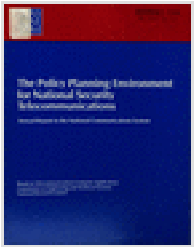

The Policy Planning Environment for National Security Telecommunications: Annual Report to the National Communications System (1985)

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The Policy Planning Environment for National Security Telecommunications

Annual Report to the National Communications System

by the Committee on National Security
Telecommunications Policy Planning Environment
Board on Telecommunications-Computer Applications
Commission on Engineering and Technical Systems
National Research Council

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This report has been reviewed by a group other than the authors, according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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PREFACE

This is the first annual report of work by a committee convened in January 1984 by the National Research Council (Research Council) at the request of the Deputy Manager of the National Communications System (NCS). Following immediately on a preceding study of NCS initiatives in support of national telecommunications policy, the committee was asked to provide "objective advice that the NCS can use to effectively plan and implement measures to enhance the Nation's telecommunications support of national security leadership requirements," concentrating on applications of new technology, methods of capitalizing on likely strategies of the telecommunications industries, alternate approaches to post-attack national security telecommunications reconstitution, and the application of technical standards in the changing telecommunications environment. The Statement of Task for that work follows this preface.

In response to the Deputy Manager's request the Research Council established the Committee on National Security Telecommunications Policy Planning Environment (Committee). The Committee has conducted its review beginning March 26, 1984 and thus far leading to this annual report. Since the Statement of Task is very broad and the telecommunications environment following the actual divestiture of AT&T has continued to exhibit rapid changes, the committee has had to treat certain tasks in greater depth than others. This treatment reflects the Committee's work to date, and is not intended to indicate priority of importance of the subject areas delineated by the NCS. The Committee believes this coverage to be in accord with the NCS' desires.

The members of the Committee on National Security Telecommunications Policy Planning Environment have expertise in a variety of complementary areas related to planning, technology, networking and interoperability, standards for, survivability of, and industrial operations and management of telecommunication systems; and the policies and regulations, and industrial tactics and strategies that the rapidly changing telecommunications environment comprises. Members' backgrounds embrace such fields as computer/communication systems; telecommunication systems; radio transmission and propagation; satellite systems; video cable systems; state, local, and amateur telecommunication systems; microwave, millimeter-wave, and optical technologies; equipment vulnerability; nuclear effects; telecommunications law, policy, and regulation; standards; and government operation and organization.

Thus far, the Committee's review has examined new technologies and their effects on both survivability and standards; tactics and strategies of the major contestants for telecommunications markets and the influence of their actions on policy and regulation; and state and local telecommunications systems as possible alternate approaches to reconstitution. During the course of its activity it has had 26 briefings spread through four quarterly meetings, and has divided into subcommittees that have each pursued a particular area of concern through meetings and exchanges of discussion papers. The 26 briefings comprised 14 from federal government officials, six from state and local emergency management/telecommunications officials, five from executives of communications and information industries, and one from an executive of a telephone industry association. Forty-two review documents and extensive distribution of articles from the current industry, policy, and technical literature were provided to committee members to support their review and deliberations during this period. Between meetings committee members reviewed materials, conferred with one another individually and through subcommittee activities, attended particular meetings of NCS contractors and working groups, and prepared discussion papers and draft material for this report. In addition, committee members drew on the two reports of the predecessor Committee on Review of Initiatives in Support of National Security Telecommunications Policy as their security clearances permitted.* To provide continuity, several members of this committee were recruited from the predecessor committee.

We continue to enjoy cooperation and support from the Office of the Manager, NCS, during the course of this study, as we did during its predecessor. In particular we appreciate the support we have received from Mr. John Grimes, formerly Deputy Manager, NCS and now Director of the Crisis Management Center, National Security Council; Mr. Benham Morriss, Deputy Manager, NCS; Mr. Lonn Henrichsen, NCS Joint Secretariat; and Dr. Harold Knapp, Scientific Advisor for Operations Research, Office of the Manager, NCS.

This Committee, like others in the Research Council whose members serve part-time and without compensation, must rely heavily on its professional staff. In this regard we are particularly grateful to Richard B. Marsten for his sustained support of and contributions to our work.

A major committee effort like this imposes a heavy burden on its administrative coordinator. It is a pleasure to acknowledge the assistance of Karen Laughlin for her support of all administrative and other essential activities.

Finally, as the Committee chairman, I want to express my sincere thanks to committee members for their dedicated efforts.

JACK A. BAIRD
CHAIRMAN

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*These reports are:
(1) National Joint Planning for Reliable Emergency Communications. National Academy Press, Washington, D.C., February 1983; and
(2) Telecommunications Initiatives Toward National Security and Emergency Preparedness, CONFIDENTIAL, National Academy Press, Washington, D.C., February 1984.

COMMITTEE ON NATIONAL SECURITY TELECOMMUNICATIONS POLICY PLANNING ENVIRONMENT

BOARD ON TELECOMMUNICATIONS-COMPUTER APPLICATIONS

COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS

STATEMENT OF TASK

In a climate of unprecedentedly rapid change in the telecommunications industry and the services it provides, the National Communi- cations System (NCS) must plan for an effective national security/- emergency preparedness (NS/EP) telecommunications structure that can respond to the changes taking place. To support this effort the Com- mittee will identify and recommend to the Manager, NCS, policy options derived from the following tasks:

1. Applications of New Technical Developments. The Committee will identify new technical developments, assess their implications for national telecommunications policy and options, and advise the NCS on how to take advantage of them to enhance or maintain effectiveness of the nation's NS/EP capability or to reduce the relevant costs. It will indicate trends likely to affect survivability or vulnerability and will comment on the interactions between new technologies and institutional problems related to the objectives of National Security Decision Directives Numbers 47 and 97 (NSDD-47 and NSDD-97).

2. Telecommunications Industry Tactics and Strategies. The Committee will examine companies' shortand long-term corporate strategies and will advise the NCS on their implications for NS/EP telecommunications capabilities and policy. It will review NCS evolutionary planning with industry to meet NS/EP telecommunications policy objectives and will recommend technical, policy, legislative, and regulatory initiatives for NCS action.

3. Alternate Approaches to Reconstitution of Telecommunications. The Committee will identify and assess options, and suggest approaches, that the NCS could pursue for the reconstitution of NS/EP telecommunications. This activity should include, in coordination with appropriate federal agencies, elements of a program for survivability and management of state and local resources and a "bottom-up" approach to reconstitution.

4. Applications of Technical Standards. The Committee will review existing and emerging telecommunications technologies and suggest areas in which NCS should participate in standards activities. It will suggest policy options for NCS consideration to address compatible standards in a public policy environment that stresses competition and innovation.

Comments, findings, and recommendations of the Committee will form the basis of reports to be submitted. Two formal, annual reports will be submitted to the NCS upon completion of the normal NRC review processes.

Date: March 1984

CONTENTS

I. INTRODUCTION

National Security Telecommunications Policy, most recently stated in National Security Decision Directive Number 97 (NSDD-97), August 3, 1983, declares the nation's domestic and international telecommunications resources, including commercial, private, and government-owned facilities and services, to be "essential elements in support of U.S. national security policy and strategy." It requires "a survivable telecommunications infrastructure able to support national security leadership" as embodied in the President's responsibilities as Commander in Chief, Head of State, and Chief Executive. That leadership includes, among other things, gathering intelligence and conducting diplomacy, ensuring continuity of command and control of military forces, and providing for continuity of government and essential functions thereof. An earlier directive, NSDD-47, Emergency Mobilization Preparedness Policy, requires the preparedness of telecommunications to support the continuity of government and recovery of the nation during and after any national emergency. The National Communications System, an organization of the federal government's executive branch, is responsible for ensuring the capabilities and meeting the policies required by both these directives.

This report of the Committee on National Security Telecommunications Policy Planning Environment presents the results of the Committee's first year of work examining issues of new technology and applications, industry tactics and strategy, and the regulatory and policy reactions; state and local telecommunications; and the effects of new technology on standards; as they all may affect survivability and interoperability of telecommunications facilities and services in a rapidly changing industrial and political environment. Their effects on the ability to reconstitute facilities and services after disaster strikes are equally important in the changing environment.

The principal feature of that environment is the absence of any entity responsible for end-to-end service--a direct consequence of the divestiture of the Bell Operating Companies (now Regional Holding Companies) from AT&T. It combines with the now independent and highly competitive activities of the seven Regional Holding Companies and their various (Bell) subsidiaries providing local (exchange) services; AT&T, providing long-distance (interexchange) services; and GTE, providing both; to complicate problems of interoperability and reconstitution. All nine corporate entities are about equal in size. This group of nine has recently been joined in the competitive arena by IBM, which provides computer/communication and satellite longdistance services. Satellite long-distance services are also provided by such other independent competitors as MCI, RCA, and Western Union. In this competitive environment, and in a climate of continuing deregulation, the situation is further complicated by the ability of smaller firms to enter the market and compete. This is the environment in which the NCS must ensure survivability and interoperability of facilities and services to support reliable, end-to-end national security/emergency preparedness (NS/EP) telecommunications.

The environment remains fluid. Changes occur rapidly, both in the lines of business that the players are competing for and in judicial and regulatory decisions that permit or forbid certain tactics and strategies. It is important to emphasize, as did the predecessor committee in its final report,* that Committee ideas continue to be conceived against this changing background. The evolving telecommunications environment with its continuing uncertainties pervade all Committee deliberations.

In performing this study the Committee has focused on domestic, civil telecommunications. As its Statement of Task (page vii) suggests, no considerations have been given to problems of international or diplomatic communications, nor to military command and control. Within the sphere of civil communications, continuity of government and national reconstitution are dominant considerations. These, together with the intensity, size, scope, and type of disaster to be contended with determine the types of actions the NCS should take in fulfilling the requirements of NSDDs 97 and 47.

A. NS/EP Threat Models

The Committee distinguishes three levels or degrees of disaster:

1. Limited disasters, largely local in extent, that would include storms, earthquakes, and volcanic eruptions among the natural causes, as well as civil disturbances, major vandalism, chemical spills, or a nuclear plant accident. These represent "islands" of disaster, which are apt to remain islands, both in actuality and in the public's immediate perception. Stresses on communications capability are mostly localized and relate to sudden increases in volume, more severe demands on response time, and sudden changes in the identity and location of the most important communicating stations. State and local institutions have had much experience in quickly mobilizing resources (including communications) for providing aid and reconstruction in these cases. The federal role is usually limited, but there is much that can be done to help fund the creation of a public-safety infrastructure before the fact of a disaster, and in occasionally supplying some spot need (e.g., locating spare parts) after the fact.

2. Limited nuclear incidents, perhaps fewer than ten sites, in which the damage is limited in geographical area. In this case, too, the areas can be viewed as "islands," but the public is unlikely to be sure of this, and will certainly exaggerate the size of the islands. The U.S. public has no experience here; and mass hysteria is likely to be triggered by real casualty levels, fear of fallout, fear of further detonations, influxes of refugees, and so forth. The problems of recovery planning are quite different from the first case, and have strong national implications. In contrast to 1 above, all roads and all transpor-

*See page vi

tation facilities leading out of the damaged communities will probably be crowded to the point of impassability, and lines of communication and authority with the "islands" will be permanently disrupted. Within each "island" of destruction the situation will be the one described below in 3. The national issues are very substantial in this second case and relate to (a) rerouting the rest of the nation's communications around the "islands," (b) the inward supply of aid and reconstruction to the stricken areas, and (c) restoration of the communications resources within them.

3. Major nuclear incidents that will create disaster levels with which the Department of Defense must cope in the transattack period and in which destruction is massive and widespread. In this third case, NCS responsibility for restoration and reconstitution of communications services is understood to apply in the post-attack period--the period starting a minute or two after the end of the laydown. It is the Committee's view that the level of disruption and destruction of prime power, communications hardware, data needed to reconstruct the communications hardware, and lines of authority will be so complete that planners should assume it impossible with a finite amount of money to preplan and pre-install a communications infrastructure that will be in any way effective over the broad areas of responsibility that the President has as Commander-in-Chief, Head of State, and Chief Executive. It is possible, however, to plan for survivability of systems that meet specific objectives, such as the wartime needs of the President as Chief Executive.

The necessities of individual and family survival in the survivors' minds will outweigh for some days or months the need for coordinated efforts to rebuild local, state, and federal lines of communication and authority. Eventual communications restoration and the restoration of the people and systems resources that represent lines of authority will be a bottom-up process, using whatever human and technical resources happen to be at hand. One thing that the NCS should hope to do about this third threat level is to encourage the proliferation of technologies, usually of a "low-tech" nature, at the grass-roots level that will aid in the bottom-up recovery process.

The distinction between the most severe Level 2 situation and the least severe Level 3 situation is that in the former case there is at least one "island" left with enough undestroyed capability for it to act as a nucleus of supplies, authority, and communications for the recovery of the rest of the nation. At the low end of 3, there may be such an island or islands, but they will not have this capability; for example, because they are rural, relatively resource-deficient areas.

There are NCS responsibilities in all three cases, and in all of these the requisite approach is to use what's left. As one considers these three levels of destruction in sequence, it is seen that not only is there less and less left, but the ability to predict, to plan, and to control what is left becomes more and more limited.

B. Time Scales In Execution Of Planning

The Committee has not specifically addressed the several time periods that are important in planning for and execution of NS/EP initiatives. It plans to do so in the second year of its activities. The time scale for consideration can be separated into periods that may include the following:

- PREPARATION. This period includes the months and years in preparation for possible events. It includes planning, implementation, training of personnel, exercising of systems, getting agreements among agencies and organizations, and possibly getting changes in regulations or laws. In the work of the Committee so far, this period, without having been specifically defined, has been the one addressed most often. It will continue to get a substantial amount of the Committee's time and attention.

- IMMEDIATE PRE-EVENT PERIOD. This period, if it exists, will be measured in minutes or hours depending on the nature of the event. In this period there may be some time (e.g., hours in the case of hurricanes) to move personnel, make planned-for adjustments to systems, and take other actions to optimize the effectiveness of communications following the event.

- IMMEDIATE POST-EVENT PERIOD. This is the period of reaction. It is characterized by operation with what has survived the event and may continue for a few days depending in part on the scale of the event. If the event is isolated, plans could certainly be made to bring help to the area in a relatively short time and to minimize the impact of the isolated event on the remainder of the communications complex. This has been a characteristic of planning and operation in the telephone industry. On the other hand, if the event has massive, widespread effects the ability to do these things will be severely limited.

- RECONSTITUTION PERIOD. This period will begin as soon as possible following the event, and its progress will depend importantly on the nature of the event. It will include implementation of previously made plans (e.g., rerouting of circuits), modification or perhaps moving of surviving equipment, and in general improvising with whatever exists or can be made available.

The Committee will address these or similarly defined periods during the second year and, where appropriate, make recommendations regarding activities during each of them.

C. NCS Roles in Threat Models

The Committee believes that the NCS should consider carefully the functions it can expect to perform at the different levels of disaster represented by the three threat models.

In the limited disaster model the NCS role is established and exercised frequently by the actual disasters that occur each year. No additional commentary by the Committee seems necessary as we have had no deficiencies of substance reported to us. The National Coordination Center (NCC) charter which provides for industry assistance when needed, together with federal and state resources, appears quite satisfactory.

Model two, the "limited strike" model, presumes that there are numerous islands of destruction surrounded by relatively undamaged areas which can contribute significant aid and assistance for reconstituting communications to and within the heavily damaged areas. NCS peace-time planning activities should be based upon two alternative possibilities:

(1) the national capital region is not attacked (the "sanctuary" idea), or an NCS/NCC alternate is not in one of the damaged "islands," the best case; or,

(2) the worst-case alternative, wherein the NCS/NCC function is destroyed. Destruction will force reliance for reconstitution activity on surviving local government entities and surviving telecommunications industry management and control centers.

The Committee urges that NCS peace-time planning and exercise activities take into account both the best- and worst-case subsets of the "limited-strike" scenario. Pre-attack planning activities include:

- a continuing assessment of the capability of the national networks to support NS/EP needs;

- establishing and maintaining a data base of circuits and their restoration priorities;

- establishing and maintaining a data base of assets that could be used for restoral or reconstitution purposes;

- planning and conducting exercises for training, testing validity of the plans, and verifying accuracy of the data bases; and,

- identifying assets and supplies that would be critical to reconstitution and matching them against the resource listings in the data base to identify deficiencies.

Post-attack activities by the NCS in the "best-case" alternative include efforts to direct or coordinate:

- critical circuit and system rerouting around damaged areas;

- establishment of critical circuits into damaged areas to surviving local government and national security activities within those areas;

- assistance from undamaged areas to reconstitute telecommunications within the damaged areas by activities such as:

  - resource allocation (people and equipment),

  - arranging for supplies (e.g., fuel and repair parts), and

  - providing communications to other life-support activities rendering assistance to and within the damaged areas.

The NCS/NCC should not expect to be able to achieve any control or direction of near-term reconstitution activities in the "worst-case" alternative of model 2 since they, too, will be almost totally dependent upon outside assistance.

Model 3 is the massive destruction case, where there are only a few scattered, relatively undamaged areas; and those are incapable of rendering significant assistance to the heavily damaged national structure. Peace-time planning by the NCS must be based on the assumption that no central control will be possible and that reconstitution of telecommunications will begin at very low levels in a highly uncoordinated way as individuals begin to try to bring some order out of the chaos. Whether such efforts achieve some modicum of success or collapse into anarchy may well depend upon peace-time planning by the NS/EP community.

The Committee believes that pre-positioning of simple, standard, operating procedures (SOPs) that will enable an individual at a surviving communications facility to establish rudimentary contact with some other such facility or some local authority may be critical to beginning the recovery process. Some examples of such SOPs are given in the predecessor committee's 1984 final report (See footnote, second report, page vi). Such SOPs should be posted in every possible telecommunications facility in the country. Establishment of emergency interconnect points between different systems and onsite pre-stocking of critical supplies (e.g., fuel) are also essential planning tasks. The Committee is convinced that planning must be based upon the fundamental premise that data bases and connectivity will be destroyed and that "bottom-up" restoral will be the only hope.

D. Report Structure

The Committee's observations, and early conclusions and recommendations at this stage in its work, are presented in Chapter II. These are supported by the discussions of Chapter III, which is organized to facilitate cross-references to appropriate parts of Chapter II.

As this is an annual report, to be followed by a final report in early 1986, the contents of Chapter II represent only a preliminary view of Committee positions. The Committee has qualified certain conclusions and not made recommendations where it feels that the changing environment could affect its final position. It has endeavored as best it can, however, to present advice and recommendations that the NCS can use wherever that could be done, independent of the changing telecommunications environment.

