Interoperability in Defense Communications

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Abstract—This paper addresses the need for interoperability between communications systems that support the U.S. Defense community (tactical and strategic), U.S. Civil Government community, and Allied National communities. A spectrum of interoperability is presented that permits system objectives to be stated in more precise terms and also provides a basis for cost versus benefit analysis. A set of preliminary secure voice interoperability objectives, in terms of the spectrum of interoperability, is also developed in this paper. The results of the Worldwide Secure Voice Architecture (WWSVA) are also briefly described. The paper includes an Appendix that briefly describes the major systems that were included for study in the WWSVA.

I. THE CHANGING MISSION FOR GLOBAL COMMUNICATIONS

For many reasons, U.S. Forces overseas have been reduced. To many observers, the obvious result of this drawdown should be reduced DoD communications needs overseas. However, the relationship between force levels and supporting communications is more complex than it appears. Changes in missions and the need to show U.S. presence in the face of an expanding Soviet influence have resulted in the need to maintain, and in some cases increase, the volume of DoD worldwide communications. In addition, other new missions are establishing demands that are beyond the capability of current communications systems.

The evolving concept of controlled response also places additional severe demands on DoD communications. In particular, communications in support of command and control functions must operate efficiently to enable direction of surviving forces for counterattack. Therefore, these global command and control communications networks must be considered as prime targets. Of course, no single communications capability is adequately robust to withstand a direct attack. Therefore, it is necessary to capitalize on the aggregate capability that is afforded by intelligently combining the assets of existing and planned systems. These systems include advanced satellite systems, commercial systems, NATO systems, and the diverse capabilities that exist within the DoD. The problem of "intelligently combining" these resources is the subject of several DoD studies recently completed or currently underway.

II. BACKGROUND

Historically, communications have either been considered as separate systems (not part of weapons systems) or as afterthoughts, thus resulting in frequent mismatches between communications systems and weapons systems. In the recent past, the consequences of allowing a confrontation to get out of hand and develop into an exchange of nuclear weapons has resulted in high level interest in controlling incidents that may seem trivial to most military commanders. This "interference" by the National Command Authorities (NCA) (the President, Secretary of Defense, and/or legal successor) has been referred to as the "President to the Fox Hole Syndrome." Fig. 1 shows the chain of command that could be expected to manage day-to-day military operations. Normally, only a small portion of the database is passed to the next higher level of command, and only exceptional decisions are made above the immediately affected command level. Fig. 2 indicates the occurrence of an incident that has required a "President to the Fox Hole" connectivity. The figure shows that several levels of command could be bypassed. This bypassing process could introduce several problems: 1) an intermediate level could be giving conflicting orders, 2) additional data and experience reside at the intermediate command levels and could be useful in any decision process, and 3) if this procedure occurs frequently, it will destroy morale. Therefore, to the highest degree possible, it is essential to include the intermediate levels of command in the conference established to respond to these incidents. The inclusion of these intermediate levels of command in the conference is shown by the horizontal dashed lines. Providing multiple connectivities of this nature, over a sustained time interval, is one of the severest demands that can be placed on an aggregate communications capability.

It should be stressed that the high level interest in an individual encounter of this type would disappear if a war actually develops; however, the capability to establish and maintain such a connectivity is and will probably remain an important aspect of controlled response and crisis management. It is particularly important that command, control, and communications (C^3) systems and procedures be adaptable to rapidly changing situations ranging from day-to-day activities through crises (as indicated above) to conventional and nuclear war—including a surprise attack on the United States. The interrelationship of force postures, levels of conflict, and the command and control function required at each level is illustrated in Fig. 3 [1]. To achieve end-to-end connectivity, from the highest level authority to site commanders, requires interconnecting many communications systems that were designed to accomplish other primary missions, as shown in Fig. 4 [2], [3]. In the past, incompatibilities between systems have resulted in serious delays in establishing the desired connectivities during specific incidents (e.g., S.S. Liberty).

