Containerized communication systems within the naval environment

P. Bickers

Summary For some time Marconi Communication Systems has been supplying mobile and transportable containerized transmitting systems to meet a wide range of applications. Recent work has extended the use of containers from the more traditional land base sites to shipborne applications. Communication systems installed in containers based on the ISO freight standards offer considerable benefits for quick acquisition and installation of major systems. This is especially relevant in time of war when requisitioned merchant ships supporting naval task-force operations require improved communications to meet naval requirements. The use of international standard containers ensures the installation can be carried out in most dockyards using standard transportation and handling facilities.

The use of containers also offers considerable savings in warship construction programmes where the serial activities of installing major weapon and electronic systems can be shortened. Assembly and testing of these major systems in containers can be carried out ashore in parallel with, but independent of, the main ship construction programme. This requires a specialized approach to container design to match the warship's requirements but can yield up to 25% savings in the ship's overall construction time. To optimize this approach the containerized concept must be incorporated from the ship's initial design. On existing ship designs, or during refits, an alternative method is proposed deriving most of the benefit from assembly and testing prior to ship fitting, but without the problems of incorporating large containers within existing superstructures.

P. Bickers

Peter Bickers joined the Marconi Company in 1972 having previously worked in the defence electronics industry for a number of years on the design of communication equipment. This move to Marconi marked a return to Chelmsford for Mr Bickers who was educated at the Mid-Essex Technical College and then commenced his career with the English Electric Valve Company, both within the Chelmsford area. At Marconi he joined the newly formed ICS3 engineering team to set up the section responsible for the system and environmental proving programmes. In 1976 he became controller of the project team responsible for the communications fit for all 12 'S' Class frigates of the Royal Netherlands Navy. Three years later he returned to the engineering department as Naval Systems Manager, which resulted in travelling widely for the Company, with involvement in NATO study groups and in supporting marketing activities. In 1981 he was appointed to his present position of Group Programme Manager responsible for all naval and marine programmes within Defence Communications Division.

Introduction

A previous article in *Communication & Broadcasting* described the increasing use of standardized containers to provide the basic structure for mobile and transportable transmitter systems.[1] The article covered many typical onshore applications, including the use of containers to construct permanent broadcast stations. Similar benefits to those described are also possible in the use of containerized systems on board naval and merchant ships, where they offer considerable savings in time and cost during a ship's installation programme. Space is at a premium on board ship and containerized systems generally will need to encompass the vessel's total communication requirements. These can include both transmitter and receiver sub-systems covering the entire communication spectrum, together with their control, distribution and message-handling subsystems. The complexity and scope of these systems will depend on the type of ship and its role at sea. Container types can be divided into two main categories, standardized and specialized. There is, however, another situation, described later, where a container shell cannot be accommodated on or within the ship's structure, yet many of the advantages associated with containerization can be achieved.

ICS3 containerized system

Marconi Communication Systems has recently completed and delivered a containerized ICS3 naval communications system to the United States Navy (USN). This system forms part of an on-going ICS3 evaluation programme funded by the United States Naval Department and will be used for carrying out evaluation trials at sea on an operational USN warship. ICS3 is a major communications system and is normally installed during building or refit programmes but, in this instance, it was containerized to enable a rapid dockyard installation to be carried out with minimal impact on the warship's services, below-deck accommodation or operational role. The system is installed within two containers which can easily be swung aboard the warship, secured directly to the deck and connected into the ship's services with the minimum of dockside involvement or delay alongside. The containers will be located within the helicopter hangar or secured to the helicopter pad at the rear of the ship.

Although installation in the containers was intended for a trials situation it has aroused considerable interest within naval circles and has emphasized the advantages and flexibility provided by this type of installation. Containerized systems are used extensively in other armed forces but to date they have not been fully utilized within the naval environment. The containerization of major shipborne systems, which enables them to be delivered to the shipyard fully assembled and tested, offers a considerable advantage by reducing sequential activities during a shipbuilding programme. Besides being a positive step towards meeting central governments' increasing pressure to shorten shipbuilding programmes and reduce costs, it also provides a means of saving time and cost during subsequent ship refit programmes by allowing systems to be upgraded through the exchange of system containers on a new-for-old basis.

