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"THE ART OF COMMUNICATIONS INTERFACES"

RSI in the C^3 ARENA

19 October 1978

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: AFCEA-FM-3	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: Proceedings of the Third Annual Seminar: "The Art of Communications Interfaces RSI in the C3 Arena"	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): SEYMOUR KREVSKY, EDITOR	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Fort Monmouth Chapter, Armed Forces Communications & Electronics Association, P.O. Box 805, Eatontown, N.J. 07703	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S.Army Communications Systems Agency ATTN: CCM-RD Squier Hall Fort Monmouth, N J 07703	12. REPORT DATE: 19 October 1978
	13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Rationalization, Standardization and Interoperability, Defense Communications NATO Communications, Strategic, Tactical, Digital Communications; Telecommunications, Communications Switching; Communications Interfaces; Fiber Optics - Satellites; Common Carrier; Electronics and Electrical Engineering; Radio Communications Radio Equipment.

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Several papers by leading authorities on the political and technical aspects of NATO and U.S. Tactical and Strategic Communications Systems are presented. These cover contributions by United Kingdom and SHAPE Technical Centre as well as United States Tri-Tac experts in the analog and emerging digital communications arenas, with specific discussions of the impact of STANAG 5040, NATO's first automatic switched voice interface standard.

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78 11 21 043

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

ARMED FORCES COMMUNICATIONS AND ELECTRONICS ASSOCIATION

FORT MONMOUTH CHAPTER

(6)

PROCEEDINGS OF THE THIRD ANNUAL SEMINAR (3rd)

"THE ART OF COMMUNICATIONS INTERFACES"

RSI in the C^3 ARENA

(11) 19 OCTOBER 1978

(12) 139p.

(10) Seymour/Krevsky

P. O. BOX 805

EATONTOWN, NEW JERSEY 07724

APPROVED FOR PUBLIC RELEASE

DISTRIBUTION UNLIMITED

(14) AFCEA-FM-3

409 665

78 11 21 043

PROCEEDINGS INFORMATION

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Requests for individual copies of the papers should be addressed to the authors. Extra copies of the proceedings may be obtained from the Seminar Chairman. Requests should include a check for $15.00 per copy, made payable to.. "Fort Monmouth Chapter, AFCEA." Copies may also be obtained for a nominal fee from the National Technical Information Service (NTIS), Operations Division, Springfield, VA. 22151.

Proceedings of the First and Second annual seminars are available from Defense Documentation Center, Cameron Station, Alexandria, VA. 22314. The First seminar proceedings is numbered AD-A023907. The Second seminar proceedings is numbered AD-A 044407.

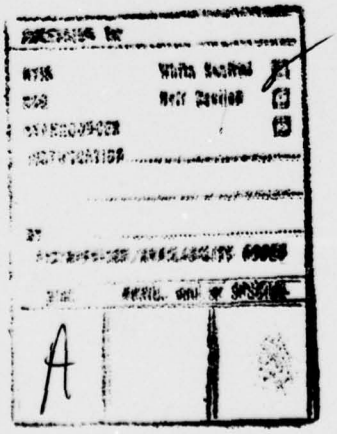
The First Seminar covered Fiber Optics Systems and Interfaces, the AN/TTC-39 TRI-TAC Switching System Interfaces and Man-Machine Interfaces.

The Second Seminar covered Strategic Systems Interfaces emphasizing Access Area Switching Systems, Digital Tropo Modem Developments and Tactical Data System Interfaces.

Seymour Krevsky
Editor

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for Research and Development

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Squier Hall
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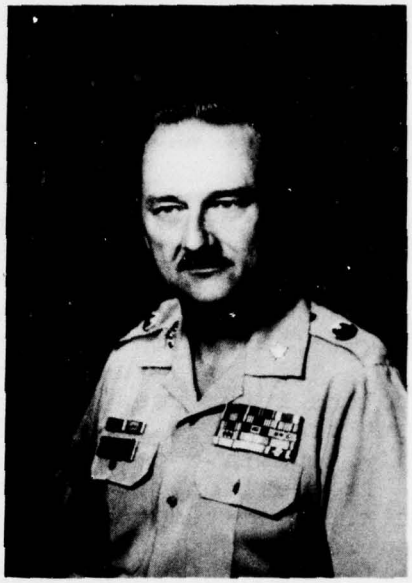


With the advent of the 1978-79 AFCEA season, one of the chapter's prime objectives is devoted to government/military/industry interface in communications, electronics, computer sciences, imagery and command and control.

Recognizing the importance of conducting seminars on emerging technology, the Fort Monmouth Chapter again is holding its Third Annual Seminar.

We trust that as a result of your participation today, the seminar has contributed toward continuing understanding in the field of communications interfaces.

Colonel Earl R. Weidner, Jr.
President
AFCEA Fort Monmouth Chapter



BIOGRAPHY

COLONEL EARL R. WEIDNER, JR.

UNITED STATES ARMY

PRESIDENT, FORT MONMOUTH CHAPTER, AFCEA

COLONEL EARL RAYMOND WEIDNER, JR., WAS BORN IN BOSTON, MASSACHUSETTS, OCTOBER 29, 1926. HE ENTERED THE SERVICE IN JUNE 1944 AS AN ENLISTED MAN AND ATTENDED SIGNAL CORPS OCS, GRADUATING AS A 2ND LIEUTENANT IN MAY 1946. AFTER A YEAR IN CHINA, COL WEIDNER LEFT THE SERVICE IN MAY 1947, REMAINING IN A RESERVE STATUS, UNTIL RECALLED TO ACTIVE DUTY IN JANUARY 1951. HE HAS HAD WIDE EXPERIENCE IN TACTICAL MILITARY COMMUNICATIONS-ELECTRONICS, HAVING SERVED AS COMMUNICATIONS CENTER AND CRYPTO OFFICER AT FAR EAST COMMAND HEADQUARTERS; OPERATIONS OFFICER FOR III CORPS SIGNAL SECTION; COMMANDER OF AN HF/COMMUNICATIONS CENTER SIGNAL SUPPORT COMPANY; SIGNAL OFFICER FOR A COMBAT COMMAND, 3D ARMORED DIVISION; OPERATIONS OFFICER OF THE 304TH SIGNAL BATTALION, KOREA; COMMUNICATIONS-ELECTRONICS STANDARDIZATION REPRESENTATIVE TO THE UNITED KINGDOM; DEPUTY COMMANDER, 21ST SIGNAL GROUP AND ASSISTANT OPERATIONS OFFICER, 1ST SIGNAL BRIGADE, BOTH IN VIETNAM; DEPUTY COMMANDANT FOR TRAINING AND EDUCATION, US ARMY SIGNAL SCHOOL; DIRECTOR, PLANS AND PROGRAMS, PM ARMY TACTICAL DATA SYSTEMS (ARTADS); AND CHIEF OF STAFF, COMMUNICATIONS RESEARCH AND DEVELOPMENT COMMAND (CORADCOM), THE POSITION HE CURRENTLY HOLDS. COL WEIDNER IS A GRADUATE OF TUFTS UNIVERSITY AND THE COMMAND AND GENERAL STAFF COLLEGE, WHERE HE SUBSEQUENTLY SERVED AS A MEMBER OF THE STAFF AND FACULTY. HIS MILITARY DECORATIONS INCLUDE THE LEGION OF MERIT, THE BRONZE STAR, THE MERITORIOUS SERVICE MEDAL AND THE ARMY COMMENDATION MEDAL.

MESSAGE FROM THE GENERAL CHAIRMAN

We of the Fort Monmouth Chapter of AFCEA are delighted to host the third annual seminar on "The Art of Communications Interfaces" and trust that the presentations and discussions will bring us closer to a technical and operational understanding of the state-of-the-art in this area.

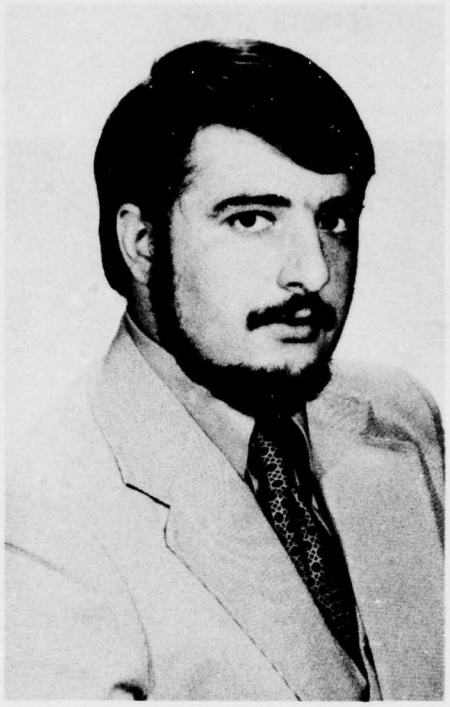
Today more than ever, the interfaces among International (NATO) Communications systems are crucial to the "timely and accurate transmission of highly sensitive command, control, and intelligence information." In addition, the above communications must be accomplished with limited communication resources. Satisfaction of these requirements will be accomplished through the goals of Rationalization, Standardization, and Interoperability (RSI). This justifies the selection of RSI as the theme for this year's AFCEA interface Seminar.

The Fort Monmouth Chapter is grateful for the time and efforts expended by Vice Admiral Boyes and Generals Dickinson, Guthrie, Lasher, McKnight, and Stoner for the promulgation of this seminar. In addition, the Chapter is grateful to the speakers and the seminar committee members and their respective organizations for their many contributions to the seminar.

Your dialog, discussions and comments are highly appreciated in improving the seminar as a forum and suggestions for future topics are also most welcome.

Bernard D. De Marinis

BERNARD D. DE MARINIS
GENERAL CHAIRMAN



BERNARD D. DEMARINIS

Mr. DeMarinis is a Project Engineer at Booz, Allen & Hamilton, Inc. He has more than ten years of professional experience in fiber optics, satellite communications systems, digital tropospheric systems, down-the-hill communications, and ECM systems. He has been extensively involved with military inventory radio equipment assemblages and their tactical and strategic communications interfaces.

Mr. DeMarinis received his B.E.E. degree from the City College of New York and his M.S.E.E. degree from the Polytechnic Institute of Brooklyn. He has also completed most of the course requirements for a Masters Degree in Business Administration at Fairleigh Dickinson University.

Mr. DeMarinis is presently Vice President of Membership for the Fort Monmouth Chapter of AFCEA and was Technical Chairman of the Second Annual AFCEA Art of Communications Interfaces Seminar. Mr. DeMarinis has been an officer of the Microwave Theory and Techniques, Antennas and Propagation, and Circuit and Systems groups of the IEEE and was general chairman of the 1976 International Microwave Symposium. He is presently Chairman of the Princeton Section IEEE and is a member of AFCEA, the Association of Old Crows, ADPA, AFA, Tau Beta Pi, and Eta Kappa Nu.

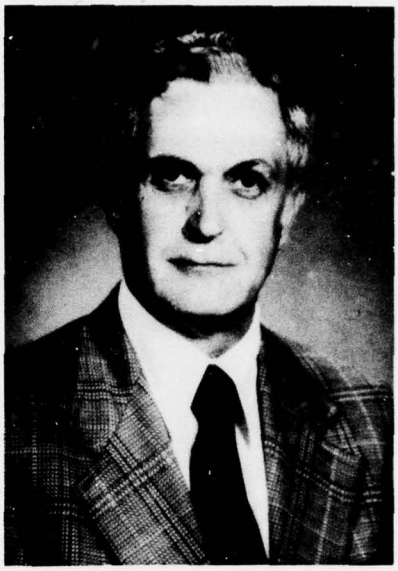
KEYNOTE SPEAKER



GENERAL JOHN REILEY GUTHRIE

John Reiley Guthrie was born at Phillipsburg, New Jersey on 20 December 1921. He was graduated from Blair Academy, Blairstown, New Jersey in 1938 and from Princeton University, Princeton, New Jersey with an A.B. degree in 1942. He was graduated in 1944 from the U. S. Army Command and General Staff School and the National War College in 1961.

His commands and assignments include the CO of 602d Field Artillery Battalion in 1952, Military Assistant to the Secretary of the Army 1959, CO of the 25th Infantry Division USARPAC 1964, Director of Developments OCRD, DA, 1966, Director RD&E HQ, AMC 1969, DCG for Material Acquisition USAMC, 1971, CG IX Corps, U.S. Army Japan 1975, and currently is Commander, U. S. Materiel Development and Readiness Command since 1977.



BIOGRAPHICAL SKETCH

DR. ROBERT E. FRESE
DEPUTY DIRECTOR FOR ENGINEERING
JOINT TACTICAL COMMUNICATIONS (TRI-TAC) OFFICE
FORT MONMOUTH, NEW JERSEY

Dr Frese received a Bachelor's Degree in Mathematics and Bachelor's, Master's, and Doctorate Degrees in Electrical Engineering from the University of Michigan. He began his professional career as a researcher and consultant in the field of air defense system countermeasures and became an instructor and assistant professor of electrical engineering at the University of Michigan.

In 1959 he was appointed to a supergrade position at the US Army Electronic Proving Ground and was later promoted in 1962 to Chief Scientist at Fort Huachuca. During this time he served for four years as a member of the Board of Directors of Consumers Union of the US, Inc., publisher of "Consumer Reports."

From 1963 to 1969 he was an executive in the Federal Systems Division of the IBM Corporation, responsible for application of data processing and lasers to tactical problems. In 1969 he became the Director of the Joint Engineering Agency for the international MALLARD Project, a joint tactical communications program by the US, UK, Canada, and Australia.

In 1971 he assumed his current position as Deputy Director for Engineering of the OSD's Joint Tactical Communications (TRI-TAC) Office. He has also been Co-Chairman of the Committee on the Interoperability of Defense Telecommunications since its inception in 1973.

PROGRAM CHAIRMAN



HERBERT S. BENNETT

Herbert S. Bennett (BSEE, MSEE, MS, Phd) is Program Analysist, Product Manager Automatic Test Support Systems, U. S. Army Communications Research and Development Command.

He has been involved in many experiments designed to analyze and evaluate human operator performance in the presence of cutaneous cues and changing environmental conditions. A joint authorship, entitled "Design of Experiments Dealing with Man-Machine Interface in current Communications Systems" was presented at the Twenty-first Conference on the Design of Experiments in Army Research Development and Testing.

Dr. Bennett is Vice President of Programs for the Fort Monmouth Chapter, AFCEA.



BARBARA ANN FISCHER

ARRANGEMENTS CHAIRMAN & REGISTRAR

Mrs. Fischer is Administrative Assistant at the Regional Marketing Office of GTE Sylvania's Electronic Systems Group in Tinton Falls, New Jersey. She has been associated with GTE Sylvania in the local facility for sixteen years.

She currently is Secretary of the Fort Monmouth Chapter and a member of the Board of Directors. For the second year, Mrs. Fischer is Arrangements Chairman and Registrar for the Third Annual Seminar. During the past decade, she has received numerous Honor Awards for her contributions to the Chapter's efforts. She is a member of the AFCEA Five Star Club.

She received an A.A. degree from the Institute of Human Affairs, Brookdale College, Lincroft, New Jersey and has completed credits towards a Bachelor's degree at Monmouth College, West Long Branch, New Jersey.



Jon L. Boyes
Vice Admiral, USN (Ret.)

Retiring from the Navy after a distinguished thirty-four year career, Admiral Boyes has experience in the technical and operational command, control and communications fields.

Born in Oakland, California, Admiral Boyes graduated with distinction from the U. S. Naval Academy on June 9, 1943 and was commissioned an Ensign. He was promoted to Vice Admiral July 1975 after a thirty-two year career at sea in destroyers and submarines, on Naval and Joint Service Staffs, and twice in the European Theater.

During his career, he was temporarily assigned as the Submarine Operations/ Communications Director for the first and only Submarine Ballistic Missile nuclear war test shot launched by the POLARIS Forces. He later also commanded the Navy's first all nuclear attack submarine division and subsequently its first nuclear attack submarine squadron. During this period, significant nuclear submarine Arctic under-ice operations, high speed submerged tactical concepts, as well as underwater missile torpedo launch evaluations were conducted.

He has served in the rank of Admiral as Plans Officer, Defense Communications Agency; Director Communications, Europe; Director Naval Communications; Director Naval Command, Control and Communications; and Deputy Director General NATO Integrated Communications Systems Agency.

His educational background includes graduate work in communications and ADP, a Masters degree in International Law (Honors) and Political Science (Honors) and a Ph.D. in International Affairs.

Vice Admiral Boyes has been awarded the Distinguished Service Medal; Legion of Merit (4 stars); Meritorious Service Medal; the Purple Heart Medal; American Defense Service Medal; Asiatic-Pacific Campaign Medal (seven operations); American Campaign Medal; World War II Victory Medal; National Defense Service Medal with bronze star; Korean and United States medals; and the Philippine Liberation Ribbon with one star. He has also been awarded the Korean Order of National Security, Third Class.

He is a member of several Scholastic Honor Fraternal Societies, and belongs to Lions International, The International City Managers' Association, AFCEA, the American Institute of Aeronautics and Astronautics, and the American Society of Association Managers.

Admiral Boyes has had a long association with AFCEA, having served as a National Vice President, an Associate Director, and as a Regional Vice President. He has been the author of several articles in the AFCEA Magazine, SIGNAL, as well as being an AFCEA convention moderator and panelist.

TACTICAL SESSION CHAIRMAN



BRIGADIER GENERAL CLARENCE EDWARD McKNIGHT, JR.

Brigadier General Clarence Edward McKnight, Jr., was born in Memphis, Tennessee on 9 September 1929. He attended the University of Tennessee, Knoxville, Tennessee for one year and was then appointed to the United States Military Academy at West Point. He received his MS degree at the University of Michigan. In 1965 he graduated from the Command and General Staff College at Fort Leavenworth, Kansas. He graduated from the United States Army War College, Carlisle, Pennsylvania in 1972.

His commands include 9th, and later 36th Signal Battalions, Republic of Vietnam; 3rd Infantry Division Signal Battalion, Germany; 22nd and 2nd Signal Group, Germany.

He was selected for promotion to Brigadier General in 1976 and on 13 June 1977 was assigned as the Assistant Commandant, United States Army Signal School, Fort Gordon, Georgia. On 1 November 1977 General McKnight was designated the Deputy Commander/Assistant Commandant, United States Army Signal Center and Fort Gordon. He was promoted to Brigadier General on 1 April 1978.

His decorations include the Legion of Merit, Bronze Star with 2 Oak Leaf Clusters, Meritorious Service Medal with 3 Oak Leaf Clusters, the Joint Service Commendation Medal, Air Medal, and the Army Commendation Medal with 3 Oak Leaf Clusters.

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THE ART OF COMMUNICATIONS INTERFACES

RATIONALIZATION, STANDARDIZATION, INTEROPERABILITY

Remarks Session Chairman

Dr. Jon L. Boyes, Vice Admiral, USN (Ret)
President, AFCEA

It is indeed a pleasure to be Chairing this morning session of the Fort Monmouth Chapter's Third Seminar on Communications Interfaces. I am particularly pleased to see traditional events grow in AFCEA which stress the technical and managerial aspects of AFCEA, for that is what our Association is dedicated to do.

Having been deeply involved in NATO since 1969, first from the vantage point of the Defense Communications Agency and later as the J 6 for CINCEUR and SACEUR and lastly for the NATO Integrated Communications Agency as the Deputy Director General, I sense sometimes that NATO tends to surge through crises, and along the way, people grow fatigued with the endless discussion and the almost pathless bureaucracy and some of them turn from NATO into other fields of interest. To do something for NATO you must stay with it long enough to become tolerant and you must be very persistent with yourself to think positively.

NATO is a very unique organization in that despite the worst of adversities and the constant nagging concerns, NATO works in deterring the Warsaw Pact.

I am afraid that an undue amount of time and words have been and are being spent on rationalization, standardization and interoperability, whilst the Soviets and the Warsaw Pact continue to improve both the quality of their conventional forces and the circular error of probability of the Pact missiles.

There are recent "doings" going on in NATO on the subjects of rationalization, standardization and interoperability in both the fields of weapons and electronics that is a very significant and optimistic situation. The fact that this group is assembled here is one such example of people getting on with while the "concerned" continue to wring their hands over NATO's failings.

As a basis of understanding the discussions which will take place in this morning session, let me set the stage by providing some rather straight-forward statements about rationalization, standardization and interoperability which I have extracted from various United States and NATO documents and boiled free of the fat and gristle.[1]

First, standardization can be common or compatible technical procedures or criteria. This statement may be expanded to include common or compatible operational, administrative and logistical procedures, and then, further broadened to include supplies, components, weapons or equipment and tactical doctrine.

I would define interoperability as the ability of systems, units or forces to provide services to and to accept services from other systems units or forces and to use the services so exchanged to enable them to operate effectively together.

With regard to rationalization that is any action that increased the effectiveness of alliance forces through more efficient or effective use of defense resources committed to the alliance.

There is a tendency to mix rationalization, standardization and interoperability as a coherent event. Rather, it seems to me that standardization and interoperability are the means by which rationalization can take place. Put another way, I view rationalization as the systems architecture, engineering and management which provide for the communications or command and control system in the most cost effective manner through the proper utilization of standards and interoperability means, among others, to achieve that system.

Rationalization would accept a digital system in tomorrow's environment to meet tomorrow's requirements and would set about now to replace existing analog equipments, systems and components with digital elements and systems. It is a fact that digitalization is more cost-effective, efficient, flexible and diverse than analog. Ergo, rationalization should deal with cost-effective techniques.

Setting aside rationalization as a necessary given which is highly dependent on the techniques of systemizing and the means of standardization and interoperability, we probably ought to focus a great deal of NATO's attention on electronics and computer standardization. Although interoperability appears an easier step to take because interoperability politically and technically shows more immediate returns in accomplishment through black boxing or inter-facing of present or on-coming equipments.

Standardization is a more apparently difficult situation with which to cope than interoperability, for it calls for agreement among technicians on national or international standards agreements. Such agreements generally lack the force of adherence, depending more on reciprocity and cultural acceptance. Yet, if one review what is going on in NATO in the communications and command and control world, one would see that there is a general agreement on international and national standards melding where possible and where not possible the setting up of useable standards, for we would be remiss in not doing such things.

International Agreements, being better known in NATO, should, in my opinion, be the guiding light, tempered by national standards, when costs and efficiencies can be improved upon. By International Agreements, I speak here to CCITT, CCIR and CEPT, among others, and to my national standards like those of the United States Bell System. Obviously it makes no sense to impose United States standards on a European environment which influences the most vital elements of NATO communications and command and control systems and imposes the most difficult and complex, legal, political and social constraints.

We often are told that various countries cannot adapt the standards which are employed by them because of the impact upon their PTTs and manufacturers.

With regard to PTTs, I do not question the problems inherent therein, particularly in West Germany which makes up a large part of the Central System of NATO's Communications and command and control. Certainly, on the surface the German PTT, and to some extent that of Norway, has reluctance to abandon what we Americans see as a set pattern of standards used in recently developed switches and lines in those countries. But I feel that there is a lack of appreciation as to what those PTT's and the PTTs of all of Europe are about by Americans. I believe that the Europeans are already outdistancing us and that we have too often argued for American standards because we Americans have developed a wide-range of standards that are not amenable to those of Europe.

I am afraid in this regard that if the top policy and decision-makers in NATO got onto what we technicians are doing with standards and our parochial approaches that we would all be severely reprimmanded and quickly told what path to take with respect to NATO.

Of course, there is a natural concern on the part of manufacturers, especially in Europe where off-the-shelf procurement tends to dominate the path of the development of systems, to be deeply concerned about shifting standards. Arguments are made about profit and loss. This is simple hogwash. I have yet to see any country suffer in NATO contracting by failing to shift to better performing or integrating standards. I have yet to see any worthwhile company not shift to whatever the customer wants within reason if there is a guaranteed profit involved -- and NATO does guarantee profit, even sometimes to its own detriment.

Interoperability can take many forms and has been in use for a number of years on a minor scale in our business: for example, over-the-counter tape exchange, interconnecting of NATO and United States nodes, swapping of channels, and other simple utilizations of each other's systems.

The NATO TARE and the United States AUTODIN are given to interconnection as is the NATO IVSN and the United States AUTOVON. How much of that interconnecting can take place is dependent upon the willingness of the countries involved to make the interconnection. Sometimes such interconnection is limited by persons who seek out legal and political arguments as well as economic rationale to avoid the link up. Here again, I doubt that there would be much delay if the Allied Commanders and the National Treasurers were apprised of the problems now being imposed by middle layers of bureaucrats and technicians.

There are obvious limits to interoperability of existing security systems and the quality of performance of equipments. It is time that we move forward to have a common sophisticated cryptographic systems for NATO of the highest quality and most advanced design. It is evident that the existing impossible situation is caused simply by self-serving ends of nations. Until the crypto situation is faced head on, NATO's system will remain unsecure, not interconnecting and interoperability limited, and the Commanders and Ministers limited to slow rated systems and poor quality secure telephony --- telephony that requires two to three telephones on each persons desk to communicate.

I am not defeated nor discouraged by what seems to be a snail-like pace of progress in NATO on standardization, interoperability and rationalization. In my view, NATO has done an exceptionally good job in melding the needs and interests of its multi and diverse membership whose skills and knowledge are varied. NATO has come a very, long way in the past twenty-five years once it began to do things for communications and command and control. I see the efforts of many people in the form of systems that are working better and are more modern each year. I see a more knowledgeable and energetic bureaucracy of professionals. I see the SHAPE TECHNICAL CENTRE as a viable base for NATO communications and command and control. I see NICSMA at the take off point as Walter Rostow describes the phrase -- advancing rapidly into a viable and dynamic posture.

Rather than take up more of your valuable time, let me sum it all by noting that there are many engineers and technical persons who have done much for NATO and are continuing to do so. These men and women are determindly moving on with the tasks at hand and the tasks that they visualize ahead and these persons are doing their bit at all levels. So, let us forget "the Nay-sayers" and "the Concerned" and continue full pace to make rationalization an effective systems approach using standardization and interoperability, as means to that end.

It is with pleasure and respect that I now introduce your panel of three distinguished gentlemen who have contributed significantly to the present good situation of NATO and are lending their skills and energies to the future architecture, engineering, implementing and management of NATO's communications and command and control. Dr. Ince, of the Shape Technical Centre, is a foremost thinker and doer in NATO communications; Brigadier Akass is a brilliant tactical communicator and engineer with a long operational background in NATO; and Major General Robert Terry of the United States has been long involved in both NATO and United States Defense Communications and is now developing quite a reputation as an international industrial communications adviser.

1

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(15) DoD Dir. 4120.3, "Defense Standardization Program," June 6, 1973

TECHNICAL ASPECTS OF STANDARDIZATION AND INTEROPERABILITY OF COMMUNICATIONS SYSTEMS IN NATO

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1. INTRODUCTION

This paper is concerned specifically with military communications systems (tactical and strategic) and their standardization/interoperability (S/I) among themselves and with civil networks on the assumption that this is required on grounds of efficiency and/or economy. Some of the comments may apply also to other electronic systems.

Full standardization implies common equipment, interoperability implies common specifications which allows, in the limit, unrestricted secure and discrete communication between individual users or cluster of users regardless of their geographic positions in the areas covered by networks of different nations and which makes possible the use of common spares and operating procedures.

The paper will address the following issues in the order shown:

(i) Reasons for present lack of interoperability.

(ii) Effects on standardization/interoperability of possible future technological developments in components and techniques.

(iii) Differences and interactions between developments in military and civil communications.

(iv) Conditions for achieving full standardization or interoperability.

(v) Discussions of the relevance of these issues in the studies for the NATO Communications System.

2. REASONS FOR LACK OF INTEROPERABILITY

(i) Differences in requirements with respect to:

(a) equipment replacement cycles

(b) existing systems and procedures (interoperability)

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(c) capacity, both numbers of users and traffic to be handled

(d) area of operation

(e) facilities required.

(ii) Funds availability influencing technical solutions and operational concepts.

(iii) Technical solutions arrived at by independent groups.

(iv) Lack of free and full exchange of information between nations particularly in COMSEC area.

(v) Industrial competition which benefits from differences in design, facilities and technology used.

(vi) National differences in technological capabilities and priorities. Accepting someone else's standards puts the acceptor at a commercial disadvantage. However, the differences in the tactical systems being fielded or implemented are not due to any differences in national technical capability.

The above factors lead to the production of concepts, equipments and systems which differ in capacity, technology and techniques used and degree of security and ECCM provided because of the differences in the epoch of development, size, wealth and the industrial potential of the countries concerned which, though allied, have secrets from each other. All these difficulties are compounded by the fact that whereas analogue systems are well established the modern digital systems still have outstanding parameters to be specified and the new systems are required to work in a mixed digital/analogue environment.

3. FUTURE TECHNOLOGICAL DEVELOPMENTS

The tactical systems being developed at present by the nations for fielding in the eighties will use the technology and components of today. The S/I discussions taking place in NATO today are strongly affected by the characteristics of these systems. But is it possible to forecast future developments in the areas of components, LSI technology and primary power generation and predict whether or not these are likely to aid or hinder S/I endeavours?

LSI technology has reached a stage where in the near future it will be possible to put about 10^7 components on a chip of 1 cm^2. To put it another way a switching element which is the building block of all digital systems would occupy a volume containing about 10^{15} atoms. When this is compared with the switching action in the nerve cell where incidently conduction of ions rather than electrons is involved we find that switching takes place in a volume several orders of magnitude smaller than the figure above. This may indicate the way to build smaller switching elements. This reduction in size will, in all probability, be accompanied by smaller power consumption and increased reliability. All this coupled with more efficient primary power supplies will lead to significant reduction in size and weight of equipment and hence more mobile tactical equipment where the size will be limited by antennas and human perceptors; ear, fingers for dialling and keying and vision with respect to display devices. The increase of mobile radio will create frequency congestion which will have to be eased by exploiting higher and higher frequencies and developing efficient voice processing and coding schemes.

It appears that higher order technologies may be required to achieve size reduction of a few orders of magnitude in LSI chips. This in turn may allow functions and concepts limited by power and size today to be used in the future systems. Strong economic motive is required for the more advanced nations to share the products of their costly research and development in materials and LSI technology with others. If this does not take place then S/I goals will be more difficult to achieve.

The development costs involved in LSI is very high and unless the LSI chips are used in large quantities they will not be economic. Perhaps here lies a clue for improved standardization for the future systems. Developers of high technology will have to sell their products worldwide to be able to benefit themselves from their use in their own systems. Large quantities, however, are required by the civil systems and unless common standards are adopted for the civil and military systems it will not be possible for the military to take full advantage of the LSI chips developed for the civil applications. It is interesting to note that since LSI chips are difficult or impossible to repair their large scale use in the systems of the future will lead to simpler and cheaper operation and maintenance where replacement of chips will be employed thus further reducing the unit price of the chip.

4. DEVELOPMENTS IN CIVIL AND MILITARY COMMUNICATIONS

It is apparent that common standards for both civil and military systems which would provide economic and other advantages mainly for the military really means adoption by the military of the civil standards. We therefore have to look at the civil developments in digital system standardization. The following are the differences between civil and military systems:

(i) Civil systems are much large in size and capacity.

(ii) The requirement of interoperation in civil systems is fully accomplished through gateway interoperability since there is not a significant number of itinerant users - as is the case in military systems.

(iii) Absence of requirements such as for security, pre-emption and survivability in civil systems lead to simpler equipments, easier to interoperate.

