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The Policy Planning Environment for National Security Telecommunications

Final 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 (U.S.).

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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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BOARD ON TELECOMMUNICATIONS-COMPUTER APPLICATIONS

PREFACE

This is the final 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 over the period from March 24, 1984 to December 17, 1985, leading to this final report. This report follows the Committee's Annual Report, issued in April 1985 and having the same title. 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 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, 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.

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 51 briefings spread through seven of its eight quarterly meetings, the eighth being devoted to drafting this report, and has divided into subcommittees that have each pursued a particular area of concern through meetings and exchanges of discussion papers. The 51 briefings comprised 19 from federal government officials, 13 from state and local emergency management/telecommunications officials, 16 from executives of communications and information industries, and three from executives of telephone industry associations. Sixty-nine review and reference 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 and the study director 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. With Committee approval, the Director accepted the invitation of the President of the National Emergency Management Association (NEMA) to address the NEMA annual meeting in March, 1985 on national security telecommunications and the background of the Committee's study. 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 continued 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 G. Grimes, formerly Deputy Manager, NCS and now Director, National Security Telecommunications, National Security Council; Mr. B. E. Morriss, Deputy Manager, NCS; and Mr. A. L. Henrichsen, Chief, Government Activities, NCS Joint Secretariat.

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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.

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

* Dr. Baird died on May 23, 1986, one month after his review and approval of this report for submission to the Research Council report review process.

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 Communications System (NCS) must plan for an effective national security/emergency preparedness (NSEP) telecommunications structure that can respond to the changes taking place. To support this effort the Committee 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 NSEP 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' short- and long-term corporate strategies and will advise the NCS on their implications for NSEP telecommunications capabilities and policy. It will review NCS evolutionary planning with industry to meet NSEP 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: May 1984

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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. The 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. The Federal Emergency Management Agency (FEMA) has responsibility for helping to support emergency planning by state and local entities under NSDD-47.

This report of the Committee on National Security Telecommunications Policy Planning Environment is the final report of its nearly two years 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 been joined in the competitive area by IBM. With its recent exchange of Satellite Business Systems (SBS) for a 16 percent share of MCI, IBM may now be regarded as a provider of computer/communications, satellite, and terrestrial long-distance services. United Telecommunications and Contel also provide such services. United and GTE's satellite and terrestrial long-distance services are undergoing a merger in which both companies will share approximately equally. Satellite long-distance services are also provided by such other independent competitors as 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 (NSEP) 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 uncertanties pervades all Committee deliberations.

In performing this study the Committee has focused on domestic, civil telecommunications. As its Statement of Task (page viii) 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.

This report is divided into three main sections. The remainder of Section I states the boundary conditions and assumptions that the Committee thinks are appropriate for the NCS to consider in planning its future. Assumptions are set forth that the Committee considers realistic about the threat scenarios, including the time scale of possible NCS responses to various disasters. These are followed by assumptions about the future structure of the telecommunications industry and the technologies it will produce. In Section II, Committee findings and recommendations are presented. These represent the view the Committee thinks the

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*See page vi

NCS should take of its own mission, the technologies that will be at hand to help it carry out its mission, and the organizational and jurisdictional problems that will have to be dealt with. Section III gives the supporting detailed considerations that led the Committee to state the specific findings and recommendations given in Section II.

A. NSEP Threat Models

As in its Annual Report, the Committee distinguishes three levels or types 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": "islands of disaster," larger and more devastated than in Threat Model 1 but still within a functioning national structure. However, 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 to surviving areas surrounding the "islands", 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 transportation facilities leading out of the damaged communities will probably be crowded to the point of impassability, and lines of communications 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. Here the aftermath will leave islands of survival in a devastated land without a national telecommunications structure rather than islands of disaster within a functioning structure. In this third case, NCS responsibility for restoration and reconstitution of communications services is understood to apply in the post-attack period -- starting with the immediate post-event period, as discussed in I.B.2. It is the Committee's view that the level of disruption and destructruction 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 National Governors' Association has defined four phases of comprehensive emergency management as 1. Mitigation, 2. Preparedness, 3. Response, and 4. Recovery. The Committee will adopt those terms.

