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Standard Guide for Hardware Implementation for Computerized Systems[1]

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1. Scope

1.1 This guide provides assistance in the choice of computing hardware resources for ship and marine environments and describes:

1.1.1 The core characteristics of interoperable systems that can be incorporated into accepted concepts such as the Open System Interconnection (OSI) model;

1.1.2 Process-based models, such as the Technical Reference Model (TRM), that rely on interoperable computing hardware resources to provide the connection between the operator, network, application, and information; and,

1.1.3 The integrated architecture that can be used to meet minimum information processing requirements for ship and marine environments.

1.2 The use of models such as OSI and TRM provide a structured method for design and implementation of practical shipboard information processing systems and provides planners and architects with a roadmap that can be easily understood and conveyed to implementers. The use of such models permit functional capabilities to be embodied within concrete systems and equipment.

1.3 The information provided in this guide is understood to represent a set of concepts and technologies that have, over time, evolved into accepted standards that are proven in various functional applications. However, the one universal notion that still remains from the earliest days of information processing is that technological change is inevitable. Accordingly, the user of this guide must understand that such progress may rapidly invalidate or supersede the information contained herein. Nonetheless, the concept of implementing ship and marine computing systems based on these functional principles allows for logical and rational development and provides a sound process for eventual upgrade and improvement.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1013 Terminology Relating to Computerized Systems (Withdrawn 2000)[3]

F1757 Guide for Digital Communication Protocols for Computerized Systems

2.2 *ANSI Standards:*[4]

X3.131 Information Systems—Small Computer Systems Interface-2 (SCSI-2)

X3.172 American National Standard Dictionary for Information Systems

X3.230 Information Systems—Fibre Channel—Physical and Signaling Interface (FC-PH)

X3.232 Information Technology—SCSI-2 Common Access Method Transport and SCSI Interface Module

X3.253 Information Systems—SCSI-3 Parallel Interface (SPI)

X3.269 Information Technology—Fibre Channel Protocol for SCSI

X3.270 Information Technology—SCSI-3 Architecture Model (SAM)

X3.276 Information Technology—SCSI-3 Controller Commands (SCC)

X3.277 Information Technology—SCSI-3 Fast-20

X3.292 Information Technology—SCSI-3 Interlocked Protocol (SIP)

X3.294 Information Technology—Serial Storage Architecture—SCSI-2 Protocol (SSA-S2P)

X3.297 Information Systems—Fibre Channel—Physical and Signaling Interface-2 (FC-PH2)

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.A

X3.301 Information Technology—SCSI-3 Primary Commands (SPC)
X3.304 Information Technology—SCSI-3 Multimedia Commands (MMC)
MS58 Information Technology—Standard Recommended Practice for Implementation of Small Computer Systems Interface (SCSI-2), (X3.131.1994) for Scanners
NCITS 306 Information Technology—Serial Storage Architecture—SCSI-3 Protocol (SSA-S3P)
NCITS 309 Information Technology—SCSI-3 Block Commands (SBC)

2.3 *IEEE Standards:*[5]

100 Standard Dictionary for Electrical and Electronic Terms
488 Digital Interface for Programmable Instrumentation
610.7 Standard Glossary for Computer Networking Terminology
796 Microcomputer System Bus
802.11 Wireless LAN Medium Access Control and Physical Layer Specifications
1003.2d POSIX—Part 2 Shell and Utilities—Amendment: Batch Environment
1003.5 Binding for System Application Program Interface (API)
1003.b Binding for System Application Programming Interface (API)—Amendment 1: Real-time Extensions
1014 Versatile Backplane Bus: VMEbus
1101.10 Additional Mechanical Specifications for Microcomputers using the IEEE Std 1101.1 Equipment Practice
1155 VMEbus Extensions for Instrumentation: VXIbus
1212.1 Communicating Among Processors and Peripherals Using Shared Memory (Direct Memory Access DMA)
1394 High Performance Serial Bus
1496 Chip and Module Interconnect Bus: Sbus
1394 32-bit Microprocessor Architecture

2.4 *ISO Standards:*[4]

1155 Portable Operating System Interface for Computer Environments (POSIX)
9945-1 System Application Program Interface (API) [C language]
9945-2 Shell and Utilities

2.5 *TIA/EIA Standard:*[6]

568-A Commercial Building Telecommunications Cabling Standard

3. Significance and Use

3.1 This guide is aimed at providing a general understanding of the various types of hardware devices that form the core of information processing systems for ship and marine use. Ship and marine information processing systems require specific devices in order to perform automated tasks in a specialized environment. In addition to providing information services for each individual installation, these devices are often networked and are capable of supplementary functions that benefits ship and marine operations.

3.2 A variety of choices exists for deployment of information processing devices and greatly increases the complexity of the selection task for ship and marine systems. The choice of a particular device or system cannot be made solely on the singular requirements of one application or function. Modern information processing systems are usually installed in a complex environment where systems must be made to interact with each other. Ship and marine installations add an even further layer of complexity to the process of choosing adequate computerized systems. This guide aims to alleviate this task by giving users specific choices that are proven technologies that perform in a complex environment.

