NAVAL RESEARCH
ADVISORY COMMITTEE

OPEN SYSTEMS ARCHITECTURE
FOR
COMMAND, CONTROL AND COMMUNICATIONS

SUMMER STUDY

JULY 1991

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I. EXECUTIVE SUMMARY

Purpose of Study

The need for precise and timely information in strategic and tactical operations, as well as optimum use of Navy sensors and weapons systems is inhibited by the limits of current Command, Control and Communications (C^3) systems architecture and its associated components.

Observations

The shortcomings of Navy combat and C^3 computer systems reveal vulnerability in warfighting capability and survivability. These shortcomings are due to narrow range and lack of flexibility in support of numerous tactical afloat and ashore users. The limiting factor in these shortcomings is the continued development of uniquely Navy systems. C^3 systems designed to Military Specifications (MILSPEC) force the Navy into unrealistic development and life cycle support time and cost. This approach diverges from the current industry utilization of Open Systems Architecture (OSA) and common standards that facilitate increased growth in processing while decreasing costs. In contrast, the Navy's approach requires a longer lead time and produces less capable and costlier C^3 systems.

Conclusions

Implementation of OSA is the best method of reducing development time and system cost while using leading technology and improving compatibility between Navy units, other service branches and industry. The Panel found several examples of effective use of OSA. Most notable of these was the Naval Tactical Command System - Afloat (NTCS-A). In addition, the endorsement of OSA by the Copernicus Architecture effort of the Director, Space and Electronic Warfare (OP-094) represents significant progress. However, examples of Commercial-Off-the-Shelf (COTS) items being randomly employed throughout a system in order to claim use of OSA results in a loss of most of the inherent benefits.

From an engineering perspective, the Panel found no technological barriers to adopting OSA and industry standards in combat and C^3 systems. Policy and cultural barriers to implementation exist, and are due to institutional inertia and minimal understanding of OSA applications by decision makers.

Recommendations

As was evident in Desert Storm operations, Navy C^3 must obtain dramatic increases in the communications bandwidth. Expansion into commercial satellites, antenna design, and ashore and afloat processing and display systems is critical. To expedite this conversion to COTS technology, particularly with computers and software, the Panel recommends that the current MILSPEC waiver policy be inverted to require a waiver for procurement of MILSPEC equipment. In addition, education of program managers and decision makers regarding advantages, capabilities and availability of commercial products should be provided.

Ruggedized commercial equipment and standards should be the norm for Navy C^3 while systems designed to a MILSPEC should require a waiver for use. This will ensure optimum fleet readiness in the future.

II. TERMS OF REFERENCE

Introduction

The primary goal of this study was to ascertain Navy's need and technological ability to move toward COTS hardware and software for C^3 and combat weapon systems. By employing experts from industry and academia, Navy, represented by OP-094 as requirements sponsor and the Assistant Secretary of the Navy (Research, Development & Acquisition (ASN (RD&A)) as acquisition sponsor, wanted industry's perspective on Navy's conduct of requiring and acquiring computer hardware and software.

The Terms of Reference (TOR) evolved over several months in late 1990 and early 1991. This timeframe overlapped the Gulf War between Iraq and United Nations coalition forces. This conflict exposed numerous C^3 shortcomings in architecture and engineering and was one of the focal points for the study.

This report specifically addresses the current status of the Navy acquisition policy relative to C^3, evaluates Navy C^3 performance in Desert Storm, and assesses the ability of meeting naval warfare needs with COTS equipment. Recommendations are made in areas of accountability, policy, education, and acquisition.

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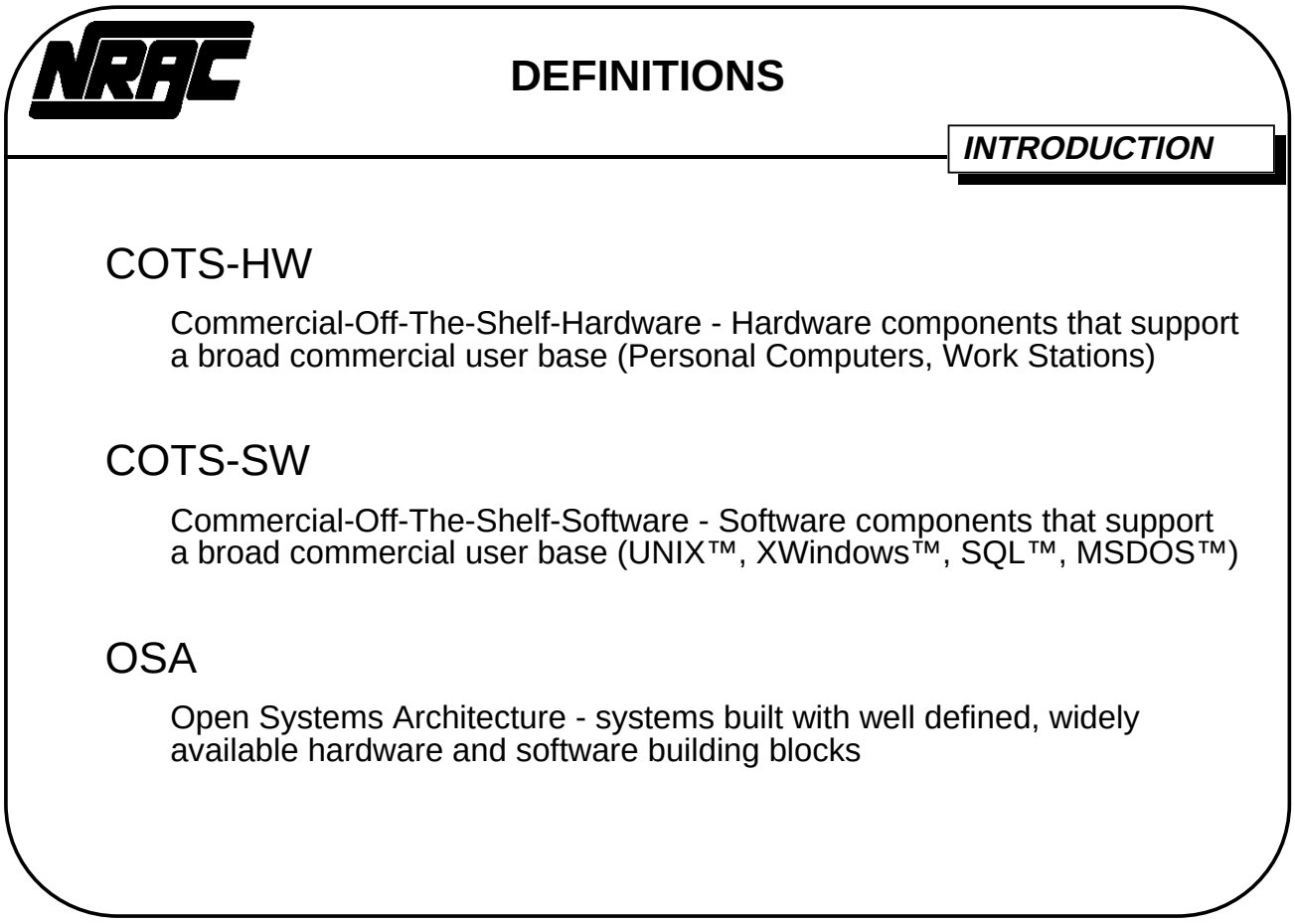
IV. INTRODUCTION



COTS-HW — Commercial-Off-The-Shelf-Hardware

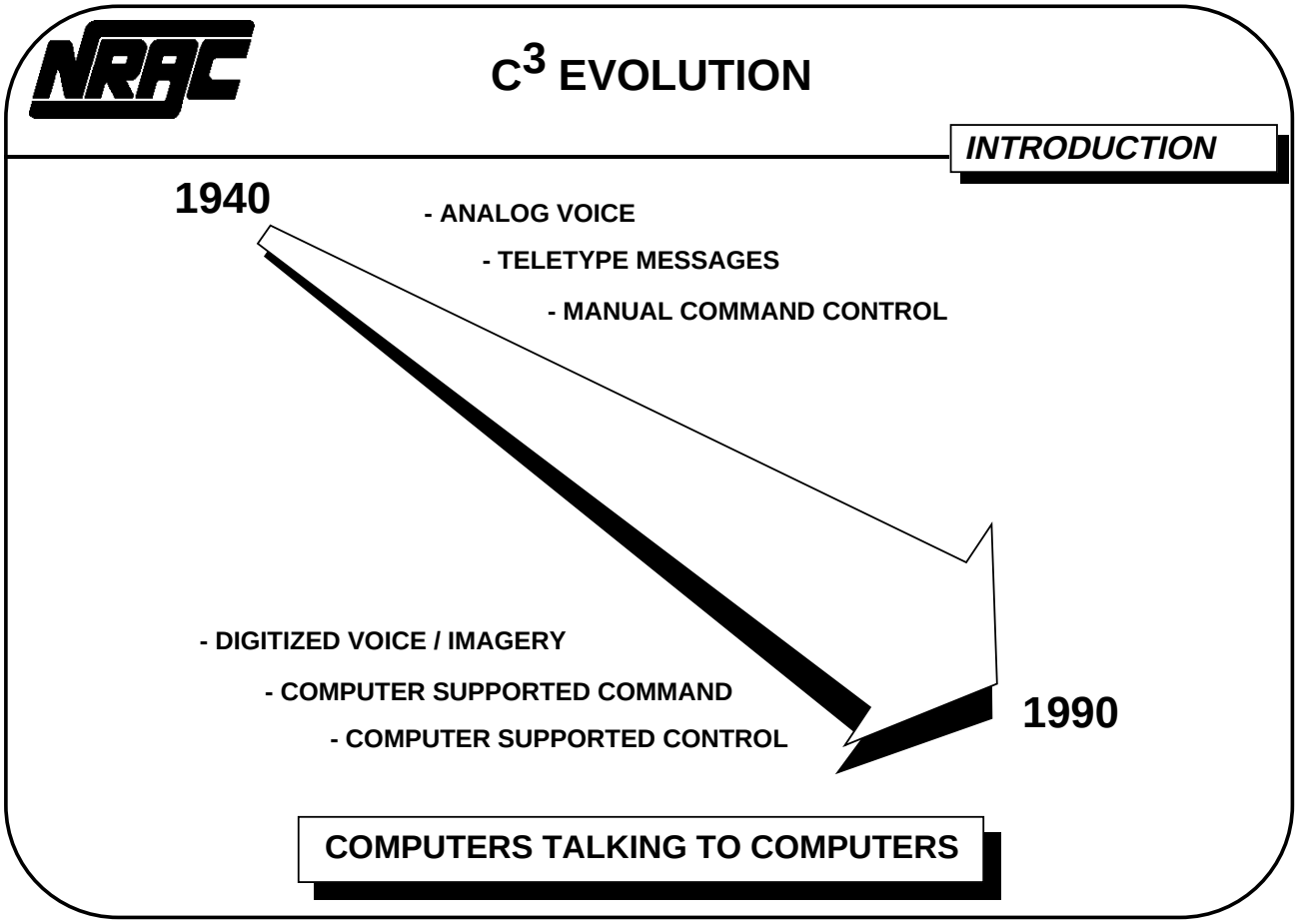
The term Commercial-Off-The-Shelf-Hardware has become commonly used to describe components that can be purchased from commercial vendors and used to fill a system requirement. Generally, the components considered are those that support a broad commercial user base. Due to the growth of open systems standards, it is possible to mix vendor equipment types to build up a complete system. Due to the large user community and strong commercial competition, these components have generally grown into reliable systems. These systems are also produced by the millions in Personal Computers (PCs) and workstations, yielding production quantities far in excess of anything Navy would produce.

COTS-SW — Commercial-Off-The-Shelf-Software

Just as hardware components have grown, software building blocks have evolved into broadly used, easily integrated packages. UNIX™ operating system, X-WINDOWS™ graphics display software, and Standard Query Language (SQL) relational data base systems are examples of widely used, fully functional software components that greatly simplify the task of building modern systems. These packages are generally very affordable and reliable due to the large user base they support. Additionally, they are continuously improved, and upgrades can be purchased at low cost.

OSA — Open Systems Architecture

Open Systems Architecture is a relatively new term that is used to represent the concept of developing systems from hardware and software building blocks provided by a variety of vendors. This concept is a revolutionary departure from the previous practice of vendors developing systems from the ground up, using unique (proprietary) equipment lines. Driven by user demand, vendors are now producing and integrating components that are compatible with internationally defined standards. This results in the capability for users to combine vendor equipments, flexibly develop system capabilities, and upgrade system components a layer at a time, independent of other components or layers.



The evolution in communications over the last decade parallels the computer revolution because of parallel technologies. Several important trends must now be considered in the future Navy systems.

Firstly, voice communication has moved almost completely away from the century old analog technology into digital technology. Computers provide the routing, switching and conversions needed in a digitized voice communications system. Many of today's long-haul land based communication links are digital. These links include microwave satellites and fiber optic cabling that encircle the globe.

Secondly, digital communications have spawned the proliferation of computer networks and information systems where computers talk to computers. Electronic mail and voice mail systems have replaced many of the voice and hardcopy communications of large corporations. Computer networking requirements have increased as the technology provides more capabilities in the hands of the end users. With increased computer capability comes increased bandwidth demands that the technical communication evolution continues to provide.

Finally, the computer and communication evolutions have forced commercial standardization. The mandatory requirement to share information and technology has caused the emergence of layered protocols. These protocols are designed to

provide an interoperable ability to communicate at the various functional layers, even when conversing hardwares are dissimilar. With a wide number of vendors implementing this hardware and software technique, Navy can reap the benefits of a variety of competing sources. In order to capitalize on this technology, however, Navy needs to depart from adapting to Tactical Digital Standards (TADSTANDS) and adopt the evolving international standards.

