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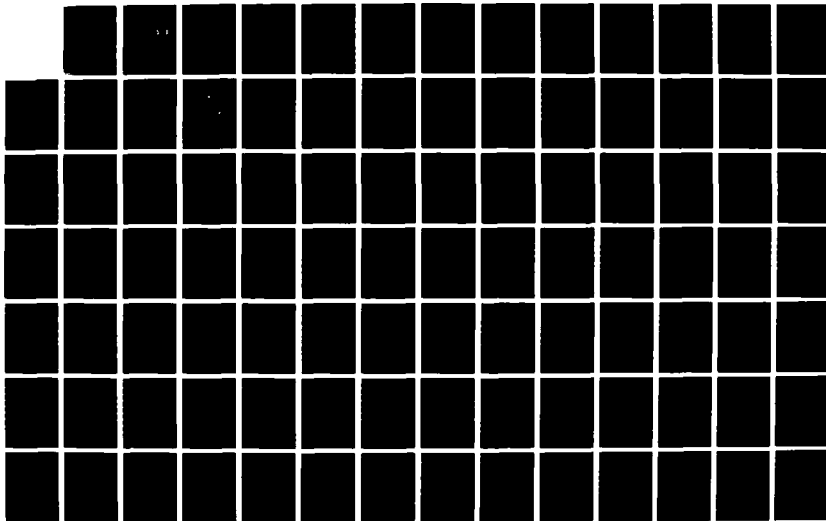
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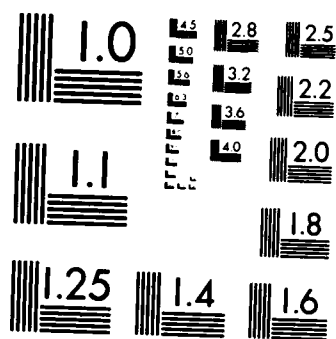
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ASSESSMENT OF DoD AND INDUSTRY
NETWORKS FOR COMPUTER AIDED
LOGISTICS SUPPORT (CALS)
TELECOMMUNICATIONS

Report AL636R1

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Executive Summary

ASSESSMENT OF DoD AND INDUSTRY NETWORKS FOR COMPUTER AIDED LOGISTICS SUPPORT (CALS) TELECOMMUNICATIONS

The Department of Defense is committed to applying the best in modern technology toward improving the transfer of design, engineering, and manufacturing technical information among weapon system contractors and DoD organizations. The Military Services, the Defense Logistics Agency (DLA), the Defense Communications Agency (DCA), and industry are undertaking or planning telecommunications support for such transfer. In view of these many and diverse efforts, the Computer Aided Logistics Support (CALS) Steering Group through the CALS Communications Working Group has recognized the need for evaluating them.

We have undertaken the evaluation and conclude that:

- While CALS data transmission requirements have not yet been fully determined, the Defense Data Network (DDN), as it is currently configured, cannot be used to transmit the anticipated high volumes of weapon systems engineering drawings and technical data.
- Because telecommunications standards have not been fully developed, it is difficult for the Services to undertake policy and implementation strategies for transitioning to the Open Systems Interconnection (OSI) standards.
- While there are intelligent gateway (IG) technology efforts underway to accommodate CALS, most DoD and commercially available IGs have been designed to support transmission of much smaller amounts of information than are usually associated with engineering drawings and technical documents. In addition, an IG architecture for CALS must accommodate the more complex translation requirements associated with graphics and technical data that are not fully addressed in the OSI standards.

We recommend that:

- The Services define specific data storage and transmission requirements and determine associated data volumes and, as the volumes are determined, inform DCA of them so that the DDN can be expanded accordingly.

- A phased approach be taken in developing and implementing the OSI standards. In the first phase, new telecommunications applications within DoD should be connected to the DDN using the DoD message routing standard. National Bureau of Standards (NBS) OSI protocols defined for use by the Government should be implemented as products become available. Subsequent phases should incorporate International Standards Organization (ISO) terminal protocol standards, dynamic routing protocols, and network management protocols.
- DoD CALS programs include funding for R&D efforts for the development of IGs because IG capabilities will be needed to accommodate translations between dissimilar procedures and practices supporting graphics and technical data even after OSI standards are implemented.

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SECTION 1

INTRODUCTION

1.1 BACKGROUND

The Department of Defense is committed to applying the best in modern technology toward improving the transfer of technical information (engineering drawings, bills of material, etc.) among weapon system manufacturers, contractors, DoD organizations, and maintenance activities. The Computer Aided Logistics Support (CALS) Steering Group was established to foster the application of such technology, to improve weapon system support from initial design to operational logistics.

The CALS Framework document states the basic principles and concepts behind the CALS program. The Phase I and Phase II CALS Core Requirements are being developed as the foundation for a phased approach to the three CALS system architectures developed in the Framework.

The benefits to be derived from Phase I and Phase II activities, as developed by the D. Appleton Company (DACOM), are summarized in Table 1-1. The information architecture addresses the interdependent functions performed by individual users. The delivery system architecture encompasses computer hardware and software, including storage and processing media, as well as technologies of communications, network management, data management, and user interface. The control architecture ensures that the total application area is effective and efficient while both user requirements and computer technologies change during the life cycle of the weapon system.

In today's high-technology environment, sharing technical information involves telecommunications; the CALS Communications Working Group will therefore assist the CALS Steering Group in the areas of data transmission requirements and communications protocols. The Working Group is concentrating on communications requirements for interfacing with industry and communicating CALS data within DoD.

TABLE 1-1
THE DoD CALS PHASED MIGRATION PLAN

Architecture	Today	Benefits
Information architecture	• Minimal R&M • Batch LSAR • Islands in logistic infrastructure • Too many DIDs • Out-of-date technical manuals • Limited configuration control • Slow reprourement of spares	• Reduced life-cycle costs • Improved product quality • Shortened leadtime • Increased availability • Increased competition
Delivery system architecture	• Paper exchange • Redundant digitization • $n(n - 1)$ record transforms • Mixed media • Inconsistent geometric models	• Increased data integrity • Increased data accessibility • Increased timeliness of data • Lowered paper costs • Lowered paper-handling costs
Control architecture	• No organized concept of an integrated data system	• Reduced cost of technical data • Faster response to new data requirements • Reduced computer and communications costs • Reduced manpower to build Government data systems

Note: R&M = reliability and maintainability, LSAR = logistics support analysis record, DIDS = Defense Integrated Data System

The responsibilities of the Working Group include:

- Reviewing and assessing CALS telecommunications requirements and capabilities, and recommending telecommunications transition strategies
- Reviewing and assessing communications aspects of DoD Component CALS plans, including telecommunications protocols, value-added networks, internetting with non-Defense Data Network (DDN) networks, and submitting comments and recommendations to the CALS Steering Group as to the acceptability of these plans
- Identifying security, survivability, and interoperability requirements for CALS elements
- Advising the CALS Steering Group about the availability of off-the-shelf products supporting required telecommunications standards
- Identifying interface requirements to DDN and other Defense Communications Systems supporting CALS elements
- Identifying DoD and international protocol standards that should be implemented by CALS elements
- Providing guidance on how CALS elements should identify their requirements to the Defense Communications Agency (DCA) to ensure timely telecommunications support
- Maintaining coordination with the CALS Specifications and Standards Working Group in areas related to telecommunications
- Maintaining coordination with an industry focal point to ensure effective interchange on CALS-related communications initiatives.

To provide the Steering Group with planning guidance, the Working Group must: (1) determine the most effective network protocols between DoD and contractors, (2) determine the optimal role of the DDN as it relates to CALS, (3) evaluate the use of intelligent gateway (IG) processors for CALS to ease the use of diverse hardware and software, and (4) determine the role of telecommunications standards in CALS.

1.2 OBJECTIVE

All the Services, the Defense Logistics Agency (DLA), and DCA have a number of efforts, existing and planned, to provide telecommunications support for intra- and inter-Service communications. In addition, a number of initiatives are underway to support communications over telecommunications media between the Services and

commercial organizations. In view of these ongoing efforts, the Working Group intends to propose a CALS telecommunications plan or architecture that would best accommodate both existing and planned efforts in DoD and industry while incorporating the communications protocol standards of the international community.

Transmission of engineering drawings and technical data poses unique requirements in terms of data volume and protocol standards at the upper layers. The CALS Specifications and Standards Working Group, with support from the National Bureau of Standards (NBS), is addressing standards for such data transfers. The CALS Communications Working Group is concerned with the protocol standards proposed for Layers 1 through 5 of the Open Systems Interconnection (OSI) Seven Layer Model and the types of communications media to be used for transmitting CALS data. Even when standards are adopted, the upper layers will continue to present a challenge for data transmission. Not only is it difficult and time consuming to identify and agree to use a specific subset of a standard [e.g., a subset of the Initial Graphics Exchange Standard (IGES) for vector graphics], but such factors as cost to convert or translate into the standard may be unacceptable, or the final product may not yield the desired results. The Communications Working Group is, therefore, also addressing the use of IGs to ease transmission and conversion of CALS data at the upper layers (Layers 6 and 7).

The object of this effort is to identify the telecommunications requirements for CALS-related efforts in the Services and DLA and to assess Service CALS Implementation Plans in terms of local and long-haul telecommunications requirements. A follow-on task will develop a proposed CALS Telecommunications Architecture, including guidelines for transmitting data over long-haul lines, recommendations for making optimal use of the DDN and alternative means of data transmittal, and proposals for uses of IG technology. Other considerations to be addressed include cost, timeframes for implementation, and possible effects on Service and DLA operations.

We have evaluated the telecommunications requirements and approaches within the Services for automating and modernizing depositories for engineering drawings and technical data, as well as the direction of policy for planning and implementation of Service-wide telecommunications. We have also identified and evaluated commercial state-of-the-art communications standards and networks.

Section 2 discusses CALS-related telecommunications requirements within DoD. Major efforts for automating repositories for engineering drawings and technical data are discussed, as well as the overall direction being taken within each Service for telecommunications support. IG efforts are discussed in terms of accomplishments to date, planned implementation, and limitations and expectations in terms of use for CALS-related activities. DCA's proposed use of the Defense Commercial Telecommunications Network (DCTN) as a backbone to provide T1 and higher speed lines is also addressed.

Section 3 concentrates on the status of various commercial protocol and network initiatives, including the Manufacturing Automation Protocol (MAP) and the Technical and Office Protocol (TOP), the Integrated Services Digital Network (ISDN), the Fiber Distribution Data Interface (FDDI), T-Carrier Services, and NBS' Government Open Systems Interconnection Profile (GOSIP) document. These approaches are analyzed and compared in relation to the OSI Seven Layer Model.

Section 4 assesses the status of CALS-related telecommunications and presents conclusions and recommendations.

SECTION 2

CALS TELECOMMUNICATIONS IN DoD

In this section we discuss the telecommunications requirements set by the Services and DLA for their major efforts toward modernizing repositories for engineering drawings and technical data. Our discussion also includes their plans and developing policies for telecommunications support. Where IG efforts, both existing and planned, are appropriate they are discussed. We begin with an overview of the technology in place and planned for use by the DDN Program Management Office (PMO) to support transmission of CALS data. Table 2-1 lists the project offices visited. Refer to the glossary for definition of acronyms.

The definitions of protocols to be used within any of the Services or within individual projects may be in flux. Therefore, any differences or incompatibilities may simply indicate that work is still being done.

2.1 DEFENSE COMMUNICATIONS AGENCY TELECOMMUNICATIONS EFFORTS

2.1.1 Defense Data Network

Since most of the CALS umbrella projects have specified use of DDN for their long-haul data communications needs, we reviewed the DDN to determine its applicability as a transmission medium to support the CALS projects data transmission requirements. Two major parts of DDN were investigated: the physical subscriber access links and backbone network, and the protocol suite that provides end-to-end connectivity.

2.1.1.1 Current DDN Environment

The DDN is a DoD common-user, wide-area, packet-switching network under the control and management of DCA. The DDN is comprised of several physically separate subnets, ranging from the unclassified Advanced Research Projects Agency Network (ARPANET) to the top secret Sensitive Compartmented Information Network (SCINET). The Military Network (MILNET) segment is dedicated to unclassified data access.

TABLE 2-1
OFFICES VISITED

Project/office	Location
U.S. Air Force	
HQ USAF – CALS office	Washington, D.C.
ATOS	Wright-Patterson AFB, Ohio
EDCARS	Wright-Patterson AFB, Ohio
IDS	Wright-Patterson AFB, Ohio
ASD/SIPX	Wright-Patterson AFB, Ohio
ULANA	Washington, D.C.
U.S. Navy	
NAVDAC – CALS office	Washington, D.C.
EDMICS	Washington, D.C.
SPLICENET	Washington, D.C.
SSN-21	Washington, D.C.
TLRN	Washington, D.C.
U.S. Army	
HQ Department of the Army	Washington, D.C.
DSREDS	Huntsville, Ala.
HQ AMC	Alexandria, Va.
CECOM	Fort Monmouth, N.J.
Defense Logistics Agency	
HQ DLA-Z/DCLSO	Alexandria, Va.
DLA-ZW	Alexandria, Va.
Defense Communications Agency	
HQ DCA, DDN PMO	McLean, Va.

The DDN backbone is homogeneous in its transmission services, relying mainly on point-to-point dedicated lines running at 56 kilobits per second (kbps). In general, these lines are leased from American Telephone and Telegraph's (AT&T's) Dataphone Digital Service (DDS). Some use is made of the DCTN, a satellite-based network, but this is restricted to 56 kbps subrate channels and is used for non-CONUS United States access. Subscriber access links (depicted in Figure 2-1), which interface the user to a packet-switching node (PSN), range from relatively slow dial-up links to dedicated 56 kbps access links. Acquiring a 56 kbps line now takes between 18 and 24 months. The PSNs are C/30 computers provided by Bolt,

Beranek and Newman (BBN) Inc. They implement a dynamic, adaptive routing algorithm to route packets through the backbone network. The C/30s are limited to a maximum of 56 kbps line speeds. Network access to a PSN is accomplished via the DoD-specified implementation of the Consultative Committee on International Telephony and Telegraphy (CCITT) X.25 standard interface between Data Terminal Equipment (DTE) and Data Communication Equipment (DCE). The current protocol suite that supports end-to-end or host-to-host connectivity consists of the Internet Protocol (IP) and the Transmission Control Protocol (TCP). The IP connects the various subnets that make up the DDN. TCP provides end-to-end connectivity.

Three application-level protocols have been defined: (1) File Transfer Protocol (FTP), which performs bulk file transfer; (2) Simple Mail Transfer Protocol (SMTP), which supports electronic mail; and (3) the TELNET protocol, which provides terminal access for the asynchronous, scroll-mode class of terminals. FTP, SMTP, and TELNET have been implemented by various vendors and have been used over DDN for several years. A fourth application protocol – the Display Services Protocol (DSP) – was recently approved by DCA. It will provide terminal access for synchronous, block-mode class of terminals. The current Terminal Access Controller (TAC) supports asynchronous terminals only. DSP support should be available in 18 months within the new mini-TAC. The mini-TAC will support up to 16 synchronous or asynchronous terminals.

Operator control, information gathering, and fault isolation of DDN is accomplished at regional monitoring centers operating the C/70 BBN processor. The individual Services fund DDN with annual contributions that cover 90 percent of its operational expenses. DCA has identified subscriber requirements that include connecting 7,000 host processors and 17,000 terminals to the DDN.

2.1.1.2 Planned DDN Environment

The relationship of the DoD Protocols to the OSI Model is illustrated in Table 2-2. DCA plans to adopt the suite of OSI protocols as they become accepted by NBS. The GOSIP document should supply the impetus required by DCA to begin the transition. The transition should start in 1987 with adoption of the International Standards Organization (ISO) Internet Protocol and the ISO Transport Protocol. The OSI lower layers for long-haul packet-switched networks is the same as those now used by DDN, i.e., the X.25 DTE-to-DCE interface. This similarity allows both

to connect to the DDN. To achieve connectivity between end systems that are within a single subnet of DDN, not requiring a gateway passthrough, requires just the X.25 connection.

TABLE 2-2
RELATIONSHIP OF THE OSI REFERENCE MODEL
TO THE DoD PROTOCOLS

OSI layer	DoD protocol category
Application	Application protocols (TELNET, FTP, SMTP user services)
Presentation	
Session	Host-to-host protocols (IP and TCP)
Transport	
Network	Network access control (X.25 and ARPANET Protocols, such as 1822)
Data Link	
Physical	

Note: FTP = File Transfer Protocol; IP = Internet Protocol; SMTP = Simple Mail Transfer Protocol; TCP = Transmission Control Protocol

To achieve connectivity throughout the various subnets that make up DDN via a gateway, both the DDN IP and the ISO Internet Protocol have to coexist within the DDN internet. The coexistence of these two protocols will allow end host systems to communicate over the DDN using either the OSI upper layer protocols [e.g., Transport Protocol Class 4 (TP-4) and File Transfer, Access, and Management (FTAM)] or the DoD protocol suite (e.g., TCP, FTP). The DDN will thus be comprised of two closed communities – one for ISO host-to-host and one for DDN host-to-host – using the DDN backbone as the transmission medium. In the transition period until full acceptance and implementation of the ISO/OSI protocol suite, parallel operation of the two closed communities is required. This approach could be greatly enhanced by the use of protocol gateways that would allow interoperability between the two closed communities. NBS is developing such a protocol gateway.

DCA plans to upgrade the physical transmission medium used in the backbone network. The changes involve use of a new PSN, called the C/300, and T1 [1.544 megabits-per-second (Mbps)] channels. DCA now expects the T1 capability in 5 years. The classified subnets will be fully integrated into DDN when BLACKER technology is implemented (in 1988–1989). BLACKER technology will provide a multilevel, host-to-host security system for DDN and allow for the sharing of backbone trunks and other resources. Once the BLACKER technology is fully implemented, the DDN will be divided between an unclassified segment, MILNET, and a classified segment, the Defense Integrated Secure Network (DISNET). BLACKER technology will require use of the TCP/IP protocols. The MILNET unclassified segment will use the KG-84 encryption devices on the subscriber access links and backbone trunks. DCA also plans to implement a usage charge-back method that will be based on kilopackets sent over DDN. The DDN tariffs for cost recovery that are to go into effect in FY90 are listed in Table 2-3.

TABLE 2-3

DDN TARIFFS

Charges	Cost
Monthly charges	
Host-56 kbps-single home	\$4,000.00
Host-56 kbps-dual home	\$6,500.00
Host-9.6 kbps-single home	\$1,750.00
Host-9.6 kbps-dual home	\$2,700.00
Hourly dial-in charge	\$ 4.50
Kilopacket charges	
Peak time usage	\$ 1.25
Off peak time usage	\$ 0.60
Precedence 2	\$ 2.00
Precedence 3	\$ 3.00
Precedence 4	\$ 4.00

The kilopacket charge will be based on packets of any size; the maximum packet size of 1,024,000 octets or bytes should therefore be used. To take advantage of the substantial reduction in cost, off-peak time use of DDN is also recommended

for transmission of non-time-critical data. The costs of DDN are expected to be competitive with commercial packet networks.

2.1.1.3 CALS Use of DDN

Use of DDN by the various CALS projects would create a significant problem within the network. The problem stems from the physical transmission bandwidth (56 kbps) provided by DDN. Graphical data, even in a greatly compressed state, requires millions of bits. The anticipated workload of just one CALS project, the Army Digital Storage and Retrieval Engineering Data System (DSREDS) at Picatinny Arsenal, would saturate the entire DDN with its daily volume of inter-site data transmissions. The anticipated daily load between Picatinny Arsenal and Rock Island Arsenal is 12 gigabytes. Dividing by 20 for an average compression ratio of 20:1 results in a total of 600 megabytes of graphics information to be transmitted between the two locations. At 56 kbps or 7,000 bytes per second, the DDN can transmit 25.2 megabytes an hour. Dividing 600 megabytes by 25.2 megabytes equals 23.8 hours of transmission time. This assumes a dedicated medium that is overhead-free. Add to this the estimated overhead of 25 percent imposed by the various protocols and acknowledgments within DDN, and the time to transmit approaches 30 hours.

Note that what is being discussed is the workload from just one project. It does not include text transfer requirements. Add to this the transmission workloads of other CALS projects and DDN's existing users, and the magnitude of the problem becomes clear. The bandwidth provided by DDN (56 kbps), with an estimated overhead of 20 to 30 percent, is not sufficient to handle the estimated CALS workload.

The cost of DDN should also be considered. On the basis of kilopacket charges scheduled to start in 1990, the cost of transferring 600 megabytes of graphics (the daily compressed load anticipated for Picatinny Arsenal) would be approximately \$725. This assumes a worst case of 60 percent prime-time transmission and 40 percent off-peak time to accommodate the 30 hours computed above.

Although the DDN cannot now accommodate the data required for transmission by CALS projects, it can provide some CALS support. The present DDN can

be used to order drawings from connected organizations or obtain status information regarding a drawing or technical order.

Before connection to the DDN, DCA will analyze the transmission requirements of individual activities. The results of these studies are called Functional Requirements and Interface Documents (FRIDs). These FRIDs are used to evaluate transmission requirements and recommend specific courses of action with regard to connection to the DDN. Every prospective CALS project should request such a study by DCA. The CALS projects should also inform DCA of their anticipated transmission volumes, to document the need for increased transmission bandwidth. DCA publishes a list of exemptions from the mandate that dictates use of DDN by all DoD activities. One such exemption applies to the requirement to interface with a non-DoD host that is shared by several CALS projects. This exemption could justify a dedicated point-to-point connection to a manufacturer's computer system.

2.1.2 Defense Commercial Telecommunications Network

The DCTN is a satellite-based network that is used primarily for voice and video. DCA is the program manager for DCTN, which has been operational since February 1986. The DCTN is essentially a service that will provide many major military locations with T1 transmission speeds. It is built of basic AT&T digital components consisting of a Digital Access Cross-Connect System frame and a No. 5 Electronic Switching System (5ESS). The service provides support for both dedicated and switched facilities, and can be reconfigured dynamically from a network control center. All transmissions and switching are digital. At present, DCTN is made up of satellite and 15 terrestrial nodes, 9 of which are collocated with earth stations that support satellite transmission and reception. The remaining six nodes are linked to the earth station sites by terrestrial T1 links. DCTN terrestrial links support switched voice, dedicated voice and data, and video conferencing. The bandwidth is now divided into 24 voice channels of 56 kbps each, in the typical T1 manner. Dynamic allocation of bandwidth is being used to support video conferencing.

2.1.2.1 Satellite Based Networks

Some general properties of satellite networks are relevant to CALS telecommunications requirements. A satellite in geosynchronous orbit is visible to about one-quarter of the earth's surface, and transmission costs are independent of the

distance within the satellite's area of coverage. Both broadcast and point-to-point applications are possible. The earth-to-satellite-to-earth round trip imposes a propagation delay of about one quarter-second on transmissions. Satellites operate in the 4 to 6 gigahertz (GHz) range and provide approximately 500 megahertz (MHz) of bandwidth. This 500 MHz of bandwidth is divided into 12 subchannels of 40 MHz each, using frequency division multiplexing (FDM). The usable bandwidth of each of these subchannels becomes 36 MHz after a 4 MHz guard band is extracted to prevent interference. This 36 MHz of bandwidth can be further divided by use of either FDM or time division multiplexing (TDM). With FDM, the subchannel can be divided into 1,200 voice circuits. Use of TDM could provide varying bandwidths over the 36 MHz channel. Typical divisions are: one 50 Mbps channel, sixteen T1 channels, four hundred 64 kbps channels, or six hundred 40 kbps channels.

2.1.2.2 CALS Use of DCTN

DCA is developing plans to expand DCTN. As more information about DCTN is obtained, it will be disseminated among CALS participants. This technology and service may be able to provide the high-bandwidth service required by the CALS projects.

2.2 NAVY TELECOMMUNICATIONS REQUIREMENTS

The Navy Standard Data Communications Architecture now under development addresses the Navy's plans to transition from the DoD protocol suite to the OSI standards. Two projects present somewhat different requirements for storage, retrieval, and transmission of engineering drawings – the Navy Engineering Drawing Management Information and Control System (EDMICS) and the SSN-21 Advanced Attack Submarine Project. Two examples of approaches to the development and implementation of IGs are the Stock Point Logistics Integrated Communications Environment (SPLICE), which accommodates gateway processing at all seven layers of the OSI Model, and the Technical Logistics Reference Network (TLRN), which has a simpler approach and handles gateway functions at the upper layers only.

2.2.1 Navy Standard Data Communications Architecture

The Navy Data Automation Command (NAVDAC), the Navy Telecommunications Command (NAVTELCOM), and designated System Command

representatives are reviewing major computer networking efforts with plans to publish, as a joint effort, a compendium of protocols that would have to be supported to implement CALS technology. Such a review will provide insight into the extent to which translators will have to be developed for widespread data exchange.

NAVDAC is also developing a draft standard data communications architecture for Navy-wide implementation. The document is not yet available for distribution. It is to provide specific guidance, as available, for procurement and development of interoperable data communications support. All shore-based information systems are expected to meet this standard. Of course, some tactical situations will require deviations from the architecture. These deviations will be closely monitored and managed by the Space and Naval Warfare Systems Command (SPAWAR).

The international protocol suite — not the DoD suite — was chosen as the basis for development of the Navy standards. Although DoD protocols are more widely implemented now than international standards, international protocols are expected to overtake the DoD protocols in availability by 1988. Therefore, use of international standards is mandatory for systems targeted for implementation in 1988 and beyond. Extensive system modifications will be required to implement interaction of Navy application environments. Systems implemented with DDN protocols will have to be changed again within 2 years. Navy guidance, therefore, encourages use of international standards for new developments unless there is a compelling requirement for interoperability with an existing system using DoD protocols before 1988. This does not preclude use of other protocols in situations where interoperability is not needed.

Systems and networks are to be implemented with a single suite, either Navy standard or DoD. Intermixing of protocols will not be approved. In the meantime, the following is recommended:

- For proprietary vendor implementations, push for international protocol suites in the vendor line. Minimize development of systems and capabilities that extend dependence on vendor-unique products [e.g., System Network Architecture (SNA)]. Use DDN electronic mail hosts rather than specific vendor system constraints and formats.

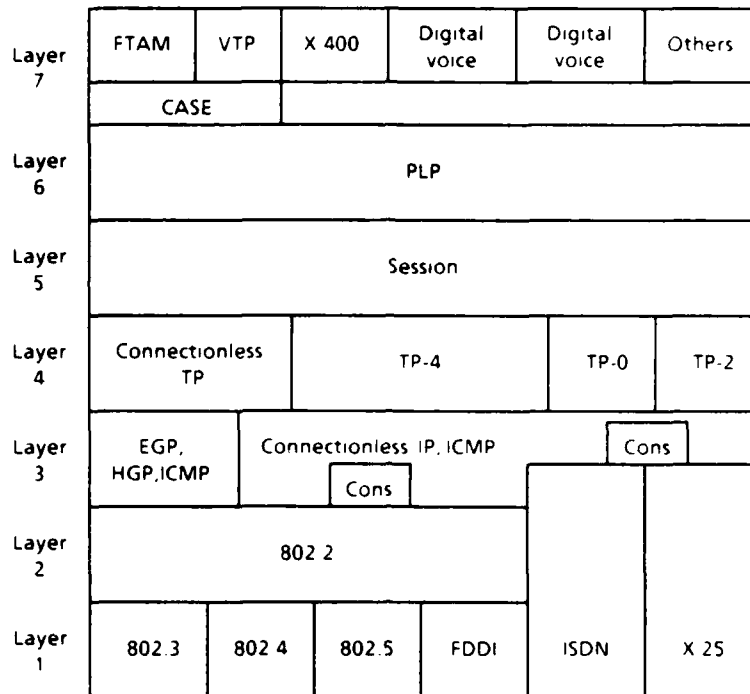
- For those connected to DDN using X.25 protocols, X.25 is common to both suites and will not require any retrofitting. Continue using DDN with X.25 and also do above.
- For those connected to DDN with full DoD protocol support, continue using the DoD suite. Plan on using the NBS/DoD-provided gateway to interact with Navy standard systems and look for an opportunity to transition from the DoD suite.
- For those already implementing the Navy standard environment, connect to DDN using X.25 and request a waiver from DoD protocol implementation via NAVDAC.

Figure 2-2 displays the set of standards and protocol suites designed to ensure interoperability of Navy information systems. The suite is composed of international standard protocols, augmented as necessary by proposed protocol efforts and Navy standards. These standards and the subsets to be included in the Navy standard are described in detail in Appendix A.

Use of record level interaction (Transport) with Common Application Service Elements (CASE) and Navy Standard Addressing is expected to significantly enhance implementation and operation of the standard Navy system. Applications-level security and standard graphics problems are still outstanding. The Navy indicates that FTAM satisfies Navy requirements completely. Performance has not been adequately measured, but experience suggests that additional performance options may be desirable. These, however, are low-priority concerns at this point. TOP, which incorporates X.400 (Message Handling Protocol), and Navy Standard Addressing will satisfy Navy requirements today. DoD SMTP is a suitable substitute for separate electronic mail hosts.

Additional protocol requirements not yet addressed in the proposed Navy standards include:

- Ship-to-Shore Protocols
- Network Management Protocols
- Network Security Protocols
- ISDN
- Video Teleconferencing.



Note: FTAM = File Transfer, Access, and Management; VTP = Virtual Terminal Protocol; CASE = Common Application Service Elements; PLP = Packet Level Protocol; TP = Transport Protocol; TP-4 = Transport Protocol Class 4; TP-0 = Transport Protocol Class 0; TP-2 = Transport Protocol Class 2; EGP = Exterior Gateway Protocol; HGP = Host-to-Gateway Protocol; ICMP = Internet Control Message Protocol; IP = Internet Protocol; FDDI = Fiber Distribution Data Interface; ISDN = Integrated Services Digital Network

FIG. 2-2. PROPOSED ARCHITECTURE FOR NAVY PROTOCOL SUITES

The Navy will be undergoing a complex, continuing transition in data communications support for the next 5 to 10 years. Navy protocol implementation estimates are:

- Vendor implementations only (80 percent plus).
- Vendor implementations with connections to DDN using X.25 for long-haul circuit consolidation (most systems — 15 percent).
- Use of DoD protocol suite in applications programs and connection to DDN (labs only — 5 percent).
- Use of international protocols. The Navy standard protocol suite is implemented at NBS, NAVDAC, and the Navy Regional Data Center (NARDAC) Washington to demonstrate interaction (less than 1 percent).

In summary, the Navy operational support is primarily vendor-specific, with minimal use of DoD protocols.