(iv) There is a growing and strong economic/ social need for civil international communications which gives impetus to interoperation. In military systems growth is less and economic motive is lacking.

(v) Cycle time of civil systems are longer and reasons for digitalization almost purely economic and not for security or improved mobility and this allows more time for the nations to experiment and negotiate common specifications which they do through CCIR and CCITT.

(vi) Because of the need for link-by-link conversion from analogue to digital, PTTs have adopted 64 kb/s PCM whereas 32/16 k/bs Δ-mod has been selected for use in tactical military systems for reasons of economy in bandwidth and also for easing the problem of intersymbol interference. However, this latter aspect (dispersion) may be dealt with by adaptive modems being developed today.

The above explains why the civil administrations appear to have had, and are having, better success with interoperation

(not standardization) than the military. There is no doubt that adoption of civil standards and/or components, if and when compatible with military operational needs, would lead to the production of military systems which are cheaper and potentially more reliable than they would be if developed independently. However, the scope for common standards seems to be very limited.

5. CONDITIONS FOR FULL INTEROPERABILITY

Improved standardization/interoperability requires:

(i) Acceptance by some nations of curtailing the useful life of their systems in being or developed for fielding in the 1980s.

(ii) Compromise in scope and extent of national requirements and in performance of systems to be acquired.

(iii) Maximum degree of information sharing relative to research, development, concepts and technology to avoid creating imbalance in technical capabilities between nations and joint development of standards as early in the procurement cycle as possible.

(iv) Acceptance of non-optimum systems because of long lead times required for S/I agreements, development/production of equipment and unforeseen technological developments in the intervening period.

(v) Great care in not stifling individual inventiveness and enterprise in trying to achieve uniformity.

(vi) Not to insist on specilization as a means for standardization or on solutions which give undue advantage to one or a few countries.

(vii) Tackling organizational problems of interoperable systems in parallel with their technical development.

(viii) To follow closely and use civil standards and equipment as much as is consistent with military tactical environment.

(ix) Where full system or sub-system standardization appears impossible, to go for the next best solution of module, component standardization needing frequent replacement, etc.

Development of standard/interoperable systems to meet the military and industrial requirements of sovereign nations of differing sizes and financial and technological capabilities cannot be easy to accomplish. If real economic motivation could be brought to bear on the question of S/I which at present rests on claimed but untried operational advantage then progress towards S/I could be faster. This motivation may come via the developments in civil digital networks which are, however, taking place slowly but surely.

6. INTEROPERABILITY OF TACTICAL NETWORK

The main characteristics of various national tactical area switched networks are shown in Fig. 1 which also shows the dates by which these systems are expected to be in the field(1). Five types of interface have been identified for possible interconnection between EUROCOM and TRI-TAC;

(a) Network gateway

(b) Multi-channel static access

(c) Multi-channel mobile access

(d) Single channel mobile access

(e) Single channel static access.

The approach to interoperation will probably be evolutionary, and in the initial stages it will be achieved by using the network gateway interface developed to STANAG 5040. Later, interoperability will be achieved by adopting agreed parameters which will apply, gradually, to all the interface points between new national systems. Agreement has already been reached on the characteristics of the parameters, shown below, for a multi-channel trunk interface which will permit a network gateway to be established between a EUROCOM nodal switch and a TRI-TAC switch without requiring the use of an interface equipment:

Agreed EUROCOM/TRI-TAC parameters:

- Network timing
- Multiplex frame structure
- Frame alignment
- Signalling
- Routing
- Precedence
- Crypto
- Radio characteristics
- Line characteristics
- Voice terminal equipment.

SYSTEM AND ENTRY DATE	VOICE CODING METHOD	SWITCHING FUNCTION	TRANSMISSION RATE/CHANNEL	SCRA CODING
NL-INTERIM*	ANALOGUE	MANUAL	DELTA 32 kbit/s	
NL-ZODIAC† (1983)	DELTA 16 kbit/s	DIGITAL	DELTA 16 kbit/s	DELTA 16 kbit/s
UK-BRUIN*	ANALOGUE	SPACE	PCM 40.5 kbit/s	
UK-PTARMIGAN† (1983)	DELTA 16 kbit/s	DIGITAL	DELTA 16 kbit/s	DELTA 16 kbit/s
US-TRITAC (1980)	DELTA 16/32 kbit/s	DIGITAL	DELTA 16/32 kbit/s	DELTA 16 kbit/s
FR-RITA	PCM, 6-bit	DIGITAL	PCM 48 kbit/s	DELTA 19.2 kbit/s
BE-RITA† (1980)				
GE-AUTOKONETZ*	ANALOGUE	SPACE	PCM 48 kbit/s	STILL UNDER
GE-AUDI† ?	DELTA 16 kbit/s	DIGITAL	DELTA 16 kbit/s	DISCUSSION
IT-CATRIN† (1983)	DELTA 16 kbit/s	DIGITAL	DELTA 16 kbit/s	STILL UNDER DISCUSSION

* *System in service*

† *EUROCOM member system*

Fig. 1 Characteristics of national tactical area switched networks

SYSTEM	METHOD OF PROVIDING GATEWAYS									
	BE RITA	FR RITA	GE AUTOKONETZ	GE AUDI	IT CATRIN	NL INTERIM	NL ZODIAC	UK BRUIN	UK PTARMIGAN	US TRITAC
BE RITA		D	I	I	I	I	I	I	I	I
FR RITA	D		I	I	I	I	I	I	I	I
GE AUTOKONETZ	I	I		N	I	I	I	I	I	I
GE AUDI Ø	I	I	N		D		D		D	D
IT CATRIN Ø	I	I	I	D		I	D	I	D	D
NL INTERIM	I	I	I		I		N	I	I	I
NL ZODIAC Ø	I	I	I	D	D	N		I	D	D
UK BRUIN	I	I	I		I	I	I		N	I
UK PTARMIGAN Ø	I	I	I	D	D	I	D	N		D
US TRITAC	I	I	I	D	D	I	D	I	D	

I : USING INTERFACE BOX (STANAG 5040)
D : DIRECT INTERCONNECTION
N : NATIONAL CHOICE
Ø : EUROCOM SYSTEM

Fig. 2 Methods of providing gateways

The methods which will be used to set up gateways between the different tactical area switched networks are summarized in Fig. 2.

The range of parameters for the interfaces (b) to (e) above are similar to that for the network gateway. However there are some significant differences particularly as far as signalling, crypto and radio parameters are concerned. The interface parameters, particularly for lower levels of interoperability are under study and are still to be agreed within EUROCOM as well as between EUROCOM and TRI-TAC.

7. INTEROPERABILITY OF NICS AND NATIONAL SYSTEMS

NICS

The NATO Integrated Communication System, NICS, has been outlined in several publications[2,3]. Suffice to say here that NICS will be implemented by the NICS Management Agency, NICSMA, in two stages. The first stage, the construction of which is at present well underway, will be an automatically switched voice network and will use stored-program controlled space-division switches and common-channel signalling. Both terrestrial and satellite links will be used to provide nominally 4-kHz analogue circuits as bearers of clear and narrow-band secure voice as well as of record traffic which will use store-and-forward message switches, TAREs. In the second stage of NICS implementation it is envisaged[4] that digital switches would be added and all transmission media would be digitalized in an evolutionary manner so as to enhance the survivability and security of Stage I NICS and at the same time improve the interoperability of NICS with national strategic and tactical networks.

The general characteristics of NICS are illustrated in Fig.3. NICS is required to interoperate through network gateways with tactical systems and make use, in peace and war, of national civil networks (PTTs). It follows therefore that NICS interoperability involves interfacing with analogue systems as well as with digital ones which, as has been indicated above, are being developed using different techniques and technologies and in different epochs. The different digital standards that are being used are EUROCOM, TRI-TAC, EUROCOM/TRI-TAC and CCITT/CEPT in Europe and TRI-TAC and Bell Standards in North America.

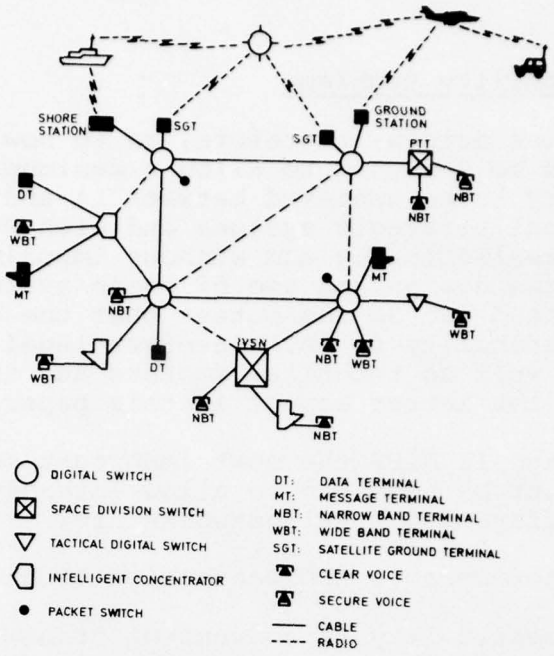


Fig.3 Future NICS architecture

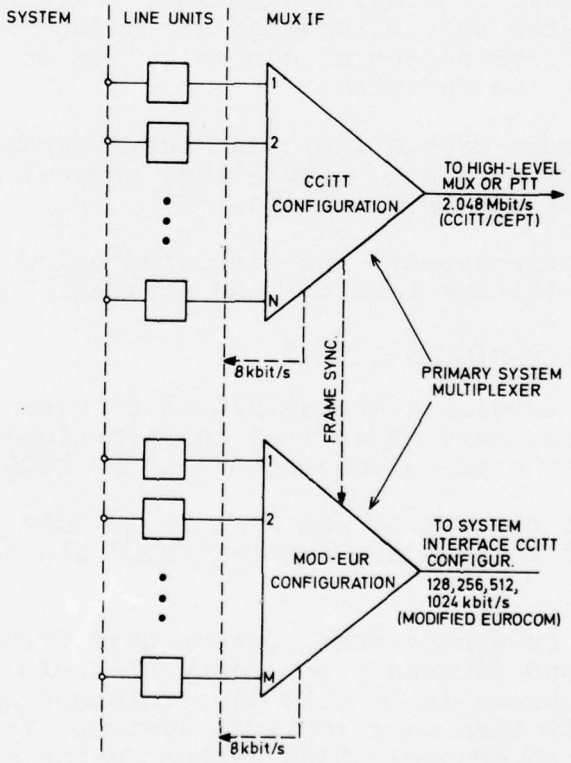


Fig.4 A possible primary system multiplexer for NICS

Interoperability Problems

The question arises, therefore, as to how The NICS Stage II should be designed to allow a maximum degree of interoperability to be achieved between it and the national tactical/strategic systems and with PTT networks economically, realistically and without imposing undue constraint on the design and use of these systems[1,4]. It must be pointed out at the outset that the realization of the interoperability in NATO involves legal and operational as well as technical factors and that we shall only deal with the latter aspect in this paper.

In the Stage II NICS the most important technical factors that must be resolved to allow interoperability between two different digital networks are:

(i) interoperable A/D conversion techniques;

(ii) compatibility at convenient transmission multiplex hierarchy levels;

(iii) compatible switching involving numbering plans, routing, signalling, training and system control schemes depending on the desired degree of compatibility of service features;

(iv) common crypto logic and interoperable crypto-related signalling, keying, and call set-up protocols.

Some of these aspects are discussed below in terms of PTT, national military tactical and strategic systems.

Digital Standards for NICS

There are several reasons related to cost and bandwidth utilization advantages as well as to operational considerations for choosing delta modulation as the NICS A/D technique.

Since most of NICS is and will be in NATO Europe it then appears logical to base the internal NICS standards on EUROCOM.

It should be appreciated however that transmission costs and standards and frequency occupancy of radio systems pose more severe problems in an extensive inrernational network such as The NICS than in a tactical system. It follows therefore that an economic NICS system design may require internal standards which may, in certain respects, be different from those agreed by EUROCOM but which may however

include portions of EUROCOM and CCITT/CEPT plus additional combinations of digital rates and multiplex levels.

More specifically, the A/D conversion of analogue signals in the NICS may be performed by a form of delta-modulation, namely Digitally Controlled Delta Modulation (DCDM) which will permit the digital sampling rate to be changed, under switch control, on a call-by-call basis, in discrete steps of 2^N X 16 Kbps. These basic digital channels may then be dynamically allocated on a call-by-call basis by the switches into the appropriate interswitch trunk group digital bit stream. Allowance may also have to be made for future introduction of 8 Kbps voice or data streams into the NICS multiplex structure.

Digital Multiplexing

The following is an example of a primary multiplexer which is flexible and appears to satisfy the diverse requirements of the NICS. Fig. 4 provides a basic block diagram for this multiplexer. Organized as a single, modular unit, the multiplexer will integrate many of the concepts of the commerical (CCITT/CEPT) and military (EUROCOM/TRI-TAC) systems into a compatible, multirate device which will permit considerable intersystem inter-operability and provide the basis for a gradual transition from the current, predominantly analogue NICS to the future integrated digital nodal network. Using concepts developed for computer systems and implemented in commercial LSI subsystems and components, the control for the primary multiplexer can be organized to provide rapid manual reconfiguration of transmission connectivity and pre-programmed or remote switching of circuits or groups of circuits. For large capacity digital transmission systems, a high-level multiplexer will have to be used which will combine from two to eight synchronous/asynchronous 2.048 Mbit/s bit streams into a single high-rate digital stream (approximately 4 to 17 Mbit/s). In addition, a line multiplexer will be provided for low capacity (e.g. 3 to 4 channels at 16 kbit/s) access line applications, where carrier circuits will be provided by the PTTs. Many of the modules used in the primary multiplexer will also be used in the line multiplexer.

Although it can be implemented as a single unit, the multiplexer has two fundamental operating modes:

(a) A CCITT/CEPT compatible configuration based on 64 kbit/s channels organized in 8-bit time slots, with an output rate of 2.048 Mbit/s.

(b) A modified EUROCOM configuration based on 16 kbit/s and/or 32 kbit/s.

A set of line interface units, common to both operating modes, provides access to external analogue (voiceband) channels and to digital inputs from 8 kbit/s to 1024 kbit/s (8×2^N kbit/s).

The CCITT/CEPT configuration has two applications. It can function as a completely independent multiplexer using PCM and companded-deltamodulation codecs for A/D conversion, or as a second level multiplexer which accepts the outputs of other primary multiplexers operating in the modified EUROCOM configuration and combines their outputs (with a small number of voice and/or data and telegraph channels) into a single 2.048 Mbit/s stream. In both cases, the mode of operation is the same and the basic frame format would be essentially that used for the CCITT/CEPT frame format (although the signalling channel would not be required and the information channels would generally carry signals derived from sources other than PCM codecs). If provided with PCM codecs as line interface units, the primary multiplexer will produce an output identical to that produced by a commercial 32 channel PCM system (less the signalling channel). Otherwise, mixtures of PCM and deltamodulation codecs (at 16, 32, or 64 kbit/s) and digital inputs from 8 kbit/s to 1024 kbit/s (8×2^N kbit/s) can be combined into the output 2.048 Mbit/s stream.

In its second configuration (see Fig. 4), the primary multiplexer is a dual mode, variable output rate, bit-interleaved multiplexer similar in principle to, and compatible with, the EUROCOM system multiplexers. In one mode it produces outputs interoperable with the multi-channel gateway specified for the EUROCOM/U.S. tactical systems (if all deltamodulation codecs and an external signalling processor are used), thus providing system interoperability with EUROCOM-based and TRI-TAC systems. In the second mode, the framing channel is subdivided to provide framing, signalling, and alarm channels, thus reducing the total system overhead relative to the conventional EUROCOM system. The same input line units as utilized in the CCITT/CEPT configuration are used in the modified EUROCOM configuration. Thus, the multiplexer can accommodate analogue inputs or digital inputs at rates up to half the output rate (8×2^N kbit/s). The following table summarizes the multiplexer configurations in terms of equivalent 16 kbit/s and 32 kbit/s channel capacity.

Number of Channels (including framing)	Output rate at: 16 kbit/s	32 kbit/s
8	128 kbit/s	256 kbit/s
16	256 kbit/s	512 kbit/s
32	512 kbit/s	1024 kbit/s

The eight channel system is not a EUROCOM standard and is not, therefore, compatible with the EUROCOM system.

Routing, and signalling

Both NICS and tactical systems will use adaptive routing but employing different principles. Tactical systems will have a deducible directory whereas NICS is unlikely to do so. Interoperability of NICS with these systems may be achieved by the calling network gateway offering to the called network gateway the digits of the called subscriber number. This would allow each network to use its own routing technique to establish the connection between the subscriber and the gateway. As far as interconnection of NICS with PTTs are concerned the intention is to lease transmission links and crcuits and there would therefore be no routing and numbering problems. It should be appreciated, of course, that if we attempted to interconnect NICS with the PTT networks we would be faced with an intractable problem.

Leased Digital Links

While the civil digital multiplex standards for Europe conform to CCITT Rec.G732 (30 channels at 2048 kbit/s) the United States and Canada have adopted standards recommended in CCITT Rec.G733 (24 channel 1544 kbit/s). Therefore, there is a problem in providing transatlantic digital links for the NICS. The basis for interworking should be at the channel level. Rec.G732 provides for transparent 64 kbit/s channels, whereas Rec.G733, allows only 56 kbit/s to be used transparently. Because of this difference the best that can be expected for the provision of transatlantic channels is 56 kbit/s per channel, or alternatively 48 kbit/s as defined in CCITT Rec.XI for digital data circuits. An alternative would be to use an analogue group link and equip it with modems operating at 48 kbit/s or possibly 128 kbit/s.

NICS will of course have SATCOM links of its own across the Atlantic which will be used to provide digital links for the NICS. The aggregate digital streams of various channel

rates up to 1024 kbit/s may be routed to North American networks using 1544 kbit/s bearers with bit stuffing

Yet another possibility which is being proposed for NATO-wide adoption for the strategic military digital networks which, however, is unlikely to find application in NICS is to use STANAG 5043 (draft). This STANAG provides a mechanism for European (CCITT) standard digital groups at 2048 kbit/s to be carried on systems employing NA standard groups at 1544 kbit/s and vice versa.

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Biography of Dr A N Ince

Nejat Ince is Chief of the Communications Division at SHAPE Technical Centre (STC), The Hague, The Netherlands. He joined STC in 1961 and worked as a scientist and later as Head, Radio Branch, before he was promoted in 1968 to his present position where he is responsible for research, development and system planning activities in support of communications for SHAPE and NATO. Dr Ince has been involved in the development of almost every international communications system for NATO. In the mid 1960s he took a leading part in the definition and implementation of the NATO SATCOM system which is successfully operating today. He was the leader of a team of his staff who developed the concept for The NICS. In the last several years, he and his Division have been leading technical engineering support to NICSMA in the development and system engineering of The NICS including issues such as digitalization and interoperation between NATO/National Systems and the planning of a new generation of satellites to be launched in the mid 1980s.

The work done at STC involves experiments and trials in the laboratories and field stations as well as computer simulation of satellite systems and switched networks. Dr Ince is the manager of one of the most comprehensive satellite experimental facilities in Europe including several satellite ground terminals some of which he designed himself.

Prior to joining STC, Dr Ince worked at the engineering departments of The Turkish PTT and Broadcasting Administrations. He received his B.Sc and Ph.D degrees from the Universities of Birmingham and Cambridge, UK, in 1952 and 1955 respectively. He is a Fellow of the IEEE and the author of over forty technical papers and reports on subjects ranging from propagation and signal processing to satellite communications.

FORT MONMOUTH CHAPTER
ARMED FORCES COMMUNICATIONS AND ELECTRONICS ASSOCIATION
THIRD ANNUAL SEMINAR: 19TH OCTOBER 1978

THE ART OF COMMUNICATIONS INTERFACES, RATIONALISATION, STANDARDISATION AND INTEROPERABILITY.

TACTICAL INTEROPERABILITY

BRIGADIER J L AKASS*

I would like to begin by saying how much I appreciate the honour of being invited to speak at this important AFCEA seminar at Fort Monmouth. As some present will remember, I had my first contact with international negotiation of standards for tactical interoperability in Fort Monmouth at the first quadripartite meeting on MALLARD in September, 1965 and, with breaks for field service, have been involved ever since - continuously for the last 8 years! I had wondered what my credentials were for my invitation and decided that I had been involved as a negotiator in more working groups and projects than most in pursuing interoperability and perhaps I might have picked up something useful on the way. Mind you, I still cannot compete for the record of continuous international service with my friend from TRI-TAC, Jack Faherty.

As one of the two European contributors today it is obviously my role to put points of view which may strike a few sparks from the home team and hence stimulate debate. What follows is my personal view based on military and procurement experience in the communications electronics field and particularly experience of trying to achieve improved interoperability through the negotiating table.

I would like to say at the start that I believe the future for the interoperability of tactical area communications looks bright but it will continue to be a long hard grind for the negotiatiors. We have made considerable progress since the occasion in 1970 when NATO Panel VIII made a cry of despair about the failure to make progress "because of the intractable problems of national timescales and industrial considerations". It was a bleak time for interoperability in the fall of 1970, when congressional action stopped dead

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Project MALLARD, a most successful international communications standardisation endeavour. Of course it was an ABCA project, not NATO, but Europe was just as concerned as the UK, Canada, and Australia, because MALLARD was clearly regarded by many as the way ahead for NATO as well. You may ask why I bring up MALLARD again - it is because I believe that the political and psychological effects of that unilateral US decision are still with us and take a lot of effort to counteract. Luckily, the technical benefits of MALLARD were not lost and TRI-TAC, the UK PTARMIGAN project and the other EUROCOM systems were all founded on MALLARD principles, because although the project stopped the people concerned in government and industry went on working internationally and maintained the close association built up over five years hard work. "Interoperability and standardisation" have become almost a cult in recent years: no high level meeting fails to put them on the agenda and they are on the lips of MPs and Congressmen, Secretaries of State and Commanders-in-Chief in many, and to me sometimes unsuitable, contexts. Some of these cry that "all is disaster", but I do not believe it. In fact, tactical communicators do manage to work together and soldiers are remarkably good at communicating at the essential level with what they have got. A US Commander-in-Chief in Europe, General James H Polk, said it clearly in the AEI Defence Review in 1977:

> "The standardisation of weapons, supplies, tactics and communications within NATO have become a fixation within our Government, an uncritical pre-occupation believed to assure increased effectiveness while reducing costs. To speak against standardisation might seem like coming out against motherhood. Yet experience raises questions about the viability of standardisation, and most of the influential advocates of this approach appear unaware of them. They tend to believe without question that total standardisation is the long range goal while inter-operability (in increasing degree) is the pathway to it. The thrust of the present discussion, however, is that a much more limited practical approach - emphasising war fighting rather than peacetime economics - is appropriate to NATO".

I find it difficult to greet with enthusiasm any more interoperability initiatives in the C3 area. The problem was recognised long ago - what is lacking in the main is the completion or implementation of the work on standards already done and only time and will-power can help there. Progress that has been made is due to the determined application over long periods of what NATO calls "experts", that is,

specialist servicemen and engineers applying practical knowledge based on experience of the design and use of real systems. Broad brush statements made in haste at high level may mean in reality that these experts are faced with a decade or more of negotiation of standards and then their implementation, so it beholds us all to make sure that our policy makers are well briefed on the "necessary" and the "attainable" rather than the "ideal". I would like to remind you why the timescale to reach agreement is so long, because I sometimes feel that our experts get an undeservedly bad press.

It is relatively easy to define an interface to enable us to join two analogue telephones together. Digitising the speech makes it a little more difficult, but an agreed specification for an interface is still only a few pages long. It is when you add in the signalling requirements between fully automatic digital switch systems with fixed deduceable directories and precedence, plus perhaps cryptographic control, and all of these run by processors under software control, that the agreements on parameters begin to run into thousands of items. There are then opportunities to differ about detail on every page and almost every entry interacts with others. The more the parties concerned know about the systems involved, because of their own on-going programmes, the worse the problem of resolving differences becomes because of the realisation of the consequences to their own systems in terms of technical change, cost and in-service date. Human nature being what it is, national pride and the NIH factor play their parts and quite small points can cause years of delay.

Looking at the subject more systematically, I believe that it is essential to have a clear long term aim of the final system envisaged, even if it can only be reached in stages. This aim must be maintained through many years, although tempters will always be suggesting other courses with breath-taking, but usually elusory advantages. The approach being taken in NATO towards tactical trunk system interoperability by means of a gateway shows a clear long term course agreed by all. Unfortunately there is not a similar agreed aim for Single Channel Radio Access (SCRA) or Mobile Subscriber Equipment (MSE). We all want "one" but what nations want to do with it differs in fundamental ways and the concept of SCRA has already been debated for several years in EUROCOM without success hence preventing further progress on the technical front.

We must of course agree that the operational requirement for the system interoperability is real and not dreamt up for extraneous reasons and that we can agree exactly what it is. After all interoperability of every aspect of the system is not, per se, necessary or desirable, and to try to achieve more than is required can be expensive, and counter-productive, in not gaining the wholehearted support of the people involved. The US and European nations take a different view of "operational requirements" because of the scale of national resources. European nations rarely make speculative developments without fully stated military needs, while in the US, it is quite common to develop systems in the expectation that some will fulfill needs which the military have not yet expressed. It was put to me recently that this approach was desirable in this era of high technological progress but most nations cannot afford to do it.

Like software programmes, time is well spent in getting the requirement clearly defined and this is an area where NATO has often fallen down because of gaps in the organisation. The Conference of National Armament Directors (CNAD) has a range of bodies such as TSGCEE to cover equipment matters but we have always been short of authoritative military bodies giving clear operational guidance.

When the vital technical standards resulting from the requirements have been defined by negotiations then stability of these standards is paramount otherwise a useable agreement will never result and it will be impossible to produce equipment to the standards when needed. Inevitably there will be some changes in operatinonal requirements or technology, which must be reflected in the standards, but consistency of approach by the whole group concerned is essential. Whenever possible negotiators must be part of real project teams spending money, and not study groups, so that they are committed and have a stake in the result: direct industrial involvement (as in EUROCOM) can be a considerable advantage.

We are just at the stage now of presenting to NATO the Standardisation Agreements (STANAGS) relating to the multi-channel radio relay link or "gateway" joining two digitally switched tactical national networks. The need for consistency in reaching such standards is made obvious when it is realised that work started on them in EUROCOM in 1971 (based on MALLARD work), and we are now just formalising the standards for implementation in the 80s and onwards. It is already too late for major changes in the specifications of systems which must comply with them and the systems are likely to be in service until the next century.

It should go without saying that the interoperability aim must be attainable, not only in terms of technology, cost, timescales, but even more important in the ability of national and international forces to use them without imposing excessive demands for manpower or for command and control or on commanders and staff. For example, the complete elimination of "liaison detachments", which has turned up as an aim on several occasions I would personally put in the "unattainable" class, for practical military reasons such as lack of a common language and lack of common organisations and operating methods. But the NATO Interface Box to STANAG 5040 is in the "attainable" class because it builds on existing systems and on procedures we are used to.

Finally you will note that I have talked a lot about interoperability, I have mentioned the importance of a consistent and stable approach to the essential set of standards for interfaces, gateways or complete systems; all essential to enable us to interwork national and NATO systems. However, I do not include equipment or system commonality as an essential. Obviously, the acquisition of common systems through common procurement by nations can have economic and military advantages. But, forgetting for the moment all other considerations for and against, as a communications engineer I believe that in this age of rapid technical advance, the alliance must always be evolving its communications in step, and total equipment commonality would freeze the clock for perhaps 20 years. In many nations this would also totally inhibit the development of new military communications equipment and cuase research and development support to wither away.



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Joined Army February 1946 in Royal Corps of Signals.

Graduate in Mechanical and Electrical Engineering of University of Cambridge (1952-55).

Served in field Signal Units in Germany, Egypt, Cyprus and Aden, concerned with tactical and fixed communications at Regimental, Corps and Army level.

Instructor at School of Signals 1955-58 and directing staff at the Royal Military College of Science, Shrivenham 1962-64.

Commanded 8th Signal Regiment 1967-69, concerned with tactical trades training, and 4 Signal Group, responsible for tactical and fixed communications in British Forces in Germany behind 1(BR) Corps.

Member of the UK team to the ABCA QSWG MALLARD 1965-66: EUROCOM and NATO Working Groups on Interoperability 1971 to date.

Concerned with the UK tactical trunk communications system PTARMIGAN since January 1971.

As DACP from June 1973 to January 1977 was responsible for the procurement of PTARMIGAN system, tactical radio relay equipment (TRIFFID) and the in-service BRUIN tactical trunk system.

In January 1977 became DMCP and took on, in addition, responsibility for the procurement of combat net radio equipment (the CLASMAN programme), commercial radio equipment, static communications equipment and radio relay, SATCOM ground terminals, terminal equipment, communications EW and various ancillaries.

AN INDUSTRY VIEW OF RATIONALIZATION AND STANDARDIZATION INITIATIVES WITHIN THE NATO ALLIANCE

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The logic of common defense persuaded North Atlantic nations almost thirty years ago to form the North Atlantic Treaty Organization. The benefits of this logic accrue each year as Soviet forces remain constrained to areas defined by the close of World War II. The dynamic equilibrium in Europe that has existed for almost thirty years now, between NATO and the Eastern Bloc clustered around the Soviet Union, appears seriously threatened today by (1) the cumulative effect of Soviet efforts over ten to fifteen years to improve Eastern Bloc military capabilities and (2) NATO distractions involving Vietnam, U.S. nuclear superiority and economic competition. In attempting to preserve the dynamic balance that currently exists, individual NATO nations confront a problem of two interrelated major aspects, namely economic policy and military security.

This paper will review the present situation from both military and economic aspects, develop the key issues involved, then measure current rationalization and standardization proposals against those issues and propose additional alternatives.

The Military Situation

Admiral of the Fleet Sir Peter Hill-Norton and General Alexander M. Haig, at a recent NATO seminar in Brussels[1], articulated military security aspects of the present situation in these terms. The Soviet Union has global power now. Fifteen years of continuing increases in defense spending form the basis for their relentless growth. In addition to the defense buildup in Europe, this growth provided equipment to build up 45 divisions on the Chinese border and military hardware for Third World recipients, that last year amounted to the equivalent of $ 4 billion. Strategic nuclear parity exists now between the West and the East. In Europe, the West has the edge in terms of tactical nuclear capability, while Eastern Bloc forces outnumber Western conventional forces of NATO by two or more to one. At the present time NATO forces can still deter, although adverse trends continue to erode that capability. The International Institute for Strategic Studies[2] provides additional details on the theater balance between NATO and the Warsaw Pact. Their publication, after a detailed comparison of ground formations, manpower, reinforcements, equipment, logistics, airpower and theater nuclear

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[1] "New Directions for NATO" Conference sponsored by Aviation Week & Space Technology, 26/27 June 1978, Brussels, Belgium

[2] "The Military Balance 1977/78" (International Institute for Strategic Studies, London, England) p. 109

weapons, concludes with the following description:

"CHANGES OVER TIME
The comparisons above begin to look rather different from those of a few years ago. The effect of small and slow changes can be marked and the balance can alter. In 1962 the American land, sea and air forces in Europe totalled 434,000; now the figure is around 300,000. There were 26 Soviet divisions in Eastern Europe in 1967; now there are 31 and they are larger in size (despite the increase of some 25 divisions on the Chinese front over the same period). The numerical pattern over the years so far has been a gradual shift in favor of the East, with NATO relying on offsetting this by a qualitative superiority in its weapons that is now being eroded as new Soviet equipment is introduced. While NATO has been modernizing its forces, the Warsaw Pact has been modernizing faster and expanding as well. In some areas (for example SAM, certain armored vehicles and artillery) Soviet weapons are now superior, while in other fields (such as tactical aircraft) the gap in quality is being closed. The advent of new weapons systems, particularly precision-guided munitions and new anti-tank and air defense missiles, may again cut into the Warsaw Pact's advantage in tank and aircraft numbers, but in general the pattern is one of a military balance moving steadily against the West."