MITIGATION. This phase includes activities that eliminate or reduce the probability of occurrence of a disaster and activities that reduce the effects of unavoidable disasters. We would include in this phase the hardening or burying of critical communications facilities, and designs to minimize the effects of the various nuclear radiations on communications equipment. In the present, highly competitive environment the NCS cannot expect commercial organizations to meet such critical NSEP needs without some financial incentive.

PREPAREDNESS. The major activity in this phase is planning. It is here that the NCS plays a major role. Important activities are training, emergency exercises, resource inventories, emergency contact lists, mutual assistance agreements, and, very importantly, the establishment of standard operating procedures for anticipated emergencies. It may also be necessary in this phase to get changes in existing laws or regulations where there are currently barriers to needed operations in emergency situations.

RESPONSE. We divide this phase into two parts:

1. IMMEDIATE PRE-EVENT PERIOD. If it exists, this period will be measured in minutes or perhaps hours, depending on the event. The communities in New York and Connecticut hit by the Atlantic hurricane Gloria in September 1985 had a full day to prepare. In contrast the earthquake which damaged Mexico City that same month gave no warning, although the area was known to be prone to quakes. In cases where warning is given, preplanned actions can be taken to improve the effectiveness of surviving communications capability.

2. IMMEDIATE POST-EVENT PERIOD. This is the period of reaction to make the best use of what is available. Where control or coordinating centers exist and survive, they can begin immediately to take actions to control communications traffic and make routing changes to maximize the effectiveness of facilities that remain in operation. This has been a characteristic of the planning and operation of the telephone industry and has proved very effective in limited disasters. To be effective plans must be firmly in place, with all participants well trained for action.

RECOVERY. This is the period of reconstruction which begins as soon as the situation permits. Depending on the scale of the event, supplies, equipment, and personnel can be moved to affected areas to begin the process of restoring vital operations. It is important to have as much information as possible in the hands of people at the lower levels of operation prior to the event to increase their effectiveness, in case they must enter the recovery period with little help from a central agency. Standard operating procedures in place for such situations prior to the event should have a high priority.

C. Assumptions About Industry Capabilities by the Year 2000

In its Annual Report, dated May 1985, the Committee indicated its intention to develop assumptions about the likely nature and structure of national telecommunications capabilities in the year 2000 and to use those assumptions in developing a final set of recommendations. The purpose of this section is to state the assumptions that have emerged during our consideration of the rapidly changing telecommunications structure in the United States.

1. Telecommunications Industry Structure

a. Deregulation of the intercity telecommunications providers will essentially be complete. Competitive forces will be the dominant factor in determining what services are available to the NSEP community.

b. There will be a few (perhaps three) nationwide service providers that provide all types of service to all customers, including message switching (voice and data), private lines and networks, specialized or enhanced services of the software-defined network (SDN) or integrated services digital network (ISDN) type, and video and/or other wideband data services.

c. There will be a much larger number of regional or specialized service providers whose offerings are targeted at particular market segments. Examples are:

- Particular market segments
  - Residential and business long-distance calling
  - Large corporate users (private networks, ISDN and WATS-like services)
  - Large-scale information providers
  - Government

- Particular industry segments
  - Travel and lodging
  - Financial
  - Entertainment
  - News media
  - Manufacturing
  - Retail sales

- Particular technologies
  - Satellite
  - Optical fiber
  - Mobile/paging/position location

These would all represent "niche" strategies. They may proliferate rapidly. Success will come to those who know their customers' needs and will cater to customers by providing high-quality services tailored to their needs and having reasonable prices -- not necessarily the cheapest.

d. Deregulation will come much more slowly in the local-exchange service areas. There will be some movement towards deregulation, but at a very uneven pace among the various state regulatory authorities. However, there will be increasing competition from alternative suppliers and user bypass activity. Again, the extent of this competitive activity will vary from state to state depending upon the attitudes of the various state regulatory bodies and legislatures. Thus, local service will probably still have many of the characteristics of the regulated-monopoly form of industry structure.

e. There will be some companies that offer to provide telecommunications management services, including end-to-end service responsibility, for large government and industry users. They may be either service providers (i.e., common carriers) or companies that provide only management services and that thereby claim impartiality.