Fig. 5 shows the interrelationships of the systems that could be used to support such an incident [4]. It may be necessary to provide concurrent connectivities to a Mayaguez, a joint contingency party, a fleet commander, Subic Bay, CINCACFLT, CINCPAC, the Joint Chiefs of Staff, and the
Secretary of Defense. The Defense Communications System (DCS) provides most of the long haul communications for these connections, but tactical systems and access lines are also included, and for the case of a commercial ship, it may be necessary to include civilian radio nets and State Department participation. Obviously, other sources of intelligence will also be used when available. Resolving these interoperability problems has been a primary reason for the Office of the Secretary of Defense to undertake several architectural efforts and joint programs. These communications architectures are user-oriented and examine the needed capability on an end-to-end basis across management boundaries. The results of these analyses identified interoperability problems associated with current and planned systems and established functional capabilities and standards for future systems.

The coordination problems associated with developing interoperable communications systems within the United States environment is probably more complicated than within other countries. This is due to the autonomy of the many organizations involved. The commercial telecommunications networks within the United States are not managed by a Ministry of Telecommunications that has responsibility for both military...
and civilian telecommunications, as is the case in many other nations. In the United States, there are several common carriers, many competing manufacturers, and even within the DoD there are independent communications systems. Therefore, in addition to normal technical interface problems, there are significant policy issues relating to management and control.

The architectural efforts have indicated the lack of a commonly accepted definition for interoperability which has led the Defense Communications Agency (DCA) to develop a definition of a spectrum of interoperability. This detailed definition of interoperability will allow system interoperability objectives to be stated in more specific terms. Section III discusses the seven levels of interoperability, including technical and management/control considerations, and applies the spectrum concept to a specific example.

The DoD has historically divided communications into strategic and tactical systems with some command and control communications crossing over the boundary between the two realms. However, recent usage of communications in conflicts, together with the rapid changes in supporting technology, have made it difficult to differentiate between strategic and tactical communications. The need to readily cross over from the strategic to the tactical realm to accomplish the "President to the Fox Hole" connectivities has also caused the justification for such a boundary to be questioned, particularly from a technical standpoint. The Worldwide Military Command and Control System (WWMCCS) has been established to overcome any technical interface issues that would limit critical command- and control-related communications. When the need to provide security and survivability for these essential connectivities is considered, the interface problems become even
more difficult. However, advances in state-of-the-art technology are helping to find answers to these difficult problems.

III. INTEROPERABILITY CONSIDERATIONS

The two most important factors constraining interoperability are technical interfaces and management/control philosophies. Technical interface possibilities range from: 1) it is impractical to interface user communities (i.e., HY-2 and ELCROVOX, two narrow-band secure voice digitizers which use different processing techniques); 2) it is feasible to develop an interface box to allow interoperability; 3) one or both system equipments can be redesigned to allow connection between systems without having to utilize interface boxes; and 4) if both systems use common equipment, there are no technical interface problems.

Management/control possibilities range from: 1) complete independence between systems (i.e., requires two phones for a subscriber who is a member of both communities); 2) memorandum of understanding to share resources; 3) agreement for subscribers to talk to one another with no impact on individual system; 4) agreement for subscribers to talk to one another and it is important to the mission (i.e., survivability considerations), but retain individual prerogatives; 5) willingness to accept significant impact on system from actions taken by subscribers and management/control of external systems; and 6) separate systems placed under common management/control, thus becoming the same system.

By combining these two measures, it is possible to derive a spectrum of interoperability that permits cost-versus-benefit tradeoffs. The seven levels of interoperability considered are

1) separate systems (1, 1)
2) shared resources (1, 2)
3) gateways (2, 3)
4) multiple entry points (2, 4)
5) conformable/compatible systems (3, 4)
6) completely interoperable systems (3, 5)
7) same system (4, 6).