"SUMMARY
It will be clear from the foregoing analysis that a balance between NATO and the Warsaw Pact, based on comparison of manpower, combat units or equipment is an extraordinarily complex one, acutely difficult to analyze. In the first place, the Pact has superiority by some measures and NATO by others and there is no fully satisfactory way to compare these asymmetrical advantages. Secondly, qualitative factors that cannot be reduced to numbers (such as training, morale, leadership, tactical initiative and geographical positions) could prove dominant in warfare. However, three observations can be made by way of summary:

First, the overall balance is such as to make military aggression appear unattractive. NATO defenses are of such a size and quality that any attempt to breach them would require major attack. The consequences for an attacker would be incalculable and the risks, including that of nuclear escalation, must impose caution. Nor can the theater be seen in isolation: the central strategic balance and the maritime forces (not least because they are concerned to keep open sea lanes for reinforcements and supplies, and because of their obvious role in the North and in the Mediterranean) play a vital part in the equation as well.

Second, NATO has emphasized quality, particularly in equipment and training, to offset numbers, but this is now being matched. New technology has strengthened the defense, but it is increasingly expensive. If defense budgets in the West are maintained no higher than their present level and manpower costs continue to rise, the Warsaw Pact may be able to buy more of the new systems than NATO. Soviet spending has been increasing steadily in real terms for many years. Furthermore, technology cannot be counted on to offset numerical advantages entirely.

Third, while an overall balance can be said to exist today, the Warsaw Pact appears to be more content with the relationship of forces than is NATO. It is NATO that seeks to achieve equal manpower strengths through equal force reductions, while the Pact seeks to maintain the existing correlation."

Currently the United States spends 4 to 5% of GNP for defense purposes while the Soviets are spending an estimated 15% of GNP for defense. The Belgian Defense Minister[3] estimates the Warsaw Pact is spending the equivalent of $ 170 billion annually for defense, while the total NATO defense budget in 1977 was $ 175 billion. Thus it would seem that Warsaw Pact governments are pressing additional hardships on Eastern Bloc populations in order to meet military security objectives and, at the same time, are utilizing more effectively roughly equivalent total defense expenditures to tip the military dynamic balance increasingly in their favor.

The initiatives introduced by the present U.S. administration within the North Atlantic Alliance over the past year and a half relating to rationalization, standardization and interoperability add new emphasis to repeated attempts to improve military effectiveness throughout the almost thirty-year history of the Alliance. Realistically, these renewed efforts must be evaluated against a background in which United States military spending as a percentage of GNP has declined from slightly over 9% in 1968 to about 4.8% in 1978. At the same time, the United States has cancelled the production of the new B-1 bomber electing to depend instead on an aging B-52 fleet. In addition, Missile X, the Minuteman replacement, has been delayed and cruise missiles which, when available, should enhance the Western defense posture, have been introduced into SALT discussions as a negotiable capability. From a broader viewpoint, the 3% per year increase in defense spending, agreed to by the NATO nations in their conference of May of 1978, already appears jeopardized. The Economist[4] , in a recent estimate, identified six NATO nations that appeared sure of increasing defense spending by the agreed 3% in real terms for this next year. It identified five more that would not meet this objective, and three others where the probable action of the current government could not be estimated with confidence. This reaction has to be further considered in the light of defense expenditures within NATO which for the period 1970-76 average below 3% of GNP for five NATO nations and above 5% for only three[5]. By their own actions, NATO nations collectively force an objective observer to question how seriously the Alliance as a whole really regards the Soviet threat.

The Economic Situation

Now let's consider the other major area of concern, the economic situation and economic policy.

About a year ago, Mr. Henry C. Wallich, member of the Board of Governors of the Federal Reserve System, gave the Congressional Subcommittee on Europe and the Middle East, an excellent top level summary of the then current

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[3]Paper by Peter Van Den Boeynants, Belgian Minister of Defense, at NATO Conference - see note 1

[4]"NATO - Paying Up", The Economist, 15 July 1978, pp. 46 and 47

[5]"Western Europe in 1977: Security, Economic and Political Issues", Hearings before the Sub-Committee on Europe and the Middle East of the Committee on International Relations, June 14, 1978; July 20, 27; Oct 3 and 14, 1977, page 222

economic situation. He said, "European economies generally have been slow to move out of the deepest recession in the post-war era. Unemployment rates in many countries are as high or higher than they were two years ago at the recession's trough, although real GNP is generally higher than it was two years ago. Inflation rates have come down significantly from recent peaks, but are still high, and in a number of countries have remained in the vicinity of 10%. There has been some noticable improvement in current account positions this year in some countries, e.g. the United Kingdom and Italy, but serious external imbalances remain in some other countries. While some, but not enough improvement in inflation rates is expected, only moderate economic growth is in prospect for the near term. The OECD, in its July "Economic Outlook, forecast average growth of real GNP in the four major European countries - Germany, France, United Kingdom and Italy - at an annual rate of less than 3% in the second half of this year and the first half of next year: a similar growth rate was forecast for the smaller European countries. Unexpectedly weak growth of demand in the first half of this year has not improved the outlook since rates of growth are not likely to be sufficient to reduce unemployment."[6]

He stressed inflation. "Inflation in the United Kingdom and Italy rose to an annual rate of 20% or so. Germany never got into the double digit range. At the present time the rate there is 4%. Italy is still in the low double digit range. In the United Kingdom, depending upon what period of the last year one looks at, the rate of inflation may be very high, something like 18%. During the latter part of this year, the United Kingdom inflation rate has come down to approximately 10%."[7]

In this economic environment, Dun's Review of August 1978[8] reports what it calls "Europe's Subsidy Spree", commenting: "Largely to save jobs, Western European governments are pouring huge sums into aid for a growing roster of companies. The U.S. is demanding that these subsidies be cut back." The article goes on to detail significant subsidy actions. For example, "in France, the government last year took a one-third share in Dassault, maker of the Mirage jet fighter, and Dassault will probably be merged with the state-owned aircraft group Aerospatiale xxx and the government plans to spend nearly $ 1 billion this year in undisguised job preservation."

In other examples, Dun's Review reports also on Germany and Britain as follows: "Germany, despite its ideological commitment to market disciplines, has always had a sizeable public sector and is now beefing up government involvement through massive loans. It has earmarked $ 30 million to help revamp the steel industry in the Saar plus $ 100 million more to subsidize non-steel firms in the area. In the coal industry, on top of $ 2 billion already spent, it is planning to shell out $290 million a year through 1982 to guarantee investment and jobs."

"Britain also is spending heavily on job saving and on boosting weak but 'strategic' industrial sectors. Hundreds of companies are receiving bonuses if they refrain from hiring and firing workers or take on new ones. Last year the government nationalized the entire shipbuilding and ship-repair industry. It is also keeping afloat the state-owned British Steel Corporation which lost $ 1.6 billion last year and is $ 9.7 billion in debt -

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[6]ibid p. 256
[7]ibid p. 252
[8]Jean Ross-Skinner, "Europe's Subsidy Spree", Dun's Review, Aug. 1978, pp. 57-59

and is currently a target of U.S. dumping charges. Meanwhile, the ill-starred state controlled British Leyland Corporation which lost $ 85 million last year, has received further state loans and equity capital. Its struggling competitor, Chrysler U.K., is also being propped up by state funds in a job saving move."

In May of this year, Dr. William A. Cox, Deputy Chief Economist, Department of Commerce, headed a group from Commerce which testified before the Congressional Special Subcommittee on NATO Standardization, Interoperability and Readiness on the trade balance of the United States with Western Europe. He brought Mr. Wallich's earlier projection up to date by noting[9] "Our economy has grown much faster since 1975 than those of our European allies and continues to do so. From 1975 to 1977 our real growth in terms of GNP averaged 5.5% while the other NATO countries averaged less than 3.8%." He also discussed 1978 and 1979 in these terms:[10] "The economic outlook for 1978 (U.S.) is for real output growth at a rate of 4.5%, an inflation rate of 6 3/4 to 7%, and an unemployment rate declining only slightly from its present level, if at all. Although it is much harder to forecast for 1979, we hope to maintain economic growth at about the same pace and to achieve at least some reduction in the rate of inflation and unemployment."

In a macro-economic context he noted[11]: "Our total military deliveries to NATO countries in 1977 were about $ 1 billion, a little more than $ 1 billion. In fact they have averaged within $ 100 million of this level within the past four years. Even in an extreme case in which half of these exports were eliminated through licensing arrangements and the other half offset by equivalent imports--reducing the military equipment surplus to zero--the net reduction of $ 1 billion in production of military equipment in a $ 1,900 billion economy--circa 1/20 of 1 percent--is in the same size class with many other shifts constantly taking place in the economy and is not to be treated as an important economic issue in the context of overall GNP growth (US economy)."

In the context of total U.S. merchandise trade with NATO countries including Canada, he commented as follows:[12] "Since 1970, total export of goods to the NATO countries has risen by 155%, partially due to price increases, to total $ 53.9 billion in 1977, valued as the Census Bureau does it, in terms of goods "free alongside ship". A substantial part of this increase, of course, was due to inflation. At the same time, the value of merchandise imports rose at a similarly rapid pace to $ 52.6 billion. Thus, our total merchandise trade with the NATO countries was in surplus by $ 1.3 billion in 1977, down from $ 6 billion in 1976. Our merchandise trade with other countries of the world showed a $ 28 billion deficit, which is largely to Japan and the OPEC countries. These composite figures for NATO trade disguise quite different trade patterns with the European NATO members on one hand and with Canada on the other. In 1977, merchandise trade with the 12 European members was in surplus by $ 5 billion (census data). Trade with Canada, in contrast, showed a deficit of $3.6 billion."

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[9]Transcript, Hearings before the Committee on Armed Services (Special Subcommittee on NATO Standardization, Interoperability and Readiness) 31 May 1978 p. 7

[10]ibid p. 14

[11]ibid p. 17

[12]ibid p. 21

Specifically with respect to military expenditures, he provided the following data:[13] "The Commerce Department's Bureau of Economic Analysis has estimated total exports of military goods and services to NATO countries under government military sales contracts at $ 1.1 billion for 1977, xxxx Net commercial trade in military goods with NATO is estimated by the Department of Defense to have yielded a surplus of $ 65 million in 1977. Thus, the U.S. surplus in trade of military equipment and services with NATO countries, not including procurements in support of U.S. Forces stationed abroad, of a not directly military nature has run at somewhat less than $ 1 billion annually for the years 1974 to 1976. It ran $ 1.1 billion in 1977. However, this component of our overall surplus in military trade has constituted a steadily declining share of the total U.S. surplus in military trade since 1969."

"When total U.S. defense related expenditures in NATO countries are considered, of course, the picture changes substantially. Defense related expenditures for goods and services in the NATO countries for fuel, other supplies, employment of foreign nationals and other purposes outweight U.S. military exports to these countries every year. These expenditures came to $ 3.1 billion in 1977 for an overall deficit in defense related transactions with NATO countries, of $ 2 billion."

In sum, the picture of economic factors that emerges includes nations on both sides of the Atlantic struggling with a series of economic problems. Many are troubled with unemployment and high inflation. The close relationships in European nations between government and industry involving forms of ownership and subsidies, reflect the acceptance of socialistic philosophies and the continued fragmentation of European markets. Conversely, the United States with an arm's-lenth relationship between government and industry has exploited large integrated domestic markets through extensive industrial competition. Lacking an export trade promotion policy and hampered by government regulations stemming from a variety of political philosophies, the U.S. confronts an increasing export trade deficit that in 1978 will be in the region of $ 30 billion. The differences in government/industry relationships between the United States and NATO European countries appear to cause less concern when their industries are competing in third markets than when they attempt to interface effectively and support cooperative programs. One significant missing link in the government-to-government discussions involving RSI has been and remains the absence of effective U.S. industry input to these discussions. With respect to the trade situation between the United States and NATO Europe, total trade figures between the United States and European NATO nations show a surplus of $ 5 billion in favor of the United States referred to U.S. exports of goods to NATO countries (including Canada) of $ 53.9 billion (1977 figures). When total U.S. defense related expenditures in NATO countries are considered with respect to U.S. military exports to these countries, there is a surplus favoring European NATO countries of $ 2 billion referred to total U.S. expenditures of $ 3.1 billion (1977 figures). Finally, considering only trade in military equipment and services, there is a surplus in favor of the United States that has run at somewhat less than $ 1 billion annually for the years 1974 to 1976. This economic quantification, imprecise as it may be, defines a situation identified by many solely in terms of the debated ten-to-one or five-to-one ratio. These ratios may reflect an emotional issue, but hardly express a logical analysis.

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[13] ibid p. 25

Into this Mulligan stew of economic problems and military needs, the flavoring of nationalism and national interests is added in unique measure by each country. England and France developed their own nuclear capabilities so as not to be dependent solely on that of the United States. Each NATO country, no matter how small, seeks to protect defense industries as a security need of their own future. Just as the United States does not care to be bound to the political will of its allies through unilateral production sources of military equipment, so do our NATO Allies reject being bound to the historically shifting political initiatives of the United States. To a considerable extent the impact of nationalism and national interests on the defense problems of the Western Alliance differs by an order of magnitude from similar influences in the Eastern Bloc. While the political leadership of the Soviet Union cannot totally neglect the aspirations of satellite nations or their populations, these interests are by no means accorded the stature of those of sovereign nations. Nationalism and national interests pertain also to the worldwide roles of the United States and the Soviet Union. As General Haig so eloquently pointed out in his speech at the AFCEA National Convention, "Finally this relentless application of resources to the defense sector in the Soviet Union has changed the very nature of the threat itself. At the outset of this alliance we were confronted with a threat that was essentially Continental in character and Eurasian in scope. The focus on force balances in the central region of Europe and the deterence of a classic military onslaught across the Western frontier, which predominated then, was indeed the appropriate response to challenges with which we were faced, but today this is no longer the case. Global in character and broadened in its applications, the Soviet threat now challenges the political, economic and security nexus of Western vitality, far beyond the territorial limits of Western Europe. It is for this reason that the most important task for the West in the future will be the management of global Soviet military power."[14] This strategic observation by General Haig underlines the unique national interests of the United States and projects a concept which the NATO Alliance has yet to accept.

The last two NATO summit conferences have focused on improving the military capabilities of the Alliance and responded to initiatives proposed by the present administration in the United States. These conferences and their results, placed in the economic context of NATO nations and national interests, have in turn led to the emergence of significant issues involving Congress, U.S. industry and the administration. The discussion focuses on 5 issues relating to standardization, technology transfer, co-development and co-production, world markets or third country sales, and interoperability. Defense Department spokesmen have articulated DOD proposals involving these issues to the Congress, to various organizations and associations, and in smaller discussions on specific issues. While DOD conceptual thinking is clearly evolving, current views appear to be those identified in subsequent paragraphs.

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[14]Gen. Alexander M. Haig, Signal Magazine, Vol. 32, No. 10, August 1978, p. 36

Concepts for standardization focus on equipping many different national forces with the same weapons systems. Reflecting a current of European opinion against purchasing weapons systems from the United States, the Administration has accepted the need for "a two-way street" in weapons procurement and proposed "a family of weapons" concept to partially achieve that two-way street.

The "family-of-weapons" concept proposes that families of related next generation weapons systems be divided by international agreement between NATO nations with one country taking the lead in developing each element of the family. After development, then all NATO countries could buy or license and build the resulting systems and all would have common systems. In the conceptual theory, development costs would be reduced, volume would reduce production costs and by accepting this increased degree of interdependence either overall defense budgets could be reduced or increased military capabilities generated within the same volume of defense spending. From a military viewpoint, the advantages are obvious. Standardization, with the resultant simplification in maintenance and support functions, should translate directly into momentum as a desired capability for military forces in combat. At the same time standardization would come at a price. That price involves: (1) increasing interdependence between the members of the Alliance (viewed as a price by those who insist on the doctrine of national sovereignty), (2) for the United States conflicts between European NATO military needs and world-wide military responsibilities (in this connection we have already seen standardization for a NATO rifle cartridge set aside in order to meet the needs of combat in Vietnam), and (3) perhaps most importantly, the bureaucratic processes of standardization can only add to the present overly long development cycle time (habitually the problem within the United States). A NATO Defense Minister has hypothesized that both cost and time required to complete a program involving a single country would be multiplied by the square root of the number of participants if the same program were undertaken on a multinational basis.[15] Standardization also comes with other fundamental problems. One of these concerns government/industry relations noted earlier. Mr. Cox provides two good examples: "The British Government--and this is an interesting contrast, especially, I guess, when you consider the results--plays a far more active and interventionist role in industrial affairs than does the U.S. Government. xxxx The government's participation includes state ownership of several large industries, financial assistance to selected private sectors, equity ownership in several companies and government assistance to promote exports. Last year both the aircraft and shipbuilding sectors were nationalized. Government financial assistance to these industries had been heavy and will continue. Previously nationalized industries, such as British Steel Corporation and British Leyland, the auto firm, also receive substantial government support to offset operating losses.xxx This close relationship between major industries and government insures the survival of many firms and doubtless puts great political pressure on the government to provide financial, procurement, and other support to them."[16]

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[15] Lt.Col. Eiland, USA, "The Two-Way Street in NATO Procurement", The Strategic Review, Summer 1977, p. 65

[16] Transcript, Hearings before the Committee on Armed Services (Special Subcommittee on NATO Standardization, Interoperability and Readiness) 31 May 1978, p. 7

He commented on France as follows:[17] "The French economy, and therefore the industrial sector, is subject to a system of 'indicative' planning which leads to a much greater extent of government intervention than in the United States. Furthermore, government ownership of major industries is more widespread than in the United States. xxxx Both government-owned and private-held corporations benefit from an array of subsidies intended to steer investment toward high technology industries and those which promote exports. xxxx The French Government applies a de facto preference for domestic goods through negotiated contracts rather than open bidding. xxxx A 1976 report on the French aerospace industry indicates that by June 30, 1976 the French Government had provided loans of $ 366 million for this project (Airbus), almost none of which have been repaid."

The experience of almost thirty years suggests that standardization cannot be achieved for any significant number of weapons systems within the current mechanisms of the Alliance. Standardization may be achievable for a limited number of costly weapons systems using new innovative procedures.

Technology transfer looms as a difficult issue. Proponents argue that in order to make the most effective use of technological developments funded by national governments, the United States with $ 12 billion annual expenditures, must transfer technology to Europe with $ 4 billion annual expenditures. Pragmatists rebel, pointing out that historically the results of military research and development flow into civilian product lines and world-wide markets. As a consequence, from both military and economic viewpoints, the technology developed in the United States must be viewed as a national asset and expended by transfer only to meet the most demanding needs and then in a manner consistent with normal business practice. Mr. Cox commented to the Special Subcommittee on the issue of technology transfer as follows:[18] "The most troublesome economic questions likely to arise in the implementation of NATO standardization policies will involve the transfer of advanced U.S. technological know-how -- through licenses, including blueprints and other technical data and instructions -- without which European allies will not be able to produce their share of the "co-production" hardware and other products up to the standards of U.S.-made counterparts. xxxx The trouble is that much of the advanced technological know-how currently used in manufacture of military equipment also is usable in production of internationally traded technology-intensive "civilian" products, and the greater superiority we have in this technology the more products we can export. xxxx We have been losing this superiority gradually in manufacturing technology for some time, and there is a danger that the transfer associated with policy of standardization might accelerate these losses. As far as we can see, the only way this danger can be avoided is by negotiation of co-production arrangements so that the co-production shares going to Europe would require mature and commercially available technology and thus minimize the transfers of technology that might hurt the United States commercially in the future."

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[17] ibid p. 38
[18] ibid p. 45

The only difficulty with Mr. Cox's solution is that it runs counter to arguments that European NATO industry must have advanced technology in order to successfully participate in the NATO defense market. The consideration of technology transfer appears to argue also for focusing multinational programs on major system requirements under carefully controlled procedures. Once again, the mechanisms of the past do not appear suitable to meet the needs of the future.

Co-development and co-production concepts tend to provide greater possibilities for effective standardization although little opportunity for cost savings. Nations participating in a co-development and co-production program would receive benefits commensurate with their contribution. National participation should help generate a broader degree of standardization.

Multiple production sources may increase costs unless production runs are high enough to justify these multiple sources. The most significant disadvantage is apt to be the increased time required for development if the square root rule applies. Innovative approaches for multinational co-development and co-production should afford the opportunity to retain a high degree of industrial competition for such programs. Selecting only a limited number of key weapons systems for co-development or co-production should focus the attention necessary to ensure success.

Worldwide markets command the attention of every NATO European country. Success in export markets remains fundamental to survival. The technology generated to meet military needs supports also civilian products for these markets. As a consequence export trade for individual nations involves both the export of weapons systems and the export of civilian products that are spin-offs from weapons systems expenditures. Without exception, any weapons system development undertaken in a NATO European country, either with or without the collaboration of the United States, will result in products, civilian and military, marketed in world export markets. In general, European NATO governments and industry correlate their activities so as to foster the development of this export trade and increase market penetrations throughout the world. The situation in the United States was well summarized in an article "The Reluctant Exporter".[19] In a broad-ranging review, that article reported both the lack of attention of many sectors of American business to export markets and the anti-export policy of Congress and successive administrations which have paid lip service to promoting exports while actually inhibiting them with laws and regulations. The policies of the current administration, restricting or inhibiting weapons systems sales for a variety of ideological arguments as well as the essentially flat (in constant dollars) national research and development effort, add to the existing adverse environment for U.S. companies to address export markets. The present administration, reacting in part to some understanding of this problem, created a task force in April on export promotion. The report submitted to the President in July and awaiting his action included recommendations that could increase U.S. export sales by $ 10 to $ 15 billion over five years. To date there is no indication that either the President or Congress yet recognize the increasing importance of export trade to the United States, nor the pressing need to address export market issues broadly and within the context of the NATO problem.

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[19] "The Reluctant Exporter", Business Week, April 10, 1978, pp. 54-57, 60, 65 and 66

Interoperability receives strongest support from military or requirements oriented activities within NATO that emphasize the needs of combat. Such key elements as interchangeable ammunition and fuel supplies, organizations and procedures which facilitate cross servicing and cross support arrangements, and the ability to interconnect dissimilar functional systems such as communications receive great emphasis. In point of fact, in the current situation, with forces already equipped with a wide variety of weapons systems and equipments, the actions that could produce the most immediate improvement in combat capability are those which relate to increasing interoperability in selected areas between NATO committed forces of different nations. This factor seems not to be emphasized by DOD spokesmen in the United States and admittedly shows little promise of reducing total defense budgets or more efficiently utilizing those defense budgets in any theoretical sense.

What can be done?

Certainly, American industry as well as every American citizen has a compelling interest in the military security of the United States. Certainly the goals proposed by the Administration and by the Congress, namely to enhance military capabilities of the North Atlantic Alliance, and to obtain more effective use of funds made available for defense purposes, are whole-heartedly supported by the vast majority of American industry. At the same time, differing views exist on methods of implementation. Many believe the Defense Department, in its effort to strengthen NATO, has not adequately consulted with other departments of the government with equally important responsibilities for the economic well-being of the country or with U.S. industry. Many believe these economic issues, of equal importance to defense considerations, must be addressed at the national level where political judgements can interrelate major economic and the security factors.

For early increases in military capability, interoperability should be emphasized. Interoperability would at least permit varied national forces to exchange ammunition, communicate effectively, refuel and service each other's aircraft and, in general, reduce many of the barriers to effective combat operations. Interoperability will not reduce the large logistic problem associated with multiple equipments and multiple sources. To focus on interoperability the NATO Defense Planning Committee should direct the preparation of a coordinated plan to improve interoperability. The plan should include agree equipment interface specifications, including form fit and function, standard practices, and/or standard procedures - any group of actions that when taken can facilitate interoperability in any effective manner. Such a plan should result in recommendations in a year or less to a NATO summit conference, in a way similar to the Long-Term Defense Program recommendations that were reported this year.

Concurrent with the emphasis on interoperability, the NATO nations together should address the reduction of tariff and non-tariff barriers on a reciprocal basis so as to develop the maximum defense industry base on both sides of the Atlantic that truly competitive processes can support. At the same time a capability should be created to monitor NATO Defense Equipment Market actions so as to identify for the North Atlantic Council those actions which can be taken to increase the effectiveness and competition within this market.

With respect to standardization, a multinational team of major NATO countries, namely the U.S., U.K., France and Germany, should blueprint a multinational Weapons System Development Management Agency. This organization would develop innovative methods and procedures to initiate and oversee cooperative weapons systems developments executed on a competitive basis by multinational industrial consortia. This organization should envision a requirement for only a small number of the most important programs. For this approach considerable benefit could be derived from European thinking regarding the evolution of the Independent European Program Group, and from experiences with the NATO Integrated Communications Systems Management Agency."

If these actions are supported then we can indeed take realistic steps toward President Carter's defined goals:

> "To eliminate waste and duplication between national programs;
>
> "To provide each of our countries an opportunity to develop, produce and sell competitive defense equipment; and
>
> "To maintain technological excellence in all allied combat forces."[20]

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[20] President Carter's Address to the NATO Conference in London, May 1977, New York Times, 11 May 1977



BIOGRAPHICAL DATA

Major General Robert D. Terry, USA (Ret), is Director International/ Government Planning (Washington) for Rockwell International. Formerly Vice Director Defense Communication Agency, his active service assignments included a wide variety of tactical and strategic communications responsibilities in both European and Pacific theaters. Since retirement, his activities have involved international business planning. General Terry graduated from the United States Military Academy, was commissioned a Second Lieutnant and assigned to the Signal Corps in 1942. During World War II he served in tactical signal units in the European and Pacific theaters. After receiving his M.S. degree in Communications Engineering from the University of Illinois in 1948, he served successively in assignments in Alaska, on the Faculty of the United States Military Academy, in the Office of the Chief of Research and Development, Army General Staff, and on the Staff of the U.S. Defense Representative to NATO. He later participated in the intervention in the Dominican Republic as J-6 of U.S. Forces, then organized and commanded the 1st Signal Brigade in Vietnam. After commanding army communication units in the Pacific, he returned to the Defense Communication Agency. On 30 June 1975, after four years as Vice Director of the Defense Communication Agency and 33 years of active service, Gen. Terry retired. He joined Rockwell International in July 1975.

NATO's FIRST AUTOMATIC SWITCHED VOICE INTERFACE -STANAG 5040-

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ABSTRACT

STANAG 5040, which provides for automatic dial-through voice service between national tactical military communications systems of the NATO nations, is described. The STANAG represents the results of several years of NATO planning and marks the first introduction of automatic service of this type in NATO. The presentation describes the historical context in which the STANAG was developed, its intended use, descriptions of its tactical employment, and a discussion of its major procedural and electrical characteristics.

I am going to speak to you this afternoon about NATO STANAG 5040. But before we delve into the specific aspects of the Agreement, I would like to lead you through a brief historical chronology, to put it into its place within the context of other NATO work in the arena of tactical communications systems interoperability. After this, I will describe the general features of the STANAG and then follow with more detailed descriptions of its use, design and capabilities. Finally, I will discuss how changes could be made to it, to further adapt it in the future. By the end of this presentation, I hope you will be sufficiently familiar with its fundamental aspects, to enable you to better appreciate the two companion presentations which will follow.

NATO efforts in communications interoperability in the early 50's (in the absence of the large scale, integrated communications approaches of today) were expended primarily at attempts to achieve limited interoperability of various communications components; thus one would find a NATO group on modems, one on radios, another on manual interconnect facilities, and so on. This situation changed in the mid 60's, with the emergence of system concepts for complete national systems. In this period, NATO committees began to wrestle, in depth, with interoperability at the system rather than the component level. NATO first attempted an idealistic approach. Why not, they asked, define a single set of common standards to which all countries would agree to design their national tactical systems? Such an approach, if successful, would result in natural interoperability, complete compatibility at all of the important interoperability points, thus eliminating completely the need for

special interface equipments to convert from one countries' standards to those of another.

It was quickly realized however that this approach was impossible to attain within the then existing time frame, for a number of reasons. The most important was that the major equipment producing countries were already engaged in extensive development programs for their own national systems, and had already become well locked into divergent technical approaches. For economic reasons alone, these programs could not have been altered, without severe economic penalties for those nations who had already made heavy R&D investments in their programs. There were, of course, extensive and irreconciliable differences in these national approaches.

One important conclusion which was reached was that in order to have a reasonable probability of success in the common standards approach, the process of discussion, deliberation and agreement must be long enough and started early enough so that no individual national approach developed divergently to the point of no return. In the 60's, most of the national developments were indeed destined to produce divergent systems which would be fielded in the 70's and the 80's. And today, the prophesy is being fulfilled; these systems are indeed well on their way toward realization and fielding.

Having realized these facts, NATO agreed to substitute another course of action, actually two concurrent courses of action. The first was to formulate an interface standard which would provide for an acceptable level of interoperability between the (now) current generation of national tactical systems. This effort culminated in the development and ratification of STANAG 5040, the subject of this presentation. The second course of action was that immediate discussions should be started on the potential characteristics of the succeeding generation(s) of systems, that is to say, the (now) next generation of systems, with the aim of producing the requisite convergence of national thinking on the future design of these systems. In this way, it was reasoned, interface equipments needed for the current generation may be gradually dispensed with, and the ideal natural interoperability would ultimately prevail. This second course of action is underway at present, in a renewed and intensified effort to produce the needed convergence of technical approach.

Hence, it is the STANAG 5040 concept, the result of the first action, which must serve as an important bridge between the present generation of systems to the future generation of systems. Because of its requirement to translate between the characteristics of two diverse national systems, its design is essentially one of compromise. The design objective for STANAG 5040 was not to achieve an "optimum" capability, but to embody the simplest and most economic approach for all nations, while still maintaining an acceptable level of interim interoperability performance. In the subsequent discussion of STANAG 5040's characteristics, you will want to keep these factors in mind.

The term "STANAG" is a short name for "Standardization Agreement." A STANAG is born when two or more NATO nations agree to adopt some sort of common practice. STANAG 5040 represents an agreement among the NATO nations to adhere to specific agreements for telephone voice service, between different national tactical systems. When nations field equipment based upon STANAG 5040, certain authorized subscribers of two adjacent national systems, can call one another automatically without the intervention of manual switchboards or other manual interoperability methods. It will also allow automatic "transit" calls, that is, dialed calls from one system to another through yet a third system (the transit system), even though the communications systems of all three nations can be different from each other. Other general features of the STANAG are the signalling of precedence levels across the interface and the capability to signal the use of non-voice terminal equipment for mode-matching purposes.

A party to the STANAG is the NICS, the NATO INTEGRATED COMMUNICATION SYSTEM. The NICS is NATO's own communications system which fulfills the need to provide the major NATO commanders and political headquarters with reliable and modernized communications. This system is being developed under the management of a special NATO agency specifically created for this purpose.