II. FINDINGS AND RECOMMENDATIONS

A. Technology and Standards

The Committee has reviewed a number of emerging technologies that are likely to have significant impact on telecommunications in the future. Commercial suppliers of telecommunications equipment and services in today's competitive environment are incorporating improvements based upon new technology as rapidly as they are proven to be costeffective. We note, however, that there are special NS/EP needs that are not of high priority for commercial networks. For that reason the Committee has concentrated on the potential for new technology developments to contribute to the unique problems posed by NS/EP. Section III evaluates the impact of many of these developments on each of the NS/EP requirements known to the Committee by creating a two-dimensional matrix. From this matrix, it is possible to highlight certain recommendations for the NCS based upon the potential impact of each new technology on each NS/EP requirement.

Current recommendations follow:

1. The Committee agrees with its predecessor committee's conclusion that power will be largely unavailable in the more highly stressed situations. In Section III A.3.a., Component Technologies, the committee identifies Complementary Metal-Oxide Semiconductor (CMOS) devices as the outstanding example of those having lower power consumption than other types of integrated-circuit devices. Since low power consumption and/or battery operation are critical features of recoverability and support for telecommunications under disaster conditions, the Committee recommends that the NCS specify the use of CMOS over other integrated circuits wherever possible. Furthermore, very low power consumption levels should be specified to provide further incentive for survivable designs that also enhance system recoverability.

2. In its final report (See footnote, second report, page vi), the predecessor committee concluded that the magnitude of the electromagnetic pulse (EMP) threat is not well understood and has probably been magnified. This Committee finds vulnerability of particular technologies to undesired radiation at best difficult to determine. Consequently, prudence suggests that the NCS specify that naturally EMP-resistant or radiation-hardened designs be incorporated into future construction or refurbishment of NS/EP-related telecommunications facilities, other factors being equal, and that well- known engineering practices (e.g., for lightning protection) also be incorporated. The Committee notes that optoelectronic devices are inher- ently less vulnerable than semiconductor devices to EMP effects, and this naturally increased survivability is one more justification for broadening the use of optical-fiber systems.

3. To enhance survivability and recoverability, the Committee recommends that the NCS attempt to influence the increasing number of programs for installation of fiber-optic cable for interoffice trunking

by promoting requirements, both for underground burial to some specified threat level and for installation of terminal and repeater equipment in manholes.

4. Because of the continuing trend in satellite communications toward smaller, lower-power, low-cost earth stations and the inherent, large-area connectivity available with a single satellite, the Committee urges the NCS to stimulate support for developments of very small, twoway satellite earth stations. An opportunity exists now for the NCS to influence the NS/EP characteristics, particularly, of the proposed mobile satellite systems.

5. Commercial versions of fault-tolerant designs form a reservoir of useful techniques for reliability. Increasing commercial interest in this area is likely to generate new ideas and designs that may be employed in satisfaction of NS/EP needs. In addition, the employment of fault-tolerant designs in certain commercial networks will raise the reliability standards of those networks to make them much more useful in fulfilling NCS needs. The Committee therefore recommends that the NCS specify and make use of fault-tolerant systems in its planning and initiatives.

6. Software-defined networks contribute to flexibility and to network diversity. Features can be added to the software that support emergency recoverability as well as other factors of specific interest to the NCS. The Committee recommends that the NCS specify other useful emergency features that are susceptible to software implementation such as privacy/- security and call priority. Such software-supportable requirements should be discussed with system designers before the software designs are released so that at least future provision for these needs is not foreclosed.

7. The NCS, with severely constrained resources in technology and standards, has been obliged to fill a void in government representation in standards activities beyond its interests in NS/EP telecommunications. The Committee is concerned that NCS resources are being applied to problems on which ample industry incentive exists to reach agreement on standards, while problems critical to the NS/EP objectives are unattended. Operations practices, network-to-network interfaces, and call priority capability in Common Channel Interoffice Signalling (CCIS) are examples of the latter: important for interoperability and restoration or reconstitution of service, these items present little incentive for industry agreements without government intervention. The Committee recommends that the NCS examine its application of resources to standards and reapply them to emphasize those areas where government participation in the standards processes is necessary and where the NCS can reasonably be expected to influence the processes.

B. Strategies, Tactics, and Policy

Among the tasks given to the Committee are: to determine the directions in which telecommunications companies are moving; to develop assumptions about the likely nature and structure of the national telecommunications capabilities by the year 2000; and to recommend specific technical, policy, legislative, and regulatory initiatives available to the NCS. The Committee has studied three topics; these studies will form the basis for subsequent recommendations. The study discussions are included in Chapter IIIB of this report, covering future industry structural relationships, the intercity carriers, and the exchange carriers. Further consideration of these and other topics will lead to a specific set of recommendations in the final report. There are, however, some conclusions and recommendations that the Committee believes to be sufficiently clearcut as to call for early consideration by the NCS, even in advance of the Committee's recommendations in its final report. They are:

1. Application by the industry of new technology such as optical-fiber cable is moving much faster than expected. The "pull" of technology is being reinforced by the "push" of competition. Hence the time remaining for the NS/EP community to influence this process grows ever shorter. If the NCS is to influence events, it must take action now by first learning all it can about the nature of the new technology being implemented and taking initiatives promptly to develop specific suggestions to industry. This applies to both exchange and intercity carriers, and could be aided through quick identification by the NCS of channels, such as the United States Telephone Association (USTA) and the Exchange Carriers Standards Association (ECSA), through which NS/EP needs could be made known. A particular example of such suggestion applies to the optical-fiber cable explosion. The radiation-resistant benefits of optical-fiber cable's immunity to radiation from lightning, EMP, and various man-made sources might be lost if simple testing indicates that repeaters are in any way susceptible to such radiations and are not shielded or adequately protected. The cost to provide such protection would be modest when the cable is being laid compared to the much higher cost of later modification. Another example deals with the many (more than 20) teleports now in planning or early implementation stages. The developers are providing many incentives to cause the satellite carriers and private network operators to locate on those teleports. An earth-station/cable interconnect facility encouraged by the NCS could probably be had at little cost; perhaps none if the developer believes it will attract his potential customers.

2. Transmission will not be a limiting factor in intercity communications. Thus the intercity marketplace, which has been dominated by availability, quality, and pricing considerations, will come to be driven by "value-added" features to be offered by the competing carriers. The rapid growth in the amount of high-quality, lower-priced transmission will result in a much richer network of transmission facilities. That richer network benefits NS/EP activities, but the benefit could be offset by the greater concentration, and therefore vulnerability, of essential functions such as signaling, switching, and data bases, caused by the proliferation of "enhanced" service offerings. Moreover, the forecasted

growth of private networks, which have little need to be compatible with others, together with the incipient loss of universal network standards, make the reconstitution problem much more difficult. These factors reinforce the Committee's view that centrally directed reconstitution following a major nuclear attack is not a feasible planning objective. The Committee strongly recommends that the NCS initiate bottom-up planning activities with state and local organizations that will ensure flexibility in the use of their telecommunications resources for reconstituting service after disaster strikes.

3. The rapid increase in transmission capacity and commercially available, software-controlled multiplexers operating at high bit rates offers the opportunity to lease transmission by bandwidth over specific paths, which may be chosen for their less vulnerable characteristics, and to derive some subset of the critical circuits which the NS/EP community feels warrant diverse routing. The Committee suggests consideration of this idea, not as a cure-all, but instead as a controlled way of achieving some measure of greater route diversity and cost benefit in contrast to the major cost penalty characteristic of diverse routing of earlier years.

4. Increasing demand for data communications and offerings of value-added (enhanced) services are accelerating the transition to all-digital systems. Installation of optical-fiber cable by exchange carriers suggests the possibility of digital systems on fiber cable all the way to the terminals as advantageous for NS/EP if serving facilities could be protected. Because of the large, installed base of analog equipment, such a transition to digital will require provision of standby analog-to-digital (A/D) conversion equipment to enable digital facilities to substitute for analog in emergency situations. To reduce vulnerability, the Committee suggests initiatives to minimize proliferation of hybrid A/D conversion in the customer premises equipment (CPE), to provide for (standby) replacement of synchronized clocking for digital channels, and to ensure ability of the remaining system to function if the master clock is lost when disaster strikes.

5. The availability of local-area networks (LANs) as alternative facilities for exchange distribution and of software-defined services comprising Integrated Services Digital Networks (ISDNs) in the transition to digital systems may generate opportunities for improved reliability, economy, and survivability. The NCS will need to understand the trade-offs between NS/EP and commercial transmission requirements in the early stages of the transition to be able to influence system development. For example, as with the vulnerability of concentrated switching centers in CCIS, the concentration of records and manpower in a few centers for centralized operation of the ISDN(s) may provide commercial economies of scale at the expense of increased vulnerability, and the NCS may contemplate initiatives to provide for redundancy and diversity in emergency situations.

6. The management problem will become more complex and costly. Reliance on a dominant carrier for the many management and coordination activities required to engineer, install, and operate an extensive net-

work or circuit involving several suppliers will become a thing of the past. The NCS will require additional skilled management resources to ensure reliable, end-to-end NS/EP telecommunications in today's multi-vendor environment. Procurement rules which try to treat all potential suppliers equally will confront a growing diversity of service offerings, some of which will be unique to only one carrier. Determining requirements will confront a growing tension between cost and capabilities. One example among many would be a desire to take advantage of the low cost per bit of fiber-optics transmission together with its radiation and intercept resistance. To exploit the low cost per bit characteristically requires a very large amount of traffic. Very many telecommunications channels would have to be grouped together to generate sufficient traffic; and large cross-sections, when interrupted, represent major losses inconsistent with the need for diversity and redundancy essential to survivability. The Committee suggests that the NCS begin now to look carefully at those government procurement practices that may hinder its ability to take advantage of future service offerings beneficial to NS/EP activities but which are unique to one vendor. Current rules, as the Committee understands them, require government specifications that foster the widest possible range of competition. Exceptions to the federal acquisition regulations may be required.

C. State and Local Telecommunications

The Committee heard presentations from a number of state and local emergency management executives of impressive installations designed, for the most part, to respond to life-threatening natural disasters or industrial-plant incidents. Additionally, an excellent presentation was made by the Federal Emergency Management Agency (FEMA), whose stated purpose is to facilitate work of state and local emergency managers. Based on information provided by the state and local emergency management executives, that seems to translate into providing funds for emergency communications systems.

At the state and local levels many of the emergency preparedness teams cut across the various governmental departments: that is, representatives of the police, fire, and medical departments are involved. However, in a variety of instances not all of these departments are involved at the same time or to the same extent. Further, the sophistication of the systems being utilized varies widely. Several presentations described systems that were put into operation or upgraded only after an emergency episode.

There are examples of warning systems or communications networks that could be effective for either a war-related response or for peacetime disasters. The National Warning System can be used not only for nuclear attack warning, but also to warn people of violent weather conditions. The Emergency Broadcast System (EBS) links together radio stations all over the country and is used by local emergency officials to give emergency information and instructions to the public.

On the whole, however, the Committee was left with the impression that what is being done at state or local levels comprises fundamentally an intrastate activity with little in the way of national or even, in some cases, statewide coordination to ensure interoperability and cooperation. In the event of a national emergency or, indeed, of a devastating local disaster wherein most normal lines of communication to the rest of the nation are destroyed, the citizenry and emergency officials for the most part would be caught without any formalized system of contact.

Federal Communications Commission (FCC) regulations indicate that while certain parts of the spectrum are allocated to public safety services, some areas of the country have already made use of all that is allocated, and there is evidence now that all states and many local entities would not be operating on the same frequencies for the same purposes. The FCC staff deals with individual states on most radio questions and the Commission has made no attempt to advocate a national emergency communications policy other than to authorize the EBS. Indeed, although the Nuclear Regulatory Commission (NRC) has passed regulations requiring that the nuclear power industry install alarm systems for the area within 12-14 miles of a nuclear plant, neither the NRC nor the industry has come to the FCC seeking additional spectrum or advocating interconnecting or at least interoperable systems from one plant site to another or to adjoining states. This situation may change following the Union Carbide incident in Bhopal, India.

This, of course, has been the history of emergency communications--reaction after catastrophe. The Committee recognizes a need for more coordination of spectrum needs and planning of spectrum uses for public safety and emergency communications, but at present reserves judgment on how that might best be achieved and where responsibility might lie. These issues will be addressed in our final report. The Committee strongly recommends, however, that a national policy be adopted, to be implemented by federal funding, mandating interconnection and interoperability of state and local emergency communications systems nationwide. Probably the first steps are to catalog all existing systems and emergency management teams across the country and then to examine spectrum issues and overall control in the event of disasters at the local, state, regional, or national levels.

Other conclusions and recommendations that the Committee considers clearcut for NCS consideration are:

1. Local entities (towns and cities, counties and parishes, states) are capable of executing actions necessary to reconstitute telecommunications, given the availability of resources. In the emergency or disaster environment the state and local entities operate without much coordination, and there is very little awareness of the federal NS/EP telecommunications program. On the other hand, federal programs dealing with NS/EP telecommunications emphasize the "top down" concept of reconstitution without adequate attention to the necessity for "bottom up" activity in disaster areas. Together with FEMA, the NCS should take the lead in promulgating a "national purpose" among the family of federal

agencies that will promote reorientation of programs toward incorporating aspects of "bottom up" reconstitution. Concurrently, the NCS and FEMA should develop a series of NS/EP scenarios for FEMA to present to the states in seminars that would generate awareness of the federal program and discuss approaches to integrated emergency telecommunications planning, practices, and management. A "reaction-after-catastrophe" posture is unacceptable for a serious disaster.

2. A national-level entity is needed to promulgate the "bottom up" concept of NS/EP reconstitution of telecommunications and to focus programs and activities on the solutions. As it did with the National Security Telecommunications Advisory Committee (NSTAC), the NCS should take the lead in proposing a presidential NS/EP advisory committee cognate to the NSTAC and having comparable liaison, composed of members representing all 50 state governors, to guide and foster expansion and strengthening of state and local NS/EP and disaster telecommunications. This national committee should be fully integrated with national NS/EP telecommunications initiatives under the cooperative oversight of the NCS and FEMA.

3. The FCC policy is to react to inputs from those officially charged with implementing NS/EP measures but not to initiate NS/EP issues on its own. With FEMA support, the NCS should propose to the FCC that all new federal telecommunications systems be required to interconnect and interoperate with local, state, and nationwide systems. Together with FEMA, the NCS should take the initiative to develop and promulgate policies and procedures to permit the use of national resources (e.g., frequencies assigned to others, channel 9 of Citizens' Band radio) by the state and local entities for disaster recovery and reconstitution of NS/EP telecommunications.

4. The increased pace of conversion to digital systems is increasing vulnerability not only by concentrating electronics, but also by concentrating software. Concentrated electronics leads to reduced manpower levels while concentrated software leads to centralization of records required for reconstitution of service over large areas. Although the NSTAC is taking steps to examine automated information processing, the overall task is quite large. The Committee suggests that the NCS approach the carriers directly to answer questions about who and how many will have access to and know how to use the information that will be required to reconstitute service, and then to develop plans to deploy the information and human resources broadly enough to ensure the survivability or at least the restorability of their systems.

5. To overcome the national tendency to react after catastrophe, the Committee strongly recommends that a national policy be adopted mandating interconnection and interoperability of emergency communications systems nationwide. Probably the first steps to be taken under the aegis of th NCS and FEMA are to catalog all existing systems and then examine spectrum issues and overall control in the event of disasters at local, state, regional, and national levels.

6. State and local entities have neither the resources nor the expertise to conduct efforts having the sophistication and complexity necessary for NS/EP telecommunications. FEMA provides funding support for state and local emergency telecommunications activities, but the state and local entities feel that FEMA should provide them additional support: for example, training services. Together with FEMA, the NCS should initiate federal planning activities with state and local entity participation, to assign personnel and resources of agencies not normally involved in disaster recovery and reconstitution of services to the state and local entities. The National Park Service personnel and equipment, including mobile radio networks, comprise one example. Further, with FEMA's advice the NCS should stimulate new programs that would make radio and other necessary equipment available to the National Guard to ensure its availability and readiness for state and local use. Finally, together with FEMA, the NCS should encourage strengthened planning activities that extend state and local planning into the interstate and national NS/EP environments. The states must be brought into the national NS/EP telecommunications planning process as a matter of urgency. Making continued FEMA financial support contingent on state and local participation in integrated, national planning activities could provide incentives for that to happen.

III. DISCUSSION

A. Technology and Standards

1. Introduction

The pace of technological development in those areas of science that have a direct bearing on telecommunications continues unabated. In fact, advances are being incorporated at a rate that increasingly outdistances the standards-setting processes traditionally applied in the industry. Now, even the traditional standards processes have been disrupted--partly by rapidly advancing technology; partly by the number of new competitors in the marketplace, each seeking some advantage, and often through advanced technology; and partly by the divestiture disturbances to the previously monolithic Bell System standards leadership. In this new environment, the NCS faces bewildering changes.

In an attempt to bring some order to the current situation, the Committee has chosen to address technology issues in a different fashion through the use of a matrix for more sharply focused analysis. The matrix directs attention to those features and requirements which are particularly important to NS/EP considerations or which are unique to the government network.

In examining the current state of telecommunications standards, the Committee notes the increasing mismatch between the time scales for employing technological developments on the one hand and standards-setting procedures on the other. Furthermore, some of the computer industry participants have traditionally not stressed interoperability between their systems and those offered by competitors. As computer companies enter the telecommunications marketplace with equipment and services, the standards discipline of the telephone network is threatened. Their new data-oriented networks do not offer either the interconnectivity or interoperability that the NCS requires. Experience to date with commercial, local-area networks (LANs) supports the view that voluntary standardization was not sought.

In the area of government-decreed standards, the Committee notes growing attention by federal, state, and municipal agencies to the possible health effects from non-ionizing microwave radiation. The Committee is unaware of any determination of proven danger to health from microwave radiation nor, consequently, of any maximum permissible levels for such radiation. Thus the cost and service impacts of a reduction in the permissible level of radiated power from terrestrial microwave and satellite links used in the telephone network has never been estimated, nor are the effects of such changes in power level clear.

a. Technology Matrix. New technical developments that would improve performance, reduce costs, promote safety, or widen the usefulness of telephone services have been sought by both AT&T's Bell System and other participants in the pre-divestiture telephone business. There is no reason to believe that the post-divestiture environment will in any way lessen service suppliers' interests in incorporating and using new technology for these commercial goals. In fact, one of the stated purposes of divestiture was to correct a lag in the use of new technology by opening the market to increased competition. The Committee concludes that these forces will work and that each new development will be carefully reviewed by service and equipment suppliers for commercial advantage in the competitive marketplace. For that reason, the NCS is in a position to take advantage of these commercial pressures, which are likely to improve many aspects of telephone services without direct NCS encouragement.