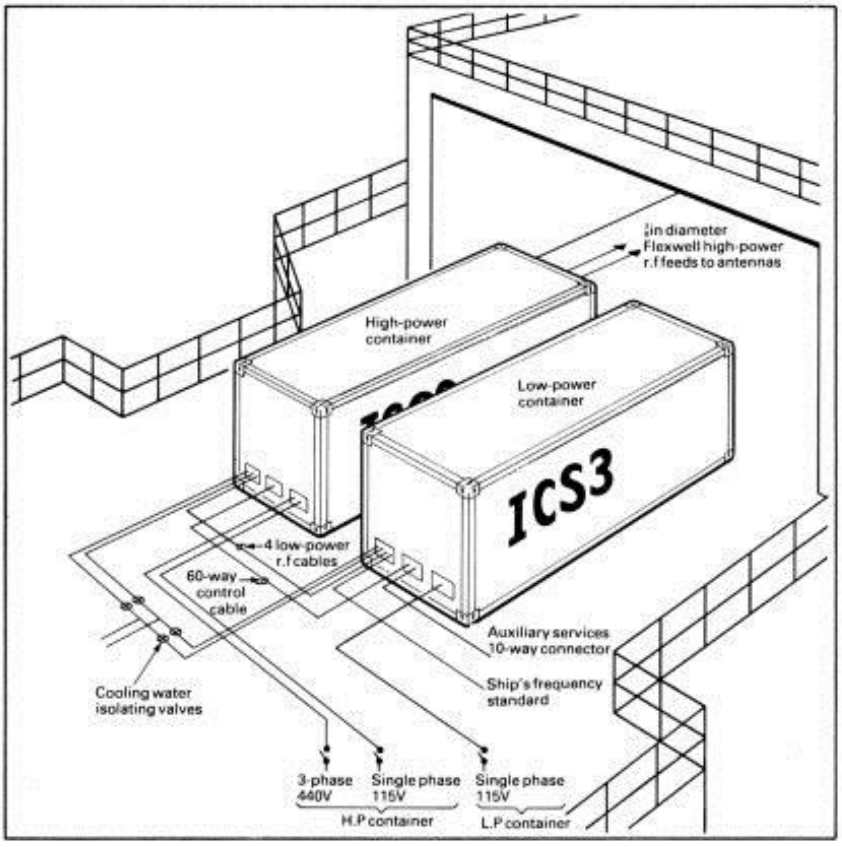

Fig. 1. ICS3 container installation on a USN Ship

The USN installation

The ICS3 system delivered to the USN is representative of an installation for a frigate class of some 3500 tons and provides the full operational flexibility of

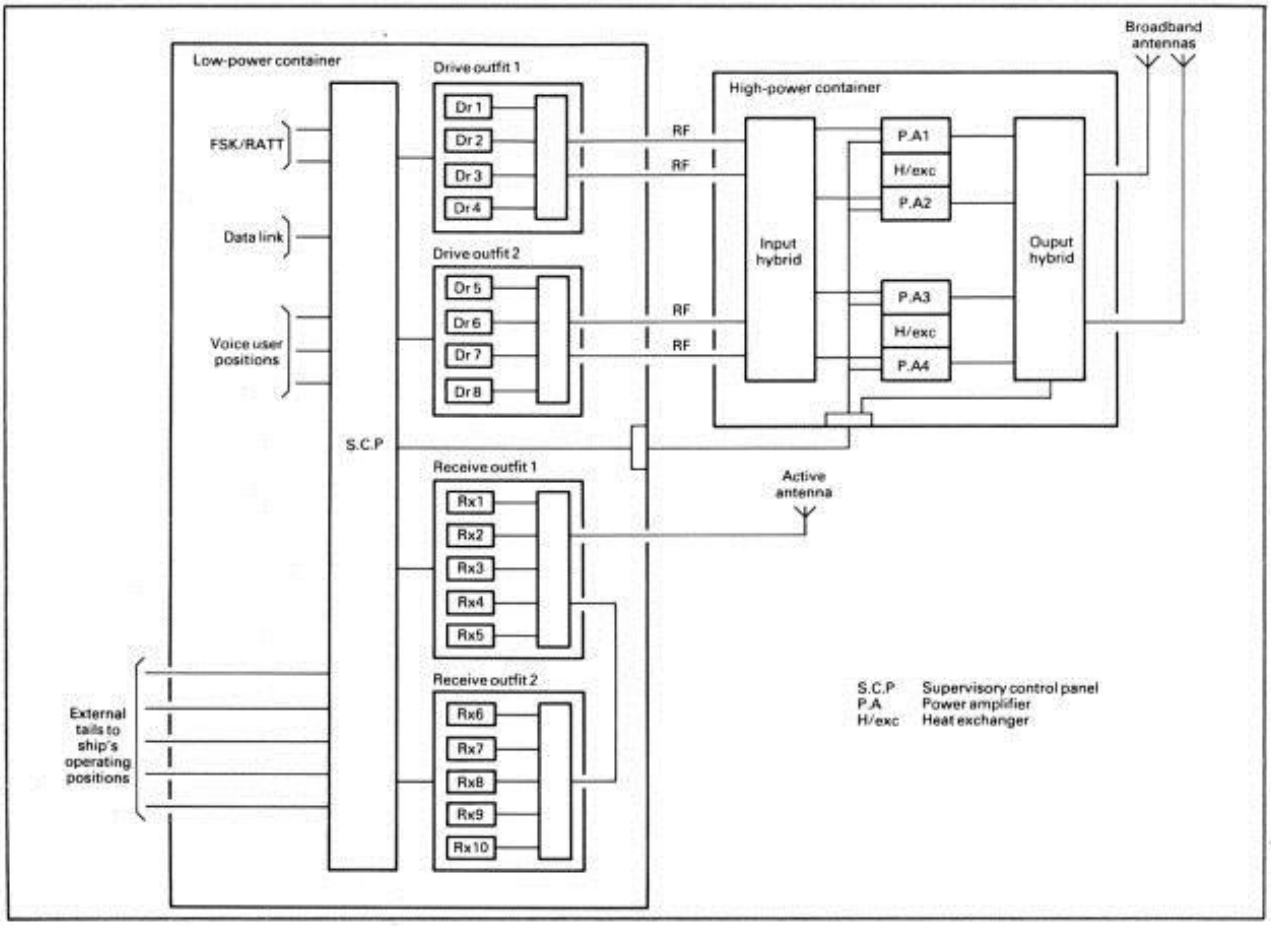

Fig. 2. ICS3 system layout in ISO containers showing typical distribution to base band equipment

an ICS3 communications system. The initial delivery consists of a broadband transmitter sub-system of eight drive units feeding, in parallel, a power bank of four broadband amplifiers and their associated hybrid combining networks. The supervisory and control functions are provided by a centralized supervisory control panel which displays the status of all major equipment in the form of a mimic diagram. This initial system configuration will enable the USN to utilize the full frequency agility and operational flexibility provided by this unique h.f broadband transmitter sub-system. The containers have been designed and fitted out to enable the system to be upgraded to a full installation with the delivery of the complementary broadband receiver sub-system, together with a full supervisory and distribution sub-system, early in 1983. In this instance the system supplied was specifically for h.f communications but there is adequate space for v.h.f/u.h.f, SATCOM, message-handling and extended operator equipment to provide a comprehensive communications package. The extended operator equipment needs only a small six-core cable feed from the container, via a plug and socket connection, to remote command positions within the ship.