3.3 Hardware resources used in ship and marine installations are a result of careful consideration of utility and function. These resources may require some physical specialization in order to inhabit a particular environment, but they are in no way different from equipment used in shore-based situations. Ship and marine computer system configurations, interconnections, and support services are essentially the same as those found in a land-based network environment and as a result, the skill sets of ship and marine information processing system users, administrators, and support personnel are interchangeable with those of shore-based activities.

4. Standards Profiles

4.1 Standards profiles are sets of specifications bundled together to describe the technical standard for a function or a service (such as operating systems, network, and data interchange services), and will include minimum criteria for the information and technology that support specific functional requirements. Profiles equate to the lowest level process, and document agreed-to implementation requirements used in building and operating systems. Systems using the same standards, but different options, will probably not interface correctly. The Technical Reference Model (TRM) is useful for assembling standards profiles across technology categories of Computing Resources, Information Management, and Applications.

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[5] Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., P.O. Box 1331, Piscataway, NJ 08854-1331, http://www.ieee.org.

[6] Available from ~~TIA, 2500 Wilson Boulevard, Suite 300, Arlington, VA 22201-3834.~~Telecommunications Industry Association (TIA), 1320 North Courthouse Road, Suite 200, Arlington, VA 22201, http://www.tiaonline.org.

4.1.1 The TRM identifies and specifies the support services (multimedia, communications, and so forth) and interfaces that provide a common operating environment and support the flow of information among enterprise and common support applications. This model represents the computer resources, information management, and applications categories and interfaces with the communication and networking technology categories that are appropriately represented by the ISO Open System Interconnect model. The TRM addresses standard profiles that provide seamless application support over widely distributed computing resources and attendant interfaces between the computing resources and other technologies.

4.2 Computing hardware resources represent generally consists of Central Processing Unit(s) (CPU), Input and Output (I/O) interfaces, main memory, buses, and peripherals. The external environment considerations that affect computing hardware resource selection are security, communications, real-time, and high availability. The computing hardware resource provides the environment necessary to support application software. From the perspective of the application software, services are provided by the computing resource, whether the particular services are provided locally or remotely as part of a distributed system.

4.3 The architecture needed to support a typical application consists of computers that perform as clients and servers. The servers host the primary application software and contain the processing power necessary to support multiple users. Servers also host the data needed to support the application. The standard 3-tiered application architecture consists of (*1*) an application server, (*2*) a data server, and (*3*) presentation clients (see Fig. 1).

4.4 In the future, most application processing software will be hosted on the server computers. Clients will use presentation software that connects to the servers using a common interface. At that time, client computers will likely be less expensive and tailored to the user's individual preference because application interoperability will not be a significant factor.

4.5 Today, however, most application software is hosted on the client and interoperability among clients is a critical factor. Even within the client-server application architecture, application specific software resident on the client is still prevalent. This demands consistency of client workstations across an entire installation to achieve seamless interoperability. Table 1 outlines a rationale for the client-server deployment strategy.

4.6 Driven by the current state of client-server technology, the general philosophy for implementing computing resources is the concept of homogeneous clients and heterogeneous servers. Homogeneous clients facilitate providing a consistent interface between the user and the system and make system support and maintenance less complex. Heterogeneous servers support the various computing requirements of applications needed to support ship and marine operations. The same advantages that homogeneous clients enjoy can be achieved if servers are homogeneous as well. Independent of whether or not the server suite employed is heterogeneous or homogeneous, it is important that they perform their function transparently to the user (that is, the user neither knows nor cares about the location, number, or vendor of the server being used.) Requiring servers to be homogeneous would restrict the introduction of new server technology, choking innovation and preventing the installation from taking advantage of advances in computing such as massively parallel processors.