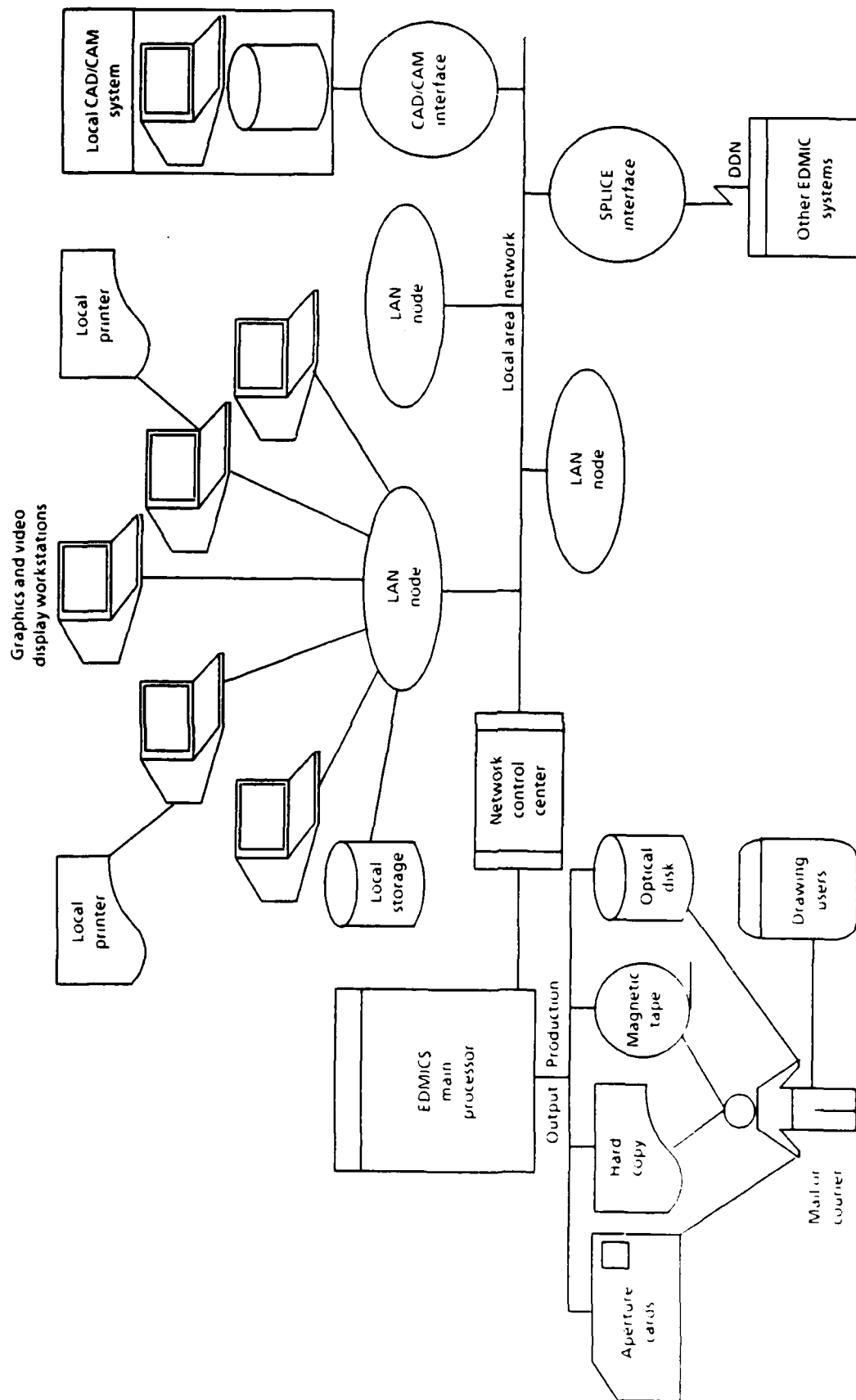
NAVDAC Newport has obtained structured protocol tests from NBS and DCA for international and DoD standard protocols and has acquired hardware to run these tests for Navy hardware suites, software suites, or both. This capability is available for use by Navy activities to demonstrate product compatibility during procurement or after major upgrades of vendor software. The Navy has offered to allow connections of vendor equipment via the OSI Network (OSINET) at NBS for testing off-the-shelf products for compatibility with Navy standards early in the vendor design process. These measures are intended to maximize the use of off-the-shelf equipment to satisfy Navy requirements.

2.2.2 Navy Engineering Drawing Modernization Efforts

The *Navy Engineering Drawing Management Information and Control System* (EDMICS) project is a joint Navy/Marine Corps/DLA initiative to provide some 40 engineering data/drawing repositories with a state-of-the-art management system. The goal of EDMICS is to provide users with accurate and timely drawing index and image information on all Navy equipment and weapon systems. Installation of EDMICS at engineering drawing repositories, Naval shipyards, Naval air rework facilities (NARFs), and electronic centers throughout the United States is to begin in the first quarter of FY88. A prototype EDMICS system for evaluation of advanced technology components and peripheral products has been installed at the Naval Air Technical Services Facility, Philadelphia, Pa.

Engineering drawing index and image information will be transmitted locally (intrasite) and long distance (intersite). Figure 2-3 illustrates the EDMICS data communications configuration.

Intrasite communications will depend on local area networks (LANs). For sites with existing LANs that meet EDMICS throughput and capacity requirements, the existing LAN will be used for intrasite communications. At other sites, a LAN will be acquired and installed as part of the EDMICS installation. The LANs acquired as part of the EDMICS contract will be a baseband LAN with coaxial cabling, providing for a minimum communications speed of 1.54 Mbps. Each LAN will be able to support up to 250 graphics and video display workstations. Users will be able to



Note: EDMICS = Engineering Drawing Management Information and Control System, CAD/CAM = computer-aided design/computer-aided manufacturing, LAN = local area network, SPLICE = Stock Point Logistics Integrated Communications Environment

FIG. 2-3. EDMICS DATA COMMUNICATIONS CONFIGURATION

query the index database and request individual drawing or drawing package reproductions in a variety of output media.

Intersite communications will be achieved through the DDN. Access to the DDN will be via SPLICE Tandems, which will be collocated at all EDMICS sites and act as an interface to the DDN. Users at one EDMICS site will be able to query the EDMICS index database at another site and request drawings on-line.

Because of the large size of drawings image files (8 megabytes or more) and the current maximum speed of the DDN (56 kbps), the exchange of image information over the DDN will not be convenient or efficient for users. Most image transmission between sites is expected to take place by postal or courier service, using optical disk, magnetic tape, aperture card, or hard copy depending on the volume. This means of communication will probably prove to be the most efficient one in terms of the costs of sending large quantities of drawings. The DDN is the most cost-effective means available to perform on-line data query and request functions. The DDN may also be used to perform priority image transfers for small numbers of images. Leased, dedicated, high-speed lines are one of the few means available for long-distance, on-line transfer of drawing images. But using leased lines costs far too much to merit application in EDMICS. When the speed and capacity of the DDN increase to such a level as to make long-distance telecommunications efficient and cost-effective, the DDN can be used for on-line image transmission.

Appendix B lists the data communication volume requirements for each of the 8 primary repositories, 8 shipyards, 6 NARFs, 4 Naval Electronics Systems Engineering Centers (NESECs), and 10 other secondary repositories. At the large repositories, the system is expected to process 5,000 or more drawing-index queries and image requests a day from as many as 250 on-line users. Of these, approximately 3,400 are expected to be from local on-line users, and 1,600 from remote users via the SPLICE interface. An estimated 50 percent of image requests will be for image viewing on a graphics display. At first, authorized remote users will initially request and view 100 or fewer drawing images a week.

Standards proposed for use as part of the EDMICS include:

- Initial Graphics Exchange Standard (IGES), Version 2.0 and all subsequent versions

- Product Definition Exchange Specification (PDES), Version 1.0 format and all subsequent versions
- CCITT Group 4 Recommendations for drawing image data compression, CCITT Recommendation T.6 "Facsimile Coding Schemes and Coding Control Functions for Group 4 Facsimile Apparatus", and all "T" Series Recommendations from the CCITT "Red Book" Volume VII, "Terminal Equipment and Protocols for Telematic Services"
- Standard Generalized Markup Language (SGML)
- TCP/IP
- CCITT Recommendation X.25
- Institute of Electrical and Electronic Engineers (IEEE) Standard 802 for LAN Implementation
- Navy Data Automation Technical Standard 17.8A, "Navy Data Network Connection Standard."

The *SSN-21 Baseline CALS Project* will demonstrate elements of an end-to-end computer-aided logistics support concept, integrated with the planning and detailed design phase of a major acquisition program, the SSN-21 Advanced Attack Submarine. During demonstration planning and execution, the working group will emphasize categories of data to be transferred between the Navy and contractor organizations, including nonprocessable text and graphics; processable data, such as bills of material; engineering drawings and illustrations; and other aspects of a digital product model representing the ship and its major systems/subsystems. Other areas of concern to be addressed include use of text and graphics standards for digital data interchange; data validation and security; integration of selected reliability, maintainability, and testability analysis tools with evolving computer-aided design (CAD) database development; use of an on-line integrated database of logistics support analysis (LSA) information; and generation of technical documentation, using as a starting point selected data sets stored within the CALS/ILS (integrated logistics support) data repository.

There are no current plans for direct communication lines with contractors or transmission of the information between shipyards over long-haul lines. Data transfer for design and construction of the SSN-21 class of ships is handled via magnetic tape, since most of the data is classified. There is a need for ability to

access the systems directly, but funding constraints and the unavailability of the needed technology do not make such access feasible for the near term.

One of the major problems to overcome is the fact that two shipyards (the Electronic Boat Division of General Dynamics and the Newport News Shipyard) have responsibility for the design of separate but interrelated components of the submarine. The design is being handled by two contractors using different CAD systems. General Dynamics uses Computer Vision; the Newport News shipyard uses CADAM. Both Computer Vision and CADAM have developed pre- and post-translators into IGES, but much work still needs to be done for an effective translation. There will never be a 100 percent translation capability. The process of cleaning up a complex drawing with manual intervention has been reduced to 3 to 4 hours. The SSN-21 Project supports approximately 300,000 to 400,000 drawings between the two shipyards. Additional drawings are received in hard copy from other vendors for various components of the submarine. The Program Office intends to develop a quality assurance process for translation.

Another problem is the fact that, despite agreement on standards, different procedures and practices (engineering models) are used in the design process at the two shipyards. As a result, different pictures are displayed on the two systems for the same data represented in the same IGES subset. Other system differences include the fact that in some cases there is simply no representation in one system for elements represented in the other. There is a need to develop standards for procedures and practices for the design of Navy systems. Again, other priorities and funding constraints make it difficult to address standardization of procedures at this time. However, the SSN-21 Program Office is committed to the development of standards, and this has been impressed upon both shipyards.

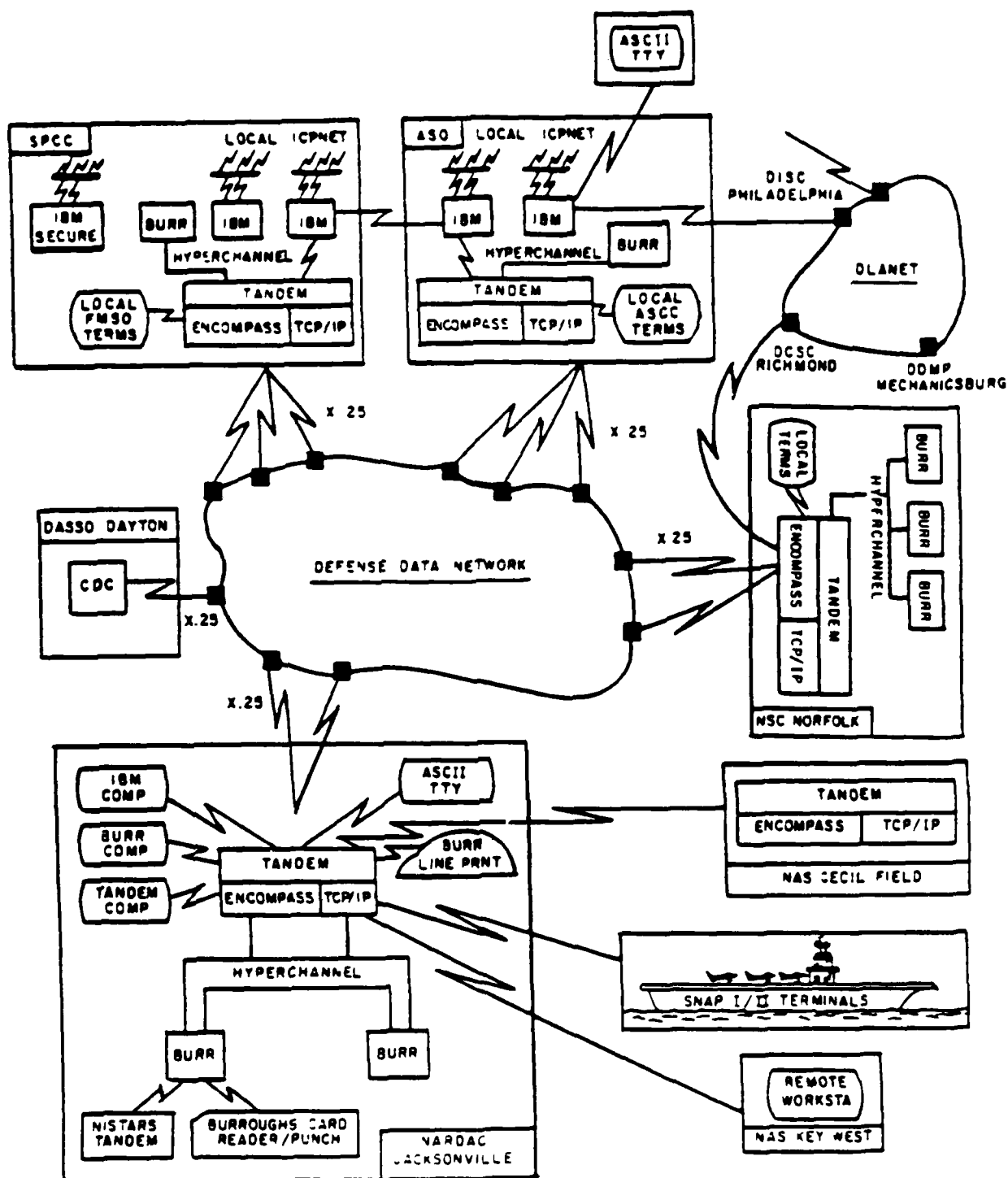
2.2.3 Intelligent Gateway Projects

The primary objective of the *Stock Point Logistics Integrated Communications Environment* (SPLICE) is to provide Navy and other DoD customers with responsive and economical Uniform Automated Data Processing System – Stock Points (UADPS-SP) support by using a standard minicomputer hardware and software suite for telecommunications, interactive processing, front-end processing, and terminal concentrator requirements.

The SPLICE Network (SPLICENET), as depicted in Figure 2-4, serves three purposes. First, it replaces front-end and terminal concentrator processors in the UADPS-Burroughs environments. Second, it replaces various stand-alone minicomputer suites, which support a number of projects, with a standard minicomputer environment that will also support UADPS functions and new automated information systems such as the Automation of Procurement and Accounting Data Entry (APADE) System. Third, it provides, through DDN, teleprocessing connectivity for the inventory control points (ICPs), stock points, and specific users of logistics information. SPLICE uses Tandem linearly expandable, fault-tolerant technology and will operate at 62 regional sites, including ICPs, stock points, Naval reserve readiness commands (NRRCs), and NARDACs. Tandem's commercially available protocols include an interface to X.25 networks, a proprietary set of Layer 3 through 5 protocols called EXPAND, and a Tandem file transfer protocol and mail protocol.

It is Tandem's intention to allow different synchronous terminals from different vendors to communicate with application programs within a Tandem computer. Tandem has its own synchronous protocol for its terminals (this protocol is called the 6530). In addition, Tandem plans to allow synchronous terminals from different vendors that are connected locally to a Tandem to communicate across a packet-switched network to an application program in another Tandem computer. Currently, Tandem has developed these interfaces for International Business Machines (IBM) Corporation compatible synchronous terminals (2780/3780/327X), and the Federal Data Corporation (FDC) has developed the interfaces for Burroughs look-alike asynchronous and synchronous terminals. Basically, this means that the IBM and Burroughs protocols are translated into the Tandem synchronous protocols (6530 protocol). The 6530 protocol is then used to communicate with application programs, either in a local Tandem host or in a Tandem computer that is connected by a communications network.

Tandem currently provides file transfer capabilities between Tandem and other vendor computers, such as IBM, UNIVAC, and Honeywell. The Navy has developed file transfer capabilities between Tandem and Burroughs. These file transfers are for flat sequential files only, and do not apply to indexed files. SPLICENET also supports security, automatic routing, network management and



KEY: ASO AVIATION SUPPLY OFFICE
 BURR BURROUGHS
 CDC CONTROL DATA CORPORATION
 DASSO DEFENSE AUTOMATED ADDRESSING SYSTEM OFFICE
 DLA DEFENSE LOGISTICS AGENCY
 FMSO FLEET MATERIAL SUPPLY OFFICE
 ICP INVENTORY CONTROL POINT

NARDAC NAVY REGIONAL DATA CENTER
 NAS NAVAL AIR STATION
 NISTARS NAVAL INTEGRATED STORAGE
 TRACKING AND RETRIEVAL SYSTEM
 NSC NAVAL SUPPLY COMMAND
 SNAP SHIPBOARD NON-TACTICAL ADP PROGRAM
 SPCC SHIPS PARTS CONTROL CENTER

FIG. 2-4. SPICENET

control, and gateway functions for IBM SNA and IBM bisynchronous hosts that enable users in the ICPs, the stock points, and DLA to communicate with each other.

The Naval Supply Systems Command (NAVSUP) has two requirements for interoperability – one within the Navy Stock Point environment for communication between Tandem nodes in the SPLICENET community, the other for interoperable communications outside the SPLICENET community.

NAVSUP plans to use the X.25 interface to DDN and the Tandem EXPAND protocols to communicate among SPLICE sites. Communications between a SPLICE site and other non-SPLICE DoD sites will be conducted by the X.25 access to DDN through a front-end processor or outboard controller that implements TCP/IP and TELNET separate from the Tandem to provide end-to-end transport of the data across the DDN. Therefore, within the Tandem host there will be two sets of protocols – one based on the Tandem vendor-specific suite, the other on the DoD suite.

The *Technical Logistics Reference Network* (TLRN) is an information service that has evolved over the past 10 years through testing and use within the Department of the Navy, specifically the Naval Sea Systems Command (NAVSEA) and the Naval Air Command (NAVAIR). This service is designed to improve the visibility and usefulness of material information supporting the phases of the military hardware life cycle, from system design to acquisition, through maintenance and refurbishment, to final phaseout.

Users at all Navy shipyards currently have terminal access directly to the TLRN host to use the Federal Supply Catalog database resident on the central host. The TLRN will also enable a user at a shipyard to do the following by terminal:

- Access the local shipyard information system
- Link into DLANET (DLA Network) to access the Standard Automated Material Management System (SAMMS)
- Access other shipyard management information systems directly
- Access other host machines connected to the TLRN, including the central TLRN host.

Access to these systems will be provided through a Tandem gateway. Users will interface to the Tandem with currently available "on station" hardware, such as

microcomputers, dumb terminals, and printers. At first, the TLRN supported asynchronous terminals only; now it supports some synchronous terminals as well. The programs, developed by Innovative Technology Inc., can be used on any asynchronous intelligent terminal supporting Microsoft Disk Operating System (MS DOS) and on IBM personal computer (PC) or equivalent devices that have an asynchronous communications adaptor board. The system is seen simply as another user to the target system. It does not know and has no need to know what hardware, software, or database management system (DBMS) is used at the remote location. All it needs to know is that data is to be sent in asynchronous, American Standard Code for Information Interchange (ASCII) format.

Once the full range of TLRN capabilities is operational, the user will be able to either access a remote host directly, which would require familiarity with the host operating system, or use the TLRN capabilities to execute batch programs to retrieve the requested information from remote systems, all transparent to the user. In both cases, the user would be able to take advantage of downloading and post-processing routines developed to meet user-specific needs.

2.3 AIR FORCE TELECOMMUNICATIONS REQUIREMENTS

Air Force policy for telecommunications implementation is presented here in the context of the Unified Local Area Network Architecture (ULANA) initiative. The Automated Technical Order System (ATOS) and the Engineering Data Computer Assisted Retrieval System (EDCARS) provide information on the technical requirements for transmission of technical data and engineering drawings respectively. This section also discusses two IG efforts in the Air Force – the Central Datacomm System (CDS) and the Logistics Data Information System (LOGDIS).

2.3.1 Air Force Communications Policies and Standards

In the last decade, new classes of problems have emerged as Air Force planners and system developers have faced the complexities of integrating large numbers of independently developed automated capabilities. The goals of linking real-time computer programs with LANs and long-haul digital data communications to achieve intersystem communications of major Air Force systems required major

software and hardware reengineering and system integration based on advanced information system technologies.

The purpose of the ULANA I program is to create a set of standard components for implementing data communications networks for unclassified and classified data on Air Force Bases to provide communications among heterogeneous hosts and terminals. The ULANA I component requirements will allow a wide variety of architectures to be implemented so that almost all Air Force LAN requirements can be met. It can be used by a large percentage of current Air Force terminals and hosts, which include everything from PCs to mainframes.

The ULANA I implementations will provide terminal-to-host, host-to-host, and terminal-to-terminal communications. DDN gateways, facilities for network management, and bridges to connect subnetworks will also be provided. The American National Standards Institute (ANSI)/IEEE Standard 802.3 protocol and standard DoD protocols are required for all ULANA I components and the distribution system. The Air Force plans to upgrade ULANA I installations to ULANA II, which will use capabilities that are not technically feasible now or are based on standards that are not yet complete. Examples of these capabilities include the ISO protocols, IEEE 802.1 network management standard, and multilevel network security.

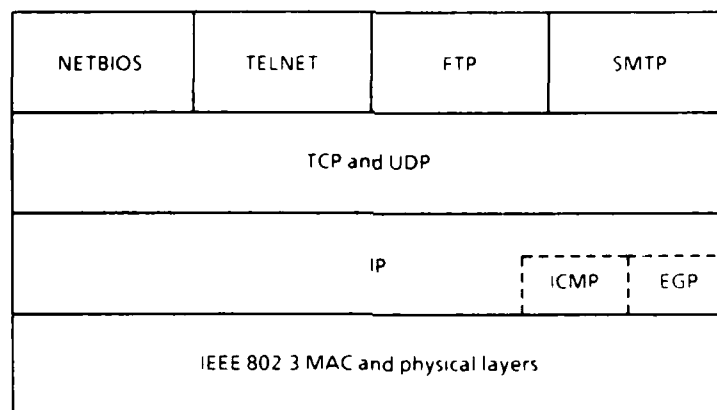
ULANA I components will operate on the following media:

- Broadband coaxial cable (single- and dual-cable systems) as described in IEEE 802.7, with the exception that the coaxial cable systems will comply with the delay, budget, and diameter constraints defined in IEEE 802.3 and that the minimum loop loss will be the loss of that described in IEEE 802.7 or 44 decibels (dB), whichever is lower, and the maximum loop loss will be the greatest of that described in IEEE 802.7 or 56 dB, whichever is higher.
- Baseband coaxial cable, as described in IEEE 802.3 and IEEE 802.3A.
- Dual-window optical fiber cable with an outer cladding diameter of 125 microns. Other characteristics are to be defined by the contractor.

The following protocols will be implemented as depicted in Figure 2-5:

- Applications Utility Layer Protocols – SMTP, FTP, TELNET, and an IBM PC-compatible NETBIOS will be implemented above the transport layer protocols on IBM PCs and Zenith 248s running DOS 3.1, DOS 3.2, and Xenix 2.0, and VAX 780s and Micro VAX IIs running Ultrix 1.2.

- Transport Layer Protocols – TCP and the User Datagram Protocol (UDP).
- Network Layer Protocols – IP, the Internet Control Message Protocol (ICMP), and IP address to Media Access Control (MAC) address translation.
- MAC Sublayer and Physical Layer Protocols – Implemented as specified in IEEE 802.2, Standard Network Access Protocol (SNAP) implementation, IEEE 802.3, IEEE 802.3A, and IEEE 802.3B.
- Exterior Interface Protocols – The Exterior Gateway Protocol (EGP) and a certified DDN X.25 standard interface.

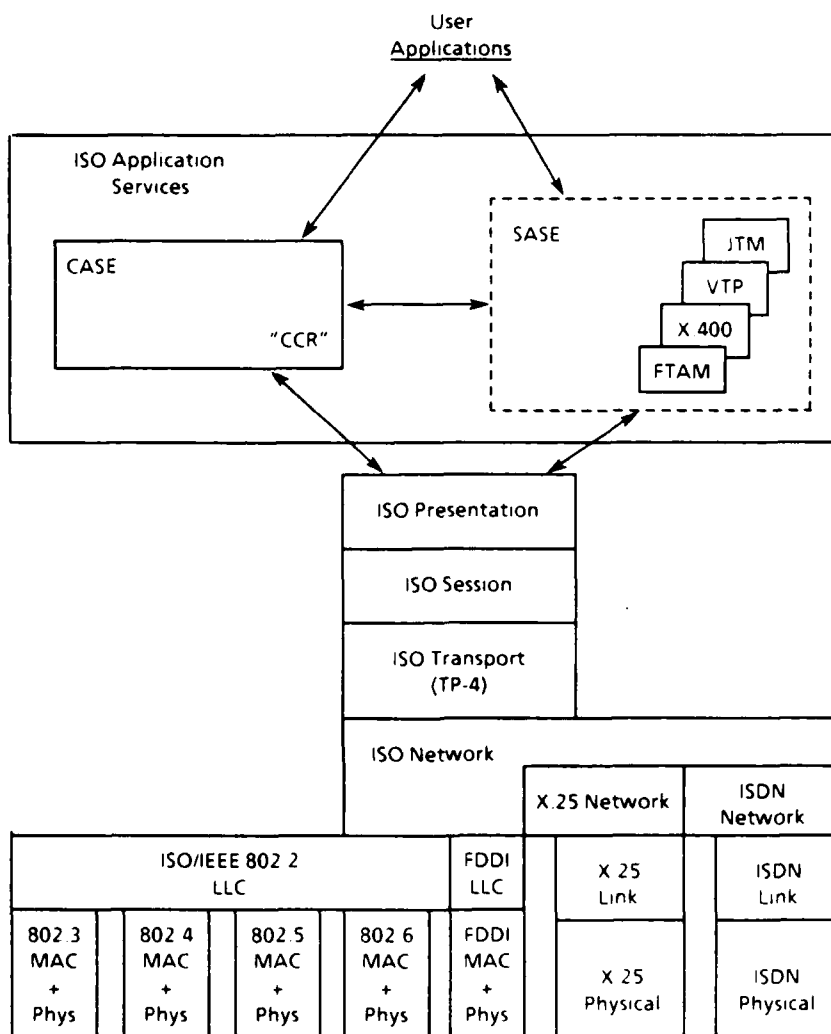


Note: FTP = File Transfer Protocol; SMTP = Simple Mail Transfer Protocol; TCP = Transmission Control Protocol; UDP = User Datagram Protocol; IP = Internet Protocol; ICMP = Internet Control Message Protocol; EGP = Exterior Gateway Protocol; MAC = Media Access Control

FIG. 2-5. ULANA I PROTOCOLS

ULANA II enables the ULANA program to transition to the ISO protocols. All ULANA II data networking components are based on the anticipated ISO protocols depicted in Figure 2-6. Any Air Force applications that must use the DoD protocol suite during the ULANA II life cycle will be interconnected to the ULANA II networks via the OSI/DoD Application Layer gateway being developed by NBS under contract to DCA. This gateway provides automatically staged translations between FTP and FTAM, TELNET and Virtual Terminal Protocol (VTP), and SMTP and X.400.

The ULANA II networking multilevel security approach is based on the three layers of encryption being standardized in the ISO community by ANSI. Link encryption is to be provided at the Data Link Layer by ANSI X3.105-1983 or its



Note: ISO = International Standards Organization; CASE = Common Application Service Elements; CCR = commitment, concurrency, and recovery; SASE = Specific Application Service Elements; JTM = Job Transfer and Manipulation; VTP = Virtual Terminal Protocol; X 400 = CCITT Message Handling Protocol; FTAM = File Transfer, Access, and Management; TP-4 = Transport Protocol Class 4; IEEE = Institute of Electrical and Electronic Engineers; LLC = Logical Link Control; MAC = Media Access Control; FDDI = Fiber Distributed Data Interface; ISDN = Integrated Services Digital Network

FIG. 2-6. ARCHITECTURE OF ULANA II CONCEPTUAL PROTOCOL SUITE

successor. End-to-end encryption in a nonstorage channel (i.e., an end-to-end channel that offers no store-and-forward capabilities) is to be provided at the Transport Layer by ANSI X3T1-85-50 or its successor. Process-to-process encryption, which guards against security threats in a storage channel, is to be provided at the Presentation Layer by ANSI X2T1-81-106.19 or its successor.

The ULANA I family of gateways should be augmented to include gateways to the emerging ISDN standards, and to include gateways to proprietary networks. Application Layer gateways are used to interconnect to ULANA II any Air Force applications and hosts that obtain waivers to continue using the DoD protocol suite. DCA intends to commercialize these gateways via the NBS development effort.

Furthermore, to the extent that DDN will transition to an ISO-based protocol suite within the ULANA II life cycle, appropriate modifications will have to be made in the ULANA I DDN gateway protocols and protocol management algorithms.

2.3.2 Air Force Technical Data and Engineering Drawings Modernization Efforts

The *Automated Technical Order System* (ATOS) is an automated publications system for storage, distribution, revision, and updating of Technical Orders (TOs), i.e., documents that describe how to operate, maintain, and use equipment through narrative text and illustrations. ATOS is to be implemented in two phases:

- Phase I – TO Publication System
 - ▶ Automate TO change preparation
 - ▶ Increase organic capabilities
 - ▶ Digitize selected existing TOs
- ATOS Pilot Program
 - ▶ Automate TO distribution at Air Logistic Centers (ALCs)/Aerospace Guidance and Metrology Center (AGMC)
 - ▶ Receive aerospace contractor TO in digital form
 - ▶ Interface with Phase I for TO changes
 - ▶ Management of TO databases
 - ▶ Digital database for active TOs.

SYSCON Corporation is the contractor for Phase I. The Phase I configuration has been installed at each ALC and at the AGMC.

The request for proposals (RFP) for the Pilot Program will include a subset of B-1B bomber TOs rather than all Air Force TOs. The Pilot Program RFP is scheduled to be released before the end of 1987. Contract award is scheduled for 1988.

The Air Force expects to receive data in digital form from industry on magnetic or laser media rather than over communication lines. Requirements have yet to be defined for interfaces that warrant use of DDN or other communication lines for transmitting data to the other Services or DLA. There may now be an occasional requirement to mail up to one page of data to one of the other Services.

A TRW, Inc., proprietary broadband Carrier Sense Multiple Access with Collision Detection (CSMA/CD) LAN will be used for the ATOS in the local environment. Host-to-host connections will be over one or two channels on this broadband LAN, using the Ethernet 802.3 standard. Fiber optics have been installed at two ALCs; more are to be installed at the other ALCs in the future. Fiber optics can provide better service in the transmission of large volumes of data at the Air Force Logistics Command (AFLC) bases.

The AFLC LANs are also comprised of a separate WANGNET and Ungermann-Bass networks (broadband, dual cable). A prototype intersite gateway (ISG) for connections with the DDN has been developed and is being tested under a contract with ARINC in Annapolis, Md. Another gateway under development will provide connections to the Automatic Digital Network (AUTODIN).

Though no decision has yet been made about interface standards, they should be available by late summer FY87. The standards relating to ATOS include MIL-STD-1840, which calls out IGES, SGML, CCITT Group 4, and Computer Graphics Metafile (CGM).

The Air Force has conducted an ATOS Pilot System Communications Loading Study to project traffic loading for local and long-haul communications for the Pilot System, based on Rockwell's standard planning factor (100 pages per B-1B TO) for all Rockwell "make" and "buy" B-1B TOs. Rockwell describes the "typical B-1B TO" as 60 percent text and 40 percent illustration. Files of B-1B TOs in Rockwell's

Automated Technical Publications System are composed of ASCII text and vectorized illustrations compiled directly from CAD/CAE (computer-aided engineering) systems and some from scanners used to digitize paper drawings. A full page of TO text is projected at 5,000 bytes per page. A full page of moderately complex high-resolution artwork is projected at 400,000 bytes. A total B-1B TO is estimated at 16,300,000 bytes, or more than 130 megabits per TO. Estimated traffic loading characteristics for intersite channels are listed in Table 2-4. All traffic loading represents raw data and does not include overhead. Under the current AFLC LAN concepts, both inter- and intrasite traffic will be handled via the AFLC LAN cable plant. The estimated total intersite daily traffic loading from the AFLC LAN across the DDN is 556 megabytes (556 million bytes).