The entire system can be self-contained with external power and cooling being provided by a generator set and heat exchanger mounted in an adjacent container or, where capacity is available, these services can be fed direct from the ship's own supplies. The external services required by the two ICS3 containers, detailed in Table 1, will initially be supplied by the ship's own services.

The design of the containers is based on International Standards Organization (ISO) specifications, to which the majority of the world's container freight conforms. This ensures that handling and transportation equipment for the containers is available internationally at all major ports.

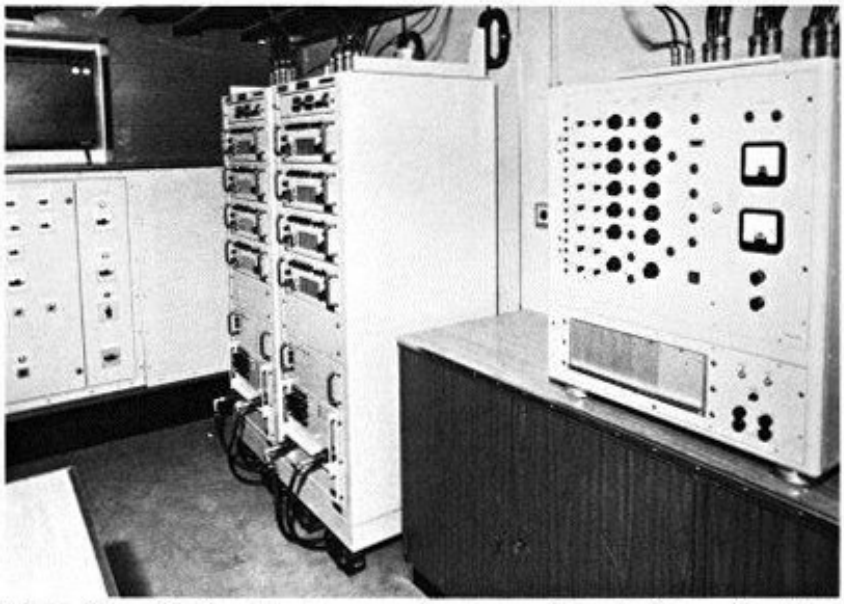

Fig. 3. View of interior of low-power container showing Drive Outfits 1 and 2, with the Supervisory Control Panel in the foreground

Further, by utilizing the design experience gained during earlier container contracts, and the use of standard components, the design and manufacturing cycle were accomplished within a six months period to meet the availability of the USN ship during a scheduled dockyard visit.

Construction

The containers were specified to meet the arduous conditions found on board a warship and consist of a rigid welded steel box-section frame with heavy-duty longitudinal bottom members. A double-skin construction was adopted, consisting of an integral interior aluminium box inside the framework, which provides the main r.f screen, and an aluminium outer skin on the framework which is overlapped and sealed to provide the waterproof outer barrier. The inner skin is isolated from the framework to provide electrical and thermal insulation from the outer skin. This enables the inner and outer skins to form two independent boxes bonded only at the door aperture, to form a Faraday cage construction to minimize the effects of the high levels of electrical interference found on board warships. The gap between the skins is filled with a fire-retardant structural foam to provide thermal insulation and to enhance the structural strength. This results in an extremely robust construction which can withstand man-handling during the installation phase and does not require a specially prepared and level siting once on board. All primary power inputs are routed through r.f filter networks before breaching the inner aluminium skin. These filter networks are mounted in an r.f screened compartment at the end of the containers. The primary power is distributed within each container by local power-distribution boards which provide the means of isolating both incoming power and individual items of main equipment. The entrance door is fitted with a compressible r.f mesh seal and a separate compressible water seal.

The comfort of trials personnel has been well taken care of. They will enjoy a reasonable working environment provided by the integral air-conditioning units, a well-lit interior,

Table 1: External services for ISO containers

Phase	Service	Low-power container	High-power container
Initial transmitter system	3-phase 440V 60Hz		40.4kVA
	Single-phase 115V 60Hz (primary)	9·1kVA	6·7kVA
	Anti-condensation heaters	0·81kVA	1·1kVA
	Cooling water 7°–14°C	131 US gal/hr	867 US gal/hr
	Frequency standard (1MHz)	320mW into 50Ω	
Future receiver system extension	Single-phase 115V	3·8kVA	
	Cooling water	131 US gal/hr	