2. Telecommunications Capabilities

a. High-quality digital transmission will be plentiful. An extensive network of fiber-optic cable will interconnect all major population areas. Single-mode fiber will dominate the intercity area and the electronics will be operating at speeds well above 1 gigabit per second. Satellite and digital microwave will provide "thin-route" access and egress to the major fiber routes.

b. Satellite transmission will be dominant in broadcast applications and in those situations where rapid extension of communications capabilities into unserved or inadequately served areas is needed. Mobile services in lightly populated areas, nation-wide paging connectivity, and position-location services will also be provided, largely by satellite. On-board message switching synchronized with electronically hopped spot beams, very-small-aperture antennas for two-way communications applications, cross-linked satellites, higher power K_u- and early K_a-band satellite technology will keep satellite service highly competitive with terrestrial fiber-optic systems for thin routes and for many network applications.

Contrary to widespread popular belief, the proliferation of optical fiber will not ease the radio-frequency congestion problem. There will continue to be such a heavy demand for frequencies that the

NCS will need to have the most effective possible mechanism for satisfying needs for NSEP channels. Better mechanisms than are now available will have to be devised.

c. Integrated Services Digital Network (ISDN) service, in which the connectivity of a slowly evolving hardware facility can be redefined rapidly by program reloads of network configuration/control software, will be available nationwide, and international connectivity to Western Europe, Japan and other developed countries will exist. There will be several companies supplying such service, particularly to interconnect Local Access and Transport Areas (LATAs) but also likely intraLATA. ISDN standards will tend to dominate interoperability issues.

d. The number of toll switching centers in the major nationwide service providers' networks will be greatly reduced as switching machines become much more capable and transmission becomes more plentiful, less expensive, and more highly concentrated in the major fiber routes. As interconnectivity among these switching centers increases, the familiar hierarchical routing scheme will give way to non-hierarchical routing concepts. There will be a concomitant increase in concentration of network data bases required to provide the many special services offered to the network users.

e. Much more reliable, digital, solid-state subsystems, together with greater use of more sophisticated automation in network and facility control activities, will continue the long-term trend of further reductions in the operations and maintenance work force.

f. The present variegation of local-area networks (LANs) will continue indefinitely. Systems based on augmenting PBX functions, computer-based systems using rings or buses, and cable television (CATV)-based systems will continue to flourish independently. Attempts to standardize on one LAN architecture will continue to fail. However, pressures to standardize on interLAN interfaces will succeed, with emphasis on an ISDN-based solution.

g. With the widespread, continuing growth of optical-fiber networks, transmission capacity will be more than adequate and transmission costs will drop. Interconnection among fiber-optic networks may offer great, additional redundancy for NSEP telecommunications purposes.

D. State and Local Involvement in NSEP Telecommunications

The presentations heard by the Committee from state and local agencies indicated strongly that the state and local agencies have focused on local and regional problems only. Historically, they have been given to believe by Federal agencies that national problems are beyond their purview and also beyond their authority. Thus it is not surprising that they have not been made a part of the NSEP planning process. Virtually all NSEP planning has been and is being done by the Office of the Manager, NCS (OMNCS), with participation of such NCS member agencies as the Federal Emergency Management Agency (FEMA). This governmental "top-down" approach has appeared logical because the main responsibility of the NCS is to provide critical communications services to support leadership functions of the Federal government.