However, it is clear that a number of specialized NCS requirements for services that are needed by government will not offer competitive advantage in the public marketplace. Therefore, it is important to identify these special requirements and to examine the impact on each one that may be offered by each new technological development. It is with this approach in mind that the Committee applied the matrix technique to review the usefulness of each new technology.

Some ordered and structured method is needed if any study is to consider the impact of all new technology on all the hardware and software that combine to make today's telecommunications possible. The enormity of that task is beyond the role of the Committee and is unnecessary as well. By narrowing the focus to the NCS' unique and special requirements, and by examining only the relevant and critical technologies, the Committee is able to concentrate on important changes. In order not to overlook key intersections between a new technology and an NS/EP requirement, a two-dimensional matrix structure was chosen as the format for the examinations. In each block where a technology intersects a requirement, there is an opportunity to outline the potential applicability of the technology and evaluate its positive or negative effect. The matrix appears in Section 2.

b. NCS Requirements for NS/EP (Matrix Rows). In addition to the standard specifications for normal communications services combined with those special features offered in the commercial marketplace, the NCS has a number of needs approaching the status of formal requirements for the government network. The Committee has identified these features, which it has chosen to call requirements, and has attempted to list these in priority order starting with interoperability. These requirements, listed in the left column of the matrix, identify the several rows.

The list represents the Committee's best judgment at this time. The Committee feels that most of the requirements are self-evident in meaning but two need some explanation. "Recoverability" is the ability of technology to contribute to recovery of service after a disaster: this has frequently been subsumed under the NS/EP requirement for reconstitution of facilities and service. "Vulnerability" is the susceptibility of service to damage through direct damage to technology in a disaster: "invulnerability" is, then, immunity or resistance to damage to the technology. From its study so far the Committee believes that the proposed listing is substantive, and it can be expanded as new needs are brought out.

c. Technologies (Matrix Columns). The Committee has divided the horizontal axis of its matrix into two distinctly different portions. This choice is necessary if the matrix is to remain two-dimensional rather than three. Thus, the first portion of the matrix lists component technologies such as CMOS and gallium arsenide (GaAs) as headings for the vertical columns, while the second and more extensive portion lists forms of the key elements of telecommunications systems such as transmission media, signal processing, architecture, and switching as column headings.

Because component technologies themselves are not directly applicable to certain NS/EP requirements (e.g., interoperability, network diversity, and call priority capability) such requirements do not appear in the row headings for the first portion of the matrix. They do, however, in the second portion, where the focus of the key systems elements embodies applications of the various component technologies. The Committee's recognition that the word "technologies" carries implications of systems as well as component technologies is thus embodied in the choice of systems elements that match the traditional major disciplines into which telecommunications have been divided.

2. The Matrix

The matrix appears here as the Committee had developed it by the end of its first year of work. It is not complete. Certain major items such as switching and the management (software) systems used to maintain and operate telecommunications systems, need to be added. One example of management systems is the Trunks Information and Record Keeping System (TIRKS) described in detail in the predecessor committee's final report. In addition, the Committee's conclusions and recommendations concerning the implications of new technologies for national security telecommunications are tentative and will be developed more thoroughly for its final report.

Entries in the matrices give the Committee's judgment about whether a given technology is highly advantageous (+ +), moderately advantageous (+), neutral (no indicator), moderately disadvantageous (-), or highly disadvantageous (- -) in its effects on a given NS/EP requirement. Many of the technologies listed, although quite prominent in current discussions of the immediate technical future, are not, in our opinion, likely to make much difference to NS/EP requirements for many years. Technologies and applications such as gallium arsenide, Open Systems Interconnection, and videoconferencing are not imminent for broad application in any NS/EP sense. Even though some of the technologies are being successfully installed, their pervasiveness will come only slowly.

A typical example is optical fiber, an important transmission medium of the future. Telephone trunking and local area networks are experiencing the benefits of this technology. However, when a multitude of small communities and parts of communities begin to communicate using fiber, its full NS/EP role will become exploitable. Conversely, some technologies have the negative NS/EP property that they increase vulnerability through concentration. CCIS central office switching control is a good example. Even if there were several times the current number of centers, their limited number represents a vulnerability that must be interpreted as a negative factor.

MATRIX 2a: RELATIVE NS/EP CHARACTERISTICS OF VARIOUS COMPONENT TECHNOLOGIES

NS/EP REQUIREMENT	TECHNOLOGY							
	Si CMOS	Si NMOS	Si Bipolar	GaAs IS	GaAs Laser	GaAs Detector	Si Detector	Vacuum Tubes
Low power required	++		-	+	NA	NA	NA	NA or --
Survivability								
EMP				-	+	+	+	++
Radiation hardness	+	-		++	++	++	++	
Low costs	-		-	--	NA	NA	NA	NA

NA: Not applicable for single-device applications.

MATRIX 2b: RELATIVE NS/EP CHARACTERISTICS OF VARIOUS TRANSMISSION MEDIA

NS/EP REQUIREMENT	TECHNOLOGY						
	Fibers	Broad-cast Satel-lite	Fixed-Service Satel-lite	Vehicular Mobile	Personal 2-way Radio	DTS Micro-wave	CATV
Interoper-ability		++	-	+	+	-	
Low power required	++	+	+		++		
Invulner-ability	++(1)	--	--				--
Recover-ability		++(3)	++(3)	++	++	+	--
Network di-versity	-(2)	++	++	++	++	-	+
Low costs	++	+	+		++		
Privacy and security	++	--(5)	--(4)	--	--	-(4)	+(5)
Call priority capability		+	+	--	--	++	++

NOTES:
(1) If buried. No radiation or EMP except terminals and repeaters.
(2) Near-term installations will be backbone only.
(3) One re-launch builds a large connectivity.
(4) Fixable using cryptography.
(5) Fixable using cryptography. Some capability will be available with pay TV.
(6) No significant installed base for at least seven years.

MATRIX 2c: RELATIVE NS/EP CHARACTERISTICS OF VARIOUS TRANSMISSION SIGNAL PROCESSING TECHNOLOGIES

NS/EP REQUIREMENT	TECHNOLOGY				
	Compression	Encryption/ Decryption	Spread Spectrum	Error Coding	Modems
Interoperability	-	-	-	-	+(4)
Low power required	+		++(3)	+	
Invulnerability			++	+	
Recoverability		--	-		
Network diversity					+
Low costs	+	-	-	+	
Privacy and security	+(1)	++	++(2)	+(1)	
Call priority capability		+	+		+

NOTES:
(1) Coding for compression of error control provides a weak form of encryption.
(2) Spread spectrum can provide a fair level of encryption.
(3) Large power gains against man-made noise, but no gain against natural background noise.
(4) Modems are more widely standardized than the other technologies on this matrix.

MATRIX 2d: RELATIVE NS/EP CHARACTERISTICS OF VARIOUS COMMUNICATIONS SYSTEMS TECHNOLOGIES

NS/EP REQUIREMENT	TECHNOLOGY					
	OSI	SNA	ISDN	CCIS	Conferencing	Fault-Tolerant
Interoperability	++	+(2)	++	+	+	
Low power required					-	
Invulnerability				--(3)		++
Recoverability			+	1/+(1)	++	--
Network diversity	-/+(1)	+	-/+(1)	++	--	
Low costs				+	-	--
Privacy and security		+		+(4)		
Call priority capability		++	?	+(5)	+	

NOTES:
(1) No significant installed base for at least five years.
(2) Over 20,000 SNA networks installed.
(3) Only 14 Signal Transfer Points in the United States.
(4) Cannot identify intercepted calls because signaling is separate. Encryption of CCIS makes it even more secure.
(5) "Software defined" or definable functions.

3. Technologies

a. Component Technologies.

(1.) The matrix. Matrix 2a lists various existing and developing active component technologies and their relative performance in environmental conditions associated with NS/EP scenarios. The markings are to be interpreted as relative among the devices listed, with "+" indicating "better" and "-" indicating "worse." Absence of a marking indicates a relatively neutral performance: neither better nor worse than older technologies already in place. Absolute numbers are difficult to obtain, and would vary substantially among specific devices within a technology. Nevertheless, Matrix 2a is intended to point out the trends in components that will or could be used in modern communications systems. Popular silicon and gallium arsenide electronic technologies are listed along with selected Si and GaAs optoelectronic devices. For comparison, vacuum tubes are also included, even though the circuit complexity available with these devices is by no means comparable. However, it should be noted that small projects to develop planar, integrated, vacuum, electronic microcircuits for extreme high-temperature and high radiation-flux environments have been recently undertaken. Microwave tubes are still in widespread use in satellite and terrestrial microwave links, and high-power vacuum tubes still dominate the broadcast services.

Particularly notable in the table is the low power consumption generally exhibited by CMOS devices relative to negative-charge-carrier MOS (NMOS) and GaAs integrated circuits (ICs). For battery operation of portable communications equipment or extended operating time for fixed equipment from emergency power sources, power consumption of electronic equipment is a key factor and should be a major consideration in NS/EP specifications for telecommunications equipment purchases. The present, slightly higher differential cost of CMOS relative to NMOS should decrease as the popularity of CMOS in commercial applications increases. Indeed, a governmental specification on low power consumption for telecommunications equipment used in government circuits could well be a driving force in this trend. GaAs ICs have a somewhat lesser advantage over NMOS than CMOS in power consumption and the cost differential is substantially worse. However, the increased radiation hardness may be a consideration in particular applications. In any case, the Committee reiterates recommendations made in its precedessor committee's final report (See footnote, second report, page vi) that provision of backup emergency power supplies is essential to support emergency telecommunications regardless of power consumption levels.

Vulnerability of a particular technology to undesired radiation (e.g., lightning, EMP, and high-power man-made radiation.) is difficult to determine at best, since it is likely that the overall engineering used is a much more important factor than the sensitivity of a basic device to burnout. As noted in the predecessor committee's final report, however, adequate attention to lightning protection is quite likely to suffice in many cases for EMP protection as well. For example, sensitive semiconductor devices must be isolated from the electromagnetic radiation pickup of long cables. This is well-known radio-wavelength radiation practice for lightning protection. As shown in the matrix, CMOS, NMOS, and bipolar devices are not significantly different in basic vulnerability to radio-frequency radiation, while GaAS ICs are likely to be slightly more vulnerable. Single opto-electronic devices such as lasers and detectors are far less vulnerable because of their inherent design for high bias values: high forward-biased current in lasers and high reverse-bias voltage in the detectors. Conventional, vacuum, electron devices are inherently rugged, and even the micro-integrated versions are likely to retain this capability.

There are other environmental considerations for NS/EP threat models that are likely to occur, particularly temperature and humidity extremes (even inundation). However, for these factors there is less difference due to basic device technologies than there is due to packaging variation. It is well known that all solid-state devices are vulnerable to moisture, perhaps GaAS ICs a little more so. Special high-humidity packaging considerations should be included in a specification for components used in NS/EP sensitive electronic equipment. The same applies to other potentially vulnerable components in the equipment, such as liquid crystal display (LCD) panels, high-voltage power supply components for cathode-ray tube (CRT) displays and traveling-wave tubes, microphones, loudspeakers, keyboards, and switches. As far as temperature extremes are concerned, it is likely that the basic electronic chips will survive much higher and lower tem- peratures than the plastic packaging used in the rest of the equipment components.

(2.) Electro-optical technologies. Because these are still evolving and their applications, except for cable, are not clear, they are not included in Matrix 2a. Nevertheless, the increasing uses of optical-fiber cable suggest that electro-optical technologies may play an important future role in telecommunications systems. Consequently, the Committee felt the following discussion to be relevant to future NS/EP considerations.

The wide use of optical fibers in telecommunications systems requires that a comparison be made with other transmission media in the NS/EP environment. The substantially lower cost per unit bandwidth for wideband fiber cable compared to coaxial cable is the force driving the rapid fiber proliferation. However, in lower-capacity trunks, terrestrial microwave links may still win out, even in new installations; certainly existing terrestrial microwave circuits (e.g., TD-2) that satisfy their trunk demands will not be replaced by fiber cables for years to come. Despite the rapid growth in fiber links we will continue to have a healthy diversity of transmission-media technologies from an NS/EP standpoint: fibers, terrestrial microwave, satellite microwave, millimeter wave, and coaxial links.

Transmission systems employing optical fiber cables can be much less vulnerable to damage by radio-frequency (r-f) radiation (e.g., EMP and lightning) because the cables can be made with no conducting elements to act as giant antennas that pick up and transfer energy to the sensitive electronic devices at the system terminals and repeaters. The glass fibers themselves are completely unaffected by strong r-f fields. However, some fiber cables use metallic wires rather than polymer cords as strength members, and some use metallic conductors to carry power to remote repeaters. In these cases, fiber cables could be as bad as or worse than shielded coaxial cables in r-f pickup, depending on the engineering practices used to cope with radiation stresses. Thus, NS/EP considerations would favor the use of completely nonmetallic fiber cables wherever possible.

In terms of hardness to ionizing radiation, glass fibers are definitely more vulnerable than metallic conductor cables. Two different radiation-induced effects are noted in glass: a permanent increase in transmission loss on exposure due to darkening of the glass medium itself, and a larger transient loss. The physical origins of both mechanisms are the subject of much current study. But three general observations can be made regarding these effects:

- The resistance to permanent radiation darkening varies greatly with glass composition [a factor of over 1,000 in the loss exponent: 1/2 dB/km to 1,000 dB/km for 1k Rad(si) loss]. Highly radiation-resistant fibers can be made with pure silica, for example, but these are not yet generally used in telecommunications applications because of their higher cost and higher normal transmission loss.

- The transient darkening of the glass in fibers is typically 10 dB greater than the permanent darkening and typically decays in seconds for pure silica to minutes for germanium glasses.

- For today's telecommunications-type fibers an exposure of 1k-Rad(si) will cause a significant increase in the loss exponent, say from 1 dB/km to 10 dB/km. Note that the radiation exposure at the earth's surface required to produce this exposure in underground fibers depends greatly on how deeply the fiber is buried. Note also that it is unlikely that a very long length of fiber will receive the highest dose from a singular nuclear event. For example, perhaps only 1 km of fiber near the target area of a 20-km length between repeaters would be significantly affected. It is thus likely that a sufficient system margin could overcome the few dB loss added by singular nuclear events. Even this could be planned for by using higher-cost, radiation-resistant fibers near anticipated target areas (e.g., city outskirts and missile silos).

Temperature extremes should have little effect on fibers: polymer coating or jacket material is likely to be more vulnerable, just as in insulated wire links. Glass fibers need to be protected from moisture, however, to retain their mechanical strength. Newly pulled fibers are very strong, but microcracks quickly develop on exposure to water vapor, and continue to grow on continued exposure. The solution to this problem is to coat the fiber with a thin polymer or metallic coating as it is drawn; metallic coatings (e.g., aluminum) are generally much more impervious to moisture than polymers, and yield the longest-life, highest-strength fibers. (Of course, the metallic coatings also increase the r-f impulse pickup properties.) Increased optical transmission loss can also result from water vapor attack through the diffusion of hydrogen into the glass itself; hydrogen bonds resonating in the desired, low-loss, 1.3 and 1.5m bands cause added absorption at these wavelengths. The problem may seriously limit long-life, undersea cables, where the high hydrostatic pressure greatly enhances the diffusion rate of hydrogen into the glass. (On the other hand, the constant cold temperature on the sea bottom slows the diffusion rate relative to that at room temperature.) This phenomenon is currently the subject of intensive study.

Integrated optical circuits are not considered vulnerable components in this study for several reasons: first, none is in current service--simple source-fiber-detector links are all that is being installed now. Second, it is not clear which technology would be employed: glass films, ion-diffused lithium niobate, epitaxially grown GaAs layers, or others. These and more have been studied in laboratory experiments for modulators, directional couplers, filters, and other system components. None has gained a clear superiority. Indeed, it is not clear that any optical integration (analogous to microwave waveguide or stripline integrated circuits) is really needed or desired. The ease with which GaAs lasers and detectors can now handle 10-GHz bandwidths by direct modulation may preclude the need for any optical integration. More likely, there will be an integration of microwave signal circuitry on GaAs substrates with lasers and detectors. Some of this has already occurred, but it remains to be seen whether integration or discrete elements will win out. In either case, the NS/EP considerations would be the same as those of Matrix 2a for GaAs ICs.

b. Transmission Media. The NS/EP performance of the various transmission media (e.g., coaxial cable, microwave link, fibers, satellite, and ground radio) depends on the specific threat level and the time period after disaster strikes. Also, the range of technologies available will be quite different 10 years from now from the situation today.

Most present-day terrestrial communications routes will be expanded over the years with the use of optical fiber because of its low cost and wide bandwidth. Growth requirements suggest that, while the new medium of fiber is going in, existing media (e.g., coaxial cable and microwave link) will remain in service for some time. This is true for local-area, metropolitan, and interoffice distances, including undersea connections. The expansion process is already occurring in a highly visible way in interoffice trunking. With appropriate precautions as suggested in the preceding discussion, fiber can be a rugged communications medium, especially if laid underground. It has little value for NS/EP until it becomes more pervasive. Growth of fiber as a percentage of network mileage is rising slowly. Even today, only a few East Coast and a few West Coast cities are linked by fiber; its use in local-area networks is at the prototype level only; and although its use in the metropolitan cable television (CATV)-like environment is virtually nonexistent, the FCC has authorized an entry into this environment with its authorization to Chesapeake and Potomac Telephone Company to construct CATV facilities in Washington, D.C. that include fiber-optic cable transmission from studio to cable head-end. A second inroad for fiber-optic cable is Times Fiber's CATV offering in Alameda, California, where the CATV network is fiberoptic cable up to the local-area hub.

The current program to install fiber media for interoffice trunking should give a strong emphasis to underground burial adequate for survival to some specified threat level and to the installation of terminal and repeater units in manholes. Although some current practice uses utility poles and other above-ground structures for copper cables--leaving such facilities subject to violent weather, transportation vehicle accidents, and blast and radiation effects--current practice with optical-fiber cable is always to bury it. Survivability requirements, not the practice, comprise the issue.