The numbers following the levels of interoperability indicate, first, the technical interface possibility, and second, the management/control possibility. The levels increase in interoperability as the number of the option increases. Level 1 has no interoperability between systems unless a man exchanges information in both systems. The only benefit of "shared resources" is the "economy of scale" that is gained when communications are traversing the same network or same transmission facilities. An example of shared resources would be when NATO utilizes bandwidth on the DSCS satellite as part of its own network, but does not talk to other DSCS users. Of course, there is a certain degree of "hardware" interoperability required for the transmitted signals to be at the correct frequencies and proper power levels.

A true, but low level of "communications" interoperability would be achieved when a few, perhaps expensive, gateways are employed. With these gateways, it is possible to cross over from one system to another and permit the subscribers in one system to access subscribers in the other system. But in this case, there are a very limited number of places where this transition occurs, usually at major nodes.

As the number of gateways increases, the level of interoperability moves up the scale to multiple entry points. Twelve to 20 gateways would be required to reach the level of interoperability classified as multiple entry points. The number of gateways is increased primarily to enhance survivability.

Conformable/compatible systems are still a higher level of interoperability. This level does not demand that the systems be identical, but it does mean provisions have been made for one system, at least, to accept the characteristics of the other
systems so that it will be easy to transition from one system to the other at the information transfer interfaces.

A still higher level of systems interoperability would be defined as completely interoperable systems. Different hardware designs/fabrications are possible, but they require the system control elements to talk to each other; they also require an identical set of signaling formats and preemption protocols. In this case, it is possible to cross from one system to another at any point in either system; all that is necessary is to make a connection. With this level of interoperability, it could be possible for one system to cause the other system to crash or to be overloaded. This consideration is important to the decision to make systems completely interoperable.

The highest level of interoperability, of course, would be the integration of separate systems into one system. In this case, all resources are under the same management/control. This could also allow the easy interchange of equipment and the utilization of common supply systems and training facilities.

The level of interoperability may not be the same for each of the services (i.e., voice, data) that a system provides its subscribers. Therefore, it is necessary to treat each service separately, resulting in the matrix presentation shown in Fig. 6. If it were possible to evaluate each service of System A on how well it interoperates with the comparable service in the DCS, its overall interoperability could be summarized by Fig. 7. An example of how the matrix might be used in the architectural efforts is shown in Fig. 8. The goal capability could be hypothesized as shown and the cost-versus-benefit tradeoff performed to determine the desirability of achieving the goal.

Systems have been connected in the past, and many of the different levels of interoperability shown in Fig. 8 have been obtained. Particularly with analog systems, it has been quite feasible to accomplish this. As we move into the digital world, it is important to be able to continue to achieve system interoperability at varying levels. Flexibility becomes an important issue in establishing the level of interoperability between two digital systems. A middle level of interoperability (i.e., multiple entry points) can be implemented by either expanding the number of gateways or by managerially placing constraints on systems that have the inherent capability to achieve high levels of interoperability. Obviously, the second approach is more flexible if a crisis or policy change should dictate the need for an increased level of interoperability.

**IV. ESTABLISHING INTEROPERABILITY GOALS/SECURE VOICE COMMUNICATIONS**

It should now be apparent that there is a well-stated need for telecommunications interoperability between certain communities of interest. However, the lack of a measure of interoperability by which to state goals for specific systems, and the lack of persistent pressures by a higher level system manager during the design of subsystems, has resulted in inadequate levels of interoperability. When proper consideration is given to interoperability during the early phases of design, interoperable modes can be established at little additional cost, even when the implications of security and survivability are factored in. Therefore, it is important to establish interoperability objectives in measurable terms and assure compliance through the operational and developmental phases of a system.

The operational phase is important since it is the period when operational procedures and software are adapted to comply with the mission as perceived by the operating manager. Unless configuration control is maintained and frequent testing is performed (joint exercises), even the TRI-TAC equipment could become noninteroperable as it is assimilated into the different organizations. Stress should be placed on establishing the minimum number of interoperable modes that satisfy interoperability objectives. This permits the highest
possible level of autonomy for the subsystems and prevents burdening individual equipment with unnecessary complexity.