The predecessor committee recognized, however, that the means to communicate from the top down to outlying areas will not be available after a nuclear disaster. This Committee firmly concurs in that conclusion. It is therefore clear to us that a reconstitution plan based on top-down reconstruction alone will not work. On the other hand, the state and local agencies have shown time and time again that each can and will reconstitute from the bottom up, but each only for its own mission. The Committee feels that resources at state and local levels are now organized and managed effectively within the capabilities of those entities' resources to cope with the emergencies for which state and local emergency management agencies have responsibility. Some of those emergencies may be nearly as severe as those expected after a nuclear attack. State and local entities, however, appear to the Committee to be prevented by Federal regulations from using certain resources that should be available to them when they need them most to support emergency and recovery operations; but those resources are not incorporated into NSEP planning. For example, Federally sanctioned use of National Guard facilities and/or units, and the use of CB channel 9 might well make emergency operations more effective.

The Committee views the results of domestic nuclear disaster, for example, a nuclear facility explosion, as having characteristics similar to those of limited nuclear strike. Accordingly, reconstitution efforts should be modeled upon those advocated for Threat Model 2.

For these reasons the Committee strongly reasserts its support for the bottom-up concept of reconstitution. All meaningful planning for reconstitution at the national level should begin from that premise. We consider this issue so important that this Final Report of our work places it first in the sequence of topics the Committee was asked to consider.

II. FINDINGS AND RECOMMENDATIONS

A. Change in Management Focus of the National Communications System

The NCS has the unenviable responsibility of developing the architecture for and managing the response of telecommunications operations and recovery over a very wide spectrum of emergency conditions. The traditional view of these responsibilities is that if the emergency is localized and of low level of severity, then the matter of immediate recovery is one for state and local jurisdictions; Federal management of the recovery scenarios is appropriate at the high end of the disaster spectrum.

The Committee feels that a proper examination of Threat Model 3, given in Chapter I, leads to a somewhat different conclusion. This is that at the highest levels of severity of disaster, Federal action probably cannot be effective at all. State and local organizations will be in only a slightly better position to coordinate recovery.

The recovery of telecommunications (as well as other resources) will be a bottom-up process. Leadership will fall to individuals having no preplanned leadership responsibility. Resources for communications recovery will be found in those places that happen to have survived. Lines of communication that will be most effective will have little to do with any known or preplanned picture of a national network. And the technologies that will be most effective in the process are likely to be "low-tech," such as amateur radio, CB and other forms of mobile communication, and commercial broadcast facilities.

Severe damage levels will occur not only in nuclear-war-related situations, but as well in situations of severe natural disaster: the Mt. St. Helens eruption and severe earthquakes are two examples. In all of these restoration of service and reconstitution of facilities depend heavily on the preparedness of the local entities and population. Local "bottom up" recovery procedures and "low-technology" solutions, which hold the key to such situations, need to be developed in this light. Such procedures and solutions will depend heavily on interoperability of Federal, state, and local telecommunications facilities.

1. Bottom-up Recovery

The Committee has concluded that it is essential for Federal planners to endorse as a matter of policy the principle that recovery and reconstitution of services begin at the lowest levels.

We recommend that all emergency-planning documents for NSEP telecommunications incorporate a policy statement to this effect. In light of such a policy statement, we further recommend that all emergency-planning documents be drawn implementing it.

2. Federal, State and Local Interoperability

The Committee has concluded that there should be Federal policies that encourage or require radio communications equipment employed by state and local agencies to incorporate provision for immediate activation of emergency communication channels. These emergency channels should reach several other agencies with which emergency cooperation is important. We feel that Federal leadership is necessary since frequency assignments are now specific to each agency, and equipment for each that supports only those specific assignments forecloses interagency communication and cooperation under emergency conditions.