The STANAG also provides an automanual operation capability to allow those countries not yet possessing the necessary automatic switched service within their own systems to still access other national systems on a manual basis.

The principle of STANAG 5040 can be illustrated as follows; take two different national systems and connect them together through some sort of conversion device which transforms the channel and signalling characteristics of one into the other (Figure 1a). If we were to stop here, several problems would arise. Who supplies the box, and who designs and builds it? Even more serious, each country could require up to 15 of these boxes, all differently designed to match into the characteristics of 15 potentially different national systems.(1) The next step in the process is the crucial one and eliminates these difficulties. The box is simply chopped in half (Figure 1b), and the halves are connected by a multipair cable, (Figure 1c). Each half-box is called an NATO Interface Unit (NIU) and the point between the two NIUS is referred to as the common NATO Interface Point. At this point, common NATO standards based upon analog voice and DC signalling are defined. Each nations designs (only once) its own NIU which can serve to connect to that of any of the other thirteen nations and the NICS.

You may ask, as this point, if STANAG 5040 will provide this rationalization why should NATO bother to look further? The answer is that STANAG 5040 is a compromise solution, developed to fill a gap in time, and consequently it has fundamental disadvantages in flexibility, mobility, security, speed and other important factors, compared to what is achievable by present technology. It must inevitably be supplemented by interfaces based upon more current techniques and, eventually, it is

(1)This includes the NICS.

hoped, by common system design parameters. Nevertheless, with all of its inherent deficiencies, STANAG 5040 is a great first step forward in NATO communications flexibility and utility, and, as you shall see, parts of STANAG 5040 will be capable of modification in the future to meet possible new requirements.

I want you to know that NIUS have been built by Germany and France in the fully automatic version. The UK has developed it as an automanual initial version. All three of these countries have tested them both individually and together with excellent results. The US has also built automatic prototypes under the TRI-TAC Program. We intend to use these NIUS with both the TRI-TAC AN/TTC-39 switch, and with the AN/TTC-38 switch. Early next year, we will join with France, Germany and the UK for another series of joint tests of these units. So you can see, we are not speaking about a theoretical idea, or a useless piece of paper in the files. The nations have already embodied STANAG 5040 in equipment design, hardware, and test. It is a real life thing and this makes it all the more interesting to present it to you.

In Figure 2, we have a idealized illustration of an arrangement of national communications systems. Four national systems and the NICS are shown. The circles represent national tactical automatic switches, and each system is shown operating independently. Next (Figure 3), we show how the interface links are established to interconnect the systems at several points. Borrowing from already existing well established military doctrine, when an interface link is to be set up, it is the system to the left, facing the front, or the system to the rear of the front which bears the responsibility for the link to its neighbor. In most cases, the interfacing switches will be separated by a considerable distance, which will require the use of a radio relay link to be put into operation. The left hand or rear system will provide such a multichannel link, which will be terminated in an NIU, pictured as a rectangular box. Numerous such links are set up to establish a multi-connectivity among the several national systems.

The next illustration, (Figure 4), shows how a call request is connected through from one subscriber to another in an adjacent system through one of the interfaces. Finally, Figure 5 shows a transit call through a third system. In this case, the US system is playing the transit role. I want to describe to you, the several levels of agreements called for by STANAG 5040, and I choose to illustrate these levels in a manner which differs from that actually used by the STANAG. By this device, I shall be able to differentiate more clearly the role which each level of standardization plays.

Level One Standards, (the terminology is mine), are those agreements which require each national system individually to be capable of adaptation to the STANAG, (Figure 6). The most important ones are listed here.

All subscriber numbers are either seven or ten digits in length. When NATO began developing this STANAG, several of our fellow nations had

systems using other than these lengths. One had a five digit length, one a six, and one even used an open numbering plan ranging from four to eleven digits. Standardization on a common number length produces several important simplifications of hardware and software, so our fellow nations not using seven or ten agreed to modify their own systems to seven digits, even though their own system concept did not require this.

Next, country codes for exit dialling had to be agreed, and national systems had to be able to recognize these codes and use them to route to the appropriate interface point. Three-digit codes were agreed, selected from 900 to 919. The use of codes 900 to 919 makes it possible to associate each national system with a specific code according to an agreed assignment plan, (Figure 7).

The design of this number represents another interesting compromise. European countries have agreed that 9 in the lead digit always represents the beginning of an exit code, but the US system relies on either a 0 or 1 in the second digit to signify the same thing (a hold-over from the DCS and Commercial Bell System). Many US tactical seven digit numbers do in fact begin with the digit nine and to avoid confusion both criteria appear in the NATO exit code number. All exit numbers begin with either 90 or 91 so that, one way or the other, all NATO countries can recognize exit codes properly. The code set has four spare numbers which can be used to assign to special detached informations, or to solve the case where one system is bordered on either side by forces of the same nation.

Each national system uses its own routing procedures within its own system boundaries. For preemption, each system must be able to recognize one of the three standard NATO precedence codes across the interface and make a suitable translation into one of its own categories. The STANAG contains a precedence conversion chart which shows how each nation should make the conversion. Three levels of precedence are standardized across each NATO interface, "Routine", "Ordinary", and "Special". "Special" ranks highest, "Routine" equates to no precedence, and "Ordinary" ranks between the two. The number of national precedence levels vary from nation to nation. Some nations presently have two levels and some, like the US have as many as five. Some form of rationalization across the interface was required and STANAG 5040 provides this by showing how each countries' precedence levels should be translated into one of the three NATO levels at each interface and then translated back into the interfaced nation's precedence system.

All systems will be able to recognize a mode digit in the signalling sequence. The mode digit distinguishes normal calls (calls in unsecured analog form at the interface) from vocoder calls (calls which are to be vocoder encrypted across the interface). The use of this mode digit allows mode matching between systems employing vocoder service to certain subscribers and also potentially allows certain sophisticated delta systems to provide loop around vocoder/delta conversion automatically at a switch.

Each automatic system also allows their subscribers to dial the appropriate mode, precedence, country codes and subscriber numbers into their system for both direct and transit calls.[1] Finally, each system must check its subscribers' authorization to place NATO calls.

Level 2 Standards (Figure 8) are those which must be observed between the two interfacing switches themselves, and are standards of format; that is, the sequencing of line supervision, signalling, and address timing. For most nations, these signals are generated by the interfacing switches.

Level 3 Standards (Figure 9) apply between the NIUS themselves and deal directly with the electrical structure and the arrangement of cable wiring between the NIUS of the interfacing nations. Figure 10 shows a more detailed view of a typical interface link between two neighboring switches, and delineates the division of responsibilities for the link. In this case, system A is responsible for activating a multichannel radio relay link (usually 8 channels) to the B switch. All of the equipment contained within the ellipse is located in a secure area within the switching center complex of system B. All the equipment up to and including the cable, is provided by system A's resources. System B provides only its own NIU, which contains a connector into which the cable connector can be easily plugged.

A key provision of the STANAG provides for standardization of the cable connector; it is the U-185B/G, of hermaphroditic design. Each pin on the connector is specified in terms of channel number and voice or signalling wire. The cable itself is specifically wired to the connector in a "crossed over" manner. This provides for automatic interchange of receive/transmit wires for both signalling and voice, which makes field assembly between two NIUS simple and rapid. The cable itself is 50 meters long, allowing some flexibility in the relative locations of the equipments.

Each channel in the cabling between NIUS (Figure 11) is composed of a six wire group and there are up to eight channels per interface, not all of which have to be used. A common ground serves all eight channels. Each channel has a four wire group for full duplex voice, and two wires for signalling, (each wire together with the common ground carries signalling in each direction, Figure 12). Each channel carries its own individual signalling pair. All signalling between NIUS is accomplished on a DC basis.

A typical signalling sequence for a call originating in System A would proceed as follows, (Figure 13). NIU A signals a request (seize) by establishing a positive DC level on its signalling wire S(AB). NIU B responds, after a time, with an acknowledgement (seize ack) by placing an identical DC condition on its signalling wire S(BA). When NIU A recognizes this seize ack, it starts pulsing its signalling wire, S(AB),

[1] Mode and precedence may be provided by the system in certain cases.

to indicate, successively, the mode digit, precedence digit, and address digits including any three digit country codes needed to establish a transit connection (up to 13 address digits can be transmitted). After the pulsing of address digits, NIU A reverts back to its "seize" condition and, when the connection is established, voice communications can be maintained over the other four voice wires. Both signalling wires stay at DC levels to indicate that the circuit is busy. Communications is terminated when "release" is given by one of the two sides, (the seize or seize acknowledge condition is nulled), in which case "release acknowledge" is returned by the other NIU and the circuit is now back in the idle condition in which we originally found it.

Although we just spoke as though the NIUS were responding to each other intelligently, these processes are really being carried out by the interfacing switches, where the signalling and supervision signals are generated and recognized. The NIUS are merely signalling converters which change the signal formats into the electrical standards agreed by NATO.

Incidentally, here is where an interesting problem occurs in signalling. Because of the bilateral symmetry of the signalling wires and the signal DC levels themselves, the seize and seize ack signals are electrically identical. Were both sides to attempt a seize almost simultaneously, both sides could be fooled into thinking that a "seize" was a "Seize Ack." To avoid this "glare" problem, STANAG 5040 incorporates the use of "guard times" to separate "seize ack" from "double seizures." The guard times were initially calculated to work correctly over normal terrestrial radio links and with switch processing times of up to 400 milliseconds. However, NATO recently recomputed these guard times using typical satellite delays and switch processing times which incorporated national fixed transmission and conversion delays as well. The recomputed values are applicable to both US automatic switches, the AN/TTC-38 and 39. Later this afternoon, in a companion paper, this subject will be explored in considerable depth.

Now that we have gone through the three levels of standardization, let us go once again back to an overall picture of two interfaced systems and describe the process of placing and routing a call through the interface. A subscriber in System A wishes to call a subscriber of System B, (Figure 14).

Subscriber (a) dials enough information to allow his system to reach the interface point. All this is called Part A of the address format. If this description sounds vague, remember that each national system places different demands upon its subscribers in terms of dialling formats and no one format can be prescribed for all systems. The form of Part A is a national prerogative, but will certainly include the country code, in this case 903 for France. Subscriber (a) also dials information on the mode (T) and precedence (P) which is desired.(1) All of this information is followed by the seven or ten digit telephone number of subscriber (b).

(1) Unless this information is switch-supplied.

Subscriber (a)'s parent switch interprets the information of Part A, and sets up the path to the interfacing switch on the US side, which, recognizing an interface call, finds an idle channel across the interface and signals its neighboring System B (France) as described previously. It then passes only the seven or ten digit telephone number of subscriber (b), to system B, through the interface. System B's interfacing switch interprets these digits and proceeds to set up the path to subscriber (b).

Another example shows the transit case (Figure 15). German subscriber (a) desires to call US subscriber (b) whose number is 2147263. Using the country codes specified by STANAG 5040, subscriber (a) will dial a number which contains Part A (which includes 903) followed by 914, (the country code of the US), followed by subscriber (b)'s telephone number (2147263). Thus the entire dialled number, exclusive of mode or precedence digits, will look like 903-914-214-7263. As in our previous example, System A, (Germany), uses 903 to route to the German/France interface. The German interfacing switch then drops 903 and signals 914-214-7263 across it. At this point, the French interfacing switch will recognize 914 as the interface code for interfaces with the US system. It will then route to the France/US interface where France will delete 914 and signal 2147263 across it. The US then uses the telephone number to route to subscriber (b).

I said earlier, that STANAG 5040 possessed the capability to change in the future. It should now be clear that of the three levels of standardization, two are related to capabilities of the national switches themselves, and only one is directly related to the design of the NIUS. Most of the functions associated with the national switches are implemented in software, and these can of course be upgraded. The switches themselves provide for country code recognition, routing, pre-emption, and mode recognition. In essence, the NIUS function primarily only as signalling converters and to provide voice-band analog traffic channels.

So it is entirely conceivable, that by future agreements, the national switches can be upgraded to perform more sophisticated operations without necessitating changes in the NIUS themselves. For example, country codes may be passed <u>through</u> each interface, rather than deleted prior to interface transmission. This could enable multiple transits instead of a single transit to which the STANAG is now limited.(1) Another extension could be to enlarge the country code length to include a national area code as well. This would generalize the set of country codes in a manner which could better cater to deployments involving national forces which are geographically split or where one national force is placed under the temporary command of another national force. A discussion of the versatility and flexibility which could be achieved by these extensions is beyond the scope of this presentation, however, they are well within the reach of most national systems to implement.

(1) In some cases, two transits are possible.

In summary, what I have presented to you represents the major voice interoperability features of the STANAG. As you can see, the conception of the NIUS and the NATO standards between them are simple enough. More complex are the Level 1 and 2 agreements which relate to the procedures and formats which impinge on national switch processor capabilities. It was in the area of these agreements that a significant portion of the years of development of the STANAG was devoted.

As further NATO work in tactical communications progresses, we hope to witness the introduction of new STANAGS which will feature digital interface procedures. These will offer substantial improvements in the flexibility of interface service and will not need to utilize the dual translation of STANAG 5040.

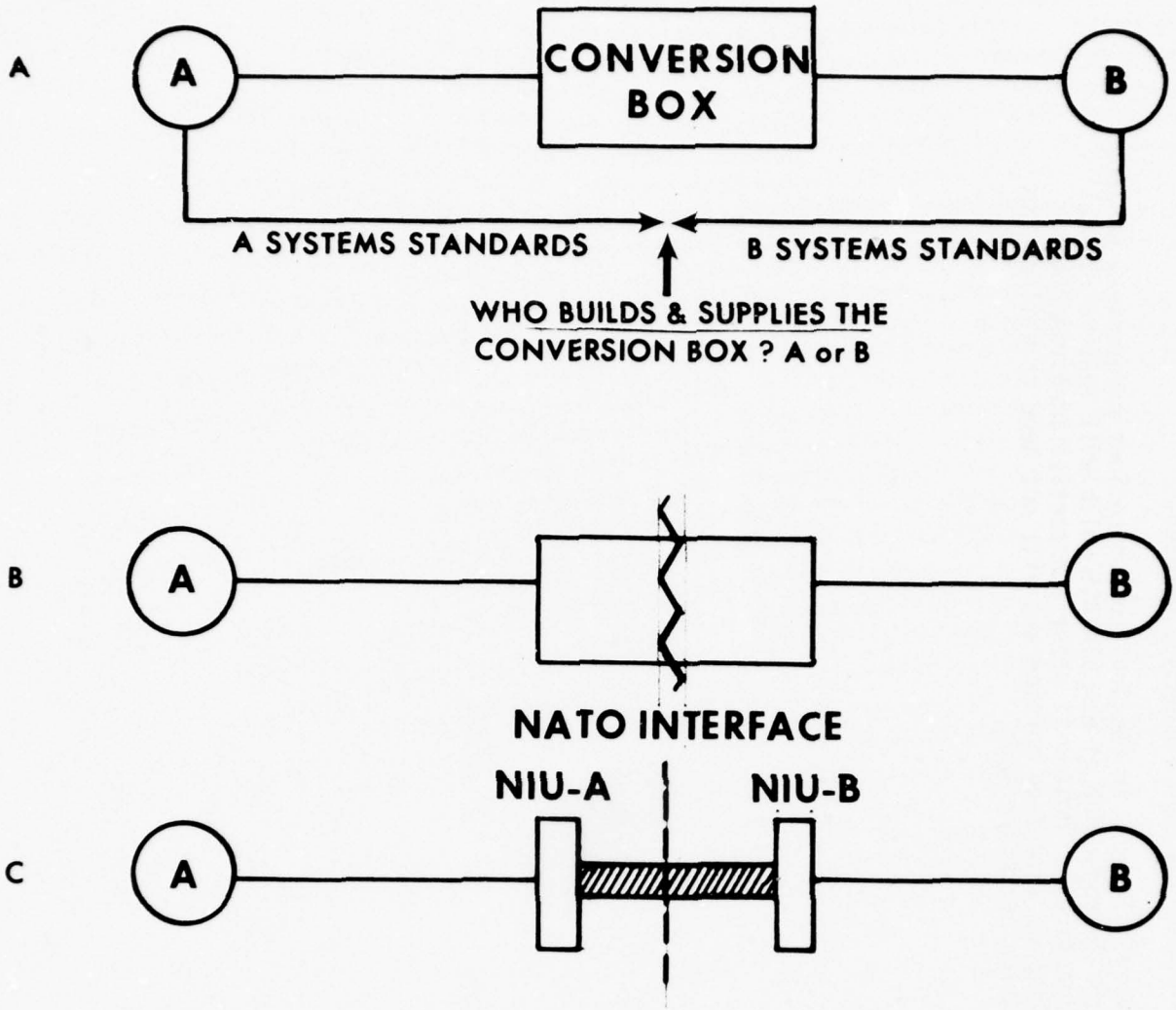


FIGURE 1 - DEVELOPMENT OF INTERFACE PRINCIPLE

NATIONAL SWITCH

TRANSMISSION LINK

NATO INTERFACE CABLE

NATO INTERFACE UNIT (NIU)

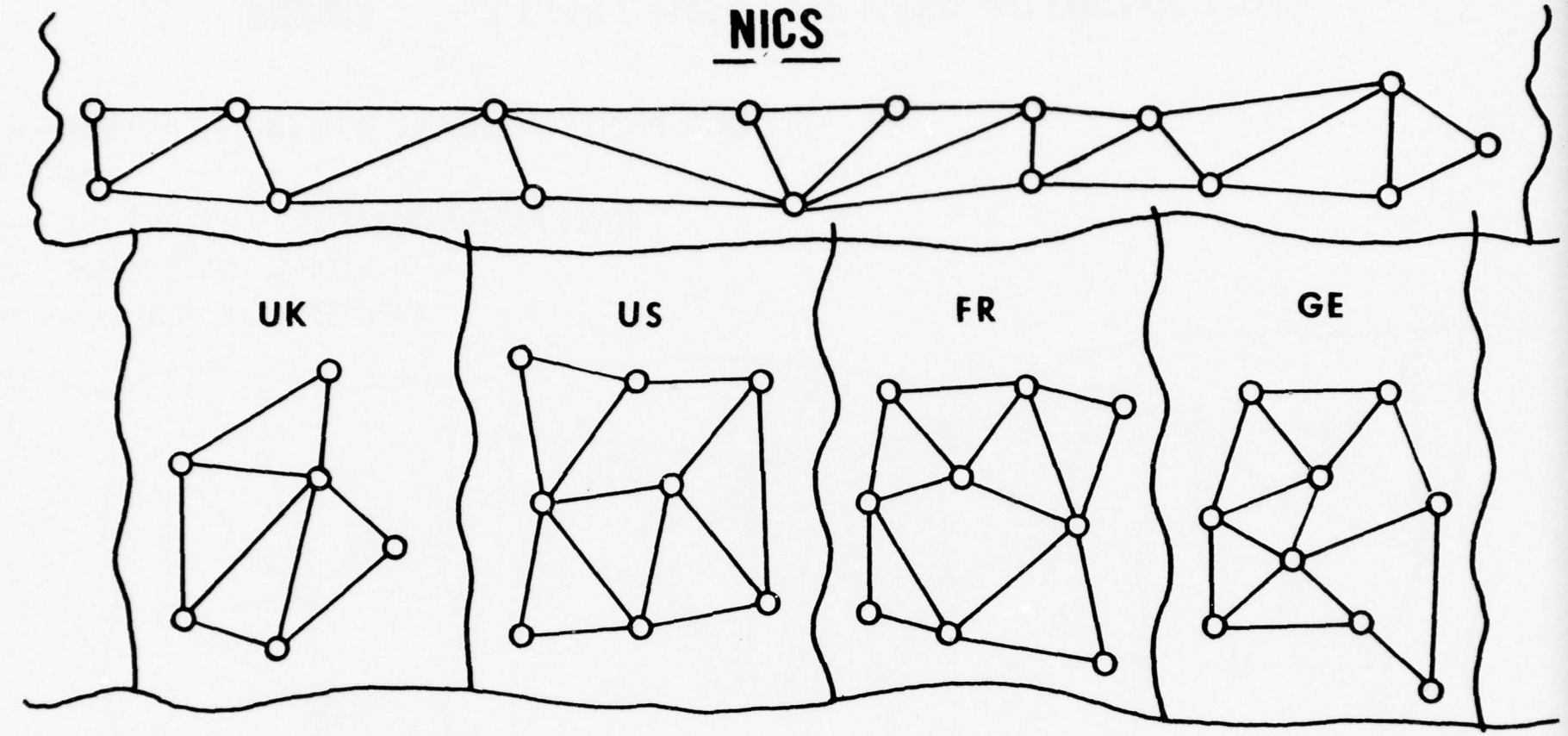


FIGURE 2 - SCHEMATIC DEPLOYMENT OF NATIONAL SYSTEMS

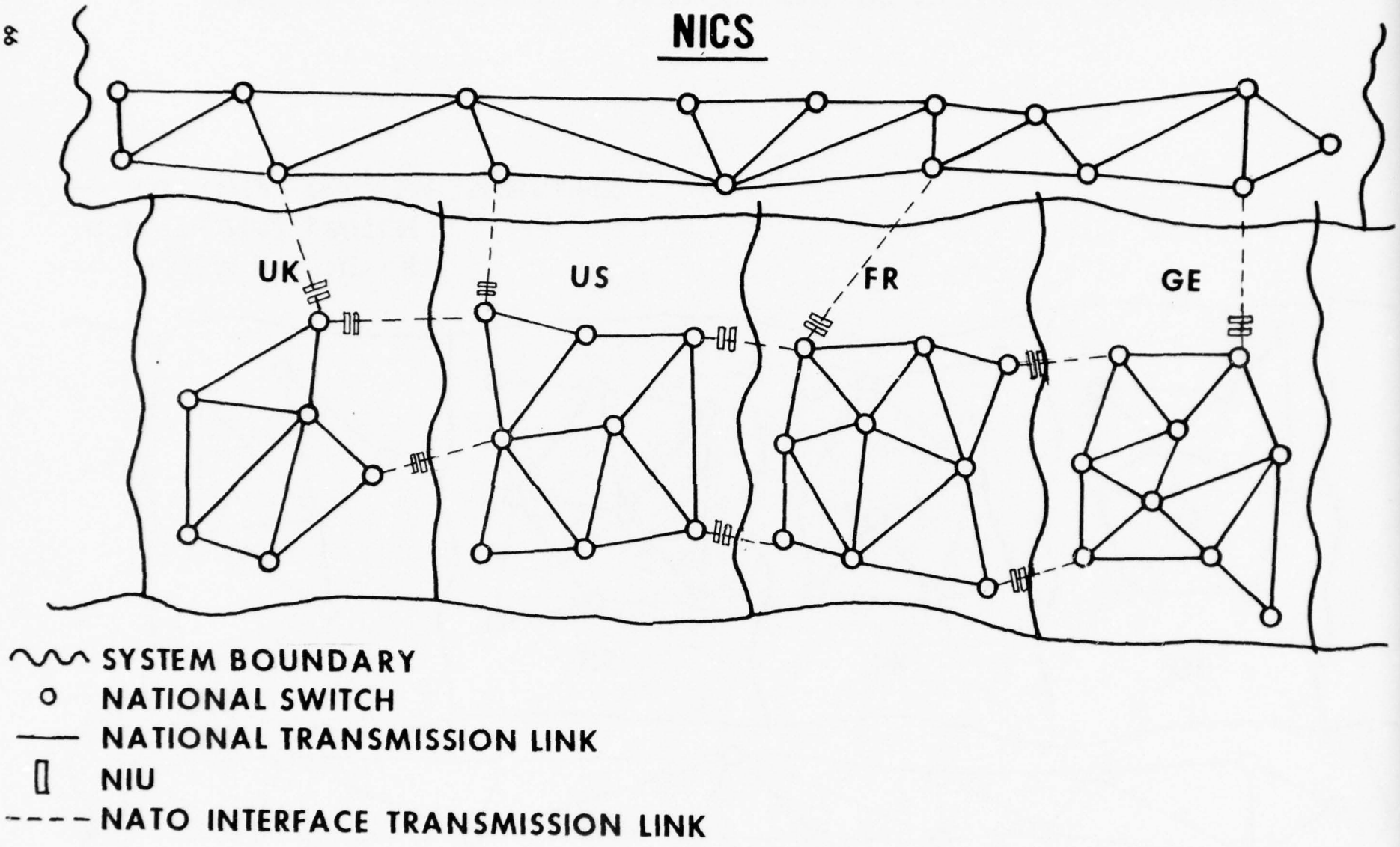
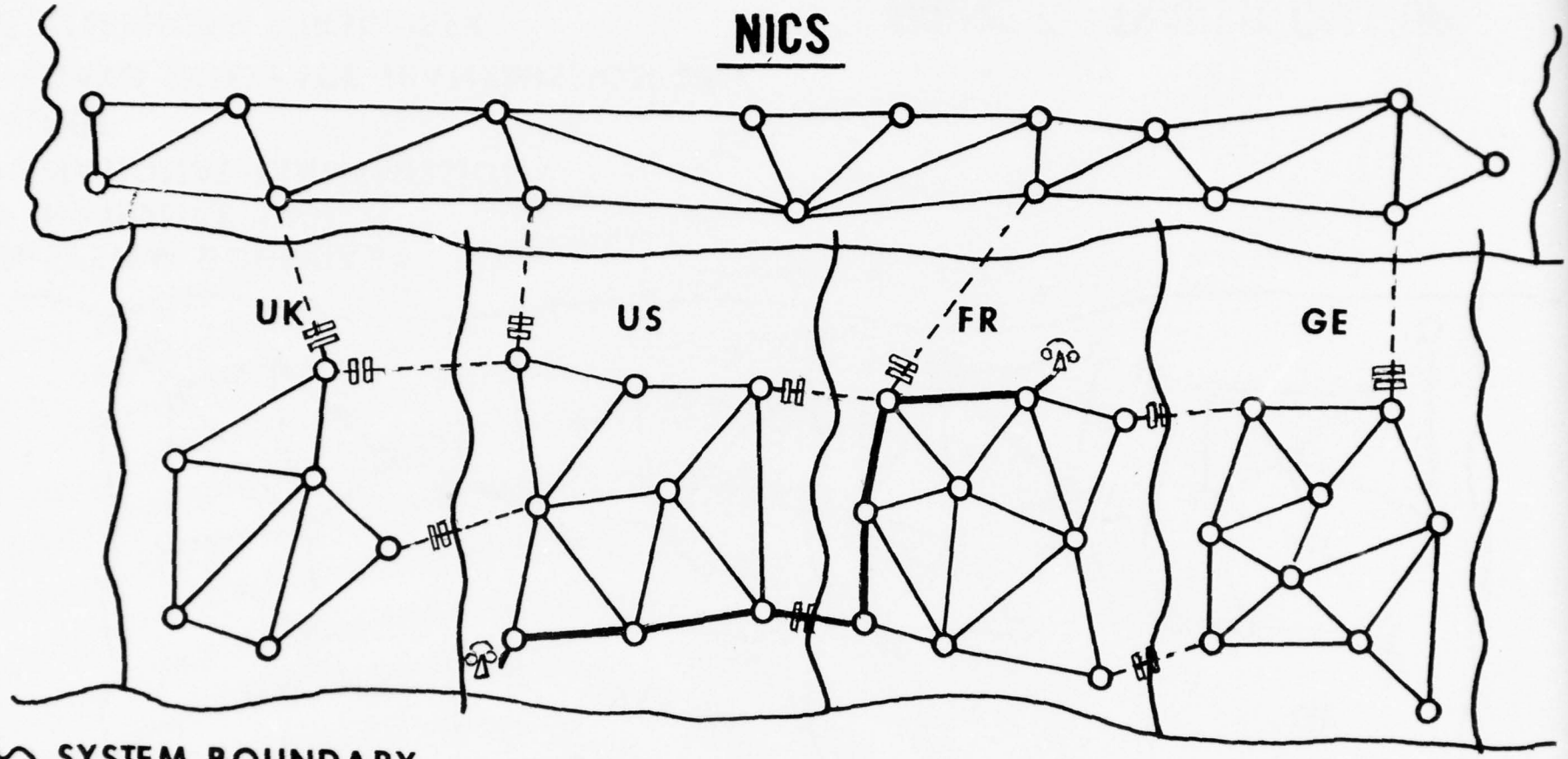
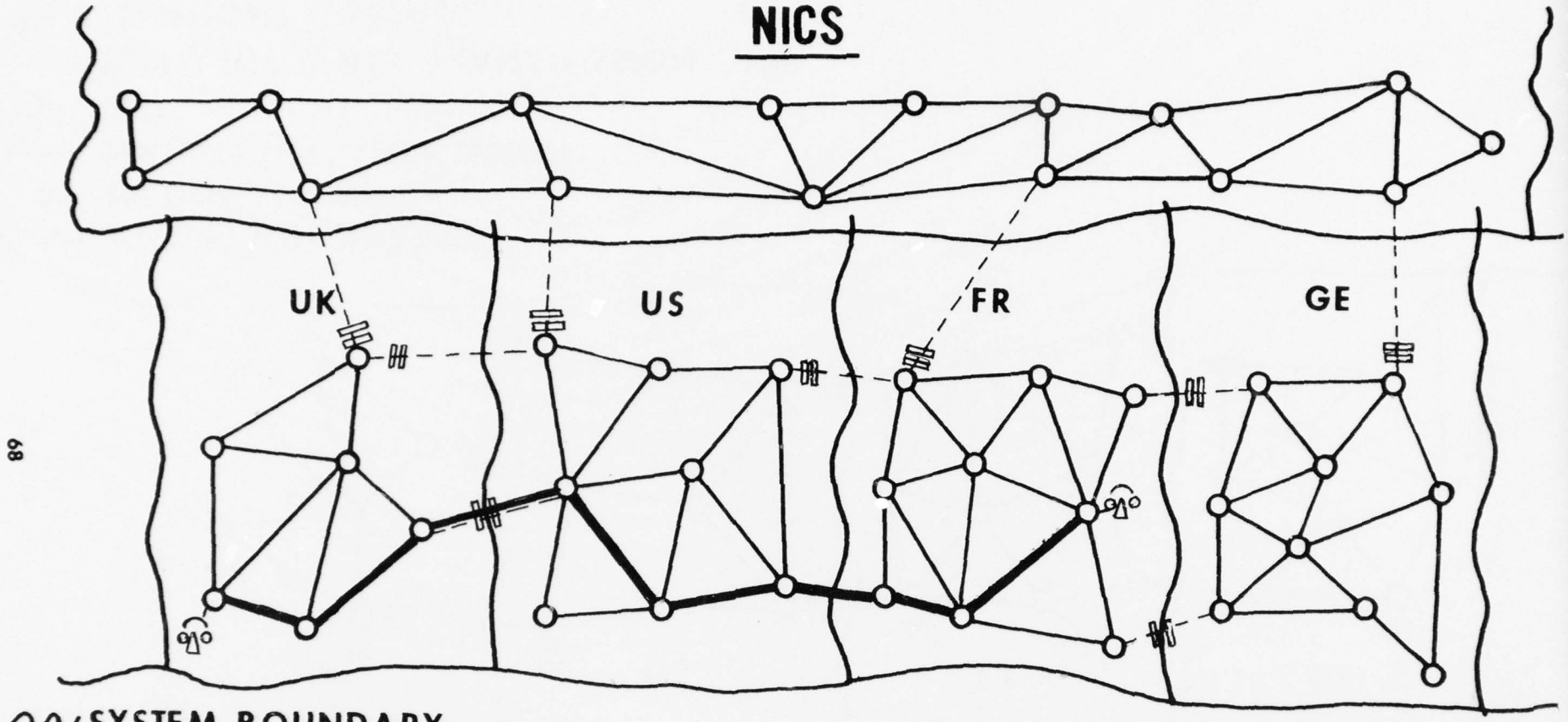