Nowhere has a lack of interoperability been a greater problem to the Defense Department than in the secure voice area. The difficulty of the technical problems when confronted by the several communications communities each with its own peculiar constraints has led to rather different systems being fielded, resulting in severe interoperability problems. A major contribution to these problems is the fact that secure voice quality degradation often occurs when systems using disparate voice processing algorithms are interfaced. The Worldwide Secure Voice Architecture (WWSVA) [5] is the name given to an effort to develop an approach to DoD's secure voice systems to improve this situation by establishing coordinated evolutionary approaches to all of the communities. The WWSVA presents a first iteration set of objectives, described in terms of the spectrum of interoperability, for the communities of interest shown in Fig. 9. The connectivities between the systems designed to support these communities of interest were determined to be as shown in Fig. 10. The Appendix presents a short description of the major system elements supporting these communities of interest; many of these systems are discussed in greater detail in other papers in this issue. Fig. 11 shows how different the constraints are that are levied on the design of the individual systems that make up the WWSVA. These differences make it impossible to develop an optimum design that would be acceptable to all users; therefore, it is desirable to establish interoperable modes that impose the least impact on individual designs. (Fortunately, the advent of low cost microprocessors will make it much easier to arrive at acceptable solutions. By placing this additional microprocessor-derived intelligence in the terminals and in switches near the subscribers, it should be possible to develop an architecture that satisfies most of the constraints in Fig. 11.) In order to establish the WWSVA interoperability objectives, the following questions pertaining to interoperability were examined in detail in [5].

1) What is the size of the community and extent of interaction with DCS subscribers?
2) What is the geographic location of subscribers?
3) What is traffic in and among the communities of interest?
4) What is the mobility of subscribers in support of the mission and their normal deployment?
5) Is there a need for special requirements like preemption and rapid speed of service?
6) What is the existing capability?
7) Are there existing or planned programs that could preclude interoperability improvements?
8) Would it be desirable to restore service over another system to improve survivability?
9) Are there significant cost advantages to be gained by extending through another system or using another system to off-load peak traffic?
10) Does one of the other systems expect to rely on DCS links for internal command and control?
11) Is there an economic or operational advantage in providing common logistics?
12) Are there established management constraints that restrict the level of interoperability?

The resulting levels of interoperability for peacetime [day-to-day operations and crisis or support of conflict (when it is outside the immediate geographic region)] are shown in Fig. 12. The resulting levels of interoperability for conflict [tactical conventional war, theater nuclear war, and strategic nuclear war (when they occur within the immediate geographic region)] are shown in Fig. 13.

Peacetime interoperability is shown pictorially in Fig. 14. Gateways are sufficient for access into the DCS by both the CIVIL and NATO communities. Multiple entry point level of DCS interoperability is sufficient for garrisoned tactical wide-band subscribers since high level commanders, who need pre-emption capability, are also DCS Secure Voice component (SEVOCOM) subscribers. On the other hand, tactical narrow-band subscribers (i.e., Fleet Commanders) only have access to their tactical terminal and the ability to obtain preemption through the DCS is necessary. Therefore, the tactical narrow-band subscriber requires a DCS interoperability level of completely interoperable.

The levels of interoperability required to respond to conflict, as shown in Fig. 15, are significantly different from those for peacetime. For survivability reasons, it would be advantageous to increase the level of DCS interoperability for the CIVIL and NATO communities to conformable systems. The ability to reconstitute the DCS with tactical equipment, and the complete interdependence of communications networks in a theater of operations, would drive the DCS and TRI-TAC toward the highest degree of interoperability, i.e., same systems. The role of supporting communications for tactical narrow-band subscribers has not changed above that of peacetime, except to require more of the same.