NAVY STANDARDS - UNIQUE SYSTEMS

INTRODUCTION

OPNAVINST 5200.28 LIFE CYCLE MANAGEMENT OF COMPUTER RESOURCES....

"Standard computer hardware, support environments, high order languages and documentation shall be used....TADSTANDs establish standard...."

TACTICAL DIGITAL STANDARDS (TADSTANDs)

TADSTAND A - Definitions

TADSTAND B - Hardware Standards (Grey Boxes)

TADSTAND C - High Order Languages (Ada, CMS-2, etc.)

TADSTAND D - Reserves Requirements (50%)

TADSTAND E - Software Development / Documentation Standards

Current Navy policy, contained in the OPNAV Instruction (OPNAVINST) 5200.28 and TADSTANDs, mandates the use of fully militarized hardware at the box level. Also included in existing policy are prescribed software languages, development standards, and reserve capacity. Though these policies allow pursuit of alternative computer resource solutions, a substantial deterrent effect is encountered by program managers because of the extensive cost-effectiveness analysis which must be prepared in order to obtain a waiver from using Navy's standards.

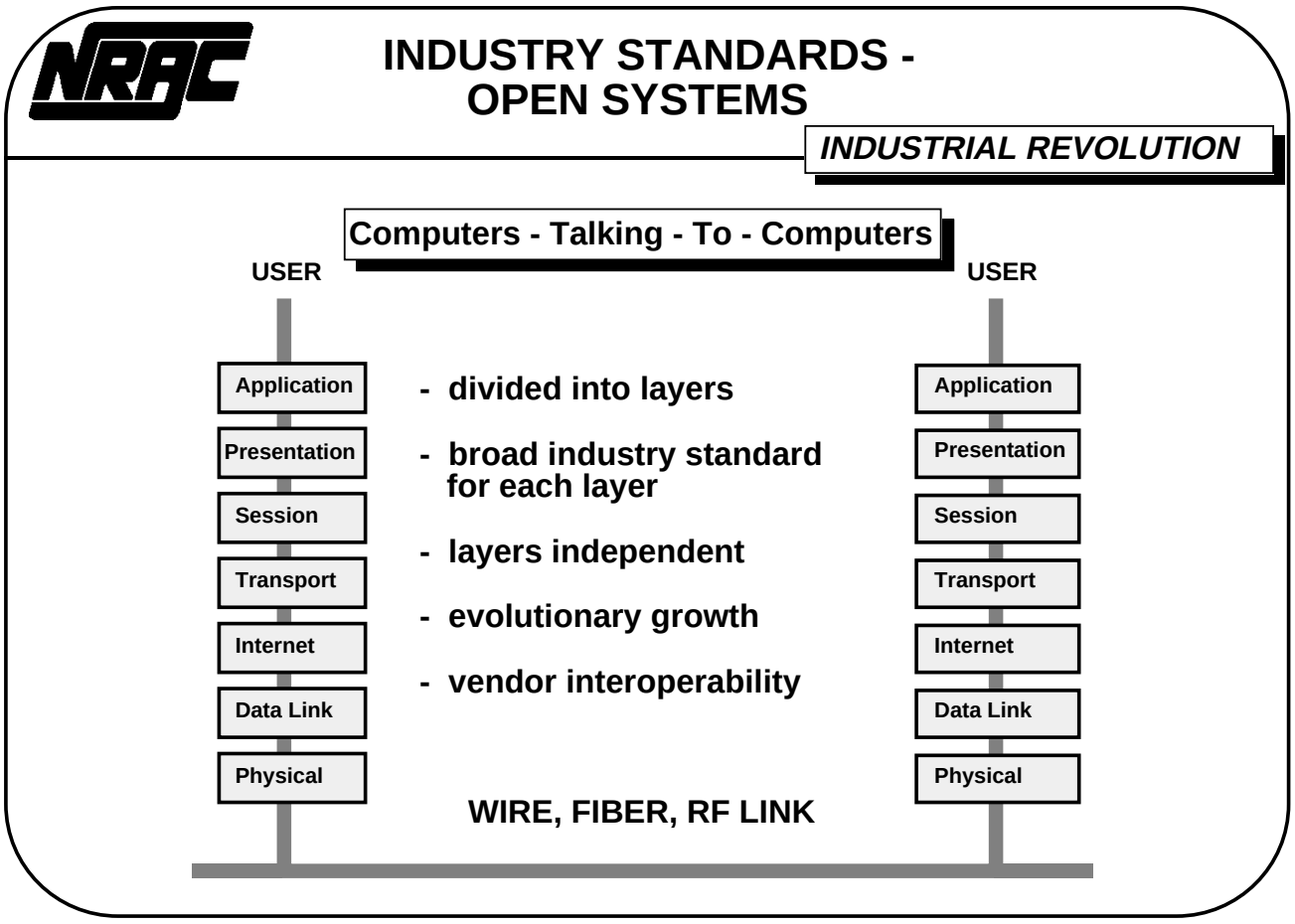
These policies led to:

- ***Submission***, use of Navy standards (even though it may not be the most cost or time effective way to meet requirements).

- ***Passive Resistance***, which generally uses delay tactics to assure success of waiver requests.

At the time these standards were initiated, they were effective at solving organic Navy problems. With the increased emphasis on Joint, Allied, and industry interoperability, these standards are no longer effective.

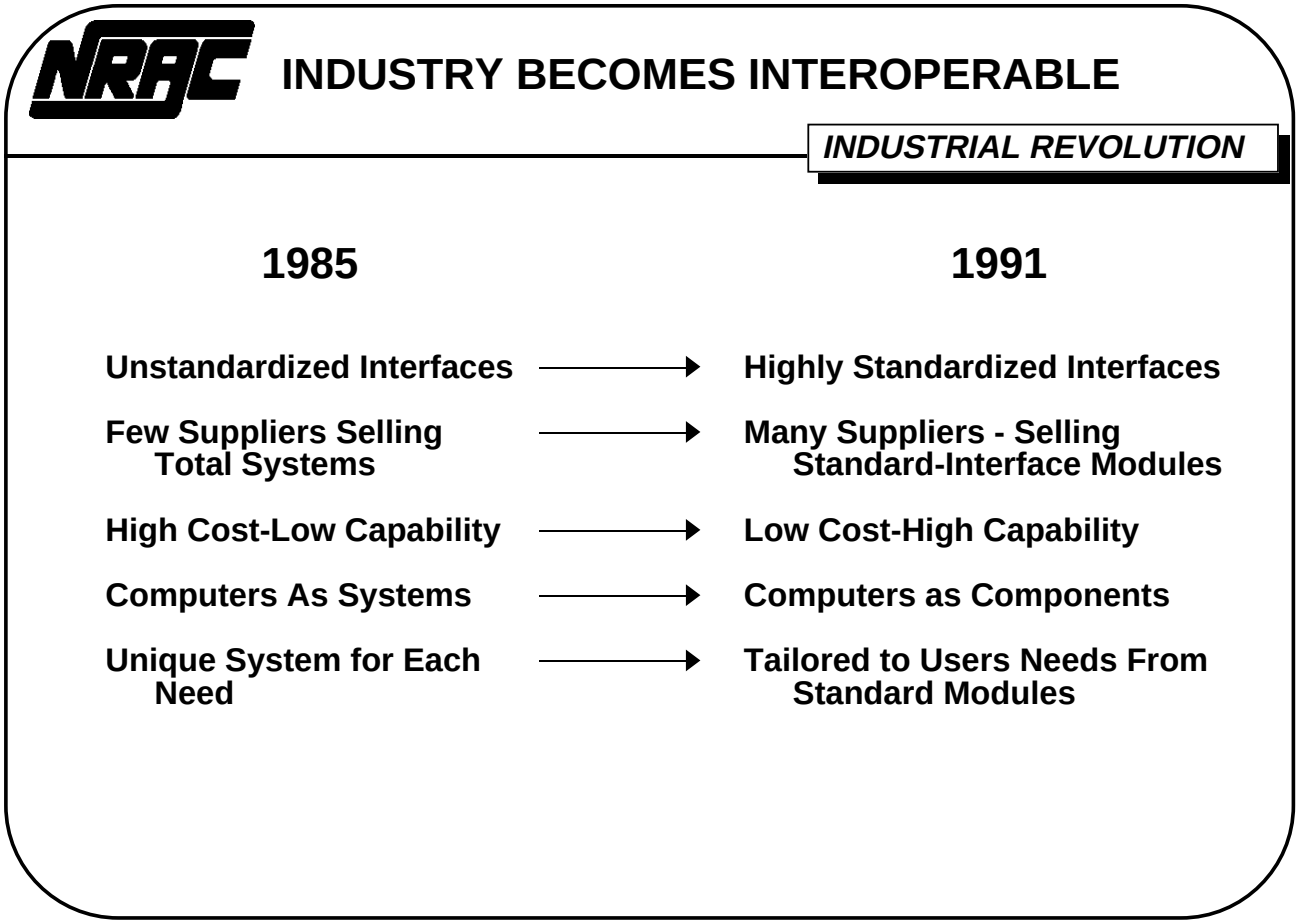
V. INDUSTRIAL REVOLUTION



Initial manifestations of computer and communications standards emerged in the early seventies, largely within Department of Defense's (DoD's) Advanced Research Projects Agency Network (ARPANET). For the first time, a communication system was being developed to enable computer users to exchange information. Some of the early Advanced Research Projects Agency (ARPA) standards focused on the electrical interface, bit oriented protocol for attaching the Automated Data Processing (ADP) equipment to communication computers. Other standards were initiated to establish a common control language for the diverse terminals that would be using the network. As traffic grew and the number of users increased, a need for a more efficient data control protocol elicited development of the Transmission Control Protocol and the Internet Protocol (TCP/IP) specification. This was eventually adopted as the DoD standard.

TCP/IP standards were important, but they relied on the original analog connection standard. In the early eighties, the International Standards Organization (ISO) began working on a totally layered set of standards known as the ISO Standards for Open Systems Interconnect (OSI). These standards focused on a larger set of issues dealing with computers and communications. The lower layers solve the communication interconnection problem. The upper layers solve the digital computer interconnect problem. The seventh (top) layer addresses the common application interface standards, thus allowing the complete flexibility of application transportability.

For the first time, OSI standards allowed different manufacturers to develop products for different layers which could be used by other manufacturers. The proliferation of products in computer and communication systems allows industry to use the building blocks from many companies. This phenomenon will not only continue, but will accelerate, resulting in an even tighter integration of communications and ADP. This is further evidenced in the Integrated Services Data Network (ISDN) standards being deployed today. These standards provide integration of digital voice, video, and data.



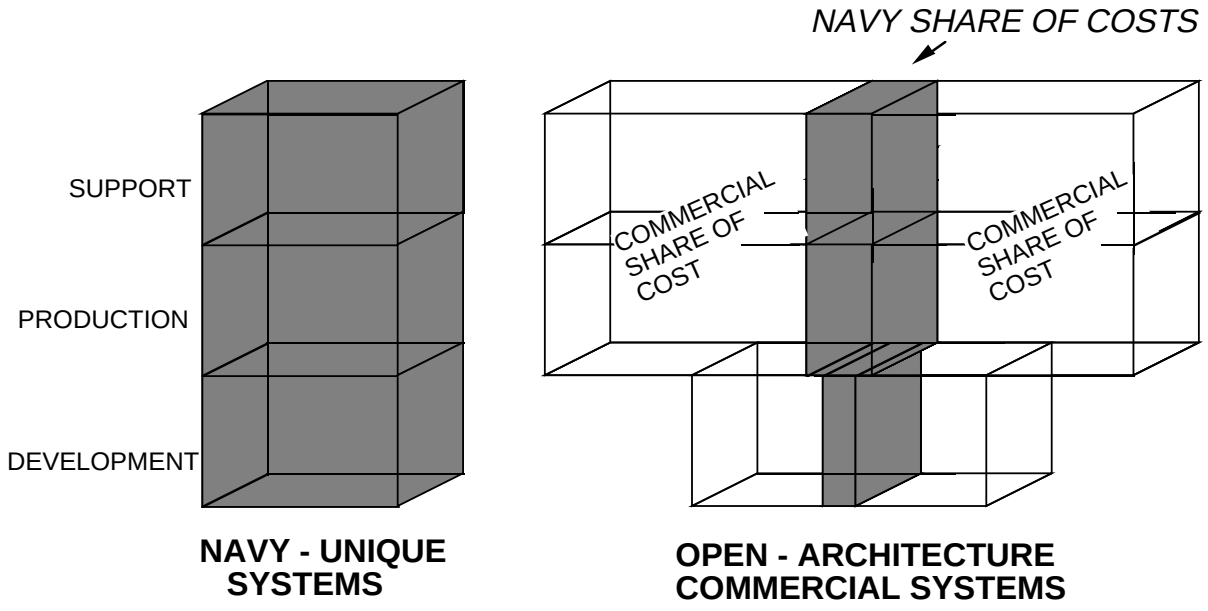
The computer is the epitome of "high tech," but until a few years ago the computer industry itself was relatively small and organized almost along "cottage industry" lines, like the auto industry before Henry Ford, or the aircraft industry before World War II. As technology allowed small, affordable PCs to be built, users began to require more application software. Vendors were driven by their customers to produce interoperable components. Eventually everyone, including vendors, began to benefit from this. Today, we are in the final stages of a true "industrial revolution" in computer hardware and software which has totally transformed the industry. Navy has no choice but to adopt these changes. By leveraging the industrial revolution, Navy can reap great benefits in increased capability and decreased cost. If Navy continues to develop unique product lines, it will likely face spiraling costs while falling further and further behind in capability.