Conversely, satellite communications, particularly using small, two-way, customer-premise or "mobilesat" earth stations, while not very resistant to deliberate attack, promises an extremely pervasive, lowcost, low-power-consumption medium that can grow rapidly and ought to be widely available in, say, 10 years. Meanwhile, the one-way, direct-broadcast satellite service should be widely available in five. Satellite communications has the property that even if a satellite is destroyed, one relaunch quickly provides a very large connectivity. The Committee recommends that the NCS give strong support to developments of very small satellite earth stations, particularly those affording two-way transmission. An early opportunity exists to do this in the proposed systems of Mobilesat and Equatorial Communications, Inc., where the additional flexibility of communications though mobile terminals is contemplated.

Looking closer in time and at the "low-tech" solutions appropriate to the more severe destruction levels, point-to-point radio continues to be the most promising technology. This is borne out by countless real emergency experiences in which amateur radio, citizens' band, and mobile emergency radio played key roles. Not even the pervasive telephone system allows the user such flexibility in where and when he can communicate immediately after disaster strikes.

New developments, such as cellular radio, small earth stations, hand-held-radio computer terminals, and nationwide paging are promising components of the emergency communications picture and can play important roles in it as they become more widely used. The role of CATV is likely to remain a minor one, since most locations reached by cable are also reached by telephone and over-the-air direct broadcasts. The individual CATV systems are not interconnected with one another, but many can be reached simultaneously by satellite.

The Committee concludes that radio-frequency technologies appear to comprise the key emergency transmission medium, including satellite communications for those threat levels and time periods in which actual destruction of the satellite is not a factor. Fiber, while not likely to be pervasive for a long time, can have excellent characteristics as a resistant, cheap, low-power and high-capacity medium. When so many other technologies are moving in directions that compound NS/EP problems (e.g., the dependence on concentrated switching centers and on computerized databases), it is gratifying to note that transmission media are moving in a favorable direction.

c. Transmission Signal Processing Technologies. These technologies include error encoding, cryptography, data compression, spectrum spreading, and other digital techniques. None of them plays a central NS/EP role, except for particular situations in which security is important. Spectrum spreading and error coding are aimed at ensuring circuit reliability, the former in a jamming situation. Data compression has mostly economic benefits. Encryption plays an important role in those few situations in which the emergency communication must be pri- vate. A very weak but sometimes usable level of security is provided by some data compression techniques, by some encodings for error control, and certainly by spectrum spreading.

In the Committee's view security, which is so important to the military, is of subsidiary importance in most phases of the NS/EP process. The component technologies used to implement these signal handling processes, however, are important to NS/EP telecommunications, as are the device designs and practices used. The Committee believes, as did its predecessor committee, that power will be widely unavailable in the more highly stressed situations. Most of the power expended in communicating never gets transmitted, but is consumed in the switching, control, and signal-handling processes. Accordingly, because of its very low power consumption, the Committee recommends that the NCS promote the use of CMOS technology for analog and digital large-scale integrated circuits for key communication and control components.

d. Systems and Interconnect Architectures. This category includes actual overall system designs such as Open Systems Interconnection (OSI), System Network Architecture (SNA), the proposed Integrated Services Data Networks (ISDN), Common Channel Interoffice Signalling (CCIS), and new teleconferencing systems. Fault-tolerant designs are specifically singled out for attention since their increasing use in businesses and by communications carriers adds to the national capabilities for survival and recovery.

When it finally becomes available and widely installed, Open Systems Interconnection will have the important consequence of improving interoperability of computer systems, including existing ones. This will aid in the recovery process as systems and networks that never had to interact before now have to do so and will become able to. Meanwhile, in the absence of the widely-installed OSI "glue" that allows inhomogenous systems to interwork, interconnection of existing systems of the same architecture would be needed in recovery situations. The most prevalent is IBM's SNA, which is widely used in commercial systems (over 20,000 "networks"). These form a redundantly large number of individual, privately owned networks, many having national and international coverage. Other widely installed systems include DECNET (about 2,000 networks), the Defense Department's TCP/IP (hundreds), Xerox, and Burroughs.

CCIS control of the telephone network has certainly improved the controllability and therefore the security, flexibility, availability, and recoverability of the telephone system compared to the earlier in-band signaling systems. Such improvements will continue and expand as more "software definition" is put in place, building on the basic CCIS structure. The Committee is concerned, however, with the increased vulnerability of the system because of the small number of installed and planned signal transfer points, which was reduced from 21 to 14 in 1984.

The increasing pervasiveness of software definition of traffic handling services of the U.S. telephone companies can be exploited in directions supportive of NS/EP. Software features that can be designed, implemented, tested, and kept in readiness include not only those that support "network diversity," the aim of the NCS Class 4/5 Switch Study, but those that support recoverability, privacy/security, and call priority capability.

4. Standards

In its charge to the Committee, the NCS has indicated that it views standards as a key concern. The development of standards that would facilitate interoperability of telecommunications networks is certainly important to national security and emergency preparedness. With its limited resources, however, the NCS must be judicious in the way it goes about attempting to encourage this end. Representatives of numerous vendors and users have appeared before this Committee to reiterate the importance of standards for telecommunications. Standards serve a variety of important objectives, not only for NS/EP telecommunications, but for the commercial communications carriers as well. The carriers have strong economic incentives to reach agreement on standards for interconnection and interoperability. Some of the incentives also benefit government in its acquisition of telecommunications services. The incentives include:

- Interoperability. Without interoperability standards communication cannot take place at all, thus limiting the services that can be marketed.

- Economizing procurement. Standards allow the carriers or the government to solicit competitive bids for equipment from many suppliers, thus reducing their equipment costs.

- Private investment in commercial products. Standards that ensure a viable market help induce semiconductor manufacturers to invest in VLSI protocol implementation. In the absence of such standards, they are reluctant to invest.

- Reduced support costs. Standards reduce the costs of maintenance, inventory, and spare parts that would otherwise be required to support several different technical solutions.

The federal government's interests in standards go far beyond concerns of interoperability for NS/EP. Like other major consumers of telecommunications services, the government favors standards that lead to multiple suppliers and lower prices. The selection of standards can have major implications for the competitiveness of U.S. firms in international trade in telecommunications equipment and services.

The responsibility for articulating all of these various objectives for telecommunications standards has fallen largely to the NCS. One might have expected the General Services Administration (GSA) to take the lead in representing the interests of the government as a consumer of telecommunications. However, GSA does not currently have the technical expertise to represent the United States in this way. The National Bureau of Standards (NBS) has some expertise, but is currently devoting all of its efforts to the critical area of computer communications. Trade interests are represented in part by the National Telecommunications and Information Administration (NTIA) in the Department of Commerce and technical experts from NTIA's Institute of Telecommunications Sciences, but the staff in this area is also limited.

As a result, the NCS has been obliged to fill the void in government representation in telecommunications standards activities. The Committee agrees that the NCS must take on these responsibilities, especially in its own interest for NS/EP telecommunications. However, the result has been to strain the resources of the NCS in this arena where simply meeting the NS/EP objectives would be challenge enough.

To contribute as effectively as possible to achieving all of its missions in the standards arena, the NCS must make several determinations:

- Which standards areas currently under review by various standards bodies are most critical to achieving each of the various standards missions?

- Which of these standards is least likely to be developed in a satisfactory way without government participation, simply as a result of the economic incentives of carriers and manufacturers alike?

- At what stage and by what means can the NCS most effectively influence the development of standards to achieve its missions?

Presentations from NCS officials have raised Committee concerns that the NCS may be dissipating its efforts on problems that are not the most critical to its interests. For example, the NCS mentioned modem standards as an area in which it has been active. There is ample commercial incentive for manufacturers to agree on standards for switched modems, and thus little of importance for NCS to do in this area. For leased-line modems, whether there are one or two standards is of relatively little importance considering that procurements are generally made in matched pairs.

Conversely, the Committee heard presentations from industrial firms which emphasized that operations practices and network-to-network interfaces were two areas in which there appeared to be insufficient economic incentives for carriers to reach agreement quickly. Similarly, call priority capability could easily be added to the functionality of CCIS systems at the present stage of development if the NCS were to indicate its importance. In the Committee's view, it is in these areas that intervention by the NCS could be more valuable in the pursuit of NS/EP objectives.

In view of the scarce resources available to it, the Committee concludes that the NCS must improve its efforts to target areas in which the standard is of major importance to NCS objectives, the NCS can reasonably be expected to have a significant influence on the process, and the means of effecting the standard are carefully chosen to be both efficient and effective.

B. Industry Strategies and Government Positions

The government's policies of deregulation in telecommunications and its position regarding divestiture of AT&T have produced a dynamic, competitive environment in which short-term tactics and long-term strategies of the competing players generate changes in policy, regulation, and law. This section of the report addresses three aspects of this complicated environment: changing relationships in the industry, intercity communications, and the exchange carriers. The directions of change within the telecommunications industry, between industry and government, and of the environment as a whole lead to assumptions about the likely nature and structure of our national telecommunications capabilities by the year 2000. In the Committee's final report these assumptions will be used to develop a final set of recommendations for the NCS. Early conclusions and recommendations of the Committee have been presented in Section IIB.

1. Common Carriers and Private Carriers: Changing Relationships in the Telecommunications Industry

a. Background. The new telecommunications environment in the United States can be characterized by two fundamental changes in the rules of the game: horizontal deregulation or competition, and vertical separation or regulation. The intersection of these two changes has created a situation in which a host of new institutional players have appeared and are likely to continue to thrive, providing horizontal or vertical segments of telecommunications services under a format far different from that for traditional universal common carriage.

The implications of these trends for national security and emergency preparedness are many. The appearance of multiple players will certainly lead to the construction of redundant transmission paths, thus increasing path diversity. At the same time, it will greatly increase the number of entities whose networks must be coordinated if service is to be restored following an emergency.

b. Horizontal Deregulation. Beginning in 1968 with the Carterphone decision, the United States has gradually torn down the barriers to competition in the provision of various elements of telecommunications service. The Carterphone decision struck down the barriers to competition in the provision of customer premises equipment (CPE). From virtual monopoly of the market for private branch exchanges (PBXs), telephones, and data terminals by AT&T, the United States has moved to a fully competitive environment in which AT&T currently holds no more than 21 percent of the PBX market.

In long distance, the "Above 890" decision in 1959 paved the way for private firms to begin constructing microwave communications facilities for their internal use. Beginning in 1969, totally new carriers were authorized to build microwave systems for the provisions of private-line services on a common-carrier basis. This was followed by competition in the resale of private lines leased from AT&T. In 1978, with the Execunet decision, competition in switched telephone services was authorized. The advent of satellite technology and fiber optics has greatly lowered the cost of building a nationwide network and has led to a host of newcomers, from SBS to the railroads and gas pipeline companies, who own the right of way needed for fiber-optic installations. Equal access to the local network by the competitive carriers may lower AT&T's share of the inter-LATA (Local Access and Transport Area) market to 80 percent or less within two years.

Competition in value-added services such as electronic mail and distributed data processing is uninhibited by regulation, and is vigorously contested by companies as different as IBM, McDonnell Automation, and General Electric. In the local exchanges, the telephone companies face competition from operators of shared tenant services, digital termination systems, cable television operators, and rooftop satellite installations.

In short, today there is vigorous competition where before a single monopoly provided service or equipment in each of these markets. Many of these competitors will enter the marketplace in a manner which does not subject them to traditional common-carrier regulation nor impose traditional common-carrier obligations on them. These new players pose a significant challenge, both to the financial health of the traditional carriers and to expectations regarding common carrier obligations.

c. Vertical Regulation. At the same time that new competition is allowed, regulations which prevent companies from offering vertically integrated services have increased. What used to be an integrated network under common control is increasingly becoming a series of fragmented subnetworks with legally mandated boundaries. Local telephone companies are prohibited from offering long-distance service. They may offer customer premises equipment only through a separate subsidiary. AT&T must separate its long-distance service company from its subsidiary that sells CPE.

Public policy also compels a separation between so-called "basic" telecommunications and "enhanced" services, and these, too, must be offered by separate corporate entities. Thus, packet switching can be offered by AT&T Communications, but packet assembly and disassembly for dumb terminals must be offered by a separate subsidiary, AT&T Information Systems, using separate facilities and separate personnel. Similar restrictions affect the local telephone operating companies.

To offer a videotex service, the activities of several companies must be coordinated: one company that can sell terminals, another that can sell local communications, a third that can provide enhanced data communications, and a fourth that can supply information content. No major existing carrier--only new entrants--can legally supply them all in an integrated fashion.

Increasingly, the provisions of telecommunications can be viewed as being broken up into a number of horizontal layers. Some entities may be vertically integrated across these layers, but many are not. These layers include:

- Physical facilities (e.g., a satellite transponder, a fiber, a switch, or handset);

- Transmission service (transmission of information over a channel derived from a physical facility);

- Network service (switching, batching, routing, or otherwise controlling the flow of traffic over a connected set of transmission links);

- Value-added service (protocol conversion, information storage, and other processing-related functions); and

- Information service (the provision of information content or intellectual property for delivery through a telecommunications system).

In many cases, current FCC policy has created barriers to the vertical integration of these functions in a single entity. Generally, if an entity is in a dominant position with respect to any one of these functions, it will not be allowed to integrate vertically to provide functions in another layer. While these layers may appear similar to the Open Systems Interconnection reference model they are not the same, and do not represent the same division of functions and services.

d. New Institutional Forms. In the 1840s, as telegraph companies sprang up following Morse's Baltimore-Washington demonstration, they did not interconnect with each other. Each attempted to impede its competition by refusing to carry its competitors' traffic. The Postal Roads Act of 1856 offered various attractive inducements to the telegraph industry on condition they agree to accept common-carrier obligations and to interconnect.

Common-carrier obligation requires firms so classified to carry traffic from all comers, including competitors. Thus by accepting the designation as common carriers, the telegraph companies set a precedent which has justified all later forms of regulation for both telegraph and telephone companies. Today full common-carrier obligations are viewed by Congress and the FCC to include an obligation to provide "universal service"--service to users anywhere at affordable prices.

In the process of opening up the telecommunications marketplace to competition while simultaneously imposing structural barriers, the FCC has created a series of new organizational forms with quite different degrees of common-carrier obligation. A sample listing would have to include:

- Fully regulated, dominant, common carriers. They own their own facilities, provide service, are dominant in some market, and carry full common-carrier obligation (i.e., universal service).

- Competitive common carriers. They provide facilities and services but do not possess significant market power.

- Facility construction and management. Companies such as Fibertrak, Lightnet, and Orion that propose to construct transmission facilities and then sell portions of them condominium style to carriers or noncarriers. The builder may also provide maintenance and other shared services.

- Shared service resellers. These include entities created by a group of companies with a common link [e.g., the Aeronautical Radio, Inc. (ARINC) network organized by the airlines] to acquire communications from carriers and resell it on a nonprofit basis to their members.

- Resale common carriers. Carriers such as Allnet and First Phone, who acquire transmission capacity from others and resell it, generally along with multiplexing or switching services, on a for-profit basis to all comers.

- Enhanced services providers. These entities not only acquire underlying communications value from others, but they add value prior to resale; for example, through the addition of packetizing services or protocol conversion services. Under Computer Inquiry II (CI-II), the FCC forbears from regulating these entities.

- Private carriers. FCC Docket 83-246 proposes to create a new class of microwave carriers designated "private carriers." These companies would be able to go beyond current facilities providers to offer communications services to unrelated subscribers on an entrepreneurial basis. However, because such service would, theoretically, be offered only by subscription to a limited number of clients, it would not be considered a generalized offering of service such as would constitute common carriage.

- Shared tenant services (STS). Entities providing STS own switching equipment and inside wiring which is shared among several tenants. The STS entity may or may not engage in resale of transmission capacity.

- Private entities. Private entities, whether corporations, non-profit institutions, or governments, may acquire both transmission and switching facilities for their own use. They may also sell excess capacity on these systems, under one of the above organizational forms.

The Committee contends that significant fractions of current network traffic will gradually be diverted from entities under common carrier obligation to entities which are not under any such obligations. These entities will provide a diverse range of services, frequently customized for a small group of customers. These diverse and customized offerings will multiply the facilities from which communications capability can be reconstituted following a disaster, making the problems of reconstitution of the network following an emergency incident more complicated. Further, as common carrier obligation is eroded by the development of new institutional forms, the ability of the FCC or other regulatory authority to influence the providers of communications services to undertake various obligations in the service of NS/EP needs will be com- promised. By giving up domestic construction approval authority under Section 214 of the Communications Act of 1934 for every carrier except AT&T and the Bell Operating Companies (BOCs), the FCC has already given up a most powerful way to influence carriers to construct facilities adequate for NS/EP needs through deregulation.

The following section looks specifically at some of the incentives giving rise to these new organizational forms, and particularly to private corporate networks. The proliferation of individual corporate networks, which may or may not employ standards identical to those used by the carriers, is an issue of significant long-run concern.

e. The Rise of Private Networks. As early as 1959, companies such as the railroads and the oil companies began building their own telecommunications facilities to reach out-of-the-way places not served by the common carriers. With the development of new technologies such as millimeter-wave antennas and rooftop satellite dishes, it has become economically feasible for even relatively small firms to invest in their own networks.

In the last five years these networks have been expanding at an ever accelerating rate. In 20 years the telecommunications industry might look less like the current, integrated quasi-monopoly and more like the electric power industry where hundreds of firms are both buyers and sellers of service. Fragmentation of the network may lead to lower prices, economies of specialization, and greater diversity of services. It may also lead to diseconomies of small scale, lower reliability due to less redundancy, and great difficulty in coordinating global innovations such as the Integrated Services Digital Network or the migration to personal telephone number.*

The potential for a drastic shift of traffic away from the existing network operators is real. At the level of facilities, private entities (e.g., Citibank and Wang) are buying fibers and transponders for their own use, as well as the more common microwave and cable systems. Transmission services are being acquired from new, unregulated transmission service companies as well as from the traditional facilities-based carriers. Switching services can be provided internally through sophisticated, customer-owned PBXs or shared tenant services. Some companies are beginning to acquire central-office-class switches for use in their private networks. For instance, Wang has recently ordered a #5 Electronic Switching System. Enhanced services have traditionally been supplied more frequently on a private than on a public basis.

The reasons for this shift are multiple. They include tariff anomalies, FCC structural barriers, and changing strategic perceptions by companies whose lifeblood is information. These motivations are detailed in the following sections.

f. <u>Network Pricing and Bypass</u>. The telephone plant can be thought of as consisting of three basic components: non-traffic-sensitive plant (such as the line that runs to the subscriber's premises from the central office), which is shared by all services; local-usage-sensitive plant which provides intraexchange calling; and the interexchange or interLATA plant. Historically, part of the income collected for interexchange calls--currently about eight cents per minute for each local end--has been used to cover part of the cost of the non-traffic-sensitive (NTS) plant.