TABLE 2-4
ATOS DAILY ESTIMATED DDN TRAFFIC LOADING

Sender	Sent to	Number of bytes sent
Oklahoma City ALC	Sacramento ALC	326,500,000
	Dyess AFB	16,300,000
	Ellsworth AFB	16,300,000
	Grand Forks AFB	16,300,000
	McConnel AFB	16,300,000
Sacramento ALC	Oklahoma City ALC	163,500,000
	Dyess AFB	100,000
Ellsworth AFB	Oklahoma City ALC	100,000
	Sacramento ALC	100,000
Grand Forks AFB	Oklahoma City ALC	100,000
	Sacramento ALC	100,000
McConnel AFB	Oklahoma City ALC	100,000
	Sacramento ALC	100,000
Total daily traffic		556,000,000

Note: ALC = Air Logistics Center, AFB = Air Force Base

If the chosen architecture for ATOS provides for telecommunication of bit-mapped (raster) images, the loading of the expected intersite TO transfers would result in processing over 4 gigabits (4 billion bits) a day. Even if the DDN could

provide an optimum sustained and accurate (no data losses, no contention, and no retransmittals) data transfer rate of 56 kbps, transferring the daily load would take over 22 hours.

The traffic loading estimates take into account the fact that the most efficient means of forms processing, from a communications viewpoint, is to store the formatting information for the forms at the user workstation rather than transmit the formatting data with user-entered data. In addition, a system design based on transmittal of "TO changes" instead of "changed TOs" and provision of an active indexing system that automatically verifies currency of the databases would reduce the requirement for weekly download communications. Therefore, data redundancy would be a requirement until the system could support transfers of the required volume.

The *Engineering Data Computer Assisted Retrieval System* (EDCARS) is an automated system for capturing, storing, distributing, revising, and updating the engineering drawing information currently stored in paper and aperture-card form. It is being developed by the Air Force jointly with the Army's DSREDS.

The EDCARS Data Communications (DAC) subsystem consists of one front-end processor (FEP) to interface remote and nonremote devices, and a LAN to interface high-speed graphics devices. The FEP is functionally compatible with the IBM 3275 series hardware; the NCR Comten Advanced Communications Function/Network Control Program (ACF/NCP) software is functionally compatible with IBM's ACF/NCP.

The LAN is a token passing bus implementation of the IEEE 802.4 standard via coaxial baseband cable. The FEP is designed to use SNA with the Virtual Telecommunications Access Method (VTAM). The protocol employed is bisynchronous (BSC) in a 3270 environment. Asynchronous devices access the system via protocol converters and look like BSC 3270s to the Process Controller.

The FEP provides communications capability for up to 75 user graphic display terminals (GDTs) operating at 9,600 bits per second (bps), for 1 DDN interface at 56 kbps, for up to 50 user video display terminals (VDTs) operating at 1,200 bps, and one interface at 9,600 bps to the 3B2 Aperture Card Output Controller. The

ALPHAREL LAN supports a minimum speed of 1 megabit per second. Six channels on the TRW LAN are dedicated to EDCARS.

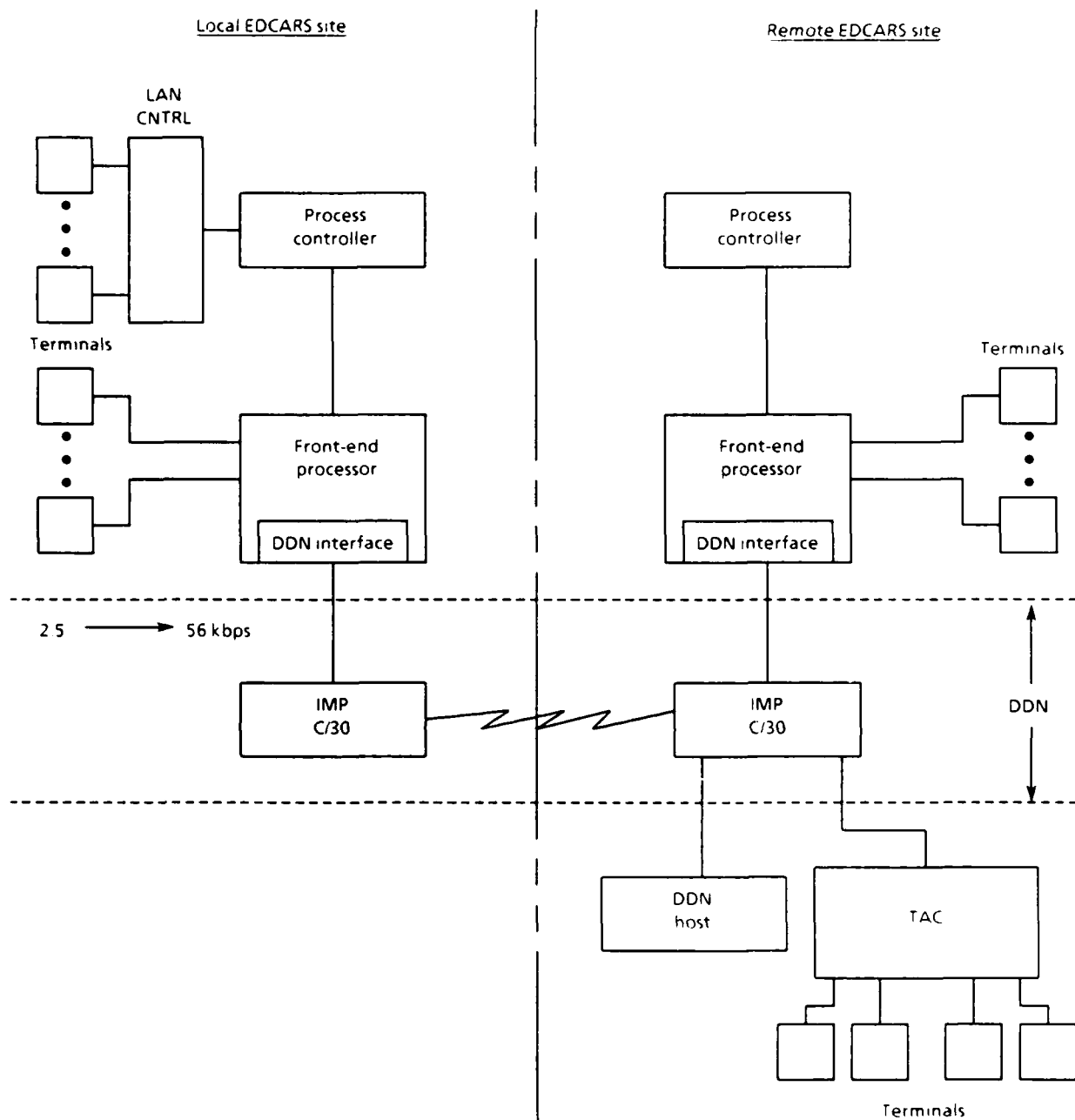
Figure 2-7 represents the EDCARS remote terminal and DDN communications architecture. The DDN interface is provided in the DAC by the Communications Processor. The communications portion of the DDN protocol layers will run in the FEP. The applications portion of the DDN protocol layers will run in the Process Controller. The Air Force believes the Communications Processor and the currently available Process Controller interface software provide the best available working solution to the complex DDN interface. The following protocol layers will be provided:

- Link Layer – High-Level Data Link Control (HDLC) Distant Host (HDH) Interface
- Network Layer – IP (defined by MIL-STD-1777)
- Transport Layer – TCP
- Session Layer – TELNET
- Application Layer – FTP, SMTP.

EDCARS also expects to use a subset of IGES and PDES, MIL-STD-1840, and CCITT Group 4.

Transferring engineering drawings via the DDN is not recommended because of slow speeds and DDN overhead. However, it is estimated that 95 – 98 percent of all engineering data used by an ALC will be stored at that center, so the need for long-haul transmittal of drawings will be minimal. Today, only a small number of the total requests for engineering drawings are from other stations. Although there may be data redundancy between stations, each station will make modifications to the drawings at its location to make the drawing station unique to accommodate site-specific weapon systems. In the Air Force, there is a greater requirement for long-haul transmission of TOs than for engineering drawings.

Although Strategic Air Command (SAC) activities could benefit from the use of vector data, they represent only 1 percent of the total requests for engineering drawings. For that reason, and because the technology to convert raster readily to vector is not available, the Air Force intends to support raster data only. Once the



Note: EDCARS = Engineering Data Computer Assisted Retrieval System; LAN = local area network, CNTRL = Controller; DDN = Defense Data Network, kbps = kilobits per second, IMP = Interface Message Processor, TAC = Terminal Access Controller

FIG. 2-7. EDCARS REMOTE TERMINAL AND DDN COMMUNICATIONS ARCHITECTURE

capability is available to convert raster to vector without manual intervention, the Air Force will consider supporting vector data in its databases.

Today, all CAD systems and their terminals are proprietary. There is not a terminal that will allow a user to access different graphics systems. For this reason, proprietary AT&T terminals will be used to access the EDCARS. Standards must be established before another approach is feasible.

The Air Force feels that the EDCARS provides a capability that is better than the manual approach used today. The Air Force prepared for the EDCARS data conversion effort by generating new aperture cards or by making copies of the existing aperture cards, which were then read by laser scanners for conversion.

Any digitized data received from industry will be through the mail on magnetic or laser media rather than over communication lines. Basically, one Service procures the data, then reproduces the drawings and sends it to the other Services. There may be interface requirements with EDMICS and DSREDS, although specific requirements have not yet been defined. The system will primarily support user access to the data stored by EDCARS.

The Cataloging and Standardization Center (CASC) in Battle Creek, Mich., has presented a needs assessment in two parts to the EDCARS program. Part A is based on the initial intent of the EDCARS system to provide technical data to the user through the use of GDTs. The projected requirement is for 131,000 queries a year. While there is no requirement to modify drawings, access to both proprietary and nonproprietary drawings is needed.

Based on these requirements, CASC has requested 16 GDTs with printers. It is projected that the additional technical data support provided by EDCARS could result in a 5-year logistics cost avoidance of over \$1.9 million. A decrease of 1,850 items requiring entry into the Federal Supply System (annually) due to increased availability of technical data has been projected. The projected cost avoidance takes into consideration both previously stocklisted and not previously stocklisted items.

Part B of the CASC response is based on what they see as a potential enhancement of the system, inclusion of provisioning data. It is estimated that a total of 336,000 provisioning drawings a year will be added to the system. It is also projected

that CASC technicians will submit approximately 200,000 queries a year to this database. What additional hardware may be needed to meet this requirement has not been determined.

The potential benefits fall into two categories: the administrative cost savings associated with eliminating the need to manually manage hard copy aperture-card data, or both, and the cost avoidance realized through the improved ability to prevent duplicate and less preferred items from entering the Federal Supply System. Though cost avoidance is hard to estimate, CASC regards the potential payback for CASC and the rest of the command as significant. Acquiring technical data will continue to be a primary purpose of CASC's efforts in the coming months.

The present EDCARS contract will end in 1988. The Sacramento ALC will most likely become the lead ALC through the AFLC for continuing EDCARS efforts. The EDCARS concept will then be expanded to include Configuration Control Management, Provisioning and Cataloging Data, and other areas as enhancements of the current design.

2.3.3 Intelligent Gateway Projects

The Air Force has recently awarded a contract for development of the *Central Datacomm System* (CDS), which will be the front end for all large computer systems in the Air Force Systems Command (SYSCOM). It will serve as the single point of access for anyone attempting to access SYSCOM systems from off-base. The CDS will basically have the same functionality as LOGDIS under development in the Logistics Command, but unlike the LOGDIS will not support such office automation functions as spreadsheets. The CDS is to support DDN protocols over Ethernet.

SYSCOM has requirements to support access to a heterogeneous environment that includes Control Data Corporation (CDC) Cybers, Crays, VAX, Eclipse, and Pyramids. A few of the goals of the CDS project are: to reduce the myriad connections between user stations and the Aeronautical Systems Division (ASD) Information Systems and Technology Center (ISTC) computer systems; increase the functionality and speed of transfer of user data to and from the ISTC; provide a single point-of-entry for user and account validation and resource authorization; and provide a focused, controlled point-of-connection between Wright-Patterson Air Force Base (WPAFB) LANs and the ISTC.

The System Program Offices (SPOs) and SPO support organizations comprise a large portion of the ASD community. They plan, develop, and manage the acquisition of new aeronautical systems. These efforts include upgrading existing aircraft, such as the F-15 and F-16 fighters, and development and procurement of new aircraft, such as the B-1B bomber and the C-17 transport. Computer support in engineering is provided by several organization-owned VAX minicomputers and microcomputers (e.g., Zenith-100s).

In addition, the SPOs and supporting organizations depend heavily on the processing capability of the ISTC computer systems. There are, at present, few engineering support networks within the SPOs and supporting organizations. However, this will change with the acquisition of the scientific engineering workstations (SEWs) in the near future. [ASD has recently awarded a contract for development of the SEWs, which is to serve as a standard source of supply for both SYSCOM and the Logistics (LOG) Command.]

The TRW LAN supports the ASD systems. It is a CSMA/CD broadband dual cable LAN, able to support as many as 240 channels. Two 56 kbps circuits to DDN are now used; this number may grow to five. The CDS will eventually interface to at least 16 T-1 circuits supported by the DCTN. A Digital Equipment Corporation Network (DECNET) LAN is also used to support ASD operations. There is a future requirement to interface with weapon system contractors. There are a few connections today over dedicated lines with contractors such as Rockwell and Boeing. The Air Force is working on similar connections with General Electric (for the F-16) and McDonnell-Douglas (for the C-17).

The *Logistics Data Information System* (LOGDIS) Intelligent Gateway Processor (IGP) provides tools for managing data within the office and for connecting the office to outside sources of information. The IGP automates and provides access to multivendor hosts via the DDN, asynchronous RS-232C interfaces, or LANs. Software support automates access to other host computers, data retrieval, security processing, and control of information resources. The IGP also provides functional software, such as electronic mail, personal calendar system, word processing, spreadsheet programs, relational DBMS, user-oriented menus, system administration menus, and routines for maintaining software. The UNIX operating system is the foundation of the IGP; the IGP software is therefore not vendor specific although it is operating system specific. The Air Force intends to provide office

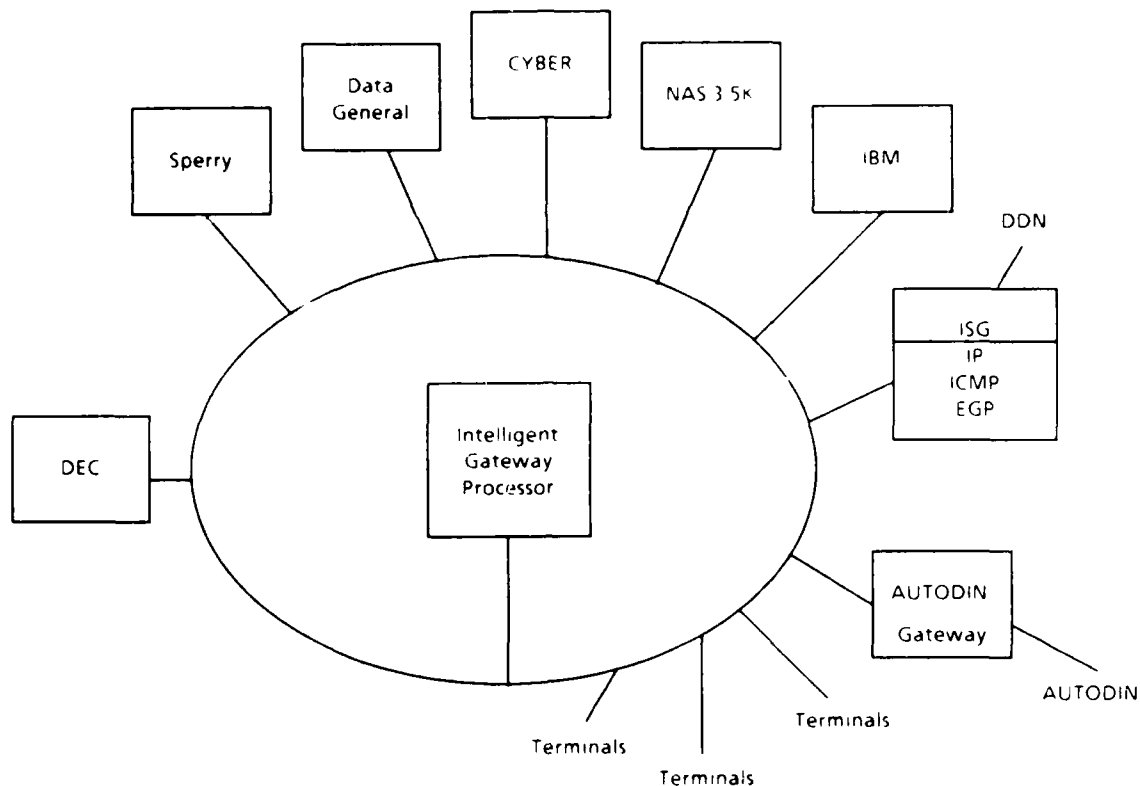
automation functions through a separate multi-Service system development effort. The office automation functions would then be removed from LOGDIS. The goal in the Air Force is to build simple gateways that allow the user access to heterogeneous systems. However, the office automation capabilities are so integrated in the LOGDIS IGP that separating them from the gateway may be difficult.

The LOGDIS IGP operates in an asynchronous terminal environment, selects optimum communications pathways, translates protocols through external protocol emulators, provides the host-to-host dialogue, translates files, and offers post-processing. LOGDIS also provides overall transaction control, accounting, and security. Interactions with users are menu-driven and self-guided, and on-line help for several levels of expertise is offered. The user must be familiar with the selected resource, since search negotiation must proceed according to the syntax and logic of the target system. Extracted information can be placed in data files for subsequent postprocessing, analysis, and graphical display.

The latest versions of the operational LOGDIS IGP have been installed at WPAFB and at Hill AFB on a PLEXUS P-60 machine. The IGP's serve as hosts on the AFLC LANs (Figure 2-8) to supply intelligent processing for dumb terminals. Not all terminals will pass through the gateway; only those users that require the intelligence provided by the gateway, such as transparent connectivity to a local or remote host or the capability to down-load information from a host for further manipulation, will be connected. Users will have the ability to tailor an IGP to their unique applications.

One component of the *Integrated Design Support (IDS) System* involves development of a prototype MULTIBASE front end to enable Air Force personnel and aerospace contractors and subcontractors to gain access to design manufacturing and engineering data on the development of weapon systems. This work is being performed by the Computer Corporation of America (CCA) as a subcontractor to Rockwell International, the prime contractor for B-1B bomber development. Interfaces must also be provided for AFLC and the many other second- and third-tier subcontractors in the B-1B program.

MULTIBASE is a software system that provides a uniform, integrated interface for retrieving data from heterogeneous, distributed databases. Because it



Note: DDN = Defense Data Network; ISG = intersite gateway; IP = Internet Protocol; ICMP = Internet Control Message Protocol; EGP = Exterior Gateway Protocol; AUTODIN = Automatic Digital Network.

FIG. 2-8. PROPOSED LOCAL AFLC LAN ARCHITECTURE

features an integrated schema and a single query language, familiarity with one system interface is all that is needed.

The language provided to global users by MULTIBASE is DAPLEX, a data definition and manipulation language for database systems. DAPLEX provides a natural language interface to the database. The component architecture of MULTIBASE is illustrated in Figure 2-9. MULTIBASE has two types of modules: a global data manager (GDM) and a local database interface (LDI). All global aspects of a query are handled by the GDM, and all specific aspects of a local system are handled by an LDI. There is one LDI for each local DBMS accessed by MULTIBASE.

DAPLEX can pull together the two disparate codasyl and relational data models. Through MULTIBASE, relatively powerful views can be constructed over lower-level schema.

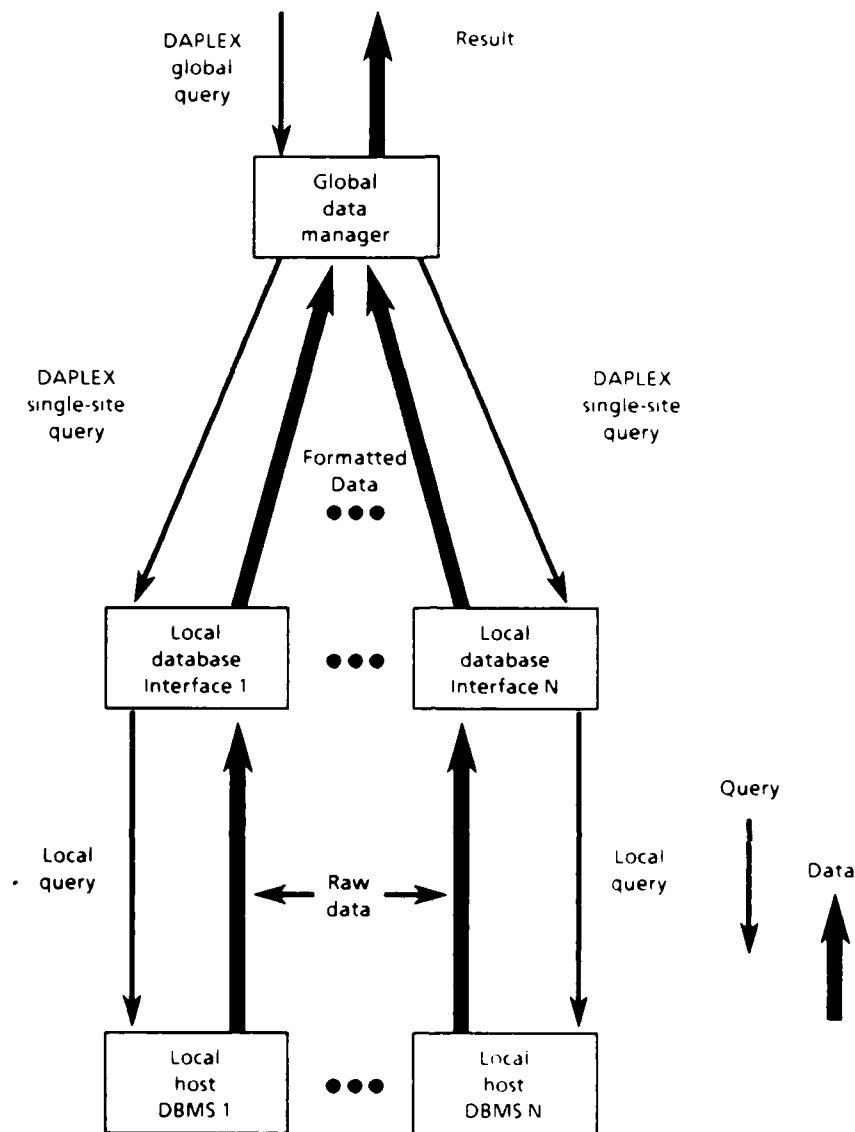


FIG. 2-9. MULTIBASE COMPONENT ARCHITECTURE

The Air Force MULTIBASE system is being implemented on a VAX 11/780 to interface with ORACLE and the Relational Information Management (RIM) DBMS on the same VAX 11/780. The technical feasibility of this approach is still questionable. Security restrictions and data dictionary incompatibilities must be overcome. The data dictionary is expected to require between 1 and 10 gigabytes of storage. Other considerations include a capability for network transaction management, file transfer, executive control system, and rules for configuration

management. Some of these considerations will be addressed in the prototype, and other problems may be identified.

Response time is an issue in any MULTIBASE implementation, and performance has not yet been addressed. As an interim measure, however, MULTIBASE can provide a user community with an ad hoc means to quickly generate reports that today require from 6 months to more than 1 year from request through implementation.

The Air Force policy is to use the Structured Query Language (SQL) as the standard database language. The Air Force, Army, and Navy have signed a memorandum of agreement to develop a standard database machine to be used as a standard component in applicable systems. Future acquisitions will focus on issues related to security in the DBMS environment.

2.4 ARMY TELECOMMUNICATIONS REQUIREMENTS

This subsection describes communications architecture concepts and strategies underway in various Army Commands, including the Army Materiel Command (AMC) and the Army Information Systems Command (ISC). Army-wide telecommunications requirements for CALS are being developed by the Army Communications - Electronics Command (CECOM). In addition, the DSREDS Project is discussed in terms of the status and major issues associated with automating the Army's repositories of engineering drawings. A brief description is also given of the MULTIBASE effort as the Army's approach to the use of IGs.

2.4.1 Network Initiatives in the Army

Every major command in the Army is developing an overall telecommunications architecture to be submitted to Headquarters (HQ) Army. The *Army Materiel Command* (AMC) has developed an overall installation architecture. The AMC strategy classifies LANs into one of two types: a closed or "local" LAN and an installation or post-wide LAN. The local LANs are typically self-contained networks, with relatively few users working on an application of limited interest to the post or base as a whole. The post-wide LAN provides connections to post computers, access to DDN, and communications for office automation functions. Implementation of these LANs will enable users to query all of AMC's databases from a single terminal.

AMC believes that all DDN requirements can be satisfied by DDN-to-LAN gateways and need not affect the design of the LAN itself. These DDN-to-LAN gateways will be the preferred method of connecting to DDN, since they impose the fewest restrictions on the user. Devices not compatible with DDN can still be used on the LAN, since the gateway would resolve the incompatibilities and provide the DDN connection. It is also much simpler to install and maintain one or a few network connections to DDN than many different device connections.

The present approach in the overall AMC network architecture is to merge the communications center function with the automation functions. That is, all message traffic will be received through a gateway on the LAN rather than through a separate message center, as is done today. A number of computers will therefore be connected directly to the AUTODIN or DDN for the receipt of message traffic. Transaction and batch processing will be received through an FEP.

AMC hardware configurations consist of IBM-compatible equipment running under MVS and UNIX-based operating systems. Access to this hardware is either through a direct connection, LAN, dial-up, AUTODIN, DDN, or some combination.

AMC is developing its LAN plans within the set of LAN technical standards and planning guidelines for overall Army use developed by ISC. Approximately 40 LANs have been identified and approved for use within AMC. The intention is to use fiber optics with a mix of coax and twisted-pair cable.

The *U.S. Army Information Systems Command* (USAISC) has developed an architecture plan to meet the base information transfer aspect of its information systems mission over the next decade. ISDN technology will be the architecture of choice for long-term Army base information transfer modernization actions. This includes a local high-speed information transfer network at the end of many of the ISDN digital local loops to handle the high level of internal office/unit information transfer needs, while maintaining connectivity and single-line-unique numbering for the individual information devices.

The strategic and long-haul information-transfer requirements for external Army base communications will be satisfied by the Defense Communications System (DCS) and commercial carriers. The primary DCS service for data communications is the DDN.

The information system for the sustaining base in CONUS will use numerous cable technologies as the transmission media. Fiber optics will be the cable technology of choice for use at Army Bases. The cable system on the Army Bases will, of necessity, be a mix of fiber optic, coax, and copper cable.

The fiber optic cable will be used for the high-speed (1.544 Mbps and greater) digital information transfer. The lower speed digital information transfers will use copper cables. The fiber optic cable system at Army Bases will evolve from two directions – the long-term ISDN basewide modernization and the near- to mid-term office/unit information transfer initiatives.

Long-term ISDN basewide modernization will focus on the ISDN switches and the fiber optic cable network to connect these ISDN switches. This fiber optic cable network will form the nucleus of the base digital backbone network. The transmission of data through the interswitch trunks will be typical of the information transfer service of the base digital backbone network. Channels of 1.544 Mbps (or $n \times 1.544$ Mbps) are multiplexed into a higher rate digital signal and transmitted over the fiber optic cable. The fiber optic base digital backbone network must also support high speed ($n \times 1.544$ Mbps) digital information transfer service for computers and end-user information devices.

This architecture may not satisfy all requirements. We also recognize that networking will evolve and define new information services and protocols. These new information services and protocols will be incorporated in the architecture as it becomes feasible.

STARNET is the concept for the Army's integrated worldwide network of computer processors and peripherals that is the primary provider of information processing, storage, display, and network services for the sustaining base. *STARNET*, a subset of the sustaining base portion of the Army Information Architecture, relies heavily on other standard systems for supporting services, such as networking. More than 90 sites are planned for *STARNET* facilities.

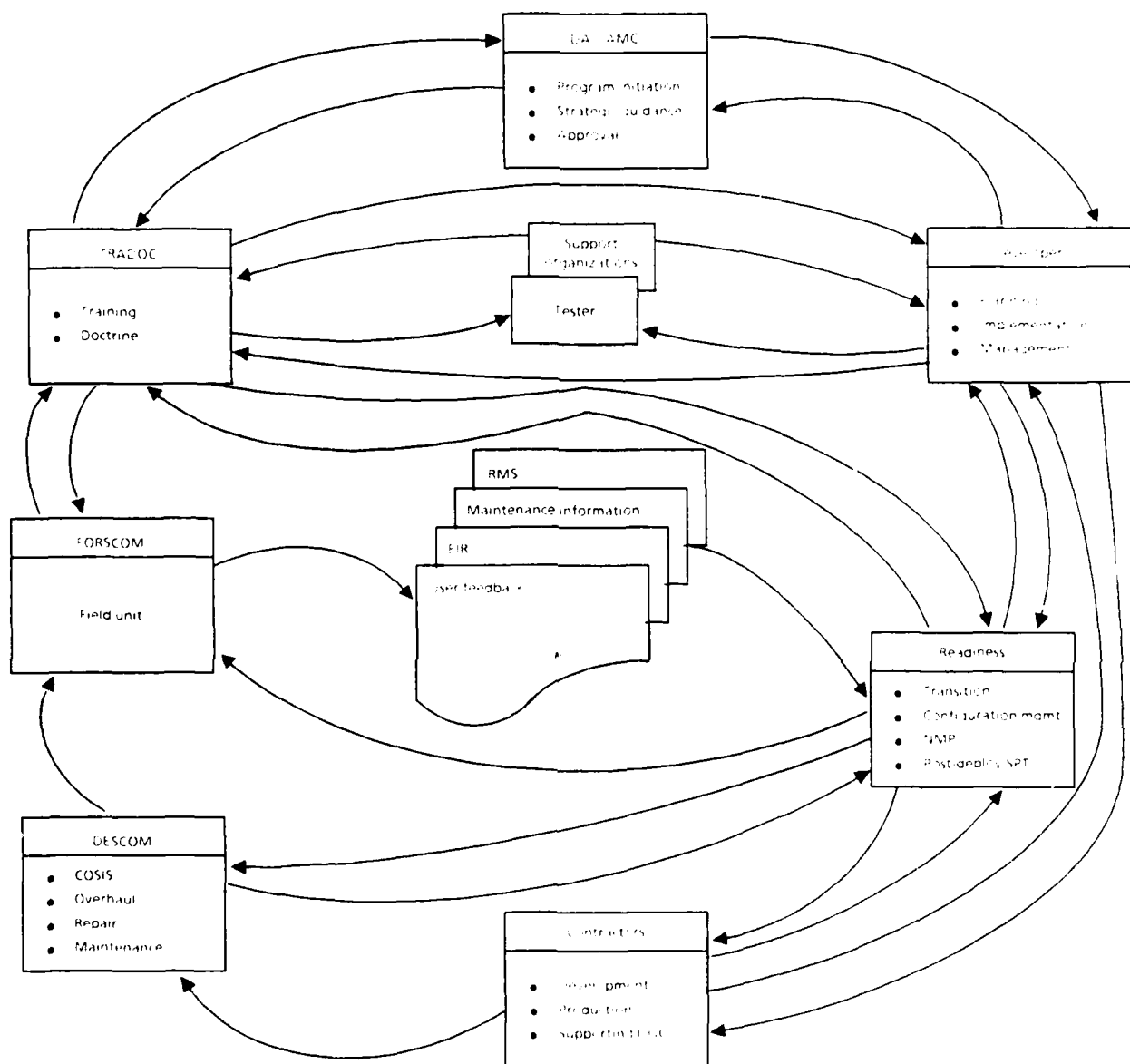
The 1992 *STARNET* is seen as a highly distributed, richly connected set of user sites. True multilevel, secure operating systems will still be a high-risk technology. However, low cost but high throughput processing and encryption technology could allow the user to perform multilevel file transfer into a desk or a portable work station and operate each device at the highest level of access allowed to the

individual user. Network standards will be ISDN and OSI, with fifth-generation languages becoming the norm for complex tasks.

