions in the training, planning and documentation areas. Industry is providing the handbook and installation documentation in parallel with the design and production activities.

IMPROVED PERFORMANCE

The improvements are not confined to the technical performance of the system but extend very much into the man/machine interface area in relation to operational use and maintenance. In fact the major technological improvements are aimed as much at improvements in the operational use of the system as they are to the system performance itself, for example:

(a) Simple and rapid channel frequency selection is provided either centrally or at the appropriate user positions.
(b) Modern methods are provided for the reception, transmission and relay of signals by automatic telegraphy.
(c) Message processing and handling including display units, high-speed printing and direct message distribution to high-speed copiers in selected areas of the ship.

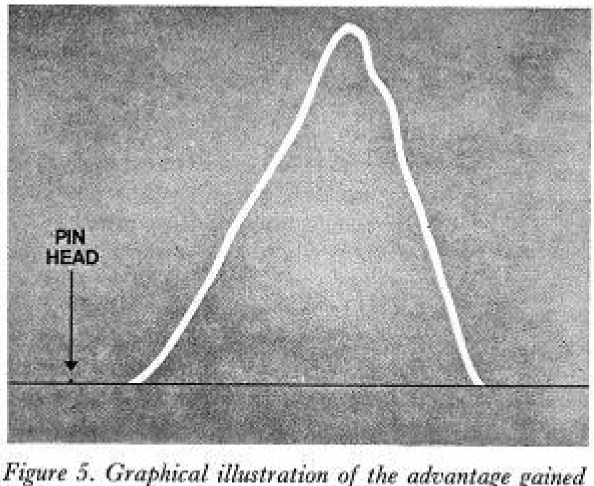

Figure 5. Graphical illustration of the advantage gained by using a small active antenna and improved receiver and drives

REDUCED CHANNEL SPACING

A reduction in the minimum permissible channel frequency spacing in the h.f band permits more flexibility in frequency planning and reduces problems of mutual interference. This is achieved as follows:

(a) Use of a receiver antenna system comprising a small active antenna and a distribution amplifier. This system considerably minimizes the pick-up of own ship's transmitter voltages, but maintains reception performance substantially constant over the frequency range (Mount Everest has been reduced to 1000m).
(b) Increased dynamic range of the whole receiving system.
(c) Minimized spurious responses of the receiver.
(d) Improved wideband noise spectrum of the frequency synthesizer.
(e) Improved noise and spurious performance of the transmitting system.

(The latter points effectively make the mountain thinner and thus permit clear observation of the pin-head.)

These improvements have been achieved by the design of new, very high performance, h.f receiver and drive equipments.

IMPROVED DISTRIBUTION AND SUPERVISORY FACILITIES

A central distribution matrix, housed in the Main Communications Office, allows any user line to be rapidly switched to any h.f, v.h.f/u.h.f or SCOT equipment line by pressing the appropriate pushbutton switch. An adjacent mimic panel shows the state of readiness of all equipment lines and permits centralized channel frequency selection to be carried out. Circuit performance checking facilities are also provided.

A secondary relay matrix in the operations room permits users to switch rapidly between communication circuits by the use of remote line switching units.

Voice processing and control facilities are provided at each remote user position.

IMPROVED MESSAGE HANDLING FACILITIES

The facilities provided vary according to the size of system package but may include any or all of the following:

(a) Visual display unit operation with editing facilities.
(b) Direct or real-time method of operation.