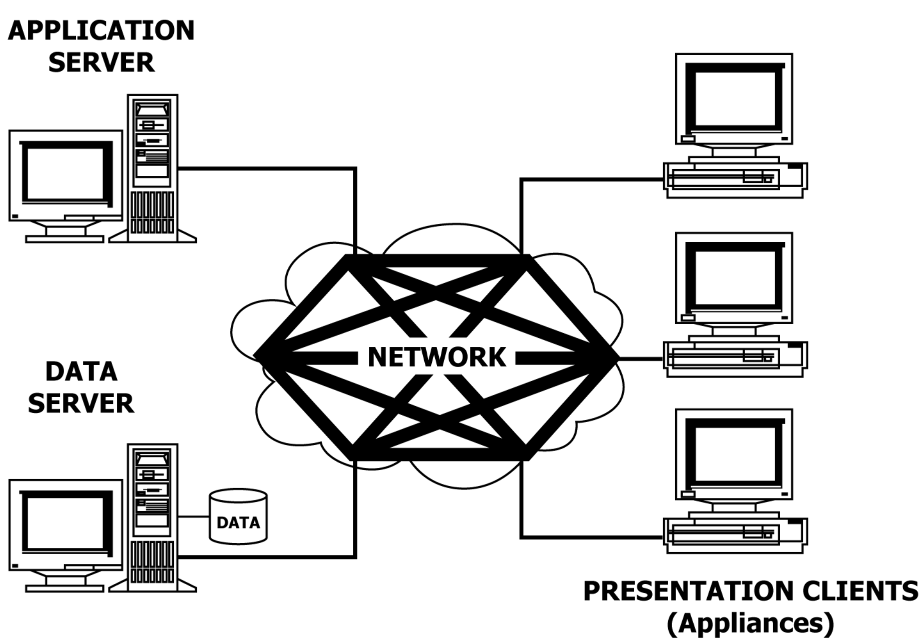

FIG. 1 Three-Tiered Application Architecture

TABLE 1 Client-Server Deployment Rationale

Rationale for Heterogeneous Servers	The server must be tailored to the specific application that may not be supportable by computers most prevalent in the marketplace.
	Many applications work well in their current computing environment and it is not cost effective to change.
	It is not practical to have all applications on a common server for multiple reasons including the need to maintain competition between computer developers and vendors.
	Encourages innovation by not restricting the type of computer used for the development of applications.
Rationale for Homogeneous Clients	Allows for a common, consistent user interface.
	Maximizes interoperability.
	Minimizes re-training required as users transfer to different organizations within the enterprise.
	Maximizes the ability to use common support and maintenance skills, parts and labor; thereby minimizing cost.
	Maximizes portability of support for applications across the enterprise as well as portability of user skills.
	Allows for economies of scale in both procurement (volume discounts) and support (more focused skill set for help desk personnel).

5. Computing Hardware

5.1 *Computing Resources*—Computing resources consist of many computing hardware components and configurations of these components. This section covers the various hardware components that make up a computing resource system and examines how these components are commonly configured.

5.2 *Component Technologies*—The major hardware components of Computing Resources are the Central Processing Unit (CPU), one or more backplane buses, main memory (both RAM and cache), Input/Output (I/O) interfaces, and peripherals. This section will examine each of these areas and provide guidance on the selection of these component technologies as part a computing resource system.

5.2.1 *CPU*—The CPU is the "engine" of the computer system and, combined with the OS (operating system), forms the core of the computing resource. Since the OS drives many decisions concerning the computer resource, a CPU that is compatible with the OS becomes an overriding factor in determining the type of CPU. Other than the OS, the main factors to consider in determining the type of CPU for the computer are processing speed (performance) and cost. For computing resources, such as servers and multiprocessors, scalability of the number of processors can be a significant factor in determining CPU.

5.2.2 *Bus*—The computer bus connects the different components of the computer resource together and allows them to pass data between them at high speeds. Computer resource configurations, such as personal workstations, often limit or determine the type of bus that will be used. Often there are multiple buses connected together to allow for multiple types of component cards or to extend a non-expandable system bus. Considerations in determining the type of bus to use are: number and type of commercial products compatible with the bus architecture, number of parallel data bit lines, clock speed, and cost. Once the appropriate bus architecture is determined, an important computer resource factor becomes how many interface slots are available on the bus for component cards.

5.2.2.1 Use buses that provide the necessary performance economically and are compatible with the board level components that are needed to meet requirements. For buses that provide slots for component cards, use standard buses that are supported by multiple vendors providing compatible component cards.

5.2.3 *Main Memory*—Main memory is the storage warehouse of the computer where data and programs are stored for efficient processing. In the context of this section, main memory refers to cache and RAM. The main factor to consider in acquisition of a computer system is the quantity (in megabytes) of RAM. Other considerations are access speed, mounting design, and parity. Computer systems with too little memory run slowly, won't load, and crash often. Mounting designs today generally provide for easily upgradeable Memory Modules. SDRAM (Synchronous Dynamic Random Access Memory) has long been a standard for memory, but more advanced designs such as DDR (Double Data Rate) and Rambus memory offer better speed and throughput and are rapidly gaining wide acceptance. Older architecture memory designs are generally slower and less efficient and should be avoided to the extent possible.

TABLE 2 CPU Sample Implementations

Clients, Servers, and Special Purpose
Intel Pentium/Celeron
AMD K6/Athlon/Duron
VIA C3/Cyrix
Motorola PowerPC
Transmeta Crusoe
Servers and Special Purpose
MIPS 32/64
Compaq Alpha
Hewlett Packard PA-RISC
Sun Microsystems SPARC/UltraSPARC
Motorola PowerPC

TABLE 3 Sample Bus Implementations

PCI
VME/VXI
SBUS
VXI
CardBus
GPIB/HP-IB
EISA

5.2.3.1 Cache is usually hard wired to the motherboard and has a faster access time than RAM. Computer system caches of 512 KB or larger are generally satisfactory.

5.2.3.2 RAM can often be on a separate memory board and is used to store the OS, applications that are running, and data files. The amount of RAM needed for a computer system can vary with the environment and the OS. Servers generally need about an order of magnitude more RAM than personal workstations. For personal workstations with a 16/32 bit operating system, 64 MB or more of RAM is recommended; for workstations with 32/64 bit operating systems, 128 MB or more is recommended. For servers, use the Network Operating System (NOS) guidelines based on the environment. The three major factors used to determine the amount of RAM for a server are number of user connections, number of processes running, and amount of hard drive space.

5.2.4 *Input/Output (I/O) Interfaces*—I/O interfaces allow the computing resource to move data between the "outside world" and the CPU and main memory. Operations like loading a program or file from a floppy or CD, sending and receiving information over the LAN or WAN, or sending a document to the printer to get a hardcopy use I/O interfaces. Quite often the information is sent to or received from a peripheral, which is discussed in the next section.