Currently the Army has large, disjointed data networks. In addition, they use close to 3,000 Government and commercial leased data circuits. STARNET will take advantage of the large investment and capability that exists in these networks. Since STARNET will rely on commercially available products, the pace of the evolution of the network will be set by technologies such as OSI, multilevel security (MLS) such as the BLACKER technology, and ISDN.

The initial phase of the *CECOM* effort documented the current paper-based logistic support information system by surveying Army users to establish data flow patterns, demand rates, storage requests, and usability criteria. This data collection and requirements analysis has produced a conceptual architecture for the implementation of CALS in the Army. *CECOM* recently published its draft of the CALS Existing Data Communications Baseline, which provides information on: (1) critical CALS information data flow between selected sites; (2) a quantitative analysis of the existing data flow for each CALS site; and (3) existing DDN architecture, connectivity, equipment availability, and usage. The Army CALS technical information flow between major Army commands and industry is depicted in Figure 2-10.

The report depicts existing volume for text, engineering drawings, and illustrations, which are now exchanged largely in hard copy form and microfilm. Volume is defined as total pages or page equivalents per year to and from each organization. Page size for all the calculations is 8 ½ inches by 11 inches. Total bits per page has been computed to be 42,000 bits/page for text and 512,000 bits/page for engineering drawings. Table 2-5 shows a sample of data transfer requirements for *CECOM*. Bits are presented in billions of bits per year. Appendix C presents Army-wide data transfer requirements.



Note: DA = Department of Army, AMC = Army Materiel Command, TRADOC = Training and Doctrine Command, FORSCOM = Forces Command, RMS = Resource Management System, EIR = Equipment Improvement Recommendation, NMP = National Maintenance Point, SPT = support, DESCOM = Depot Systems Command, COSIS = Care of Supplies in Storage, DOC = documentation

FIG. 2-10. ARMY CALS TECHNICAL INFORMATION FLOW

TABLE 2-5

CECOM DATA TRANSFER REQUIREMENTS

U.S. Army Communications - Electronics Command (CECOM)

CECOM	Text	EDWG ^A	LLUS ^B	Billion bits	CECOM from	Text	EDWG ^A	LLUS	Billion bits
ALC	2,250	7,200		3.81	ALC	2,250	7,200		3.81
ALC	3,500			0.15	ALC				
AMC	59,258	16,096	16,165	19.04	AMC	13,739	648	708	1.29
AMCCOM					AMCCOM	3,500			0.15
AMSAA	3,500			0.15	AMSAA				
ANAD	241,569	2,601	180,891	104.21	ANAD	241,569	2,601	180,891	104.21
AVSCOM	3,500			0.15	AVSCOM	3,500			0.15
CAC	3,500			0.15	CAC				
CCAD	242,295	2,971	180,891	104.14	CCAD	242,295	2,971	180,891	104.14
Coml print	73,800		34,150	208.65	Coml print				
Contractor	520,640	222,400	132,200	220.41	Contractor	918,170	28,192	22,402	64.77
DA	8,049	648	708	1.53	DA	2,990			0.13
DESCOM	296,372	6,559,068	331,018	3,564.61	DESCOM	74,000	17,618	16,830	20.87
DLA	2,250	7,200		3.81	DLA	2,250	7,200		3.81
DLSC					DLSC	2,250	7,200		3.78
FORSCOM	5,980			0.21	FORSCOM	2,990			0.11
Ft. Bragg	2,250			0.04	Ft. Bragg				
Ft. Carson	2,490			0.11	Ft. Carson	500			0.03
Ft. Gordon	531,199	648	648	213.76	Ft. Gordon	14,909	648	648	1.29
Ft. Knox	180,495	6,556,369	321,600	3,530.21	Ft. Knox	180,475	6,556,369	321,600	3,530.21
Ft. Lewis	29,600	14,800	14,800	16.11	Ft. Lewis	29,600	14,800	14,800	16.11
LBAD	1,332,680	6,544,997	634,815	3,733.79	LBAD	1,332,680	6,544,997	634,815	3,733.79
LEA	3,500			0.15	LEA				
LEAD	212,848	665	179,400	1,012.11	LEAD	212,848	665	179,400	1,012.11
MICOM	3,500			0.15	MICOM	3,500			0.15
MRSA	454,980	6,192	192	22.15	MRSA	440,500			18.63
MZAD	270,271	4,743	182,331	107.21	MZAD	270,271	1,714	182,331	112.25
Navy	2,250			0.10	Navy	2,250			0.10
NBG	4,980			0.21	NBG	2,490			0.10
NCAD	241,020	2,360	180,891	104.01	NCAD	241,020	2,360	180,891	104.01
OTEA	3,500			0.15	OTEA				
RRAD	269,967	4,591	182,331	107.10	RRAD	269,967	4,591	182,331	107.10

^A Engineering Drawing^B Illustration

The report also contains an analysis of the existing Army DDN facilities and provides information on:

- DDN facilities locations
- The identification of DDN PSNs Interface Message Processors (IMPs)
- The identification of DDN host processors at each location
- The identification of TACs at each location.

Copies of the report may be obtained from CECOM at Fort Monmouth, N.J.

2.4.2 Army Engineering Drawing Modernization Efforts

The DSREDS is being developed by AT&T at Redstone Arsenal, Ala. The overall DSREDS/EDCARS contract is managed by the Army. The Air Force is responsible for and manages its own side of the project. The system will serve as a builder of technical data packages for procurement. Approximately 2,500 images are retrieved each day for building procurement packages at Redstone Arsenal. The typical technical data package has 20 – 25 drawings (200 megabytes of images), with a requirement to reproduce 40 copies of each package. This results in a tremendous number of cards that must be generated and distributed throughout the local environment.

DSREDS technical requirements include the ability to input 950 aperture cards per hour and 20 "C" size hard copy drawings per hour. (Drawings range in size from A through E, C being the average-size drawing.) Interactive engineering data retrieval requirements include 3-minute response time for retrieval of 25 "C" size drawings within 3 minutes to be displayed on 25 different remote GDTs. There are also requirements to be able to generate the microfilm for 1,700 images per hour, produce 9,600 copies of aperture cards per hour, and to plot a full-size high-resolution plot of an "E" size drawing in less than 3 minutes.

Based upon system performance requirements, the Government originally projected that it would take 4 months to load the existing images at the Army Missile Command (MICOM). Because of a number of problems, it appears that it will take 50 percent longer. For example, more than 40 percent of the aperture cards are not scannable, for a variety of reasons. AT&T's response to the Army's RFP proposed to design a system to read and store drawings based on the Government

specifications provided to them. However, the specifications were not followed by Government and contractor personnel when the drawings were originally made. The Air Force alleviated some of the physical problems associated with storage and age of the drawings by generating new cards or making copies of the old aperture cards. The Army used its original cards, many of which had degraded as a result of long periods of storage.

All the companies bidding on this contract proposed using off-the-shelf hardware and software. AT&T, after contract award, became aware that much that was needed to support the DSREDS/EDCARS requirements is not available off-the-shelf. AT&T has a firm fixed-price contract with the Army and had originally intended to invest some of its own money in this effort. As a result of the problems encountered, many of which were unknown at the time of contract award, AT&T is, in fact, investing a substantial amount of money in this development effort. In consideration of failure to meet contract terms, the Army has received a value of over \$7 million in enhancements. The enhancements include laser printers, improved scanners, an upgraded central processor unit, and a COMTEN FEP. The Army suspended on-site acceptance testing for 57 days while AT&T fixed problems with the system.

Although there may be problems in implementing the system, the Army is convinced that this is still the way to go. The system to be replaced by DSREDS requires five customer engineers to handle maintenance problems. Parts are not available. Maintenance is very expensive, and the system is down one-third to one-half of the time. The predominantly manual system results in losses of data from misfiled cards. The digitization of data would be permanent, with no problems from missing cards.

The original contract includes a two-tier-oriented set of options. The Air Force has obligated all its money by exercising all of its options (four options for five systems). The Army, on the other hand, has exercised only the basic system and one option out of six options for seven systems, and therefore has approximately \$22 million left, so long as the funding remains available.

The Army sees a need to communicate not only between the EDCARS and DSREDS systems, but also with DLA and the Navy. In past procurement efforts, there have been areas where all could benefit by exchanging engineering drawings.

A test is currently underway with the Sacramento EDCARS to download data from the Air Force system to the Army system.

The Army plans to store vector data in a library that will be available for access by the user. The Army is also trying to define vector-to-raster requirements so that graphics stored in vector form can be translated into a two-dimensional image to be stored in DSREDS. AT&T has contracted to develop a CAD/CAM (computer-aided manufacturing) interface, once the IGES 3.0 subset standard has been defined for CALS. The Army also plans to add a Tech Data Configuration Management System (TDCMS). Although the current contract does not provide for a number of capabilities, the intention is to develop a system that can be upgraded later with enhancements.

The technical data packages generated by DSREDS at the Army MICOM at Redstone Arsenal will, for the most part, be transmitted within the local environment only. Only a small number of drawings will have to be transmitted to remote locations over DDN. It will be 3 to 4 years before the broadband network is installed at Redstone Arsenal. The Army will use T-1 carrier lines initially and will then convert to broadband.

DDN will be used for text and mail, but not for images. Other commands have indicated that they will have requirements to transmit large numbers of drawings to remote locations over DDN. For example, the Armament, Munitions, and Chemical Command (AMCCOM) at Picatinny Arsenal has a requirement to transmit master bid sets and aperture cards (an average of 1,500 aperture cards a day) to Rock Island Arsenal, which handles all supply procurements. At an average of 8 megabytes per image, and assuming a 20:1 compression ratio, it would take approximately 30 hours to transmit just the graphics information over the DDN. This estimate includes the 25 percent overhead incurred when using the DDN. Where the need is to transmit only a few drawings, long-haul communications lines (DDN) could prove satisfactory. However, where large numbers of drawings must be transmitted, overnight mail would be more efficient and faster.

The Army is concerned by the proposed CCITT Group 4 standard for CALS. Group 4, as it stands today, is a facsimile standard that has not been expanded beyond the 8 1/2 inch x 11 inch size drawing. The Group 4 "wraparound" (a modified version of CCITT Group 4) used by the DSREDS/EDCARS effort, incorporates an

expanded algorithm that accommodates the transmission of engineering documentation for drawings larger than "A" size. The wraparound version performs the functions required for compressing larger size engineering drawings. Testing and research recently undertaken by West Coast Systems and Lawrence Livermore National Laboratories (LLNL) points to slight advantages in speed, number of bytes to store, and overall efficiency to using the wraparound version, with virtually little difference between the two versions.

It will be another year or year and a half before an expanded algorithm is developed for Group 4. The DSREDS/EDCARS effort has already implemented and stored tens of thousands of drawings based on the wraparound version. Both the Army and the Air Force have indicated that it would cost DSREDS/EDCARS \$3 million to \$5 million to redesign, retrofit, and reload the drawings. As an alternative, pre- and post-processors could be developed to convert from the wraparound version to Group 4. No estimate has been given for the cost associated with the development of these translators. The Army is willing to support the logical choice of standard in this area. However, both the Army and the Air Force recommend that CALS adopt the Group 4 wraparound, since that is all that is available today and there is no proof that there will be anything better. The CALS Specifications and Standardization Working Group is addressing the issue.

2.4.3 Intelligent Gateway Projects

CCA is under contract with AMC to develop a MULTIBASE front end for two DBMSs resident on IBM mainframes (System 2000 DBMS and AMC's in-house-developed Data Management Routines). MULTIBASE is a software system that provides a uniform, integrated interface for retrieving data from preexisting, remotely distributed, heterogeneous databases. It was designed to allow the user to reference data in these databases with one query language over one database description (called a schema). MULTIBASE enables the user to access data in multiple databases. Because there is an integrated schema and a single query language, the user has to become familiar with one system interface instead of several. The MULTIBASE architecture is described in Subsection 2.3.3.

MULTIBASE does not require any changes in existing databases, their DBMSs, or their application programs. The system assumes complete responsibility

for knowing the location of the local databases, accessing the data at each, resolving data incompatibilities, and combining the data to produce a single result.

A conversion of MULTIBASE to full Ada is included in the contract with CCA. A number of performance enhancements will be made including the addition of a query interrupt capability. MULTIBASE will run under the VAX VMS operating system and a gateway (TCP/IP-Ethernet) will be developed to interface the VAX 11/780 to the IBM hosts using the TCP/IP protocol as the interface standard. The IBM at the Automated Logistics Management Systems Activity (ALMSA) in St. Louis, Mo. will be used to access test data and aid development of the system. A prototype implementation will be installed at CECOM at Fort Monmouth, N.J.

To execute multi-database queries correctly and efficiently, MULTIBASE has to solve such problems as transforming a query expressed in the user's global query language into a set of subqueries in the languages supported by the different DBMSs; formulating an efficient plan for executing a sequence program for accessing the data at single or multiple sites; moving and storing the results of subqueries; resolving incompatibilities among the databases, such as differences in data types, and conflicting schema names; resolving inconsistencies in copies of the same information that are stored in different databases; and combining the data into a single answer.

Response time is an issue in any implementation of a data retrieval system of MULTIBASE's scope and capabilities. Significant improvements in performance have been made over earlier versions of the MULTIBASE software. Additional improvements are planned as development of the software continues. As currently configured, MULTIBASE will provide dramatic improvement over current data retrieval and consolidation activities involving multiple heterogeneous databases. Additional improvements are expected in the development of standard reporting programs and systems since MULTIBASE can provide a user community with an ad hoc means to quickly generate reports that today can require from 6 months to more than 1 year from initial request through final implementation.

SECTION 3

TELECOMMUNICATIONS INITIATIVES IN INDUSTRY

In this section, we discuss a number of initiatives now underway in the private sector in the area of telecommunications, including MAP/TOP and the NBS GOSIP specification. In addition, three industry efforts to provide high-bandwidth networks are examined: T-Carrier Services, the emerging ISDN, and FDDI. Each of these digital connectivity mechanisms makes possible higher transmission speeds, improved error performance, and higher throughput than does DDN. They are at varying stages of the development cycle and represent the current undertakings of the communications industry to provide the wide-bandwidth service that will be required to support the graphical/image data volumes anticipated by the CALS projects. The subsections that follow explain briefly the services offered, estimate the expected dates of availability, and examine their use in the CALS environment.

3.1 MANUFACTURING AUTOMATION PROTOCOL/ TECHNICAL AND OFFICE PROTOCOL

We have evaluated the MAP suite and the TOP suite to determine their applicability to the data transmission and protocol requirements of the Service's CALS projects and to determine their status as standard architectures in the private sector. These two protocol suites are the primary forces driving implementation of the OSI communication standards in the United States.

The purpose of both MAP and TOP is interoperable, multivendor, nonproprietary implementation of the OSI communications standards. Both are based on the OSI seven-layer architectural model developed by ISO. Mainly, the individual standards referenced are those specified by ISO/OSI, but they also draw on IEEE and CCITT standards. The reasons for the differences between the two protocol suites are the diverse environments in which each is to work: MAP in a factory environment. TOP in an office environment. Both suites of protocols provide various options at the individual layers to provide the user with flexibility in meeting application-unique requirements and environment concerns. Both MAP and TOP are user-driven initiatives that are committed to the use of existing standards.

Neither suite is developing new standards. Both suites will be expanded, particularly at the Application and Presentation Layers, as new standards are developed and accepted in the international community. A joint user/vendor group has been formed to propagate and expand the two standards and to provide a forum for both vendor inputs and user concerns. This group, called the MAP/TOP User Group, is located at One SME Drive, P.O. Box 930, Dearborn, Mich., 48121.

The primary sponsor of MAP has been the General Motors Corporation, whose factory communications needs were not being satisfied by the communications industry. They require support of the concept of flexible automation, which enables a single manufacturing facility to produce a variety of different, constantly changing products through changes in programming. With flexible automation, companies can respond rapidly to varied market needs, design changes, and product customization. These communications needs are unique to the factory environment, and MAP has been put in place to satisfy them. Simply, MAP is a set of rules for data communications among devices made by different vendors, optimized for the needs of factory automation, communications, and control. MAP can be thought of as a specialized implementation of the OSI Model, specifically configured for factory automation. Table 3-1 illustrates the MAP Version 3.0 architecture according to the OSI Seven Layer Model.

The primary sponsor of TOP has been the Boeing Computer Services Company. This protocol suite is designed to operate in an office environment, linking such equipment as word processors, PCs, and computer mainframes. Applications that are to be supported include electronic mail, word processing, editable text and nontext document exchange, graphics interchange, and file transfer. TOP has increased the functionality of their specification by adding various data exchange standards to accommodate the transmission and representation of certain types of data. Table 3-2 illustrates the TOP Version 3.0 architecture according to the OSI Seven Layer Model.

3.1.1 MAP/TOP Architecture Comparison – Shared Standards

As Tables 3-1 and 3-2 show, MAP and TOP duplicate each other exactly at the Presentation, Session, Transport, Network, and Data Link Layers. This subsection is concerned with the application protocols common to both suites.

TABLE 3-1
MANUFACTURING AUTOMATION PROTOCOL
(MAP Version 3.0)

Layer	Standard
Physical	Broadband Token Bus (10 Mbps) Carrierband Token Bus (5 Mbps)
Data Link	IEEE 802.4 Token Passing Media Access IEEE 802.2 Class 1 (Connectionless Link Level Control)
Network	ISO Connectionless Network Service (CLNS-Datagram) End System to Intermediate System (ES-to-IS) Routing Exchange Protocol
Transport	ISO Transport Protocol Class 4 (TP-4) Service
Session	ISO Full Set
Presentation	ISO Abstract Syntax Notation (ASN 1)
Application	ISO File Transfer, Access, and Management (FTAM) EIA RS-511 Manufacturing Message System (MMS) ISO Associative Control Service Elements (ACSE) ISO Common Management Information Protocol (CMIP) ISO Network Directory Services

Note: Mbps = megabits per second; IEEE = Institute of Electrical and Electronic Engineers; ISO = International Standards Organization; EIA = Electronic Industries Association

3.1.1.1 Data Link Layer

The common data link protocol, IEEE 802.2 Logical Link Control Class 1 (LLC 1), provides a connectionless-oriented communication service that allows for exchange of data between two logical entities without establishment of a connection. It does not provide for message sequencing, acknowledgment, flow control, or error recovery. The use of 802.2 LLC 1 and an appropriate bridge allows the connection of two LANs. Use of this connection scheme requires that all node addresses on both LANs be unique.

3.1.1.2 Network Layer

At the Network Layer, both LANs use the End System to Intermediate System (ES-to-IS) routing exchange mechanism to provide a dynamic routing capability.

TABLE 3-2
TECHNICAL AND OFFICE PROTOCOL
(TOP Version 3.0)

Layer	Standard
Physical	Baseband Bus (10 Mbps) Broadband Bus (10 Mbps) Carrierband (5 Mbps) Shielded Twisted Pair (4 Mbps)
Data Link	IEEE 802.3 CSMA/CD Media Access IEEE 802.4 Token Bus Media Access IEEE 802.5 Token Ring Media Access IEEE 802.2 Class 1 (Connectionless Link Level Control) CCITT Link Access Protocol Balanced (LAPB)
Network	CCITT X.25 Packet Level Protocol (PLP) ES-to-IS Routing Exchange Protocol ISO Connectionless Network Service (CLNS-Datagram)
Transport	ISO Transport Protocol Class 4 (TP-4) Service
Session	ISO Full Set
Presentation	ISO Abstract Syntax Notation (ASN 1)
Application	ISO File Transfer, Access, and Management (FTAM) ISO Associative Control Service Elements (ACSE) CCITT X.400 Message Handling System (MHS) ISO Virtual Terminal Protocol (VTP Basic Class) ISO Common Management Information Protocol (CMIP) ISO Network Directory Services

Note: Mbps = megabits per second; IEEE = Institute of Electrical and Electronic Engineers, CSMA/CD = Carrier Sense Multiple Access with Collision Detection, ES-to-IS = End System to Intermediate System, ISO = International Standards Organization

The ES-to-IS routing mechanism can be considered a sublayer within the ISO Connectionless Network Service (CLNS) Protocol, which is used to provide interoperability within a concatenated networking environment. This protocol is used to connect more than two LANs together or to connect with a wide-area network (WAN). The standard used to support long-haul connectivity is the CCITT X.25 Packet Level Protocol (PLP) with the Link Access Protocol Balanced (LAPB) at the Data Link Layer. Connection to an X.25 WAN requires

implementation of the Subnetwork Dependent Convergence Protocol (SNDCP) between CCITT X.25 and the ISO CLNS protocols.

3.1.1.3 Transport Layer

The common transport protocol, ISO Transport Protocol Class 4 (TP-4), is a connection-oriented protocol that assumes the use of an unreliable, underlying network service. TP-4 provides the transport service with multiplexing, error detection, and error recovery. Specifically, TP-4 service makes sure that data is not lost, duplicated, or corrupted in transit and that it arrives at its destination in the right order. TP-4 has end-system-to-end-system significance, where each end is defined as a corresponding transport entity. TP-4 is functionally equivalent to DoD TCP.

3.1.1.4 Session Layer

The common session protocol, ISO Full Session, provides a means for cooperating presentation entities to organize and synchronize their conversation and to manage the data exchange. ISO has defined three subsets of the 12 functional units that make up the full session protocol: the Basic Combined Subset (BCS), Basic Synchronized Subset (BSS), and Basic Activity Subset (BAS). Different subsets are required by different application protocols.

3.1.1.5 Presentation Layer

The common presentation protocol, Abstract Syntax Notation (ASN 1), specifies rules for defining and recording the meaning, or semantic content, of messages.

3.1.1.6 Application Layer

Both protocol suites specify use of the Associative Control Service Elements (ACSE). There are two parts to ACSE – the Common Application Service Elements (CASE), which provide general use capabilities needed by nearly all applications, and the Specific Application Service Elements (SASE), which provide services to specific applications.

The FTAM protocol is also specified by both suites. FTAM is logically divided into two sections. The first section, file transfer protocol, deals primarily with the way a file is moved from one system to another. The second section, file access and

management, deals with file attributes and protection. The FTAM protocol provides for the transfer of data files in a manner that is transparent to the semantics of that file. This means that although FTAM knows nothing about contents, it can be used to transfer files between systems. Both suites also share the Common Management Information Protocol (CMIP) specification and the Network Directory Services specification. The two major components of OSI management are Systems Management and Layer Management. Systems Management deals with the control, monitoring, etc., of multiple layers. Layer Management deals with the control, monitoring, etc., of a single layer. The CMIP is designed to provide the total Systems Management function. Additional protocols to provide the Layer Management functions are being developed.

3.1.2 MAP/TOP Architecture Comparison – Differing Standards and Options

This subsection discusses the differences and the options provided by MAP/TOP at several of the layers.

3.1.2.1 *Physical Layer*

The backbone MAP Physical Layer is a radio-frequency broadband bus providing high immunity to radio frequency and electromagnetic interference caused by the types of machinery located on the factory floor, ease of reconfiguration, which can be accomplished without adding additional cable, and suitability for campus-sized LANs spanning several miles. The bandwidth provided by the broadband bus is analogous to that of cable television, which can simultaneously handle dozens of different television signals. This type of medium uses frequency division multiplexing to divide the total bandwidth (approximately 400 Mbps), into separate channels to accommodate the various types of traffic. The MAP specification calls for two data channels operating over the broadband medium, each operating at 10 Mbps. To accomplish this type of simultaneous medium operation, all stations must use either a frequency-agile or fixed-frequency type of radio frequency (RF) modem to gain access to the physical medium. These strengths, plus the fact that there is a need within the factory environment to transmit various types of information (e.g., video, data, voice) over the same medium at the same time, make it the perfect medium for use in the factory environment.

The MAP architecture also provides for use of Carrierband, which is a 5 Mbps token passing bus. This is a less expensive way to link terminals and other devices

located in a single work group or cell. Carrierband is similar to the IEEE 802.3 standard in that it uses the entire bandwidth of the cable when transmitting data, but differs in the media access method, i.e., token passing vs. CSMA/CD. Carrierband is less expensive because it does not require use of relatively expensive RF modems or a headend remodulator as do broadband systems.

TOP initially specified a digital baseband bus as its physical media standard; with Version 3.0, other choices were added. A baseband bus is used to transmit primarily data traffic and provides only one transmission channel at a time. Baseband media provide a data rate of 10 Mbps limited to 500 meter network segments and a maximum of 1,025 nodes. This type of medium is generally favored for the office environment because the capacity to handle multiple channels is frequently not required and would be prohibitively expensive. The TOP users group acknowledges that the selection of transmission media at the Physical Layer is based on user requirements and has specified implementation specifications to accommodate various types of cables to meet user requirements.

The other physical media standards that are specified are MAP's Broadband (10 Mbps) and Carrierband (5 Mbps) standards, as well as shielded twisted-pair wire (4 Mbps), which is used in IEEE 802.5 token ring networks.

The costs associated with broadband and baseband are directly related to the bandwidth that each provides. A generalization can be made that the broadband method is about 2 to $2\frac{1}{2}$ times more expensive than its baseband counterpart because of the RF modems, headend remodulator, and physical cable plant required. Moreover, maintenance costs and maintenance staffing requirements pertaining to the broadband network are more expensive and more difficult. The selection of a physical medium is dependent on the specific application and environment. The decision regarding physical media depends on such factors as the number of nodes/terminals that have to be supported, the distances that must be spanned by the network, transmission speed and volume requirements, and environmental concerns.

3.1.2.2 Media Access Control

A second difference between the two protocol suites is in the choices available to provide media access control. Media access control specifies how the individual stations on the physical network may gain access to the backbone media. MAP uses

the IEEE 802.4 token-passing method, in which permission to use the network is passed from station to station in a predetermined order. The MAP network is therefore deterministic, because it guarantees access to the network by every station within a predictable period. This deterministic access capability is important in the factory environment, where critical data regarding the status of a factory operating robotic device might have to be reported to a control program in an absolutely predictable manner.

TOP initially specified the CSMA/CD method to gain access to the physical network media. With Version 3.0, the TOP users group has added the IEEE 802.4 token bus passing media access protocol and the IEEE 802.5 token ring passing media access protocol. CSMA/CD is a contention access method where each station on the bus contends for the physical medium, so that access to the network by a specific station cannot be guaranteed within a certain time period. With the CSMA/CD access scheme, a station that wishes to transmit data listens to the medium to find out whether it is in use; if it is, the station does not transmit. If the medium is not in use, the station transmits its data and monitors the medium to detect a collision of its data with that of another station. If a collision is detected, the station backs off for a preset time and then attempts retransmission. The main reason for choosing the IEEE 802.3 CSMA/CD in the first place is that it allows easy migration from an existing installed base of Ethernet LANs and that network components developed for Ethernet networks are widely available. In addition, the CSMA/CD technology running on the 10 Mbps cable has proven capable of handling a variety of technical and office applications, from document exchange to graphics exchange, in both business and engineering.

Comparison of the two types of media access methods – i.e., MAP's token passing deterministic and TOP's CSMA/CD contention schemes – is appropriate. Traffic load characteristics have a heavy influence on the selection of a specific media access technique. Generally, deterministic protocols, those used with MAP, are better suited for heavy traffic loads than the contention based probabilistic protocols used with TOP. Deterministic protocols allocate the available bandwidth more efficiently by giving each station predetermined access to the medium. When traffic loads are light, however, deterministic protocols provide individual stations with slower response and less throughput in comparison with contention-based probabilistic protocols. The reason for the slower response is that stations have to

wait their turn, even though no other station may have anything to transmit. The smaller throughput results from limitations on the amount of data a station may send before it has to relinquish access to the medium.

Probabilistic protocols have the opposite traffic-handling characteristics. They behave poorly under heavy traffic loads because transmission bandwidth is wasted by stations contending for the medium; the result is an increase in the number of collisions. But, under light traffic loads, they provide stations with quicker response and higher throughput than deterministic protocols. Quicker response is possible because stations may access the medium immediately whenever it is idle. Higher throughput results from the ability to access the medium quickly, over and over again, without the delay inherent in a token passing deterministic scheme. Probabilistic access methods are more suited for the random, bursty, unpredictable traffic common in the office environment. A great deal of debate is going on in the industry regarding the percentage of traffic load that would cause the probabilistic media access method to degrade in performance. Generally, it is agreed that degradation occurs when between 60 and 90 percent of the capacity is being used. Selection of media access protocol is thus dependent on the user's specific application and environment.

3.1.2.3 Application Layer

The third major difference pertains to specific standards chosen at the Application Layer of the OSI Model. The two protocol suites differ in the specification of the standard that pertains to the handling of message/electronic mail traffic between stations on the network. The MAP architecture specifies the Manufacturing Message System (MMS), which is designed to be a real-time system, used to control and monitor programmable controllers and other intelligent factory devices. There are a wide variety of such intelligent devices operating in the modern factory, and the goal of MMS is to make them work as a team, to produce high-quality products at minimal cost.

TOP uses the CCITT X.400 Message Handling System (MHS), which is designed to support interoperability between office equipment and electronic mail systems in a store-and-forward manner. The TOP specification also includes an additional application protocol, i.e., ISO VTP. The VTP specified by TOP is the ISO Basic Class Virtual Terminal Service/Protocol. This standard is built around an

object-based model that represents a terminal as a collection of arrays. Each array element may contain a single element. This Basic Class VTP provides only a command-line type of capability with simple scrolling and is analogous to the DoD TELNET protocol. VTP is expected to be enhanced to accommodate forms-type applications in the future.

3.1.2.4 TOP Data Exchange Standards

In addition to the common network services represented by the OSI Model, TOP specifies several common data interchange formats in its Version 3.0 specification. To accommodate the types of vector graphics data used in CAD and CAM environments, TOP specifies the use of IGES Version 3.0. This specification defines a format for creation of a file that enables the data in commercially available CAD/CAM systems to be exchanged or archived. IGES Version 3.0 offers increased capability in both geometry and nongeometry data exchange. The applications of printed wiring boards, finite element models, and mechanical products are supported. Another standard that TOP has specified is CGM. CGM is an ANSI standard for transporting graphics pictures among different devices. CGM is designed to accommodate graphics representations that do not require the detailed product data information of an engineering drawing. The CCITT Group 4 standard is specified to handle raster images and facsimile-type pictures. The Office Document Architecture (ODA) and Office Document Interchange Format (ODIF) are also specified. ODA/ODIF are a family of standards for the interchange of office documents, such as memos, reports, letters, and forms. Graphics Kernel System (GKS) is specified as the graphics language standard. GKS is a two-dimensional language and can handle both raster and vector graphics.