FIGURE - -3 DEPLOYMENT OF NATO INTERFACE LINKS



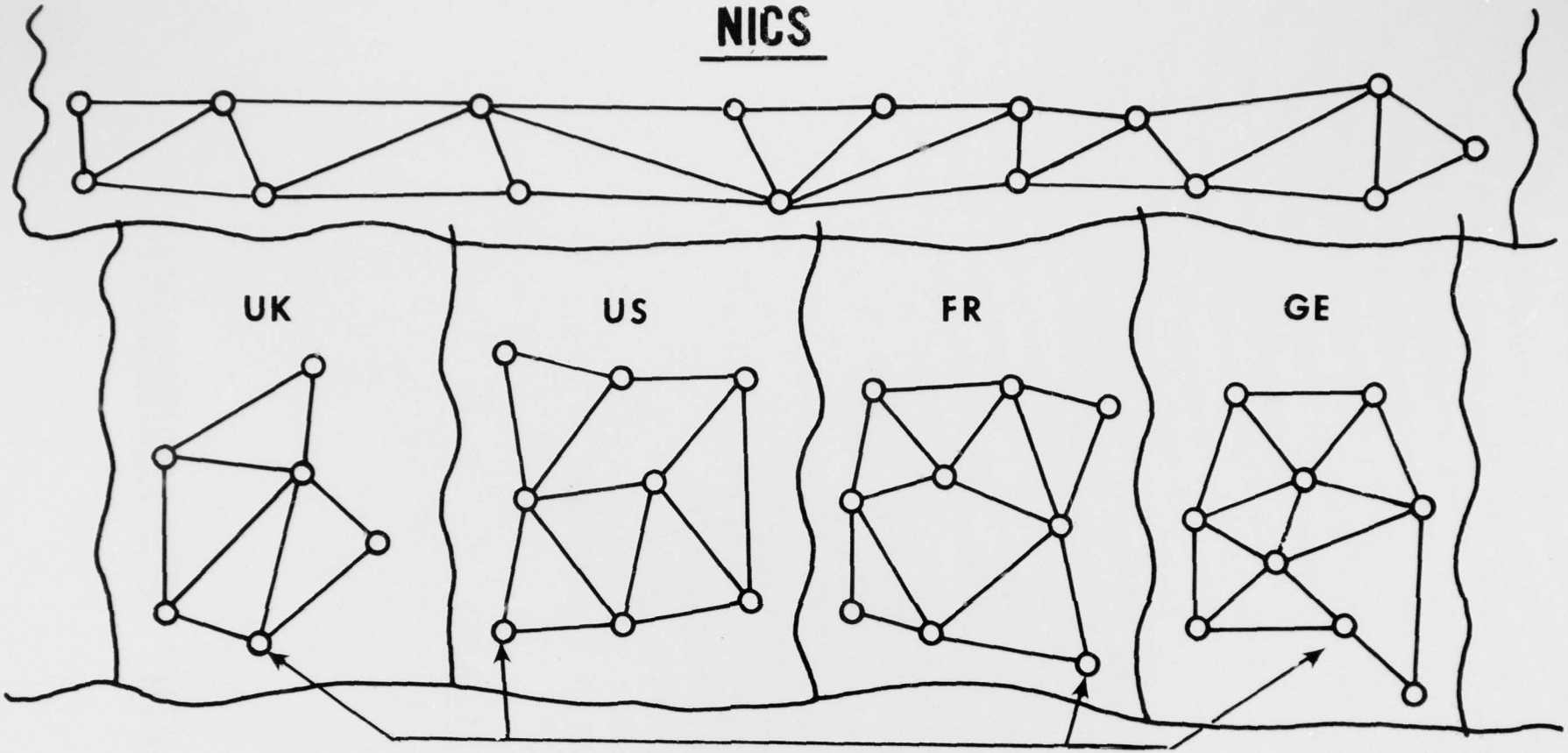
SYSTEM BOUNDARY
NATIONAL SWITCH
NATIONAL TRANSMISSION
NIU
NATO INTERFACE TRANSMISSION LINK
TELEPHONE SUBSCRIBER
CALL SET-UP PATH

FIGURE 4 - DIRECT INTERFACE CALL SET-UP



SYSTEM BOUNDARY
NATIONAL SWITCH
NATIONAL TRANSMISSION
NIU
NATO INTERFACE TRANSMISSION LINK
TELEPHONE SUBSCRIBER
CALL SET-UP PATH

FIGURE 5 - TRANSIT CALL-UP



SYSTEM BOUNDARY
NATIONAL SWITCH
NATIONAL TRANSMISSION

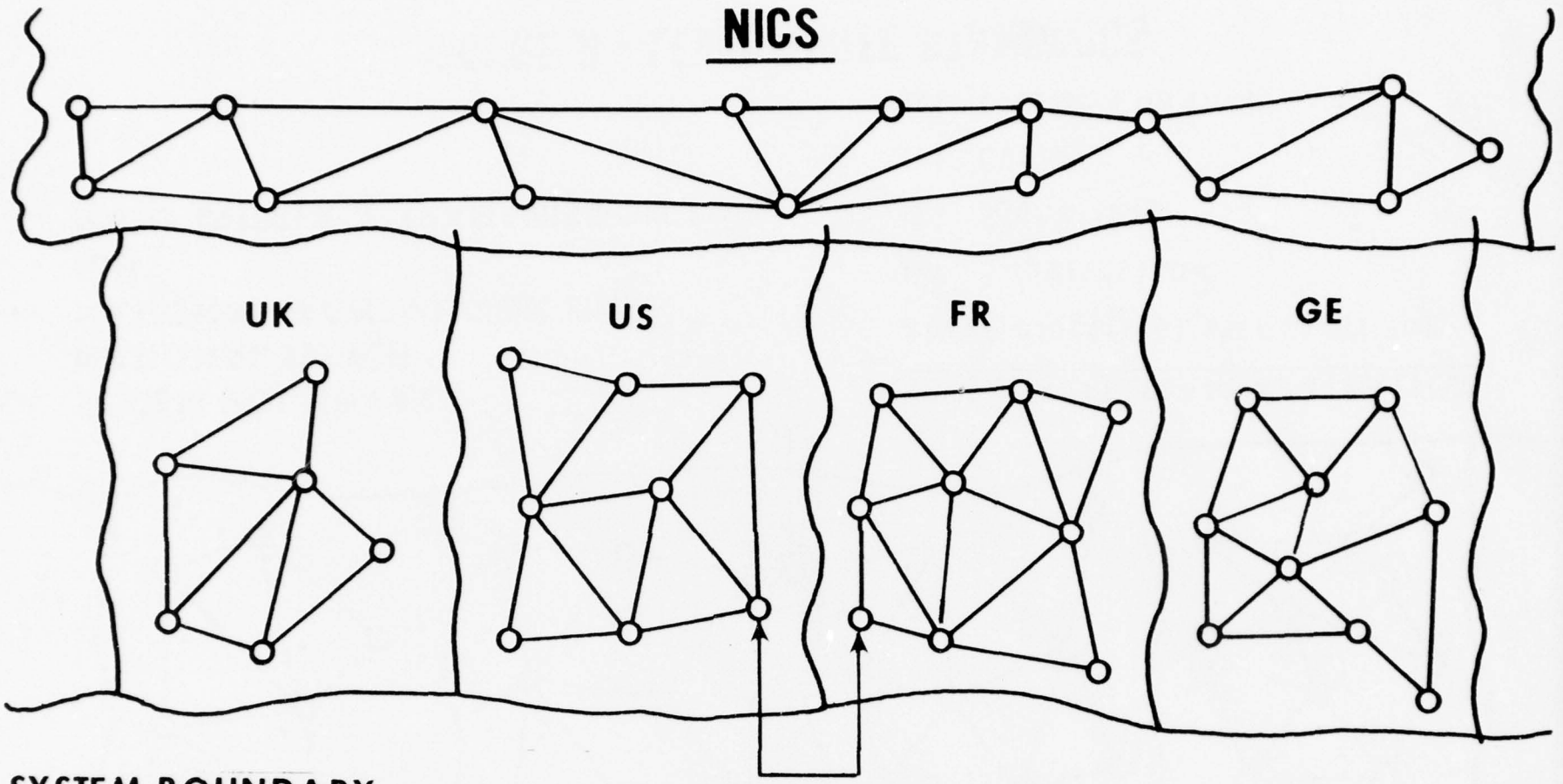
LEVEL ONE STANDARDIZATION

(a) Agree number of dialled address digits
(b) Agree meaning of exit digits (country codes)
(c) Provide for intra-system routing to interfaces
(d) Provide for mode and precedence recognition
(e) Provide for dialling of NATO call requests
(f) Authorization to qualified interface callers

FIGURE 6 - LEVEL ONE STANDARDS

900...BELGIAN AREA
901...CANADIAN AREA
902...DANISH AREA
903...FRENCH AREA
904...GERMAN AREA
905...GREEK AREA
906...ICELANDIC AREA
907...ITALIAN AREA
908...LUXEMBOURG AREA
909...NETHERLANDS AREA
910...NORWEGIAN AREA
911...PORTUGUESE AREA
912...TURKISH AREA
913...UNITED KINGDOM AREA
914...UNITED STATES AREA
915...NICS
916
917 SPARES
918
919

FIGURE 7 - COUNTRY CODE ASSIGNMENTS



SYSTEM BOUNDARY
NATIONAL SWITCH
NATIONAL TRANSMISSION LINK

LEVEL TWO STANDARDIZATION

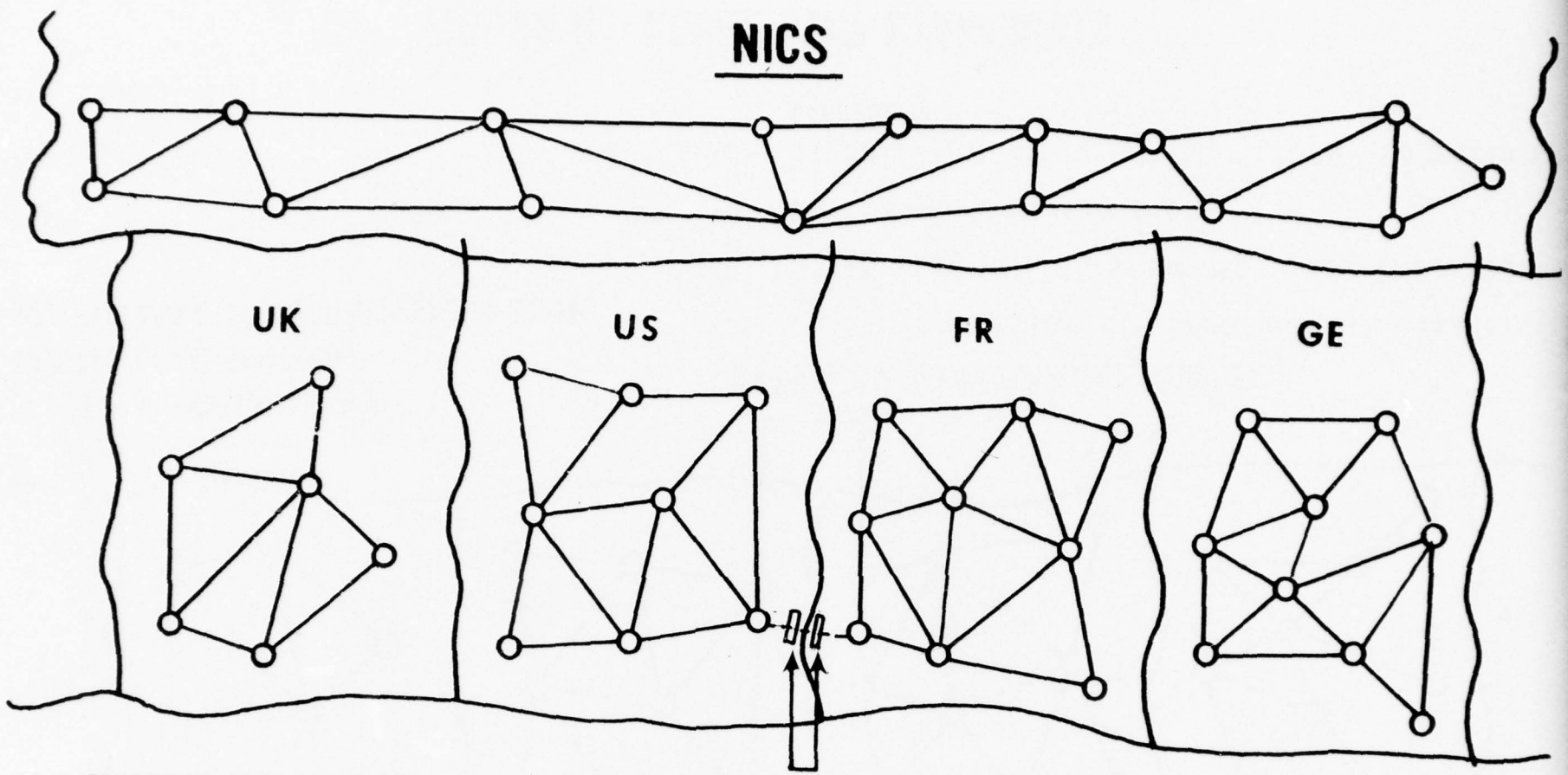
(a) Agree formatting of signalling and traffic

(b) Define signalling sequence over interface

(c) Define line supervision

(d) Define signalling timing, glare protection, timeouts

FIGURE 8 - LEVEL TWO STANDARDS



SYSTEM BOUNDARY
NATIONAL SWITCH
NATIONAL TRANSMISSION LINK
NIU
NATO INTERFACE TRANSMISSION LINK

LEVEL THREE STANDARDIZATION

Agree electrical standards for

(a) Supervision

(b) Signalling

(c) Cable

(d) Traffic Channel

FIGURE 9 - LEVEL THREE STANDARDS

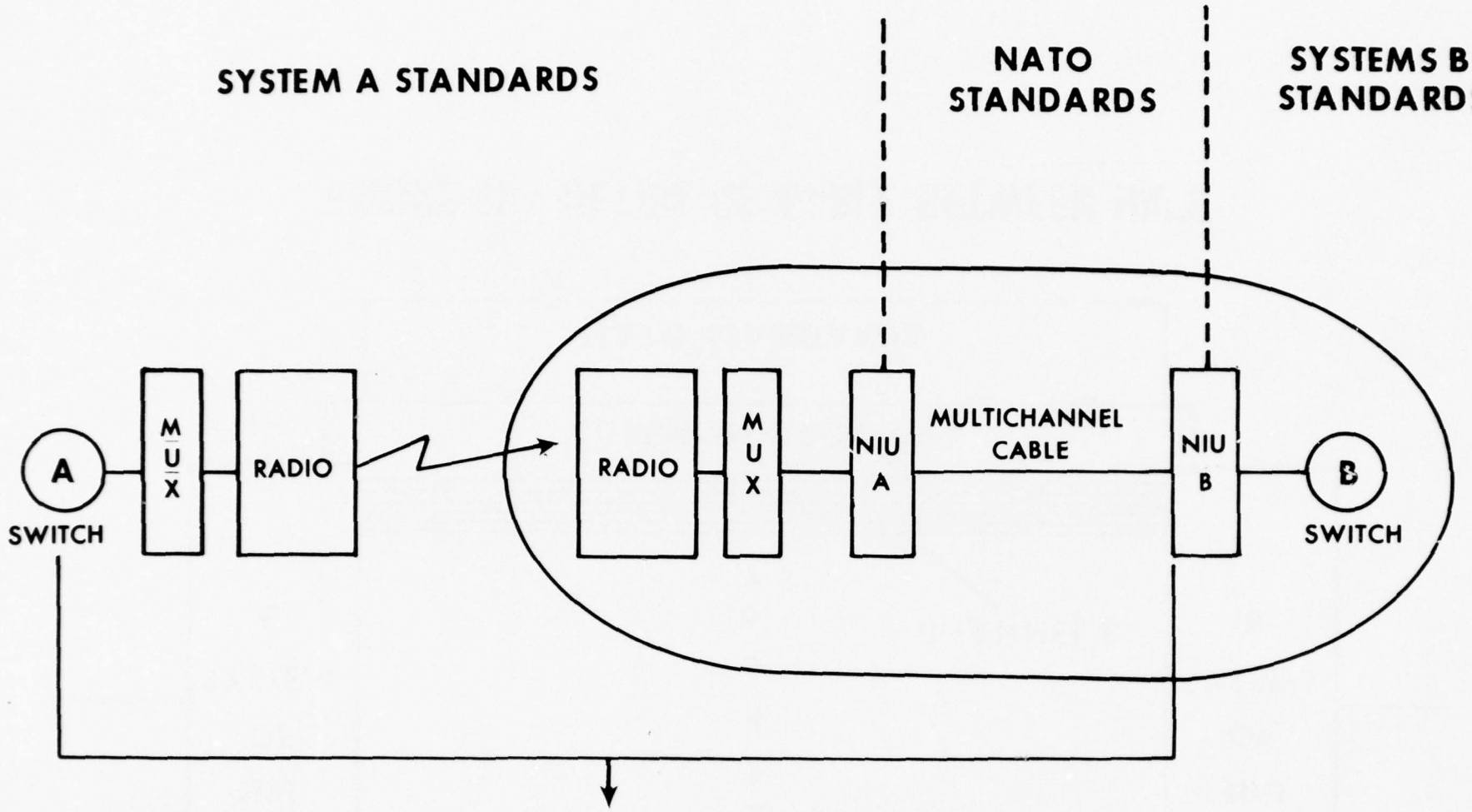


FIGURE 10 - DETAIL OF INTERFACE LINK

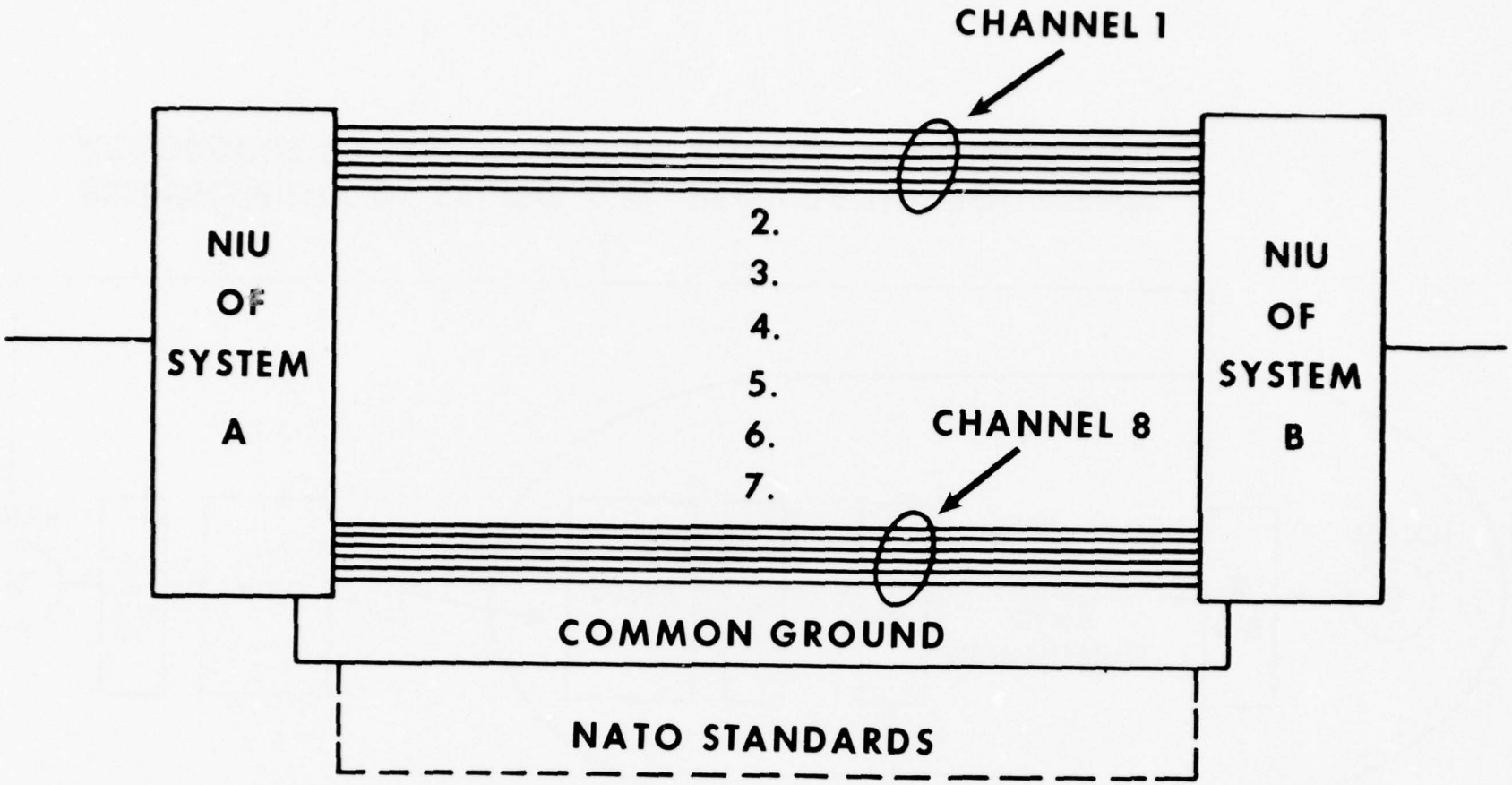


FIGURE 11 - DETAIL OF CABLE BETWEEN NIU'S

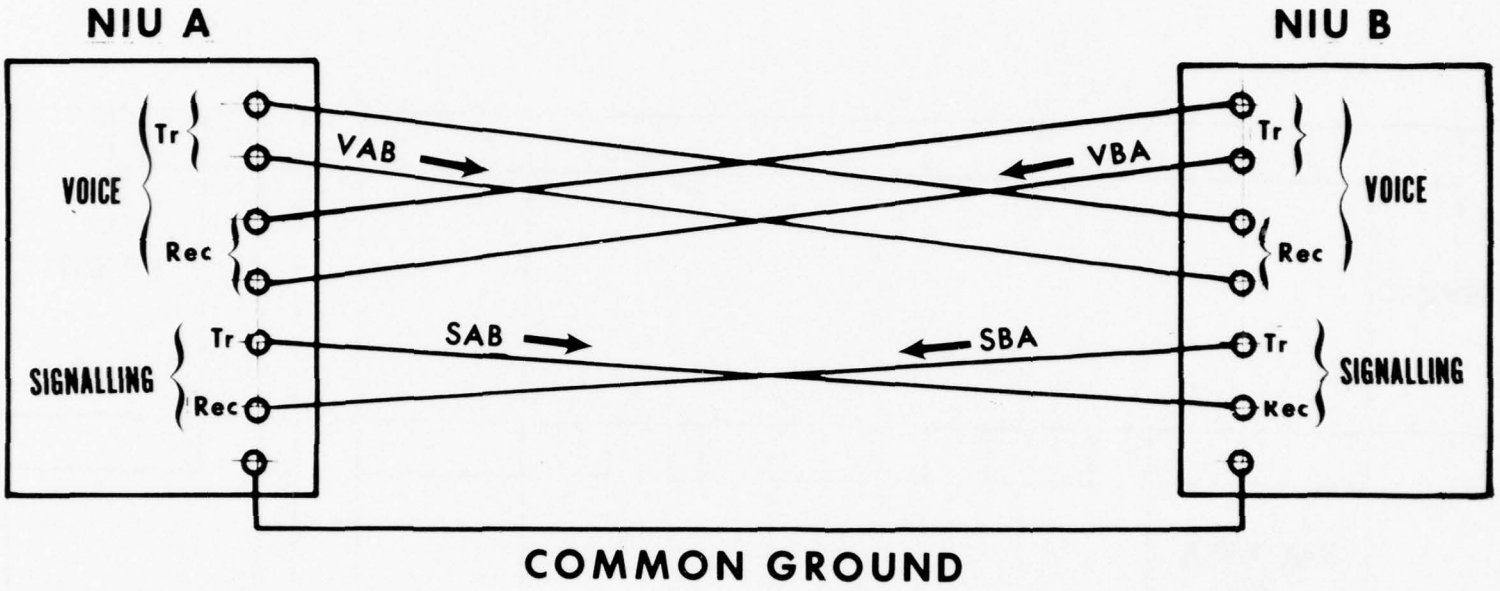


FIGURE 12 - A TYPICAL SIX WIRE CHANNEL

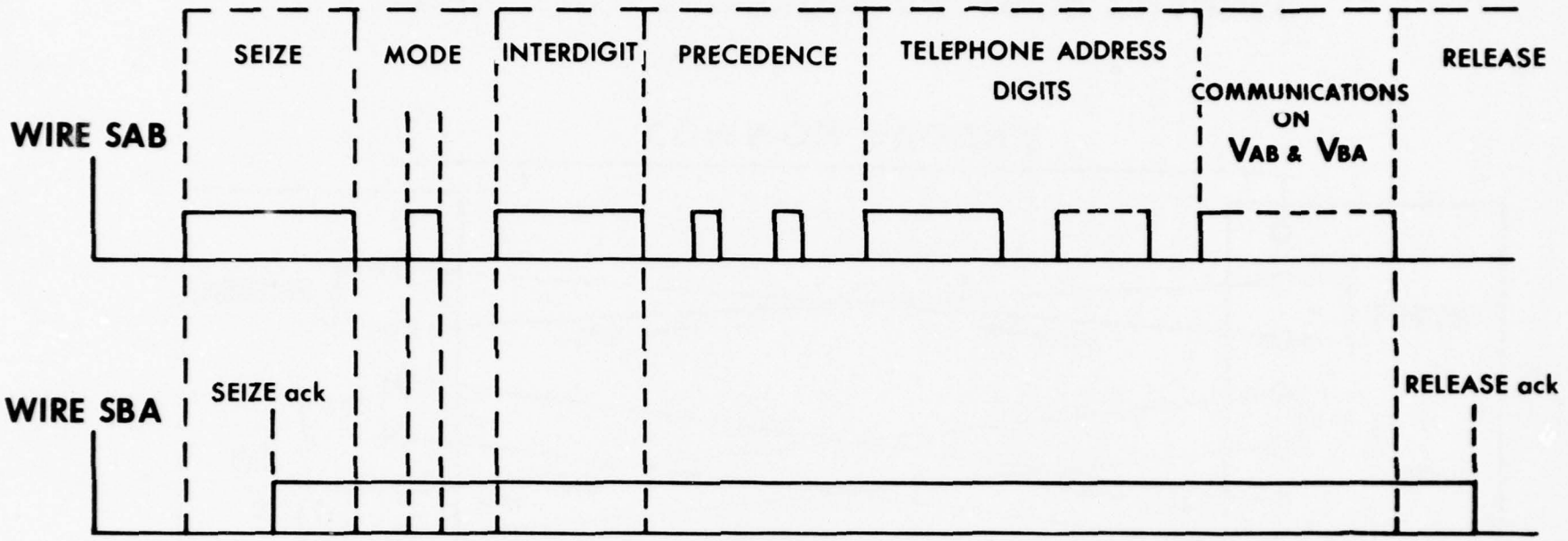


FIGURE 13 - SEQUENCE OF SIGNALLING ACROSS INTERFACE

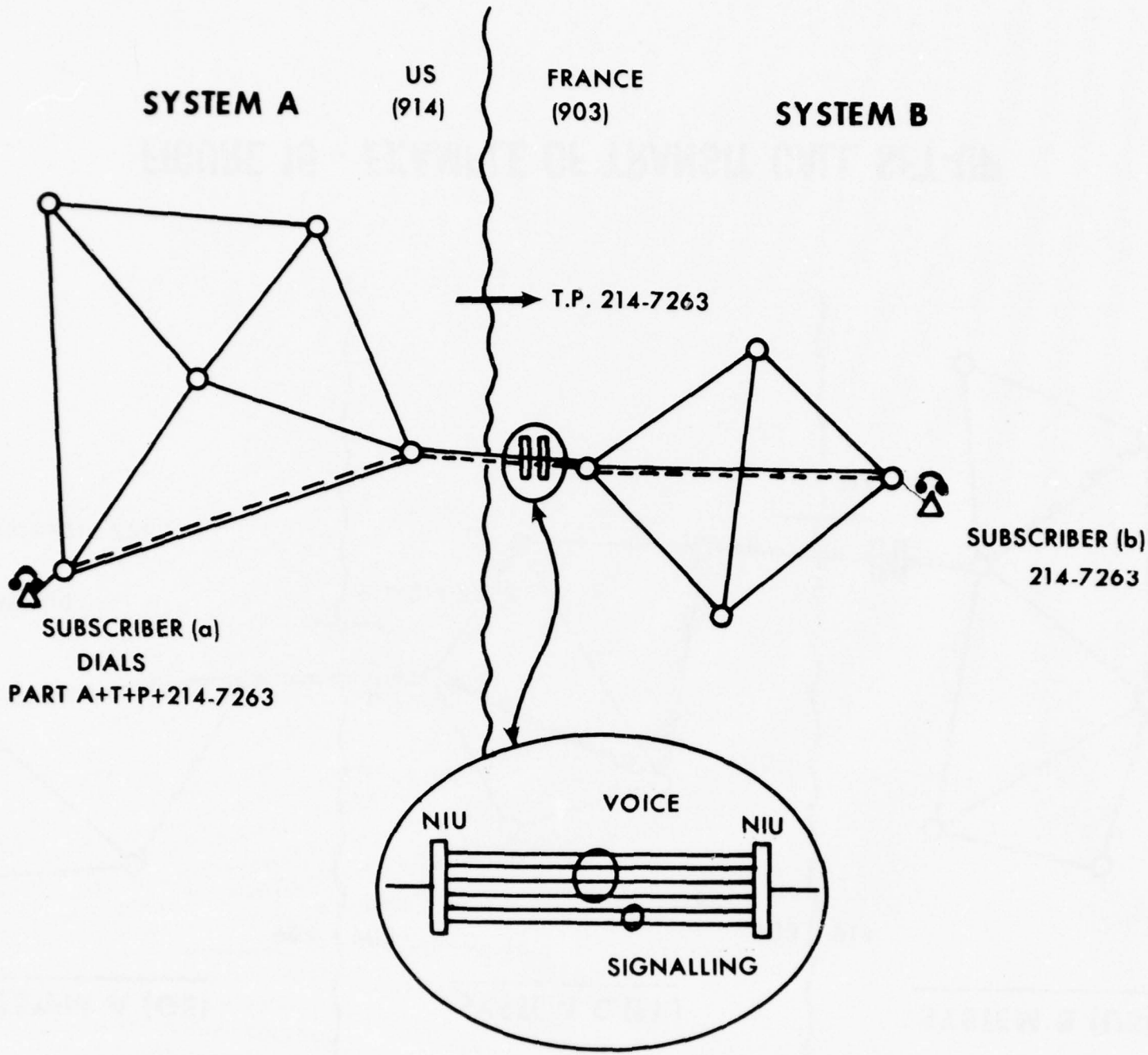


FIGURE 14 - EXAMPLE OF DIRECT CALL SET-UP

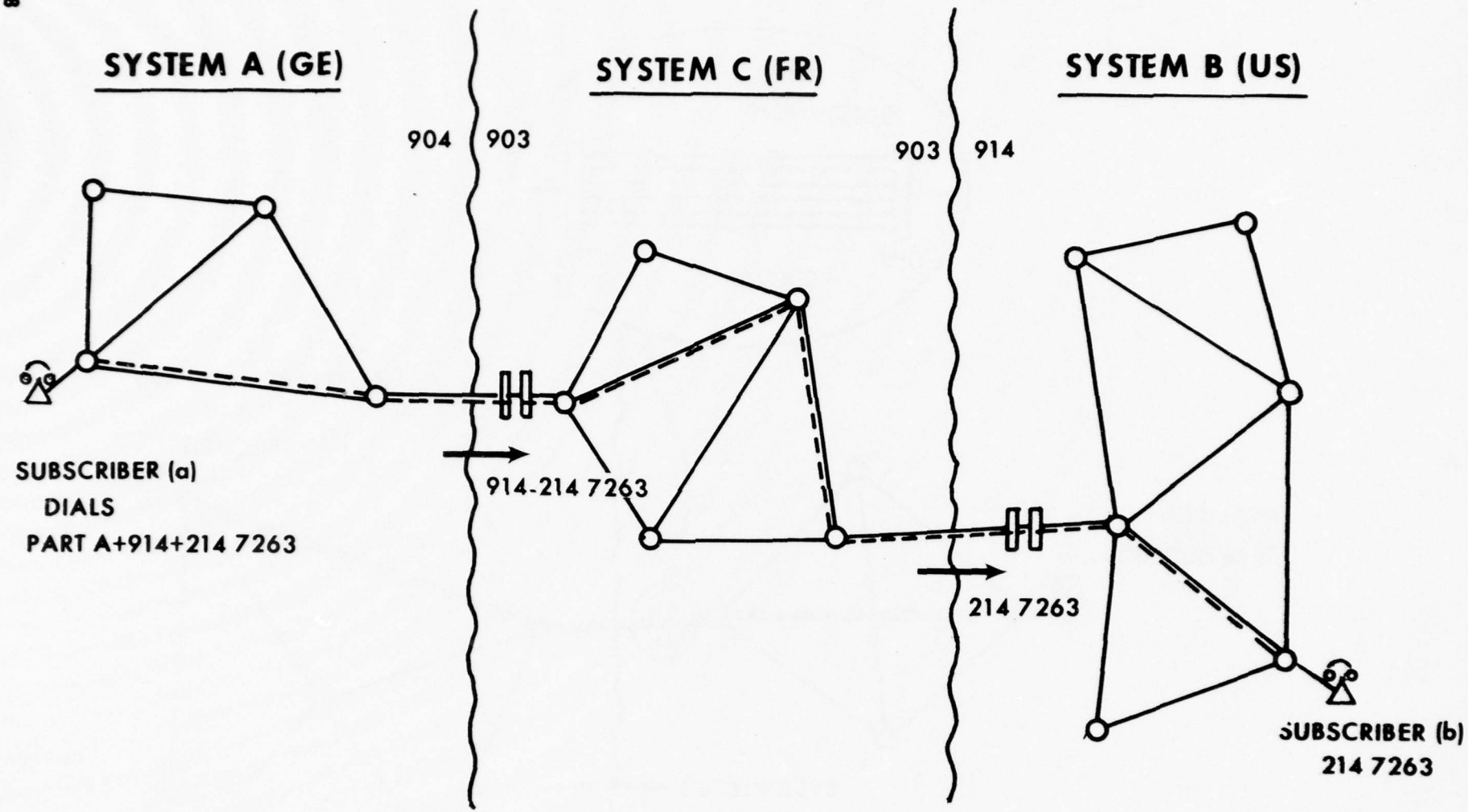


FIGURE 15 - EXAMPLE OF TRANSIT CALL SET-UP



Jerry M. Dressner, in his 25 year career, has contributed to a wide variety of military engineering efforts spanning radio research, equipment development, transmission systems planning, switch systems development and national and international standardization.