The WWSVA effort examined the feasibility of achieving the desired levels of interoperability described in the previous paragraphs. One of the recurring problems is the inability to assure the use of common equipment by all secure voice subscribers. This is due to management prerogatives and different time scales for implementation. Therefore, the use of disparate equipment is accepted as a fact of life, particularly in the near to midterm, and barring extraordinary technology advances,
Communications that utilize constrained channels such as high frequency (HF) propagation.

** Communications that are not physically constrained by the transmission channel.

Fig. 10. Interoperability of WWSVA communities.

<table>
<thead>
<tr>
<th>COMMUNITY</th>
<th>DATA RATE CONSTRAINTS</th>
<th>PHYSICAL CONSTRAINTS</th>
<th>QUALITY</th>
<th>DOMINANT CONSTRAINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tactical Narrowband</td>
<td>≤ 2.4 Kb/s</td>
<td>Moderate size, weight, power</td>
<td>Good intelligibility</td>
<td>Data rate</td>
</tr>
<tr>
<td>Tactical Wideband</td>
<td>Can be as high as tens of Kb/s</td>
<td>Small size, low power, low cost</td>
<td>Good intelligibility</td>
<td>Size, weight, power</td>
</tr>
<tr>
<td>Civil</td>
<td>Limited by VF channels of civil networks</td>
<td>Office environment, convenience of use</td>
<td>Good intelligibility and quality</td>
<td>Use with civil networks</td>
</tr>
<tr>
<td>DCS</td>
<td>Limited by VF channels of civil and military networks</td>
<td>Office environment, moderate cost, convenience of use</td>
<td>Good quality and high intelligibility</td>
<td>Interoperability with above communities</td>
</tr>
<tr>
<td>NATO (NICS)</td>
<td>Similar to DCS</td>
<td>Similar to DCS</td>
<td>Similar to DCS</td>
<td>Similar to DCS</td>
</tr>
</tbody>
</table>

Fig. 11. Design constraints.

DCS = Gateways
DCS = Gateways
DCS = Multiple Entry Points
DCS = Multiple Entry Points to Completely Interoperable

Fig. 12. Peacetime interoperability objectives.

DCS = Conformable System
DCS = Conformable System
DCS = Same System Overseas Completely Interoperable CONUS
DCS = Completely Interoperable

Fig. 13. Conflict interoperability objectives.

even the future architecture must provide a mode of operation that will accommodate various secure voice terminals.

Currently, several communities use a variety of terminals at several data rates. The DCS with the greatest interoperability burden uses a combination of high quality PCM terminals and low quality channel vocoders, the former serving as the vehicle for interoperability, through tandem connections. However, the cost of the 50 kbit/s circuits limits their number. Also, the limited number of potential transmission paths for the wide-band service impacts survivability. Poor response time can normally be expected, except for nearly instantaneous service provided to a few selected subscribers. The difficulty in using the system also reduces the users' acceptance of the service. In order to fill the urgent need for expanded service, many new secure voice terminals using disparate algorithms are in the process of being fielded by the user. This proliferation of terminal types will cause serious interoperability problems.

The midterm (around 1985) secure voice capability will
and is expected to be the primary mode of operation. The narrow-band tactical users. The essential purpose of the WWSVA analysis determined that it was impractical and unnecessary to expect the goal architecture to achieve a level of interoperation of “same system” that would be managed by a single manager. However, by capitalizing on new technology and moving the intelligence in the system closer to the user, with a modular switching capability it will be possible to achieve many of the advantages of a “same system” architecture. This is accomplished by careful planning and coordination to make proper use of the distributed system capability to reduce response times and costs, and to also improve the ability to restore service over other networks. Survivability is enhanced by providing the capability to obtain interfaces with other networks at or near the subscriber; this capability presents the greatest number of possibilities for diverse routing.

V. CONCLUSIONS

1) There is a well-established need for telecommunications interoperability between certain communities of interest; however, the current levels of interoperability are not adequate, and the situation could get worse unless exceptional management is initiated.