TOP has indicated that future work includes FDDI and ISDN at the Physical Layer, as well as Distributed Transaction Processing and forms class of the VTP protocol at the Application Layer. In the data format exchange area, SGML, PDES, Electronic Data Interface (EDI), and standards for imaging are planned. TOP will also address the Remote Database Access area as well as the security issue.

3.1.2.5 CALS Use of MAP/ITOP

MAP and TOP are emerging as the protocol standards that will be used in their respective environments to provide interoperability among networked devices. MAP and TOP are designed to connect with one another. This is accomplished in the local

environment at the Network Layer that is common to both architectures and resides above the media access protocols.

Both suites were initially developed for the local environment, but TOP Version 3.0 includes the CCITT X.25 standard to accomplish long-haul connectivity. The TOP specification includes the X.25 PLP at the Network Access Layer and LAPB at the Data Link Layer. Note that both the MAP and TOP protocol suites use the ISO/OSI standards at the upper layers and not the DDN suite of protocols. The two protocol suites are not capable of interoperation. This means that the end points involved in the conversation must apply the same standards. It is possible to link a MAP or TOP implementation with a peer MAP or TOP implementation over DDN, if DDN is used as a backbone medium only and there is no requirement to gateway among the various segments of DDN. This can be accomplished without significant problems and requires only a gateway at the Network Layer. To meet the packetizing, addressing, buffering, and flow control requirements, an X.25 network access interface would have to be acquired. To interoperate over the entire DDN internet, including all the network segments, the ISO Internet Protocol must coexist with the DoD IP and be recognized by the gateway PSNs. To gateway between the MAP/TOP protocol suites and the DoD protocol suite, (e.g., DoD FTP to/from OSI FTAM protocol) would require considerable work. NBS is working on such an application protocol gateway.

Another consideration in the transmission of data from one MAP or TOP implementation over DDN to another MAP or TOP implementation is the bandwidth disparity between the two transport media. The DDN is made up of 56 kbps backbone links with either 9.6 or 56 kbps subscriber-access links; the MAP/TOP transport mechanism operates at megabit-per-second speeds. To transfer the typical graphical image, in the million-byte range, over the DDN packet-switching network would take considerable time.

3.1.2.6 Standardization and Testing

Another problem that must be addressed has to do with implementation of the various protocols by the vendors. Both the MAP and TOP architectures are implementation specifications for the various ISO and other standard protocols that have been selected to support communications in their environments. The specific implementation specifications are based on the NBS OSI Implementors Workshop

Agreement documents. Centralized testing facilities have to be put in place to verify that a vendor implementation follows the standard and that it can interoperate with other vendor implementations.

One step toward establishment of a testing/demonstration system for OSI conformance is the OSINET. OSINET is a WAN, based on X.25 packet-switching technology designed to help foster the development and testing of OSI products and services. AT&T's Accunet X.25 packet network is currently used as the OSINET backbone. Vendors will have to perform interoperability testing with five other OSINET participants to demonstrate conformance.

Two other organizations are involved in putting testing and conformance facilities into place. The Corporation for Open Systems (COS), which is new to the community of standards, is now developing test cases and establishing a test bed for the MHS and FTAM protocols. The Industrial Technology Institute (ITI) has become the testing organization for the MAP/TOP user group and offers test services and test development for the protocol suites through its Network Evaluation and Test Center (NETC). The work of these two organizations should greatly accelerate the acceptance and use of the new protocol suites.

3.1.2.7 *Future of MAP/TOP to CALS*

In conclusion, the TOP architecture specification is more applicable to the types of data transmission required to support the CALS projects. Figure 3-1, based on material received from the Boeing Computer Services Company, depicts areas of commonality between TOP 3.0 and CALS, and between TOP 3.0 and GOSIP. (GOSIP is discussed in the next subsection.) The TOP specification has – or plans to provide – all the protocol implementation specifications required to support the CALS projects. The 10 Mbps baseband physical media with the CSMA/CD media access control mechanism should be sufficient to accommodate the CALS projects in the local environment. This takes into consideration the cost of the physical media and the bursty type of traffic load that is anticipated in the CALS environment. Although the baseband Physical Layer is recommended in most cases, broadband coax cable may be appropriate for campus-type installations where there is a requirement to support a mix of communications over longer distances or where additional bandwidth is required to support the data volume. In this case, the assignment of specific data subchannels over the broadband channel can

accommodate CALS-related projects data transmission requirements. This is accomplished by means of the broadband version of IEEE 802.3 and the appropriate medium attachment units. The selection of the physical medium is a site-dependent concern that must be addressed by the various CALS projects.

Adoption of this architecture will enable the Services to interface with industry when TOP becomes widely accepted in the private sector. MAP- and TOP-compatible products will start to become widely available in 1987 – 89. Most vendors have indicated support for the two protocol suites, and several are already introducing products that conform to the MAP/TOP specifications. Thus, use of TOP is a solution for CALS for the mid term, meaning in 1 to 3 years.

3.2 GOVERNMENT OPEN SYSTEMS INTERCONNECTION PROFILE

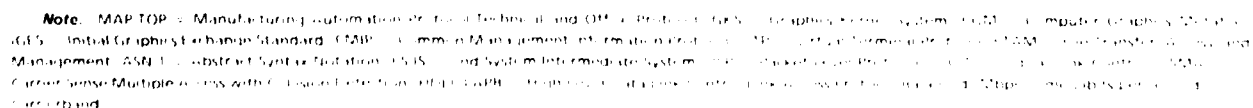
We have reviewed the GOSIP document to determine its relevance in support of CALS projects. The document specifies a set of OSI and other standard protocols that will be used in Government procurement documents in FY87 and FY88. The GOSIP document is based on the Implementation Agreements for OSI Protocols, NBS document NBSIR 86-3385. GOSIP addresses the need of the Federal Government to move immediately to multivendor connectivity and provides specifications for both end and intermediate systems.

3.2.1 GOSIP Architecture

Table 3-3 depicts the overall GOSIP architecture. GOSIP provides various options at the lower layers to support both the local and long-haul environment. For a particular procurement, the Government will select the appropriate options based on the specific environment. GOSIP specifies use of either IEEE 802.3 (CSMA/CD) or IEEE 802.4 (Token Bus) for media access in the local area. The IEEE 802.2 LLC 1 data link protocol is specified at the Data Link Layer. The CCITT X.25 PLP is specified for use in the long-haul environment.

The intermediate protocols specified are those endorsed by OSI: CLNS, TP 4, Session Protocol, Presentation Protocol ASN 1, and ACSE.

Two application protocols are specified, the FTAM protocol and MHS X.400. The FTAM protocol provides for transfer of data files in a manner that is transparent to the semantics of that file. This means that, although FTAM knows nothing about



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TABLE 3-3
GOSIP ARCHITECTURE

Layer	Standard
Physical	Baseband Bus (10 Mbps) Broadband Token Bus (10 Mbps)
Data Link	IEEE 802.3 CSMA/CD MAC IEEE 802.4 Token Bus MAC IEEE 802.2 Logical Link Control HDLC/LAPB
Network	ISO Connectionless Network Service (CLNS-Datagram) CCITT X.25 Packet Level Protocol (PLP)
Transport	ISO Transport Protocol (TP Class 4 or Class 0 Service)
Session	ISO Full Set of Functional Units
Presentation	NBS-AS3 Abstract Syntax Notation (ASN 1)
Application	ISO Associative Control Service Elements (ACSE) ISO File Transfer, Access, and Management (FTAM) CCITT X.400 Message Handling System (MHS)

Note: Mbps = megabits per second; CSMA/CD = Carrier Sense Multiple Access with Collision Detection; MAC = Media Access Control; HDLC/LAPB = High-Level Data Link Control/Link Access Protocol Balanced; ISO = International Standards Organization; CCITT = Consultative Committee on International Telephony and Telegraphy

contents, it can transfer files between systems. FTAM thus becomes the mechanism to transfer both text and graphics data between CALS systems.

The GOSIP specification is closely aligned with similar industry specifications for open systems, namely MAP and TOP. The GOSIP specification is a proper subset of the TOP specification. The differences between TOP and GOSIP are minimal within the basic OSI Seven Layer Model. GOSIP does not specify the options of Carrierband or shielded twisted-pair at the Physical Layer or the use of the IEEE 802.5 token ring media access. Nor does GOSIP specify use of the ES-to-IS routing exchange mechanism, which provides dynamic routing and is thus limited to static routing. In the application area, GOSIP does not specify the VTP, CMIP, or network directory services. NBS has taken a conservative approach on what is specified in GOSIP to allow flexibility in procurements. It is the plan of the GOSIP

committee to adopt additional application and presentation protocols as they become available.

3.2.2 GOSIP Implementor Concerns

The GOSIP document indicates areas, other than selection of applicable protocols, that have to be addressed before procurement. These areas have to do with additional requirements that are application or environment-specific. Two major areas must be addressed: site-dependent performance requirements and Service interface requirements. GOSIP does not cite performance criteria. Any performance criteria or benchmarking criteria used to validate performance are to be specified by the Government Acquisition Authority. And GOSIP does not recognize or specify any testing service for validating conformance with the implementation specification. COS may perform this testing role beginning in 1988. Conformance testing criteria and methodology are now to be specified by the Acquisition Authority. Service interface specifications are required to integrate user applications with the various layers and to provide operator control and management. Interfaces are important at the Network and Transport Layers. These are needed to implement the specification and to provide the Services with a usable and efficient system.

3.2.3 CALS Use of GOSIP

The current GOSIP document is a significant step toward interoperability between the Government and industry. It should help to focus the market by informing vendors exactly what is required by the Government. Although the application/presentation protocols required to support the transfer of documents and graphics are not specified, GOSIP intends to address these in 1987 – 89. The work being done on MIL-STD-1840 – specifically on SGML, IGES, CCITT Group 4, and CGM – is applicable to these protocols and should be adopted by GOSIP. The TOP Version 3.0 also addresses the data exchange protocols required by CALS projects. The TOP protocol suite, which is a superset of the GOSIP document, should suggest the additional protocols that will be specified by GOSIP. The implementor concerns, discussed in the preceding paragraph, will have to be addressed by the CALS community to ensure interoperability. The GOSIP document, providing direction for implementing all the protocols, should help greatly in eliminating the problem of vendor-specific implementations, which have been a barrier to connectivity in the past.

High-bandwidth support at the Physical Layer, in the long-haul environment, is required to satisfy the CALS projects' transmission needs. This requirement will be addressed by the emerging ISDN and FDDI standards. These two standards are GOSIP priorities for 1988 – 89.

3.3 T-CARRIER SERVICES

The first T-Carrier service, a digital facility, was introduced into the hitherto analog telephone network in 1962. It used an algorithm called Pulse Code Modulation (PCM) to digitize voice signals and enabled 24 of these digitized voice signals to be multiplexed over two pairs of wires by means of TDM. This first service, called T1, provided a data rate of 1.544 Mbps. It has since evolved into what is termed the T-Carrier Services, which provides a hierarchy of increasing transmission data rates. T1 service became commercially available in 1983. The T2 service provides 6.312 Mbps, the T3 provides 44.736 Mbps, and the T4 provides a data rate of 274.176 Mbps.

3.3.1 T-Carrier Overview

T1 Carrier service is a telephone transmission technology with transmission over two pairs of wires. It was designed to take as much advantage as possible of existing analog telephone transmission technology, i.e., twisted-pair wire. T1 repeaters are designed to be spaced every 3,000 to 6,000 feet, an arrangement that allows for one-for-one replacement of the existing analog lines' induction loading coil. The T1 composite data rate (1.544 Mbps) can be either used in its entirety or channeled. The most common channeling scheme divides the T1 composite into 24 channels, each capable of carrying 64 kbps. Each 64 kbps channel is designated Digital Signal Level 0 (DS0); and the entire 24-channel composite is designated DS1.

T1 applications are of three basic types: (1) point-to-point, (2) drop-and-insert, and (3) networking. Point-to-point transmission and the associated multiplexers used to accomplish it provide only one active T1 link, and they transmit inputs only from point A to point B. Drop-and-insert multiplexers provide the capability to establish point-to-point links with many drop points within the network. This allows single-DS0 channels to be removed from the T1 composite at intermediate locations in the network and new DS0 channels, targeted for other locations, to be added to the composite.

The drop-and-insert approach is not recommended for applications involving more than a few intermediate locations because of associated technical problems. Networking multiplexers enable an entire DS1 composite to be switched as a whole, in addition to making it possible for individual DS0 channels to be added and extracted from a composite. To achieve this networking capability requires either a Digital Access and Cross-Connect Service (DACS) from AT&T or private DACS switches. With private DACS switches, users can use non-AT&T transmission carriers.

Some ancillary features to look for in designing a T1 network are Automatic Alternate Routing (AAR), network management capabilities, dynamic reconfiguration capabilities, and rapid addition of circuits. In a small T1 network, e.g., two nodes connected point-to-point, many of these features would be unnecessary. However, in multinode networks, these features become much more important. These features add to the price of the equipment at every node.

Users subscribing to anything above T1 are rare. They are usually handled by special construction tariffs between the local phone company and the customer. In almost all these cases the high-speed circuits serve only to link the customers premises in a point-to-point connection and do not pass through the telephone company's central office. In fact, Data Switch Inc. recently announced a product that allows channel-to-channel connection of IBM mainframes across a T3 pipe. This would permit direct connection of IBM mainframes across virtually unlimited distances without the use of an FEP.

3.3.2 T-Carrier Costs

The following are the costs of recently tariffed AT&T Accunet T1.5 (T1) service and T45 (T3) service. We assume for purposes of analysis that there are three nodes with 100 miles between them, and that there are 24 channels on each link.

Accunet T1.5 pricing —

- Recurring monthly charges:

▶ Base T1 price	\$ 2,600	
▶ Mileage charge @ \$15.50 per mile	\$ 1,550	
▶ Central office charge	<u>\$ 62</u>	
▶ Total Monthly	\$ 4,212	
▶ 3 links (total monthly × 3)		\$12,636

- One-time charges:

▶ Typical 24-channel multiplexor	\$25,000	
▶ T1 installation charges	<u>\$ 620</u>	
▶ Total one-time	\$25,620	
▶ 3 links		\$76,860

A typical multiplexor in this price range would allow the following: connection of geographically dispersed sites using single T1 transmission link, voice, and data capabilities; automatic circuit path selection based on availability and performance; dynamic change of channel rates; clear-channel capabilities; and AAR in the event of circuit failure. Prices on T1 multiplexing equipment vary from \$5,000 to more than \$100,000, depending on the options chosen.

AT&T T45 (T3) service pricing (using same network described above)

- Monthly charges:

▶ Base T45 price	\$ 1,400	
▶ Mileage charge @ \$205 per mile	\$20,500	
▶ Central office connection	\$ 1,000	
▶ M28 Multiplexor from AT&T	<u>\$ 1,700</u>	
▶ Total monthly	\$24,600	
▶ 3 links (total monthly × 3)		\$73,800

- One-time charges:

▶ Multiplexor	\$ 60,000
▶ T45 installation charges	<u>\$ 1,000</u>
▶ Total one-time	\$ 61,000
▶ 3 links	\$183,000

The M28 Multiplexor gives the user 28 T1 lines. Prices vary on the basis of terms covering mileage and length of lease as follows (commercial rates):

- 1 – 50 miles
 - ▶ 1-year lease \$400 + \$220 per mile
 - ▶ 2-year lease \$400 + \$190 per mile
 - ▶ 3-year lease \$400 + \$170 per mile
- 51 – 100 miles
 - ▶ 1-year lease \$900 + \$210 per mile
 - ▶ 2-year lease \$900 + \$180 per mile
 - ▶ 3-year lease \$900 + \$160 per mile
- 101 + miles
 - ▶ 1-year lease \$1,400 + \$205 per mile
 - ▶ 2-year lease \$1,400 + \$175 per mile
 - ▶ 3-year lease \$1,400 + \$155 per mile.

These prices assume that the local AT&T central office is equipped to handle T45 service. For special services, an experimental surcharge of \$34,000 a month is added. T45 transmission is guaranteed to be all-fiber-optic. Tariffs generally apply to interstate and inter-LATA (local access and transport area) applications. A single multiplexor would handle 28 T1 inputs from two nodes. Maximum speed on any one channel would be 1.544 Mbps (T1) and would support up to 768 input channels.

The T1 market has become highly competitive in the past year. This has led to price declines and the addition of many new features on T1 multiplexors. Both MCI and U.S. Sprint also offer T1 service. But local T1 access provided by the local

telephone company is required, no matter which long-distance carrier is selected, and is not included in the T1.5 and T45 prices given above.

3.3.3 T-Carrier Standards

T1 will probably be adopted as the primary rate access for ISDN implementations in the United States. This will entail substantial changes in the way control and signaling is handled by T1 transmission. The current signaling standard, DS1, places the requirement that no more than eight consecutive zeros pass through the public network. The public telephone network loses timing and synchronization if this requirement is not met. To prevent timing loss, a "1" bit is inserted at eight-bit intervals. This "bit-stuffing" lowers the effective data rate to 56 kbps from 64 kbps on each of the 24 T1 subchannels.

Because of the pressure on the United States to join the international push for "clear-channel, full-64 kbps" ISDN standards, both AT&T and various U.S. standards organizations are working on restructuring the way signaling information is carried over a T1 link. Many new standards are proposed to address the "1" requirement, as well as the other problems that exist with current digital signaling standards. Most of these specifications have been proposed by AT&T but, because of divestiture, AT&T can no longer dictate what happens in the T1 market place. Consensus must be reached by the regional Bell operating companies (RBOCs) as well as the various standards organizations before any new standard can be implemented. Many of the T1 multiplexor vendors have their own proprietary scheme to achieve the proper "1" insertion for transmission over the public telephone network. This, however, forces the user to use that vendor's equipment at all terminations of the network.

Though microwave or fiber-optic transmission schemes may use the T-Carrier rates, they do not use the transmission technology classically considered T1. The equivalent fiber-optic line type designation is FT3 for T3 (44.736 Mbps) and FT4 for T4 (274.176 Mbps). Fiber-optic repeaters have spacing requirements of 4 to 5 miles. Many of the transmission facilities that connect telephone company central offices have been converted to fiber optics.

3.4 INTEGRATED SERVICES DIGITAL NETWORK

ISDN is a digital communications medium evolving from the present – mainly analog, public, switched – telephone network. When fully implemented, it will provide end-to-end digital connectivity, access and service integration, user control of services, upward compatibility with present services, and a set of *standardized* network interfaces. It will provide end-to-end connections and simultaneous support for digitized voice and nonvoice traffic via a single access. It will allow the end users to change the usage of their ISDN interface dynamically at different times of the day. ISDN is to bring standardization to the widely proliferating voice and data communications systems. Data communications will probably surpass voice communications in the near future.

3.4.1 Integrated Services Digital Network Architecture

ISDN will provide two broad categories of service – Teleservices and Bearer. Teleservices involve the OSI Seven Layer Model's upper layers, i.e., Transport and above. Services to be provided include teletex, videotext, and electronic mail. Teleservices are still being defined by the CCITT.

Bearer services involve the lower layers, i.e., Physical through Network, of the OSI Model. Two basic Bearer services will be offered by ISDN. The first, Circuit Mode Information, is 64 kbps unrestricted digital information (UDI) and is used in such applications as speech and audio transmission. Circuit mode also supports varying bandwidths to accommodate various types of data. These range from 364 kbps to 1,920 kbps. The top rate in European implementations of ISDN will be 1,920 kbps. The second Bearer service, Packet Mode, provides transfer of user data through either virtual-call, switched circuits, or permanent virtual circuits. Virtual-call service entails setting up and tearing down the circuit for each call and is analogous to dial-up service. Permanent virtual circuits remain established until changed by a network administrator and are analogous to dedicated lines. The access protocol for virtual circuit service is Layer 3 of CCITT standard X.25. It is the user's responsibility to package the data; ISDN will not alter the data.

There are two types of subscriber access to the ISDN: Basic and Primary Access. The Basic access consists of two 64 kbps Bearer (B) channels and one 16 kbps Delta (D) channel. This is known as 2B + D access. The B channel transmits bidirectional digital voice and/or data traffic; the D channel carries signaling for call

set-up, call clearing, etc. Both the B and D channels can also be used for packet-switched data applications. The Basic access will be oriented toward residential and small business subscribers. Basic access will also be used to connect users in large organizations to a central distribution system, e.g., a LAN or Private Branch Exchange (PBX).

The Primary access is used for connecting local distribution systems to ISDN. It provides a transmission bandwidth of 1.544 Mbps (T1). Known as 23B + D, the Primary access consists of 23 B channels and a single D channel, all operating at 64 kbps. Because of the limitations of current T1 technology, 8 kbps of each channel are required to support timing overhead. The effective throughput of each 64 kbps channel, therefore, is only 56 kbps. One of the requirements of ISDN is that all 64 kbps of each channel be usable by a subscriber; this is called clear channel capability.

Higher speed applications, such as teletex, videotext, and electronic mail can be served via Higher Speed Channels, H channels. The H0 channel provides a bandwidth of 384 kbps; the H11 channel provides 1,536 kbps. Various combinations of H and B channels can be configured by the subscriber. The Primary access, although not yet approved as a standard by the U.S. representative to CCITT, will closely resemble AT&T's standard T1 transmission format.

3.4.2 Integrated Services Digital Network Standards Organization

The CCITT has primary responsibility for generating ISDN standards on an international level. The object of the CCITT is to establish recommendations for end-to-end performance, interconnection, and maintenance of international networks used for telephone, telegraph, and data communications. The Office of International Communications Policy, under the Bureau of Economic Affairs within the Department of State, is the official U.S. representative to the CCITT. The CCITT ISDN standards began with the *Red Book*, which was issued in 1984. The *Red Book* stated the basic architectural model and the types of services that were to be offered. The next milestone was the *Grey Book* issued in 1986. It contained the specifications for Layers 1 and 2. The next specification, the *Blue Book*, is to be issued in 1988. It will contain the complete specifications for Layers 1, 2, and 3.

Many of the ISDN standard recommendations come from the T1 committee (not related to the 1.544 Mbps T1 specification). The T1 committee develops

interconnection standards for the U.S. telecommunications network. DCA has representatives on the T1 committee. The Exchange Carriers Standard Association (ECSA) is the administrative body for the T1 committee. The ECSA came into being after the divestiture of AT&T which, before divestiture, was the only U.S. standard-making body for telephone interfaces. The T1D1 subcommittee is preparing ISDN-related standards for submission to the U.S. CCITT representative.

3.4.3 Integrated Services Digital Network Status

In most European countries there is only one telephone company, and the standards developed for ISDN within any country may differ from those developed in the United States or others. The CCITT is to make sure that standards developed for inter-country ISDNs are compatible. The T1D1 subcommittee will probably approve circuit-mode specifications by the summer of 1987; and with compatible products, will probably be introduced shortly thereafter. However, true compatibility of ISDN products in a multivendor environment will probably take 2 or 3 more years. Vendors are apprehensive about committing to something that will probably change in the future. Most of the RBOCs are working on some kind of ISDN implementation. Because of the substantial costs associated with conversion of all the RBOC central offices, full conversion to digital is not projected until 1990. Furthermore, local non-Bell phone companies may never convert to digital. The Ameritech RBOC recently began a pilot ISDN project with McDonald's Corporation in Chicago. At this writing, however, there are no conclusive results to report. In another trial scheduled to start in mid-1988, AT&T, Shell Oil, and Tenneco Inc. have contracted with Southwestern Bell to provide an ISDN network. Most trade publications indicate continued testing and development through 1988, with some commercially viable implementation available as early as 1989. Full ISDN implementation will probably not be available until the year 2000.

Approved tariffs for ISDN services are not available, and costs associated with converting to ISDN are unknown. Cost justification for ISDN on the part of subscribers should come from added functionality and from the lowered costs of network administration.

One of the most important considerations in implementing an ISDN system is its effect on the existing installed base of computer/data processing equipment.

Effective deployment of ISDN will require terminal adapters to interface with existing non-ISDN terminal equipment.

3.5 FIBER-DISTRIBUTED DATA INTERFACE

Three elements make up a fiber-optic system: the transmitter, the receiver, and the optical cable that connects them. The transmitter is a modulated-voltage to modulated-light converter; the receiver reconverts modulated light to modulated electrical voltage. Unlike long-haul intercity fiber optics where every interface is a T-Carrier, building and campus fiber-optic lines carry an amalgam of protocols and vendor-proprietary transmission formats. It is in this area where FDDI will have its greatest effect. The FDDI is being developed by ANSI and specifies a standard for 100 Mbps serial data communications over optical fiber. FDDI networks will be best suited for mainframe-to-mainframe computer links; for backend, high-performance transport; and for networking engineering workstations. The media access protocol specified for FDDI is a token-passing over physical ring topology and conforms to the structure of the IEEE 802.5 standard.

3.5.1 Fiber-Distributed Data Interface Architecture

The FDDI consists of primary and secondary rings, each independent of the other and each with a speed of 100 Mbps. This architecture allows transmission in opposite directions simultaneously, so that there is an effective throughput of 200 Mbps. At present, two types of fiber for the cabling system are common, and each is defined by the diameter of the optical core. The first, 62.5 micrometers core diameter, is supported by AT&T. The second, supported by IBM, has a core diameter of 100 micrometers. Because of cost, the 62.5-micrometer core will probably predominate. The 100-micrometer fiber is about $2\frac{1}{2}$ times more expensive than the 62.5. FDDI also offers such benefits as virtually unlimited bandwidth, very low attenuation, very low susceptibility to electromagnetic interference and radio frequency interference, as well as a high level of security.

In an FDDI ring, there are class A stations and class B stations. Class B stations are the cheaper of the two because they can connect to either the primary or the secondary ring but not to both. Class A stations are connected to both rings and, although more expensive, offer the benefit of continuous operation in a reconfigured

ring. An FDDI network can be configured as a ring, a star, or a branched tree (similar to cable television installation).

As a back-end network, FDDI could connect computer peripherals, such as tape and disk, with little regard for the distance between them. FDDI could also be used to connect mainframe computers and eliminate the need for the FEPs normally used for this purpose. It is compatible with lower performance standards such as Ethernet and token ring, and its unusually high performance would make it an ideal backbone for LANs. Graphics workstations and CAD/CAM applications, which can easily clog existing networks, will benefit greatly from the greater bandwidth offered by FDDI.

3.5.2 Fiber-Distributed Data Interface Status

Interest in FDDI by standards organizations and vendors is quite high. Because few vendors have any products or proprietary interests to protect, FDDI has become one of the fastest evolving standards efforts in recent times. As documentation for the FDDI standards nears completion (scheduled for mid-1987), vendors and Government agencies alike will begin prototype efforts for this emerging network standard.

SECTION 4

CONCLUSIONS AND RECOMMENDATIONS

Telecommunications requirements unique to CALS, including data exchange protocols and standards, exist. CALS requires transmission of specific types of data at a high bandwidth to accommodate the large volume of data associated with engineering drawings and technical data. However, communications media and networks to support CALS will, in most cases, be the same as those supporting the DoD community as a whole. Therefore, any recommendations in telecommunications for CALS must consider other efforts in DoD and industry. CALS must accommodate protocols and communications media that support DoD interoperability requirements and the interface with industry systems. In addition, CALS projects must work with non-CALS projects. Design of CALS projects requires an understanding of the issues associated with integrating the various systems and databases supporting other DoD operations.

Three major categories of issues or areas of concern for CALS telecommunications were identified as a result of the analysis of DoD and industry communications initiatives:

- Volume requirements for CALS-data transmission
- Efforts to specify communications protocol standards in both DoD and industry
- Use of intelligent gateways (IGs).

Table 4-1 summarizes the conclusions and recommendations presented in the subsections that follow. An overall approach or architecture for telecommunications for CALS is presented in the CALS Telecommunications Plan. Specifics for implementation of protocols and use of IGs, as well as security issues, are addressed in that report.

4.1 CALS DATA TRANSMISSION VOLUME REQUIREMENTS

Many of the CALS efforts include automating what are primarily manual operations today. For that reason, it has been difficult to determine the long-haul

TABLE 4-1

ASSESSMENT OF DoD AND INDUSTRY TELECOMMUNICATIONS

Conclusion	Recommendations
DDN in its current configuration will not be able to accommodate the large volumes of information associated with engineering drawings and technical data	The Services need to define requirements for both data storage and data transmission. Capacity modeling techniques using data from ongoing projects would be useful. Prospective CALS projects should inform the DCA of their projected data volume requirements, as they become available, to speed the installation of higher bandwidth media. Alternatives for reducing the cost and volume of CALS-related traffic need to be developed and evaluated. These include storing formatting information at user workstations, transmitting changes to documents rather than changed documents, and maintaining redundant databases. The Services should more thoroughly investigate the advantages of establishing common communication links with other DoD and industry organizations and avoid establishing proprietary links with industry.
There are discrepancies between developing Services' telecommunications policy and specific implementations to support various projects. The reason for much of this is that standards for transitioning to OSI have not yet been defined, and the Services' policy is still under development.	A phased migration to the OSI standards is needed. Users must require product certification and carefully evaluate each implementation to ensure full compatibility with OSI. Projects that have not yet implemented the DoD protocol suite should connect to DDN at X.25 only and avoid implementation of DoD Application Layer protocols (e.g., SMTP, FTP, etc.) to ease transition to OSI. CALS projects should adopt the GOSIP specification as a baseline protocol suite and push for inclusion of VTP, ES-to-IS, IS-to-IS in the GOSIP document, which will make the GOSIP document functionally equivalent to the present DDN suite. CSMA/CD should be used in the local CALS environment to link workstations with host processors. CSMA/CD running on 10 Mbps cable can accommodate both document and graphics interchange cost-effectively. Individual requirements must be taken into consideration. Transition to future standards developments in ISDN, FDDI, and T-Carrier Services should be planned carefully for adoption, as mature standards and certified specifications become available. The Services should give careful consideration to long-range needs before granting waivers for situations where it has been determined that interoperability is not needed.
The DoD and commercially available IGs (as opposed to communications gateways) have been designed to support transmission of much smaller amounts of information than is generally associated with a request for engineering drawings or technical documents. In addition, the IG architecture for CALS involves more complex translation capabilities than IGs to support simple queries and retrievals of data.	More sophisticated R&D efforts are needed for the development of an IG architecture to provide a user at a single terminal with data access and retrieval capabilities from multiple heterogeneous sources. The IG architecture for CALS must address translations between different graphics and technical standards. Standardization of procedures and practices (engineering modeling) is needed before graphics standards are useful to a great extent. IGs can provide solutions in the interim. To avoid some of the limitations associated with the use of standards, subset options can be defined for use by different applications. Though gateways, with their inherent inefficiencies, represent an interim step to the adoption of specifications and standards, such products will provide the best means for accommodating communications between dissimilar systems for many years to come.

communication requirements for CALS-related data. As part of the effort to automate their repositories of engineering drawings and technical data, the Services are now defining not only data requirements for local databases but also requirements for transmitting these data over communications media. The added task of determining what data are actually needed in digitized form adds another layer of complexity to the problem. The Services must take account of the likelihood that once the capability is provided, more and more users will take advantage of the services offered, far exceeding estimates based on current use.

Figure 4-1 depicts the volume of data associated with a typical weapon system's databases as determined by the Air Force IDS System Program Office. Both existing and future database storage requirements are presented. Some of these data will be available on-line; other data will be archived and used infrequently during the life of the weapon system. This distinction is important because providing on-line access is generally a great deal more expensive than providing access to archived data.

The process of collecting information about the volume of data is itself difficult and time-consuming. Capacity modeling techniques will be useful for projecting CALS-related data transmission requirements and are discussed in more detail in the CALS Telecommunications Plan.