B. State and Local Participation in NSEP Planning

In its Annual Report the Committee made a number of recommendations that, in effect, could be gathered into a "program plan" for bottom-up restoration (see pp. 12-13). Many of these recognized FEMA's responsibility for supporting state and local emergency telecommunications, and were accordingly based on joint effort by the OMNCS and FEMA. FEMA has no jurisdictional authority over state or local entities, but because of its involvement in state and local activities the Committee recommends that it be charged officially with the responsibility for achieving state and local coordination with the NSEP telecommunications program. We recommend that the mandate for this responsibility be spelled out in initiative form, much as the predecessor committee recommended for using the NSTAC as an NSEP telecommunications resource. The Committee recommends the set of initiatives to be found in III A-1, pp. 24-25.

The Committee indicated in its Annual Report that it has seen positive evidence of the dedication and resourcefulness of state and local entities. Some state and local entities have made interesting technical innovations to overcome some of the restrictions imposed by federal agencies. They have been able to overcome frequency assignment problems, for example, by use of frequency-agile receiving equipment (scanners). This has led to the resolution of some problems that the frequency-allocation system has created or been unable to solve.

Local entities are capable of planning, testing and executing actions necessary to reconstitute communications, given the availability of resources. Spectrum and hardware are the chief resource limitations preventing the increased effectiveness of local disaster-planning integration. There is no plan in existence that recognizes the overriding precedence of recovery from a disaster. The spectrum available to the state and local entities, and as a result the hardware to use it, is the same as that in use during business as usual. To make matters worse, there is no Federal agency recognition of any permissive use of spectrum outside formal, nonemergency allocations during an emergency in the interest of saving lives, let alone for recovery and reconstitution.

1. A Program Plan for Bottom-Up Restoration

● Our recommendations from the Annual Report begin with the establishment of a governors' Presidential advisory committee, cognate to the NSTAC and with similar liaison to the President, comprising all 50 governors or their designates. Based on a joint initiative of the OMNCS and FEMA, the NCS Committee of Principal should recommend this to the National Security Council. The OMNCS and FEMA should propose this. The Committee suggests the National Governors Association (NGA) as an appropriate organization: there is no need to invent one. The NGA should accept the responsibility although it may wish to designate the National Emergency Management Association to represent it.

● The Committee considers this step an essential component of a program plan to achieve state and local participation in NSEP telecommunications. With it, the program that could be assembled from recommendations in our Annual Report follows.

With FEMA, the OMNCS should:

- Promulgate an NSEP "national purpose" among Federal agencies, promoting reorientation of (their) NSEP programs toward bottom-up restoration and reconstitution.

- Develop a series of NSEP scenarios that FEMA would present to state and local entities in seminars. The presentations would generate awareness of Federal NSEP programs, and in the seminars the state and local entities could discuss approaches to integrated emergency telecommunications planning, practices, and management with FEMA and with one another.

- Propose NSEP requirements to the FCC for interconnection and interoperability of new Federal telecommunications systems with state, local, or regional systems. More broadly, not restricted to state and local involvement but certainly including it, such proposals could also encompass interconnection and interoperability with non-carrier, private systems.

- Catalog all existing state and local systems and emergency management teams.

- Examine spectrum issues and overall control at all levels, in order to

- Initiate Federal planning with state and local participation. Such planning should involve resources not normally assigned NSEP responsibilities, such as the National Guard, and should stimulate new programs to make radio and other equipment available for emergency use. As an incentive, FEMA could make such participation a condition for its continued support.

- Bring states into NSEP telecommunications planning as a matter of urgency, and encourage extension of state and local planning into interstate and national environments.

- Promulgate a national policy mandating interconnection or the capability to interconnect, and interoperability among state and local systems nationwide by a realistic date. The Committee cannot emphasize the importance of this action strongly enough. We recommended it in our Annual Report. As part of this initiative, stimulate more coordination of spectrum uses and their planning for public safety communications.

- Pre-position simple, standard operating procedures (SOPs) at all possible telecommunications centers. That will enable survivors to contact other facilities or local authorities, and to establish emergency interconnect points. Clearly, the state and local participants will exercise a major share of the responsibility for getting this done.