2) The requirements and interoperability considerations between the different communities are so drastically different, particularly during peacetime, that it is unrealistic to expect the communities to accept the same systems.

3) To provide manageable entities and reasonable realms of
responsibility, again particularly in peacetime, it is desirable to provide the highest possible degree of autonomy for the individual systems.

4) Since the individual system designers will be designing their systems to different criteria, only one of which is interoperability, it is important to reduce the number of interoperable modes to a minimum.

5) Interoperability goals should be established early and expressed in measurable objectives and terms that are understood.

6) Provision must be established to assure that the objectives are achieved in the design phase and maintained throughout the operational life of the system.

APPENDIX

SYSTEM DESCRIPTIONS

Strategic Systems

Supporting the National Command Authorities (NCA) in control of the Armed Forces is the National Command System (NMCS). The NMCS consists of the National Military Command Center (NMCC), the Alternate National Military Command Center (ANMCC), and the National Emergency Airborne Command Post (NEACP), with their interconnecting telecommunications and ADP support. These facilities receive, evaluate, and display intelligence, warning, and force status information, and direct and control the forces in carrying out national decisions.

Worldwide Military Command and Control System: The President needs a responsive, reliable, flexible, and survivable command and control system to serve the NCA in all types of military operations. This is provided by the Worldwide Military Command and Control System (WWMCCS), which incorporates a number of unique and independent command, control, and communications (C3) systems to assure better connectivity with the strategic forces.

Minimum Essential Emergency Communications Network (MEECN): MEECN spans the entire radio frequency spectrum from ELF through SHF to provide the connectivity, redundancy, and flexibility needed for the command and control of the strategic submarine, bomber, and ballistic missile forces.

Defense Communications System (DCS): The DCS is a general-purpose system composed of Government-owned and leased transmission media, relay stations, and switching centers. The system embraces all of the long haul point-to-point DCS assets of the Army, Air Force, Navy, and Marine Corps. Service to customers is provided primarily through common user switched networks. These networks include AUTOVON, AUTODIN, and AUTOSEVOCOM. Each of these networks is characterized by a degree of automatic switching, a military precedence system, worldwide trunking, and service to a large community of Defense and other U.S. Government users. However, the DCS also provides special communications services for certain classes of high priority customers requiring immediate responsive command and control communications. The DCS specifically does not include air-to-air, ship-to-ship, air/ground, or ship-shore communications, nor those broadly defined as tactical, except in support of the NCA or unified or specified commanders.

Tactical Systems

Tactical C3 systems must operate in an integrated fashion with sensor and intelligence systems to provide timely warning, responsive control of forces, and assessment of operations. Those functions are essential to creating a highly integrated, mobile, and capable fighting force. Our individual weapons systems and those of our Allies will be insufficient to engage the larger number of similar Soviet systems effectively unless they operate as a cohesive combined arms team [1].

Joint Tactical Communications Program (TRI-TAC): TRI-TAC will provide common multichannel communications equipment for all the Services. The equipment will be mobile, secure, survivable, and capable of rapid dissemination of messages and voice communications using automatic switching. Interoperability throughout the theater will be ensured by the use of TRI-TAC common equipment, which will also provide interfaces between single channel tactical users and other theater systems, as well as between United States and Allied systems. The individual TRI-TAC development programs are divided among the Services and are well underway with some operational testing in progress [1].

Combat Net Radio: Close to the Forward Edge of the Battle Area (FEBA), command and control are exercised primarily through the use of combat net radios. The Army is the leading service in developing a family of jam-resistant, manpack, vehicular, and airborne FM radios in the VHF frequency range for all the Services. The program, called the Single Channel Ground and Airborne Radio Subsystem (SINCGARS-V), is in development [1].