The large size of drawing files (8 megabytes or more) and the current maximum speed of the DDN (56 kbps) make the exchange of large volumes of image information over the DDN inconvenient or inefficient. The DDN in its current configuration will not be able to accommodate the large volume of information associated with CALS. Transmitting 1,500 aperture cards or images over the DDN from one base to another would take approximately 30 hours. This assumes a 20:1 compression ratio and includes an estimated overhead of 25 percent imposed by the various protocols and acknowledgments used within DDN. For organizations with a requirement to transmit similar volumes on a daily basis, overnight mail will be more effective for the near term.

The Services plan to transmit queries to the databases or index files by DDN and send large volumes of data by overnight mail. Depending on the volume of information, the data may be sent on optical disk, magnetic tape, aperture card, or hard copy. In the near term, this is the most cost-effective way to transmit data.

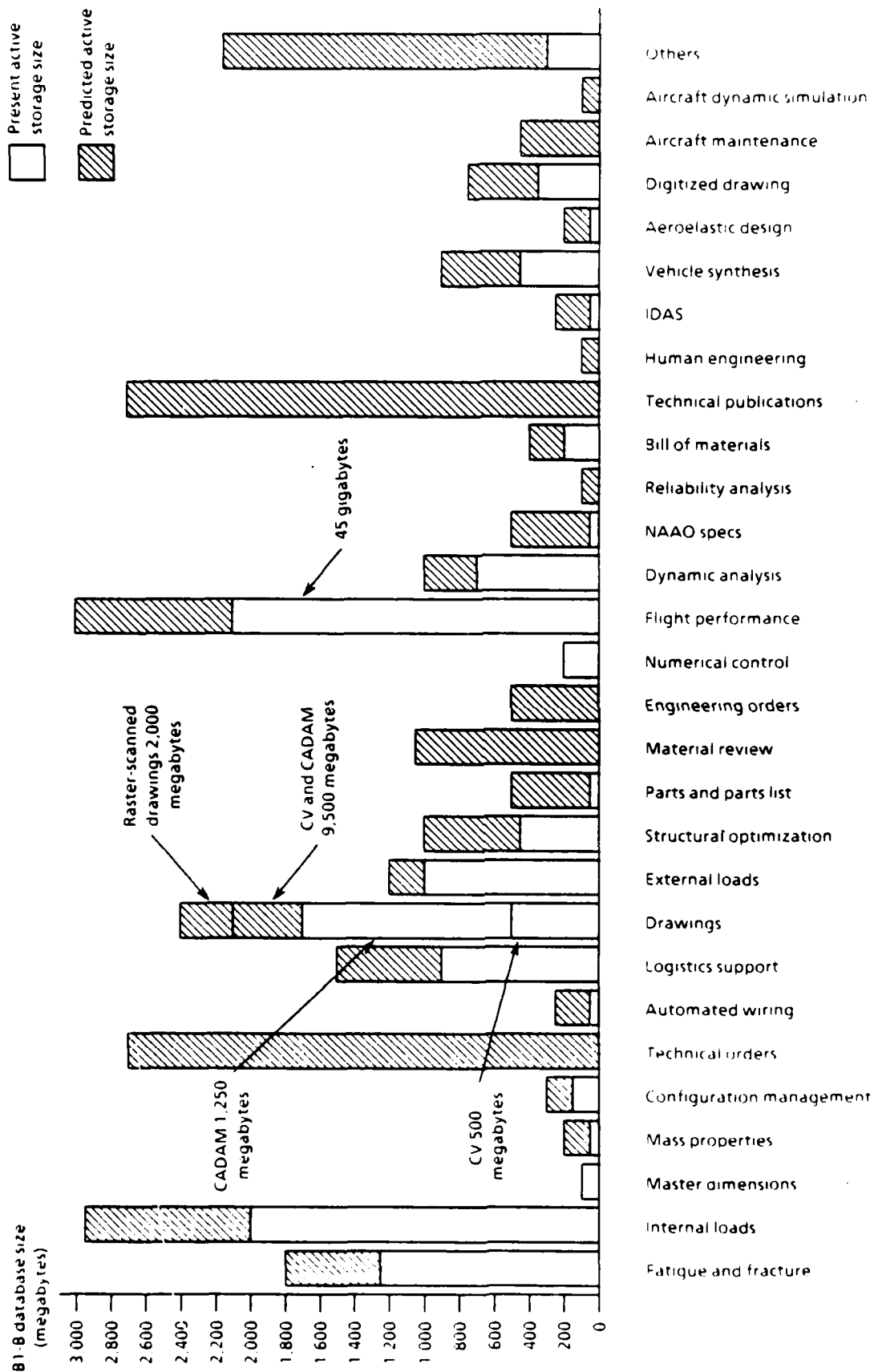


FIG. 4-1. TYPICAL WEAPON SYSTEM DATABASES
(IDS System)

Standards for these off-line media are being addressed by the CALS Specifications and Standards Group.

The DDN may also be used to transmit a small number of priority technical documents. Drawings should be transmitted over the DDN during non-peak hours only. Leased dedicated high-speed circuits is one of the few means available to achieve the long-distance, on-line transfer of drawings. But leasing circuits is costly. As the technology develops and becomes standardized, as DCA makes use of the new technology to increase the speed and capacity of the DDN (estimated to be in 5 years for T1 capability), and as long-distance telecommunication becomes efficient and cost-effective, the Services will increase their use of communications media for transmitting these data. Actual transfer requirements for technical documents are still being determined and should be subjected to cost-benefit analysis. All prospective CALS projects should inform the DCA of their projected data volume transmission requirements, as they become available, to justify the installation of higher bandwidth media to support data transfer requirements.

The most efficient means of forms processing, from a communications viewpoint, is to store the formatting information for the forms at the user workstation rather than transmit the formatting data with user-entered data. In addition, transmitting changes only rather than transmitting entire documents would essentially eliminate the need for weekly download communications. Data redundancy would be a requirement until the communications media could support transfers of the required volumes.

Although projections vary concerning the volume of CALS-related data that will be transmitted from one Service to another, all the Services do have to transmit such data electronically to one another. Moreover, many programs within the Services have indicated that they have no intention, in the near term, of establishing communication links with private industry, but will accept data in the form of optical disk, magnetic tape, aperture card, or hard copy. There are a few continuing efforts in DoD to establish communication links with various commercial organizations. Most of these projects rely on proprietary communications media. It should be expected that, over the long term, the need for such communication links will increase as their value becomes more evident.

4.2 EFFORTS FOR SPECIFYING PROTOCOL STANDARDS IN DoD AND INDUSTRY

The Office of Management and Budget (OMB) is reviewing considerations for a 5-year plan to meet the automation and telecommunications needs of the Federal Government and calls for a Government-wide policy for OSI. NBS Workshops for Implementation of OSI will continue to promote implementation of state-of-the-art network standards leading to development of off-the-shelf commercial products. The OMB, at the same time, clearly recognizes COS, the private-member consortium dedicated to implementation of OSI standards. NBS and COS do not represent conflicting interests; they are working together toward implementation of OSI standards. NBS will continue to pursue Federal Information Processing Standards (FIPS) that will include protocol specifications, conformance tests, and user guidance for optimal usage by Federal agencies. The goal is to issue FIPS for all seven protocol layers within the next 2–5 years.

Both the Navy and the Air Force are developing planning strategies for transitioning to the ISO standards as they become available. All the Services have indicated their intention to migrate to ISDN in the future. Navy guidance encourages use of international standards for new developments unless there is a compelling requirement for interoperability with an existing system using DoD protocols before 1988. This does not preclude use of other protocols in situations where interoperability is not needed. However, careful consideration should be given to long-range needs. The Navy has stated that only 5 percent of Navy facilities – made up primarily of the research community – have implemented such Application Layer protocols as FTP and SMTP. The bulk of Navy facilities (approximately 80 percent) are using proprietary protocols (e.g., SNA and DECNET). Therefore, unless there is an urgent need to interoperate with another facility and unless packages can be bought off the shelf (it can take at least 1½ staff-years to develop these protocols for a specific hardware/software suite), not only the Navy but all the Services should begin to gear up for OSI standards rather than the DoD Application Layer protocols.

Discrepancies in protocols specified by various Air Force programs are under review by HQ Air Force. The ULANA II Conceptual Protocol Suite Architecture is very similar to TOP and is a superset of GOSIP. The CDS project specifies ULANA I protocols; EDCARS specifies the HDH Interface to DDN, which is very old and should be replaced with X.25/LAPB. The Air Force is looking into protocols being

specified by these and other programs to ensure conformity with ULANA II. In addition, proprietary protocols are installed with each implementation of a fiber-optic network in the Air Force. Since fiber-optic standards are not yet available, Air Force programs should wait for FDDI and be consistent with ULANA II specifications.

Service plans are still in draft form and are waiting for DCA guidance on which protocols or subsets of protocols should be implemented. The Services keep up with the development of protocol standards in DoD through the Protocol Standards Steering Group, chaired by the Defense Communications Engineering Center (DCEC). The protocols outlined in the individual Services' plans should be expected to change as standards agreements are reached. To ensure conformity within DoD, development of these plans should be reviewed as they become available.

The Services are looking to the OSI/DoD gateway under development at NBS to provide the necessary interfaces between the DoD protocols as they exist today and the ISO standards to be adopted by DoD in the future. A draft of the transition plan should be available by mid-1987 as part of this joint NBS/DCA/OSD gateway prototype project. An experimental phase is expected to last for approximately 2 years. During this period, areas in which GOSIP falls short of DDN capabilities will be addressed. NBS is concerned primarily with development of an application gateway to support translations from FTP to FTAM, and from SMTP to X.400. This gateway should be available by early 1988. DCA has contracted with the MITRE Corporation for development of the network gateway to support the lower-layer translation requirements. Several OSI conformance tests are available or planned. The NBS is also developing protocol testing facilities. This will greatly aid and expedite implementation of the OSI protocol layers.

Such gateways are the best means of accommodating communications between existing implementations of the DoD protocols suite and the OSI suite. However, users should be aware that gateways impose additional overhead on the overall communications process. Therefore, projects that have not yet implemented the DoD protocol suite should connect to the DDN at X.25 only and adopt the GOSIP specification as a baseline protocol suite. Although gateways, with their inherent inefficiencies, are an interim step to the adoption of specifications and standards.

such products will provide advantages and benefits for communication among dissimilar systems for years to come.

In the private sector, COS and the MAP/TOP Users Group have agreed to co-sponsor an exhibition devoted primarily to the display of MAP/TOP networks. Planned for the summer of 1988 in Baltimore, Md., the exhibition will demonstrate the MAP/TOP and COS computer communications specifications operating in a real-world environment. More than 50 computer and communications vendors are expected to participate. This supports the fact that OSI will eventually overtake DDN and that vendors are committed to the OSI protocols.

COS will be using the exhibition as an opportunity to launch its testing and certification processes. It is sponsoring the development of tests for FTAM and MHS X.400. The MAP/TOP Users Group is sponsoring the development of tests for manufacturing message services, network management, and network directory services protocols. Unlike the MAP demonstration at the Autofact '85 show, which was a prototype version of future products, the users group wanted the MAP/TOP Release 3.0 demonstration to show product-level components. The user organization decided that a series of tests would be needed to achieve this. All suppliers, including hardware and networking vendors, will be required to pass the conformance tests to make sure that their products adhere to the MAP/TOP Release 3.0 specifications. MAP/TOP Release 3.0 was originally scheduled to debut this November. The delay of the exhibition has nothing to do with the development of the MAP/TOP Release 3.0 specifications, which should still be ready by the end of 1987.

The complex and expensive task of establishing networking standards for the factory floor and office environment has prompted the MAP/TOP Users Group to seek both technical and financial assistance from COS. COS will take development and financial responsibility for approximately 40 percent of the testing effort, which will have a total estimated cost of between \$15 million and \$20 million.

A phased migration plan to the OSI standards is needed in DoD because several of the protocols required by CALS projects are not yet available. This is the approach taken in the CALS Telecommunications Plan. Several vendors have implementations of the OSI protocols, and many more have said they will provide products in the near future. Users must require product certification and carefully evaluate each implementation to ensure full compatibility.

Specific recommendations for DoD CALS telecommunications include:

- CALS projects that have not yet implemented the DoD protocol suite should connect to DDN at the X.25 layer only and avoid implementation of the upper-layer protocols (e.g., FTP, SMTP, etc.) to facilitate transition to OSI.
- The CALS projects should adopt the GOSIP specification as a baseline protocol suite. The CALS projects should push for inclusion of the VTP basic class, the ES-to-IS Routing Exchange Protocol, and the Intermediate System to Intermediate System (IS-to-IS) Routing Exchange Protocol in the GOSIP specification as soon as possible. Inclusion of these protocols will make the GOSIP specification functionally equivalent to the present DDN suite. These protocols should be available within the year. In the meantime, the CALS projects will be able to accomplish file terminal access until VTP and the changes that must be made to the Mini-TAC are accomplished. The plan to accommodate remote-terminal access is based on having the Mini-TACs upgraded to support both protocol suites. This is not part of the present contract and would most likely become an extension to it. No acquisition approach has been determined to date. In the absence of the ES-to-IS, only static routing will be available. The TOP User Group has deemed both ES-to-IS and VTP complete enough for inclusion in their Version 3.0 architecture. The IS-to-IS protocol will probably not be available before April 1988.
- The NBS application gateway being developed will provide FTP to FTAM and SMTP to X.400 protocol translations by the beginning of 1988. Use of the NBS gateway, once delivered, should be minimized. Translation gateways of this type are inefficient because of the overhead imposed by translation. For the long term, it is better for the Services to plan to implement the OSI protocols rather than rely on gateways.
- The TOP protocol stack, Version 3.0, already specifies the above-listed protocols, as well as others that are applicable to the CALS projects. This protocol stack, which is being promoted by the private sector, should provide direction for a complete CALS telecommunications plan. The TOP data exchange protocols specified are also required by the CALS projects and should be adopted.
- The MAC protocol known as the CSMA/CD protocol should be used in the local environment to link CALS workstations with host processors. CSMA/CD running on 10 Mbps cable can accommodate both document and graphics interchange in a cost-effective manner. The physical medium selected is dependent on the specific project requirements. Broadband coax cable may be appropriate where there is a requirement to support a mix of communications over longer distances or additional bandwidth is required to support the data volume.

- The MIL-STD-1840 specification now states that the DDN protocols TCP/IP will be used to ease transmission. The GOSIP-specified ISO/OSI protocols should also be included as an alternative to DDN for providing the communications protocols below the data exchange protocols specified in MIL-STD-1840.
- ISDN will be a solution to CALS data transmission workloads in the 1990s. There is still considerable work that must be completed before it is standardized and the required broadband services are made available.
- FDDI should be made available in 1988–89. This specification should be used for optical systems implemented to support CALS projects.
- T-Carrier services are available but not yet standardized. Prospective users should be made aware that vendors are using proprietary schemes that will make heterogeneous communications difficult and probably dictate the use of only one vendor's equipment. A cost-benefit analysis is required before this can become a viable solution.

4.3 USE OF INTELLIGENT GATEWAYS

The previous subsection addressed the importance of communications gateways, such as the OSI/DoD gateway under development at NBS, for accommodating communications at all seven layers of the OSI Model. These products address the overall basic communications functions for communicating between dissimilar systems. IGs, on the other hand, are more concerned with data formats, semantics, and differences in application software and DBMSs among different systems.

An IG is a hardware/software configuration that enables a user at a single terminal to access and retrieve information from dissimilar systems readily. An IG may or may not include communications gateway functions along with the higher level (Layers 6 and 7) application programs written to support the required user interfaces. For purposes of this report, the DoD IG efforts presented in Section 2 can be described as one of two types. The first, referred to here as Basic Gateway Systems, provides a comparatively inexpensive means of providing a user at a single terminal with data access and retrieval capabilities from multiple heterogeneous sources. The Basic Gateway Systems provide the user with transparent log-on to the target host. In some cases the menu-driven systems will also retrieve the information from the target host and reformat the data for the user, or the user can make use of a pass-through capability to the target host. However, once logged on in this manner, the user must know the command language of the remote system.

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ASSESSMENT OF DOD AND INDUSTRY NETWORKS FOR COMPUTER
AIDED LOGISTICS SUPP.. (U) LOGISTICS MANAGEMENT INST
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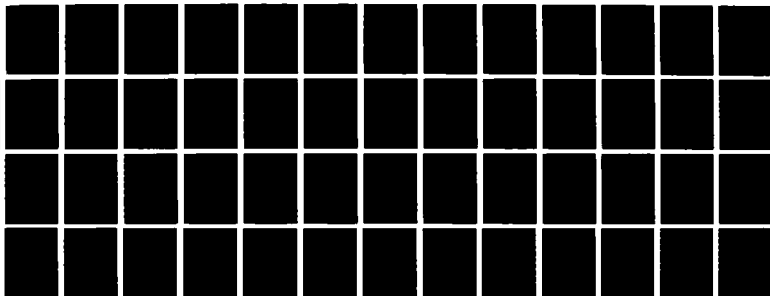
2/2

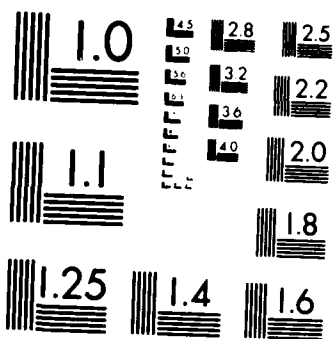
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

The basic gateway approach is the simplest to implement. The system itself is seen as a terminal by the target computer system and, in general, does not know and has no need to know what hardware, operating system, DBMS, or other software is supported at the remote location. The system only needs to know that data is to be sent in asynchronous ASCII format. The following capabilities are provided by some of the commercial gateway applications available today:

- Transparent dial-up and log-on
- Menu-driven system for formulating user queries
- Software to determine which database(s) should be accessed
- Data retrieval and postprocessing.

Any and all conversions (to ASCII and to accommodate record layout and data element format requirements) are handled by the gateway. The target computer system simply receives and processes the data sent by the gateway, without knowing where the data have originated. The basic gateway systems offer a limited search strategy that is more than adequate for the types of data retrieval needed to support many CALS operations. Examples of Basic Gateway Systems in DoD include the Air Force's CDS and LOGDIS, and the Navy's TLRN. The Navy's SPLICE is also a form of IG which, in addition, provides communication protocol translations not supported in the other gateway projects.

The second type of IG is the heterogeneous distributed database management system (DDBMS). These systems offer the full range of capabilities needed by programmers and experienced users. The heterogeneous DDBMSs are also highly experimental at this time and are much more expensive to implement than the Basic Gateway Systems. These systems have been designed primarily to provide the more experienced user with a global data definition language for retrieving data from heterogeneous databases rather than using menu-driven prompts. These systems interface directly with the DBMS on the target host. They do not require any changes to the preexisting databases, their DBMSs, or their application programs. They provide the user with a more flexible and far-reaching data retrieval capability. Examples of heterogeneous DDBMS projects include the MULTIBASE efforts underway in the Army and the Air Force's IDS project.

The basic gateway approach can support a limited number of types of queries where: (1) the request is a standard, predefined query, (2) only one to a few programs

(batch or interactive) have to be accessed at the target system, and (3) only some data elements must be accessed in the databases or files on the target host. In such cases, the users' questions and the responses to them are known in advance; in such situations, the basic gateway approach could prove to be the most cost-effective one. The target host facility would have more control over user access to its data.

For the long term, an IG should enable the user to formulate a wide range of queries accessing any data element in the target database(s). In this case, it is not possible to predefine the questions to be asked or the data elements to be retrieved. An intermediary or common query language, such as that developed in the heterogeneous DDBMS projects, is needed to accommodate translation to various DBMSs and files. Security is a major issue to be addressed in such projects.

Existing IG projects for the most part handle queries that result in the transmission of much smaller amounts of information than is generally associated with a request for an engineering drawing or technical data. The IG for CALS must address two main issues: how to accommodate the transmission of large volumes of information and how to handle translation between different graphics and technical data standards. The problems of conversion and translation of text are more or less straightforward. However, as we have seen, in graphics there are a number of problems that make the task difficult and economically infeasible within available technology. Even if agreement is reached for use of a particular subset of a standard, there must also be agreement on the practices and procedures (engineering models) used to work with or display those data. The IG may be able to accommodate these to some extent. A number of companies are developing pre- and post-translators between their CAD graphics package and IGES. For example, Computer Vision and CADAM have both developed such translators. It will be some time before these products will be completed, but they will never be able to provide the 100 percent translation that is needed for effective use of CAD/CAM data between two or more proprietary CAD/CAM systems.

Other system differences that must be addressed include the fact that in some cases there simply is no representation in one system for elements represented in the other. In order not to be too limiting, a number of options, corresponding to different applications, could be made available as subsets to the standards. Although there may be resulting limitations within any one particular application, the risk could be

lowered with options that would depend on the application, thereby increasing the scope of the standard.

The Services are adopting SQL as the standard database language. SQL is appropriate for simple query requirements, but the SQL model is at too low a level to meet DoD requirements for engineering systems. For example, the Army MULTIBASE effort recently completed a conversion to Ada, complying with the mandate to use Ada with the Common Ada Programming Support Environment (APSE) Interface Set (CAIS) as the user interface language. SQL cannot interface effectively with the more complex functions supported by CAIS and, therefore, cannot be used on the database side of CAIS. The CALS Telecommunications Plan will address the major issues, difficulties, and complexities associated with the use of IGs to integrate heterogeneous systems and databases.

4.4 CALS TELECOMMUNICATIONS PLAN

The CALS Telecommunications Plan was available for distribution in draft form in June 1987. The plan presents an overall approach or architecture for telecommunications for CALS and provides a timetable for implementation of specific communications functions and protocols. The architecture provides a comprehensive list of data communications protocols, data exchange protocols, and transmission media to ease local and long-haul communications within DoD and between DoD and industry.

The approach for CALS telecommunications is divided into three phases. Implementation for the near term (1987-88) concentrates on commercially available, off-the-shelf technology. The mid-term phase (1989-91) concentrates on technology that is expected to become stabilized or standardized in that timeframe. The long term (1992 and beyond) completes the communications architecture required to support the CALS environment and its specific needs.

An IG architecture for CALS is developed in the plan concentrating on Layers 6 and 7, addressing the distinction between simple "interfacing" and "integration" or understanding. A number of issues associated with achieving the integration goal include:

- Integrating across different data models
- Integrating across different software systems

- Integrating across different business environments
- Providing an effective user interface
- Ensuring data quality
- Addressing performance and security.

An overall approach for realizing the IG architecture in these timeframes is presented.

Each phase will build on the preceding phase in capabilities provided and contain recommendations on technology refreshment. The final plan will serve as a statement of direction to vendors and industry contractors of the standards that will be used to provide interoperability.

GLOSSARY

A&L	=	Acquisition and Logistics
AAR	=	Automatic Alternate Routine
ACC	=	Army Communications Command
ACF	=	Advanced Communications Function
ACSE	=	Associative Control Service Elements
AFB	=	Air Force Base
AFLC	=	Air Force Logistics Command
AGMC	=	Aerospace Guidance and Metrology Center
AAR	=	Automatic Alternate Routine
ALC	=	Air Logistics Center
ALMSA	=	Automated Logistics Management Systems Activity
AMC	=	Army Materiel Command
AMCCOM	=	Armament, Munitions, and Chemical Command
ANSI	=	American National Standards Institute
APADE	=	Automation of Procurement and Accounting Data Entry
APSE	=	Ada Programming Support Environment
ARPANET	=	Advanced Research Projects Agency Network
ASC	=	Accredited Standards Committee
ASCII	=	American Standard Code for Information Interchange
ASD	=	Aeronautical Systems Division
ASN 1	=	Abstract Syntax Notation
AT&T	=	American Telephone and Telegraph
ATOS	=	Automated Technical Order System

AUTODIN	=	Automatic Digital Network
B	=	Bearer
BAS	=	Basic Activity Subset
BBN	=	Bolt, Beranek and Newman
BCS	=	Basic Combined Subset
bps	=	bits per second
BSC	=	bisynchronous
BSS	=	Basic Synchronized Subset
CAD	=	computer-aided design
CAE	=	computer-aided engineering
CAIS	=	Common APSE Interface Set
CALS	=	Computer Aided Logistics Support
CAM	=	computer-aided manufacturing
CASC	=	Cataloging and Standardization Center
CASE	=	Common Application Service Elements
CCA	=	Computer Corporation of America
CCITT	=	Consultative Committee on International Telephony and Telegraphy
CCR	=	commitment, concurrency, and recovery
CDC	=	Control Data Corporation
CDS	=	Central Datacomm System
CECOM	=	Communications – Electronics Command
CGM	=	Computer Graphics Metafile
CLNS	=	Connectionless Network Service
CMIP	=	Common Management Information Protocol
CONUS	=	Continental United States
COS	=	Corporation for Open Systems

COSIS	=	Care of Supplies in Storage
CSMA/CD	=	Carrier Sense Multiple Access with Collision Detection
D	=	Delta
DA	=	Department of the Army
DAAS	=	Defense Automatic Addressing System
DAC	=	Data Communications
DACOM	=	D. Appleton Company
DACS	=	Digital Access and Cross-Connect Service
dB	=	decibel(s)
DBMS	=	database management system
DCA	=	Defense Communications Agency
DCE	=	Data Communication Equipment
DCEC	=	Defense Communications Engineering Center
DCS	=	Defense Communications System
DCTN	=	Defense Commercial Telecommunications Network
DDBMS	=	distributed database management system
DDN	=	Defense Data Network
DDS	=	Dataphone Digital Service
DECNET	=	Digital Equipment Corporation Network
DESCOM	=	Depot Systems Command
DIDS	=	Defense Integrated Data System
DISNET	=	Defense Integrated Secure Network
DLA	=	Defense Logistics Agency
DLANET	=	DLA Network
DoD	=	Department of Defense
DOS	=	Disk Operating System
DS0	=	Digital Signal Level 0

DSP	=	Display Services Protocol
DSREDS	=	Digital Storage and Retrieval Engineering Data System
DTE	=	Data Terminal Equipment
ECSA	=	Exchange Carriers Standard Association
EDCARS	=	Engineering Data Computer Assisted Retrieval System
EDI	=	Electronic Data Interface
EDMICS	=	Engineering Drawing Management Information and Control System
EGP	=	Exterior Gateway Protocol
EIA	=	Electronic Industries Association
EIR	=	Equipment Improvement Recommendation
ES-to-IS	=	End System to Intermediate System
5ESS	=	No. 5 Electronic Switching System
FDC	=	Federal Data Corporation
FDDI	=	Fiber Distribution Data Interface
FDM	=	frequency division multiplexing
FEP	=	front-end processor
FIPS	=	Federal Information Processing Standards
FORSCOM	=	Forces Command
FRID	=	Functional Requirements and Interface Document
FTAM	=	File Transfer, Access, and Management
FTP	=	File Transfer Protocol
GDM	=	global data manager
GDT	=	graphic display terminal
GHz	=	gigahertz
GKS	=	Graphics Kernel System
GOSIP	=	Government Open Systems Interconnection Profile

H	=	Higher Speed
HDH	=	HDLC Distant Host
HDLC	=	High-Level Data Link Control
HGP	=	Host-to-Gateway Protocol
HQ	=	headquarters
IBM	=	International Business Machines
ICMP	=	Internet Control Message Protocol
ICP	=	inventory control point
IDS	=	Integrated Design Support
IEEE	=	Institute of Electrical and Electronic Engineers
IG	=	intelligent gateway
IGES	=	Initial Graphics Exchange Standard
IGP	=	Intelligent Gateway Processor
ILS	=	integrated logistics support
IMP	=	Interface Message Processor
IP	=	Internet Protocol
IPS	=	Information Processing Systems
IS-to-IS	=	Intermediate System to Intermediate System
ISC	=	Information Systems Command
ISDN	=	Integrated Services Digital Network
ISG	=	intersite gateway
ISO	=	International Standards Organization
ISTC	=	Information Systems and Technology Center
ITI	=	Industrial Technology Institute
JTM	=	job transfer and manipulation
kbps	=	kilobits per second
LAN	=	local area network

LAPB	=	Link Access Protocol Balanced
LATA	=	local access and transport area
LDI	=	local database interface
LLC	=	Logical Link Control
LLNL	=	Lawrence Livermore National Laboratories
LMI	=	Logistics Management Institute
LOG	=	Logistics
LOGDIS	=	Logistics Data Information System
LSA	=	logistics support analysis
LSAR	=	logistics support analysis record
MAC	=	Media Access Control
MAP	=	Manufacturing Automation Protocol
Mbps	=	megabits per second
MHS	=	Message Handling System
MHz	=	megahertz
MICOM	=	Missile Command
MILNET	=	Military Network
MLS	=	multilevel security
MMS	=	Manufacturing Message System
MS DOS	=	Microsoft Disk Operating System
NARDAC	=	Navy Regional Data Center
NARF	=	Naval air rework facility
NAVAIR	=	Naval Air Command
NAVDAC	=	Navy Data Automation Command
NAVSEA	=	Naval Sea Systems Command
NAVSUP	=	Naval Supply Systems Command
NAVTELCOM	=	Navy Telecommunications Command

NBS	=	National Bureau of Standards
NCP	=	Network Control Program
NESEC	=	Naval Electronics Systems Engineering Center
NETC	=	Network Evaluation and Test Center
NMP	=	National Maintenance Point
NRRC	=	Naval reserve readiness command
OASD	=	Office of the Assistant Secretary of Defense
ODA	=	Office Document Architecture
ODIF	=	Office Document Interchange Format
OMB	=	Office of Management and Budget
OSD	=	Office of the Secretary of Defense
OSI	=	Open Systems Interconnection
OSINET	=	OSI Network
PBX	=	Private Branch Exchange
PC	=	personal computer
PCM	=	Pulse Code Modulation
PDES	=	Product Definition Exchange Specification
PLP	=	Packet Level Protocol
PMO	=	Program Management Office
PSN	=	packet-switching node
R&D	=	research and development
R&M	=	reliability and maintainability
RBOC	=	regional Bell operating company
RF	=	radio frequency
RFP	=	request for proposals
RIM	=	Relational Information Management
RMS	=	Resource Management System

SAC	=	Strategic Air Command
SAMMS	=	Standard Automated Material Management System
SASE	=	Specific Application Service Elements
SCINET	=	Sensitive Compartmented Information Network
SEW	=	scientific engineering workstation
SGML	=	Standard Generalized Markup Language
SMTP	=	Simple Mail Transfer Protocol
SNA	=	System Network Architecture
SNAP	=	Standard Network Access Protocol
SNDCP	=	Subnetwork Dependent Convergence Protocol
SPAWAR	=	Space and Naval Warfare Systems Command
SPLICE	=	Stock Point Logistics Integrated Communications Environment
SPLICENET	=	SPLICE Network
SPO	=	System Program Office
SQL	=	Structured Query Language
SYSCOM	=	Systems Command
TAC	=	Terminal Access Controller
TCP	=	Transmission Control Protocol
TDCMS	=	Tech Data Configuration Management System
TDM	=	time division multiplexing
TLRN	=	Technical Logistics Reference Network
TO	=	Technical Order
TOP	=	Technical and Office Protocol
TP	=	Transport Protocol
TP-4	=	Transport Protocol Class 4
UADPS-SP	=	Uniform Automated Data Processing System – Stock Point

UDI	=	unrestricted digital information
UDP	=	User Datagram Protocol
ULANA	=	Unified Local Area Network Architecture
USAISC	=	U.S. Army Information Systems Command
VDT	=	video display terminal
VTAM	=	Virtual Telecommunications Access Method
VTP	=	Virtual Terminal Protocol
WAN	=	wide-area network
WPAFB	=	Wright-Patterson Air Force Base
X.400	=	CCITT Message Handling Protocol

APPENDIX A

NAVY COMMUNICATIONS PROTOCOL STANDARDS

NAVY COMMUNICATIONS PROTOCOL STANDARDS

APPLICATION LEVEL

The Navy is considering use of the following protocols for the specified actions:

File Transfer

Use: File Transfer, Access, and Management (FTAM)

Spec: Information Processing Systems – Open Systems
Interconnection (IPS-OSI) – FTAM (in four parts)

Part 1 – General Description ISO DIS 8571/1

Part 2 – The Virtual Filestore ISO DIS 8571/2

Part 3 – Service Definition ISO DIS 8571/3

Part 4 – Protocol Specification ISO DIS 8571/4

Electronic Mail

Use: Electronic Mail Consultative Committee on International Telephony and Telegraphy (CCITT) X.400 Recommendations

Spec: Message Handling Systems Series

X.400 – Systems Model – Service Elements

X.401 – Basic Service Elements and Optional User Facilities

X.408 – Encode Information Type Conversion Rules

X.409 – Presentation Transfer Syntax and Notation

X.410 – Remote Operations and Reliable Transfer Server

X.411 – Message Transfer Layer

X.420 – Interpersonal Messaging User Agent Layer

Application Access Control

Use: Common Application Service Elements (CASE)

Spec: Information Processing – OSI

Definition of CASE

Part 1 – Introduction ISO DP 8649/1

Part 2 – Basic Kernel ISO DP 8649/2

Part 3 – Commitment, Concurrence, and Recovery ISO DP 8649/3

Specification of Protocol and Interconnection

Part 1 – Introduction ISO DP 8650/1

Part 2 – Basic Kernel ISO DP 8650/2

Part 3 – Commitment, Concurrence, and Recovery ISO DP 8649/3

Manufacturing Automation

Use: Manufacturing Automation Protocol (MAP)

Spec: Working Draft

Office Automation and Workstation Support

Use: Technical and Office Protocol (TOP)

Spec: Working Draft Specification Rev X.5.0 of 9 September 1985

Full Screen Terminal Support

Use: Virtual Terminal Protocol (VTP)

Spec: IPS-OSI Virtual Terminal Basic Class Service

Part 1 – ISO DP 9040

IPS-OSI Virtual Terminal Basic Class Protocol

Part 2 – ISO DP 9041

Restrictions: Use only in local environments, not across long-haul networks.
Do not use as a basis for interoperability or distributed processing. Use regular data-transfer facilities (above).