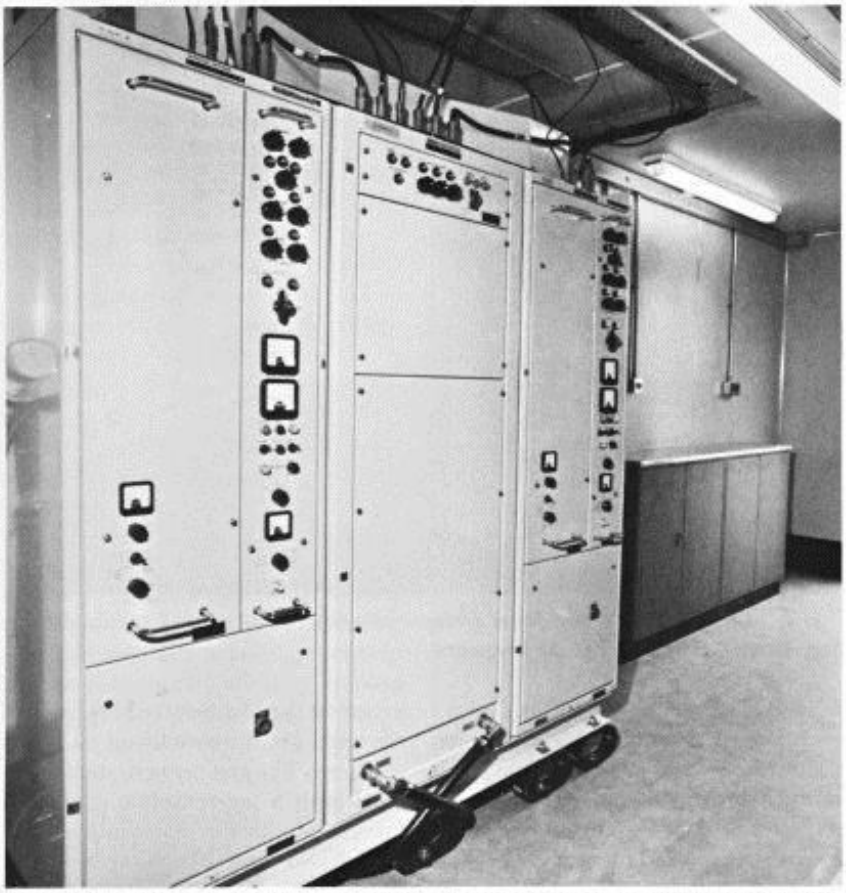

Fig. 4. View of interior of high-power container showing part of the power-bank configuration

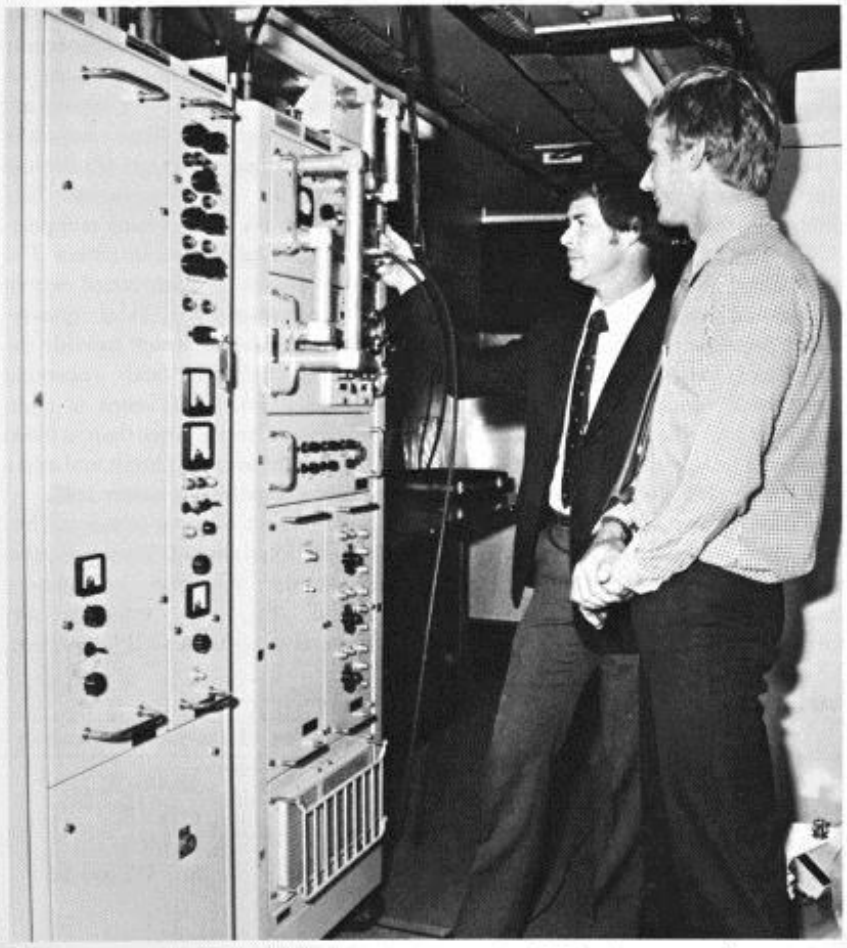

Fig. 5. Final acceptance of the containerized system by USN project personnel

wipe-clean wall cladding, ample cupboard space and sufficient desk and worktop areas. The main ICS3 communication equipment is installed to full warship requirements with all cabinets mounted on shock attenuator mounts which allow the containers to be hard-mounted directly to the ship's structure.

Standardized container systems

This form of containerized communication system, using standard ISO type containers, offers considerable advantages when a situation arises requiring a rapid system installation or upgrading. Such a situation would arise when merchant shipping is requisitioned and deployed to support naval task-force activities. Containerized communication systems procured in readiness for such a contingency would provide the means of rapidly upgrading the merchant ships' communications to be compatible with naval requirements. An excellent example of this situation was the urgent assembly of the merchant contingent for the recent Falklands Task Force. Container ships, liners and car ferries were requisitioned, fitted out and loaded in a very short time. The conversion from peacetime activities into naval-force support ships was a massive task with some ships turned around in as little as 72 hours. Communications were upgraded where possible but full compatibility was not always possible within the time available and many ships sailed with limited task-force communications compatibility. To speed up this exercise, some ships were upgraded by the use of army or air force containerized equipment, which is a common method of acquisition within those two forces. The availability of containerized naval communications equipment specifically for this purpose would have proved a great advantage, especially to the large merchant ships with the capability to support major task force actions such as the San Carlos landings.