Army:

The Tactical Communications System: The backbone of the Tactical Communications System is the Corps and Divisional multichannel networks. The Tactical Communications System is formed from the Command and Area Networks which use pulse code modulation, time division multiplexing, and link encryption to encrypt the multiplexed signal. For transmission of the multiplexed signal, either cable, line of sight radio relay, or tropospheric scatter equipment is used. The Command Multichannel System is a point-to-point network connecting the Corps and Divisional Headquarters to the Maneuver, Fire Support, and Combat Support Units. The Corps Area Multichannel System is a network interconnecting the Corps Area Signal Centers (nodes). The Corps Area Multichannel System interconnects each Corps Area Signal Center (node) with at least two other centers (nodes). The locations of Area Signal Centers are selected to permit service to units within geographical areas. The Command Signal Centers are located to serve the Corps Headquarters echelons. The Area Signal Centers contain the radio and multiplex equipment which interworks with the multichannel systems, voice switching and terminal equipment, teletypewriter terminal equipment, facsimile equipment, tape relay facilities, messenger elements, and communications control elements. The future Army system is the Integrated Tactical Communication-
lower combat units, VHF-FM single channel radios are pre-
the communications function of end-to-end information and 
includes all end terminal processing equipments necessary for
mission systems and the National Communications System
ating environments has created the need for a broad range of
systems and equipment to provide the required C3 capability.
is being developed. It will permit jam-resistant fleet broad-
ically exempted, all such systems afloat, ashore, and airborne
moderate the expanded communications requirements necessi-
tated by more capable weapons systems and will improve the
NCA's capability to exercise command and control of
U.S. forces throughout all levels of conflict [1].

Navy:

Naval Telecommunications System (NTS): The NTS is a
complex of terminal, transmission, switching, cryptographic,
and control devices that collectively provide the electrical and
optical communications capability for the exercise of com-
mand and control over the naval operating forces, for the
transmission of operational information to and between units
of such forces, and for the administration of forces, shore
establishments, and other components of the Navy.

Organizationally, the NTS provides electrical and optical
communications from the Commander in Chief and naval
commanders to and down through all naval forces under their
command.

Conceptually, the NTS includes portions of the DCS trans-
mision systems and the National Communications System
(NCS) and the DCS switched networks, as well as fleet support
nets (broadcast, ship–shore, air–ground) and direct interunit
fleet nets. Most of the shore establishment is served by the
DCS, not by the NTS.

For definition and system engineering purposes, the NTS
includes all end terminal processing equipments necessary for
the communications function of end-to-end information and
data transfer. This includes all media for the transmission,
emission, and reception of signs, writing, images, and sounds
or information of any nature by wire, radio, visual, electro-
magnetic, electrooptical, or acoustical systems. Unless specif-
cally exempted, all such systems afloat, ashore, and airborne
are considered to be a part of the NTS.

Naval forces must operate in all tactical environments: air,
sea, subsurface, amphibious, and shore. This diversity of oper-
ating environments has created the need for a broad range of
systems and equipment to provide the required C³ capability.
The Fleet Satellite Communications system (FLTSATCOM)
is being developed. It will permit jam-resistant fleet broad-
cast and two-way communications between naval aircraft,
ships, submarines, and land-based facilities, and as such will
be the backbone of the NTS. These NTS systems will accom-
modate the expanded communications requirements necessi-
tated by more capable weapons systems and will improve the
NCA's capability to exercise command and control of
U.S. forces throughout all levels of conflict [1].

Marines: From 1979 to 1980, the Marine Corps Communi-
cations System will remain primarily an analog system. At
lower combat units, VHF–FM single channel radios are pre-
dominant. Improved devices for data processing are being in-
roduced for record, narrative, and graphic traffic. Substantial
COMSEC equipment is also being introduced for voice traffic
during this time frame. Communications Centrals function as
the transmission and reception point for teletypewriter opera-
tions and provide for torn tape relay between senior com-
mands and subordinates. The introduction of some automatic
telephone switching provides improved service to telephone
subscribers. Manual switchboards remain in use to service
those smaller communities of subscribers where switching
speed is not critical. Multichannel transmission systems are
available for relatively static command posts.