At ECOM, Fort Monmouth, he participated in the Army's first experiments in tropospheric scatter, microwave diffraction research and the development of microwave radio-relay equipment. He later joined ECOM's UNICOM Project, contributing to the development of digital transmission systems. Under the Mallard Program and TRI-TAC, he worked on traffic engineering, transmission subsystems and systems synchronization techniques. He has also served as US Army representative to NATO's tactical communications panels.

He was on a DOD assignment with the NATO Integrated Communications System Management Agency (NICSMA), in Brussels, Belgium from 1972-1976, where he worked on the systems engineering of the NICS and development of the technical parameters for the NATO Initial Voice Switched Network (IVSN).

In 1976, he returned to ECOM, (now CORADCOM) where he resumed his work in US military communications. He is currently Chief of the Plans and Programs Branch, of the Plans, Programs and Analysis Directorate, CORADCOM. Mr. Dressner received a BS Degree in Physics from the City College of New York and an MSEE Degree from Rutgers University, and is a member of Sigma XI, IEEE, and the AFCEA.

USE OF STANAG 5040 SIGNALING PROCEDURES ON SATELLITE LINKS

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ABSTRACT

The NATO Standardization Agreement (STANAG 5040) defines standards for interfaces required to achieve interoperability among switched NATO telecommunications facilities. This paper assesses the suitability of using STANAG 5040 signaling procedures to ensure interoperability among NATO switches employing satellite interface links. STANAG 5040 timing parameters are analyzed to determine if sufficient protection against premature time outs and double seizure/glare is available. Where protection is insufficient, modifications are recommended to the STANAG 5040 timing parameters to ensure interoperability. Emphasis is placed on the significant delays encountered in the equipment chain and in particular, in the AN/TTC-39 interface.

INTRODUCTION

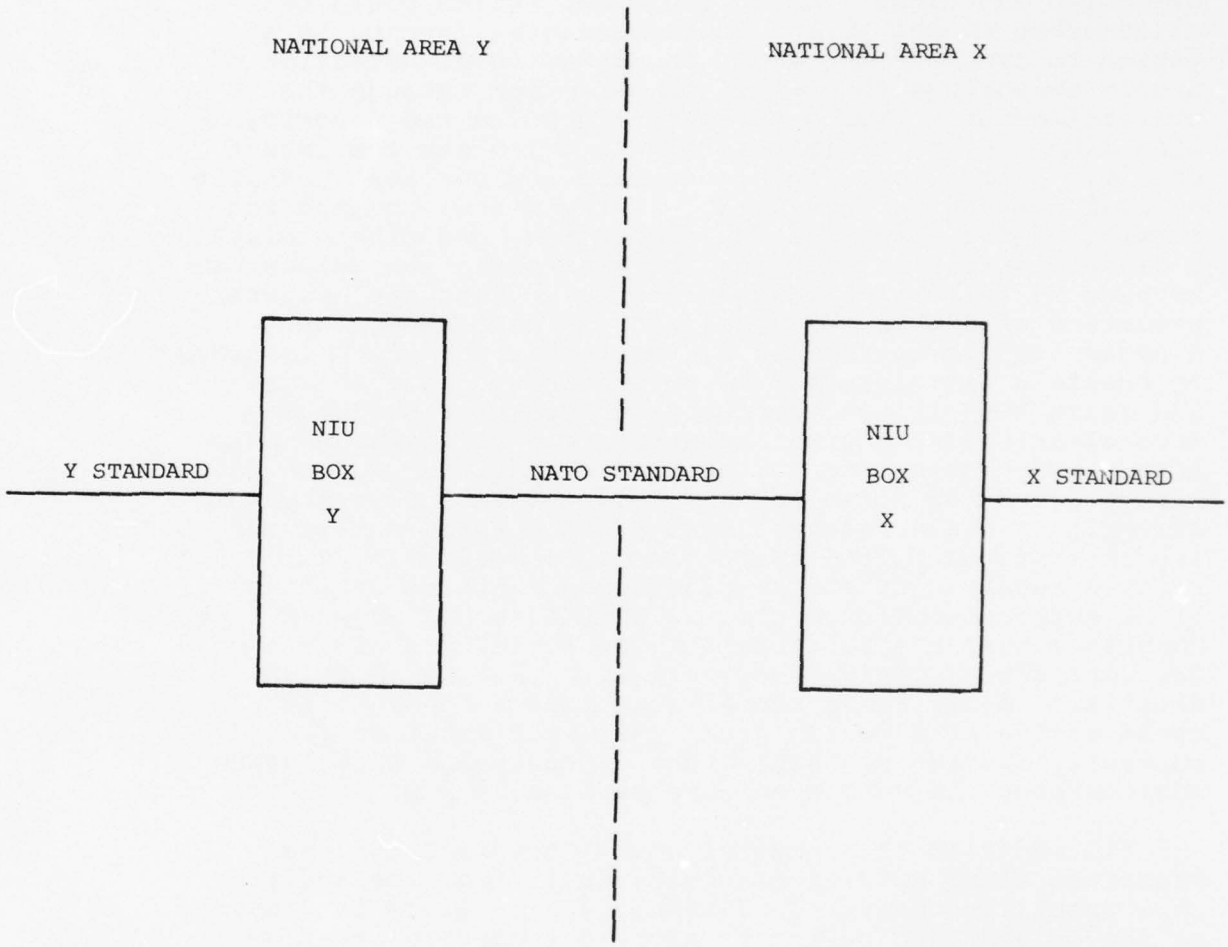
The specification, NATO Standardization Agreement (STANAG 5040), has been developed by NATO to ensure near-term communications interoperability among NATO nations. Its signaling timing parameters were originally based on the premise that terrestrial transmission facilities with fixed transmission delays of less than 50 milliseconds (ms) will interconnect the interfacing national switches. With the introduction of satellites across these interfaces, the one-way transmission time increases to 325 ms, which could create timing incompatibilities among interfacing switches programmed to operate over terrestrial links. This paper analyzes the suitability of using STANAG 5040 signaling procedures on NATO interface links employing satellite transmission facilities, and determines the modifications which are required to the STANAG 5040 timing parameters to ensure reliable operation over both satellite and terrestrial transmission facilities.

Interface communications in the near-term among NATO countries will be via analog circuits. To establish the circuits, trunk signaling information must be transmitted between switching centers prior to the transfer of voice/data traffic between subscribers.

The trunk signaling approach selected to establish NATO circuits requires the use of special interface devices known as NATO Interface Units (NIUs), as depicted in Figure 1. To provide an interface link, two NIUs are required, one supplied by each NATO nation. The purpose of the NIU is to convert one nation's signaling technique (tone, codeword, etc.) to the common DC standard specified in STANAG 5040. If a switch identifies a request to establish a NATO call, it will signal, using the national signaling technique, to its NIU that a circuit is desired. The NIU will transform the request into the STANAG 5040 specified DC level to the connecting foreign NIU, alerting the foreign NIU that a request to establish a circuit has been made. The foreign NIU then signals, by its nationally selected technique, to its home switch that a request to establish a circuit has been made. The foreign switch processes the request and sends an acknowledgment signal back to its NIU. The foreign NIU converts the acknowledge signal to the STANAG 5040 standard DC level, connecting the NIU which initiated the request. This NIU then sends acknowledgment back to the originating switch and the analog circuit is established.

The signaling approach selected by the U.S. between the U.S. switch and U.S. NIU is a 2600-Hz "tone off" technique. When the circuit is in the idle state, 2600 Hz appears on the line between the U.S. switch and NIU. When either the U.S. switch or NIU desires to establish a circuit, it removes the tone from the line for a fixed period of time. This "tone off" state is in turn detected by the U.S. switch or NIU (by the U.S. switch if the foreign switch originated the call, by the U.S. NIU if the U.S. switch originated the call). If the call originates at the U.S. switch, the U.S. NIU, after detecting "tone off", would then supply the specified DC level to the foreign NIU. After processing in the foreign network, the foreign NIU supplies a DC ACK to the U.S. NIU. The U.S. NIU sends acknowledge to the U.S. originating switch by again removing the 2600-Hz tone from the circuit. Both requests for circuits and acknowledgments are made by removal of the 2600-Hz signal.

FIGURE 1
Cross-National Connection



A typical trunk signaling problem encountered in switched networks is a condition known as glare or double seizure. Double seizure occurs when two switches simultaneously seize the same trunk where each switch is attempting to establish a call. If this condition occurs and is detected at each switch, both switches can drop the requests and attempt to establish the call on another circuit. In more sophisticated networks, one switch could be classmarked to accept double seizure, thereby enabling that switch to establish the circuit while the other switch could be classmarked to not accept double seizure, forcing this switch to drop the request. In STANAG 5040, detection of double seizure at the switch is performed through the utilization of a timing parameter known as the discrimination time. Since it is possible to calculate the latest possible arrival of a double seizure and earliest possible arrival of a seize acknowledge (calculations include the summing of the transmission, processing, and other delays), a discrimination level placed between these two values can be used by the originating switch to prevent the misinterpretation of double seizures as seize acknowledgment. A pause time is introduced by the receiving switch in order to create a time interval or to separate double seizures and seize ACKs in time so that the receiving switch may more clearly distinguish between double seizures and seize ACKs. (The pause time is the time a receiving switch waits before returning seize ACK and does not include processor delays.) Signals received before the discrimination time are interpreted by the switch as double seizures, while signals received after the discrimination time are considered to be seize acknowledgments. STANAG 5040 has adopted time constants that are suitable for double seizure prevention for terrestrial links. However, with the introduction of a satellite delay, it is conceivable that a double seizure could arrive at a switch after the discrimination time currently specified. Hence, the switch could once again misinterpret the double seizure as a seize ACK.

In addition to potential double seizure problems, premature alarm conditions could result from the addition of a satellite delay. In STANAG 5040, an alarm is provided at the originating switch to alert the operator that a seize acknowledge has not been received. The alarm time was chosen at a value slightly greater than the latest seize acknowledgment arrival time, which can be easily determined. For satellite paths, premature alarm conditions exist because the added satellite delay increases the arrival time of the seize ACK to a value greater than the specified alarm time. In this case, the alarm would occur before the seize ACK is received.

The double seizure and premature alarm problems are analyzed from two points of view. First, the impact of the satellite delay on STANAG 5040 signaling procedures based solely on information contained in the STANAG 5040 specification is examined. STANAG 5040 identifies equations and procedures used for selecting the discrimination, alarm, and pause timing parameters. The same equations are analyzed with the satellite delay rather than the 0-50 ms terrestrial transmission delay used in STANAG 5040. Latest arrivals of double seizures and earliest and latest arrivals of seize acknowledgments are determined and compared to the STANAG specified discrimination and alarm times to determine if sufficient double seizure protection and alarm times are provided. The timing values are plotted on timing diagrams and where sufficient double seizure or alarm protection is not provided, proposed modifications to the discrimination, pause, or alarm times are identified.

Since the STANAG 5040 analysis provided only early estimates of the characteristics of national systems, a second analysis is performed to determine what impact the satellite delay has on AN/TTC-39 NATO calls. In this analysis, specific timing parameters on the AN/TTC-39 side of the NATO interface are considered while the foreign system delays used (processor recognition times, constant transmission delays, etc.) are as specified in STANAG 5040. Latest arrivals of double seizures, and earliest and latest arrivals of seize acknowledgments, with satellite delays, are again compared to the specified discrimination, pause time, and alarm times to determine if sufficient double seizure protection and alarm times are provided. Timing plots are also used to determine the adequacy of double seizure and alarm protection. Where insufficient protection is provided, specified discrimination, pause, or alarm times are recalculated for the added satellite delay to provide the required modifications.

ANALYSIS OF STANAG 5040 PARAMETERS

A. Time Out and Double Seizure Analysis

This analysis examines potential double seizure protection problems and premature time outs over satellite facilities based solely on assumptions contained in STANAG 5040. Particular capabilities of specific systems are not considered. The results of this analysis will determine whether or not the parameters specified in STANAG 5040 are sufficient to accommodate a satellite delay.

For the purpose of this analysis, it has been assumed that all interfaces and systems make full use of specified tolerances. This assumption is not realistic in practice, but must be made if interoperability is to be ensured under all circumstances. A summary of the significant parameters, timing thresholds, and definitions of terms and equations from STANAG 5040 for terrestrial transmission facilities is contained in Table 1.

Assuming that a satellite with a round trip transmission delay of 650 ms is presently employed, the equations with the new transmission delay times provide the following thresholds:

- t_1 = 2050 ms
- t_2 = 2500 ms
- t_8 = 4200 ms.

The impact of the satellite delay is shown in Figure 2. The figure identifies the STANAG 5040 specified discrimination and alarm times and plots the latest arrival of double seizures, and earliest and latest arrival times of seize ACK for satellite applications. As shown in the figure, two conditions exist which will not permit completely reliable operation over satellite links.

t_1, the latest time to receive a double seizure at the originating switch, has been increased by 550 ms to 2050 ms. This value is now 350 ms greater than the discrimination time. Hence, all double seizures arriving at the originating switch between 1700 and 2050 ms will be misinterpreted as seizures. Therefore, it can be concluded that the STANAG 5040 parameters do not provide sufficient double seizure protection for satellite transmission facilities.

t_8, the latest possible time to receive a seize ACK at the originating switch, has increased by an additional 550 ms to the level of 4200 ms. Those seize ACKs arriving after 4000 ms will be lost since an alarm condition will have occurred at 4000 ms. Plots for both satellite and terrestrial links are shown in Figure 3.

B. Proposed Modifications to STANAG 5040

Preliminary changes to the STANAG 5040 parameters can be made which will ensure reliable operation over both satellite and terrestrial transmission facilities. Through

TABLE 1
Summary of Specified
STANAG 5040 Parameters

Proposed STANAG 5040 Parameters as of March 1978

Pause Time, T_p	2000 ms ±150
Discrimination Time, T_d	1700 ms ±100
Alarm Time, T_A	4000 ms ±250
Transmission Time, T_t	$0 \leq T_t \leq 50$ ms
Processor Recognition Time, T_R	$0 \leq T_R \leq 700$ ms

Definition of Terms

- T_p (Pause Time) - Upon recognition of seize request, the switch will pause for a period of time, T_p, before returning seize ACK.
- T_d (Discrimination Time) - The time at which a switch differentiates between a seize ACK and a double seizure. Before T_d expires, the originating switch interprets a received seize signal as a double seizure. After T_d expires, the originating switch interprets the signal as a seize ACK.
- T_A (Alarm Time) - Switch times out and initiates alarm. Alarm occurs when seize ACK is not returned.
- T_t (Transmission Time) - The one-way time required to transmit seize/seize ACK to adjacent switch.
- T_R (Processor Recognition Time) - The time required for the switch processor to recognize a seize request and inhibit requested channel.

TABLE 1 (2)

STANAG 5040 Timing Thresholds for Terrestrial Transmission Facilities

$$t_1 = 2(T_{RMAX} + T_{tMAX}) = 1500 \text{ ms}$$

$$t_2 = 2(T_{RMIN} + T_{tMIN}) + T_p - \Delta T_p = 1850 \text{ ms}$$

$$t_8 = 2(T_{RMAX} + T_{tMAX}) + T_p + \Delta T_p = 3650 \text{ ms}$$

Definition of Terms

- t_1 - The latest time to receive a double seizure at originating switch
- t_2 - The earliest time to receive a seize ACK at originating switch
- t_8 - The latest time to receive a seize ACK at originating switch

FIGURE 2
STANAG 5040
Signaling Thresholds

t_1 - Latest time to receive a double seizure at originating node

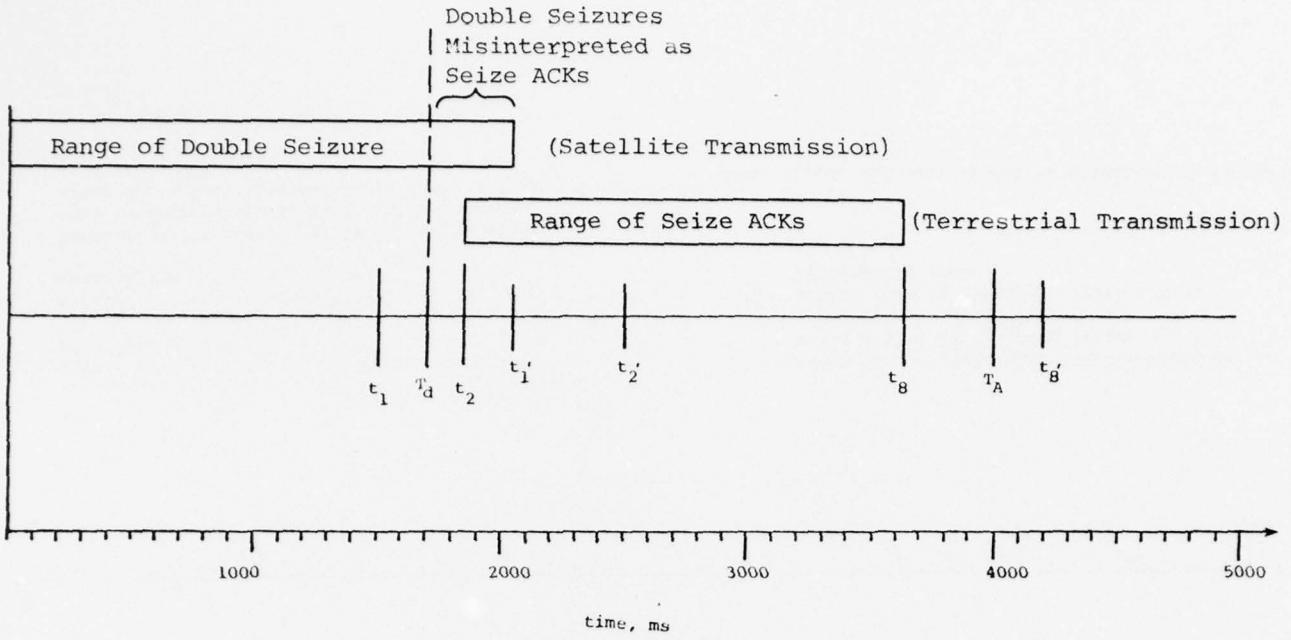
t_2 - Earliest time to receive a seize ACK at originating node

T_d - Discrimination time. Before T_d, originating node interprets signal as a double seizure. After T_d, originating node interprets signal as a seize ACK.

T_A - Alarm time. (Time out) ACK for seize or release must be expected before t_6'.

t_8 - Latest time to receive a seize ACK at originating node.

NOTE: Primes indicate satellite transmission facilities.



t_1 - Latest time to receive a double seizure at originating node

t_2 - Earliest time to receive a seize ACK at originating node

T_d - Discrimination time. Before T_d, originating node interprets signal as a double seizure. After T_d, originating node interprets signal as a seize ACK.

T_A - Alarm time. (Time out) ACK for seize or release must be expected before t_6.

t_8 - Latest time to receive a seize ACK at originating node.

NOTE: Primes indicate satellite transmission facilities.

FIGURE 3
STANAG 5040
Signaling Thresholds

an examination of Figure 3, it is apparent that the following changes must occur:

- Since t_1' (latest double seizure with satellite delay) is fixed, t_2 (earliest time to receive seize ACK over terrestrial transmission path) must be increased to a value greater than t_1'.
- T_d (discrimination time) must be relocated between t_1' and the new value of t_2.
- T_A (alarm time) must be increased to a value greater than t_8' (latest arrival of seize ACK with satellite delay).

The first condition can be satisfied by increasing the pause time by 400 ms to 2400 ms. This has no effect on t_1' and increases t_2 to 2250 ms, creating a 200 ms gap between the latest arrival of double seizure with a satellite delay (t_1') and the earliest receipt of a seize ACK (t_2) over a terrestrial transmission path. The discrimination time, T_d, can now be placed in the center of the 200 interval at 2150 ms and will still maintain a tolerance of $\pm$ 100 ms. At these values, sufficient protection is provided against double seizure conditions.

The introduction of an additional 400 ms pause increases t_8', the latest arrival of a seize ACK with satellite delay, to 4600 ms. Hence, the alarm time, T_A, should be specified at a minimum value of 4650. If a tolerance is desirable, then the alarm time should be specified at 4650 ms +250 ms. Table 2 summarizes the STANAG 5040 parameters, timing thresholds, and the proposed modifications to STANAG 5040. Figure 4 plots the timing thresholds with the proposed STANAG 5040 modifications. As the diagram indicates, double seizures, misinterpreted as seizures, and premature alarm conditions do not occur, thus ensuring reliable operation over both terrestrial and satellite transmission facilities.

ANALYSIS OF AN/TTC-39 NATO INTERFACE

This analysis is similar to the previous analysis, however, actual equipment delays (U.S. NIU, AN/TTC-39 processor delays, etc.) are considered on the U.S. side of NATO calls. Since a variety of systems will interface with the AN/TTC-39, it would be difficult to select a single system which would be representative of all foreign networks. Therefore, the STANAG 5040 parameters are used to characterize

TABLE 2
Summary of STANAG 5040
Parameters/Thresholds and Proposed Changes

PARAMETERS	STANAG 5040 Parameter Values, March 1978	Proposed Changes to STANAG 5040 Parameters
Pause Time, T_p	2000 ms $\pm$150	2400 ms $\pm$150
Discrimination Time, T_d	1700 ms $\pm$100	2150 ms $\pm$100
Alarm Time, T_A	4000 ms $\pm$250	4650 ms $\pm$250

TIMING THRESHOLDS	Threshold Values Based on Specified STANAG 5040 Parameters		Threshold Values Based on Proposed Changes to STANAG 5040 Parameters	
	Terrestrial, ms	Satellite, ms	Terrestrial, ms	Satellite, ms
Latest Double Seizure, t_1	1500	2050	1500	2050
Earliest Seize ACK, t_2	1850	2500	2250	2900
Latest Seize ACK, t_8	3650	4200	4050	4600

FIGURE 4
STANAG 5040 Signaling Thresholds
With Modifications

t_1 - Latest time to receive a double seizure at originating node

t_2 - Earliest time to receive a seize ACK at originating node

T_d - Discrimination time. Before T_d' originating node interprets signal as a double seizure. After T_d' originating node interprets signal as a seize ACK.

T_A - Alarm time. (Time out) ACK for seize or release must be expected before t_8'.

t_8 - Latest time to receive a seize ACK at originating node.

NOTE: Primes indicate satellite transmission facilities.

the foreign network. (The U.S. parameters, primarily those of the AN/TTC-38 and U.S. NIU, were later adopted to characterize the foreign networks. These delays were greater than other national systems, thus creating additional margins.)

Additionally, the STANAG 5040 discrimination, alarm, and pause times again serve as guidelines for determining if AN/TTC-39 NATO interface design characteristics provide satisfactory operation over satellite transmission facilities. Modifications of the STANAG 5040 timing parameters to permit reliable operation over any AN/TTC-39 NATO satellite link are again proposed.

Since this analysis considers the operation of a particular switch on one side of the interface, certain steps must be performed prior to determining any modifications to STANAG 5040. Initially, the significant signaling parameter delays on the U.S. side of a NATO call must be identified. Once the parameters are described, the AN/TTC-39 pause time, based on STANAG 5040 guidelines, is determined. This is followed by a summary of the switch-to-switch timing delays. At this point, all timing parameters are available and the values of the latest arrivals of seize ACKs and requests are calculated. These values are then compared to the specified STANAG 5040 discrimination and alarm times to assess the adequacy of time out and double seizure protection. If sufficient protection is not provided, modifications to provide reliable service are recommended.

A. Identification of U.S. Signaling Parameter Delays

As depicted in Figure 5, the equipment adding significant delays on the U.S. side of the interface are the U.S. NIU, AN/TTC-39 Single Frequency receiver/transmitter, (SF adapter), and the AN/TTC-39. The U.S. NIU, shown in the signaling sequence of Figure 6, converts 2600-Hz SF signaling tone into the NATO standard DC level. The major delays associated with the U.S. NIU are the SF receiver delays which include the following:

- Guard interval for absence of SF tone: 140 $\pm$ 5% ms
- Waiting period between end-of-guard and beginning of state change: 30 $\pm$ 5% ms.
- State change discrimination time: 20 $\pm$ 2 ms.