NATO interest

This type of installation also fits in well with recent naval thinking within NATO, where considerable interest has been shown in the United States

project ARAPAHO, which is studying the feasibility of using merchant ships as a rapid deployment defence force, and in a Shipborne Containerized Air Defence System (SCADS), a British Aerospace concept which uses standard ISO containers to house missile and radar weapon systems.[2] Such ships would be quickly converted to operate air support VSTOL aircraft and anti-submarine helicopters from a platform laid along the top layer of deck-mounted containers. To support their new operational role these ships will require extensive tactical communications, which, if installed in standard containers, could conveniently be mounted under the operations platform along with other containers housing maintenance workshops, armaments, aircraft spares and operational accommodation.

To achieve a quick response to an emergency situation, containerized systems will need to be procured in advance and stored together with detailed installation kits and drawings for potential shipfits. Specifying a standard container system, or a limited range of systems, will ensure communications compatibility and also will enable the method of installation to be standardized. Ships can be prepared to receive these standard containers during routine peacetime refits or during new ship construction. To ensure their state of readiness, the containers would be stored with power available to maintain the equipment conditions and to allow periodic maintenance and system performance checks. Alternatively the containers could be used to provide on-shore training facilities or temporary coastal installations, ensuring the readiness of operators as well as equipment when required.

Installations should not prove difficult as most modern merchant ships and dockside facilities can handle the standard ISO containers. Naval dockyard facilities would not be required and in an emergency the containers could be deployed by air-lift to the nearest friendly country for installation in a local dockyard, rather than having to wait for the ship's return to a home port. Once secured aboard, the installation work is limited to providing essential services, that is, primary power, cooling and the outgoing r.f feeds to the antennas, all of which can be carried out by ship crew and the service men posted to the ship.

Fig. 6. Container being loaded for despatch to USA

Specialized container systems

Containerized installations of weapons and electronic systems also offer considerable advantages to warship construction programmes. Within such programmes there are many serial activities where the commencement of an installation task depends upon the completion of a previous construction or fitting-out task. This tends to extend the building programmes and can lead to serious problems where a key task is running late and holding up following tasks. This is especially true when installing the many major weapon and electronic systems. Installation of these major systems in containers would allow them to be manufactured, assembled and tested in parallel with, but independent of, the vessel construction, and offers potential savings to the overall shipbuilding programme. Containerized installations on warships will require a more sophisticated approach as deck-mounted standard containers would be unacceptable as a permanent feature. Blohm & Voss AG of Hamburg has taken the containerization of major ships systems to an advanced stage with its MEKO concept (MEKO=multi-purpose standard ship) and is now using this method of construction for a new range of frigates. The programme of construction calls for major weapon and electronic systems to be assembled and tested ashore in special-purpose containers under workshop conditions, and then to be delivered at the required time to the dockside for installing into the ship. This leads to a considerable saving in time and cost over the more conventional methods of shipbuilding. Blohm & Voss claim that savings of 25% in initial construction time are possible, together with the possibility of additional savings when upgrading systems by exchange of containers as and when required during future refit programmes.

The MEKO frigate installation

Defence Communications Division of Marconi Communication Systems was involved in working closely with Blohm & Voss and its sub-contractors to supply and fit the ICS3 system in the largest MEKO frigate completed to date. This is the Nigerian Navy's NNS Aradu, a frigate of some 3600 tons, completed in 1981.

The communications fit was installed in three containers, one for the high-power transmitter equipment and the other two for the low-power equipment including the supervisory and control sub-system. These last two containers were constructed as open-sided boxes and fitted together in the ship to provide a large radio command centre. The majority of the containers were seated on shock attenuator mounts which isolated the entire installation, and obviated the need to shock mount the equipments individually. Standard connections were provided for primary power, cooling water and ventilation, and these were