The key to these changes and to Navy's ability to use them to advantage is OSA. The open systems approach discards yesterday's monolithic take-it-or-leave-it total systems approach. Instead, hardware and software now is sold in modular component packages with highly standardized interfaces. Integrators can use these packages to assemble systems tailored to user needs quickly and inexpensively. In today's environment it makes no sense to design and construct unique, specialized computer hardware or software.

DoD is no longer the dominant acquirer and user of computer technology. DoD can influence, but no longer dictate, the direction of technology development. However, by riding the crest of computer technology development, Navy, in particular, and DoD, in general, can significantly expedite computer system development and deployment, increasing deployed system performance, and reducing costs.

NAVY-UNIQUE VS. COMMERCIAL SYSTEMS

INDUSTRIAL REVOLUTION



Leaving behind the era of systems that are custom-made to meet Navy's unique requirements promotes a sense of losing control, but the benefits to Navy are enormous.

As long as Navy custom-tailors systems to unique specifications, it must pay the entire cost of their development, production and support. As computer systems grow in complexity, these costs increase substantially.

When Navy buys OSA commercial systems, it pays only a fraction of the development cost. The large production volume of open systems and the competitive environment in which they are sold drive unit costs down dramatically, bringing about substantial savings. Thus, Navy saves twice, in development cost and in unit cost.

Savings in time are as dramatic as savings in dollars. A system can be assembled from OSA COTS hardware and software modules in months. Compare this to the years required to design and build turnkey systems to meet unique Navy requirements. Since the COTS system will embody far newer technology, it will most likely be able to better meet Navy needs. The quality of the products is also derived from the high volume of production. In addition, the large user base continually tests and refines these products. Navy unique systems are limited in production, volume, and the extent of testing that can be conducted.

WHY COTS SOFTWARE SAVES MONEY & TIME

INDUSTRIAL REVOLUTION

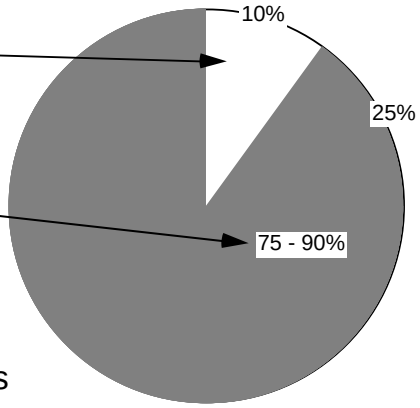
A Typical System Consists of:

Non-COTS (10 - 25%)

- Application Specific Code

COTS (75 - 90%)

- Operating System
- User Interface
- Network and/or Communication Interfaces
- Device Drivers
- Database Manager



The "industrial revolution in software" has led to a fundamental change in how software can be created. Just a few years ago, ***fabrication*** was the appropriate metaphor because most software systems were written largely from scratch. System developers invariably wrote their own user interfaces, and in extreme cases, they even had to add basic utilities to some sort of raw operating system kernel.

Today, however, the appropriate metaphor is ***assembly.*** System developers can build their systems largely by combining widely used components tested by tens of thousands of users, thus avoiding work on generic code such as that found, for example, in user interfaces.

Accordingly, system developers, i.e. Navy, can concentrate on producing more capable applications with fewer bugs at less cost because the ratio of supporting software to application specific software is almost always more than 3:1. A more typical figure for small and medium-sized problems is 9:1.

COTS COMPARED TO MILSPEC

INDUSTRIAL REVOLUTION

MIPS / $:

- About 100 X

Technology:

- 7-10 years ahead

Operator interfaces:

- Decrease training time and expense
- Increase operational performance

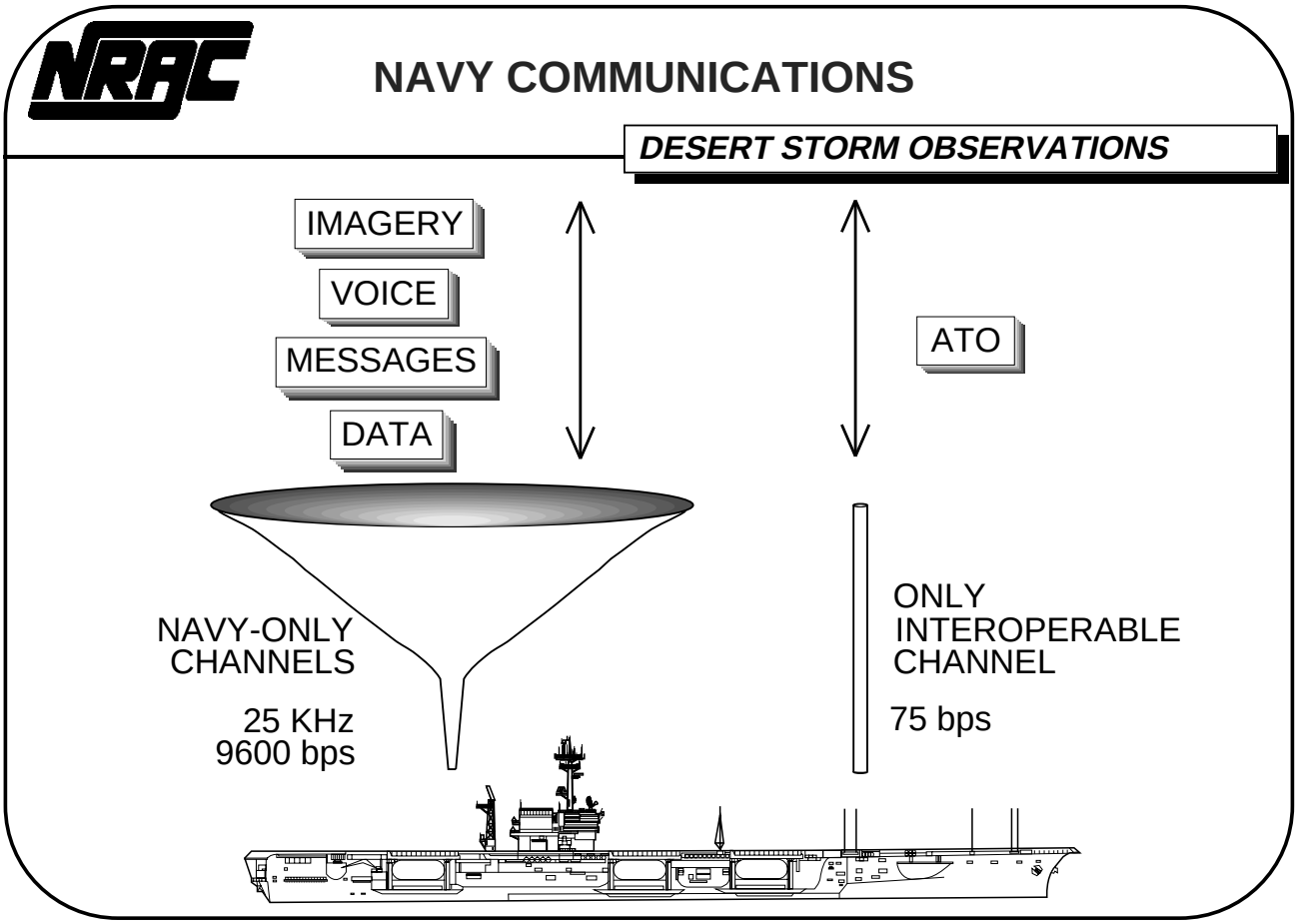
Quality:

- Varies by vendor
- Ruggedized and MILSPEC available

The technology in MILSPEC computers is approximately seven years behind the technology in current COTS computers. This means that MILSPEC computers are at least an order of magnitude slower and have an order of magnitude less memory and disk storage than current COTS computers. Moreover, given the limited market for many MILSPEC computers and their high development cost, they are at least an order of magnitude more expensive than COTS computers. Combining these two factors provides a price/performance advantage of two orders of magnitude for COTS computers.

One area that has seen rapid development and standardization over the past five years is graphical user interfaces. For example, the emergence of X-WINDOWS™ and Motif are having a major impact in the commercial arena. By adopting such graphical standards, Navy can avoid the development and maintenance costs while improving the functionality of human interfaces. Moreover, the use of such standards will promote human interoperability and efficiency across various Navy systems. This will significantly decrease training expenses while increasing flexibility and operational ability.

VI. DESERT STORM OBSERVATIONS



Navy faces another kind of resource squeeze which can also be alleviated with the use of commercial approaches. Desert Shield/Storm showed clearly that Navy long-haul, over-the-horizon (OTH) communications are grossly inadequate. Vital tactical information, such as joint service tasking orders, imagery for strike targeting, and inputs for retargeting of Tomahawk Land-Attack Missiles (TLAM), slowed to a trickle, even when bandwidth was dedicated to these purposes.

Navy is well behind the Army and Air Force in available bandwidth. The singular lack of aircraft carrier available bandwidth caused a significant reduction in air strike planning time, target intelligence, and integration of carrier forces with land based forces.

Navy has organized its communications systems to support the nearly autonomous operations of a Battle Group (BG). For example, very little bandwidth was available to support joint service operations which led to the inability to electronically receive the Air Tasking Order (ATO) from U.S. Central Command (CENTCOM).

OP-094 greatly accelerated the fielding of numerous C^3 systems in deploying BGs during Desert Shield/Storm. OP-094 has initiated a number of extensive efforts based on lessons learned from the Gulf War. Top priority is to increase Navy C^3 throughput by employing Super High Frequency (SHF) communications. During

Desert Storm, OP-094 installed SHF Satellite Communications (SATCOM) in USS BLUE RIDGE, BELKNAP, NASSAU, LASALLE, and USS TARAWA. SHF provided a major leap in speed, functionality, anti-jam and reliability. Without SHF, operations in these ships would have slowed down because of slower data flow and the taxed state of the UHF system.

SHF provided direct-dial secure voice capability to fleet commanders, vice-routing through the Communications Area Master Station (CAMS) switch. It also provided connectivity to the SHF ground mobile force terminals, thereby providing connectivity between forces ashore and forces afloat. The development of a lightweight SHF system which can be used on more ships (which implies antenna sizes on the order of 4 feet) needs to be identified as a future objective.

The performance derived from SHF installations in these ships was more recently provided to USS ABRAHAM LINCOLN to support the evacuation operations in the Philippines.

KEY FINDINGS DESERT SHIELD/STORM

DESERT STORM OBSERVATION

Navy bandwidth limited by dependence on vulnerable UHF

- Bandwidth partitioning (voice and data) limited interoperability
- Joint Service record traffic at 75 bps (CUDIXS)
- Imagery support is inadequate

Desert Shield/Storm provided insights into the critical need for communication of large volumes of information (voice, data, images) to support the needs of decision makers and warfighters. High volume transmissions are transmitted over UHF satellites which are vulnerable to jamming. Available channels are rigidly partitioned into voice and data. Demand Assigned Multiple Access (DAMA) positions data into dedicated nets such as Tactical Data Information Exchange System (TADIXS), Tactical Intelligence Information Exchange Subsystem (TACINTEL), and Fleet Imagery Support Terminal (FIST), which are not compatible with the other services. Record traffic over the Fleet Broadcast (FLT BCST), which is common to all services, is limited to 75 bits per second (bps). Transmission and management of imagery is provided by the FIST which does not provide the capability to transmit and receive high resolution images.

In summary, these examples confirm the severe limitations of Navy's communications capacity that were observed initially in UHF satellite circuits and later in circuits designed to disseminate images and data to both afloat and Marine units. These communication shortfalls need attention to support joint forces in the future battlefield where the "contest for information" will likely determine the victor. Commercial satellite systems were used to help eliminate, in part, some of these problems.

DESERT STORM
BANDWIDTH CONSTRAINTS

DESERT STORM OBSERVATION

Record Traffic (e.g., CUDIXS, FLT BCST)

	Pre - Desert Shield / Storm		During Desert Shield / Storm	
	Avg Backlog	90 %	Avg Backlog	90 %
Flash	0.6	1.0	8.6	18.0
Operation Imm.	2.9	7.0	8.7	18.0
Priority	6.7	19.0	42.0	135.0

(all units in hours)

(CNA Hot Wash-up data)

With the commencement of Operation Desert Shield, Navy units experienced significant delays in receiving record message traffic. For example, the backlog at the CAMS serving these units grew to 36,000 messages in the Western Pacific and 21,000 in the Mediterranean. This surge in record message traffic caused large delays in delivery of these messages to all USN assets and had a major impact on afloat units. This chart shows the time delay (from message date-time-group to time-of-receipt by the user) in record message traffic at different precedent levels for the period prior to Desert Shield/Storm and during Desert Shield/Storm.

Several Total Quality Management (TQM) actions were taken to significantly reduce the excessive backlogs in record traffic during Desert Shield. Message screening boards were established, worldwide "minimize" was implemented, additional Common User Data Information Exchange System (CUDIXS) suites were brought on-line, and several software modifications were made to the message processing system. At the start of Operation Desert Storm, another major increase in the volume of flash message traffic caused backlogs to grow which persisted into the first week of the air war.