PRESENTATION LAYER

All required functions provided under CASE above.

SESSION LAYER

Use: Basic Synchronized Subset (BSS)

Spec: IPS-OSI Session Service Definition – ISO IS 8326

IPS-OSI Session Protocol Specification – ISO IS 8327

TRANSPORT LAYER

Information Systems

Use: Transport Protocol Class 4 (TP-4)

Spec: IPS-OSI Transport Service Definition – ISO IS 8072

IPS-OSI Transport Protocol Definition – ISO IS 8073
Formal Description of Transport – Working Draft

Tactical Systems

Use: Transport Protocol Class 0 (TP-0)
Spec: Same specification as for information systems

NETWORK LAYER

Internet Addressing

Use: Internet Protocol (IP)/Internet Control Message Protocol (ICMP)
Spec: Network Service Definition – ISO IS 8348
 Addendum 1 – Connectionless-Mode Data Transmission – ISO IS 8348/AD 1
 Addendum 2 – Network Layer Addressing – ISO IS 8438/DAD2
Protocol for Providing Connectionless Network Service – ISO IS 8473
 Addendum 1 – Provision of the Underlying Service Assumed by ISO 8473 – ISO IS 8473/DAD1
 Addendum 2 – Formal Description of the Specification of an Internet Protocol – ISO IS 8473/PDAD2
Internal Organization of the Network Layer – ISO DP 8648

Interaction Between Networks/Gateways

Use: Exterior Gateway Protocol (EGP)
Spec: Intermediate System to Intermediate System (IS-to-IS)
 Protocol: Draft Network Layer Protocol for the Exchange of Routing Information Between Intermediate Systems
 Accredited Standards Committee (ASC) X353.3/85-224

Interaction Between Hosts and Gateways

Use: Host-to-Gateway Protocol (HGP)
Spec: End System to Intermediate System (ES-to-IS) Routing Exchange Protocol for use in Conjunction with ISO 8473. ISO TC 975C6N4053.

DATA LINK LAYER

Packet-Switched Network Access [Including Defense Data Network (DDN)]

Use: DoD X.25

Spec: DoD parameters used with CCITT Recommendation X.25, Interface between Data Terminal Equipment (DTE) and Data Communication Equipment (DCE) for Terminals Operating in the Packet Mode on Public Data Networks – ISO DIS 8208.

Local Connections

Use: Institute of Electrical and Electronic Engineers (IEEE) 802.2 Type 1 Class 1

Spec: IEEE Project 802 Local Area Network Standards – IEEE 802.2 Logical Link Control – ISO DIS 8802/2

PHYSICAL LAYER

Campus Backbone

Use: Present through 1988 – Broadband
1988 and beyond – Fiber Distribution Data Interface (FDDI)

Spec: Physical Layer Protocol X3T9.5/83-15
Token Ring Physical Layer Medium Dependent X3T9.5/84-48
Token Ring Medium Access Control X3T9.5/83-16
FDDI Hybrid Ring Control – Working Draft
FDDI Token Ring Station Management – Working Draft

Intra-Building

Use: IEEE 802.5 – Token Ring (Cable or Twisted Pair)
Spec: IEEE Project 802 Local Area Network Standards – IEEE 802.5
Token Passing Ring Access Method and Physical Layer Specification – ISO DIS 8802/5

DoD PROTOCOL STANDARDS

DoD has standardized protocols as MIL-STDs. The Navy allows use of the following DoD protocol standards:

Applications Layer

File Transfer

Use: File Transfer Protocol (FTP)

Spec: MIL-STD 1780

Electronic Mail

Use: Simple Mail Transfer Protocol (SMTP)

Spec: MIL-STD 1781

Asynchronous Terminal Support

Use: TELNET

Spec: MIL-STD 1782

Restrictions: This should be used for interoperability with existing systems only. Use of this protocol is discouraged.

Presentation

(none)

Session

(none)

Transport

Use: Transmission Control Protocol (TCP)

Spec: MIL-STD 1778

Network

Use: IP and ICMP

Spec: MIL-STD 1777

Lower Levels

Use: DDN X.25

Spec: Defense Communications Agency (DCA), DDN X.25 Host Interface
Specification, December 1983

APPENDIX B

ENGINEERING DRAWING MANAGEMENT INFORMATION AND CONTROL SYSTEM (EDMICS) DATA COMMUNICATIONS

Volume Requirements

DATA COMMUNICATION REQUIREMENTS FOR PRIMARY REPOSITORIES (Continued)

[illegible]

TABLE B-2

DATA COMMUNICATION REQUIREMENTS FOR SECONDARY REPOSITORIES (SHIPYARDS)

Data class	Communication medium	Data medium	Frequency	Source/destination	Annual volume
Engineering drawing input	File	Aperture card	Daily	Contractors, change agents, Government agencies	1) 114,000
					2) 6,650
					3) 152,000
					4) 9,975
					5) 34,200
					6) NA
					7) 144
					8) 56,050
	File	Hard copy	Daily	Contractors, change agents, Government agencies	1) 25,000
					2) 12,000
					3) 8,200
					4) 42,000
					5) 36,000
					6) 286,000
					7) NA
					8) 36,000
	Storage tape, print-out, hard copy	Ingot, image	Weekly	Contractors, change agents, Government agencies	1) 6,000
					2) 350
					3) 8,000
					4) 575
					5) 1,800
					6) NA
					7) NA
					8) 29,500
Engineering drawing output	File	Aperture card	Daily	Drawing users	1) 114,400
					2) 18,400
					3) 58,000
					4) 180,000
					5) 26,000
					6) 8,000
					7) NA
					8) 20,000

Note: 1 = New York; 2 = Philadelphia; 3 = Baltimore; 4 = Cleveland; 5 = Detroit; 6 = Philadelphia; 7 = Portsmouth, NH; 8 = Norfolk, VA.

TABLE B-2

DATA COMMUNICATION REQUIREMENTS FOR SECONDARY REPOSITORIES (SHIPYARDS) (Continued)

Data class	Communication medium	Data medium	Frequency	Source destination	Annual volume
Engineering drawing output (continued)	Data	Hard copy	Daily	Drawing users	1) 59,500
					2) 3,000
					3) 31,513
					4) 424,000
					5) 5,000
					6) 5,000
					7) NA
					8) 29,000
	Data	Screen images	Daily	On-line users	1) 513,100
					2) 76,600
					3) 263,513
					4) 1,144,000
					5) 109,000
					6) 37,000
					7) NA
					8) 109,000
	Data	Screen images	Daily	On-line users	1) NA
					2) 8,280
					3) 32,400
					4) 14,940
					5) 67,500
					6) 62,100
					7) NA
					8) 144,000
	Data	Request form	Daily	Drawing users	1) NA
					2) 970
					3) 36,000
					4) 1,660
					5) 7,500
					6) 6,900
					7) NA
					8) 16,000

Note: 1) Norfolk Island, 2) Norfolk Island, 3) Norfolk Island, 4) Norfolk Island, 5) Norfolk Island, 6) Norfolk Island, 7) Norfolk Island, 8) Norfolk Island.

TABLE B-3

DATA COMMUNICATION REQUIREMENTS FOR SECONDARY REPOSITORIES (NARFs AND NESECs)

Interface	Communication medium	Data medium	Frequency	Source destination	Annual volume
Contractors change agents Government agencies	Film	Aperture card	Daily	Contractors change agents Government agencies	1) 100 2) 19,000 3) 203,018 4) 46,677 5) 0 6) 57,573 7) 1,425 8) NA 9) NA 10) 4,489
					1) 100 2) 302 3) 0 4) 480 5) 5,000 6) 1,400 7) 0 8) NA 9) NA 10) 1,400
					1) 100 2) 1,000 3) 10,000 4) 2,612 5) 0 6) 3,020 7) 75 8) NA 9) NA 10) 2,36
					1) 100 2) 3,000 3) 118 4) 100 5) 3,000 6) 700 7) 0 8) NA 9) NA 10) 210
					1) 100 2) 3,000 3) 118 4) 100 5) 3,000 6) 700 7) 0 8) NA 9) NA 10) 210
					1) 100 2) 3,000 3) 118 4) 100 5) 3,000 6) 700 7) 0 8) NA 9) NA 10) 210
					1) 100 2) 3,000 3) 118 4) 100 5) 3,000 6) 700 7) 0 8) NA 9) NA 10) 210
					1) 100 2) 3,000 3) 118 4) 100 5) 3,000 6) 700 7) 0 8) NA 9) NA 10) 210
					1) 100 2) 3,000 3) 118 4) 100 5) 3,000 6) 700 7) 0 8) NA 9) NA 10) 210
					1) 100 2) 3,000 3) 118 4) 100 5) 3,000 6) 700 7) 0 8) NA 9) NA 10) 210
Contractors change agents Government agencies	Film	Aperture card	Daily	Contractors change agents Government agencies	1) 100 2) 19,000 3) 203,018 4) 46,677 5) 0 6) 57,573 7) 1,425 8) NA 9) NA 10) 4,489
					1) 100 2) 302 3) 0 4) 480 5) 5,000 6) 1,400 7) 0 8) NA 9) NA 10) 1,400
					1) 100 2) 1,000 3) 10,000 4) 2,612 5) 0 6) 3,020 7) 75 8) NA 9) NA 10) 2,36
					1) 100 2) 3,000 3) 118 4) 100 5) 3,000 6) 700 7) 0 8) NA 9) NA 10) 210
					1) 100 2) 3,000 3) 118 4) 100 5) 3,000 6) 700 7) 0 8) NA 9) NA 10) 210
					1) 100 2) 3,000 3) 118 4) 100 5) 3,000 6) 700 7) 0 8) NA 9) NA 10) 210
					1) 100 2) 3,000 3) 118 4) 100 5) 3,000 6) 700 7) 0 8) NA 9) NA 10) 210
					1) 100 2) 3,000 3) 118 4) 100 5) 3,000 6) 700 7) 0 8) NA 9) NA 10) 210
					1) 100 2) 3,000 3) 118 4) 100 5) 3,000 6) 700 7) 0 8) NA 9) NA 10) 210
					1) 100 2) 3,000 3) 118 4) 100 5) 3,000 6) 700 7) 0 8) NA 9) NA 10) 210

Note: 1) Contractors change agents; 2) Government agencies; 3) Contractors change agents; 4) Government agencies; 5) Contractors change agents; 6) Government agencies; 7) Contractors change agents; 8) Government agencies; 9) Contractors change agents; 10) Government agencies.

TABLE B-3

DATA COMMUNICATION REQUIREMENTS FOR SECONDARY REPOSITORIES (NARFs AND NESECS) (Continued)

Data class	Communication medium	Data medium	Frequency	Source/destination	Annual volume
Engineering drawing output (continued)	Data	Hard copy	Daily	Drawing users	1) NA
					2) 16,936
					3) 52,411
					4) 9,000
					5) 95,000
					6) 95,550
					7) 225
					8) NA
					9) NA
					10) 750
	Data/Data	Screen images	Daily	On-line users	1) NA
					2) 31,336
					3) 52,884
					4) 9,400
					5) 111,000
					6) 98,670
					7) 225
					8) NA
					9) NA
					10) 1,590
Drawing requests	Data/Data	Screen images	Daily	On-line users	1) NA
					2) 5,850
					3) 94,500
					4) 46,800
					5) 1,800
					6) 35,100
					7) 90
					8) NA
					9) NA
					10) 450
	Data on display/telephone	Request form	Daily	Drawing users	1) NA
					2) 650
					3) 10,500
					4) 5,200
					5) 200
					6) 2,900
					7) 10
					8) NA
					9) NA
					10) 50

Note: 1 = Los Angeles; 2 = Chicago; 3 = Cincinnati; 4 = Dallas; 5 = Denver; 6 = Detroit; 7 = Houston; 8 = Los Angeles; 9 = New York; 10 = San Francisco. Data = Data; Screen images = Screen images; Drawing users = Drawing users; Request form = Request form; On-line users = On-line users; Hard copy = Hard copy; Data/Data = Data/Data; Data on display/telephone = Data on display/telephone.

TABLE B-4

DATA COMMUNICATION REQUIREMENTS FOR SECONDARY REPOSITORIES (OTHERS)

Data class	Communication medium	Data medium	Frequency	Source destination	Annual volume
Contractors change agents	Full	Aperture card	Daily	Contractors change agents Government agencies	1) 285 570
					2) 4 949
					3) 0
					4) 2 660
					5) 9 500
					6) 764
					7) 87 998
					8) 180 500
					9) 14 250
					10) 11 400
Contractors change agents	Full	Hard copy	Daily	Contractors change agents Government agencies	1) 14 860
					2) 3 183
					3) 1 174
					4) 5 060
					5) 2 670
					6) 764
					7) 6 920
					8) 200
					9) 7 000
					10) 515
Contractors change agents	Full	Digital image	Weekly	Contractors change agents Government agencies	1) 15 030
					2) 260
					3) 0
					4) 140
					5) 500
					6) 764
					7) 4 637
					8) 9 500
					9) 750
					10) 600
Contractors change agents	Full	Aperture card	Daily	Drawing users	1) 146 376
					2) 0
					3) 800 000
					4) 160
					5) 41 000
					6) 2 000
					7) 69 600
					8) 0
					9) 5 000
					10) 910

Note: 1) Data class 2) Data class 3) Data class 4) Data class 5) Data class 6) Data class 7) Data class 8) Data class 9) Data class 10) Data class

DATA COMMUNICATION REQUIREMENTS FOR SECONDARY REPOSITORIES (OTHERS) (Continued)

[illegible]

APPENDIX C

ARMY COMPUTER AIDED LOGISTICS SUPPORT (CALS) INTERSITE DATA FLOW MATRIX

TABLE C-1

ANNISTON ARMY DEPOT (ANAD)

ANAD to	Text	Engineering drawing	Illustration	Billion bits	ANAD from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	16,225	79,317	60,224	72.21	AMCCOM	16,225	79,317	60,224	72.21
CECOM	241,569	2,601	180,891	104.20	CECOM	241,569	2,601	180,891	104.20
MICOM	444,099	1,950,465	725,510	1,389.40	MICOM	444,099	1,950,465	725,510	1,389.40
TACOM	1,221,947	5,358,012	2,234,101	3,940.30	TACOM	1,221,947	5,358,012	2,234,101	3,940.30
TROSCOM	54,378	601	50,688	28.60	TROSCOM	54,378	601	50,688	28.60

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-2

U.S. ARMY ARMAMENT, MUNITIONS, AND CHEMICAL COMMAND (AMCCOM)

AMCCOM to	Text	Engineering drawing	Illustration	Billion bits	AMCCOM from	Text	Engineering drawing	Illustration	Billion bits
Aberdeen AD	9,000	1,500	375	1.34	Aberdeen AD				
AFLC	63	150		0.08	AFLC	63	150		0.08
ALC	3,500			0.15	ALC				
AMC	24,053	676	676	1.71	AMC	15,853	676	676	1.41
AMSAA	3,500			0.15	AMSAA				
ANAD	16,225	79,317	60,244	72.21	ANAD	16,225	79,317	60,244	72.21
CAC	3,500			0.15	CAC				
CECOM	3,500			0.15	CECOM				
Coml print	321,756	1,500	80,890	55.81	Coml print				
Contractor	103,700	902,100	375	466.60	Contractor	434,814	15,767	8,265	77.31
DA	87,468	676	676	4.39	DA	71,615			3.33
DESCOM	103,046	77,639	7,880	18.20	DESCOM	16,883	109	139	1.57
DLA	63	150		0.08	DLA	63	150		0.08
DLSC					DLSC	63	150		0.08
FORSCOM	142,830			6.33	FORSCOM	71,615			3.32
Ft. Bragg	63	150		0.08	Ft. Bragg				
Ft. Hood	76,115	600		1.52	Ft. Hood	1,900	600		1.53
Ft. Knox	507,679	12,186	80,706	79.37	Ft. Knox	86,628	676	676	1.35
FWDA	75,725	961	53,375	6.23	FWDA	75,725	961	53,375	6.23
LB&G	75,423	811	53,375	6.41	LB&G	75,423	811	53,375	6.41
LEA	3,500				LEA				
LEAD	72,612	1,500	7,695	5.23	LEAD	72,612	1,500	7,695	5.23
MICOM	3,500				MICOM				
MRSA	703,850	29,345		9.38	MRSA	26,017			
MA&G	227,677	81,114	60,244	42.11	MA&G	227,677	81,114	60,244	42.11
TRACOM	75,725	961	53,375		TRACOM		961		

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-2

U.S. ARMY ARMAMENT, MUNITIONS, AND CHEMICAL COMMAND (AMCCOM) (Continued)

AMCCOM to	Text	Engineering drawing	Illustration	Billion bits	AMCCOM from	Text	Engineering drawing	Illustration	Billion bits
Navy	63	150		0 08	Navy	63	50		2 06
NCAD	65,810	104	52,906	29 90	NCAD	65,810	104	52,906	29 90
NGB	142,830			6 03	NGB	7,415			3 02
OTEA	3,500			0 15	OTEA				
Picatinny	13,046	77,639	7,880	48 20	Picatinny	16,883	11,139	6,33	1 52
PUDA	164,348	77,657	60,716	105 80	PUDA	156,848	6,451	60,416	38 90
RRAD	161,941	6,610	60,244	37 71	RRAD	161,941	6,610	60,244	37 71
SAAD	344,805	79,142	45,275	78 30	SAAD	337,305	4,141	45,275	39 60
SEAD	430,151	79,153	98,128	109 00	SEAD	422,651	4,153	98,128	70 24
SHAD	65,810	104	52,906	29 91	SHAD	65,810	104	52,906	29 91
SIAD	163,958	77,461		46 60	SIAD	156,450	2,461	60,176	38 70
SSC	142,830			6 03	SSC	71,415			3 02
SVAD	75,725	961	53,775	31 23	SVAD	75,725	961	53,775	31 23
TACOM	3,500			0 15	TACOM	3,500			0 15
TAG	321,756	1,500	80,890	55 81	TAG				
TEAD	43,059	80,177	98,128	109 50B	TEAD	422,659	5,177	98,128	77 20
TECOM	19,858	1,241	676	1 82B	TECOM				
Tester					Tester	3,500			0 15
TOAD	98,494	77,641	7,863	47 50B	TOAD	91,494	2,641	7,863	9 24
TRADOC	161,543	676	676	7 52B	TRADOC	72,055			3 04
UMDA	163,958	77,461		46 60B	UMDA	156,450	2,461	60,176	38 70
USAMPS	75		25	0 02B	USAMPS				
USAREUR					USAREUR	200			0 09

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-3

U.S. ARMY MATERIEL COMMAND (AMC)

AMC to	Text	Engineering drawing	Illustration	Billion bits	AMC from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	15,853	676	676	1 30	AMCCOM	24,051	676	676	1 30
AVSCOM	18,416	916	916	1 80	AVSCOM	17,093	832	832	1 07
CECOM	13,739	648	708	1 29	CECOM	89,258	76,096	76,096	9 02
MICOM	13,245	1,380	300	1 12	MICOM	32,121	1,892	1,333	1 49
PARSA					PARSA	155	6	6	0 01
SPARC					SPARC	100	6	6	0 01

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-3

U.S. ARMY MATERIEL COMMAND (AMC) (Continued)

AMC to	Text	Engineering drawing	Illustration	Billion bits	AMC from	Text	Engineering drawing	Illustration	Billion bits
OC&S	50		5	0.01	OC&S	50	2	5	0.01
TACOM	11,145	525	585	1.04	TACOM	34,921	2,265	3,542	1.15
TECOM	25	2	1	0.01	TECOM				
TROSCOM	4,365			2.23	TROSCOM	1,764		112	30
USAES					USAES	15		3	0.01

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-4

U.S. ARMY ARMAMENT RESEARCH AND DEVELOPMENT CENTER (ARDC)

ARDC to	Text	Engineering drawing	Illustration	Billion bits	ARDC from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM					AMCCOM	9,000	1,500	375	1.34

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-5

U.S. ARMY AVIATION SYSTEMS COMMAND (AVSCOM)

AVSCOM to	Text	Engineering drawing	Illustration	Billion bits	AVSCOM from	Text	Engineering drawing	Illustration	Billion bits
AFCE	35,300			1.18	AFCE	35,300			1.18
AFCE	3,500			0.15	AFCE				
AMC	51,091	1,832	1,421	1.11	AMC	19,416	1,000	1,580	0.94
AMNSAA	3,500			0.15	AMNSAA				
CCF	3,500			0.15	CCF				
CCFCE	975,240	1,351,828	645,047	64.27	CCFCE	54,000	1,120	100	
CECOM	3,500			0.15	CECOM	1,000			
Com print	224,000	56,000		0.84	Com print				
Contractor	1,511,100	1,817,875	60,120	2.03	Contractor	2,321,060	1,112,000	56,000	1.00
DA	29,196	2,491	1,000	0.10	DA	1,000	1,000	1,000	0.10
DESCOM	291,111	1,294,041	199,988	19.16	DESCOM	1,240			
DAW	65,101			0.10					

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-5

U.S. ARMY AVIATION SYSTEMS COMMAND (AVSCOM) (Continued)

AVSCOM to	Text	Engineering drawing	Illustration	Billion bits	AVSCOM from	Text	Engineering drawing	Illustration	Billion bits
DLSC					DLSC	35,000			46
FORSCOM	2,880			0.12	FORSCOM	9,340	1,975	1,975	2.72
Ft. Carson	1,920	15		0.09	Ft. Carson	8,720	1,990	1,975	2.38
Ft. Lewis	12,000			0.51	Ft. Lewis	12,000			
Ft. Rucker	316,110	3,449	55,377	11.73	Ft. Rucker	278,355	2,817	55,377	41.58
LBAD	46	22		0.02	LBAD	46	22		0.02
LEA	3,500			0.15	LEA				
LEAD	13,720	2,054	7,695	5.61	LEAD	13,720	2,054	7,695	5.61
MICOM	3,500			0.15	MICOM				
MRSA	20,615	4,588	4,790	5.67	MRSA	7,900	1,975	1,975	2.36
Navy	35,000			1.48	Navy	35,000			1.48
NCAD	12,827	1,549	7,726	5.31	NCAD	12,827	1,549	7,726	5.31
NGB	2,880			0.12	NGB	1,440			0.07
OFEA	3,500			0.15	OFEA				
SHAD	12,827	1,549	7,726	5.31	SHAD	12,827	1,549	7,726	5.31
SSC	2,880			0.12	SSC	1,340			
TACOM	3,500			0.15	TACOM				
TAG	259,740	1,895	54,121	39.66	TAG				
TECOM	34,342	916	916	2.39	TECOM				
Tester					Tester	3,500			0.15
TRADOC	37,222	916	916	2.51	TRADOC	2,681		142	1.08
USAICS	6			0.01	USAICS				
USAREUR					USAREUR	7,900	1,975	1,975	2.36

Note: All numbers are on an annual basis. A blank indicates to be decided.

TABLE C-6

U.S. ARMY BELVOIR RESEARCH & DEVELOPMENT CENTER (BRDC)

BRDC to	Text	Engineering drawing	Illustration	Billion bits	BRDC from	Text	Engineering drawing	Illustration	Billion bits
FORSCOM	17,380	86,450	11,925	66.14	FORSCOM				

Note: All numbers are on an annual basis. A blank indicates to be decided.

TABLE C-7

U.S. ARMY COMMUNICATIONS-ELECTRONICS COMMAND (CECOM)

CECOM to	Text	Engineering drawing	Illustration	Billion bits	CECOM from	Text	Engineering drawing	Illustration	Billion bits
AFEC	2,250	7,200		3.81	AFEC	2,250	7,200		3.81
ALC	3,500			0.15	ALC				
AMC	59,258	16,096	16,165	19.04	AMC	13,739	648	108	29
AMCCOM					AMCCOM	3,500			1.15
AMSA	3,500			0.15	AMSA				
ANAD	241,569	2,601	180,891	104.21	ANAD	241,569	2,601	180,891	104.21
AUSCOM	3,500			0.15	AUSCOM	3,500			1.15
CAC	3,500			0.15	CAC				
CCAD	242,295	2,971	180,891	104.41	CCAD	242,295	2,971	180,891	104.41
Coml print	73,800		34,150	208.65	Coml print				
Contractor	520,640	222,400	132,200	220.41	Contractor	918,170	28,192	22,402	64.71
DA	8,049	648	708	1.53	DA	2,990			0.13
DESCOM	296,372	6,559,068	331,018	3,564.61	DESCOM	74,000	17,618	16,830	20.81
DLA	2,250	7,200		3.81	DLA	2,250	7,200		3.81
DLSC					DLSC	2,250	7,200		3.78
FORSCOM	5,980			0.21	FORSCOM	2,990			1.11
Ft. Bragg	2,250			0.04	Ft. Bragg				
Ft. Carson	2,490			0.11	Ft. Carson	500			0.03
Ft. Gordon	531,199	648	648	213.76	Ft. Gordon	14,909	648	648	1.29
Ft. Knox	180,495	6,556,369	321,600	3,530.21	Ft. Knox	180,475	6,556,369	321,600	3,530.21
Ft. Lewis	29,600	14,800	14,800	16.41	Ft. Lewis	29,600	14,800	14,800	16.41
LBAD	1,332,680	6,544,997	634,815	3,733.79	LBAD	1,332,680	6,544,997	634,815	3,733.79
LEA	3,500			0.15	LEA				
LEAD	212,848	665	179,400	1,012.11	LEAD	212,848	665	179,400	1,012.11
MICOM	3,500			0.15	MICOM	3,500			1.15
MRSA	354,980	6,192	192	22.51	MRSA	140,500			8.41
MZAD	270,271	1,164	82,331	117.27	MZAD	270,271	1,164	82,331	117.27
Navy	2,250			3.30	Navy	2,250			3.30
NBC	4,980			1.27	NBC	2,090			1.11
NCAD	211,120	2,360	80,891	104.17	NCAD	211,020	2,360	80,891	104.17
OTEA	3,500			0.15	OTEA				
RRAD	269,967	3,591	182,111	112.17	RRAD	269,967	3,591	182,111	112.17
SADL	1,120,918	6,544,875	155,315	1,633.21	SADL	423,168	6,125	14,374	8.41
SGAD	211,120	2,360	80,891	104.17	SGAD	211,120	2,360	80,891	104.17
SSC	4,980			1.27	SSC	2,090			1.11
TACOM					TACOM	14,909			1.11
TSC	73,800			8.41	TSC				
TRC/M	168,338	290	1,296	2.11	TRC/M				
Trigler					Trigler	1,164			1.11
TRADL	1,120,918	6,544,875	155,315	1,633.21	TRADL	423,168	6,125	14,374	8.41
TRADL	168,899	648	648	2.11	TRADL	8,164			1.11
TRADL					TRADL	1,164			1.11
TRADL					TRADL	1,164			1.11

Note: All numbers are in millions of bits unless otherwise indicated.