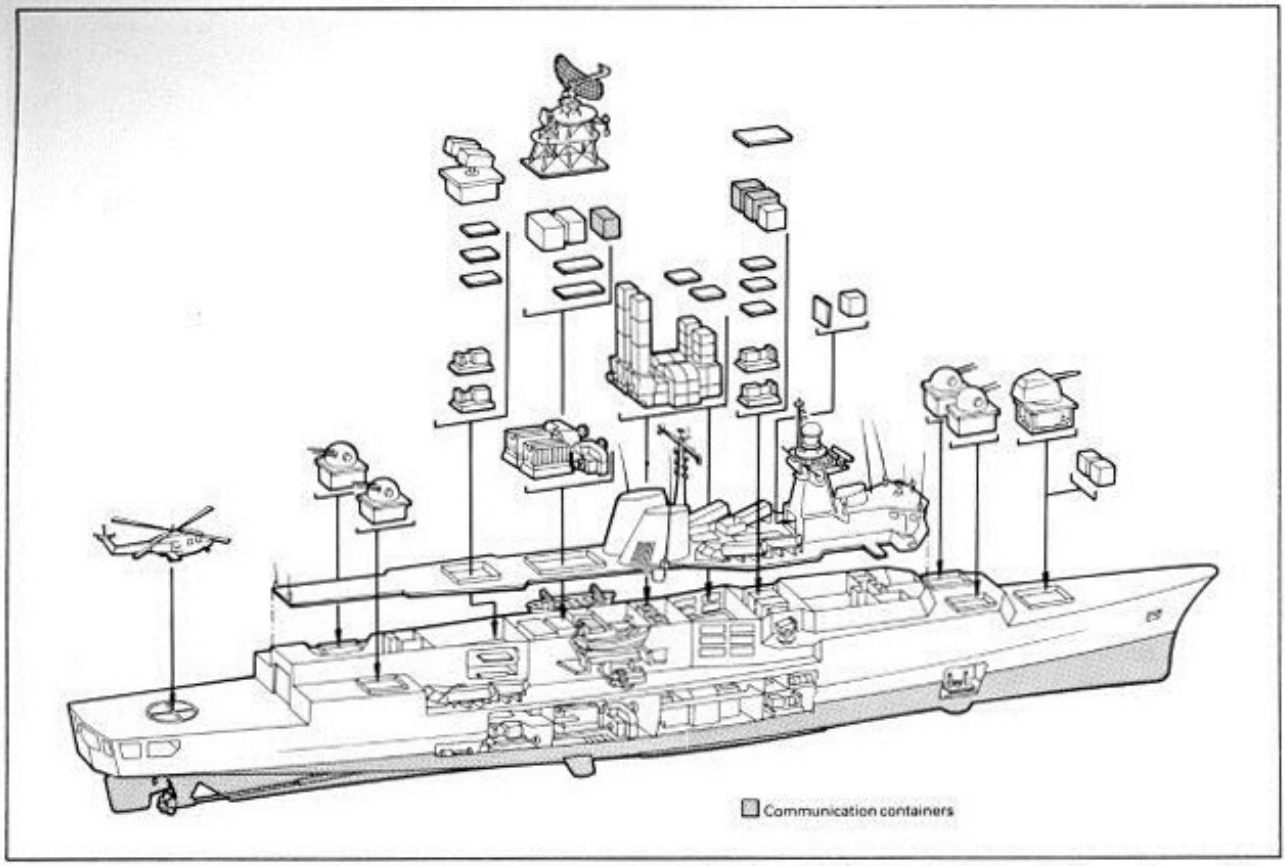

Fig. 7. Exploded view of the Blohm & Voss MEKO Type 360 frigate illustrating the extent of containerization possible in a modern warship

arranged to accommodate the movement of the containers on their mounts.

The containers were fully fitted out prior to delivery and this included, besides the electronic equipment, final surfaces and floor finishes, light fittings, interphone, fire extinguishers and a host of other detailed items. Totally fitting out the containers before ship installation reduced the level of shipyard involvement and enabled the work to be carried out under workshop conditions with higher levels of quality control.

The communications containers were constructed by Blohm & Voss and delivered to its German subcontractor in Kiel for fitting out with ICS3 equipment. Installation and testing at the sub-contractors were carried out under the supervision of a Marconi site engineer. System acceptance testing, including antenna testing, was carried out in the sub-contractor's workshops, under conditions which were far superior to those found on a ship during the construction phase. On completion of the acceptance trials, the containers were delivered to the Blohm & Voss shipyard in Hamburg where they were lowered into their positions, secured to the ship's structure and connected into the ship's services. Minimal work was then required to check out the system using the ship's inter-container cabling, before harbour acceptance and sea acceptance trials commenced.

An alternative approach

The MEKO type of construction offers considerable advantages but it does require the containerized concept to be incorporated from the ship's inception and is therefore limited to new ship designs. It would be extremely difficult to incorporate this level of containerization into ships already under construction or into existing ship's refit programmes. Another approach is therefore required which utilizes the advantages of pre-installed and tested containerized systems but without the physical restraints of installing large boxes into existing ship's structures. The main functions of the container are to house the equipment for handling purposes, to tie the equipment together physically and to reduce the number of items to be transported and installed in the ship from a large number of small items to one or two large boxes. It also allows assembly and system testing to be done in parallel with the main ship-building task, in the knowledge that it is the final assembly and will be kept intact during ship fitting.

Preformed installations

However, assembling and interconnecting equipments into a system and carrying out system tests does not necessarily require a container, so a reasonable compromise is to pre-form the system in an identical layout to the final ship's installation. Equipment is linked on common plinths, cables formed to match the ship's cable runs, and the system set to work and tested all within the manufacturer's workshops in parallel with the ship's construction or refit programme. When complete, the system is broken down into the largest convenient sizes for transport and handling and is delivered to the dockside together with a comprehensive installation kit of preformed cables, pipes, brackets and fixings. This needs to be programmed into the main ship construction programme to ensure minimal delay in installing the system using, if possible, the personnel who broke it down after system tests. Detailed planning should ensure the system is quickly installed and set to work. System acceptance is carried out prior to delivery and a