DESERT STORM BANDWIDTH CONSTRAINTS (Cont. 2)

DESERT STORM OBSERVATION

TLAM mission data updates (e.g., TADIXS / OTCIXS)

- Median of 4 hrs net time
- As long as 16.5 hrs

Secondary imagery dissemination (via FIST) is only low resolution

- Transmit / receive of high resolution is not supportable

Air tasking order (e.g., CUDIXS, FLT BCST)

- On order of 5 hrs

All mission data updates for the TLAM were sent to firing platforms via Officer In Tactical Command Information Exchange Service (OTCIXS) and/or (TADIXS-A), thus limiting the use of these nets for other tactical purposes. These updates required a median of 4 hours of net time and occasionally removed the net from other tactical use for as long as 16.5 hours.

Current fleet communication bandwidth and shipboard antenna characteristics prohibit transmission of digital imagery to afloat units in acceptable volume and resolution. Currently, FIST is limited to receiving low resolution imagery (512 x 512 pixels) and does not satisfy afloat imagery exploitation requirements. Transmission of hi-resolution imagery products (37 to 150 megapixels) would require in the order of 80 hours at current 2400 baud capacity.

No electronic solution was found for disseminating the ATO to afloat units. Several alternative methods were tested but yielded only marginal improvements by the end of Desert Storm. Navy found that the best way for assured distribution of the ATO was to fly an organic fixed wing carrier-ased aircraft (S-3) to/from Riyadh, Saudi Arabia, return it to the carrier, and subsequently deliver it to other BG units via helicopter. Similar problems with the ATO were experienced by the Marine Expeditionary Forces (MEFs), but were quickly resolved due to the availability of an SHF Ground Mobile Facility (GMF) which was interfaced to the COTS Local Area Network/ Wide Area Network (LAN/WAN) Desert Storm Hub.

COMMERCIAL SATCOM IN DESERT SHIELD/STORM

DESERT STORM OBSERVATION

Commercial SATCOM used to work around data transmission deficiencies

- Interoperability with MIF (Maritime Interdiction Forces)
- Transfer of large quantities of administrative data
- Logistics support

The International Maritime Satellite (INMARSAT) System served as a vital link for coordinating the efforts of Commander, U.S. Navy Central Command (COMUSNAVCENT) on USS BLUE RIDGE and Commander, Naval Central Command Riyadh (NAVCENT RIYADH). It was also used for real time coordination of the ATO input between the Navy Joint Forces Air Component Commander (JFACC) representatives and the Arabian Gulf Battle Force Commander on board USS MIDWAY. (The Red Sea battle force commander's flagship did not have an operational INMARSAT until late in the war.) INMARSAT was often the only communications circuit common to coalition force ships. The Aviation Supply Office (ASO), Philadelphia, discovered that it was more efficient to transfer its large data files using INMARSAT rather than the military message system. One current limitation is INMARSAT cannot be used with Secure Telephone Unit (STU) IIIs in a broadcast mode to disseminate encrypted data to several ships simultaneously (nor exchange military operational data).

Defense Advanced Research Projects Agency (DARPA) completed technical testing of a demonstration lightweight communications satellite called Multiple Access Satellite (MACSAT) just as communications overloading became a problem in Desert Shield. This MACSAT, fabricated from COTS components, was called into service by the Marine Corps during Desert Shield/Storm to exchange critical logistics data with the forces in the Gulf.

Other commercial satellite systems (e.g., Skynet, PAN AM) were employed by the U.S. to link CENTCOM C^3 nodes with National Command Authorities (NCA).

AMPHIBIOUS COMMUNICATIONS

DESERT STORM OBSERVATION

UHF limited to one voice channel (allocation by CINCCENT)

HF limited by atmospheric problems

Land-based Marine communications adequate

- LAN / WANS (COTS)
- DSCS (SHF)
- VHF Local Communications

At the onset of the deployment, single channel radio was the primary means of communication both internal and external to the Marine Air Ground Task Force (MAGTF). Rapidly installed single channel HF, VHF, and UHF satellite circuits provided connectivity for the 7th Marine Expeditionary Battalion (MEB). Further, UHF single channel satellite communications was initially the only link to CENTCOM in Riyadh, Saudi Arabia. Commercial telephone was available. As the multichannel communication system developed with expanded GMF satellite and microwave networks, the single channel radio network became a secondary means of communications. Nevertheless, throughout the operations, single channel radio provided reliable service for the MAGTF at many critical times.

Because of the force separation from the MAGTF command element, the GMF satellite communication SHF network offered the most reliable means of both internal and external connectivity. Consequently, the focus of the battalion effort quickly changed from single channel radio in the initial phase to interfacing with the GMF network via a COTS LAN/WAN. This network served as the primary Marine Corps ashore command and control system. This communications network is discussed later as a COTS success story. However, despite the number of alternative communication paths available to the Marines, in the event that an opposed amphibious landing was to be conducted, only a single UHF voice channel would have been available to support the operation.

VII. SUCCESS STORIES

TRANSITION COMPARISON

SUCCESS STORIES

PRE-PARADIGM SHIFT (ACDS BLK I)	POST-PARADIGM SHIFT (NTCS-A)
• UTILIZE AVAILABLE HARDWARE	• UTILIZE LATEST GENERATION HARDWARE - NDI and COTS
• OPERATING SHELL NEEDED FOR EXECUTIVE	• COMPLETE OPERATING SYSTEM AVAILABLE
• DISPLAY SCREEN S/W TOOLS UNAVAILABLE	• SCREEN LANGUAGE & S/W TOOLS AVAILABLE
• UNIQUE S/W SUPPORT REQUIREMENTS	• STANDARD S/W SUPPORT
• MIL- LOGISTICS SUPPORT	• COMMERCIAL SUPPORT BASE
• TEN-YEAR CYCLE TO A WORKING PROTOTYPE (150 MAN YEARS)	• ONE-YEAR CYCLE TO A FIELDED SYSTEM (15 MAN YEARS)
• CV CONFIGURATION - $20M	• CV CONFIGURATION - $1.8M

During the course of this study, briefings were provided addressing numerous on-going programs. Two programs of roughly equivalent functionality are compared here. Since their initiation is separated by the paradigm shift boundary of Navy unique versus OSA, they represent what "was" and what "can be." A comparative evaluation of these two programs is instructive from several perspectives.

Firstly, using Navy unique hardware, a pre-shift norm, because it is a sunk cost and mandated, will be very expensive in today's environment. Getting the equipment to fulfill its desired functional role within currently acceptable standards will require considerable time and money.

Secondly, industry has reached the consensus that the development of proprietary (unique) operating systems as well as display screen tools for each application is a dead-end path. This consensus has been a real forcing function in moving from the old to the new order in the commercial market place. Product viability is being driven by productivity requirements.

Thirdly, the issue of the reliability and maintainability of software cannot be overlooked. Documentation of a unique operating system is, at best, difficult. Further, given a small core of users, identification and resolution of any new problem is critically dependent upon a few experts and does not occur during production,

rather errors are identified in the fielded system. When there is not a large constituency for making and keeping things right, an environment for generating large costs, lengthy fielding delays and reduced operational ability is created.

Finally, by the time a ten-year development cycle is completed, what may originally have been a state-of-the-art conceptual system has become obsolete. When one does not drive the state-of-the-art, the only prudent policy is to use the output of those who do.

COTS AND MILSPEC SIDE-BY-SIDE

Favorable reports from fleet

- Operability
- Reliability

Four major casualties

- USS Stark - 2 Exocet Missile Hits
- USS Samuel B. Roberts - Mine
- USS Princeton - 2 Mines
- USS Tripoli - Mine

NO OBSERVED DIFFERENCE IN SURVIVABILITY

Most of our ships today have both COTS and MILSPEC systems, often placed or sitting alongside each other in the same space. Fleet users universally endorse the COTS systems' operational value, ease of use, and reliability. Their only real concerns are for logistic support — concerns we believe can easily and economically be resolved. Each of the four ships which suffered major battle damage in the Arabian Gulf over the past few years had many spaces in which COTS and MILSPEC systems stood side by side. Some systems were destroyed, some survived but were put out of action, although most survived and continued to function. We could find no instances in which a COTS system failed while a MILSPEC system survived comparable damage. Nor could we find a case where *either* COTS *or* MILSPEC information systems were a limiting factor in the ship's ability to continue to fight. Damage to the platform itself was the real problem. We expect that this will continue to be true in this era of increasingly powerful weapons. We believe the "ilities" and state-of-the-art computing capabilities of COTS will increase combat systems' capabilities, thereby contributing significantly to the Fleet's ability to defeat threats before they can harm our ships. The following paragraphs detail two recent examples:

USS PRINCETON

USS PRINCETON was subject to two influence mines during Operation Desert Storm. The first mine caused damage, while the second mine was too far from the ship.

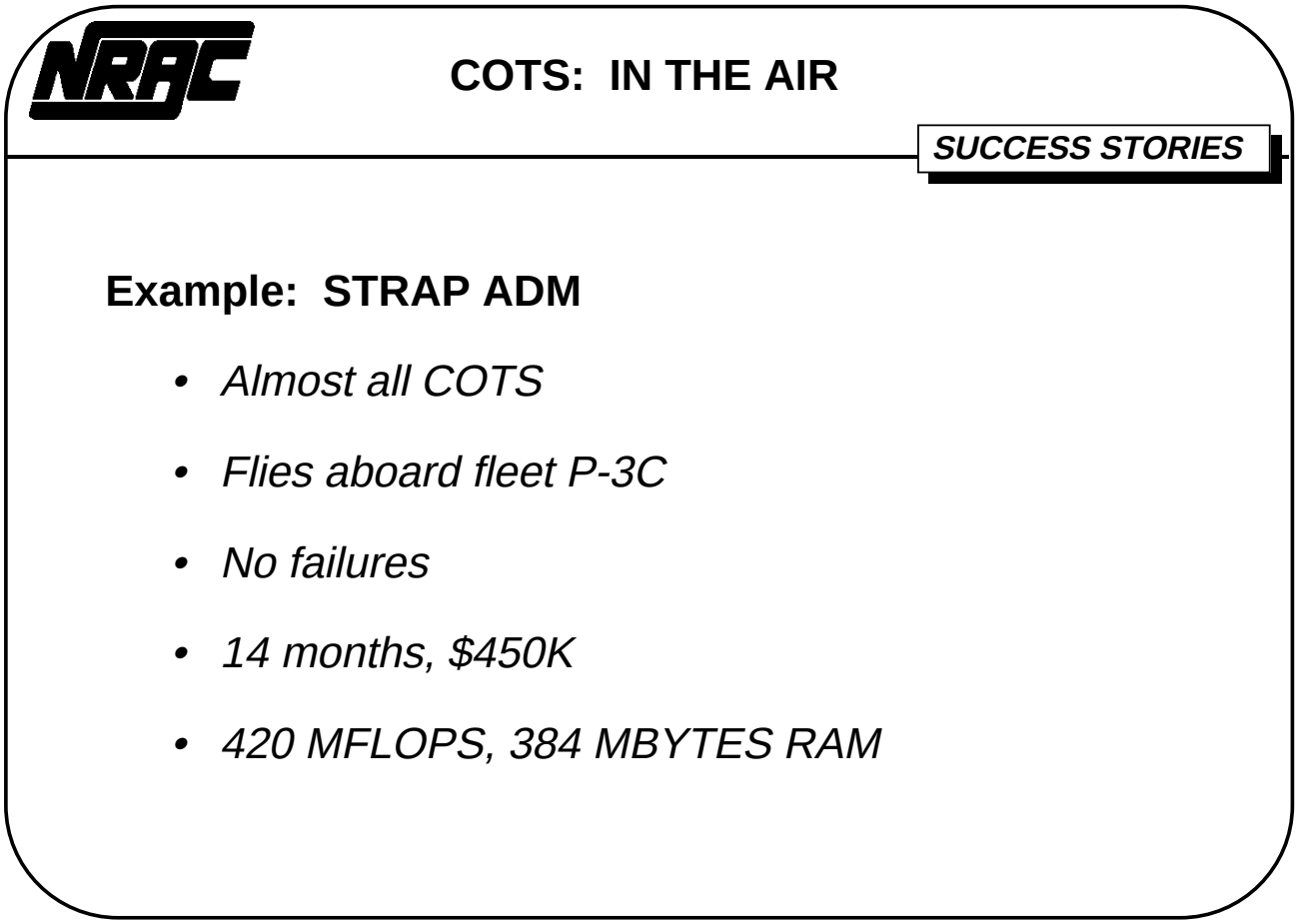
This first mine detonated directly beneath the stern resulting in localized damage due to initial shock levels above designed keel shock factors. Other structural damages occurred due to whipping factors.

Keel shock factors were rapidly dampened so that shock and vibration values were negligible upon arrival in the combat direction spaces. While 60 Hz and 400 Hz power were continuously available, isolated power interruptions did cause both MILSPEC and COTS computing systems to drop off line. These systems were manually restarted within 2-4 minutes with no damages to either COTS or MILSPEC systems.

There were no discernable survivability differences between MILSPEC and COTS computing systems.

USS STARK

The U*SS STARK* suffered damage from two Exocet missiles fired from an Iraqi F-1 Mirage in 1987. These Exocets struck in combat areas and caused extensive destruction to both MILSPEC and COTS systems. The initial shock of impact severely damaged both computing systems. The MILSPEC systems was no more survivable than the COTS system in this situation.