- Stimulate pre-stocking of critical parts and materials. The SOPs would establish guidelines for their distribution and use.

2. <u>Organizing for Effective Bottom-Up Emergency Response</u>

The Committee urges three organizational changes that it believes necessary for FEMA to be effective in promulgating this program.

- One of the offices reporting to the Manager/Deputy Manager, NCS (either the Joint Secretariat or Plans and Programs) should have an individual whose only responsibility is to develop approaches and procedures to assist FEMA in this program.

- The Committee finds the continued absence of a FEMA representative from the NCC staffing roster discouraging. FEMA should have a full-time representative in the NCC, preferably as NCC assistant deputy manager. FEMA could then, on behalf of the NCS, help to bring NCC resources to bear on assisting the states to develop their emergency plans and procedures for: integrating public communications resources within each state, integrating state and local resources among contiguous states, and integrating all those resources with privately owned telecommunications.

- The NCS should identify or estabish one organization 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, possibly Technology and Standards, could also be charged to follow activities at regulatory agencies -- not only the FCC and the Interagency Radio Advisory Committee within the Federal government, but relevant state groups as well -- and advise the OMNCS so that it can comment on proposals in timely fashion and, together with FEMA, advocate policy appropriate to NSEP.

C. The Role of the NCC

The NCC, heavily staffed with representatives of NSTAC members; is an important mechanism for ensuring effective use of industry resources to sustain continuity of service and its restoration or reconstruction in emergencies. Although the NCC has been in operation for two years, it is premature to judge its effectiveness. The Committee is convinced that effectiveness could be greatly enhanced through participation of NCC members in planning and exercising for emergencies rather than simply responding to those imposed on the NCC from time to time. That participation in planning is inhibited by a concern over antitrust allegations because of the partial staffing of the NCC by representatives of potentially competing firms.

In addition, one agency of the NCS -- FEMA -- has a significant overlap of its day-to-day responsibilities with its NSEP telecommunications obligations. FEMA is the Federal agency charged with oversight and support of state and local activities in emergency management. But FEMA is absent from the NCC roster.

- Accordingly, the Committee recommends that the Department of Justice convene and chair a meeting of the General Counsels of corporations represented in the NCC, with participation by the FCC and other appropriate government agencies, to review the risks associated with cooperation among potential competitors in the interest of NSEP telecommunications and to determine if these present any serious impediment to the cooperative planning desired. If there is none, planning activities should be led by one of the NCC industry representatives, selected especially for (his) planning abilities and knowledge of the commercial plant.

- The Committee has already recommended full-time FEMA participation in the NCC, on the preceding page. However, we feel so strongly about the necessity for that participation if the NCC and the bottom-up program are to be fully effective that we take this opportunity to repeat and emphasize that recommendation.

D. Joint State and National Emergency Planning

This Committee and its predecessor have emphasized that state and local entities must be part of national NSEP planning, since reconstitution of the national communications resources must begin from the bottom up under Threat Models 2 and 3. This means that the reconstitution will commence at local-jurisdiction levels -- the surviving "islands" -- and expand outward. A multiplicity of such island recoveries is anticipated.

It is clear that the tools to be employed during any such reconstitution will be only those at hand at the time. Any additional equipment or other resources needed for communications recovery will, in all likelihood, take a back seat to such basic necessities as shelter, medical supplies, food, water, power equipment, fuel, and clothing. As a result, preplanning leading to the prepositioning of the necessary resources is essential. Obviously, maximized use of all on-site resources is critical.

The Committee has talked about assets that are accessible to state and local entities in the preceding sections of this report. Other resources are available in local areas which must also be integrated into state and local entity planning, in the form of spectrum and equipment under federal agency control. Many agencies of the federal government have personnel, equipment and spectrum assignments at precisely the locations where they are needed most. In the event of a disaster these resources need to be available to the surviving local entities freely and without caveat. The nature and purpose of the mission of each entity during the pre-disaster epoch must automatically become subservient to the reconstitution mission.