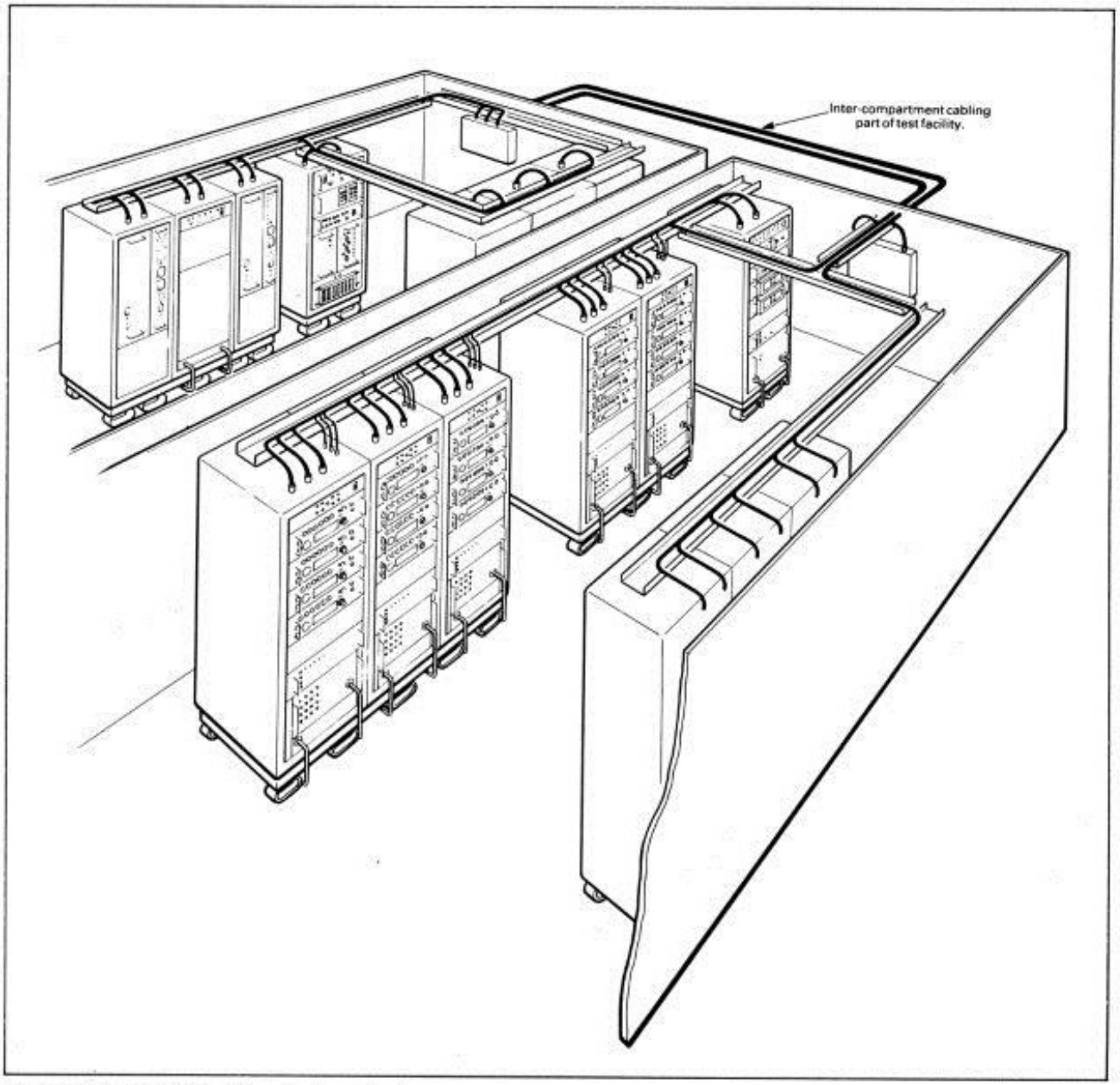

Fig. 8. Typical installation for a pre-formed system

repeat check of important parameters ensures the system is ready for harbour-acceptance and sea-acceptance trials.

ICS3 flexibility

The flexible modular design of ICS3 is well suited to this approach, where cabinet assemblies are all routed back to a centralized control system via easily accessible multi-way plugs and sockets. Cabinet assemblies are normally mounted on common plinths for shock mounting purposes and this provides a convenient grouping of equipment when breaking the tested system down for delivery to the ship. Marconi Communication Systems has pre-assembled naval communication systems in the past and has also carried out acceptance tests prior to delivery. This method has proved successful and has shown considerable savings in time when final installation and setting to work is carried out at the customer's site. These exercises have mainly been first-off trials systems for land-based sites and have been planned and implemented by the system engineering department. However, the principle is the same and, providing responsibilities and co-ordination between shipbuilder and electronics systems contractors are clearly defined, the use of pre-formed systems will offer the possibility of shorter construction and refit times for existing warship designs, where the physical structure prohibits the use of containers.

Further advantages

Clearly containerizing and pre-forming communication systems both offer considerable advantages in shipbuilding or refit programmes but they also provide benefits aside from the main objective. By carrying out system assembly, setting to work and testing within the system manufacturer's facilities, more of his staff such as designers, engineers and workshop personnel become identified with the end use of the equipment to which they have contributed. This allows individual printed-circuit boards or small

units with which personnel are familiar to be identified in relation to the overall system, thus increasing interest and improving commitment to the product. By moving the initial system testing back from the shipyard into the manufacturer's workshop, initial equipment failure modes can be identified at an earlier stage and can be eliminated before they become a problem on board where they are more difficult to deal with. Control over the entire system assembly and testing activity can be carried out by the manufacturer's quality control organization, which ensures that the basic system performance responsibility resides in its rightful place. Pre-delivery system burn-in activities can also be carried out to improve initial system reliability. All of these activities, which enhance the role of the containerized system, can be carried out in parallel with, but independent of, the ship's construction programme.

Conclusion

Containerized systems have obviously much to offer in the naval field for shortening construction or refit programmes, reducing dockside system activities and improving installed system quality.

Acknowledgement

The author wishes to thank Blohm & Voss AG for permission to reproduce figure 7.