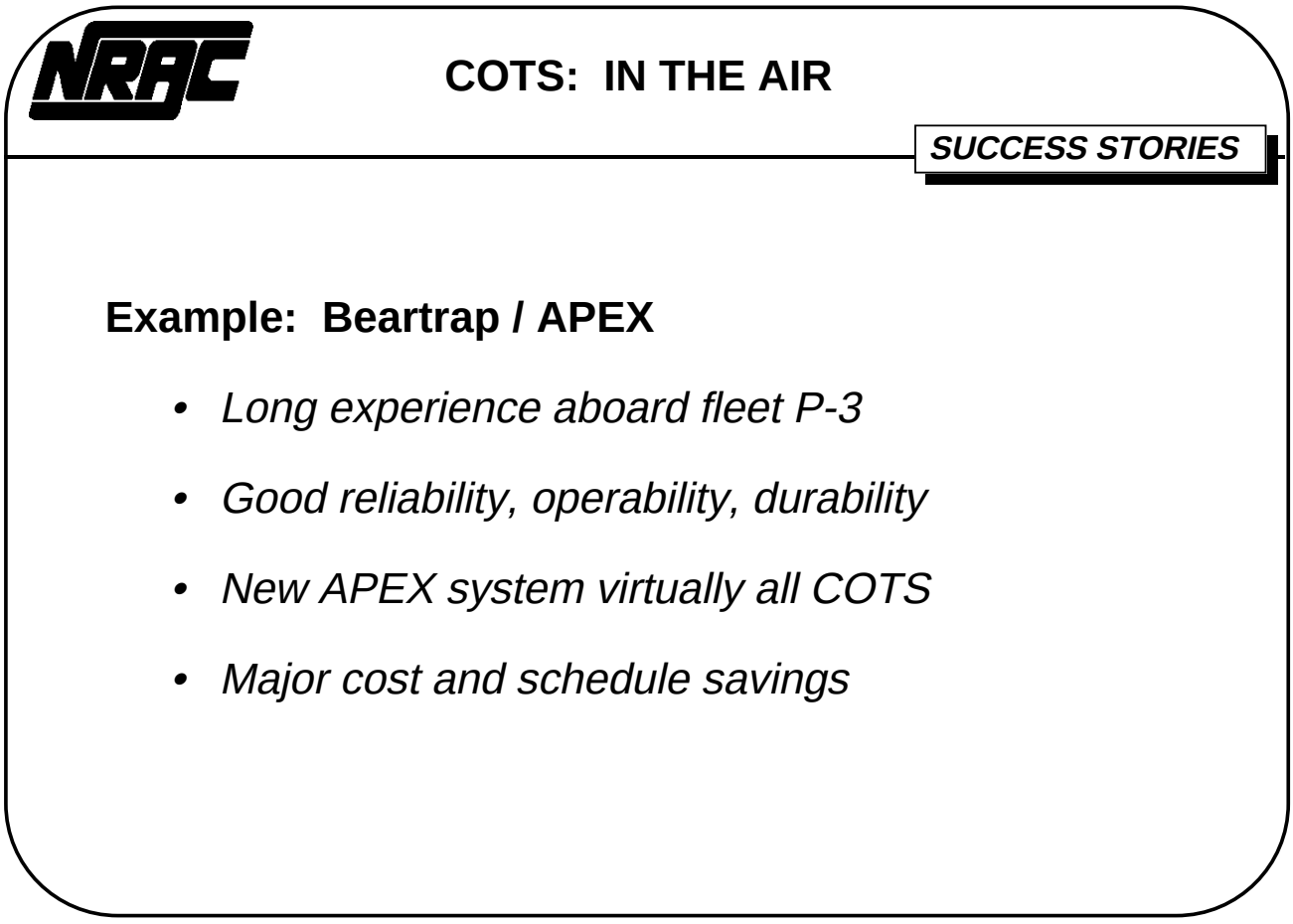
COTS has not as yet seen use in aircraft as widely as aboard ship. We would not expect or urge that COTS be seen as a broadly-applicable substitute for specialized avionics systems at this time, since many aircraft impose environmental demands which can not be met by current-technology COTS systems, even with special packaging and mounting.

Many other avionics systems, however, operate in crew compartments. It is wasteful to require these systems to survive any environmental stress that would render the crew inoperative — and in general, high-quality COTS systems can readily be made to survive the same stresses as a human. COTS has the potential to fill many of the needs for avionics to operate in conditioned compartments. With minor modifications COTS can meet specific needs of the aircraft environment. This is particularly important because many crew-compartment avionics systems are devoted heavily to operator interface, an area where the superiority of COTS is especially marked.

STRAP ADM

An example of airborne COTS is provided by the Advanced Development Model (ADM) for the Sonobuoy Thinned Random Array Program (STRAP). STRAP is an innovative and advanced Naval Ocean Systems Center (NOSC) concept for achieving

very high gain and directivity in an air-deployed passive or bistatic active acoustic surveillance system. To demonstrate this concept, the ADM had to have far more advanced acoustic processing capabilities than anything currently deployed in the Fleet, and yet be mountable in an unmodified fleet aircraft for testing. By using COTS hardware and software, NOSC was able to assemble a 420 Million Floating Points of Operations per Second (MFLOPS) system in 14 months. The equipment costs only $450,000 per set. The ADM flies aboard a Fleet P-3C aircraft and has operated without failure in this environment. The P-3 UPDATE IV is the next generation advanced acoustic processing and display system. The fielded ADM has about half of the capacity of the UPDATE IV system, currently under developjment.



BEARTRAP/APEX

Another good example of COTS application in aircraft is the wide variety of COTS equipment used by Project BEARTRAP for computing and display functions over the past several years. BEARTRAP was led to COTS to answer its need for a very flexible, highly capable processing and display environment for investigation of innovative acoustic and non-acoustic techniques for airborne Anti-Submarine Warfare (ASW). BEARTRAP COTS systems have flown for hundreds of hours in fleet P-3 aircraft, often from forward bases. The capability provided by COTS has been far in advance of that achievable with MILSPEC systems; reliability and durability have been satisfactory, and savings in time and money have been immense.

The BEARTRAP project produced many valuable lessons learned in how to successfully apply COTS in the airborne environment. This knowledge has been applied in developing BEARTRAP advanced ASW Prototype Experimentation (APEX) system, a 100% COTS system. APEX uses a variety of COTS equipment interfaced to FUTURE+ and VME buses to create a system with four to ten times as much processing throughput as the P-3 UPDATE IV at a unit cost of no more than $2.5M - less than 20% of the cost of an UPDATE IV system.

Note: This is meant only as a point of reference; APEX has a mission which is different from that of UPDATE IV and can not be substituted for UPDATE IV.

COTS: IN THE FIELD

SUCCESS STORIES

Example: Marine HMMV Mobile Communications System

- Brigade LAN / WAN port
- COTS computing

Example: MOCC

- Air-transportable Anti-Submarine Warfare Operations Center (ASWOC)
- Full COTS
- $1.5M vice $13M
- 3 in Desert Storm

COTS has seen wide use in very demanding mobile operations ashore. Two systems illustrate the range of applications.

In direct response and preparation for Desert Shield/Storm, and to provide their forward brigades with access to their terrestrial local area and wide area networks (WAN/LAN), the Marines assembled a system using COTS processing. This mobile communications system used a combination of a backbone WAN, made up of a series of 22 8 ft and 20 ft microwave antennas and other equipment. This system was carried throughout Desert Shield/Storm in Marine High Mobility Multipurpose Vehicles (HMMVs) without any significant failures. The HMMVs with standard COTS Z-248 PCs, keyboards, printers, and KG series crypto equipment would link into the WAN. Interoperability was provided because their COTS equipment use industry standards. Preventive maintenance consisted of blowing the sand out of the equipment daily with a commercial air compressor.

The COTS hardware/software system was reliable throughout the spectrum of combat and environmental stress factors. The communications suite allowed real-time processing of tasking and maneuvering orders, including the ATO, received through the mobile COTS microwave WAN.

The Mobile Operations Control Center (MOCC) provides an air-transportable capability to support forward-deployed Maritime Patrol Aircraft (MPA) squadrons.

The MOCCs depend almost entirely on COTS to perform their functions of mission planning and crew briefing, communications, acoustic analysis, intelligence analysis and mission reconstruction. MOCCs have been deployed in support of many MPA operations, including three units deployed for Desert Shield/Storm with high reliability. The cost per MOCC system is $1.5 million, compared to an estimated $13 million for an equivalent MILSPEC system.

VIII. CONCLUSIONS

CONCLUSIONS

OSA, COTS hardware, and COTS software can:

- Meet the growing need for "information"
  - *60-80% less development time*
- Capture commercial advances
  - *Technology doubling every 18-36 months*
- Adjust to smaller budgets
  - *75% less development cost*
- Facilitate system "Interoperability"
  - *Navy-Navy; Navy-Services; Navy-Industry*

There is little question that in the immediate future we will continue to see rapid expansion in the amount of information needed to conduct military operations. This expansion will be generated by the need for more precise and timely information about all phases of both strategic and tactical operations. The ability to integrate all-source information into real or synthetic video will place heavy demands on both communication and computational resources in Command and Control. At the same time, the real-time requirements for target detection, classification, assignment and weapon guidance will see corresponding growth.

It is also apparent that mission effectiveness will depend increasingly upon software. This dependence mandates the development of better software tools. These tools will enable rapid, effective, mission dependent modifications to critical software (e.g., Patriot vs. Scud). Hardware life will be extended via software upgrades.

One needs only to observe the short time between the introduction of each generation of workstations and increased capabilities of their backward and forward compatible software to understand the existing environment for change. Application software will become long lived as it migrates from one computing platform to another in the line of Open Systems.

Given the fact that there will be fewer new start programs, emphasis must be placed upon the increased use of system updates to maintain technical viability. In

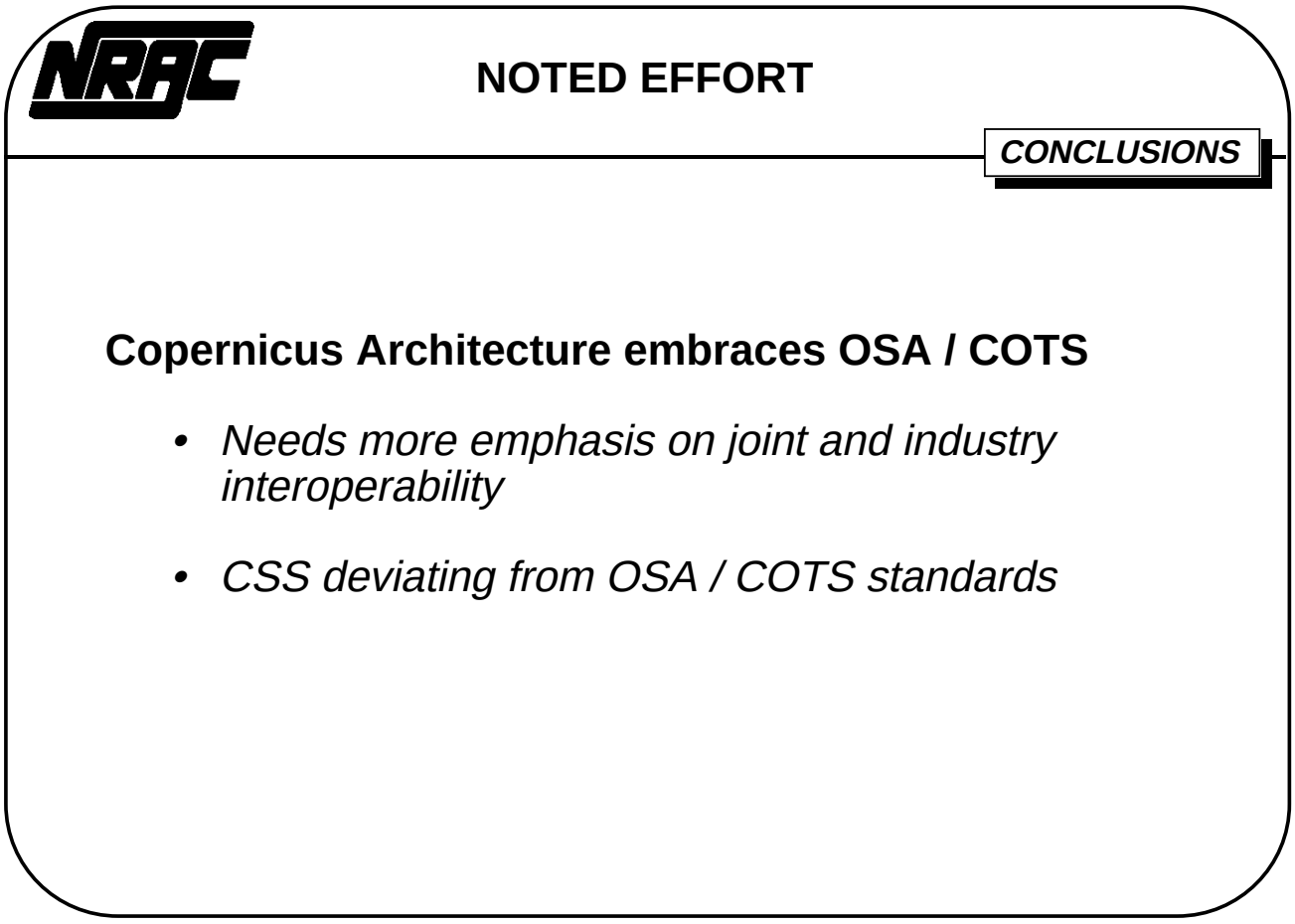
addition, by adopting compatible hardware and software standards, the flexible manufacturing capabilities of the commercial world can be readily used in times of crisis.

If there is any chance for the command, control, communications, and intelligence (C^3I) community to remain at "state-of-the-art", advantages must be taken of this rapid commercial growth. The DoD budget is declining. The facts are that the 1991 DoD budget shows a projected drop of 29.6% in real dollars through 1995. Defense spending will comprise only 18% of the Federal budget which is down from 28% in the 1980's and is comparable to the level in the late 1930's.