5.2.4.1 Use I/O interfaces that use open access standards, support open device connections, and are platform independent.

5.2.5 *Peripherals*—Peripherals provide data access, input, storage, and connectivity for a computing resource. The number of peripherals available on the commercial market continues to explode, generally driven by processor speeds, memory/storage capacities, and I/O speeds. Although there are many different types of peripherals, such as printers, facsimiles, modems, scanners, video cameras, microphones, speakers, and so forth, the main issue in specifying/procuring these items is the compatibility of their I/O interfaces with the computer (see 5.2.4) and application software. Apart from these compatibility issues, the major considerations for acquiring peripherals are cost and performance (which can include both speed and quality). A major category of peripherals is static storage devices. As distinguished from main memory (covered in 5.2.3), static storage devices retain data when the power is off. The remainder of this section will discuss storage devices. Use peripherals that support standard I/O interfaces and are platform independent.

5.2.5.1 *Storage Device Standards*—Storage refers to the capability to store information outside the central processor. For most computers, the predominant technology for storage has been magnetic disk and will remain so for the next few years.

(1) Storage media is the physical material on which data is stored. The choice of media is usually determined by the application needs in terms of data accessibility, storage density, transfer rates, and reliability. Broad industry standards exist for 3.5-in. magnetic disk, 4-mm digital audio tape (DAT), 8-mm helical tape, digital linear tape (DLT), ½-in. tape, and compact disk-read only memory (CD-ROM). However, industry is in the process of agreeing on a standard for Digital Versatile Disk (DVD) which will able to read CD-ROMs as well as the new DVDs. Standards do exist for write once read many (WORM) optical and magneto-optical (MO) disks. Although the physical medium for optical technologies conforms to an open standard, the device's recording format may not.

(2) Archived data on outdated storage media (for example, 5.25-in. floppy disks) should be transferred to media that is more current to avoid data being "trapped" on obsolete media that cannot be read by devices currently on the market.

(3) As networks proliferate and storage requirements expand, storage technology that uses standard interfaces and promotes hardware and software supplier independence is necessary. This technology will enable us to take advantage of the open systems environment.

(4) Implement storage technology and storage device media that use open access standards, support open device interface standards, and are platform independent.

5.2.5.2 *RAID Technology*—Redundant Array of Independent Disks (RAID) technology protects from data loss by providing a level of redundancy immediately within an array. The array contains removable disk drive modules that are automatically rebuilt in the event of a device failure without causing the system to shut down. When RAID levels other than 0 are used, no downtime is required to replace a failed disk drive. Data is continuously available while reconstruction of the failed disk occurs in the background. Much of the benefit of RAID technology lies in its capability to off-load storage management overhead from the host system. To realize this benefit, RAID developers endow their array controllers with significant levels of intelligence. For instance, Adaptive RAID supports multiple RAID levels based on workload characteristics. Choose the RAID level based on your specific need.

5.3 *System Configurations*—The hardware component technologies mentioned in 5.2 can be configured in many different ways to accomplish different tasks and meet different requirements. This section examines some of the common configurations (Personal Workstations, Servers and Embedded Computers) with guidance on what component technologies to use for each configuration.

NOTE 1—Peripheral Connect Interface (PCI) bus is quickly gaining favor as a low-cost preferred system bus architecture. PCI provides the necessary throughput to support the high-end data rates required by many of today's applications. Most commercially available computers come with a PCI bus.

5.3.1 *Personal Workstation*—Personal Workstations (PW) are devices that contain at least one CPU (sometimes several) and provide a user interface, typically a GUI, as well as personal productivity tools, local data storage, and a flexible method for accessing and manipulating data. These PWs are commonly known as Personal Computers or PC's, desktop computers, portables (laptops or notebooks), or workstations and use one of several bus architectures. Low-end PWs are used primarily to support the general office work place. More powerful PWs are predominantly used in high-end computer applications such as Computer-Aided Design/Computer-Aided Manufacturing/Computer-Aided Engineering (CAD/CAM/CAE), application development, multimedia, and decision support data analysis presentation.

5.3.1.1 Also included in PWs are handheld computers—Personal Digital Assistants (PDAs), also referred to as Personal Information Managers (PIMs). Handhelds are computer systems that fit in a person's hand and are extremely portable. Handheld systems also tend to have two types of input methods: pen or keyboard. The pen input can be used as digital ink, a mouse, or for handwriting recognition.

5.3.1.2 Combine components that provide flexible, scaleable, and easy-to-use personal workstations that support the Client/Server model of computing, data access, and multimedia. Allow for an external communication device such as a modem or network interface card.

5.3.1.3 Table 9 provides a quick summary of the nominal specifications for Personal Workstation implementation.

5.3.2 *Servers*—Servers are computing resources that can be configured to support groups from small teams (work group servers) to entire ships (campus servers). Work group servers provide support, such as directory, file, print, and authentication services, in a LAN environment. Campus servers may augment and, for many new applications, replace traditional mainframes. Selecting systems that address and support features and services of both systems management and reliability, availability, and serviceability is important. Campus servers often implement RAID storage technology to provide services with high reliability and availability (see 5.2.5.2).