The first step in a process which would lead to this posture would need to be taken by the OMNCS, with support from FEMA. The states first, and then selected local jurisdictions, need to be made totally familiar with Executive Order 12472 redefining the NCS, its mission, its function, and the Executive Office responsibilities of the NCS and other government agencies for NSEP telecommunications. They then need to be fully informed of the actions taken by the NSTAC and those actions under way. Following this, the results of the work of this Committee should be disseminated to these jurisdictions. The Committee hopes that the states would pursue their own efforts, in cooperation with the NCS and FEMA, to help achieve establishment of a state-level organization cognate to the NSTAC.

Emergency communication is a national problem. It must not be a problem seen only in terms of the federal government's activities. Planning for federal government systems must also consider and be responsive to state and local communications systems and reflect the State Governors' leadership role in responding to emergency situations accurately. The Committee continues to see this as an urgent matter. We recommend that the OMNCS and FEMA approach the NGA and the National Association for State Information Systems to coordinate and support their proposed petitions (see III. C.5., pp. 69-71) to the NSC for inclusion in the NSEP planning process. This is a good opportunity to establish the governors' committee cognate to the NSTAC.

State and local entitites, and organizations under state control such as the National Guard, have communications assets in geographic areas that will be important in many types of emergencies. Their use should not be restricted only to the case of a nuclear disaster. Thus, participation of the states is important to the final selection of the systems solution as well as to the operational implementation of that solution. The NCS needs to include this aspect of planning in its preparations for including state and local jurisdictions in the NSEP planning process.

o A most critical aspect of joint federal and state NSEP planning is the participation of FEMA in this process. The need for full-time FEMA participation was stated in the Committee's Annual Report. The Committee cannot emphasize this strongly enough. We consider FEMA's leadership vital to state and local participation in NSEP telecommunications. FEMA has the responsibility for these major and important relations with state and local entities. It should be the focal point within the NCC for Federal activities involving the state and local jurisdictions' effective integration into the NSEP planning and implementation processes.

E. The Trend Toward A Software-Defined Environment and its Effects on NSEP Telecommunications

As competition and technical innovation proceed in the years ahead, the communications fabric of the U.S. will undergo large increases in capacity, in availability of alternate paths, and in decentralization of function. The implementation of these trends involves the execution of software in literally thousands of interconnected microprocessors and medium- and large-scale machines. This mixture of interacting technologies has a number of NSEP consequences.

The retention of network configuration data in software rather than in the structure of the hardware has several NSEP implications. For moderate levels of damage, the flexibility of modern software-based networks is an advantage. As one considers more severe levels of damage, the dependency on software becomes a liability, since computer systems are relatively fragile, the required databases are large and fragmented, and the skill levels to reconstitute them are high.

Dynamic routing offers a self-healing property for networks that have been damaged, and this capability is more effective for NSEP the more completely it can be automated. AT&T has made commendable progress in at least implementing a manual Dynamic Non-Hierarchical Routing (DNHR) system based on predicted traffic loads. Other carriers have yet to follow suit. Ultimate automation of dynamically computed rerouting capability is desirable, since it allows response to new emergency-induced traffic patterns never before experienced and minimizes reliance on off-line computation and historical data.

U.S. participation in ISDN standards activities should include emphasis on such NSEP considerations as alternate route provision and avoidance of a few catastrophic failures. The Committee notes with satisfaction that the NCS is playing an active role in the work of the Exchange Carriers Standards Association (ECSA) in seeing that these aspects of the standardization effort are receiving attention. We urge the OMNCS to continue this emphasis on ISDN standards even if it means leaving to other U.S. participants the role of pushing for other important but nonNSEP-related issues.

- The Committee urges the OMNCS to take action to ensure that user-defined services in ISDN and more immediately available networks include specifications of NSEP-related parameters, e.g., the ability of the customer to order a set of connections guaranteed to have physical route diversity.