FIGURE 5
Major Equipment for U.S. NATO Call

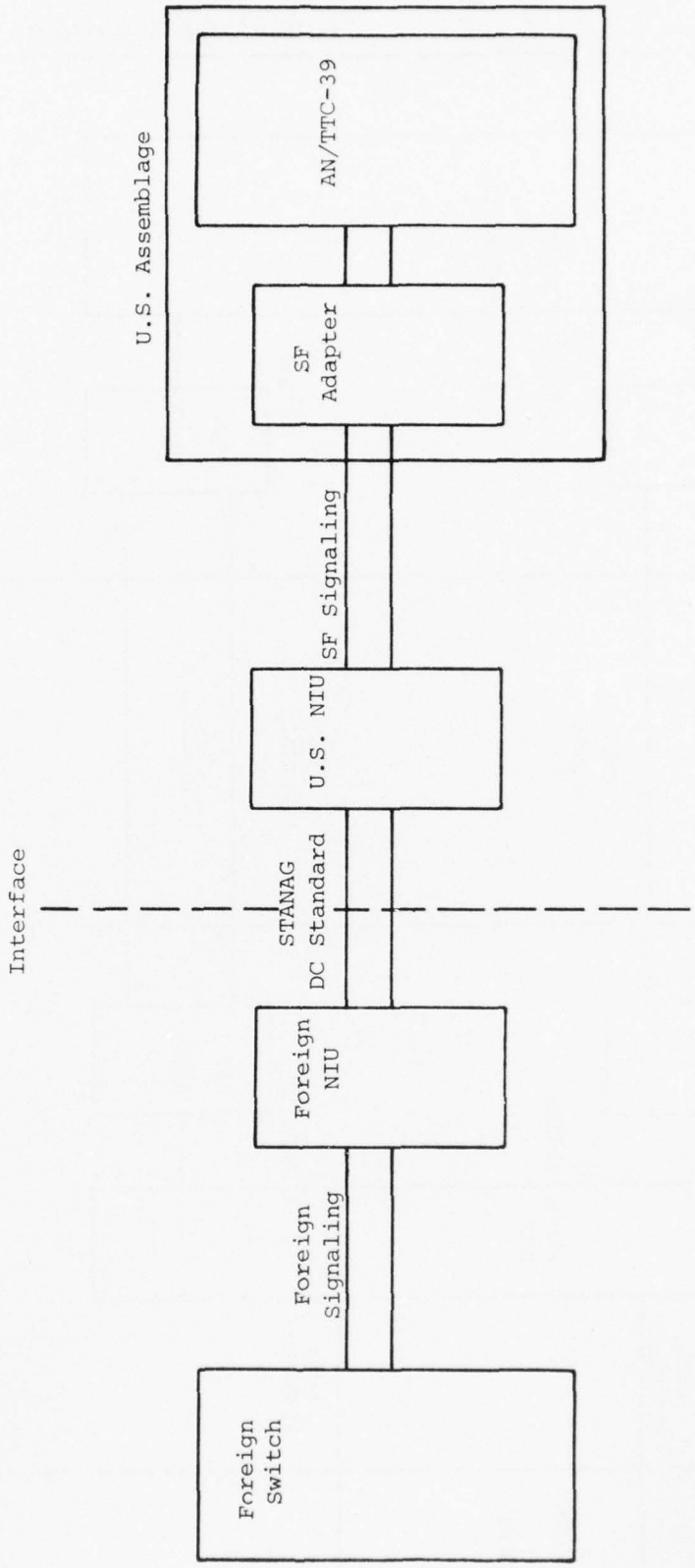
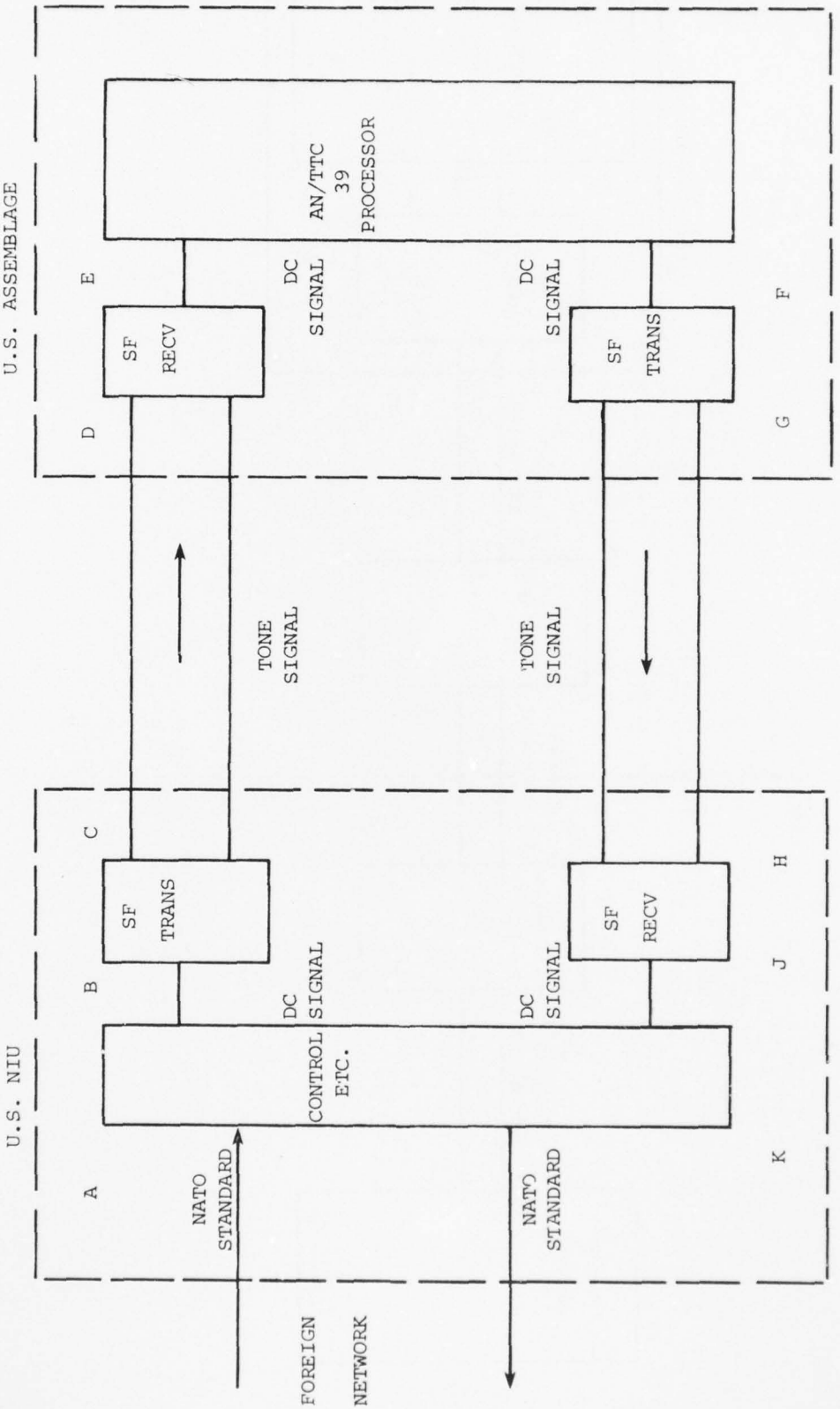


FIGURE 6
Signaling Sequence



The AN/TTC-39 SF adapter provides the interface between the U.S. NIU and the AN/TTC-39. The adapter is composed of a receiver and sender which accepts and supplies an SF signaling tone to the U.S. NIU. Control of the tone is via a DC signal between the SF adapter and the AN/TTC-39. The significant delay in the SF adapter is the receiver "tone off" guard which is used to guard against false "tone off" signals. The delay is 140 $\pm$ 5% ms.

The AN/TTC-39 processor delays include the scanning time required to detect the DC signal from the SF adapter, the time required to process the seize, and the time required to signal the SF transmitter. Assuming the switch processes the seize in a single cycle, estimates for the AN/TTC-39 delays are as follows:

- Scanning time: 0-100 ms (one cycle, maximum)
- Process seize: 0-100 ms (one cycle, maximum)
- Signal SF transmitter: 0-100 ms (one cycle, maximum).

The delays are summarized in Table 3.

B. AN/TTC-39 Pause Time

STANAG 5040 specifies the switch pause time at 2000 ms $\pm$ 150. This time can be interpreted in two ways. First, the time could be the time the switch waits between processing the seize request and supplying a command to the SF adapter to return seize ACK. The specification could also be interpreted such that the pause time value of the switch should be set to give a nominal delay of 2000 ms $\pm$ 150 between the receipt of a DC seize signal at the U.S. NIU and the return of the DC seize acknowledge signal to the foreign NIU. This delay would not include previously specified transmission and processing delays. Assuming the second interpretation, the total pause time at the interface will be the same for all systems. Since this would enable a nation establishing a connection to know exactly what delays to expect from the foreign counterpart, this would be the desirable approach. Additionally, this approach would mean that the processor pause time would discount all non-processor fixed hardware delays on that nation's side of the interface. For the U.S. system, this includes the SF adapter and NIU delays.

The AN/TTC-39 processor pause should be set at 1670 ms $\pm$ 130. This value was obtained by subtracting the average non-processor fixed hardware delays listed in Table 3 from the specified 2000 ms $\pm$ 150 pause time. This delay

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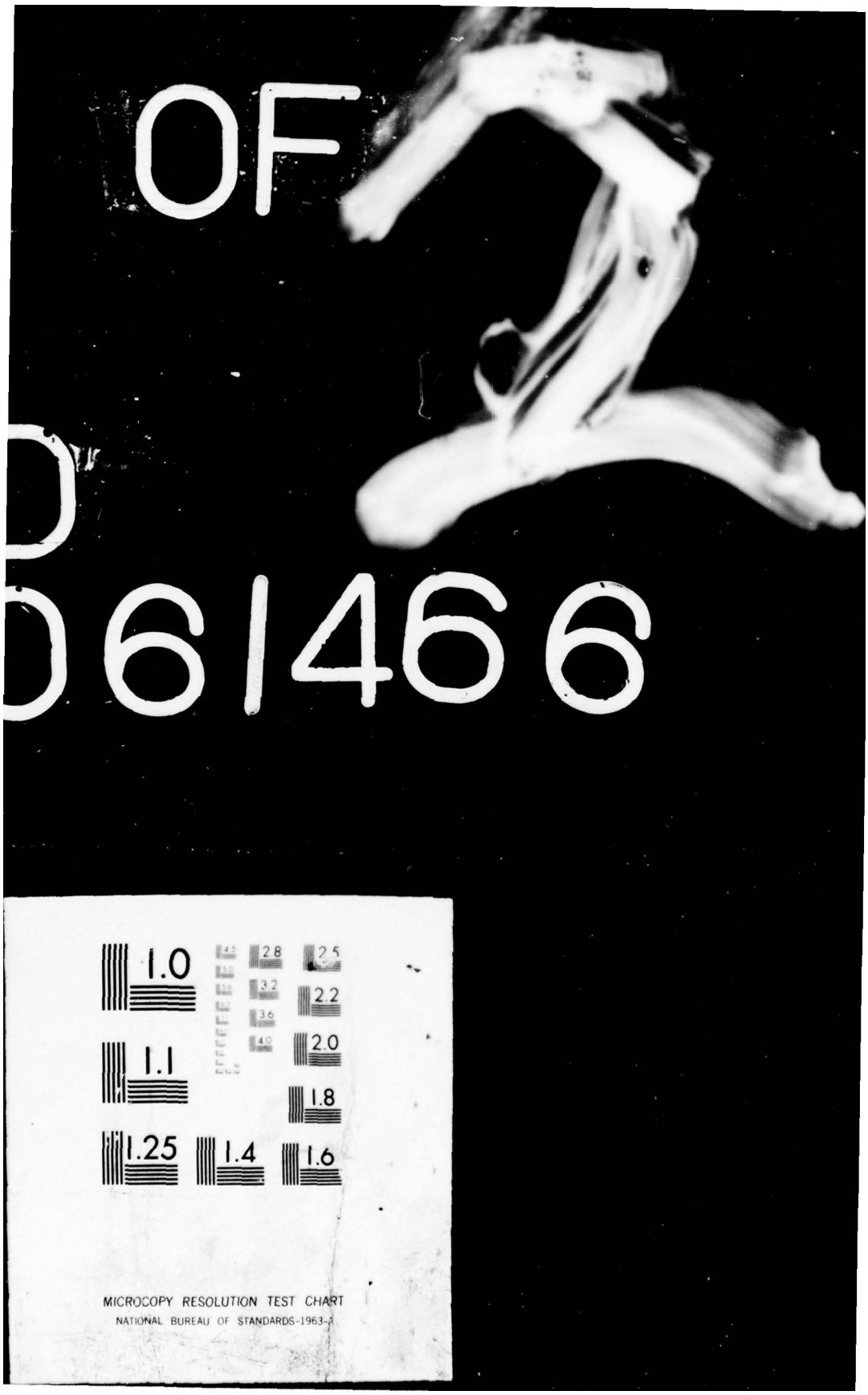

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TABLE 3
Fixed U.S. Signaling Delays

REFERENCE ID*	EVENT	SIGNALING DELAY PARAMETER VALUE (ms)
A-D	U.S. NIU Receives DC Signal from Foreign NIU and Sends Seize to SF Unit	0
D-E	AN/TTC-39 SF Receiver Guards "Tone off"	140 ±5%
E-F	AN/TTC-39 Recognition**	
	. Scanning Time	0-100
	. Process Seize (One Cycle, Maximum)	0-100
	. Signal SF Transmitter (One Cycle, Maximum)	0-100
F-H	Processor Sends Seize ACK Signal to SF Transmitter	0
	SF Transmits Sends Seize to NIU SF Receiver	
H-J	NIU SF Receiver Delays	
	. Guard Interval for Absence of SF Tone	140 ±5%
	. Waiting Period Between End of Guard and Beginning of State Change	30 ±5%
	. State Change Discrimination Time	20 ±2

*See Figure 6 for reference ID.
**AN/TTC-39 recognition time does not include processor pause time, T_p.

The AN/TTC-39 SF adapter provides the interface between the U.S. NIU and the AN/TTC-39. The adapter is composed of a receiver and sender which accepts and supplies an SF signaling tone to the U.S. NIU. Control of the tone is via a DC signal between the SF adapter and the AN/TTC-39. The significant delay in the SF adapter is the receiver "tone off" guard which is used to guard against false "tone off" signals. The delay is 140 ± 5% ms.

The AN/TTC-39 processor delays include the scanning time required to detect the DC signal from the SF adapter, the time required to process the seize, and the time required to signal the SF transmitter. Assuming the switch processes the seize in a single cycle, estimates for the AN/TTC-39 delays are as follows:

- Scanning time: 0-100 ms (one cycle, maximum)
- Process seize: 0-100 ms (one cycle, maximum)
- Signal SF transmitter: 0-100 ms (one cycle, maximum).

The delays are summarized in Table 3.

B. AN/TTC-39 Pause Time

STANAG 5040 specifies the switch pause time at 2000 ms ± 150. This time can be interpreted in two ways. First, the time could be the time the switch waits between processing the seize request and supplying a command to the SF adapter to return seize ACK. The specification could also be interpreted such that the pause time value of the switch should be set to give a nominal delay of 2000 ms ± 150 between the receipt of a DC seize signal at the U.S. NIU and the return of the DC seize acknowledge signal to the foreign NIU. This delay would not include previously specified transmission and processing delays. Assuming the second interpretation, the total pause time at the interface will be the same for all systems. Since this would enable a nation establishing a connection to know exactly what delays to expect from the foreign counterpart, this would be the desirable approach. Additionally, this approach would mean that the processor pause time would discount all non-processor fixed hardware delays on that nation's side of the interface. For the U.S. system, this includes the SF adapter and NIU delays.

The AN/TTC-39 processor pause should be set at 1670 ms ± 130. This value was obtained by subtracting the average non-processor fixed hardware delays listed in Table 3 from the specified 2000 ms ± 150 pause time. This delay

does not include the processor recognition and transmission times which are specified separately. By subtracting the non-processor fixed hardware delays as discussed above, significant timing delays usually not considered (SF adapter and NIU delays) can be accounted for.

C. Switch-to-Switch Timing Delays

The switch-to-switch timing delays, summarized in Tables 4 and 5, have been based on the STANAG 5040 specified parameters and fixed U.S. signaling delays. These delays include the time from the transmission of a seize signal from either the foreign interface switch or the AN/TTC-39 to complete processing and recognition at the terminating switch.

The timing thresholds t_1, t_2, and t_8 can be summed by using Tables 4 and 5, a 1670 ms $\pm$ 130 pause time for the AN/TTC-39, and the STANAG 5040 specified 2000 ms $\pm$ 150 pause time for the foreign switch. The values for t_1, t_2, and t_8 for both satellite and terrestrial applications are summarized in Table 6. Figure 7 plots the arrival times of seize ACKs and double seizures with the added satellite delay. The figure shows that the utilization of the satellite has increased the latest time of receipt of a double seizure for both AN/TTC-39 and foreign originating calls to 1997.5 ms, or about 300 ms greater than the discrimination time. As a result, all double seizures arriving between 1700 ms and 1997.5 ms will be misinterpreted as seize ACKs. Additionally, for calls originating at the AN/TTC-39, the latest possible time to receive a seize ACK is 147.5 ms greater than the STANAG 5040 specified 4000 ms alarm level. Hence, all seize ACKs arriving at the AN/TTC-39 between 4000 ms and 4147.5 ms will be lost since an alarm condition will have occurred.

D. Required Modifications to STANAG 5040

Figure 8 shows the arrival times of seize ACKs and double seizures for both satellite and terrestrial transmission facilities. Through an examination of Figure 8, it is apparent that the following changes must occur:

- Since t_1' (double seizure with satellite delay) is fixed, t_2 (earliest time to receive ACK over terrestrial transmission path) must be increased to a value greater than t_1' (foreign originating only).

TABLE 4
Delays for Calls Originating at Foreign Switch to AN/TTC-39

EVENT	Event Time, ms	Total Elapsed Time, ms			
		Terrestrial		Satellite	
		Minimum	Maximum	Minimum	Maximum
1. Foreign Switch Sends Seize to U.S. NIU*	0	0	0	0	0
2. U.S. NIU Begins Sending Seize to SF Unit	0	0	0	0	0
3. Transmission Delay	325-Sat 0-50-Terr	0	50	325	325
4. AN/TTC-39 SF Receiver Guards Tone off	140 ±5%	133	197	458	472
5. AN/TTC-39 Recognizes Seize					
. Scanning Time	0-100	133	297	457	573
. Process Seize	0-100	133	397	457	672
. Signal SF Transmitter (Tone off)	0-100	133	497	457	772
Total Time for Transmission and Recognition of Signal; Foreign Switch to AN/TTC-39		133	497	457	772

*For this analysis, it is assumed that the foreign switch pauses for the full 2000 ms and has no non-processor delays.

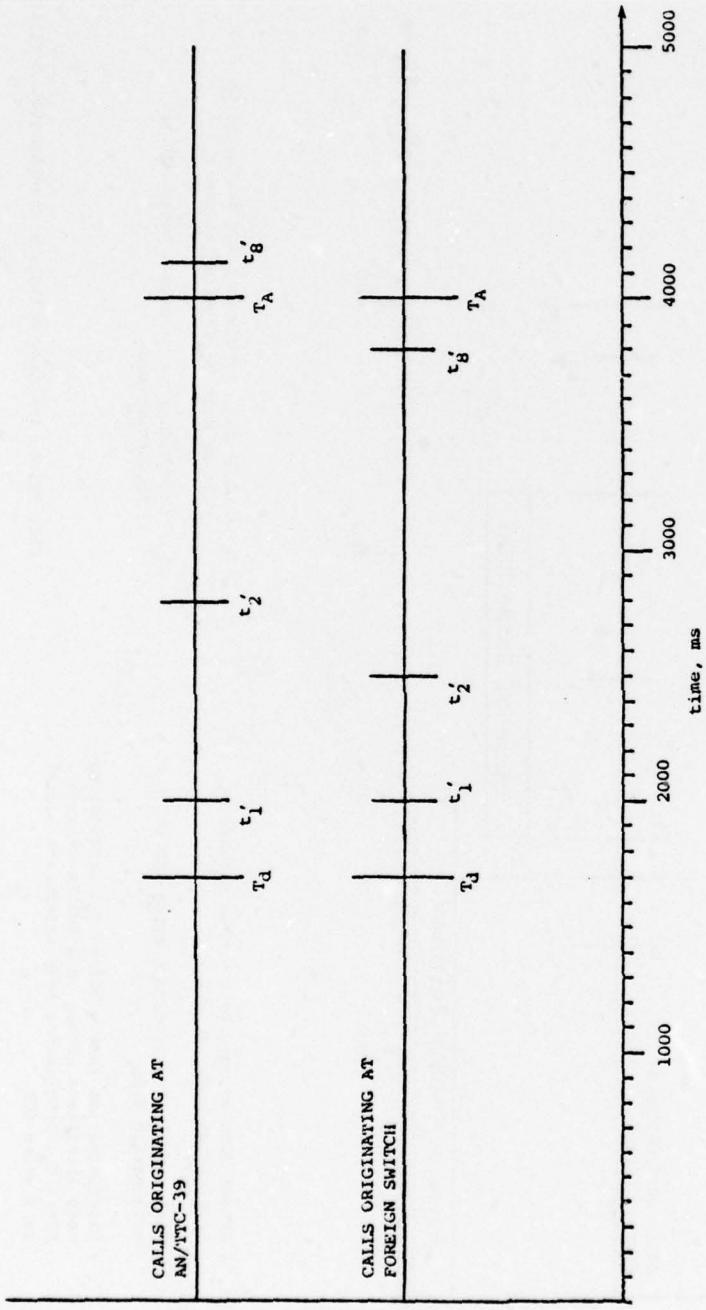
TABLE 5
Delays for Calls Originating at AN/TTC-39 to Foreign Switch

EVENT	Event Time, ms	Total Elapsed Time, ms			
		Terrestrial		Satellite	
		Minimum	Maximum	Minimum	Maximum
1. AN/TTC-39 Signals SF Adapter (Tone off)	0	0	0	0	0
2. U.S. NIU Guards Tone off	140 ±5%	133	147	133	147
3. U.S. NIU Wait; End of Guard to State Change	30 ±5%	161.5	178.5	161.5	178.5
4. U.S. NIU State Change Discrimination Time	20 ±2	179.5	200.5	179.5	200.5
5. Transmission Delay	325-Sat 0-50-Terr	179.5	250.5	504.5	525.5
6. Foreign NIU Sends Seize to Foreign Switch	0	179.5	250.5	504.5	525.5
7. Foreign Switch Recognizes Seize Signal	0-700	179.5	950.5	504.5	1225.5
Total Time for Transmission and Recognition of Signal; AN/TTC-39 to Foreign Switch		179.5	950.5	504.5	1225.5

TABLE 6
AN/TTC-39 NATO Timing Thresholds
Based on STANAG 5040 Guidelines

THRESHOLD	THRESHOLD VALUES, ms			
	Calls Originating at Foreign Switch		Calls Originating at AN/TTC-39	
	Terrestrial Transmission	Satellite Transmission	Terrestrial Transmission	Satellite Transmission
Latest Double Seizure, t_1	1447.5	1997.5	1447.5	1997.5
Earliest Seize ACK, t_2	1852.5	2502.5	2189.5	2811.5
Latest Seize ACK, t_8	3247.5	3797.5	3597.5	4147.5

FIGURE 7
AN/TTC-39 Signaling Thresholds
Across NATO Interface With
STANAG 5040 Thresholds



t_1 - Latest time to receive a double seizure at originating node

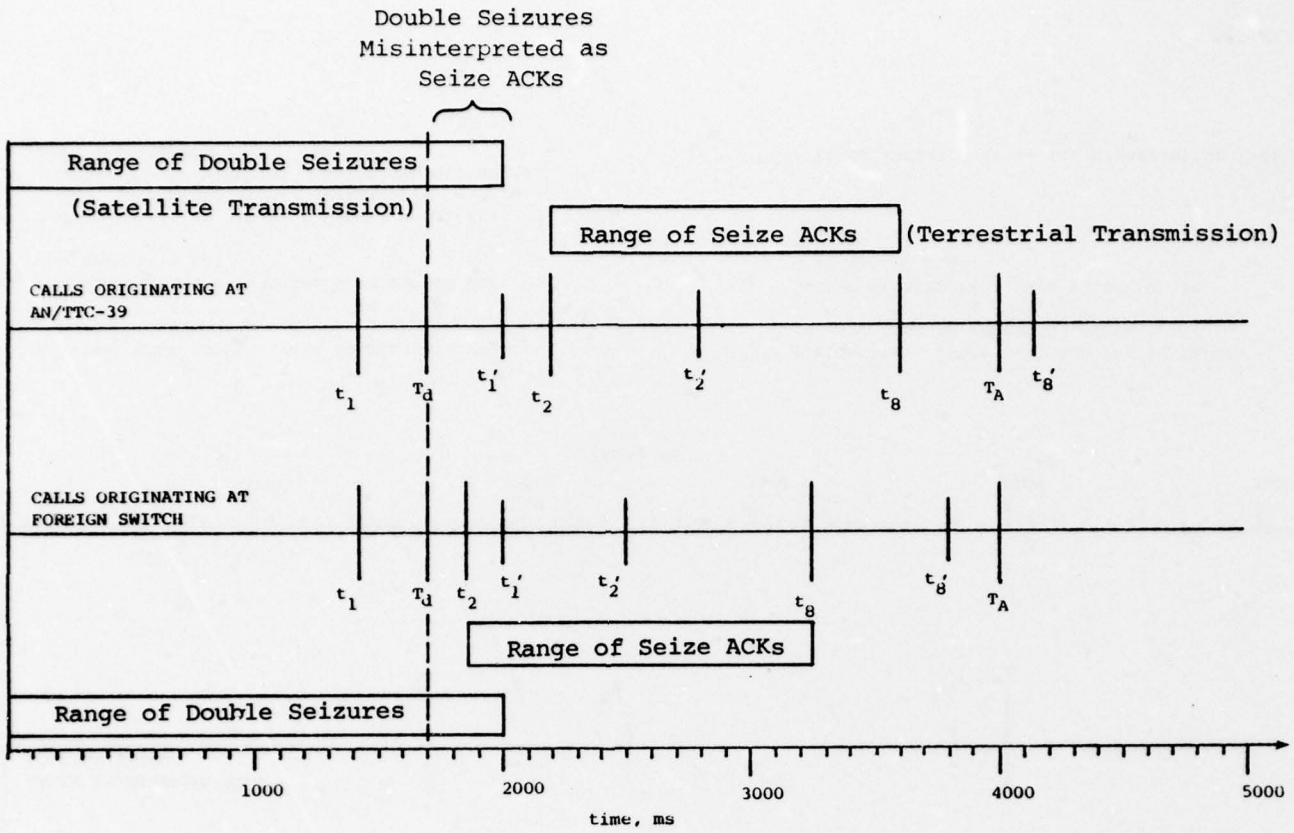
t_2 - Earliest time to receive a seize ACK at originating node

T_d - Discrimination time. Before T_d' originating node interprets signal as a double seizure. After T_d' originating node interprets signal as a seize ACK.

T_A - Alarm time. (Time out) ACK for seize or release must be expected before t_6'.

t_8 - Latest time to receive a seize ACK at originating node.

NOTE: Primes indicate satellite transmission facilities.



t_1 - Latest time to receive a double seizure at originating node

t_2 - Earliest time to receive a seize ACK at originating node

T_d - Discrimination time. Before T_d, originating node interprets signal as a double seizure. After T_d, originating node interprets signal as a seize ACK.

T_A - Alarm time. (Time out) ACK for seize or release must be expected before t_6.

t_8 - Latest time to receive a seize ACK at originating node.

NOTE: Primes indicate satellite transmission facilities.

FIGURE 8
AN/TTC-39 Signaling Thresholds
Across NATO Interface With
STANAG 5040 Thresholds

- T_d (discrimination time) must be relocated between t_1' and the new value at t_2.
- T_A (alarm time) must be increased to a value greater than t_8' (latest arrival of seize ACK with satellite delay, AN/TTC-39 originating only).

These changes are similar to the changes required of STANAG 5040 discussed earlier, with minor time variations. By increasing the pause time by 400 ms, the above conditions are satisfied. The values of t_1, t_2, and t_8, with the additional 400 ms processor pause, are summarized in Table 7. The values in this table differ from those values determined earlier when only STANAG 5040 parameters were considered since the thresholds in Table 7 consider exact parameter delays and more accurately reflect the actual signaling times, rather than the nominal times reflected in the initial analysis.

The remainder of this analysis considers additional parameter delays from which accurate values of the AN/TTC-39 NATO thresholds are determined.

t_1 and t_1', the latest double seizure times, must be adjusted to consider total, maximum non-processor fixed delays in the foreign system (NIU, etc.). These values, which are not readily available, were not considered in the above analysis. Pending the determination of the foreign NIU and other possible delays (SF adapters, etc.), we use the assumption that the maximum total non-processor fixed foreign delay is the same as the U.S. maximum total delay (NIU and SF adapter). The total delay refers to the non-processor fixed delays on that country's side of the interface from sending seize to receipt of seize ACK at the originating switch. Adjusting t_1 and t_1' to reflect the additional delay (U.S. maximum delay, 347.5 ms) increases t_1 and t_1' to 1795 ms and 2345 ms, respectively.

Additionally, for calls originating at the foreign switch, the earliest and latest arrival times of seize ACKs must be adjusted to consider the minimum and maximum foreign non-processor fixed delays, respectively. It is assumed that the minimum delay is zero while the maximum total delay is equivalent to the U.S. delay. This produces the following:

- $t_2 = 2252.5$ ms
- $t_2 = 2902.5$ ms

TABLE 7

AN/TTC-39 NATO Timing Thresholds Based on Additional 2400 ms Pause Time

THRESHOLD	THRESHOLD VALUES, ms			
	Calls Originating at Foreign Switch		Calls Originating at AN/TTC-39	
	Terrestrial Transmission	Satellite Transmission	Terrestrial Transmission	Satellite Transmission
Latest Double Seizure, t_1	1447.5	1997.5	1447.5	1997.5
Earliest Seize ACK, t_2	2252.5	2902.5	2589.5	3211.5
Latest Seize ACK, t_8	3647.5	4197.5	3997.5	4547.5

- t_8 = 4000 ms
- t_8 = 4550 ms.

t_1' (double seizure with satellite delay) is now about 100 ms greater than t_2 (earliest time to receive seize ACK over a terrestrial transmission path), creating a double seizure problem. Increasing the pause time by an additional 300 ms to 2700 ms will increase t_2 to about 2550, relieving potential double seizure problems. This additional increase in pause time also increases t_8 and t_8' (latest seize ACK arrivals) to 4300 ms and 4850 ms, respectively. The alarm time should be specified to have a minimum value of 4900 ms since t_8' now has a value of 4850 ms. If a tolerance is desirable, the alarm time should be specified at 4900 ms + 250.

Considering these additional delays, the discrimination time should be placed at:

$$T_d = \frac{t_2 + t_1'}{2} = 2450 \text{ ms} \pm 100$$

Table 8 summarizes the required timing parameter modifications. Table 9 summarizes the new threshold values with the 2700 ms pause time. Figure 9 identifies the timing thresholds with the recommended parameter modifications.

It should be noted that this analysis is based on a maximum recognition time of 300 ms for the AN/TTC-39. If other switches having recognition times greater than 300 ms are used in lieu of the AN/TTC-39, the discrimination, pause, and alarm times must be redetermined. Also, if satellite facilities are not utilized, the recommended changes will operate properly for both AN/TTC-39 and non-AN/TTC-39 NATO calls. Also, if the total maximum foreign non-processor delay is greater than the AN/TTC-39 delay (350 ms), modifications to the parameters will probably be necessary.

SUMMARY OF RESULTS

The results of the analysis are summarized in Tables 10 and 11. Table 10 lists the design parameters required to determine timing threshold values. Table 11 summarizes the timing parameters and threshold values obtained from the analysis. As delineated in Table 11, the results of the two analyses differ. The first analysis only considers information contained in STANAG 5040 and provides inaccurate results since guidelines accounting for NIU and SF adapter

TABLE 8
Summary of STANAG 5040 and Recommended Changes to STANAG 5040 to Accommodate AN/TTC-39 NATO Interface

Parameters	STANAG 5040, ms	Recommended Changes to STANAG 5040, ms
Discrimination Time, T_d	1700 ms $\pm$100	2450 ms $\pm$100
Alarm Time, T_A	4000 ms $\pm$250	4950 ms +250
Pause Time, T_p	2000 ms $\pm$150	2700 ms $\pm$130* (AN/TTC-39 Processor Pause - 2370 $\pm$130**)

* This pause time should be interpreted as the total delay from the identification of a DC seize at the NIU to the return of a DC seize ACK at the NIU. This time does not include processor recognition and transmission times.

** This pause time discounts non-processor fixed hardware delays from the identification of a DC seize at U.S. NIU to return of DC seize ACK at U.S. NIU.

TABLE 9

AN/TTC-39 NATO Timing Thresholds
Based on 2700 ms Pause Time

THRESHOLD	THRESHOLD VALUES, ms			
	Calls Originating at Foreign Switch		Calls Originating at AN/TTC-39	
	Terrestrial Transmission	Satellite Transmission	Terrestrial Transmission	Satellite Transmission
Latest Double Seizure, t_1	1795	2345	1795	2345
Earliest Seize ACK, t_2	2550	3200	2883	3532
Latest Seize ACK, t_8	4300	4850	4278	4828

FIGURE 9
Signaling Thresholds Across AN/TTC-39
NATO Interface with Recommended
Modifications

t_1 - Latest time to receive a double seizure at originating node

t_2 - Earliest time to receive a seize ACK at originating node

T_d - Discrimination time. Before T_d, originating node interprets signal as a double seizure. After T_d, originating node interprets signal as a seize ACK.

T_A - Alarm time. (Time out) ACK for seize or release must be expected before t_6.

t_8 - Latest time to receive a seize ACK at originating node.

NOTE: Primes indicate satellite transmission facilities.