5.3.2.1 There are different types of servers, performing more specific functions. Some of these server types include: database servers, multimedia servers, data push server, applications server, optical disk servers, and mail servers. A brief description of these servers follows:

(1) Database Servers—Large databases make extensive use of disk space and processor power and typically require their own dedicated database server hardware. Increasingly these database servers have more than one CPU and more than one network interface channel to keep up with the demands placed upon them by large numbers of simultaneous users.

(2) Multimedia Servers—If an installation has a large archive of audio or video data, or if it intends to distribute audio or video data in real-time, it will require a multimedia data server. Archives of audio and video data require huge amounts of disk space. Moving this data over the network (typically through streaming audio or video services and protocols) is also resource intensive. Both requirements typically require the dedicated use of a multimedia server.

(3) Data Push Servers—If an installation implements a data push mechanism for distributing information to internal and/or external desktops, it will have to host that push function on a data push server. Depending on the number and volume of channels being pushed, the data push server software may reside on hardware that is also performing other server functionality (typically the web server).

(4) Application Servers—One option for centralizing system management and reducing total cost of ownership in a network environment is to run the actual application programs on a few high-powered application servers rather than on the desktop clients. This is a common approach in UNIX-based computing environments through the use of the X Windows graphical interface to open display and control windows on one system for an application running on another system. A new variation of this approach brings current Microsoft Windows applications to systems that are under-powered (old 286 or 386 CPU PCs) or that are not running the 16/32 bit based Windows operating system (UNIX workstations, Java Network Computers). This is made possible by running the applications on shared Windows NT/2000 application servers and just sending the user interface over the network to the user's local system.

(5) Optical Disk Servers—With the huge amounts of reference data available on CD ROM and the increasing availability of CD ROM writers for organizations to use to create their own archival data storage on CD ROM, there is a growing need to have multiple CD ROM disks online at once. A new class of hardware, the CD ROM Server, is a stand-alone network device that includes a large number of CD ROM drives which can be made available as shared disks to all users on a network.

(6) Mail Servers—In an organization that has a number of networked PW clients, mail servers provide store and forward functions for electronic messages. These servers receive, store, and distribute electronic messages and require a large amount of storage, proportional to the number of e-mail accounts they carry. They also require numerous network connections and modem connections to receive and distribute messages from/to users and other organizations.

NOTE 2—EISA bus should be used only to accommodate legacy systems.

5.3.2.2 Evaluate servers for their interoperability, portability, reliability, availability, serviceability, and scalability. The capability to easily upgrade processor performance or to add additional processors, disk storage, and communications support extends the life of the platform and enhances the return on investment. Use hardware components that are standards based, primarily those that are compatible with interface bus standards. Select scaleable servers that can increase performance by adding components and by supporting standards-based network protocols. Through the use of a multiprocessing architecture, hardware should be scaleable and should enable parallel processing.

5.3.3 *Embedded Computers*—When readily available computers do not meet the requirements, components must be integrated to form a system. This often involves a design of board level components to perform the necessary functions. The major design consideration is the selection of a back plane bus that will allow all of the components to communicate with each other. This decision can impact dramatically the cost, both in the development and the logistics support of the system. Considerations in determining the bus include availability of components and existing systems bus architectures (to reduce the logistics support costs). Commercially available components should be considered first before custom designing and building the components. When designing embedded computer systems, use industry standard buses and standard components to the maximum extent possible.

6. Cable Plant

6.1 The cable plant includes copper cable and fiber optic cable. Fiber optic cable is the solid media preferred for its current high-capacity (100's of Mbps), future bandwidth potential (Gbps to Tbps), reliability, reduced susceptibility to Electromagnetic Interference (EMI), and security. (Although fiber cannot be made completely secure without encryption or proper physical protection, it cannot be "tapped" without physical manipulation.)

6.2 Fiber optic cable is required to support voice and high-speed data. Fiber optic cable is recommended in other areas where feasible. If cost limits its use, then fiber optic cable should be run at least in the backbone of the network and to major junction points (telephone closets, for example). A mix of 62.5 mm core/125 mm cladding multimode and 8 mm core/125 mm cladding single-mode fiber should be pulled in jacketed bundles, terminated, and tested. The cost avoidance of installing additional single-mode cable is relatively low compared to the future benefits it presents.

6.3 Copper cabling should be avoided in the backbone because it has inherently low bandwidth over significant distance. If copper is unavoidable, it should be limited to areas that can be easily, and inexpensively, rewired with fiber when appropriate. If copper is used, select only properly terminated and tested Category 5 ("Cat 5") cable for cable from the telecommunications closet to the desktop. (Unshielded Twisted Pair (UTP) Cat 5 is the copper standard for data rates up to 155 Mbps.) Thin-wire coax, thick-wire coax, RS-232/422, Category 3 and "telephone" wire should be avoided—the minor cost savings is not usually justifiable because of limited data rates and degraded interoperability. (Allowable exceptions are recognized when linking distant, or otherwise limited-access areas, which are already wired.)

6.4 *Definitions:*

6.4.1 *Trunk Cable—*A trunk cable is a cable that connects two main interconnection boxes or patch panels. It is used to provide connectivity between the service areas of the cable plant.