Prior to divestiture, this transfer was accomplished internally to AT&T or in settlements with the local independents. Since divestiture, the Regional Bell Operating Companies (RBOCs) have been authorized to set tariffs for interconnection of the interexchange carrier's point of presence (POP) to the local network (carrier common-line charge--CCLC) at a rate designed to collect the same eight cents per minute as a way to continue the transfer from interexchange to intraexchange costs. This method of collecting revenue to support NTS plant puts a disproportionate burden on companies which make thousands of minutes of long-distance calls per month.

With the advent of competition, particularly in the local-exchange market, this "tax" on long-distance carriers can be avoided if the subscriber connects to the interexchange carrier's POP directly without going through the local operating company. By building a private microwave or fiber-optic link from the corporate PBX directly to the inter-

*Like keeping the same extension when changing offices, a personal telephone number would be kept by an individual no matter where in the country he moved, either from day to day or during his lifetime.

exchange carrier's POP, the high cost of interconnection can be avoided at great savings to the interexchange carrier and, ultimately, to the customer. This phenomenon, often referred to as bypass, has become a major factor in the growth of privately owned and operated telecommunications networks.

Current proposals to reduce the carrier common-line charge and make up for the revenue loss with a customer access line charge (CALC) levied directly on the subscriber have met with considerable political resistance. The continuing high level of the CCLC provides continuing incentive for investments in bypass whether by private entities, private carriers, or even the interexchange carriers themselves.

As a result, corporations are moving rapidly to construct private networks in metropolitan areas to channel all of their interexchange traffic directly to an interexchange carrier. One study by the FCC suggests that firms accounting for as much as 40 percent of all the interexchange telephone traffic would find it financially attractive to migrate onto private networks in the next 10 years if the CCLC was not changed.*

g. Additional Motivations for Private Networks. If the distortions caused by the CCLC were the only reason why firms have been building private networks, the problem could be readily solved by instituting a CALC. Unfortunately, this is only one part of the varied motivations for firms to acquire their own networks. Six additional factors motivating firms toward private network construction are:

- Tariff anomalies: Misleading price signals, resulting from including a per-minute charge to support local-exchange cable plant in the price of long-distance calls and from rate averaging for private-line services.

- Carrier responsiveness: The trauma of divestiture has led to long delays by many carriers in meeting requests for new installation or private-line services. User companies may feel that building their own facilities is the only way to avoid long delays. These delays may be only a temporary rather than a long-term phenomenon.

- Economies of specialization: Users who need specialized services, such as multipoint data distribution by UPI, may find that custom-designed and -built networks are more cost-effective than using general-purpose carrier facilities, despite the carriers' economies of scale.

- Economies of vertical integration: The inability of the carriers to integrate basic and enhanced services in a single offering can lead to delay in offering new services, or to high prices when such ser-

*Brock, G. W. Bypass of the Local Exchange: A Quantitative Assessment FCC Office of Plans and Policies, WP #12; September 1984.

vices are available. Private networks do not suffer from the same restrictions on integration. For example, a private entity can integrate packet switching with code and protocol conversion, while AT&T and the RBOCs are obliged to offer these services through separate subsidiaries with separate facilities and separate management. Voice messaging can be integrated with a PBX, but cannot be integrated with a local exchange/-Centrex type service.

• Technological lag by carriers: Von Hippel's work* has shown that lead users are often in advance of vendors, particularly where the benefits of the new services are greater to the user than the additional potential sales available to the vendor.

Some firms may see private networks as a way of obtaining new services, such as ISDN, sooner than they would become available from the carriers.

• Reduced uncertainty and control: Managers do not just maximize profits; they also strive to reduce uncertainty. Gaining control over telecommunications facilities may be viewed as a way of minimizing uncertainty in turbulent times.

h. Strategic Motivations. In addition to this list of motivating factors, many of which can be addressed by effective action on the part of carriers, there is another motivation which for some firms may be the most significant of all: strategic advantage.

As communications becomes an increasingly significant fraction of the operating costs of information-intensive companies such as banks or distributors, the desire will grow to find mechanisms which can provide the firm with a strategic edge over the competition. Finding and keeping a strategic edge requires investing in capabilities not readily available to one's competitors. The use of standardized, publicly tariffed facilities reduces the level of differentiation that one firm can establish vis-a-vis its competitors. Thus, we can expect to see banks struggling to establish exclusive access to new cable communications facilities which could be used for home banking terminals.

Moreover, by designing a unique network and tying customers to the firm through it, a company can make it costly for customers to move to a competitor. Examples include the customer-oriented networks of American Airlines, United Airlines, and American Hospital Supply.

Investments in costly communications facilities cannot be duplicated by a competitor without a significant delay. Thus, these investments can have significant strategic value by providing a period during which the innovator can reap supranormal profits during the time required for competitors to catch up.

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*Von Hippel, Eric: "The Dominant Role of Users in the Scientific Instrument Innovation Process;" Research Policy, Vol. V, 1976, pp. 212-239.

i. Transmission Versus Networking. In many cases, corporate networks rely on transmission facilities leased from the common carriers while the corporations are buying their own switching capability. There are at least two reasons for this pattern: transmission facilities exhibit greater economy of scale than switching facilities given present technology, and integration of basic and enhanced services as well as provision of most custom services require control over the switching facilities.

As a consequence, a significant return to shared-carrier-provided switching or CENTREX type services is unlikely. Moreover, we should expect to see firms increasingly lease transmission capacity from private carriers and others who provide minimal additional switching or network capability. This eliminates the need to pay for switching which is used only to facilitate the provisions of a fullperiod circuit.

Second, because the carriers who provide transmission generally also provide switching, they have been slow to provide transmission ser- vices that could be used without their switching capability. Users who wish DS-1 and higher data-rate facilities generally must look elsewhere than the carriers to procure them.

j. Limits of the Shift. To date, private network use has been limited largely to internal traffic. To the extent that most telephone traffic is external rather than internal, there is a limit to the extent to which private networks can substitute for a public, universal network. However, it is not unreasonable to expect, much as it is beginning to be seen in networks, that large corporations will interconnect directly with one another, providing intercompany service without benefits of an intermediate carrier. Indeed, it is already true that many of GM's suppliers have direct links to the GM corporate network. Dealers may soon follow. Moreover, the development of industry-specific networks, such as ARINC, might provide another path for the diversion of significant inter-company traffic off the switched common carrier network.

k. Implications for NS/EP. If, as seems likely, there is an increasing percentage of telecommunications traffic carried over private facilities, the problems of coordination--in normal times as well as under emergency conditions--will be greatly complicated. At the present time, the Committee believes that the telephone carriers, particularly the BOCs through BellCore, will continue to set standards in the industry that will be followed by private concerns. The use of common standards will facilitate network interconnection. However, we are already beginning to see situations in which protocols specific to one brand of PBX are used in inter-PBX networks, with translation to common standards being accomplished only when going outside the PBX cluster. As these clusters grow, the percentage of traffic carried in these nonstandard forms will increase.

On the other hand, the existence of multiple, distributed, network control centers, each supported by a different private corporation, increases the redundancy of points capable of reconstituting some kind of network service following a disaster which strikes a carrier's network control facilities. The problem, of course, is that a reconstituted corporate network reaches only to corporate locations.

2. Intercity Telecommunications

a. Influencing Factors. The telecommunications industry is very capital-intensive. Capital requirements are so large that they could probably cause numerous consolidations over the next several years. Hence, there are likely to be two categories of suppliers--those with very large capital resources (either ready access to large amounts of capital or very large positive cash flows) and those with more modest capital resources. The former can seek to provide all forms of telecommunications services; the latter may have to serve only selected market segments. Accordingly, the Committee believes that the number of carriers may decline by the end of the century rather than increase.

The Committee has seen the intercity telecommunications arena become, and expects it will remain, highly competitive. Hence, highvolume services (e.g., long-distance telephone calls) will come to have many of the characteristics of commodities such as high volume, low margins, high advertising expense, and many and varied pricing and promotional techniques. The resultant impact on service quality is not clear. The large residential user community might be tolerant of lower quality if the "price is right."

On the other hand, the business community generates more revenue and is more insistent on quality of service. Some decline in service quality can be expected if something like a price war develops, but probably not so great a decline as to drive most of the business users to private lines or networks. Although some are likely to do so for quality-of service reasons, most of those who opt for private lines will do so in search of volume discounts, specialized services or a desire to have greater control over their telecommunications. Such specialized services may form a market niche for some suppliers. They will also produce higher profit margins, so that carriers whose principal thrust is at the high-volume market will also be drawn to the lowervolume, specialized-service market in an effort to improve their overall returns on assets. Price will always be a factor, but service quality and value-added features will assume greater importance in product differentiation.

Another major uncertainty is the impact that a major shift of high-volume users to private networks would have on the public switched network (PSN) and consequently on the cost of service to the lower-volume market. This is the bypass issue, which the Committee considers very important.

Transmission will no longer be a limiting factor in intercity telecommunications. Satellites, high-capacity microwave, and opticalfiber networks are growing at such an extremely rapid rate that an over-abundance of capacity is likely in the 1990s. Moreover, the quality and reliability will be very high; most signals will be digital. Thus, the intercity marketplace, which has been dominated by price, availability and quality considerations, will come to be driven by "value-added" features to be offered by competing carriers. Most of these value-added features will be provided by various forms of switching that exploit the growing capabilities of software-controlled machines. Networks that integrate voice, data, facsimile, and video and that can be rapidly reconfigured to varying traffic patterns will become commonplace for very large users. Others will be able to obtain specialized services from the carriers' backbone systems in the form of "software defined" networks and services.

Thus the Committee concludes that for the next several years, pricing instability and turbulence together with industry structural turbulence can be anticipated.

b. The Players and Their Strategies. One can define three general categories of suppliers in the intercity telecommunications arena: full-service carriers, specialized carriers, and resellers. Their characteristics follow.

- Full-service carriers offer all classes of service, ranging from long-distance telephone calls to private lines and value-added services. Increasingly, they serve both domestic and international markets. Extensive geographic coverage by a basic backbone network structure comprised of switching centers and all types of transmission are characteristic. They must also have major financial, management, and human resources.

- Specialized carriers are a somewhat more disparate group. They may be identified with one or more of the following:

  - a particular transmission medium, e.g., satellite;
  - a particular market segment, e.g., business users only;
  - highly specialized services, e.g., one-way broadcast of low-speed data to many locations; or
  - geographic coverage, e.g., Alaska.

- Resellers generally bundle together various users' requirements and provide service by renting other carrier facilities at a better price than could be obtained by a single user. They add value by providing switching facilities and other services, but generally lease transmission from other carriers. A corporation with its own private network can also function as a reseller by leasing its excess switching or transmission capacity to other businesses in an effort to offset the costs of its private network. Another form of resale is that of facilities rather than telecommunications services.

(1.) Full-service carriers. AT&T Communications is the dominant full-service carrier. Other than its financial and management resources together with its service reputation and customer base, its principal asset is "the network." A very large network possesses economies of scale of considerable proportions. AT&T Communications has no peer in this regard. It can, therefore, be expected to exploit that advantage to the utmost.

One can expect that new service offerings will exploit the network switching and signalling capabilities. Two examples are "software defined networks" and "customized calling services." AT&T, of course, has the lion's share of the enormous long-distance telephone market, which represents 65 percent of AT&T's 1984 revenues. It can be expected to fight to retain its market share as a first order of business. How to do so, with its pricing flexibility limited by the FCC, is a near-term problem. It can be expected to play down its dominant position and to seek deregulation as a high-priority objective. In the meantime, one can forecast that AT&T's tariff changes will be based upon the leverage provided by an in-place network of enormous proportions possessing very great flexibility.

The other full-service carrier contenders are all trying to grow market share at AT&T's expense. Most are doing so by offering "like" service at a lower price and, in some cases, at lesser quality. Some will seek to mask physical or capital constraints upon rapid expansion by asserting that "quality will not be traded for quantity." All will try to keep AT&T regulated indefinitely by pointing to its "dominant" position. All must expand their backbone networks as rapidly as possible to serve as many of the major metropolitan areas as they can. They will probably avoid the less populous areas because of the heavy capital demands of major network expansion. Most will seek to compensate partially for AT&T's economies of scale by installing only the newest and most cost-effective transmission for the route segment (e.g., fiber, high-capacity microwave, or satellite). Thus, their channel cost per mile may be lower initially than that of AT&T, with its very large embedded investment in older transmission plant.

Other than AT&T, there are several carriers that appear to aspire to the role of full-service carriers. They are MCI, GTE, Satellite Business Systems (SBS), Western Union, ITT, and United Telecommunications. Some, which do not appear to have the in-depth financial resources to become true full-service carriers, could still logically adopt a strategy that seeks to gain even a very small share of the gigantic long-distance calling market in an effort to either attract capital sufficient to become a full-service carrier, or provide cash flows to invest in other targeted market segments and subsequently to withdraw from the message toll market when pressure on margins becomes too great.

(2.) Specialized and value-added carriers. This category contains a rather diverse group of companies that have one common thread--they seek to become dominant in a particular market segment. This is frequently referred to as a "niche" strategy. Their network designs are often driven by the particular niches they address. There is a fair amount of turbulence in this group as new entrants emerge and older players are acquired by others. Vitalink and, more recently, Argo are examples of the former; ISACOMM, Telenet, Cylix, and Spacenet are examples of the latter. Some of the principal players in this group, and their characteristics, are as follows:

- American Satellite Company is a domestic satellite company which serves government and business users. It provides private-line voice, data, facsimile, and video teleconferencing services. ASC also provides private networks that integrate voice, data, and video into a single network for a specific customer. Heavy emphasis is placed on digital transmission and data services. It has a large population of earth stations (more than 150), owns 20 percent of the Westar III, IV, and V satellites, and plans to launch the first of its new series of satellites in August 1985. Currently operating in C-band, it will begin moving into the Ku-band in the near future. It can be expected to add switching capabilities, particularly for data, in order to provide value-added features to what is predominantly a transmission system today.

- Argo is a new entrant which appears to be targeting the business user market. An all-digital system currently leasing transponders, it serves three major metropolitan areas now with plans to expand into nine more in the near future. It offers switched long-distance telephone services and private-line voice and data circuits up to 1.5 megabits per second. Argo currently emphasizes price and the quality of all-digital transmission.

- Alascom provides telecommunications services within Alaska, using many earth stations, to "bush" locations and terrestrial microwave systems. It owns its satellite (one of the RCA series) and owns and operates 175 earth stations. Alascom provides communications services jointly with AT&T to the "lower 48" to and from Alaska. It essentially has a monopoly on intercity communications in Alaska and can be expected to exert every effort to protect that position by citing the high cost of providing "bush" services and the need for monopoly position in higher-density areas to survive.

- Equatorial Communications Services, using a patented spread-spectrum technique, provides a satellite-based, low-speed data (50-2400 baud), point-to-multipoint broadcast to large numbers (1,000s) of small, receive-only earth stations that they sell to the users. Tailored for the wire services (e.g., Dow Jones, AP, UPI, and Reuters), it appears well on the way towards becoming dominant in this market segment. It owns and operates the major uplink earth stations, has acquired transponders from Western Union and Hughes, and extends service to Canada via the Anik satellite. It also filed an application with the FCC to construct two satellites in the future. Equatorial can be expected to expand its proprietary technology into two-way micro-station applications to serve multiple terminal applications (e.g., point-of-sale terminals) and other low-speed data networking applications.

- RCA Americom owns and operates its own space segment of four satellites and ground segment of earth stations. It sells and leases transponders: one of its satellites functions as a "cable bird." RCA also provides private-line services, principally voice, over a backbone network directly serving metropolitan areas, and is a major supplier of voice circuits to the "reseller" and other common-carrier industries. Forty-four earth stations at government sites provide dedicated networks, both voice and high-speed data, to government. These are supplemented by seven stations leased to the government at commercial sites. RCA has acquired Cylix, which provides specialized data services to the business community. RCA can be expected to continue the systematic expansion of its general purpose network of earth stations, place increasing emphasis on private-network offerings to business users, continue to expand its government services, and at some point decide to add switching capabilities to its general-purpose backbone network.

- There are numerous other specialized carriers that are satellite-based (e.g., Vitalink), both satellite and terrestrial transmission suppliers (e.g., WTCI), and those providing terrestrial transmission only. There are also many new entrants with applications pending or already approved by the FCC but which have not yet reached operational status (e.g., USSSI, ABC, and Orion). These new entrants propose to provide services ranging from international to very highly specialized services, usually to the government and business communities.

- Value-Added Networks (VANs). There are several value-added networks now operating as public networks. Among them are Telenet (GTE), Uninet (United Telecommunications), Tymnet (McDonnell Douglas), and Net 1000 (AT&T). Additionally, at least Tymnet is in the process of providing a large, private, packet-switched network to a single customer. Of the cited companies, all but Tymnet are parts of those we have categorized as "full-service" carriers and their strategies presumably are subsumed within the overall carrier strategy. Tymnet was recently acquired by McDonnell-Douglas, which perhaps intends thereby to grow its computer services activity.

(3.) Resellers. There are well over 200 service resellers serving 154 market areas; they produced more than $700 million of revenue in 1983. Starnet and U.S. Telephone (recently acquired by United Telecommunications, Inc.) are among the major players. Some serve geographic regions; others target industry segments (e.g., Starnet for lodging and travel). One can forecast considerable turbulence in this industry group, as most have been exploiting the price differential between their services and those of AT&T.

Over time, the Committee expects the indirect subsidy to local telephone service that has been borne by long-distance telephone calls to disappear. As that happens, long-distance rates should go down. Competition by other major players will also exert a downward pressure on prices. Hence, margins will become narrower and consolidations, acquisitions, and business failures will likely be the hallmark of this industry segment for the next several years.

A special, growing form of reseller comprises those who resell facilities rather than services. Two major examples are Hughes Communi cations and SNET. The former sells transponders on its Galaxy series of satellites and the latter sells optical fibers in the LIGHTNET cable system. This is sometimes described as a "condominium" approach. Although service resellers are not regulated, the regulatory status of facility resellers is still uncertain. They can be expected to resist efforts to declare them carriers subject to regulation, other than for frequency and orbital assignment.

As can be seen from this brief summary, the intercity marketplace is marked by increasing diversity. For the next few years, the Committee expects pricing and industry structural turbulence to be commonplace.

c. Regulatory and Legislative Reaction.