Hard documented evidence was not available on the possible savings realized when building COTS systems. Yet, anecdotal evidence gathered from operating, development, and sponsor organizations, as well as the collective business and technical expertise of this Panel, indicates the numbers shown here are valid and conservative. Development time is reduced 60-80% primarily because COTS: 1) eliminates time devoted to correcting and changing equipment functions; 2) the COTS supporting software eliminates the need to develop, change or modify all but the application software; and 3) COTS provides highly automated system development support environments. These same reasons allow the cost savings to be reduced by <u>at least</u> 75% because development time is directly associated with program cost.

The fact that technology is <u>doubling</u> every 18-36 months is cause to believe that these numbers are very conservative. In the early years of computer technology, technology advances were always utilized to improve system performance. With today's powerful machines, many of the technology advances are being allocated to improving system reliability and to facilitate system and software development. This condition is improving development productivity with each new generation of equipment.

In addition to the cost, performance, and reliability advantages obtained through the use of OSA and COTS, one more large advantage accrues. OSA will provide the communications and computational sub-systems access to each other through a wide variety of industry standards. Since by definition COTS equipment will also comply with these standards, the widest level of system-system and service-service interoperability can be obtained. The current DoD Common Operating Environment (COE) effort is possible precisely because each of the services are using similar commercial standards and protocols. With very little effort they are refining the definitions of which standards and protocols are acceptable as common and hence interoperable.



The Copernicus Architecture was developed by OP-094 to provide an "operator centered" system to process and distribute the enormous amount of information required by modern warfare. The Copernicus concept proposes to support Navy's Command, Control, Communications, Computers, and Intelligence (C^4I) functions by systematically integrating the afloat and ashore commanders with modern "information processing" and "information distribution" capability. These functions are ideally suited to the leveraging of commercial OSA technology. This technology, built around the concept of layered protocols such as the ISO/OSI Standards, is intended to bring commercial data processing and data transfer into an integrated set of equipments and associated software.

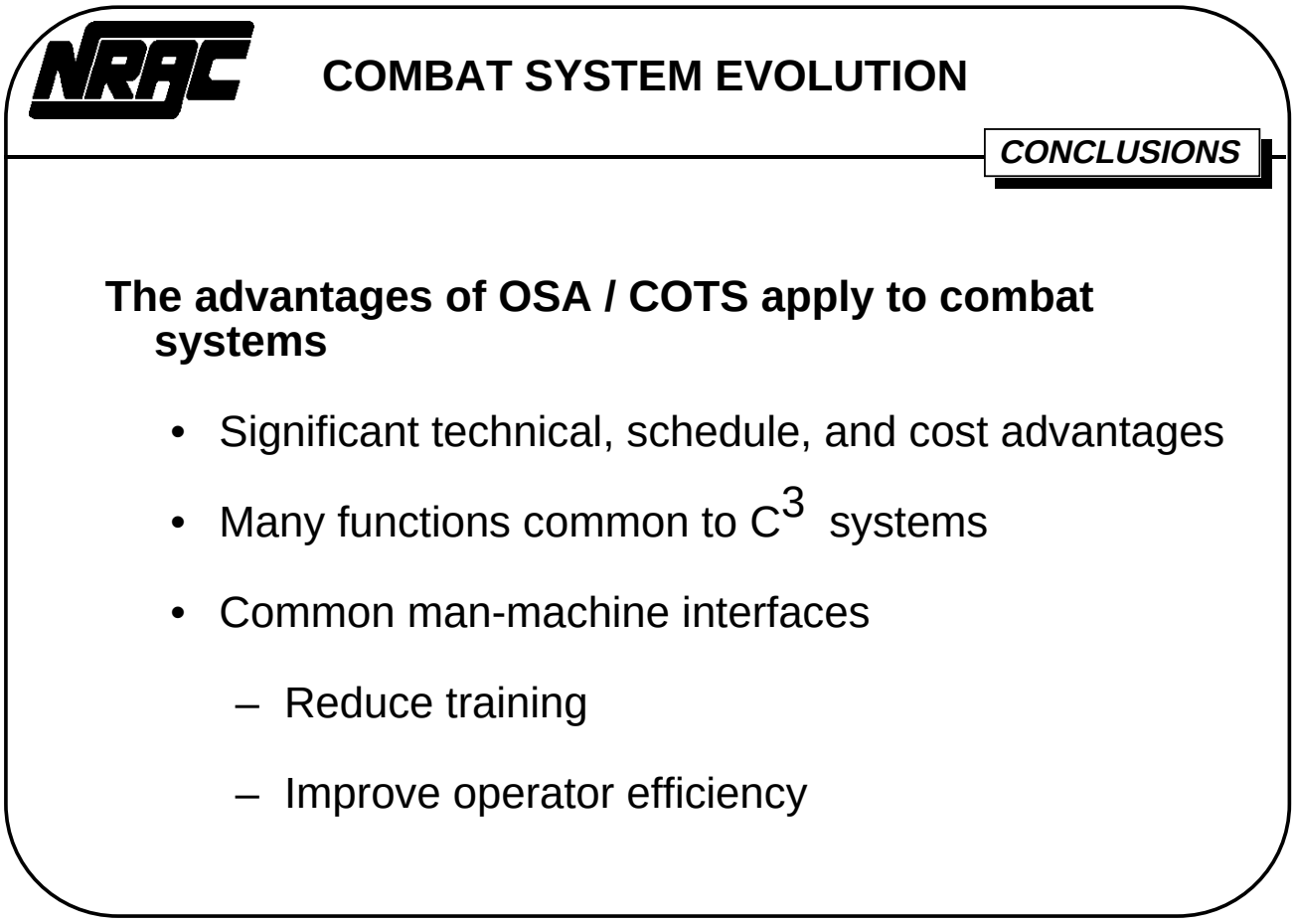
Navy can capitalize on this commercial technology by managing both information processing and information management under a more unified structure than currently exists. Initiatives such as the COE could then be coordinated across these programs, thereby encouraging the use of commercial hardware and software solutions to support an interoperable information environment. Navy's Operations Support System (OSS) and NTCS-A programs provide good starting points for this initiative. These programs are correctly moving to incorporate COTS and ruggedized COTS equipment within the open system framework.

The Communications Support System (CSS) program, while aiming to use an open system structure for processing equipment, is not taking full advantage of

commercial communications technology to augment the military communications systems. This inability to fully exploit commercial standards can be traced to Navy's low bandwidth. Low bandwidth, with commensurate low data rates, requires much greater protocol efficiency. Commercial protocols can not efficiently use the low bandwidth available to Navy. Another reason CSS is using Navy standards is because it must link Navy unique communications systems. As commercial communications systems are fielded, CSS will not be able to fully exploit their functions and interoperability unless it adopts commercial OSI standards.

Desert Shield/Storm demonstrated the value of using commercial communications systems to augment the joint military systems. In Navy's case, the available bandwidth from shore to ship and ship to ship are so limited that they create a major impediment to future information transfer growth, smarter use of existing bandwidth, not withstanding.

Commercial satellite systems such as INMARSAT, Intelligence Satellites (INTELSAT) or Direct Broadcast Satellites (DBS) should be immediately used to augment Navy communications. Even the military purchase of commercial satellites/channels to improve ocean coverage may be cost effective.



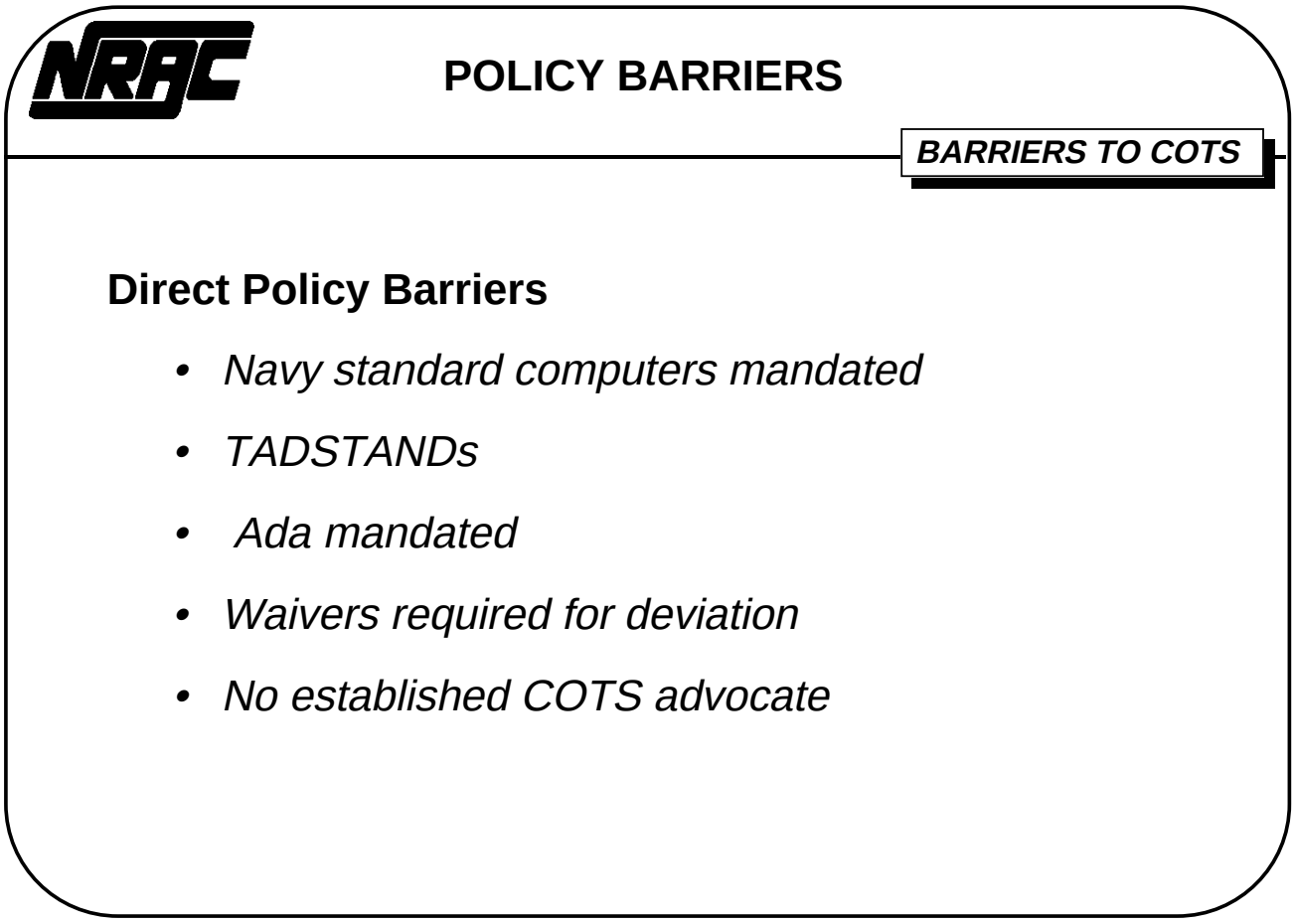
In addition to understanding Navy's use of COTS in C^3 systems, this Panel investigated current Navy practices for the development of combat systems, specifically Combat Direction Systems (CDS) such as the Advanced Combat Direction System (ACDS) currently being developed for surface combatants, amphibious ships, and aircraft carriers. The Panel acknowledges these control programs cannot avoid Navy unique interfaces and protocols used with existing weapon systems.

However, the indications and warning (I&W) and queing side of these CDSs must interface with C^3 systems now using open architectures. This promotes a natural expansion path for the combat systems. By growing new or expanding existing functionality into open system machines, Navy can capture all of the advantages of the COTS system including: improved man-machine interfaces, tremendously more powerful workstations, reduced procurement times and costs, and shared functionality with C^3 systems. As time goes on, the "open system" end of the combat systems could grow toward the weapon system interfaces and either accommodate Navy unique interfaces for the life of the weapon system or replace the interfaces in subsequent upgrades.

In the case of new combat system developments, the Panel strongly recommends that open architecture, using COTS systems, be considered. The margin of technology provided by OSA COTS can significantly improve the control of weapon

systems, reduce training requirements, and improve operator efficiency. Unlike the early days of combat system automation, today's operators are computer literate. Many of them have PCs that are more powerful than the equipment they operate in the Navy. Operators understand the level of sophistication available in modern display technology. They also understand their handicap with using older technology, better educated operators are fighting very sophisticated weapons with last decades technology. Neither retention nor survivability bode well in this lose-lose environment.

IX. BARRIERS TO COTS



Separation of the "Policy Barriers" into "Direct" and "Indirect" has been done in an attempt to define those barriers which can be attacked by "direct" action, and those barriers which will only yield to the "indirect" action of cultural change.

The use of standards has always been and will continue to be an important tool in the implementation and maintenance of discipline throughout Navy. However, it is equally true that adherence to "box level" standards beyond their useful life is a major deterrent to progressive change. The computing capability explosion, which has occurred as a result of the rapidly advancing technology in the semiconductor industry and is currently being fueled by unprecedented national commercial progress in software tool and application development, must find its way into Navy C^3 and combat systems as soon as possible.

For Navy to enjoy the capability explosion and its associated time and cost savings, the "Direct Barriers" must be clearly identified and removed, allowing in turn the required changes in the "Indirect Barriers."

The functional capability of our hardware is increasing while the size is decreasing. While attaining increased functionality, systems become grey boxes, grey boxes become modules, and modules become components. It is clear that the functional level at which standards are imposed must not remain static. These standards must reside throughout the system, down to the component.