6.4.2 *Local Cable—*A local cable is a cable that connects a main interconnection box or patch panel to user system equipment or a local breakout box.

6.4.3 *System Specific Cable—*A system specific cable directly connects two pieces of user system equipment, independent of the cable plant. A system specific cable is typically used to connect equipment within the same service area of the cable plant.

6.4.4 *Drop Cable—*A drop cable is a system specific cable between a ready movable piece of user system equipment, such as a PC or printer, and the local breakout box in the area. A drop cable is not considered to be part of the cable plant.

6.5 *Fiber Optic Cable—*Fiber optic cable is the preferred media for all network applications due to its growth potential. (In shipboard and other high Electromagnetic Interference (EMI) environments, fiber optic cable is critical in eliminating the effects of noise.) The backbone network must use fiber optic cabling, as part of the Fiber Optic Cable Plant (FOCP)—twisted pair (shielded or unshielded) or coaxial cable should not be used. Where possible, multimode graded index fiber with a 62.5-micrometre (µm) core/125 µm cladding should be used. Due to the low relative marginal cost, single-mode fiber (8 µm core/125 µm cladding) should be provided in at least the backbone FOCP and preferably to major junction points.

6.5.1 Multimode fiber (62.5 µm) is easier to terminate and test, especially in the field. However, there are distance and bandwidth limitations that cannot be overcome and single-mode fiber must be used. (Multimode fiber can support rates of up to 155 Megabits per second (Mbps) at distances up to 2 kilometres (km). It can only support 622 Mbps for hundreds of feet. Single-mode fiber (8 µm), however, can easily support units of Gigabits per second (Gbps) at up to 30 kms. Further, it can support multiple wavelengths, each operating at units of Gbps. Thus today's single-mode fiber can support tens of Gbps for tens of kilometres. Laboratory tests have shown this limit to be at least 2 orders of magnitude higher, namely Terabits per second (Tbps).

NOTE 3—Although VME bus is more popular, VXI bus offers a greater degree of standardization and therefore a greater degree of interoperability between vendor's products. These are the buses of choice for embedded systems. IEEE Std 1014 applies to VME and Std 1155 applies to VXI.

6.5.2 *Unshielded Twisted Pair (UTP)*—Category 5 UTP cable may be used only for the cabling between the appliance and the network edge device or between the workstation and other network equipment under certain conditions. Shielded Twisted Pair (STP) cable should not be used. The following factors should be taken into consideration when using Category 5 UTP cable:

6.5.2.1 Mission criticality of the application (The UTP copper cable may exhibit a lower availability than fiber due to EMI problems.)

6.5.2.2 Bandwidth or signaling rate (UTP may be used for short runs of 100BaseT, but should not be used at higher data rates or for long runs.)

6.5.2.3 Security level (UTP is easy to tap if not run in conduit.)

6.5.2.4 Length of cable run (UTP should be limited to intra-compartment runs.)

6.5.2.5 Installation factors (UTP requires exceptional care during installation, and should be thoroughly tested.)

6.5.2.6 *Environmental Factors*—EMI (UTP is subject to interference from radar and nearby high-powered equipment.)

6.5.3 In ship and marine environments, UTP cable should meet general flammability, smoke, acid gas generation, halogen content, and toxicity index requirements. Further, UTP should be limited in critical systems to due to EMI, shock, and vibrations (RJ-45 plastic connectors for UTP are not designed to withstand significant shock loads and may crack or disconnect under long-term vibration conditions).

6.5.4 *Legacy Copper-Media Networks*—For installations with copper-based legacy systems, it is recommended that those systems be selectively upgraded to fully integrate users of the backbone network based on capability requirements and funding availability. In ship and marine environments where upgrade funding availability or system requirements cannot support the decision to upgrade the system, connectivity to the ship's backbone network can be accomplished at either the backbone or workgroup switch, providing that those devices can support the legacy network protocols. In such a configuration, the backbone network switch acts as a gateway between the legacy system and the rest of the backbone. If some limited funding for system upgrade is available, and such upgrades suit the needs of the ship, a lower cost interim upgrade would be to replace the legacy copper links with fiber optic links, and integrate those links into the ship's FOCP. This interim physical integration will simplify the further upgrade from a separate legacy system to an integrated network application.

6.6 *Patch Panels, Interconnection Boxes, and Connectors:*

6.6.1 *FOCP Interconnection Boxes*—FOCP interconnection boxes and patch panels should hold a minimum of 48 connector pairs. Interconnection boxes should be sized to accommodate all of the fibers (allocated, spare, and growth) that enter the box.

6.6.2 *Local Breakout Boxes*—Local breakout boxes may be used to provide additional flexibility in locating workstations or easily moved equipment. The interconnection box should completely enclose the fiber terminations. Local breakout boxes should not be used as a substitute for rack-mounted patch panels for the interconnection of rack-mounted equipment.

6.6.3 *Location of Tx-Rx Pairs and Optical ~~Crossover —~~Crossover—*In FOCP Interconnection Boxes, local breakout boxes, and in rack-mounted patch panels, the pair of ST connectors associated with one full-duplex optical circuit should be located in a vertical line, one above the other, with the transmit (Tx) connector above the receive (Rx) connector. In a complete optical link, there must be one (or an odd number of) crossover(s) in order to connect the optical transmitter at one end to the optical receiver at the other end, and vice versa.