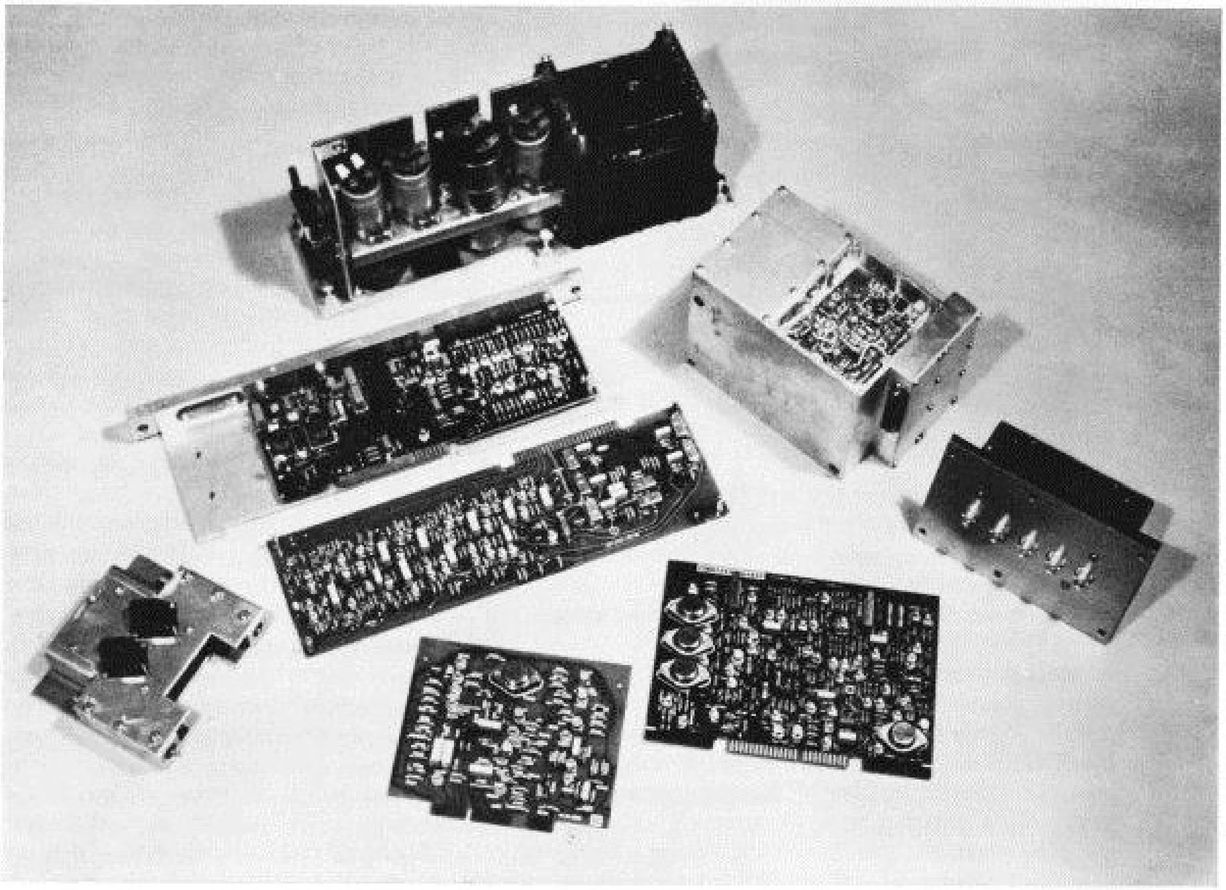

Figure 6. Sample of replaceable sub-assemblies

(c) Storage of both incoming and outgoing traffic.
(d) Detection and storage of message in solid-state stores in order of precedence, including 'Flash' message alarm.
(e) High-speed printing of journal and message file copies.
(f) High-speed printing of message copies for internal distribution.
(g) Direct message distribution to high-speed copiers sited in selected areas of the ship, for example, the Operations Room.

The Automatic Telegraph Sub-System also provides built-in testing and monitoring facilities to allow for the initial setting up of a transmit/receive circuit and to verify the quality of both transmit and receive circuits.

Some comparison between ICS3 and earlier systems

(1) Channel frequency selection time has been reduced to two seconds.
(2) Message-handling times have been considerably shortened.
(3) Operational manpower requirements have been substantially reduced.
(4) The transmit antennas are now mainly concentrated onto one mast.
(5) Only one 5ft antenna is now required to feed all receivers.
(6) Fault finding and repair have been simplified by the use of replaceable sub-assemblies.
(7) The target mean time to repair is 15 minutes with at least half the channels available even in fault condition.
(8) Channel frequency spacing has been reduced from 10 per cent to $2\frac{1}{2}$ per cent.

Also the system has been designed to accept further improvements as and when available.

Conclusion

This brief article has endeavoured to show the need for and the advantages gained by the system planning and design of naval communications installations which are required to operate to exacting specifications in adverse environmental conditions. The use of equipments selected arbitrarily for such installations often results in operational and performance limitations and also increased costs in both manpower and logistic support.

It has not been possible to discuss in detail the problems of operating transmitters and receivers simultaneously in a ship, nor the many technical improvements that are being introduced to achieve the desired improvement in performance. These will be the subject of a further article in a later number of this magazine.