Recommendations for the removal of the direct barriers identified here will lead to the cultural change required for obtaining and maintaining effective computing power and communication in the U.S. Navy.

Although DoD and Navy policy papers have been issued to encourage the use of COTS hardware and software, they are in addition to existing policy that requires MILSPEC hardware and software. Waivers apparently are attainable, but not without the effort required to staff, process, and track those waiver requests. With no current advocate for COTS and the conflicts of policy for COTS and MILSPECS, most program managers will follow conventional wisdom and build with MILSPEC equipment.

POLICY BARRIERS (Cont. 2)

BARRIERS TO COTS

Indirect Policy Barriers

- **Procurement cycle geared to "military life cycles"**
  - *Budgeting through logistics cycle*
  - *Second source and data rights*
- **Historical Barriers**
  - *System definition, including space, power and cooling, are required at program inception*
  - *Functional survivability was specified for existing battle environments*

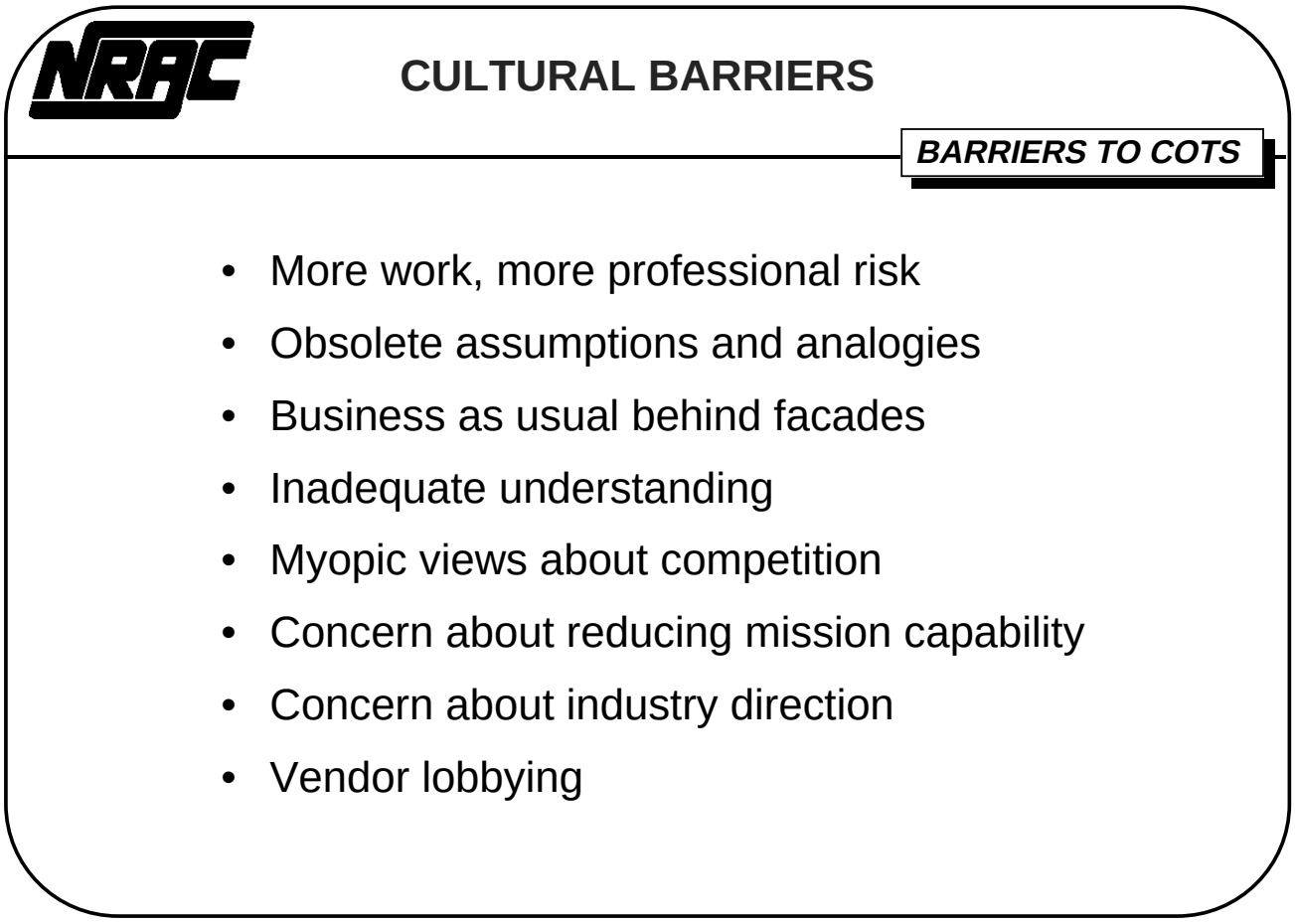
Further aggravating this condition are the indirect barriers. The current procurement process, including the entire Planning, Programming Budgeting System (PPBS) cycle, is geared to long turnkey program developments. Many of these activities, including shipbuilding, require long lead time on deliveries of computer systems or specific installation designs to accommodate the contracting process. A memorandum of agreement between OP-094 and Naval Sea Systems Command (NAVSEA) regarding the LX ship design, is a positive effort to divorce C^4 systems identification from this long lead time process.

Data rights are another long-standing barrier to COTS systems. By planning to buy and not upgrade equipments for lifetimes longer than the commercial market, the data rights issue often forces Navy systems away from commercial systems. Innovative contracting practices have merged recently in procurements like the Tactical Computer-3 (TAC-3) computer buy that mitigate data rights issues. In TAC-3, winning contractors agree to provide data rights if they stop production and support of the equipment that is still in Navy operation. In commercial industry, second tier manufactures often provide replacement parts for equipment no longer supported by the original vendor.

Perhaps the biggest barrier is the historical argument that MILSPEC is required to survive the military environment. While the Panel readily agrees that most COTS

equipment will not pass the full set of MIL 16400 environmental tests, we question the validity of these requirements in today's combat environment. When these tests were devised, ships were largely assemblies of stand alone, non-integrated combat systems subject to the shock, vibration, temperature, and humidity extremes that war represents. Early ships and aircraft were often subjected to many weapon hits before being put completely out of action.

Today's ships and aircraft are highly integrated combat systems. Each of the systems are interdependent on power, cooling, water, and information flow. When hit by modern lethal weapons, it is difficult for these platforms to continue mission operation even though they are mobile and provide full crew support. In each case investigated by the Panel, COTS equipment on ships that were damaged by weapons either survived as well as MILSPEC equipment or it didn't matter because the platform was put out of action. This would indicate that combat is not stressing equipment to the level of MILSPEC requirements. Considering the tightly coupled integration of modern platforms, it is difficult to label MILSPEC requirements as the governing system survivability factor.



All managers have too much to do, too little time, and too many difficult choices. Accordingly, buying COTS is discouraged whenever it requires a lengthy, time-consuming waiver process. In one extreme case, the lack of an easy path toward COTS was brought home to us when one briefer said explicitly he was happy that a Navy standard computer was mandated for his program because that way he "didn't have to think about what to use." Also, waivers, like other exceptions, promote a sense of increased vulnerability to criticism in the event something does not work out well. Program managers avoid risk by staying away from choices that look like lightning rods for blame.

Over and over again the Panel heard people say "It (software) costs x dollars; there is no way we are going to be able to afford to rewrite all that." This is a natural argument; one that used to be correct. At one time, the cost of the "installed base" really was a barrier to the introduction of new capabilities: However, modern software realities have changed the picture entirely, especially in light of the fact that many large Navy software systems consist largely of operating system modules, database manipulation systems, and display drivers. Today, such systems are created commercially by assembling reusable COTS components, not by writing from scratch. The fast way to increased capability is no longer to build expensively on a base of old, obsolescent code, but to build efficiently with high productivity on an inexpensive COTS base.

It is easy to sprinkle a little OSA and COTS over a development program and claim that the program is resonant with the thrust of the OSA and COTS movements. In fact, many such program are still riddled, on all levels, with Navy unique hardware and software. On the software side especially, there is a general failure to realize that the benefits of COTS are easy to lose, especially when fooling with operating system software. What appears to be a small, Navy unique change deep in a protocol hierarchy may greatly limit the use of powerful COTS software elsewhere. Moreover, within every other layer and module the small change touches will have to be maintained expensively by Navy instead of at little or no cost by COTS vendors. Ideally, Navy specific software should be limited to the application layer, and much of the software even at that level is likely to benefit from COTS. Thus, we conclude that there is a need for a mechanism that ensures the beneficial use of COTS, not just the appearance of COTS enthusiasm. Furthermore, we conclude that there is a need to educate program managers about COTS benefits, so these benefits are not lost inadvertently.

There is a general assumption that second sourcing, with all the corollary data rights and source code requirements, is the only way to achieve competition. Historically, this was true, but that was before revolutionary growth in the commercial market for computer hardware and software. Now, ordinary commercial pressures, coupled with the march of technology, has turned high performance computers into commodity items. Similarly, the development of reusable software as a base has moved software away from a develop-from-scratch process toward a module-assembly process. Accordingly, the cost of COTS hardware and software is a tiny fraction of Navy specific hardware. Computer hardware and software companies are under increasing and irresistible pressure to provide long-term support and acceptable upgrade paths for their products, protecting their customers' large hardware and software capital investments. The commercial pressures that have caused a rush toward OSA are the same pressures that ensure long product lifetimes. Religious adherence to well-intended second-sourcing practices that exclude the use of COTS hardware and software defeat the very cost-saving goals from which those practices were derived.

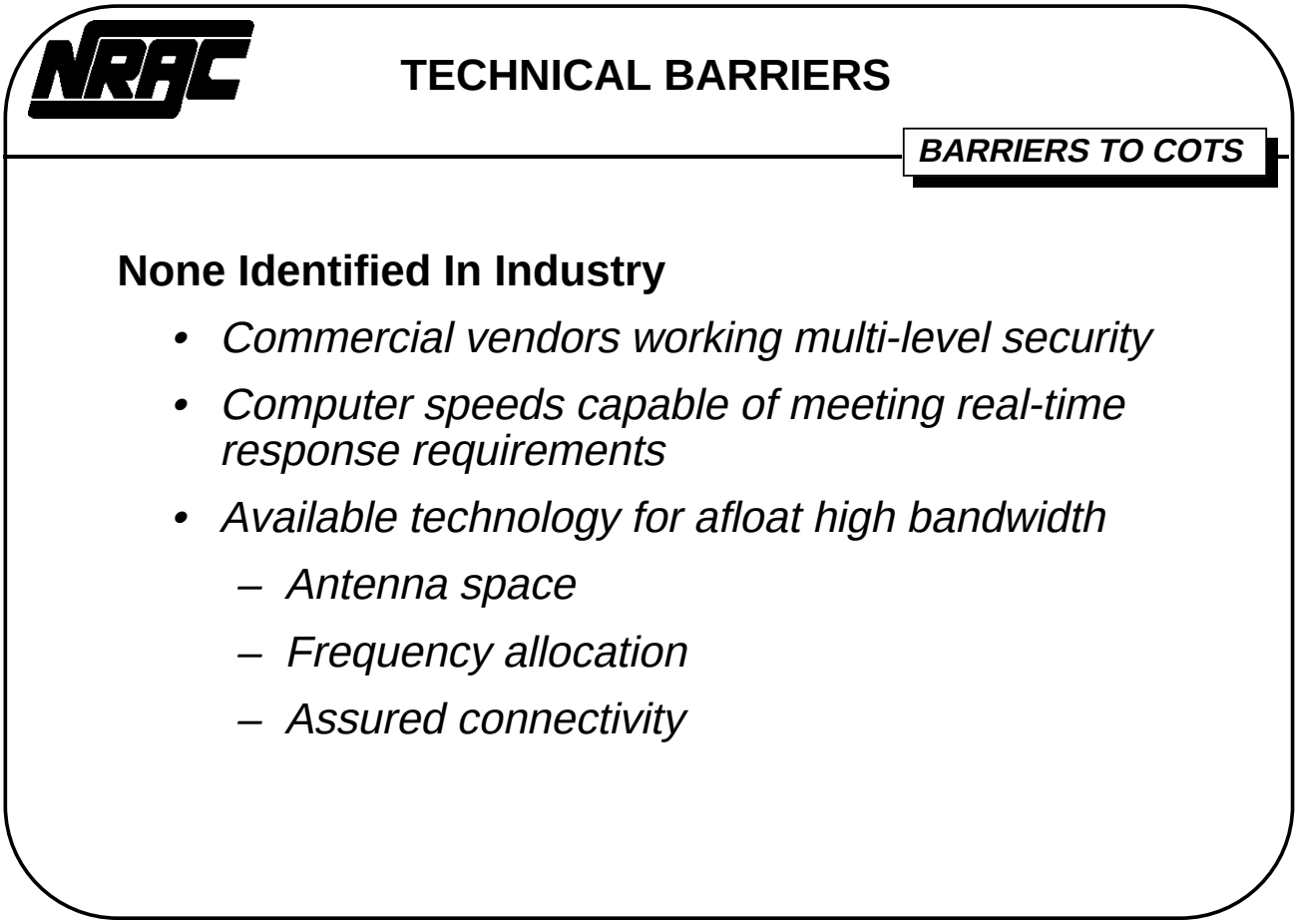
Many people are too quick to suppose that computers are failure-prone devices that are hard to keep in the logistics system for the traditional thirty years, but today, computers, relative to other electronic equipment, are not failure-prone at all. Thinking about how to keep a computer in service for thirty years is inconsistent with a world in which it is hard to find a thirty-year old computer outside of a museum, or perhaps a Navy ship.