6.7 *Connectors*

6.7.1 *Fiber Optic Cable:*

6.7.1.1 *ST-type*—ST-type connectors were, until recently, the standard for all multimode connections. In commercial applications, SC is rapidly becoming the standard. It is becoming hard to find host network interface cards with ST connectors.

6.7.1.2 *SC-type*—SC-type connectors are becoming the industry standard for both host network interface cards and backbone connections. While this is acceptable for multi-mode fiber, it has debatable merit for single-mode fiber. (Pros: more common connector, easier to insert/remove; Cons: can more easily confuse multi-mode with single-mode fiber, if single-mode transmitter accidentally plugged into multi-mode receiver, the receiver could be permanently damaged.)

6.7.1.3 *FCPC-type*—FCPC-type connectors are the standard for single-mode fiber. Many equipment vendors, however, are beginning to use SC-type connectors. Because the risk of accidentally switching multi-mode and single-mode connections exists when the same connector is used for both, it is recommended that FCPC-type be used for single-mode fiber (see discussion in the previous paragraph).

6.7.1.4 *MIC-type*—MIC-type connectors are not recommended for use within the backbone network. However, if MIC-type connectors are the only available option, it is recommended that a MIC-ST jumper cable be fabricated to allow the MIC connector at the equipment interface, but with an ST connector for connection to the FOCP or rack-mounted patch panel. MIC connectors should not be used within FOCP interconnection boxes.

6.7.1.5 *Heavy-Duty Multiple Terminus*—Heavy-duty multiple terminus connectors are recommended for equipment interfaces that require a rugged interface that is easily disconnected and reconnected.

NOTE 4—GBIB is the Standardized version (IEEE Std 488) of the HP-IB implementation developed by Hewlett-Packard.

6.7.1.6 *Mechanical Splice*—Mechanical splices are recommended only for those applications requiring higher optical performance than is available with ST-type connectors. Mechanical splices may be used in interconnection boxes, and may also be used inside rack-mounted patch panels where needed for higher optical performance.

6.7.2 *Copper Cable:*

6.7.2.1 *RJ-45 Connectors*—Category 5 cable specifications limit the connector type to RJ-45. However there are a number of pin-out standards from which to choose. Because ISDN also specifies the use of RJ-45, the ISDN pin-out specification will be used: ANSI/EIA/TIA-568-1991 Standard, Commercial Building Telecommunications Wiring. This variant is designated EIA/TIA T568A (also called ISDN, previously called EIA).

6.7.3 *Ship and Marine Environment*—In ship and marine environments, ST-type connectors are recommended for all light-duty multi-mode fiber applications. ST-type connectors may be used as the interface to equipment if sufficient cable strain-relief and protection are provided. Failure to provide sufficient strain relief and protection will result in connector breakage or failure.

6.7.3.1 Until such time as SC-type connectors are evaluated against shock, vibration, and wear, they are not recommended for use within the backbone network. However, if SC-type connectors are the only available option associated with the network equipment, it is recommended that an SC-ST jumper cable be fabricated to allow the SC connector at the equipment interface with an ST connector for connection to the FOCP or the rack-mounted patch panel. SC connectors should not be used within FOCP interconnection boxes.

6.8 *Topology, Security, and Integrated Cabling:*

6.8.1 *Basic Topology*—The recommended physical topology is a mesh, as opposed to a ring or star configuration. If a logical ring or star topology is required for near-term cost reasons, the physical mesh cable plant infrastructure can be configured to provide the required logical topology. The mesh physical architecture will support the future expansion or upgrade to a full mesh logical topology.

6.8.2 *Network Node Locations*—Node locations should be selected based on the concentrations of current and planned network users. Nodes should be located in secure areas, to preclude unauthorized access to the equipment. Nodes should also be located in temperature controlled compartments, to optimize equipment reliability. Note that there is a trade-off between the number of nodes and the total quantity of local cable required to connect users. These two parameters should be considered in conjunction with the system requirements for survivability when determining the appropriate number of nodes.

6.8.2.1 Users should be connected to nodes within the same fire zone for survivability. Also, the number of nodes installed should be selected to provide maximum coverage of the ship's fire zones, while minimizing the total network cost.

6.8.3 *Patch Panel and Interconnection Box* ~~*Locations* —~~*Locations*—Main interconnection boxes or patch panels should be collocated with the network nodes. For maximum installation and connection flexibility, it is recommended that the patch panels be installed in the same rack as the network node equipment. These rack-mounted patch panels can also be used to provide a convenient means of interconnecting equipment within the same rack, and to provide a simplified disconnect point in the event that racks must be moved.

6.8.3.1 For racks containing connection-intensive network devices, the use of a rack-mounted patch panel should be considered to serve as the interconnection box for that zone.

6.8.4 *Trunk Cable Routing*—In general, trunk cables should be routed along diverse physical paths to ensure a survivable FOCP. The degree of redundant/fail-over equipment is cost-driven but with a proper FOCP mesh, outages can be quickly restored using alternate cable paths.