(1.) Issues. There are a number of issues affecting the intercity carriers which confront those responsible for setting public policy in today's changing telecommunications environment. Each is likely to persist as an issue for some time to come. Others, as yet undefined, will emerge. Most observers believe that the technology is moving at a much faster pace than is the development of public policy. Thus, satisfactory resolution of these and future issues is not likely to occur quickly.

The bypass and access charge issues both deal with aspects of how to replace the share of exchange cable plant costs that flowed from long-distance calls to help keep the cost of local telephone service low. Intercity carriers are seen as one of several possible bypass threats. For example, a customer-premises earth station is a clear example of bypassing local-exchange facilities and thereby reducing the revenues to the local company. There is a substantial debate about the magnitude of the bypass threat, the economic and service consequences, and the basic customer reasons for bypass--economical or operational. The FCC is currently investigating the bypass issue and the Congress has considered penalizing bypassers and has criticized the FCC for its positions on access charges. Access charges are proposed for both business and residential telephone subscribers. Here, the Congress and the FCC appear to have somewhat contrary views. The proposed access charges on residential users have been approved by the FCC effective June 1, 1985, after modification as a result of congressional pressure. Other user groups (e.g., small business) have also sought congressional intervention.

AT&T is now considered the dominant carrier and hence subject to regulatory oversight to a much greater degree than "non-dominant" carriers. Implicit in such an arrangement is the issue of when to remove the "dominant" label. The resolution of this issue will depend substantially upon the further pace of deregulation and the success, or lack thereof, of the competing carriers. The issue of further interpretation and implementation of the Computer Inquiry II decision is closely coupled; that decision has been substantially affected by the Modified Final Judgment and subsequent divesititure activities.

Over the next several years, business failures, consolidations, and acquisitions can be anticipated in greater numbers than heretofore.

Older regulatory practices are probably not adequate to deal with this issue in the "deregulated" future environment.

(2.) Deregulation. The FCC seems committed to continuation of its deregulatory thrust. Its next step may be to eliminate rate-of-return regulation before the final step of general deregulation. Congress, on the other hand, may seek to constrain further acceleration of the deregulatory process. The Congress has been quite unsuccessful in enacting legislation that reflects its concerns for universal, affordable telephone service, reconciles the conflicting demands of special interest groups, and takes into account the rapidly moving technology. With the FCC pressing deregulation and the Congress unable to agree on legislation, the state and regulatory bodies find themselves having to confront many complex issues. Basically, their reaction has been to protect the local service users because that represents their largest constituency. The Committee anticipates a wide variety of local solutions to intrastate, public-policy, telecommunications issues.

d. Effects on NS/EP Planning. The very high level of activity in the intercity arena affords many opportunities and poses significant problems for the NS/EP community. Opportunities emerge both from the onset of new technology and the new infrastructure growing out of the very competitive intercity marketplace. This highly competitive environment can be expected to push the new technology wherever it will provide an economic or operational benefit that could achieve a competitive edge, and away from standardization.

The Committee sees several prominent examples of this competitive push for advantage from new technologies.

- As all intercity carriers will be expanding and modernizing their backbone networks, there will be much more diversity available in both transmission and switching. This will produce a more robust telecommunications structure, providing more diversity both for network layouts and for restoral and reconstitution activities. New services of the value-added character will appear, but only if there is cooperation among the carriers. An example would be "customized calling" which either assigns a special number that moves with particular individuals wherever they go or that provides some equivalent capability. That is the long-sought ability to maintain contact with key people in the government wherever they move under emergency conditions. It is equivalent to a portable, priority calling link for key executives, embodying the NSDD-97 goal of leadership support by telecommunications.

- Combinations of new facilities offer much more flexibility in system and network design. Extensive optical-fiber facilities offer improved protection from undesired radiation and communications intercept threats. Ready availability of satellite transmission makes highquality, wide-bandwidth transmission available into thin-route areas, where many military installations are located. Quick network expansion via transportable earth stations and unique broadcast applications will also be readily available from satellite carriers. Moreover, the ability to lease or buy transmission in the form of bandwidth and thereafter to derive channels using multiplexers or demand-assigned subsystems will give the NS/EP user the ability to control circuit routing and network layout, something generally not available in the past.

- The rapidly growing digital nature of intercity transmission will make more extensive use of bulk encryption feasible. Extension of digital lines into the local exchange area will quickly follow and make end-to-end encryption much less expensive than present efforts to compress analog voice into data rates that can be transmitted on 4-kHz analog channels.

- Finally, a major opportunity emerges to think imaginatively about how to exploit the desire of the competing carriers for economic gain and to establish new concepts of doing business. Simple management concepts based upon end-to-end service where the serving carrier provides the service as it sees fit can be selectively replaced by specifying services much more closely tailored to NS/EP needs with the expectation that there will be at least one among the competing carriers willing to supply it. The Committee will pursue this subject further in its final report.

The many new opportunities arising from the competitive intercity arena bring with them numerous problems. Not the least of these in a large bureaucracy like the government is how to take advantage of the new opportunities, most of which require changes in long-established ways of doing business and some experimentation.

The management problem will become more complex and costly. Reliance on a dominant carrier for the many management and coordination activities required to engineer, install, and operate an extensive network or circuit involving several suppliers will become a thing of the past. Additional skilled management resources will be required. Procurement rules that try to treat all potential suppliers equally will confront a growing diversity of service offerings, some of which will be unique to only one carrier. Requirements processes will confront a growing tension between cost and capabilities. One example among many would be a desire to take advantage of the low cost per bit of fiber-optics transmission together with its radiation and intercept resistance. To exploit the low cost per bit characteristically requires a very large amount of traffic. Very many telecommunications channels would have to be grouped together to generate sufficient traffic, and large cross-sections, when interrupted, represent major losses inconsistent with the need for diversity and redundancy essential to survivability. The Committee has identified three such potential losses.

- The absence of one de facto standard for "the network" is already being felt. Among other things, competition will result in innovation. Too restrictive a standards posture can hinder innovation since "one man's standard is another's straightjacket." Nor has there been a generally accepted standards process like that of the International

Consultative Committee on Telegraphy and Telephony (CCITT) in Europe, although clearly one has emerged in the Exchange Carriers Standards Association (ECSA) T-1 Committee endorsed by the American National Standards Institute (ANSI).

- Network expansion by several carriers will enhance the survivability of the nation's transmission networks. However, their growth into software-defined services may create new vulnerabilities within the system of each carrier by concentrating signaling, switching, and data--base functions in fewer locations. If different carriers choose the same locations as control centers, this concentration could prove fatal.

- The ability to influence the carriers' construction practices and plans towards greater survivability at no direct cost to government will be greatly reduced.

Summarizing opportunities and problems is best done by quoting Colonel George H. Bolling, Signal Corps, U.S. Army, in his book "AT&T Aftermath of Antitrust" in 1983:

> "For Defense, reaping the benefits of competition may be more difficult than coping with the loss of the single manager. In fact, the major challenge for Defense communicators is adapting to the new marketplace, seeking to understand and incorporate the technological capabilities emerging at an unprecedented pace."

3. <u>Exchange Carriers</u>

a. <u>Issues and Opportunities</u>.

(1.) <u>Industry structure and competing options</u>. The turmoil that is characteristic of the telecommunications industry today is reflected among the exchange carriers in spite of the relative stability of the market they serve. However the customer market may be segmented for purposes of analysis, the needs of all types of customers for basic and enhanced telephone services are more predictable than are, for example, their long-haul requirements. The options that are available with which to meet those needs are increasing rapidly. In addition to the local telephone companies with facilities reaching into every home and business, there are now video cable systems in most places, and there are, or soon will be, cellular radio and digital termination service (DTS) systems which are well-suited to the satisfaction of some communications needs.

Many exchange carriers are engaged, directly or through affiliates, in providing alternative systems. This discussion, however, will address only their role as providers of:

- conventional local telephone services over the public switched network,

- connections between users and the points of presence (PoPs) of inter-exchange carriers,

- terminals, or "customer premises equipment" (CPE), usually, although not always, furnished through a separate subsidiary or affiliated company, and

- other uses which may be made of the facilities which have been designed for the above purposes.

(2.) Private networks and the threat of bypass. The role of exchange carriers in furnishing the connections between users and their suppliers of interexchange services is subject to challenge because of several factors. Among these are:

- cost economies of scale available to large users, which may not be realizable because of uniform pricing required by some state regulatory agencies in the hope of supporting low rates for small users;

- the desire of some very large users to maintain control over every detail of their telecommunications services, for reasons which may or may not be wholly rational;

- the relative inflexibility of exchange carriers, whether caused by management inertia or regulatory restrictions;

- the inability of some exchange carriers to meet special needs in a timely fashion; and

- the pricing uncertainty that is associated with regulatory disputes and confusion.

These problems with the exchange environment, in addition to conventional economic analysis, have tended to push large users in the direction of setting up internal resources dedicated to communications management, and in some cases have pushed them in the direction of using private networks in place of the public switched network for meeting their telephone and data transmission needs. Faced with rates that do not reflect what they regard as proper economies of scale, some of these large users are choosing to bypass the facilities of exchange carriers entirely with a large portion of their traffic, by means of direct microwave or cable connection to the PoP of their chosen interexchange carrier or to the provider of their private network.

The full significance of this development will not be explored here; it is mentioned in passing because it appears that the resulting movement of traffic off the public switched network may have significance to NS/EP and should, therefore, be considered. The implications are summarized in "d" below.

(3.) Pace of change and window of opportunity. By way of introduction, it is worthwhile to mention at the beginning a conclusion of this examination of the exchange carrier situation: the rate of change of technology is such that, given the relatively long life of telephone system plant, any effort to influence the design of that plant in the interests of NS/EP should be undertaken quickly. As will be seen in what follows, the move toward digital technology is more rapid than most observers were predicting because the advantages of such a move are rapidly becoming more apparent than they were just a few years ago. The significance of these changes for NS/EP is not entirely clear at this time, but as it becomes apparent there will be little time thereafter to study the situation and to think about the implications. By the time the situation is understood, it may be too late to do anything about it.

b. Effects of Digital Technology. Advances in technology are appearing in communications systems in many forms and many places, usually (although not always) associated with applications of digital techniques in place of analog transmission, space-division or circuit switching, or the pushing of buttons required of the user. Even the use of fiber-optic transmission systems, which are sometimes analog, becomes much more significant when associated with digital techniques.

It is convenient, therefore, to organize this discussion around the application of digital technology to various parts of the telephone system.

(1.) Switching applications. All telephone switches can be looked at as special-purpose computers, for which continuity of service is the controlling criterion, and speed, accuracy, and portability are of relatively lesser importance. After 10 years or so of experience with integrated circuits, it became apparent that most of the techniques used in general-purpose computers could also be applied to telephone switching without sacrificing continuity of service. The increase in speed and accuracy were significant, as were reductions in size, power requirements, and maintenance labor.

Electro-mechanical switches, which required two years' lead time for housing, installing, and testing and were rarely removed for relocation elsewhere, are rapidly being replaced by digital switches that take one-fourth the space and can be installed and tested in a few weeks. These new switches are also "smarter;" they can be arranged in master-slave configurations that greatly increase the flexibility of network design. Ease of number translation and signalling systems that capture and forward more information about the call being set up also add materially to flexibility, so that many former constraints on the application of switches in a particular environment no longer apply. It would only be a slight exaggeration to say that what can be imagined in the network can also be built.

Estimates made 10 years ago about the rate at which digital switching would be introduced were influenced mainly by these considerations:

- cost of the new switches,

- depreciation rates on old switches,

- estimates of the demand for "exotic" features or services not feasible with older switches,

- training requirements for maintenance personnel, and

- the growth of digital transmission systems and the accompanying need for analog-to-digital (A/D) and digital-to-analog (D/A) conversions.

Most of those estimates erred in the direction of longer time periods than now appear reasonable because:

- the cost of digital products used in large quantities has fallen rapidly;

- State and federal regulators have greatly increased depreciation allowances;

- convenience features, rather than "exotic" services--e.g., the ease of push-button dialing with automatic number identification--have proved to have great public appeal;

- the prevalence of computers and the maintenance-free character of the new switches have made it relatively easy to meet the needs for trained manpower, and

- similar cost trends in digital transmission systems have increased the rate at which they are being applied, encouraging the use of digital switching to avoid the cost and service impairment of A/D and D/A conversions.

More important than many of the above, however, has been the belated recognition of the economies brought by flexibility in system design. It is no longer necessary to estimate far in advance, with great accuracy, what services will be required and where: small "slave" switches and T-1 carrier systems permit network changes to be made with little cost penalty and with great savings on carrying charges for oversized, "safe" designs.

As the use of computers in business has grown explosively, the transfer of data has grown in importance, frequently intermixed with voice on the common network. In critical applications, the presence of a space-division switch between digital transmission circuits is an anomaly. Even though data transfer on the public switched network is in less volume than was predicted 10 years ago, the ability to provide it is still important to the exchange carriers.

This increased flexibility in the design and use of the network has important positive implications for NS/EP. The prevalence of "master-slave" relationships also has some negative implications concerning the stand-alone capability that may be needed in some circumstances. The implications are summarized in "d" below.

(2.) Transmission applications. Digital techniques were applied extensively to transmission long before they appeared in telephone switches. They were also used in "pair-gain" devices, generally as an interim step. (Pair-gain devices apply electronics in combinations of switching and transmission for the purpose of gaining added circuits--real or virtual--over a limited number of copper pairs.)

The cost reduction trends mentioned above are also applicable to transmission systems and have made it more economical, in many situations, to meet growing requirements by adding electronics instead of adding copper to existing plant.

(a.) Trunk applications. While the cost of digital electronics was declining, the recognition of its advantages for handling data was increasing. As the volume of long-haul telephone traffic grew, it became attractive to use digital techniques in the expansion of high-volume long-haul routes. Particularly when combined with digital trunk switches, this essentially removed noise and other forms of signal degradation as limiting factors in the trunk plant. (Although at present only 5 percent of the PSN trunk network is digital, AT&T's plans anticipate a minimum of 34 percent by 1990.) The use of CCIS, also digital, increases the efficiency of trunk plant by assuring that a connection is possible before the commitment of trunk resources to a new call.

Both of these developments have important NS/EP implications. Digital trunks are more flexible with respect to rearrangements, as might be required in high-stress conditions, if the proper equipment is at hand and the integrity of network control (e.g., synchronization) is assured. It does not, however, present the opportunity for improvisations that is sometimes present when analog systems are in use.

The use of CCIS tends to concentrate network control at a few points, again offering both flexibility and dependence on certain resources remaining intact. But vulnerability also increases with concentration, as the Committee has already observed in III.A.3.d. and as its predecessor committee noted in its final report.

(b.) Loop Applications. The prevalence of digital trunk systems encourages digital applications in the loop plant because of penalties associated with analog-to-digital and the inverse digital-to analog (A/D-D/A) conversions. Until the A/D-D/A conversion takes place in the terminal, however, it must happen somewhere else in the network, and the choice of location has important cost implications. In the near-term future, this is most likely to take place on the trunk side of local class-5 analog switches, or on the line side of local digital switches, which then have digital trunks almost exclusively connecting them to other switches.

From the NS/EP perspective, this consideration is important only during the transition, when a mix--and possibly an unfavorable mix--of digital and analog terminals and loop plant may exist in the same place. Such a situation will reduce flexibility in emergencies. In the longer term, the dependence of digital loops upon the central office clock again reduces the opportunity for improvisation in a stressed environment.

There is as yet no clear picture of how soon subscriber loops will operate in a digital mode, but it seems nearly certain that it will happen eventually. A lack of industry consensus as to how rapidly digital techniques will be employed in the loop plant probably means that it is at least several years in the future. The driving consideration may well be the application of digital electronics to terminal equipment.

(3.) Terminal applications. The development in terminal apparatus dominating the future is the growing presence of microprocessors within telephone instruments. This is significant of itself for the increased capability it provides to simplify many features that have heretofore required the entry of coded instructions each time a particular function is to be employed. Possibly of greater importance in the longer term is that the presence of digital electronic circuits within the instruments makes it economically attractive to do other things at small incremental cost. Among the other things to be done are A/D-D/A conversions, for example, which will encourage the application of digital transmission and signaling in the local loop. This, in turn, will encourage the application of fiber optics in there. Without digital terminals, fiber would likely end one or two thousand feet from the terminal, this distance being a function of digital transmission over copper pairs. With digital terminals, fiber will be used all the way in new installations, unless this development is inhibited, as it may be, by regulatory restrictions on the provision of terminal equipment. (The prevalence of customer-owned terminals may prevent the application of digital transmission all the way to the terminal because it would instantly make obsolete the customer-owned equipment at those locations.)

Given, hypothetically, the digital terminal, what does this portend? First of all, it simplifies the automation of numerous features, both now desired and as yet unthought of. In combination with electronic memory, it offers quick, easy, repetition of often-repeated functions, and it offers relatively easy priority override under emergency conditions. The list of possibilities is almost endless.

Again, for NS/EP purposes there is a potential tradeoff of added flexibility in normal circumstances for less flexibility under stressed conditions. This has been mentioned several times before, so it is worth noting now that after digital electronics has become the prevailing mode of operation in all segments of the telephone plant, it may be as easy to improvise with digital as it used to be with analog.

(4.) Locating the A/D-D/A conversion points. The significance of the A/D-D/A conversion point is not at all clear, but it may be important from the NS/EP perspective, as has been noted above. Some of the reasons have been suggested, but there may be more of them than have yet been touched upon. The Committee cannot yet suggest what that significance might be, but it is related to the reconstitution of a communications capability after the loss of whatever central point furnished the"master" clock, or synchronization, or other means of control for the encoding, switching, and other processing of the bit stream originating at a particular point. The subject deserves careful attention, on the chance that there are decisions ahead which can and should be influenced in the interest of NS/EP.

(5.) Power implications. Electric power for the telephone systems of 10 years ago was usually provided in the following manner:

- Switching centers, whether Class 5 or higher, used batteries, nominally 48 volts, as the active power source for all equipment. These batteries were charged from commercial sources, backed up by gasoline or diesel-powered standby generators. Battery reserve power adequate for several hours of operation (e.g., three to twelve) at an average traffic load was typical, with fuel supply for the backup system sufficient for a few days.

- Transmission equipment was usually powered from commercial sources with standby generators as backup. On rare occasions, continuous ("uninterruptible") power conversion systems were used, with either batteries or (rarely) large flywheels as the bridge between commercial and standby sources. Repeaters in cable systems were usually powered over extra wires in the coaxial or paired cable from a master repeater having batteries or other standby sources.