TABLE C-8

U.S. ARMY COMBINED ARMS CENTER (CAC)

CAC to	Text	Engineering drawing	Illustration	Billion bits	CAC from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM					AMCCOM	3,500			0.15
AVSCOM					AVSCOM	3,500			0.15
CECOM					CECOM	3,500			0.15
MICOM					MICOM	3,500			0.15
TACOM					TACOM	10,300			0.44
USAICS					USAICS	2			0.01

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-9

CORPUS CHRISTI ARMY DEPOT (CCAD)

CCAD to	Text	Engineering drawing	Illustration	Billion bits	CCAD from	Text	Engineering drawing	Illustration	Billion bits
AVSCOM	768,990	114,329	51,447	1.75	AVSCOM	975,240	1,351,829	645,447	1,064.20
CECOM	242,295	2,971	180,891	104.40	CECOM	242,295	29	180,891	104.40
CDA					CDA	286,745	1,500	244,993	138.40
MICOM	65,461	481	58,153	32.80	MICOM	65,461	181	58,153	32.80
TAG, APC					TAG, APC	481,566	56,295	39,603	69.53

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-10

DEPARTMENT OF THE ARMY (DA)

DA to	Text	Engineering drawing	Illustration	Billion bits	DA from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	71,615			1.33	AMCCOM	87,468	676	676	1.39
AVSCOM	9,340	1,975	1,975	2.32	AVSCOM	29,196	2,891	3,033	3.22
CECOM	2,990			0.13	CECOM	8,349	648	158	0.15
MICOM	700			0.33	MICOM	14,245	680	800	0.86
TACOM	952	320	120	0.17	TACOM	12,349	943	943	1.0
TACOM					TACOM	25	2		
USAICS	17,280	10,800	40	0.15	USAICS	100	80	100	0.15
USARV					USARV				

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-11

FT. BLISS

Ft. Bliss to	Text	Engineering drawing	Illustration	Billion bits	Ft. Bliss from	Text	Engineering drawing	Illustration	Billion bits
MICOM	11,925	300	300	0.81	MICOM	687,791	17,030	169,925	145.32

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-12

FT. BRAGG

Ft. Bragg to	Text	Engineering drawing	Illustration	Billion bits	Ft. Bragg from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM					AMCCOM	63	150		0.08
CECOM					CECOM	2,250			0.03
MICOM					MICOM	750			0.03
TACOM					TACOM	286,933			12.12

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-13

FT. CARSON

Ft. Carson to	Text	Engineering drawing	Illustration	Billion bits	Ft. Carson from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	9,220	1,990	1,975	2.38	AMCCOM	1,920	15		0.08
CECOM	511			0.02	CECOM	2,390			0.03
MICOM	190			0.02	MICOM	830			0.03
TACOM	805	120	120	1.36	TACOM	152			0.03

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-14

FT. GORDON

Ft. Gordon to	Text	Engineering drawing	Illustration	Billion bits	Ft. Gordon from	Text	Engineering drawing	Illustration	Billion bits
CECOM	14,909	648	648	1.29	CECOM	531,199	648	648	213.76

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-15

FT. HOOD

Ft. Hood to	Text	Engineering drawing	Illustration	Billion bits	Ft. Hood from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	4,900	600		0.51	AMCCOM	76,115	600		3.52
TROSCOM					TROSCOM	80		51	0.03

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-16

FT. KNOX

Ft. Knox to	Text	Engineering drawing	Illustration	Billion bits	Ft. Knox from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	86,628	676	676	1.35	AMCCOM	507,679	62,186	62,186	9.36
CECOM	180,475	6,556,369	127,667	15,30.20	CECOM	180,475	6,556,369	127,667	15,30.20
MICOM	5,474	75	75	0.17	MICOM	2,918	75	75	0.84
TACOM	9,829	523	523	0.95	TACOM	9,829	523	523	1.14

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-17

FT. LEWIS

Ft. Lewis to	Text	Engineering drawing	Illustration	Billion bits	Ft. Lewis from	Text	Engineering drawing	Illustration	Billion bits
AVSCOM	12,000			0.51	AVSCOM	12,000			0.51
CECOM	29,600	14,800	14,800	16.41	CECOM	29,600	14,800	14,800	16.41
MICOM	3,651	1,217	2,434	2.02	MICOM	3,651	1,217	2,434	2.02
TACOM	3,651	1,217	2,434	2.02	TACOM	3,651	1,217	2,434	2.02
TROSCOM					TROSCOM	80		51	1.03

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-18

FT. RILEY

Ft. Riley to	Text	Engineering drawing	Illustration	Billion bits	Ft. Riley from	Text	Engineering drawing	Illustration	Billion bits
TROSCOM					TROSCOM	80		51	1.03

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-19

FT. WINGATE DEPOT ACTIVITY (FWDA)

FWDA to	Text	Engineering drawing	Illustration	Billion bits	FWDA from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	75,257	961	53,375	31.23	AMCCOM	75,257	961	53,375	31.23
CDR					CDR	127,935		127,935	22.17
MICOM	67,738	273	53,108	30.20	MICOM	67,738	273	53,108	30.20

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-20

U.S. ARMY DEPOT SYSTEMS COMMAND (DESCOM)

DESCOM to	Text	Engineering drawing	Illustration	Audio bits	DESCOM from	Text	Engineering drawing	Illustration	Audio bits
AMCCOM	16 883	1,139	539	1 57	AMCCOM	103 046	77 539	1 480	15 20
AVSCOM	12 878	543	574	1 12	AVSCOM	491 313	1 294 043	599 388	990 60
CECOM	74 000	17 618	16 830	20 80	CECOM	296 327	6 559 268	131 178	6 541 60
MI COM	16 438	1 851	1 228	3 10	MI COM	394 570	1 951 35	6 1 65	10 40
NCAD	33 849	3 046	3 345	4 70	NCAD	33 849	3 046	3 345	4 70
TACOM	78 144	1 761	2 509	5 49	TACOM	313 816	1 968 68	1 124 172	1 636 30
TROSCOM	15 768	689	614	1 33	TROSCOM	51 969	94 589	1 478	29 30

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-21

LETTERKENNY ARMY DEPOT (LEAD)

LEAD to	Text	Engineering drawing	Illustration	Audio bits	LEAD from	Text	Engineering drawing	Illustration	Audio bits
AMCCOM	12 672	1 500	7 695	5 27	AMCCOM	12 672	1 500	7 695	5 27
AVSCOM	12 720	2 054	7 695	5 60	AVSCOM	12 720	2 054	7 695	5 60
CECOM	212 848	665	179 439	1 021 10	CECOM	212 848	665	179 439	1 021 10
CDA					CDA	881 325	389 605	367 387	527 60
MICOM	259 637	383	7 511	50 92	MICOM	314 147	450 384	15 577	389 40
TACOM	665 329	111 529	208 673	356 00	TACOM	1 222 329	5 351 329	1 234 767	4 941 10
TAG APC					TAG APC	1 543 185	21 834	1 321 475	196 20
TROSCOM	34 815	959	1 260	31 40	TROSCOM	95 495	44 829	1 112	6 10

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-22

LEXINGTON-BLUE GRASS ARMY DEPOT (LBAD)

LBAD to	Text	Engineering drawing	Illustration	Billion bits	LBAD from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	75,423	811	53,275	30.90	AMCCOM	75,423	811	53,275	30.90
AVSCOM	46	22		0.01	AVSCOM	46	22		0.01
CECOM	1,332,680	6,544,997	634,815	7.24	CECOM	1,332,680	6,544,997	634,815	7.24
CDA					CDA	806,198	388,105	51,188	389.90
TACOM	476,390	387,910	219,022	331.00	TACOM	476,390	387,910	219,022	331.00
TAG/APC					TAG/APC	860,190	450	119,400	128.50
TROSCOM	53,932	377	50,688	28.44	TROSCOM	53,932	377	50,688	28.44

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-23

MAINZ ARMY DEPOT (MZAD)

MZAD to	Text	Engineering drawing	Illustration	Billion bits	MZAD from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	220,177	6,743	60,244	43.60	AMCCOM	227,677	81,743	60,144	92.30
CECOM	270,271	4,743	182,331	107.20	CECOM	270,271	4,743	182,331	117.20
CDA					CDA	868,813	388,105	559,786	522.30
MICOM	260,169	482	77,690	10.90	MICOM	444,699	1,950,842	725,690	1,689.00
TACOM	658,381	411,575	228,673	355.60	TACOM	1,215,461	5,357,975	2,234,161	3,940.00
TAG/APC					TAG/APC	1,416,988	23,040	212,882	180.70
TROSCOM	54,242	583	50,688	28.60	TROSCOM	542,242	583	50,688	28.60

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-24

U.S. ARMY MATERIEL READINESS SUPPORT ACTIVITY (MRSA)

MRSA to	Text	Engineering drawing	Illustration	Billion bits	MRSA from	Text	Engineering drawing	Illustration	Billion bits
AMC	155	25	4	0.02	AMC				
AMCCOM	200			0.01	AMCCOM	101,450	29,345		19.38
AMSAA	2,000			0.08	AMSAA				
AVSCOM	7,900	1,975	1,975	2.36	AVSCOM	1,147,175	1,148	1,148	1.12
CECOM	440,500			18.60	CECOM	151,790	1,142	142	1.2
Contractor					Contractor	280		6	1.4
FORSCOM	190	10	4	0.02	FORSCOM	4,567	1.7	6	2.7
LAO	70	10	4	0.01	LAO				
LEA	2,000			0.08	LEA				
MICOM	400			0.02	MICOM	30,350			1.20
TACOM	800	320	320	0.36	TACOM	31,680	1,985	640	2.27
TRADOC	10	10	4	0.01	TRADOC	180	40	16	0.04
TROSCOM	18,497	10,800	216	64.42	TROSCOM	12,227	24,500	432	11.43

Note: All numbers are on an annual basis. A blank cell may be deleted.

TABLE C-25

U.S. ARMY MISSILE COMMAND (MICOM)

MICOM to	Text	Engineering drawing	Illustration	Billion bits	MICOM from	Text	Engineering drawing	Illustration	Billion bits
AFIC	750			0.04	AFIC	750			1
AIC	3,500			0.15	AIC				
AMC	32,021	2,897	3,134	0.39	AMC	1,245	8	1	1.2
AMCCOM				0.15	AMCCOM	1,500			0.15
AMSAA	3,500			0.15	AMSAA				
ANAD	444,099	1,950,465	725,510	1,389.41	ANAD	144,099	1,950,365	125,510	189.41
AVSCOM					AVSCOM	1,500			0.15
CAC	3,500			0.15	CAC				
CCAD	65,461	381	58,153	0.47	CCAD	65,461	381	58,153	0.47
CECOM	3,500			0.15	CECOM	1,500			0.15
Contractor	1,191,111	28,777	2,408	91.97	Contractor	1,155,855	8,947	219,388	21,307
EA	14,245	1,380	100	1.46	EA	700			0.14
FORSCOM	394,510	1,951,851	670,385	1,359.97	FORSCOM	16,438	1,857	1,028	0.07
LEA	750			0.04	LEA	750			1
OLSC					OLSC	750			1
PROSCOM	600			0.03	PROSCOM				
TROSCOM	680,791	8,150	64,406	0.70	TROSCOM	400			1

Note: All numbers are on an annual basis. A blank cell may be deleted.

TABLE C-25

U.S. ARMY MISSILE COMMAND (MICOM) (Continued)

MICOM to	Text	Engineering drawing	Illustration	Billion bits	MICOM from	Text	Engineering drawing	Illustration	Billion bits
Ft Bragg	750			0.04	Ft Bragg				
Ft Carson	300			0.02	Ft Carson	300			0.02
Ft Knox	10,948	190	510	0.82	Ft Knox	5,474	95	255	0.41
Ft Lewis	3,651	1,217	2,434	2.02	Ft Lewis	3,651	1,217	2,434	2.02
FWDA	67,748	273	53,108	30.23	FWDA	67,748	273	53,108	30.23
LBAD					LBAD				
LEA	3,500			0.15	LEA				
LEAD	444,137	1,950,483	725,510	1,389.41	LEAD	259,637	483	77,510	50.92
MRSA	30,050	15,420	60	9.21	MRSA	100			0.02
MZAD	444,669	1,950,482	725,690	1,389.41	MZAD	260,169	482	77,690	10.91
NADA	67,748	273	53,108	30.21	NADA	67,748	273	53,108	30.21
Navy	750			0.04	Navy	750			0.04
NCAD	64,752	1,081	161,174	85.81	NCAD	64,752	1,081	161,174	85.81
NCB	600			0.03	NCB	300			0.02
OTEA	3,500			0.15	OTEA				
RRAD	2,233,111	7,509,279	160,190	1,064.91	RRAD	450,611	311	77,690	59.01
SAAD	985,328	1,951,485	770,708	1,434.01	SAAD	800,828	1,485	122,708	92.44
SEAD	988,850	1,951,475	770,708	1,436.01	SEAD	804,350	1,475	122,708	97.61
SHAD	64,752	1,081	161,174	85.81	SHAD	64,762	1,081	161,174	85.81
SIAD	443,715	1,950,273	725,510	1,389.01	SIAD	259,215	273	77,510	50.81
SSC	600			0.03	SSC	300			0.02
SVDA	67,748	273	53,108	30.20	SVDA	67,748	273	53,108	30.20
TAG	649,816	2,310	169,566	115.48	TAG				
TRADOC	17,325	300	300	1.04	TRADOC	1,920	1,080		0.63
TECOM	16,725	300	300	1.01	TECOM				
TACOM					TACOM	10,300			0.44
TEAD	985,328	1,951,485	770,708	1,434.01	TEAD	800,828	1,485	122,708	97.44
TOAD	193,572	983	19,537	18.34	TOAD	381,520	1,950,483	667,382	1,357.11
UMDA	343,715	1,950,273	725,510	1,389.01	UMDA	259,215	273	77,510	50.81
USAREUR					USAREUR	300			0.02

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-26

U.S. ARMY NATICK RESEARCH & DEVELOPMENT CENTER (NRDC)

NRDC to	Text	Engineering drawing	Illustration	Billion bits	NRDC from	Text	Engineering drawing	Illustration	Billion bits
AMC	25	15	15	0.01	AMC				
Contractor					Contractor	5			0.01
FORSCOM	15		2	0.01	FORSCOM				
LABS					LABS	23		2	0.01
LEA	22	15	15	0.01	LEA				
TECOM	5			0.01	TECOM				
TECOM Test					TECOM Test	8			0.01
TRADOC	22	15	15	0.01	TRADOC				
TROSCOM	17,380	86,350	41,925	632.90	TROSCOM				

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-27

NAVAJO DEPOT ACTIVITY (NADA)

NADA to	Text	Engineering drawing	Illustration	Billion bits	NADA from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	75,725	961	53,375	31.23	AMCCOM	75,725	961	53,375	31.23
CDA					CDA	127,395		110,751	62.10
MICOM	67,748	273	53,108	30.20	MICOM	67,748	273	53,108	30.20

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-28

NEW CUMBERLAND ARMY DEPOT (NCAD)

NCAD to	Text	Engineering drawing	Illustration	Billion bits	NCAD from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	65,810	104	52,906	29.90	AMCCOM	65,810	104	52,906	29.90
AVSCOM	12,827	1,549	7,726	5.30	AVSCOM	12,827	1,549	7,726	5.30
CECOM	241,020	2,360	180,891	101.00	CECOM	241,020	2,360	180,891	101.00
DESCOM	33,849	3,046	3,345	1.70	DESCOM	33,849	3,046	3,345	1.70
DISC	881,425	390,665	670,575	581.00	DISC	1,762,850	982,336	1,641,150	65.00
MICOM	64,752	1,081	161,174	85.80	MICOM	64,752	81	6,000	4.50
TECOM	176,889	88,154	226,536	111.90	TECOM	176,889	88,154	226,536	111.90
TROSCOM	5,1976	100	10,688	28.04	TROSCOM	5,1976		10,688	5.00

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-29

U.S. ARMY OPERATIONAL TEST & EVALUATION AGENCY (OTEA)

OTEA to	Text	Engineering drawing	Illustration	Billion bits	OTEA from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM					AMCCOM	3,500			2.15
AVSCOM					AVSCOM	3,500			2.15
CECOM					CECOM	3,500			2.15
MICOM					MICOM	3,500			2.15
TACOM					TACOM	10,300			2.44
TROSCOM					TROSCOM	1,000			2.44

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-30

U.S. ARMY ORDNANCE CENTER & SCHOOL (OC&S)

OC&S to	Text	Engineering drawing	Illustration	Billion bits	OC&S from	Text	Engineering drawing	Illustration	Billion bits
AMC	50		5	0.01	AMC	50		5	0.01
Contractor	4			0.01	Contractor				
FORSCOM	4			0.01	FORSCOM	10			0.01
TST Agency	4			0.01	TST Agency				
TRADOC	10			0.01	TRADOC				

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-31

PUEBLO DEPOT ACTIVITY (PUDA)

PUDA to	Text	Engineering drawing	Illustration	Billion bits	PUDA from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	156,848	2,657	60,776	38.90	AMCCOM	164,348	27,687	60,776	5.5
CDA					CDA	657,295	388,135	280,386	121.1
MICOM	259,641	185	77.5	1.89	MICOM	444,141	1,950,485	125,575	5,192
TACOM	482,535	390,972	279,322	512.80	TACOM	482,535	390,972	279,322	332.83
TAC, APC					TAC, APC	809,615	2,500	110,538	119.1
TROSCOM	54,924	875	60,688	2.873	TROSCOM	54,924	875	60,688	28.11

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-32

RED RIVER ARMY DEPOT (RRAD)

RRAD to	Text	Engineering drawing	Illustration	Billion bits	RRAD from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	161,941	6,610	60,244	37.70	AMCCOM	161,941	6,610	60,244	37.70
CECOM	269,967	4,591	182,331	107.11	CECOM	269,967	4,591	182,331	107.11
CDA					CDA	886,813	388,105	559,786	523.00
MICOM	450,611	311	77,690	59.00	MICOM	3,233,111	7,509,279	160,190	4,064.90
TACOM	661,861	410,245	228,673	355.20	TACOM	1,218,941	5,356,929	2,234,161	3,939.50
TAG,APC					TAG,APC	285,801	411,139	772,668	6,184.20
TROSCOM	54,114	469	50,688	28.50	TROSCOM	54,114	469	50,688	28.50

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-33

SACRAMENTO ARMY DEPOT (SAAD)

SAAD to	Text	Engineering drawing	Illustration	Billion bits	SAAD from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	337,305	4,141	45,275	39.60	AMCCOM	344,805	79,141	45,725	78.30
CECOM	973,168	3,425	148,476	118.90	CECOM	1,120,918	654,875	455,015	3,633.00
CDA					CDA	392,664	205	340,764	191.20
MICOM	800,284	1,483	122,708	97.44	MICOM	985,324	1,951,483	770,708	1,434.00
TAG,APC					TAG,APC	1,836,722	3,150	299,577	232.60
TROSCOM	157,739	922	22,380	19.00	TROSCOM	168,919	44,772	26,572	64.20

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-34

SAVANNA DEPOT ACTIVITY (SVDA)

SVDA to	Text	Engineering drawing	Illustration	Billion bits	SVDA from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	75,725	961	53,775	31.23	AMCCOM	75,725	961	53,775	31.23
MICOM	67,748	273	53,708	30.23	MICOM	67,748	273	53,708	30.23

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-35

SENECA ARMY DEPOT (SEAD)

SEAD to	Text	Engineering drawing	Illustration	Billion bits	SEAD from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	422,651	4,153	98,128	70.24	AMCCOM	430,151	29,153	98,128	109.20
CDA					CDA	541,469	18,181	171,875	361.21
MICOM	304,350	1,475	122,708	97.60	MICOM	988,850	95,145	70,778	416.11
TACOM	482,545	390,970	219,022	332.80	TACOM	482,545	29,145	179,122	132.80
TAG APC					TAG APC	849,615		11,188	19

Note: All numbers are on an annual basis. A blank denotes to be deleted.

TABLE C-36

SHARPE ARMY DEPOT (SHAD)

SHAD to	Text	Engineering drawing	Illustration	Billion bits	SHAD from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	65,810	104	52,906	29.90	AMCCOM	65,810	104	52,906	29.90
AVSCOM	12,827	1,549	7,726	5.30	AVSCOM	12,827	1,549	7,726	5.30
CECOM	241,020	2,360	180,891	104.00	CECOM	241,020	2,360	180,891	104.00
DESCOM	33,849	1,046	3,345	4.70	DESCOM	33,849	1,046	3,345	4.70
DLSC	881,425	190,665	670,575	580.80	DLSC	1,762,850	781,130	1,341,150	1,615.70
MICOM	64,752	181	161,174	85.80	MICOM	64,752	181	161,174	85.80
TACOM	476,889	188,157	220,535	331.90	TACOM	476,889	188,157	220,535	331.90
TRUSCOM	53,976	100	50,688	28.44	TRUSCOM	53,976	100	50,688	28.44

Note: All numbers are on an annual basis. A blank denotes to be deleted.

TABLE C-37

SIERRA ARMY DEPOT (SIAD)

SIAD to	Text	Engineering drawing	Illustration	Billion bits	SIAD from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	156,450	2,361	60,176	38.70	AMCCOM	165,958	21,116		16.6
CDA					CDA	127,935		100,000	62
MICOM	259,215	273	77,750	50.80	MICOM	311,775	95,121	2,511,111	189
TAG APC					TAG APC	849,615		10,188	19

Note: All numbers are on an annual basis. A blank denotes to be deleted.

TABLE C-38

U.S. ARMY TANK-AUTOMOTIVE COMMAND (TACOM)

TACOM to:	Text	Engineering drawing	Illustration	Billion bits	TACOM from:	Text	Engineering drawing	Illustration	Billion bits
AFLC	286,933			12.12	AFLC	286,933			12.12
ALC	10,300			0.44	ALC				
AMC	34,921	2,265	3,542	4.45	AMC	11,145	525	585	24
AMCCOM	3,500			0.15	AMCCOM	3,500			0.15
AMSAA	20,125	524	524	1.39	AMSAA				
ANAD	1,221,947	5,358,102	2,234,101	3,940.31	ANAD	1,221,947	5,358,102	2,234,101	3,940.31
AVSCOM	3,500			0.15	AVSCOM	3,500			0.15
CAC	10,300			0.44	CAC				
CECOM	10,300			0.44	CECOM				
Coml print	120,080	20,520	3,800	134.43	Coml print				
Contractor	465,991	1,595,717	6,234	849.10	Contractor	297,227	2,778	2,434	32.27
DA	12,249	844	904	1.41	DA	952	320	320	0.37
DESCOM	813,816	4,968,681	2,024,412	3,616.31	DESCOM	78,144	1,767	2,529	5.49
DLA	286,933			12.12	DLA	286,933			12.12
DLSC					DLSC	286,933			12.12
FORSCOM	1,104	320	320	0.01	FORSCOM	952	320	320	0.37
Ft. Bragg	286,933			12.12	Ft. Bragg				
Ft. Carson	152			0.01	Ft. Carson				
Ft. Knox	19,829	1,824	524	2.04	Ft. Knox	9,824	524	524	0.96
Ft. Lewis	3,651	1,217	2,434	2.02	Ft. Lewis	3,651	1,217	2,434	2.02
LBAD	476,390	387,910	219,022	331.01	LBAD	476,390	387,910	219,022	331.01
LEA	10,300			0.44	LEA				
LEAD	122,409	5,357,929	2,234,164	3,940.31	LEAD	665,329	117,529	228,673	356.2
MICOM	10,300			0.44	MICOM				
MRSA	31,680	1,985	640	2.07	MRSA	501	2	327	0.4
MZAD	1,215,461	5,367,975	2,334,161	3,940.01	MZAD	658,381	17,507	128,673	199.6
Navy	286,933			12.12	Navy	286,933			12.12
NCAD	476,889	388,157	220,535	331.90	NCAD	176,889	388,157	220,535	331.9
NCB	304			0.01	NCB	952			
OTEA	10,300			0.44	OTEA				
PUODA	482,535	390,972	219,022	332.81	PUODA	482,535	390,972	219,022	332.81
RRAD	1,218,941	5,356,645	2,234,161	3,939.18	RRAD	667,86	17,245	128,673	355.27
SEAD	482,545	390,970	219,022	332.81	SEAD	482,545	390,970	219,022	332.8
SHAD	176,889	388,157	220,535	331.91	SHAD	176,49	388,157	220,535	331.9
SSC	304			0.01	SSC	952			
TAG	219,910	1,278	206,691	176.89	TAG				
TEAD	1,769,778	5,360,437	2,356,345	3,957.81	TEAD	1,212,638	170,338	107,247	177.57
TECOM	24,125	524	524	1.36	TECOM				
Tenter	10,300			0.44	Tenter				
TRDSCOM	3,500			0.15	TRDSCOM	3,500			0.15
TRAD	547,613	20,359	1,000	1.3	TRAD	17,673	20,359	1,000	1.3
TRADCOM	20,129	524			TRADCOM	92			
TRADCOM					TRADCOM	500	92	400	0.6

Note: All numbers are on an annual basis. A blank cell indicates no data.

TABLE C-39

U.S. ARMY TEST AND EVALUATION COMMAND (TECOM)

TECOM to	Text	Engineering drawing	Illustration	Billion bits	TECOM from	Text	Engineering drawing	Illustration	Billion bits
AMC					AMD	25	2		0.01
AMCCOM					AMCCOM	19,858	1,241	676	180
AVSCOM					AVSCOM	84,342	476	476	2,39
CECOM					CECOM	168,388	176	176	1,11
Contractor					Contractor		5		11
DA	25	2	1	0.01	DA				
FORSKOM	25	2	1	0.01	FORSKOM	152	2		1.22
LEA	25	2	1	0.01	LEA				
NRDC					NRDC	5			0.01
TACOM					TACOM	24,125	524	524	15.66
TRADOC	25	2	1	0.01	TRADOC	5	5		11
Test activity	25	2	1	0.01	Test activity	150	2		0.03
TROSCOM					TROSCOM	6,251			0.06

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-40

TOBYHANNA ARMY DEPOT (TOAD)

TOAD to	Text	Engineering drawing	Illustration	Billion bits	TOAD from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	91,494	2,641	7,863	9.24	AMCCOM	98,994	77,641	7,863	11,580
CECOM	973,168	3,425	148,476	118.90	CECOM	1,129,938	6,544,875	152,215	1,676
CDA					CDA	3,372,292	24,334	191,684	28,88
MICOM	197,020	383	19,382	18.34	MICOM	381,523	195,384	667,382	111
TACOM	547,613	29,539	72,324	70.70	TACOM	547,613	23,539	72,324	71
TAG APC					TAG APC	816,122	1,151	611,111	16
TROSCOM	157,739	922	22,380	19.00	TROSCOM	68,919	84,172	26,572	612

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-41

TOOELE ARMY DEPOT (TEAD)

TEAD to	Text	Engineering drawing	Illustration	Billion bits	TEAD from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	422,659	5,177	98,128	77.00	AMCCOM	430,159	80,177	98,128	109.50
CDA					CDA	594,680	388,105	322,488	390.90
MICOM	800,828	1,485	122,708	97.44	MICOM	985,328	1,952,485	770,708	1,434.00
TACOM	1,212,638	414,031	101,047	417.50	TACOM	1,769,718	5,360,431	2,326,535	4,501.50
TAGAPC					TAGAPC	1,543,185	23,234	232,675	196.20
TROSCOM	210,942	1,125	12,993	46.90	TROSCOM	222,122	84,975	77,185	92.44

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-42

U.S. ARMY TROOP SUPPORT COMMAND (TROSCOM)

TROSCOM to	Text	Engineering drawing	Illustration	Billion bits	TROSCOM from	Text	Engineering drawing	Illustration	Billion bits
AMC	4,764		142	0.03	AMC	4,365			2.23
AMSAA	1,000		51	0.01	AMSAA				
ANAD	54,378	601	50,688	28.61	ANAD	54,378	601	50,688	28.61
BRDC					BRDC	17,380	86,350	41,925	66.41
CECOM	3,500			0.15	CECOM	3,500			0.15
Contractor	900	150	300	1.27	Contractor	600	100	200	1.18
DA	30,464	10,809	276	6.91	DA	17,280	10,800	276	6.41
DESCOM	51,969	84,859	7,378	19.31	DESCOM	15,768	689	634	1.33
EUISA	15			0.01	EUISA				
Field user	4,980			0.21	Field user	17,460	1,080.0	276	6.41
FORSKOM	9,600			0.41	FORSKOM	22,080	1,800	276	11.41
Ft. Hood	80		51	0.03	Ft. Hood				
Ft. Lewis	80		51	0.03	Ft. Lewis				
Ft. Riley	80		51	0.03	Ft. Riley				
LABCOM	80		51	0.03	LABCOM				
LEAD	53,932	377	50,688	28.44	LEAD	54,442	377	50,688	28.44
LEA	1,000			0.04	LEA				
LEAD	95,995	84,809	57,452	76.91	LEAD	84,185	459	54,260	31.11
Log center	80		51	0.03	Log center				
MRSA	42,227	24,100	432	14.34	MRSA	18,947	10,800	276	64.13
MCAD	54,242	583	50,688	28.61	MCAD	54,242	583	50,688	28.61
NCAD	53,976	300	50,688	28.44	NCAD	53,976	300	50,688	28.44
NRDC					NRDC	17,780	8,6780	170,13	66.41
OTC					OTC				

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-42

U.S. ARMY TROOP SUPPORT COMMAND (TROSCOM) (Continued)

TROSCOM to	Text	Engineering drawing	Illustration	Billion bits	TROSCOM from	Text	Engineering drawing	Illustration	Billion bits
PUDA	54,924	875	50,688	28.71	PUDA	54,924	875	50,688	28.71
RRAD	54,114	469	50,688	28.51	RRAD	54,114	469	50,688	28.51
SAAD	168,919	84,772	26,572	64.20	SAAD	157,739	922	22,380	19.00
SHAG	53,976	400	50,688	28.44	SHAG	53,976	400	50,688	28.44
TACOM	3,500			0.15	TACOM	3,500			0.15
TEAD	222,122	84,975	27,185	92.34	TEAD	210,942	1,125	12,993	36.91
TECOM	6,251			0.26	TECOM				
TOAD	168,919	84,772	26,572	64.21	TOAD	157,759	922	22,380	19.01
TRADOC	15,851			0.70	TRADOC	5,260	1,080	216	0.33
USAREUR					USAREUR	17,280	10,800	216	6.41
WESTCOM					WESTCOM	17,280	10,800	216	6.41

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-43

U.S. ARMY ENGINEER SCHOOL (USAES)

USAES to	Text	Engineering drawing	Illustration	Billion bits	USAES from	Text	Engineering drawing	Illustration	Billion bits
AMC	15		1	0.01	AMC				
Contractor					Contractor	15			0.01
DA	15		1	0.01	DA				
Field user					Field user	15			0.01
TROSCOM					TROSCOM	80		10	2
TRADOC	45			0.20	TRADOC				
Worldwide	20			0.05	Worldwide				

Note: All numbers are on an annual basis. A blank denotes to be decided.

TABLE C-44

U.S. ARMY EUROPE (USAREUR)

USAREUR to	Text	Engineering drawing	Illustration	Billion bits	USAREUR from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	200			0.01	AMCCOM				
AVSCOM	7,900	1,975	1,975	2.36	AVSCOM				
CECOM	500			0.02	CECOM				
MICOM	400			0.02	MICOM				
TACOM	800	320	320	0.04	TACOM				
TROSCOM	17,280	10,800	216	64.00	TROSCOM				

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-45

U.S. ARMY INTELLIGENCE CENTER & SCHOOL (USAICS)

USAICS to	Text	Engineering drawing	Illustration	Billion bits	USAICS from	Text	Engineering drawing	Illustration	Billion bits
AMC	2			0.01	AMC				
AVSCOM					AVSCOM	6			0.01
CAC	2			0.01	CAC				
LABCOM					LABCOM	6			0.01
TRADOC	2			0.01	TRADOC				
TRADOC schools	1,200			0.05	TRADOC schools				

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-46

UMATILLA DEPOT ACTIVITY (UMDA)

UMDA to	Text	Engineering drawing	Illustration	Billion bits	UMDA from	Text	Engineering drawing	Illustration	Billion bits
AMCCOM	156,450	2,461	56,176	38.70	AMCCOM	163,458	2,461		36.60
CDA					CDA	127,935		10,151	62.00
MICOM	259,215	273	27,510	50.80	MICOM	343,215	1,950,273	228,000	1,089,000
TAC, APC					TAC, APC	849,165	2,500	1,101,028	59.00

Note: All numbers are on an annual basis. A blank connotes to be decided.

TABLE C-47

U.S. ARMY WESTERN COMMAND (WESTCOM)

WESTCOM to	Text	Engineering drawing	Illustration	Audio bits	WESTCOM from	Text	Engineering drawing	Illustration	Audio bits
TROSCOM	17,280	12,900	276	6,400	TROSCOM				

Note: All numbers are on an annual basis. A blank indicates to be decided.

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The Department of Defense is committed to applying the best in modern technology toward improving the transfer of design, engineering, and manufacturing technical information among weapon system contractors and DoD organizations. The Military Services, the Defense Logistics Agency (DLA), the Defense Communications Agency (DCA), and industry are undertaking or planning telecommunications support for such transfer. In view of these many and diverse efforts, the Computer Aided Logistics Support (CALS) Steering Group through the CALS Communications Working Group has recognized the need for evaluating them. The report presents an evaluation of CALS-related telecommunications requirements in DoD, three major efforts for automating engineering drawing and technical data repositories, and various intelligent gateway efforts in each of the Services. The overall direction within each Service for telecommunication support and transitioning to the OSI standards is presented as well as the status of commercial efforts for defining and implementing the OSI standards and improving long-haul telecommunications support.					
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