6.8.4.1 Trunk cables should be routed to provide survivable signal paths between interconnection boxes. In general, each trunk cable should have an identical redundant cable following a separate route between the two interconnection boxes. In addition, the cables should be routed on opposite sides of the ship, with at least two decks separating them vertically.

6.8.5 *Local Cable Distribution*—If a single user has multiple local cables for redundancy or survivability, those local cables should be routed to two different interconnection boxes, and should be separated within 60 ft of the equipment.

6.8.6 *Network Fiber Allocations:*

6.8.6.1 *Inter-node*—Fibers should be allocated for all inter-node connections. The level of inter-node connectivity should be determined based on current technical requirements, future projections of requirements, and overall program cost constraints. In general, it is desirable to include sufficient fiber in the FOCP to allow for full inter-node connectivity in a mesh topology. Any interim logical configurations, such as rings or stars, should also be considered when determining fiber requirements.

6.8.6.2 *Redundancy*—Redundant fibers in survivable separated trunk cables should be provided for each active and spare user system fiber. This is particularly critical in ship and marine environments.

6.8.6.3 *Spares*—Spare fibers should be provided on a 100 % basis; that is, each actively used fiber should have an assigned spare. This is particularly critical in ship and marine environments.

NOTE 5—CardBus is the new 32-bit high performance bus defined by the new PC Card Standard released by the PCMCIA standards body and trade association. The PC Card Standard replaces the outdated PCMCIA version 2.0 and version 2.1 standards.

TABLE 4 Recommended Memory (RAM) Standards

Dynamic Random Access Memory (DRAM)
Extended Data Output Dynamic Random Access Memory (EDO DRAM)
Synchronous Dynamic Random Access Memory (SDRAM)
Double Data Rate Memory (DDR)
RAMBUS Memory

NOTE 1—Extended Data Out (EDO) DRAM was long a standard for mass-market memory, but Synchronous DRAM (SDRAM) is now the standard for currently installed machines. SDRAM is a memory architecture that incorporates many improvements over traditional DRAM technologies. SDRAM is a new technology that runs at the same clock speed as the microprocessor. The clock on the memory chip is coordinated with the clock of the CPU, so the timing of both the memory and the CPU are "in synch." This reduces or eliminates wait states, and makes SDRAM significantly more efficient than Fast Page Mode (FPM) or even Extended Data Out (EDO) memory.

NOTE 2—Even more speed and throughput improvements are being realized with Double Data Rate (DDR) and Rambus Memory; selection of a memory architecture will need to be made according to a careful consideration of cost (particularly over the anticipated service life of a system) and performance considerations.

7. Wireless Networking

7.1 The establishment of standards such as IEEE 802.11 has created the ability of computers to communicate via network protocols without physical wiring. Commonly known as wireless Local Area Networks, this innovation provides practical interconnectivity without the investment or labor required to establish physical media.

7.2 Wireless networks operate on a range of frequencies and bandwidths, with newer systems functioning at 2.4 GHz frequencies and with a bandwidth of approximately 11 Mbs. These networks operate at a range of up to 90 m indoors, and out of doors can operate up to 300 m. Actual communication methods may vary, however, and care must be exercised to ensure that equipment from various vendors is compatible.

7.3 Workstations equipped with compatible wireless networking cards can operate in a peer-to-peer fashion, but in a larger installation a more reasonable design would be to establish distinct Wireless Access Point (WAP) devices that connect directly to the cable plant and act as gateways to the physically wired network and attached servers. In this scenario, wireless workstations may be moved from location to location within a ship and connect to the network wherever a WAP is established. Laptops and PDAs are particularly well suited to support WAP installations, due to their inherent mobility.

7.4 The ability of a wireless-configured device to easily connect to another wireless device or WAP also highlights one of the disadvantages of wireless networks. Security of operating data, services and systems can be seriously compromised in a wireless installation. The 802.11 standard offers an encryption method known as Wired Equivalent Privacy (WEP) but several flaws may be found in the WEP encryption algorithms. A safer method would also involve the use of Virtual Private Networking (VPN) to establish secure communications with wired servers and systems. VPN methods vary, however, and any implementation should be thoroughly researched to ensure that the solution is applicable for all circumstances (wired/wireless, different Operating Systems) and equipment (Servers, Workstations, Laptops, PDAs).

8. Ship and Marine Facility Requirements

8.1 *Racks*—Ship and marine networking equipment should never be installed by setting them upon desks, tables, filing cabinets, etc. Small equipment can be bulkhead-mounted or hung from the overhead; however, the preferable technique for ship and marine installation of standard information processing equipment is in racks.

8.1.1 Suitable racks can be obtained from a number of vendors. However, heavy duty, industrial grade or ruggedized racks should be used, not lightweight racks intended for shore-based office environments. Standard rack widths are 19 in. and 24 in. Nearly all typical networking equipment is designed to fit into 19-in. wide racks. (Note that these are mounting widths; the overall external width of a 19-in. rack is about 24 in., and the outside width of a 24-in. rack is about 30 in..)

8.1.2 Standard 19-in. racks come in several depths, typically 17 in., 24 in., 29 in., and 36 in.. When deciding on the depth of a rack, remember to allow enough depth for recessing equipment that have front-access cabling, and to allow air exhaust space for equipment with rear-facing fans. Many pieces of networking equipment have modular assemblies that are removed from the