TABLE 10
Design Parameters

U.S. Side of NATO Call

- SF Guard Time - 140 ms ±5%
- AN/TTC-39 Scanning Time - 0-100 ms
- AN/TTC-39 Seize Processing Time - 0-100 ms
- AN/TTC-39 Pause Time*
  - Based on STANAG 5040 - 1675 ms ±150
  - Recommended Change Based on Analysis - 2375 ms ±150
- AN/TTC-39 Signal SF Transmitter - 0-100 ms
- NIU Guard Time - 140 ms ±5%
- NIU Waiting Period - 30 ms ±5%
- NIU Discrimination Time - 20 ms ±2

Foreign Side of NATO Call

- Processor Delay - 0-700 ms
- Pause Time
  - Based on STANAG 5040 - 2000 ms ±150
  - Recommended Change Based on Analysis - 2700 ms ±150
- NIU Delays Should Be Assumed When Calculating t_1, t_2, t_8

Transmission Times

- Terrestrial - 0-50 ms (one-way)
- Satellite - 650 ms (round trip)

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* These times discount non-processor fixed hardware delays.

TABLE 11
Timing Parameters and Threshold Results

Threshold/Parameter Values	RESULTS OF STANAG 5040 ANALYSIS, ms		RESULTS OF AN/TTC-39 ANALYSIS, ms	
	STANAG 5040 Signaling Analysis with Unmodified STANAG 5040 Parameters as a Guideline	Proposed Changes to STANAG 5040 for Satellite Links	AN/TTC-39 NATO Signaling Analysis with Unmodified STANAG 5040 Parameters as a Guideline	Recommended Changes to STANAG 5040 for Satellite Links
Pause Time, T_p	2000±150*	2400±150	2000±150*	2700±100**
Discrimination Time, T_d	1700±100*	2150±100	1700±100*	2450±100
Alarm Time, T_A	4000±250*	4650±250	4000±250*	4950+250
Latest Double Seize t_1, (Terrestrial, Satellite)	1500, 2050	1500, 2050	1447.5, 1997.5	1795, 2345
Earliest Seize ACK, t_2, (Terrestrial, Satellite)	1850, 2500	2250,2900	1853, 2503†	2550,3200
Latest Seize ACK, t_8 (Terrestrial, Satellite)	3650, 4200	4050, 4600	3597.5, 4147.5††	4300, 4850

* Specified in STANAG 5040.

** AN/TTC-39 pause should be set at 2375 ±100. This value discounts non-switch hardware delays from identification of seizure at U.S. NIU to return of seize ACK at U.S. NIU.

† Foreign originating calls.

†† AN/TTC-39 originating calls.

delays are not contained in the specification. The second analysis considers specific equipment delays for an AN/TTC-39 NATO call and more accurately identifies the values at which STANAG 5040 timing parameters should be specified.

CONCLUSIONS

Based on the results of the analysis, it has been concluded that under worst-case conditions, STANAG 5040 timing parameters will not provide reliable operation when satellite transmission facilities are used. Under worst-case conditions, protection against double seizures is inadequate, resulting in the misinterpretation of double seizures as seize acknowledgment at the originating switch for the worst-case. Furthermore, the time out alarm will occur prior to the receipt of the seize ACK at the originating switch for the worst-case.

Improved operation can be obtained through modifications of STANAG 5040 timing parameters. To provide reliable operation over satellite and terrestrial transmission facilities, the STANAG 5040 timing parameters should be changed to the following:

- Pause time, T_p - 2700 ms $\pm$100
- Discrimination time, T_d - 2450 ms $\pm$100
- Alarm time, T_A - 4950 ms +250.

These changes are based on a maximum recognition time of 300 ms for the AN/TTC-39 and 700 ms for a foreign switch. If another switch is used in lieu of the AN/TTC-39 and if its recognition time is greater than 300 ms, new discrimination, alarm, and pause times must be determined.

Unless the proposed changes are made, reliable operation of the NATO interface links will not be ensured. However, due to differences in implementation and the fact that worst-case conditions do not always apply, a successful interface via satellite may be possible. Moreover, these timing parameters are based on the assumption that the total maximum non-processor fixed hardware (NIU, etc.) delay is the same as the maximum U.S. fixed (NIU and SF adapter) delay, and that the total minimum delay is zero. As actual foreign NIU delays are examined, modifications to the parameters may be required if the maximum delay is greater than the AN/TTC-39 delay. (The total delay refers to the non-processor fixed delays on that country's side of the interface from sending seize to receipt of seize ACK at the originating switch.)

Another important conclusion relates to the non-processor fixed hardware delays. Delays in the U.S. SF adapter, U.S. NIU, and foreign NIU are significant and must be considered when determining the latest arrival of double seizures, the earliest arrival of seize ACKs, and the latest arrival of seize ACKs. The delays are not accounted for in the STANAG 5040 specification. STANAG 5040 should specify the expected total non-processor fixed hardware delay for one side of the interface. The fixed hardware delays should have a minimum value of zero and a maximum value of 350 ms. (The maximum value is based on maximum AN/TTC-39 delays.) The total delay includes the non-processor fixed hardware delays on one side of the interface from the transmission of seize to receipt seize ACK at the originating switch.

The pause time, as defined in the STANAG 5040, could be interpreted in different ways and should be more clearly stated to reflect that the pause time should be interpreted as the total delay from receipt of a DC seize request at the NIU to return of DC seize ACK at the NIU. The pause time should not include processor recognition and transmission times, but should discount the remaining fixed hardware delays. Hence, if STANAG 5040 specifies a pause time of x, the actual processor pause time should be set at x-y, where y is all of the non-processor fixed hardware delays (NIU, SF adapters, etc.) on that nation's side of the interface. This provides the same total pause time at the interface for all systems.

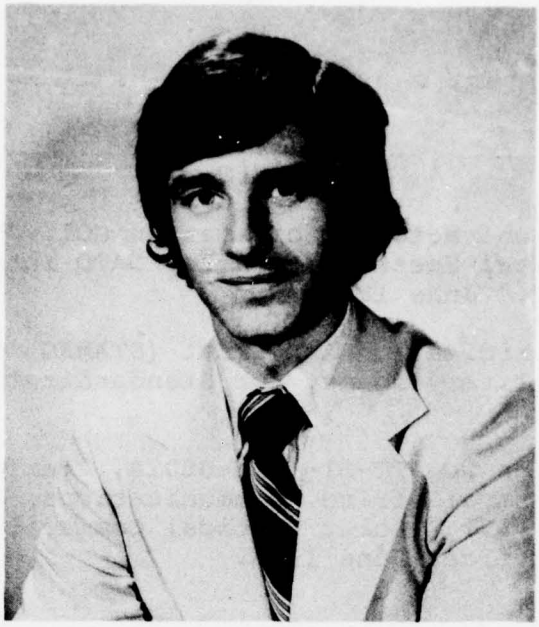
Modifications to STANAG 5040 to provide reliable operation over satellite facilities could be considerably less if the actual maximum processor recognition times are on the order of 400 ms rather than 700 ms, which is used as a guideline in STANAG 5040. Since the AN/TTC-39 has a maximum recognition time of 300 ms, it is reasonable to assume that the above condition could exist. However, it should be noted that if the maximum foreign processor recognition time is considerably less than 700 ms, the timing parameters recommended above will still provide reliable operation over both terrestrial and satellite facilities.

REFERENCES

1. AN/TTC-39 Contractor Specification C01, "Operational and Electrical Specification for NATO Interface Unit, Appendix 17," June 1975.

2. "NATO Standardization Agreement (STANAG) 5040," First Edition, Military Agency for Standardization, February 1977.

3. Specification No. TT-B1-1101-0001A, "Performance Specification Central Office, Communications, Automatic AN/TTC-39( )(V)," Joint Tactical Communications (TRI-TAC) Office, June 1974.



Mr. Dollive is an Associate at Booz, Allen & Hamilton where he has worked in connection with the Joint Tactical Communications (TRI-TAC) Office since 1972. His experience is in system analysis of telecommunications systems. Mr. Dollive participated in the initial subsystem planning effort of the TRI-TAC Office. He has defined and analyzed requirements of the Communications System Control Element (CSCE) and Communications System Planning Element (CSPE) of the Tactical Communications Control Facility (TCCF). Mr. Dollive has also reviewed several techniques of routing calls (deterministic, adaptive, flood search) in a tactical network and has determined the signaling message and channel requirements of each technique. Other areas that Mr. Dollive has worked with include the initial development of a family of orderwire control unit specifications, and the analysis of loop/trunk signaling and timing requirements for the family of unit level circuit switches. He received his B.S. and M.S. degrees in electronic engineering from Monmouth College in West Long Branch, New Jersey.

INTEROPERABILITY OF THE AN/TTC-39 CIRCUIT SWITCH WITH NATO MEMBER FORCES COMMUNICATIONS EQUIPMENT

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I. INTRODUCTION

The problems engendered by the introduction of automatic or semiautomatic telecommunication links between NATO member forces while the individual NATO member forces are simultaneously and independently upgrading their communication systems have been addressed by the NATO Army Armaments Group Telecommunications Panel and has resulted in the promulgation of STANAG 5040 which defines a standard interface, based on the analog voice channel. It was left to each national system to develop the interface box which would convert the national standards to and from the NATO standard. This paper will present the details of the interface design for the U.S. system based on the AN/TTC-39 circuit switch, currently being developed by GTE Sylvania for the U.S. Army.

II. FORM OF SOLUTION

The AN/TTC-39 circuit switch is a stored program controlled hybrid analog/digital switch available in two basic configurations: a single S-280 shelter of up to 450 external loops/trunks and a two-shelter version of up to 720 external loops/trunks. Interface capability of the AN/TTC-39 includes inventory equipments ranging from 20 Hz ringdown loops and trunks to automatic tone signaling interfaces with the AN/TTC-38 and full automatic capability to interface with and act as an AUTOVON switching center. Most significant, however, are the AN/TTC-39 interfaces to the class of Tenley and Seely digital secure equipments and the use of common channel signaling techniques over both analog and digital facilities to interface between AN/TTC-39 switching centers.

Because of its extensive interface capability, the switch already has a wide range of signaling and supervisory techniques available to interface with its NATO interface box. The choices available were:

Common Channel Signaling
Tone Supervision/DTMF or MF Signaling
SF (2600 Hz) Supervision/DTMF, MF or Dial Pulse Signaling
DC Supervision/DTMF, MF or Dial Pulse Signaling

As discussed in other session papers, the STANAG 5040 interface is defined as a DC supervised, dial pulse signaling system. Although any of the signaling systems indicated could have been converted as a "NATO Interface Unit" to the NATO standard, the simplest and hence least costly solution was determined to be a signaling/supervision system closest to that of the NATO standard which at the same time would be capable of direct transmission over radio links to a NATO Interface Unit remoted from the switch. Therefore, the decision was made to utilize SF (2600 Hz) supervision with dial pulse signaling. This selection also has the advantage of being compatible with the design capabilities of the AN/TTC-38 switch so that a single interface design allows access to both the current and future U.S. tactical network. It should also be noted that since the AN/TTC-39 has the capability to act as an AUTOVON switching center, direct NATO member forces interface to the U.S. strategic network is also possible.

III. IMPLEMENTATION

STANAG 5040 defines a system based on national prefix codes to obviate numbering incompatibilities and on the NATO Interface Unit (NIU) to standardize the signaling across national boundaries. Each member nation will have a unique national prefix code of the form 9YX where Y = 0 or 1 and X = 0 - 9. It should be noted that these areas do not necessarily correspond to national boundaries, but rather to regions of military control. The NIU is a means to connect national systems which use different signaling techniques. Each NIU accepts one national standard and converts it to the NATO standard as shown in Figure 1.

A. Electrical

The AN/TTC-39 NIU interfaces to an SF adapter located within the switching shelter and may be located directly outside the shelter or separated from the switch by a radio link. The same NIU design is utilized in either case. Figure 2 is a functional block diagram of an NIU single analog channel. Four wires connect the NIU to the AN/TTC-39 SF adapter while six wires (puls a common ground) are presented to the foreign NIU. Four, V_{YX} and V_{XY}, are for voice transmission and two, S_{YX} and S_{XY} for signaling. The basic function of the AN/TTC-39 NIU is to convert 2600 Hz SF signaling (dial pulse) and supervision to the NATO standard DC on wires S_{YX} and S_{XY}.

SF Receiver

The SF receiver (refer to Figure 2) is compatible on an end-to-end basis with standard SF signaling units, including those in use by AUTOVON. A guarding action is employed to prevent voice simulation of the 2600 Hz signaling tone and is implemented by employing the limiter capture effect and a dual level receiver

channel. Initial onset of signaling tone is recognized only as a long duration of HI-level tone; initial onset of LO-level tone or of HI-level tone of duration less than that specified is ignored by the receiver logic. The limiter capture effect refers to the fact that if a single frequency signal is hard limited, any interfering signals present are exagerated at the output of the limiter. Since the output of the limiter is at a known amplitude, the band pass filter/level detector can be adjusted to reject any specified level of interfering signal. Bandwidth of the SF receiver at a 6 dB signal/noise ratio detection threshold is a minimum of 30 Hz and a maximum of 100 Hz, centered at 2600 Hz. Receiver sensitivity is set at -16 dBm for the HI-level mode and at -31 dBm for the LO-level mode. When the receiver channel operates in the LO-level sensitivity mode, it is preceeded by a high pass filter which serves to remove information signals such as ringback and busy tone which are superimposed on the SF signaling tone. If not prevented from reaching the limiter input, these signals would capture the receiver, preventing recognition of the SF signaling tone, and result in a false off-hook being reported.

A band elimination filter, switchable into and out of the receive path under control of the NIU logic, is provided to restrict the SF signaling tone to the link from the AN/TTC-39 to the NIU. It provides 30 dB of attenuation at 2600 Hz and has a minimum bandwidth of 15 Hz and a maximum bandwidth of 100 Hz at the 30 dB point and has a bandwidth of 250 $\pm$ 50 Hz at the 3 dB point.

Receive Control Logic

The receive logic and timing provides a 140 msec. guarding interval before considering the absence of LO-level SF tone valid. This provides protection against radio fades. In addition to reporting the absence of LO-level SF tone, the receive logic also switches the channel sensitivity from LO to HI. Thirty msec. after the 140 msec. period during which LO-level SF tone is not present, the receive logic starts to track the incoming SF signal and applies the appropriate conditions to S_{XY}. Once tracking has commenced, absence of HI-level SF tone is regarded as the OFF-HOOK state and presence of HI-level SF tone is regarded as the ON-HOOK state. The receive logic stops tracking and switches the receiver sensitivity back to LO after receiving 250 msec. of HI-level SF tone. The ON-HOOK state is maintained until 140 msec. of absence of SF tone occurs.

The ON-HOOK and OFF-HOOK states are passed to the foreign NIU over S_{XY} as shown in the following table except that no state change is passed unless the duration of the change exceeds 20 msec. In other words, the SF receive logic integrates the presence of HI-level SF tone or the absence of LO-level SF tone to prevent the sending of false state changes across the interface.

State	S_{XY}
ON-HOOK	0 Volts
OFF-HOOK	+24 Volts $\pm$4 Volts

The voltage is referred to the common wire between the two NIUs with the current limited to 20 mA by the foreign NIU.

Transmit Control Logic

The SF Transmit Control Logic receives commands from the foreign NIU over S_{YX}. S_{YX} may be in one of two conditions as follows:

S_{YX}	Command
0 Volts	ON-HOOK
+24 Volts $\pm$4 Volts	OFF-HOOK

The voltage is referred to the common wire between the two NIUs and the current is limited to 20 mA by the transmit control logic.

Upon receipt of ON-HOOK, the NIU begins transmitting SF tone to the AN/TTC-39.

The SF tone is 2600 Hz and is transmitted at -10 dBm for 500 msec. or until OFF-HOOK is received, whichever comes first. If OFF-HOOK has not been received when the time-out occurs, the SF tone continues but at -22 dBm until OFF-HOOK is received. The NIU maintains a 600 ohm termination impedance when turning SF tone on and off.

Transmission Level Coordination

AN/TTC-39 trunks to the NIU are expected to be operated at 0 dB loss. To achieve this goal and to permit level coordination with carrier systems, adjustable transmission gain is provided in both transmit and receive directions. The gain is continuously variable over the following ranges:

Direction (Relative to NIU)	Range
Transmit	+10 to -15 dB
Receive	+10 to -10 dB

B. Physical

The NIU is housed in a combination case identical to that used for the GTE Sylvania developed SB-3614 30/60/90 line automatic switchboard. In this package, the NIU fully meets the remote equipment environmental requirements called out in TRI-TAC specification TT-B1-1101-0001A and summarized in Table 1. Eight voice channels are accommodated in a single case with each voice channel packaged on two printed circuit boards. The only additional components are a common printed circuit board which contains the 2600 Hz oscillator and timing logic and a power supply. Power

input is 115 Volts, single phase, 50/60/400 Hz. Total current requirements are less than 0.6 Ampere.

Each of the voice channels is provided with edge mounted jacks, trim pots and toggle switches to select and monitor an internally generated 1050 Hz test tone which can be used for transmission level coordination purposes. Standard electronic components are utilized except for the transmit and receive control logic each of which is implemented as a custom MOS chip. (The same chip is used in the SF adapter at the AN/TTC-39.)

A 25-foot power cable with one end terminated by an MS type connector and the other end by a military 3-prong connector is provided and is stored in the rear cover of the combination case. The NIU provides two signal connectors, one for interface with the AN/TTC-39 and the other for the interface with the foreign NATO interface unit. Each connector is an MS type and is the same as is used on the AN/TTC-39 signal entry panels. For the interface with the foreign NIU, a 25-foot, shielded, twenty-six pair MS to hock connector signal cable is provided. This special cable provides crossover of the transmitting terminals of one NIU to the receiving terminals of the other NIU.

Normal operation is with the front cover on, as there are no operator controls, and the rear cover removed for access to the signal and power connectors.

C. AN/TTC-39 Software Considerations

Signaling and Supervision

STANAG 5040 defines the signaling and supervisory protocol between NATO interface units. Since the NIU developed as part of the AN/TTC-39 program simply converts the NATO standard DC supervision to 2600 Hz tone supervision, the AN/TTC-39 software is essentially interacting directly with the NATO standard. All intelligence functions are allocated to the AN/TTC-39 software with the NIU and SF adapter hardware performing only basic signal detection functions. Therefore, rather than discuss the detailed signaling and supervisory protocol, only certain special cases are highlighted in this paper.

Seize glare or the simultaneous seizure of the same trunk from each end will result, according to STANAG 5040 protocol, in both ends backing down and releasing the trunk. In the case of the AN/TTC-39 end, the full set of trunk and route selection capability is available to complete the call over an alternate path. This includes selection of another trunk in the same group, if one is available, or selection of up to five alternate trunk groups if there are no trunks available in the primary trunk group. Once a trunk has been successfully seized and signaling is complete, the NATO protocol has both ends of the trunk in an off-hook state with a ringback information tone being passed from the called system to

the calling system. Since there is no answer signal provided for in the protocol, the AN/TTC-39, when it is the calling switch, considers the call to be answered at this point and passes an answer indication back through the U.S. network which results in the full through connect being established. During the traffic state of the call, it is necessary to guard against the simulation of 2600 Hz by speech which might otherwise cause the false release of the call. Although most 2600 Hz speech simulation is detected and blocked by the guarding action of the hardware in the NIU and SF adapter, as discussed previously, additional protection is provided by having the software integrate hardware reported on-hook signals for 530 msec. before considering the on-hook to be a valid release. One last aspect of signaling and supervision is the application of preemption to NATO trunks. Before preempting outward, the AN/TTC-39 transmits a 1.25 second burst of preempt tone over the trunk. This is followed by an outgoing release and, if the trunk is to be reused, by an outgoing seizure.

Numbering

Numbers transferred through the NIU, both to and from the NATO trunk, have the following format:

T P XXX X

The digit T is the traffic mode digit. At the present time, only two values of T are defined. A T equal to "1" indicates that the call crossing the interface is unencrypted secure. A T of "2" indicates that the call is using vocoder-type encryption. The digit P is the precedence designator. In the NATO standard, only three levels of precedence are defined: "1" = ROUTINE, "2" = ORDINARY PRIORITY, "3" = SPECIAL. On reception by the AN/TTC-39, a P of "1" is interpreted as ROUTINE, "2", PRIORITY, and "3", FLASH. In a call to a foreign switch, the AN/TTC-39 sets P to "1" for ROUTINE calls, "2" for PRIORITY or IMMEDIATE, and to "3" for FLASH or FLASH OVERRIDE.

The number of address digits, XXX .... X is variable but never exceeds 13. Since the number of digits cannot be predicted in advance, the AN/TTC-39 recognizes the last digit to be received from a NATO trunk by virtue of the fact that no following digit is received within 16 seconds. The same timeout requirement also applies to a NATO call from an AN/TTC-39 subscriber.

The following codes are transmitted in the following order, if present: national prefix code, area code, switch code, loop number. Not every code need be present in each call. For example, the national prefix code may be absent, or the area code, or both. The national prefix code is distinguished from a United States military system area code by the fact that the former has the form 9YX, while the latter does not. The national prefix code is an access code used strictly to indicate NATO calls.

Other than a code being used as an access code for a NATO call, the processing of 9YX is similar to that of NYX in a non-NATO call. Specifically, all of the AN/TTC-39 routing features including alternate area routing, digit editing, zone restriction and call inhibit are applicable. As an example, consider the NATO home area divided into two or more parts by one or more 9YX areas. In this case, it may be necessary to route through the 9YX area(s) to communicate between the disjoint sections of the home 9YX area. Therefore, if the call is to be routed over a NATO trunk to the called party located in the disjoint section of the home AN/TTC-39 switch, the AN/TTC-39 insures that the address digits forwarded over the trunk contain the home 9YX code.

IV. CONCLUSION

This paper has described the NATO interface Unit designed in conjunction with the AN/TTC-39 circuit switch and has shown how the design has been selected to maximize commonality with existing equipments both within the AN/TTC-39 circuit switch and with other existing equipments such as the SB-3614 and AN/TTC-38. The hardware solution has been kept simple and highly modular to minimize costs and to permit ease of maintenance. All logic relating to signaling, supervision and numbering plan functions has been allocated to software at the parent switch which means that changes to these protocols are easily accomplished without any change to the NIU itself.

TABLE 1

ENVIRONMENTAL PERFORMANCE

Condition	Limits
Low Temperature:	
Storage	$-70^{\circ}F$
Operation	$-50^{\circ}F$
High Temperature:	
Storage	$+160^{\circ}F$
Operation	$+125^{\circ}F$
Humidity	100% at air temperature of $80^{\circ}F$
Altitude	
Storage	to 40,000 feet
Operating	to 10,000 feet
Sand and Dust	Blowing fine sand and dust at wind speeds up to 40 mph
Immersion	3 feet of water for 2 hours
Salt Fog	Prolonged exposure in salt laden atmosphere
Fungus	Under conditions favorable to growth
Vibration and Shock	Field transport by military vehicles as loose cargo and by rough handling

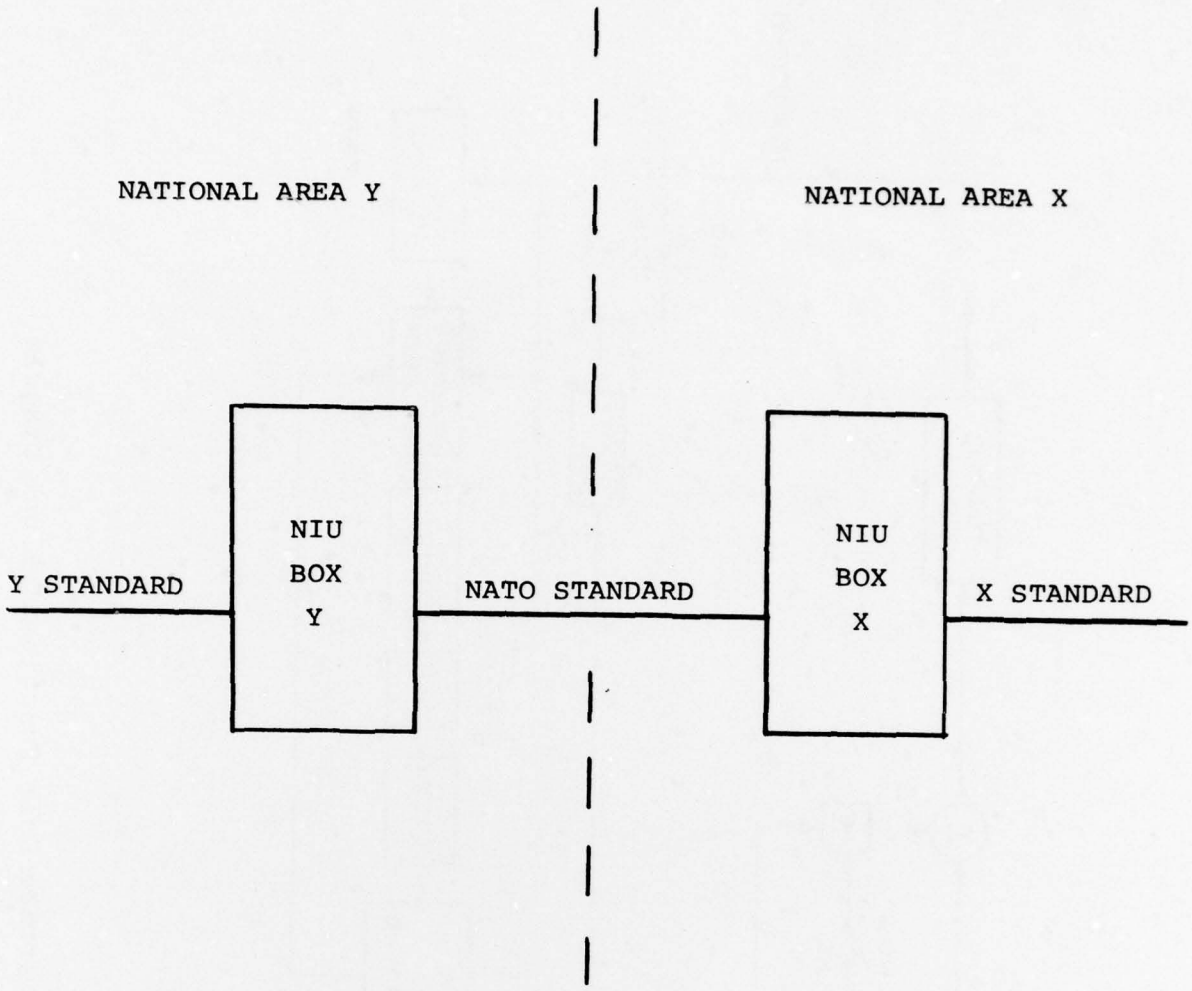


FIGURE 1

CROSS-NATIONAL CONNECTION

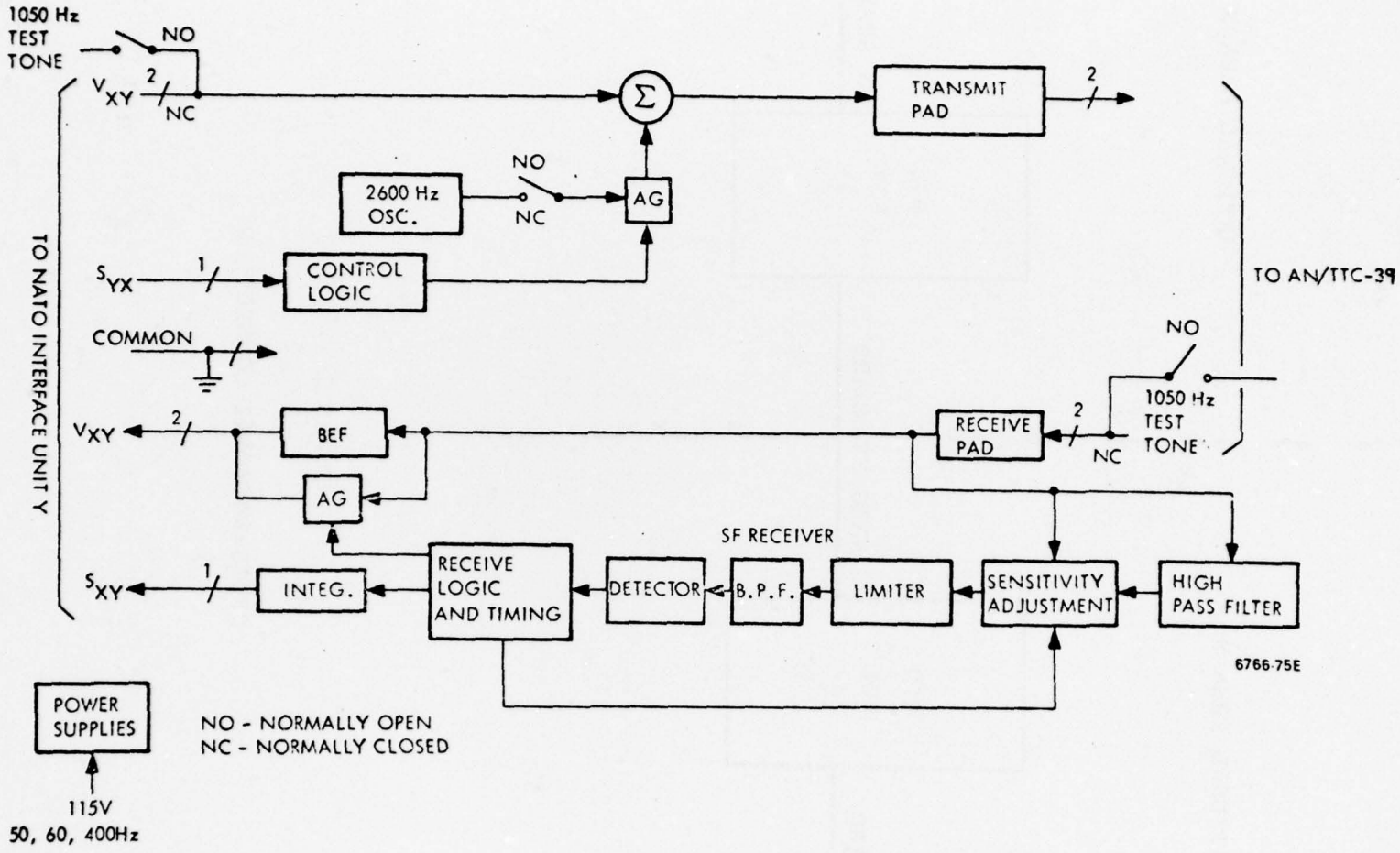


Figure 2 NATO Interface Unit Functional Block Diagram



BIOGRAPHY

Frederick Kotler received B.S. and M.S. degrees in electrical engineering from Columbia University in 1967 and 1968, respectively. In addition, he has taken graduate level courses in industrial and electrical engineering at Northeastern University.

He joined GTE Sylvania's Electronic Systems Group in 1968 and has been engaged since that time in system design, development and testing of both fixed plant and tactical communication switching equipment. His current assignment is functional test director for the AN/TTC-39 circuit switch where he is responsible for the development of test plans and procedures, performance of system integration, and conduct of the RDAT electrical and functional performance tests. Mr. Kotler's earlier role on the AN/TTC-39 program was as lead systems engineer where he was responsible for definition of the circuit switch architecture with particular emphasis on allocation of functions to software and hardware; detailed system design of the terminal interfaces and control structure; and development of the common channel signaling, routing and numbering plans.

Prior to becoming involved with the AN/TTC-39 in June 1972, Mr. Kotler worked as a member of the AN/TTC-38 system engineering design team with primary emphasis on external interfaces and on the CV-1918, CV-1919 and CV-2875 converter equipments. He has also been involved in investigating commercial applications of GTE Sylvania's electronic switching capability. This work has involved system design efforts on PABX and credit card verification type systems.

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