- PBX equipment was battery powered (either 48 or 24 volts) when continuity of service was important to the customer, with or without generator backup. In many cases, however, commercial power was the only source of supply, and in the event of power failure provisions were made for certain stations behind the PBX to be connected to trunk circuits to function simply as individual business lines.

- Terminal equipment consisting of ordinary single-line phones received all power over the same pairs as were used for communications. Multi-line phones using key equipment received power in the same way, but the key equipment itself was usually dependent upon commercial power. When this source failed, most systems automatically left each telephone line usable from one station, but key system features were lost.

The net result of all this was that telephone systems usually worked through most emergency circumstances, and when they finally failed--if they did fail--it was because of inadequacies in backup power systems. This power dependency is changing in interesting ways, both favorable and unfavorable, as electromechanical systems are replaced, first by electronic central offices and then by fully digital systems.

Electronic, analog central offices have had, at least until recently, rather large power requirements, almost independent of traffic load, with the result that vulnerablity to commercial power failure has increased. They also have been less tolerant of low voltage conditions, which are typical of battery operation with chargers not functioning.

Newer central offices, using VLSI circuitry and digital technology, are (or should be) less demanding upon battery systems. They draw less power than either early electronic systems or electromechanical systems; and the sensitivity to voltage level is at least no worse than with electromechanical offices, except that degradation is not graceful--they are likely either to work perfectly or not to work at all. There is an anomaly, however: 48-volt systems continue to be used in order to accommodate the "talking battery" and signaling systems that are expected by telephone sets having no active components and ringers, while LSI and VLSI circuits typically require only 5 or 8 volts and must be protected from the effects of 120-volt (nominal) ringing signals.

Terminal equipment is rapidly becoming fully electronic, for both communications and signalling. In most cases, this means that the 48-volt line battery is not used for all telephone set functions, leading to increased dependence upon commercial power at the user's location. Were it not for the widespread use of old telephone sets, some of them owned by customers, substantial improvements in power system sensitivity would be possible. In particular, telephones having repertory dialers and other features using microprocessors usually have small, rechargeable batteries inside to protect against total loss of memory during power failures. This same approach is possible for all-electronic telephones, providing a high degree of insensitivity to the state of commercial power.

Thus it is not clear whether the use of electronics, particularly digital electronics with full signal regeneration, is a net help or hindrance to NS/EP considerations, but it certainly changes the picture and requires evaluation.

(6.) Integration of services. When converted to electrical form, voice signals and video signals are inherently analog; data signals, on the other hand are inherently digital. Either form can be converted to the other, if one accepts certain limitations imposed by the conversion method. These limitations are serious for data; they are minor for voice. For video the consequences of conversion are mixed--the penalty in bandwidth is severe, but compression techniques are improving and may offset this to a significant degree.

In commercial telecommunications systems, flexibility is an important consideration in both economy and in marketing. The trend, therefore, is toward digital systems that are "transparent"--i.e., the system does not know nor care what kind of information is transmitted. The necessary bandwidth is specified in terms of the portion of the available digital bit stream required for its transmission, and that portion is set aside for the intended purpose. All kinds of signals can be handled and mixed, up to the limit of the bit rate employed. When this transmission capability is combined with a standardized interface that enables a customer to use the system in any manner he chooses, the system is truly transparent; it is then usually referred to as an Integrated Services Digital Network (ISDN).

Within limited distances, local area networks (LANs) link terminals of various kinds for voice, data, or video. Today, a LAN is likely to be limited to hardware of a particular brand, since there are competing LAN technologies. Trends suggest, however, that LANs will either be standardized or be interfaced with each other, and then will be linked to long-haul ISDNs.

The significance of these developments for NS/EP is not at all clear and may not extend beyond the considerations that have already been addressed. The subject requires continued attention, however, since both LANs and ISDNs are in their infancy as developing technologies.

c. Storage of Data. Some observers have suggested that reconstitution of service after a severe emergency will depend more on improvisation by experienced people than on advance planning. If this is true, several current trends are operating to make reconstitution more difficult.

- Electronics in the telephone plant contributes to a reduced level of manpower; there will be fewer people to participate in restoration efforts.

- Digital switching and signalling favor the use of master/slave relationships, with fewer and larger switching centers controlling a large number of satellite exchanges having only limited stand-alone capability.

- Records required for reconstitution of service over the entire area of one master switching center may be centralized and may not be duplicated at other locations.

These three factors taken together leave the exchange network for any given area vulnerable, and the records problem is symptomatic of the whole. Stated more broadly: Who, and how many, will have access to and know how to use the information that will be required to reconstitute service? In an information-driven society, the systems that exist to transfer information are themselves vulnerable to loss of information.

Within the NSTAC, steps are being taken to examine automated information processing (AIP), of which this is but a small part. Because the overall task is so large, it may be a long time before this effort leads to preventive steps in any particular part of the system. A direct approach to exchange carriers might be more effective, since this problem is simply stated and easily understood.

d. NS/EP Implications Summarized. Each of the following trends and strategies in the exchange carrier network and its environment have, or may have, NS/EP implications.

(1.) Alternative options for exchange distribution offer possible advantages for NS/EP. They include cable video, cellular radio, digital termination service (DTS), and possibly others. A systematic review of the possible advantages and disadvantages of each one will be appropriate after NS/EP needs in the exchange environment have been further defined.

(2.) The proliferation of private channels that bypass the facilities of exchange carriers implies greater flexibility and redundancy or diversity for NS/EP multiple routing, but possibly at the expense of interoperability. Protection against non-interoperability, if it can be secured at all, will come through efforts suggested elsewhere in this report, as part of a generic effort to achieve the greatest possible degree of compatibility in system designs. Opportunities for redundancy or diversity will depend on the locations reached by by-passing facilities. Plans and records should be established, possibly in conjunction with other NS/EP planning efforts, at the NCC, or elsewhere. This will be addressed further in conjunction with the general topic of managing in a multivendor environment.

(3.) Increased flexibility in the design of exchange carrier systems--in particular, the number and location of switching nodes and the dependence of satellite nodes on the "mother" switch-- is part of a generic opportunity and problem associated with distributed versus concentrated intelligence in the network, and will be addressed further. Each week that passes, however, is an opportunity lost to influence the design of exchange-carrier systems. Channels through which NS/EP needs can be made known must be identified quickly. The standards efforts of the ECSA offer one such channel which can be used immediately.

(4.) With digital facilities, and concurrently the inability of the network to carry signals in an analog mode, the period of greatest vulnerability may be during the transition from analog to digital facilities, and this will extend over a long period. Digital needs should, wherever possible, be met with digital facilities to encourage the shift and lessen the learning period of all who are involved in the provision of digital services. As digital facilities increase, provision should be made for standby conversion equipment that will enable these facilities to substitute for analog facilities furnishing analog services.

(5.) The use of separate channels for signaling--separate from the voice transmission path, as in the CCIS--suggests increased vulnerability. When NS/EP services are provided using such split facilities, the vulnerability of the signaling channel should be examined in detail and plans should be made for service restoral in cases of signaling failure. Some experience with such plans will suggest what routine precautions are appropriate in procurement [see also (3.) above].

(6.) The dependence of digital networks and equipment on a synchronized clock, and their ability to function if the master clock is lost require examination of the initiatives needed. The pattern will follow that of (5.) above. Again, if designs are to be influenced, time is of the essence.

(7.) The location of the first and last points of A/D and D/A conversion in the network are critical. Hybrid systems are the most vulnerable to difficulties in reconstitution after an emergency. Further attention will be given to this, but initially it appears desirable to insist that A/D-D/A conversions take place either in the same location as the switch or transmission hub, or in the terminal, and not at some intermediate point.

(8.) The presence of microprocessors within terminal hardware will provide the opportunity for full digital operation of the local loop. Again, a mix will cause a period of vulnerability, but opportunities to go to fully digital operations will probably reduce the period of mixed-plant use. Such opportunities should be taken, other things being equal.

(9.) The extension of fiber to the users' premises. Complete fiber loops will probably require digital operation all the way to the terminal location. This will be advantageous for NS/EP if the serving facilities are reasonably protected. [See (3.) and (4.) above.]

(10.) The gradual elimination of 48-volt line battery and 120-volt, 20-hertz signals for ringing as terminal equipment requiring only 5 to 10 volts comes into regular use. These higher voltages present a hazard to microcircuits, and their elimination should be encouraged after provisions have been made for restitution of digital systems so that there is no dependence upon older analog systems at a particular location. Lower voltages and small current requirements make simple battery standby power a simple expedient.

(11.) The rapid increase in local area networks among large users. LANs will offer convenient and economical data transmission, with great flexibility of physical arrangements. Most will have specialized applications, and are needed to ensure that they do not become isolated in emergency situations. The question will be: can particular transmission needs be met with reasonable trade-offs against NS/EP requirements in the early stages of digital network developments?

(12.) The introduction of ISDNs. ISDNs will bring opportunities for reliability and economy that are not yet fully understood. Once fully implemented, NS/EP considerations should be favorable, but the transition may be difficult. This subject deserves a great deal of further study before the NCS can be sure of how best to take advantage of the potential of ISDNs.

(13.) The concentration of records and of skilled manpower at a few large centers. Immediate action to assess this development is warranted, as centralized resources are economically attractive but potentially hazardous to NS/EP.

(14.) The rate of change in exchange carrier systems, which adds urgency to any effort to influence their design in the interest of NS/EP. The Committee is convinced that there is no time to lose. NS/EP considerations should be made known to the carriers, and to their regulators.

Funding options should be explored so as to mitigate the concerns of regulators already faced with cost increases for basic services. The United States Telephone Association (USTA) should be considered as a forum to address such questions.

C. State and Local Telecommunications

1. Background

The emergence of new telecommunications technologies and the deregulation of the communications industry present challenges and opportunities for state and local governments. State governments are expanding their involvement in telecommunications, going beyond their traditional regulatory functions, to encompass a broad set of public initiatives. State and local governments are not merely active users of telecommunications systems, but are increasingly involved in the development of new telecommunications systems. Rapid advances in electronic memory, transmission systems, and microprocessors are leading to the transformation of the state telecommunications infrastructure. The growing involvement of state and local governments in the design and management of telecommunications systems has important implications for national security and emergency preparedness situations.

The Committee sees three critical areas where state and local governments are influencing the development of public and private telecommunications systems.

a. State Operation and Use Of Telecommunications Systems. State and local governments are major users of voice and data networks. In addition, state education departments have traditionally exercised authority over extensive public television and radio networks. For example, it is estimated that the state of California and its local governments spend over $1 billion annually on telecommunications. A proposal is currently before the California State Senate to develop an integrated state telecommunications network for which $630 million per year savings are claimed.

New York State's Office of General Services currently operates 13 separate telecommunications systems which encompass more than 2.5 million miles of leased service. The New York State Police utilize microwave transmission systems operated by Eastern Microwave to transmit voice and data, bypassing New York Telephone. There is a growing tendency by states to design and build their own telecommunications systems. South Carolina is planning to build a state-owned microwave system that will cost $28 million and produce claimed savings of $100 million over the next two decades. Kansas is planning a statewide fiber-optic network that could serve up to half of all state telecommunications traffic. Iowa and Oregon are seeking bids for PBX nodes to link new fiber-optic trunks.

It is also important to recognize the prominent role of "911" in providing emergency services in most large metropolitan areas. Health care, criminal justice, and fire protection services are all linked to "911" systems in major cities. Further, local school districts frequently operate their own telecommunications systems, relying on the Instructional Television Fixed Service (ITFS)--usually FM, with allocation at 2500-2690 MHz--as well as other technologies.

The deregulation of the communications industry has led to substantial changes in how cities and states manage their telecommunications systems. Public agencies are aggressively seeking ways to reduce telecommunications costs, as the examples above indicate. States that formerly relied on the regional operating company are now building their own networks, bypassing the public telephone system.

Clearly, the widespread deployment of new telecommunications systems by the public sector must be considered in the design of NS/EP systems for the additional flexibility, diversity, redundancy, and basic system support that deployment could provide.

b. State Regulation of Telecommunications Services. The deregulation of the communications industry poses serious issues for state regulation and policymaking. State public service commissions are being faced with requests for large rate increases by the regional operating companies. Moreover, the principles underlying telecommunications regulations are no longer based on universal service but upon technological neutrality, changing definitions for assigning costs to services, and open entry for new carriers, while maintaining essential consumer services (e.g., "life-line service").

Several policy issues have arisen as a result of telecommunications deregulation at the federal level. The recently passed cable regulation law limits the scope of state intervention in the granting and renewal of cable television franchises. The increased competition which the regional operating companies face as a result of bypass technologies will have long-term consequences on the cost and level of telephone service available to consumers and small and medium-sized businesses. Finally, there are efforts to alter the institutional arrangements for regulating telecommunications in several states.

c. Telecommunications and Economic Development. Many state and local governments are attempting to develop a telecommunications infrastructure that could be used to retain and attract industry. The "teleport" concept--a satellite earthstation farm connected, probably by optical cable, to a major switching and distribution hub--that emerged out of the Teleport project in New York represents an example of the ways in which public sector agencies are trying to create new telecommunications facilities as means to keep and attract jobs at a regional level. At the present time, many state and regional agencies are examining the feasibility of teleports, but the only operating teleports are really "antenna farms" which are operated by private firms and which provide access to communications satellites. Several real-estate developers have proposed teleports to offer their tenants a value-added communications service.

One should not underestimate the investments by the regional operating companies in new telecommunications systems to serve large users in the nation's largest cities. NYNEX, for example, has installed an extensive fiber network in the New York metropolitan region which provides enormous capacity for voice, video, and data transmission. In Los Angeles, Pacific Telesis built a 360-mile, optical-fiber network for the 1984 Olympics that is now a major resource for business communications.

Several states are seeking to lease their rights-of-way for telecommunications systems. Railroad rights-of-way have been leased for several advanced fiber networks on an interstate basis; there is now an effort to lease rights of way on an intrastate basis. There is already such leasing of rights of way by the Metropolitan Boston Transit Authority.

Public-sector investment in new telecommunications systems as a means to attract economic development is untested and unproved. Given the intense private competition for telecommunications service, it is not clear whether the public sector needs to be supplementing current market initiatives. For many communities, telecommunications is perceived as a technological fix that can overcome other barriers to economic development. Despite this, the Committee expects an increased recognition by state and local governments of the need for some form of public involvement in telecommunications as a way to spur economic development.

The Committee concludes that the heightened public involvement at the state and local level in the development and management of telecommunications systems needs to be taken into account in national security and emergency preparedness communications. These new public communications systems constitute a potential resource which, we believe, must be included in planning and developing NS/EP telecommunications.

2. <u>The Interaction of State and Local Telecommunications with NS/EP Activities</u>

State and local emergency telecommunications agencies are remarkably disparate in their responses to emergency conditions. This is indicated in part by what they react to. For example, Mobile, Alabama reacts to hurricanes while St. Charles Parish, Louisiana reacts to chemical-plant accidents. Emergency planning is totally localized and independent, with responsible entities not wishing to integrate laterally or vertically with other organizations. The feeling at every level that upper levels of government should give money and resources but otherwise keep out helps prevent cooperation, coordination, and integration. Nowhere is there an awareness of the need for interoperability or interconnection, or of a wider NS/EP interest. This situation calls for direct, constructive action by the NCS and FEMA.

a. <u>NS/EP Awareness and National Purpose</u>. The predecessor committee endorsed the philosophy of "bottom up" recovery and reconstitution in its final report (See footnote, second report, page vi). This Committee also endorses that philosophy. The NCS and FEMA have made presentations to the Committee that also tend to support it.

The Committee has heard from six state and local government entities. It is convinced that the local entities (towns, parishes, counties, political subdivisions, and states) are capable of executing the actions necessary to reconstitute locally. The Committee thinks that these entities, with the help of volunteers such as amateur radio operators, have done remarkably well with the resources at their disposal. We find, however, a notable lack of purpose permeating the process. The federal government agencies have not extended their programs in the direction of "bottom up" reconstitution. Every federal program the Committee has examined has been designed to satisfy the federal agencies' "top down" requirements. As a result, the local entities have received little or no tangible benefit from federal program planning for NS/EP telecommunications. The NCS has recognized this in one of its charges to the Committee, seeking advice on alternative approaches such as the involvement of state and local telecommunications entities in the NS/EP process.

A national purpose must be recognized throughout the family of federal agencies so as to permit them to reorient their programs toward emphasizing those that will support the "bottom up" reconstitution process. Such programs may include the provision of hardware such as radio equipment and emergency generators. The Committee suggests a channel for provision of equipment through the Department of Defense to National Guard units. The National Guard is invariably employed during disasters and the equipment would be present and ready for use.

The Committee also suggests the establishment of procedures and policies that would enable the use of other resources not commonly brought into use during disasters. Radio spectrum, for one, is urgently required. For example, the Park Service mobile and fixed radio equipment and the radio spectrum it uses should be directed to the emergency coordinator for the period of the disaster. Use of Citizens' Band Channel 9 should be permitted to the emergency coordinator, with a restricted-use power amplifier for overcoming interference and assuring contact to citizens in their vehicles.

Many other resources involving personnel, spectrum, and hardware could be made available at the local level. The barrier that now exists at the federal level must be eliminated first. The Committee believes this must begin by the infusion of a national purpose, from which these other actions would flow.

b. Need for Federal and State Integration. The final report of the predessor committee pointed out the necessity for involving state and local governments in NS/EP planning. Based on data presented to us by FEMA and by representatives of six different state and local emergency management systems, the Committee believes that this recommendation is not being followed.

In a recently completed research project entitled "Community Response to Natural Hazard Warnings,"* the National Science Foundation (NSF) studied 22 sites which have optimal emergency management organizations. Those on which the Committee was given data are impressive in the extent not only of their planning, but also in the implementation of their plans: e.g., St. Charles Parish and contiguous parishes in Louisiana; the city and county of Denver; Mobile, Alabama; the state of Tennessee; and the Commonwealth of Pennsylvania.

The states and local communities have extensive resources in communications facilities, usually associated with their service agencies such as police, fire, public works, National Guard, and so on. The amateur radio network is both a local community and a national resource of major importance. Information from state and local authorities indicates that little or no integration exists among the various systems within a state or on a multi-state basis. It also indicates that such integration can be and is being accomplished on a local basis, driven by concerns peculiar to each local area.