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RÉSUMÉ

Cela fait quelque temps que Marconi Communication Systems fournit des systèmes émetteurs mobiles et transportables en conteneurs, s'appliquant à toute une gamme d'utilisations. L'emploi de conteneurs traditionnellement réservés aux installations à terre a, par suite de travaux récents, été étendu aux exploitations à bord des navires. Des systèmes communications installés dans des conteneurs respectant les standards fret ISO présentent des avantages considérables en ce qui concerne la rapidité d'acquisition et d'installation d'ensembles communications importants. Ces avantages sont particulièrement intéressants en temps de guerre lorsque des navires marchands réquisitionnés, pour servir d'auxiliaires aux opérations d'une force navale d'intervention, doivent être équipés de dispositifs communications améliorés et conformes aux spécifications de la marine nationale. Le fait d'adopter des conteneurs conformes aux standards internationaux permet les opérations de montage, dans la plupart des chantiers navals, en faisant appel aux moyens de transport et de manutention standards.

L'emploi de conteneurs permet également des économies considérables sur les programmes de construction de navires de guerre, grâce à l'importance des temps qui sont gagnés dans l'exécution des opérations séquentielles nécessaires pour l'installation d'importants systèmes d'armement et d'électronique. Le montage et les essais réalisés en conteneurs de ces systèmes importants peuvent se faire à terre, parallèlement, mais indépendamment de la réalisation du programme principal de construction des navires. Ceci exige que les conteneurs soient spécialement conçus pour s'adapter aux besoins du navire, mais on peut réaliser jusqu'à 25% d'économie du temps que requière la construction du navire. Pour tirer parti au maximum de cette méthode, il doit être tenu compte du principe conteneur dès les premières études de conception du navire. Sur des navires de types existants, ou lors des interventions de révision, une autre méthode peut être envisagée, qui permet de bénéficier de tous les avantages qu'offre la possibilité de procéder au montage et aux essais avant l'installation à bord, mais qui permet d'éviter les problèmes que pose l'introduction de conteneurs de grande dimension dans des super-structures existantes.

RESUMEN

Hace tiempo que Marconi Communication Systems está suministrando sistemas de transmisión en contenedores, móviles y transportables, para satisfacer una serie de aplicaciones. Además de las aplicaciones más convencionales en emplazamientos terrestres, han comenzado a utilizarse estos contenedores a bordo de buques. Los sistemas de comunicaciones instalados en contenedores basados en las normas ISO ofrecen importantes ventajas a la hora de adquirir e instalar grandes sistemas de comunicaciones. Esto tiene particular importancia en tiempo de guerra, en que los buques mercantes requisicionados para respaldar las operaciones navales requieren comunicaciones mejoradas para satisfacer las necesidades navales.

El empleo de contenedores que cumplen con las normas internacionales permite que la instalación pueda efectuarse en la mayoría de los astilleros, con medios normales de transporte y manipulación.

El empleo de contenedores también ofrece importantes ahorros en los programas de construcción de buques de guerra, ya que permite minimizar el tiempo que se tarda en instalar los sistemas de armamento y sistemas electrónicos. El montaje y pruebas de estos sistemas en contenedores puede ejecutarse en tierra al mismo tiempo que se desarrolla el programa de construcción del buque, pero con independencia del mismo. Esto requiere un enfoque especial al diseño de los contenedores para adaptarlos a los requisitos de los buques de guerra, pero podrá resultar en una reducción de hasta el 25% en el tiempo total de construcción del buque. Para optimizar este enfoque precisa incorporarse el concepto de los contenedores en el diseño inicial del buque. En los diseños de buques existentes, o durante la rehabilitación de los mismos, se propone otro método para obtener la mayoría de las ventajas del montaje y pruebas antes de rehabilitar el buque, pero sin los problemas de incorporar grandes contenedores en superestructuras existentes.

ZUSAMMENFASSUNG

Seit einiger Zeit liefert Marconi Communication Systems fahr- und tragbare, in Container eingebaute Nachrichtensysteme für eine Reihe von Anwendungen. Vor kurzem ausgeführte Arbeiten haben zu einer Anwendungsausdehnung der Container von den klassischen Festlandanlagen zu Schiffbordanlagen geführt. In nach ISO genormten Fracht-Containern eingebaute Nachrichtensysteme bieten beträchtliche Vorteile beim schnellen Anschaffen bzw. beim Einbau grösserer Nachrichtensysteme. Besondere Geltung erreicht dies in Kriegssituationen, bei denen zur Stützung von Kriegsmarineeinsätzen beigetriebene Handelsschiffe einen verbesserten Nachrichtendienst benötigen, um den Forderungen der Kriegsmarine zu entsprechen. Durch die Verwendung international genormter Container lässt sich der Einbau dieser in den meisten Werften mittles normaler Transport- und Fördergeräte verwirklichen.

Der Einsatz von Containern führt auch zu beträchtlichen Ersparnissen bei Bauprogrammen für Kriegsschiffe, u.zw. durch Verkürzung des nacheinander ausgeführten Einbaus der Haupt-Waffensysteme und der dazugehörigen Elektronik. Montage und Prüfung dieser, in Containern befindlichen, grösseren Systeme kann an Land und parallel mit, jedoch unabhängig von dem Haupt-Schiffbauprogramm ausgeführt werden. Das erfordert eine speziell auf die Anforderungen des Kriegsschiffes gerichtete Container-Konstruktion, kann aber die gesamte Bauzeit des Schiffes um bis zu 25% senken. Zur optimalen Ausnutzung dieser Idee muss das Konzept des Containers bereits bei der grundlegenden Planung des Schiffes vorliegen. Bei schon festgelegter Konstruktion des Schiffes bzw. bei Neuausrüstungen wird eine andere Methode vorgeschlagen, bei der die meisten Vorteile durch Montage und Prüfen vor dem Einbau in das Schiff erziehlt werden, jedoch ohne die sich durch das Einfügen grosser Container in bestehende Aufbauten ergebende Probleme.