In the 1985 time frame, the Marine Air Ground Task Force
(MAGTF) will require totally secure telecommunications sys-
tems with multichannel trunking, narrow-band capability for
all HF circuits, and wide-band for all VHF and UHF circuits.
A mixture of analog and digital equipment will exist. In this
time frame, the Tactical Data Systems (TDS's) [the Marine
Tactical Command and Control Systems (MTACCs)] will be
entering the field. These systems will require a significant data
transfer capability. Satellite communications will also be
introduced into the field at this time. Secure voice telephone
operations will continue to be satisfied by the KY-65 (PARK-
HILL) and the newly introduced Digital Subscriber Voice
Terminal (DSVT) (KY-68) and ANDVT. The MAGTF's will
require fully secure, highly reliable, automatic digital switching
devices to handle both narrative and data traffic.

Air Force: Air Force communications are normally air-to-
air and air-to-ground and in support of specified commands
such as SAC and NORAD. However, the Air Force has an im-
portant role in theater air defense and close air support and
interdiction. Therefore, the majority of Air Force communic-
ations is point-to-point, with an emphasis on radio links. The
Air Force makes extensive use of the HF and UHF bands and
relies heavily on the tactical satellite capability. It does, how-
ever, utilize the DCS for many normal operations including
sensor nets, logistic and personnel nets, and certain command
and control functions.

The SAC Warning and Control System (SWCS) is a real-time
processing and display system which enables actions by the
SAC Commander in Chief, upon receipt of missile attack in-
formation, to protect his forces pending decisions by the NCA.
Attack information is received over high-speed communications
links from several warning sensors operated by NORAD
such as the Satellite Early Warning System, the Ballistic Missile
Early Warning Systems, and the Sea-Launched Ballistic Missile
Detection and Warning System. The hardware and software of
the SAC warning and control system are continually upgraded
to maintain state-of-the-art capabilities in conjunction with
and compatible to sensor improvements.

Survivable two-way communications in SAC have global
dimensions, with satellite communications systems playing an
important role in fully satisfying this continuing requirement.
The Air Force Satellite Communications (AFSATCOM) pro-
gram will provide two-way record (teletype) communications
between a family of airborne and ground terminals by special
transponders which are installed “piggyback” on the DoD host
satellites.

The Data Transmission Subsystem (DTS) of the SAC Auto-
mated Command Control System is to be replaced by the new
SAC Data Network (SACDIN). SACDIN will be a record data
communications system which is faster and more accurate, has a larger message-handling capacity, a higher degree of survivability, and which offers greater reliability than the present DTS. In addition, it will extend two-way automatically encrypted communications to all existing missile launch control centers for the first time. The system will be interoperable with AUTODIN and AFSATCOM, and it will offer multiple new ground entry points for communicating with the Airborne Command Post (ABNCP) battle staffs [3].

*NATO Integrated Communications System (NICS)*

In the late 1960's, the Allies recognized their communications inadequacy. In 1970, they initiated a program to construct a NATO Integrated Communications System—the NICS—which was then the largest single program to be undertaken by the Alliance. The NICS will, in time, provide modern communications satisfying the full range of military and political requirements. The NICS Management Agency (NICSMA), located in Brussels, is procuring and installing this new system. It will be operated for the most part by the NATO military commands.

NATO is implementing the NICS in two stages. The first step has been called the “independent networks.” It will have the following capabilities:

1) a network of store-and-forward message switches, called the TARE network
2) a network of voice switches, called the Initial Voice Switch Network—IVSN
3) a small secure voice network, called by NATO the Pilot Secure Voice Program.

Also included as part of Stage I of the NICS are two major supporting programs. One is expansion of the satellite communications system to provide transmission links throughout the Alliance, and the other is the Subsystem Integration Program.

The NICS Stage II Architecture is in the concept formulation phase.

**REFERENCES**


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