To illustrate the problem the Committee cites one example. The "local" and quite understandable concern underlying the organization of the St. Charles Parish Department of Emergency Management is that of industrial accidents in the covered area's 26 major industries making many toxic substances and its nuclear reactor plant of Louisiana Power and Light Company. The big chemical plants have at least one large explosion per day. In the event of a chemical accident the available time for evacuation is only 10 minutes. In the event of a nuclear core meltdown there would be one hour. The 150-square-mile area has a resident population of 45,000 and 15,000 commuters. The area is criss-crossed by five major railroads, five major highways, and a river-boat channel. The major natural hazards are hurricanes and tornadoes.

The state of Louisiana has mandated that the area have a principal emergency operations center (EOC), but in Louisiana the state acts only as a support agent--it does not control operations. In St. Charles Parish, the EOC is operated by the Department of Emergency Management. Each major plant in the area has its own emergency task force. Exercises with industry are scheduled once per month and with all organizations once per year. The entities involved include schools (110 school buses), public works of the parish, National Guard, state police, Red Cross, the Sheriff's office, Coast Guard, boats on the river, 24 major plants, industrial parks, trucking systems, railroads, and the Louisiana Power and Light Company. Each operates relatively independently of the others, except for the municipal services that are coordinated by the EOC.

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*Carter, T. Michael, Leik, Robert K.; and Clark, John P.: Community Response to Natural Hazard Warnings; University of Minnesota, ~~July,~~ 1981.

In general the states have neither the organizational structure nor the technical expertise to initiate and maintain systems that integrate the many separate telecommunication facilities they own or which are within the state boundaries. Many of the organizations that come under the jurisdiction of NCS for NS/EP planning do have this competence; e.g., DOD, GSA, and perhaps FEMA. The Committee feels that the federal government could be of value to state and local organizations for their emergency planning by holding seminars on good communications and good management practices. In particular, the NCS and FEMA should stimulate integration of planning and exercising among emergency preparedness organizations among the local organizations within each state, and regionally among states. As an example, the local entities are required to support disaster recovery using locally franchised transportation (e.g., bus) resources and equipment. These resources and equipment need to be managed to permit sharing across jurisdictional lines in emergency situations. That may require that they be supplemented, possibly with federal aid, in a way that will permit system-wide integration. Such integration will require planners from the bottom up and from the top down to work together to ensure interoperability and interface capability on both sides. Thus, the Committee recommends that the NCS initiate actions to ensure that all new federal systems implemented should be made to interface and interoperate with in-place local systems.

c. The Role of FEMA. FEMA's charter is to support state and local governments in the fulfillment of their emergency planning, preparedness, mitigation, response, and recovery responsibilities. As necessary, the agency provides funding, technical assistance, services, supplies, equipment, and direct federal support. Its Fiscal Year (FY) 1984 budget was about $1 billion, with $169 million for civil defense, which includes emergency management assistance. That increased to $181 million in FY 1985, but has been reduced to 119 million for FY 1986. It is possible that the Congress will increase the $119 million to $141 million, but that still presents FEMA and the state and local entities with a decrease of $40 million for FY 86.

FEMA has a staff of 2,500, of whom 1,500 are in Washington.

FEMA furnishes active assistance in an emergency situation only when local and state officials decide a situation is beyond their capabilities and an affected governor requests help from the President. The latter must declare an emergency or major disaster, whereupon FEMA evaluates the damage and requirements for supplemental federal assistance and makes a recommendation to the President. If approved, it then establishes one or more disaster assistance centers in the affected area, providing a central location for aid agencies.

The Deputy Manager, NCS, has told the Committee that the NCS does not have a role in state or local telecommunications but works through FEMA, and that FEMA's assets constitute a part of the NCS picture. In turn, FEMA has no jurisdictional authority over state operations and so has to work through the local bodies in striving to achieve coordination.

There is, however, an organization, the National Governors Association (NGA), whose Office of State Services has published documents addressing comprehensive emergency management (CEM) in substantial detail from the state and local government viewpoint. Its Bulletin #1 was published in April 1982 based on data from 43 state emergency offices (SEOs). The NGA policy statements indicate that the state's role is to develop and maintain a program of emergency management that supplements and provides leadership when needed, to local effort before, during, and after emergencies. States also cooperate at multi-state levels when appropriate and are responsible for requesting supplemental federal assistance for major emergencies. Much of the above information is contained in a contract report for FEMA by Computer Sciences Corporation.*

Based on the data presented to the Committee so far, there does not appear to be any attempt at state levels to integrate the communication facilities within states, nor is there any clear indication that the states are involved in, or perhaps even aware of, the NS/EP program of the NCS.

FEMA has provided and continues to provide financial support to the states for their emergency planning and operations, but it needs to provide tangible support in other ways. As to forms of such support, state and local entities would welcome briefings or other information activities, coordination and perhaps cooperation in planning activities, and training services. FEMA and the NCS should work together on such support activities. These could facilitate integration of facilities and future planning to incorporate NS/EP capabilities in state and local systems.

In 1982 the President acted on the need to have a National Security Telecommunications Advisory Committee (NSTAC) comprising chief executives who control the design, manufacture, and operations of communication facilities. As a mechanism for integrating state and local systems into NS/EP telecommunications, the Committee feels that an equally important advisory committee should be established comprising those who wield state executive power at a high level and representative of the 50 state governors. It is quite possible, even probable, that the executive branches of the various states do not appreciate the relevance of discussions on telecommunications policy to the real and immediate problems that a major attack would generate. Accordingly, a possible planning approach would be to identify the hierarchy of needs that would exist in a post-attack environment and show their tremendous dependence on (state and local) communications capability.

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* An Overview of State and Local Emergency Mangement Operations and Information Resources Requirements. Computer Sciences Corporation, March 1984.

The Committee recommends that a new advisory committee representative of the 50 state governors be established similar to NSTAC. Presidential help would seem to be essential in any case.

d. Planning Information at the State and Local Levels. All planning on survivability, endurability, and reconstitution of telecommunications facilities or the power grid is for the purpose of having telecommunications resources available to help restore the post-attack or post-disaster situation to normal. What is the situation that needs reconstituting? Individual or household level needs would include protection from fire, looting, and nuclear contamination; water; food; shelter; medical services; transportation; and electric power. At the community level these requirements convert into city and county police, sheriff, state police, firemen, National Guard; water supply systems; sources of food (e.g., warehouses and granaries); shelter in armories, schools, hotels or motels; hospitals and ambulances; transportation systems (e.g., bus, truck, and train); and electrical power supply.

To deal with any category listed above, whether state, city, or county, local administrations first require information regarding the extent and severity of the problems they are facing. This can come to them by personal observations, by word of mouth, or by some form of telecommunication. The next step enabling administrators to take necessary action is strongly dependent on communications capability such as telephone, radio, or mobile radio for issuing instructions and orders. In most cases the telephone systems fail first.

A concomitant requirement for necessary useful action is that the administrator have access to a great deal of information regarding quantity and location of food and fuel resources, persons in charge, their locations, and back-up. There can also be a developed hierarchy of equipment values for emergency conditions. In communications these would include battery-operated radios, amateur radios with their own power supplies, mobile radios in cars or trucks, and engine-driven power supplies. Transportation would include earth-moving machinery such as bulldozers, four-wheel-drive vechicles (e.g., jeeps and trucks), and any off-the-road vehicles.

Planning must be done for these conditions, and the information stored in diverse places in hard-copy form. Similarly, lines of authority and alternates for each functional area should be spelled out and stored, again in many places.

On the whole, the Committee was left with the impression that what is being done at state and local levels fundamentally comprises local or intrastate activities with little in the way of national or even, in many cases, statewide coordination to ensure interoperability and cooperation. In the event of a national emergency, or indeed of a devastating local disaster, wherein most normal lines of communication to the rest of the nation are destroyed, the citizenry and emergency officials for the most part would be caught without any formalized system of contact.

e. National Planning and Regulatory Matters. A review of the regulations of the Federal Communications Commission (FCC) indicates that while certain parts of the spectrum are currently set aside for public safety services, some areas of the country have already made use of all of this spectrum, and there is no assurance in any event that all states would be operating on the same frequencies for the same purposes. The staff of the FCC has told the Committee that on most radio questions they deal with individual states, and there has been no overall attempt to advocate a national emergency communications policy other than authorizing the Emergency Broadcasting System (EBS) at the FCC. Indeed, although the Nuclear Regulatory Commission (NRC) has passed regulations requiring that the nuclear power industry install alarm systems over the area within 12 to 14 miles of a nuclear plant, neither the NRC nor the industry has come to the FCC seeking additional spectrum or advocating interconnecting or at least interoperable systems from one plant site to another or to adjoining states. There is some feeling at the FCC that this situation may change following the Union Carbide incident in India. The subsequent attention given to Union Carbide's similar plant at Institute, West Virginia, strengthens this expectation.

This, of course, has been the history of emergency communications--reaction after catastrophe.

The Committee strongly recommends that a national policy be adopted mandating interconnection and interoperability of emergency communications systems nationwide. Probably the first steps are to catalog all existing systems and emergency management teams across the country and then examine spectrum issues and overall control in the event of disasters at the local, state, regional, or national levels. One group has been identified which has a goal to foster this planning: the Association of Public Communications Officers (APCO). It is but one of many similar organizations, and public safety officers tend to belong to a number of them. However, this is the only one the Committee knows of that is specifically oriented toward communications specialists. They have as their objectives to:

> "Foster the development and progress of the art of public safety communications by means of research, planning, training, and education; promote cooperation between towns, cities, counties, states, and federal public safety agencies in the area of communications; represent its members before communications regulatory agencies and policy making bodies as may be appropriate, and through its efforts strive toward the end that the safety of human life, the protection of property , and the civic welfare benefit to the utmost degree.
>
> "Aid and assist in the rapid and accurate collection, exchange and dissemination of information relating to emergencies and other vital public safety functions."

APCO last did a study, "A Review and Assessment of Telecommunications Planning in the 50 State Planning Agencies" in November 1975. The study was funded by a grant from the Law Enforcement Assistance

Administration and seems to be the last extant catalog of existing emergency systems. APCO has also developed a Public Safety Communications Standard Operating Procedures Manual which would seem a key element in any national scheme. Another project has been Planning Guidelines for Law Enforcement Telecommunications Systems with a follow-on, Previews and Assessment of Telecommunications Planning in the 50 State Planning Agencies. While the Committee cannot speak at this date about their quality or comprehensiveness, these studies would appear to comprise a good starting reference.

The Committee urges that some one organization be identified or established to work on a nationwide basis to coordinate spectrum needs, equipment standards, and practice planning of all existing emergency communications systems and to identify areas where no, or inadequate, provision has been made for such systems. This organization could also be charged with following activities at relevant regulatory agencies such as the FCC to comment upon proposals and to advocate policy aimed at emergency preparedness. However, we reserve judgment on how best to address these responsibilities until our final report . As an example of the problem, a presentation has recently been made to the FCC to allow the automatic interconnection of AM radio stations across the country by means of a newly invented switching device. A unified approach toward analyzing such a proposal from the standpoint of its feasibility from state to state and its development under uniform standards and perhaps with federal funding would seem desirable, to say nothing of advocating prompt FCC attention to its resolution.

The Committee understands FCC policy towards NS/EP telecommunications to be to react to the input of those officially charged with implementing national security and emergency preparednes measures and not to analyze such issues on its own. Clearly an ombudsman with a national emergency-preparedness mandate is needed. The Committee feels that the NCS should be more active in bringing such issues before the FCC, with appropriate support from NCS principals.

f. Integrated State NS/EP Networks. Some states have conducted studies showing that state-owned and -operated systems would be cost-effective over their life cycles (e.g., state of Arkansas, December 31, 1983). As a result, some states have already moved to implement state-owned and -operated systems (e.g., South Carolina; Montana is conducting a study). These are supplementary to the existing telephone systems and are substitutes for special construction performed by the carriers.

The Committee recommends that the NCS proceed now to involve the states in the NS/EP process to permit them to consider aspects of cost as well as interoperability early in their planning. The Committee reiterates its recommendation of sections c and e, and recommends that the NCS take the initiative to bring them about and establish coordinating mechanisms with the new organizations.

The Committee assumes that all of the national resources including state networks are candidates for inclusion in NS/EP planning. Preparation of such a plan within a state or among states is a major problem. State entities do not have experience with such large-scale planning nor with operating systems of such a magnitude and complexity. A suggested starting point in the process may be series of briefings given by the NCS to the appropriate state entities and representatives. As recommended earlier, a "State NS/EP Advisory Committee" cognate to the NSTAC may be the best beginning. A candidate initial topic for such an NCS initiative might be the National Emergency Telecommunications System (NETS), its objectives, and its architecture. State entities could be included in the new NCS initiative covering the development of an advanced systems management architecture and the emerging evolutionary telecommunications architecture. This would permit the states to include this emergent technology in their systems designs.

g. State Concerns. One critical element that affects both the cost in place and the annual operating costs of a system is the physical configuration of the supporting transmission plant. Some states have very difficult problems to design against, such as high tornado incidence, difficult terrain, or severe weather extremes. Solutions to these problems tend to coincide with solutions to NS/EP design criteria.

Local and state governments have shown that they are quite capable of planning for the emergencies they have been exposed to. They routinely exercise and execute their plans with great success. In the opinion of this Committee, however, they are totally out of their element when the new dimension of NS/EP is applied. Thus, it is not surprising that states planning to configure a state-owned and -operated system would ignore NS/EP factors. However, there are considerations that can work to favor NS/EP if these factors be known to the states. If applied, a number of generic design factors common to NS/EP, as well as other drivers could make state networks valuable national NS/EP assets. Because of classical funding constraints at the state level, their funds would probably need to be supplemented to achieve these goals.

In many cases the actual transmission equipment costs are overshadowed by the cost of the land involved. This may be a very high-cost item where cable transmission is concerned. State taxpayers' funds may be difficult to justify for a "hard" system without consideration of national need and would likely result in the construction of "soft" systems. NS/EP considerations could lead to commingling of projects between the states and other government agencies, thereby supplementing state funds. Examples of the potential for formal NS/EP initiatives which could assist states in their planning are FEMA commingling and the rights-of-way issues.

(1.) FEMA Commingling. FEMA has underground facilities in some states. These need to be interconnected with comparable state facilities and facilities planning needs to be coordinated at an early stage. In at least one state, Arkansas, the state and FEMA found, in time to obviate the duplicate construction, that they had planned to put in fiber-optic cable along identical routes to the same places. A policy of early coordination of its facilities planning with the states would greatly enhance FEMA's effectiveness in achieving national awareness, and even integration, of emergency planning and operations.

A commingling of the FEMA and state projects seems highly desirable. The aims of the two coincide in many key aspects. Two of those are:

- Cost Savings: the routes involved in many cases are identical. Therefore, suitable transmission construction can be made to meet the needs of the states and FEMA at a large saving to both. Or, considering the scope of funds anticipated, commingling could allow far more capability and resource sharing.

- Rights of Way: commingling the state and FEMA projects can strengthen the requirement for interstate highway right-of-way usage. In most cases, the FEMA site is located in an area that is most easily reached via an interstate highway.

The result of such combined planning and engineering would be a system capable of providing increased survivability and reconstitutability of communications among key elements of the federal and state governments to support continuity of government and other essential functions.

(2.) Federal Contribution. In addition to the early coordination of planning activities initiated by a new FEMA policy, the federal contribution to commingling resources could take two forms:

- Cash Contribution: this could be direct cash contribution for the proportionate share of state engineering studies applicable to shared state and NS/EP services, as well as final system installation and cutover. In addition, the federal government could contribute via grants in aid to construction of specific facilities such as a hardened network control center.

- Cash Offsets: the cash value of rights of way provided by the federal government may be considered as net cost-in-place reductions to the total end-to-end state network.

h. Future Action. To be able to anticipate the future of NS/EP at both the federal and state level, it is necessary to consider the interaction of past, present, and future events and trends, together with their impacts, from the national perspective. A number of alternate scenarios should be developed by the NCS and made available to the states. These scenarios should be evolved by varying the assumptions concerning the interactions of events and trends. The Committee considers this future-oriented systems approach necessary to the integration of state and local telecommunication systems into the NS/EP complex. Action plans may then be developed which facilitate the objectives of NS/EP.

NS/EP needs to be managed on a national scale, with the role of the states a major factor. The NCS needs to take the initiative together with FEMA. The states have neither the resources nor the expertise to initiate and conduct efforts of this level of sophistication and complexity. Federal guidance and support are essential for state and local telecommunications resources to be incorporated into the NS/EP complex.

APPENDIX

GLOSSARY OF ACRONYMS

A/D	Analog-to-Digital
AIP	Automation Information Processing
ANSI	American National Standards Institute
APCO	Association of Public Communication Officers
ARINC	Aeronautical Radio, Inc.
BOCs	Bell Operating Companies
CALC	Customer Access Line Charge
CATV	Cable Television
CCIS	Common Channel Interoffice Signalling
CCITT	International Consultative Committee on Telegraphy and Telephony
CCLC	Carrier Common-Line Charge
CEM	Comprehensive Emergency Management
CI-II	Computer Inquiry
CMOS	Complementary Metal Oxide Semiconductor
CPE	Customer Premises Equipment
CRT	Cathode-ray Tube
D/A	Digital-to-Analog
DTS	Digital Termination Service
EBS	Emergency Broadcast System
ECSA	Exchange Carriers Standards Association
EMP	Electromagnetic Pulse (Note: Also referred to as Emergency Management Preparedness)
EOC	Emergency Operations Center
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
GaAs	Gallium Arsenide
ICs	Integrated Circuits
ISDNs	Integrated Services Digital Networks
ITFS	Instructional Television Fixed Service
LANs	Local Area Networks
LATA	Local Access and Transport Area
LCD	Liquid Crystal Display
NBS	National Bureau of Standards
NCC	National Coordination Center
NCS	National Communications System
NETS	National Emergency Telecommunications System
NGA	National Governors Association
NMOS	Negative Charge Carrier Metal Oxide Semiconductor
NRC	Nuclear Regulatory Commission
NS/EP	National Security/Emergency Preparedness
NSDD-47	National Security Decision Directive Number 47
NSDD-97	National Security Decision Directive Number 97

NSTAC	National Security Telecommunications Advisory Committee
NTIA	National Telecommunications and Information Administration
NTS	Non-traffic-sensitive
OSI	Open Systems Interconnection
PBXs	Private Branch Exchanges
POP	Point of Presence
PSN	Public Switched Network
r-f	Radio-frequency
RBOCs	Regional Bell Operating Companies
SEO	State Emergency Office
SNA	System Network Architecture
SOPs	Standard Operating Procedures
STS	Shared Tenant Services
USTA	United States Telephone Association
VLSI	Very Large Scale Integration (or Integrated)