MILSPEC standards for computers should be set such that the ability of the ship to carry out its mission and survive should not be compromised by those computers. All the evidence we saw indicates that COTS hardware, certainly that at the ruggedized and militarized end of the robustness spectrum, has not reduced any ship's ability to carry out its mission or to survive.

Some briefers expressed concern that vendors might choose to reverse their movement toward OSA. We firmly believe there is no going back. Now that customers

have OSA, they are demanding OSA, and no vendor can ignore that demand and survive. Other briefers expressed concern that movement to COTS might soon lead to a dependence on foreign suppliers. We believe this is a "red herring" for regulations can be written to guide purchase toward, or limit purchases to, equipment substantially made in the USA or its close allies.

A major barrier that is hard to control is vendor lobbying. COTS manufacturers are not likely to lobby for military sales because it represents such a small fraction of total sales. MILSPEC equipment vendors, interested in holding on to their military unique market, will continue to lobby. This may result in Congressional language that must be changed or adhered to.



The two technical issues most often raised by COTS skeptics and opponents are the *security issue* and the *real-time issue.* Both issues are important, but the Panel could not see any clear reason why MILSPEC would be inherently superior to COTS with respect to either issue. Quite to the contrary, COTS seems as good as or superior to MILSPEC in actual practice.

For applications requiring multi-level security, the Panel noted several COTS operating systems with B2 security ratings. Not only is this superior to that of MILSPEC systems operating in the Fleet today, but these systems were developed as much for the commercial market as the military.

For applications requiring millisecond response time, the tendency today, sensibly, is to push the computing out into the weapon itself. This movement is not outside the scope of our recommendations. For c*ombat direction systems,* like ACDS, or *weapons*, a fast COTS machine with COTS software offers response times that are at least as good as MILSPEC machines with MILSPEC software. The Panel learned, for example, that the response of the Joint Operational Tactical System II (JOTS II) was as good or better than the response of the MILSPEC combat direction system in the same room when provided with equal access to incoming information.

Other issues that were introduced by skeptics and opponents of COTS as "technical" barriers seemed to be mainly cultural and/or educational in nature.

Accordingly, the Panel believes there are no significant, strictly technical, barriers to COTS software or hardware.

X. RECOMMENDATIONS

INCREASE BANDWIDTH

RECOMMENDATIONS

Immediately increase Navy OTH communications (afloat, air, ground) using commercial satellites and COTS communications equipment to support:

- Record and administrative traffic
- Logistics support
- Mission planning support
- Imagery dissemination
- Tactical data

The primary limitation to effective C^3 among naval forces, evident in Desert Storm, and I&W and queing into combat systems, is the availability of bandwidth for day-to-day operations.

Preliminary investigation and interviews indicate commercial satellite capabilities are sufficient to meet most deficient bandwidth requests. The daily ATO took up to six hours of system time to transmit and print in Navy and afloat Marine commands. Secondary (only) imagery was not available at key commands except by manual distribution, often arriving later than tactically required.

The most immediate recommendation of this study is to appoint a key leader to plan and implement a commercial satellite solution to augment Navy and Marine communications afloat, in the air, and on the ground. Special attention must be given to OTH amphibious landing requirements.

Standards and protocols to allow Navy-Navy, Navy-Service and Navy-Industry to communicate via voice and data are imperative.

The Panel recommends an analysis be done to determine which commercial standards and technology should be adopted for naval communications. This should include, but not be limited to, theater-level communications required for record and

administrative tasking, logistics coordination, mission planning, support, and imagery dissemination.

In summary, a much broader use of COTS communications systems should be employed to augment current Navy communications. The requirement is here today as demonstrated in the extensive use of TLAM targeting data. Access to higher resolution images in larger quantities, requiring bandwidth on the order of 100 times greater than is currently available, will become critical to the success of future Navy operations.

INVERT WAIVER PROCESS

RECOMMENDATIONS

Require an Acquisition Executive waiver for MILSPEC computer and communication equipment:

- **Use COTS or ruggedized COTS**
  - *Cancel the current TADSTANDs and OPNAVINST 5200.28*
- **Eliminate Ada exemption requirement for COTS**
  - *Ada can be used as a binder language*

The use of OSA COTS should be encouraged for all combat and non-combat Navy computer and communication hardware and software.

All program managers should be required to use COTS in embedded or subsystem configurations unless a waiver is granted by the Acquisition Executive. Our findings indicate that on average, 75% cost reduction and 60-80% schedule improvement can be experienced through the use of COTS with no impact on mission achievement. In some cases, ruggedized COTS may be required to meet certain environmental requirements. Ruggedized COTS should be treated as COTS and should not require a waiver if all OSA standards are met.

The Ada language waiver process should be modified to allow OSA/COTS operating systems, database software, display graphics and application software to be used for any mission critical or non-mission critical system. An Ada waiver should be required only if new code must be developed and this code is not planned to be implemented in Ada.

Any requests for a waiver shall include a complete cost benefit analysis. In addition, any request based on the cost of replacing existing Navy software or hardware shall include a complete analysis of the net cost of replacing that existing software or hardware with COTS. This analysis will include a thorough examination

of the impact each MILSPEC choice will have on the use of COTS in other related systems.

Whenever a waiver request argues that COTS software is not available to replace existing software, forcing the rewriting of software, the waiver request shall include a description of the efforts made to identify suitable COTS software and the reasons why COTS alternatives are not acceptable.

EDUCATE PROGRAM MANAGERS

RECOMMENDATIONS

Educate program managers on the value of "Open Systems Architecture / COTS"

- *Install an "Open Systems Architecture / COTS" curriculum into Defense Systems Management College (DSMC)*

Because OSA/COTS technology potentially permeates a large portion of Navy structure, policy changes, unless coupled with education, will provide only marginal return. We believe that program managers, engineers, and logisticians, should be educated on the technology of OSA and the potential benefits of leveraging industry development in support of military systems. The Defense Systems Management College (DSMC), the mandated training course for all DoD program managers, provides a unique opportunity to expose emerging program managers to the value of participating with industry in the “Open System” revolution.

ESTABLISH ACCOUNTABILITY

RECOMMENDATIONS

Recognizing That ...

- Migration to COTS and OSA systems is important; and
- Policy and cultural barriers exist

The Acquisition Executive should ...

- Require semiannual reporting from Program Executive Officers (PEOs), Direct Reporting Program Managers (DRPMs), & System Commands (SYSCOMs) to include:
  - Report relative changes in the balance between COTS and MILSPEC systems

Overcoming difficult obstacles requires the attention of senior management and a mechanism for measuring progress. The Panel believes tracking the changes between the status of COTS and MILSPEC systems on a semi-annual basis will serve that purpose. This level of accountability would also aid the education problem by raising the awareness of this technology.

XI. APPENDIX A - GLOSSARY OF TERMS

ACDS - Advanced Combat Direction Systems

ADM - Advanced Development Model

ADP - Automated Data Processing

APEX - ASW Prototype Experimentation

ARPA - Advanced Research Projects Agency

ARPANET - Advanced Research Projects Agency Network

ASO - Aviation Supply Office

ASN (RD&A) - Assistant Secretary of the Navy (Research, Development, and Acquisition)

ASW - Anti-Submarine Warfare

ASWOC - Anti-Submarine Warfare Operations Center

ATO - Air Tasking Order

BG - Battle Group

BPS - Bits Per Second

C^3 - Command, Control, and Communications

C^3I - Command, Control, Communications and Intelligence

C^4I - Command, Control, Communications, Computers and Intelligence

CAMS - Naval Communications Area Master Station

CDS - Combat Direction Systems

CENTCOM - U.S. Central Command

CNA - Center for Naval Analyses

COE - Common Operating Environment

COMUSNAVCENT - Commander, U.S. Naval Central Command

COTS - (HW/SW) - Commercial Off the Shelf (Hardware/Software)

CSS - Communications Support System

CUDIXS - Common User Data Information Exchange System

CV - Fixed Wing Aircraft Carrier

DAMA - Demand Assigned Multiple Access

DARPA - Defense Advanced Research Projects Agency

DBS - Direct Broadcast Satellites

DoD - Department of Defense

DRPM - Direct Reporting Program Manager

DSCS - Defense Satellite Communications System

DSMC - Defense Systems Management College

EW - Electronic Warfare

FIST - Fleet Imagery Support Terminal

FLT BCST - Fleet Broadcast

GMF - Ground Mobile Facility

HF - High Frequency

HMMV - High Mobility Multipurpose Vehicle

Hz - Hertz

I&W - Indications and Warning

INMARSAT - International Maritime Satellite

INTELSAT - Intelligence Satellite

ISDN - Integrated Services Data Network

ISO - International Standards Organization

JFACC - Joint Forces Air Component Commander

JOTS II - Joint Operational Tactical System II

LAN - Local Area Network

MACSAT - Multiple Access Satellite

MAGTF - Marine Air Ground Task Force

MBYTES - Megabytes

MEB - Marine Expeditionary Battalion

MEF - Marine Expeditionary Force

MFLOPS - Million Floating Points of Operations per Second

MIF - Maritime Interdiction Force

MIL - Military

MILSPEC - Military Specification

MIPS - Million Instructions Per Second

MOCC - Mobile Operations Control Center

MPA - Maritime Patrol Aircraft

NAVCENT RIYADH - Naval Central Command Riyadh

NAVSEA - Naval Sea Systems Command

NCA - National Command Authority

NOSC - Naval Ocean Systems Center

NTCS-A - Navy Tactical Command System - Afloat

OP-094 - Director, Space and Electronic Warfare

OPNAVINST - OPNAV Instruction

OSA - Open Systems Architecture

OSI - Open Systems Interconnect

OSS - Operations Support System

OTCIXS - Officer in Tactical Command Information Exchange Service

OTH - Over The Horizon

PC - Personal Computer

PEO - Program Executive Officer

PPBS - Planning, Programming Budgeting System

RAM - Random Access Memory

SATCOM - Satellite Communications

SHF - Super High Frequency

SPAWAR - Space and Naval Warfare Systems Command

SQL - Standard Query Language

STRAP - Sonobuoy Thinned Random Array Program

STU- Secure Telephone Unit

S/W - Software

SYSCOM - Systems Command

TAC-3 - Tactical Computer 3

TACINTEL - Tactical Intelligence Information Exchange Subsystem

TADIXS - Tactical Data Information Exchange System

TADSTANDS - Tactical Digital Standards

TCP/IP - Transmission Control Protocol and Internet Protocol

TLAM - Tomahawk Land Attack Missile

TOR - Terms of Reference

TQM - Total Quality Management

UHF - Ultra High Frequency

USN - U.S. Navy

VHF - Very High Frequency

VME - Virtual Machine European

WAN - Wide Area Network

XII. APPENDIX B - PRESENTATIONS / BRIEFINGS

The Panel met for three, two-day sessions prior to the two week Summer Study session. Briefings received during these four sessions were from:

Government

Space and Electronic Warfare (OP-094)

- OP-094B, Deputy Director
- OP-941E6 (ADP Security Requirements), 941G (Voice/Data Networks), 941H (Strategic C^3)
- OP-942F (C^2 Systems Branch), 942F4 (NTCS-A, Common Operating Environment, Fleet Imagery Requirements), 942F8 (Copernicus Architecture)
- OP-943C (SATCOM Requirements Branch)

Navy Computers and Telecommunications Command (NCTC) (Special Assistant to CNTC for Mergers and Consolidations)

Office of the Director, Information Systems for Command, Control, Communications and Computers (ODISC^4)

Information Technology Acquisition (ITAC) (Navy Ada Implementation Team)

Defense Communications Agency (DCA)

- Defense Information System Network (DISN) Branch
- DCA Technical Advisor
- Chief, Defense Information System/WWMCCS ADP Modernization

Naval Research Laboratory

- Superintendent, Information Technology Division

Naval Ocean Systems Center

- Advanced Combat Direction System Project
- Consolidated System Support Project
- Navy Tactical Command System - Afloat Project
- Copernicus Architecture Project

Center for Naval Analyses

- Study Director Alternative Logistics Concepts for COTS
- Study Director SEW/C^3I Desert Storm Lessons Learned

1st Marine Expeditionary Force

- Director G-6

5th Marine Expeditionary Battalion

- Operations Officer

9th Communications Battalion

- Communications Officer

COMPHIBGRU 3

- Operations Officer

Space and Naval Warfare Systems Command (SPAWAR)

- SPAWAR 31 (ASW C^3I)
- SPAWAR 324 (NGCR Division Director, Head Supervisor)
- SPAWAR 3241 (Ada Program Office)

Naval Sea Systems Command (NAVSEA)

- NAVSEA 06K (MILSTD 2036 Project Director)
- NAVSEA 06KC (Combat System Engineer for LHD-1)
- NAVSEA PMS-377 (OTHACCS Program Officer)
- NAVSEA PMS-412 (Director)
- NAVSEA PMS-400 (USS Princeton Shock Assessment)

Industry

Mitre Corporation

- Directing Engineer ISDN
- Program Manager ISDN
- Technical Staff - Interoperable C^3 Reports
- Senior Vice President - Desert Storm Lessons Learned

Corporation for Open Systems

- Director Business Strategy

Digital Equipment Corporation

- Strategic Account Manager USN C^3I

Microsoft Corporation

- Senior Technical Consultant, Gov't National Account Executive

Hughes Aircraft, El Segundo, CA

- DBS Network Systems

Demonstrations / Tours

During the summer session, the Panel received three briefings and demonstrations/ tours of programs ongoing at NOSC; CSS, ACDS and NTCS-A. The Panel also visited the USS Ranger (CV-61).