New software-defined functions should not be concentrated in a small number of centers. The Committee recognizes that this is counter to economic pressures within the carrier's business; it is one of those NSEP measures that we feel the OMNCS should try to find ways of making attractive to the carriers by special funding arrangements.

Advanced PBXs that embody calling-route optimization for cost reduction may also be reprogrammed to provide optimization for availability of routes. This is an important capability of these new systems that may justify their procurement on a wider and more accelerated basis for government installations.

- The Committee recommends that small send-receive earth stations be procured early by emergency agencies, tested for their usability, and, as found suitable, stockpiled for use in providing high-speed, digital, point-to-point and broadcast NSEP connections with various communications satellites.

F. Critical Technologies with NSEP Leverage

1. Conclusions from the Annual Report

Basic component vulnerabilty was treated in the Committee's Annual Report. Briefly, the conclusions were:

a. Optoelectronic components in a fiber optic system may be somewhat more rugged than the usual metal-oxide-semiconductor (MOS) or gallium arsenide (GaAs) electronic components, but the extensive use of the latter will make the overall vulnerability the same as that of an equivalent-speed electronic system.

b. Some fiber systems now being installed employ metallic strength members or power lines in the cable, and thus could have the potential of picking up EMP radiation to about the same levels as conventional coaxial cable. Recent tests have shown, however, that replacing metallic strength members with nonmetallic ones is not necessary. It is far more important to protect repeater and terminal electronics from pulses that could come through the power supplies. This can be done with simple, inexpensive penetrator protection such as gas tubes or zener diodes.

Optical fibers of the type currently employed in telecommunications are subject to darkening from nuclear radiation at high exposure levels. Radiation-resistant fibers exist, but are currently too expensive to use in regular commercial applications. The actual NSEP leverage in radiation vulnerability likely depends more on the type of installation (e.g., the depth of burial) than the particular type of fiber and cable. As the predecessor committee observed and as this Committee has noted in its Annual Report, normal engineering precautions for such things as lightning protection in the construction of the links should provide satisfactory hardening.

c. Extensive use of complementary MOS (CMOS) devices in equipment will reduce the overall power consumption and offer prolonged operation from battery, solar, or other emergency power sources. This is especially important in hand-held or mobile equipment, but the use of low-power-consumption techniques will occur naturally in such equipment. Use of CMOS in other equipment (for example, PBX and central office switches) may not occur naturally, but should be encouraged for NSEP reasons. The cost/benefit ratio will be different for each situation, depending on what fraction of the power is consumed directly in the electronics and in the cooling system for the electronics.

2. Optical Links

Optical switching, amplification, and other signal processing functions will very likely not be competitive with their electronic equivalents in the next two decades, so the vulnerability of these components need not be considered. In any case, they would not be less vulnerable than the electronics that drive the optoelectronic devices. Optical switching with optical signals is even less likely to develop beyond the laboratory curiosity stage. Selected, integrated optical components such as high-speed modulators may find some application in commercial systems, but no inherent NSEP leverage would derive.

Since the technology for central switching remains electronic, the Committee finds no NSEP implications for vulnerability that it has not already stated. Perhaps the largest change that could have NSEP leverage is the overcapacity and potentially increased redundancy that are developing with the widespread installation of optical-fiber systems by competing carriers. Advance planning and agreements among the carriers will be needed, and the OMNCS may wish to stimulate that.

3. Automated Information Processing (AIP) Support for Telecommunications Operations

To achieve interoperability among the competing carriers and thereby acquire leverage for survivability and restoration of telecommunications, standardization and access to information about supporting AIP systems are needed. Standardization of operating systems among different manufacturers of computers is a positive factor in NSEP. Currently, there is a de facto standard operating system -- UNIX -- in place in the telecommunications industry. Many records essential to recovery and reconstitution are stored on commercial computers, both mainframe and miniprocessors. To take advantage of the de facto standard, the NCS should encourage portability enhancement brought about by a common operating system such as UNIX for the computers on which these data are stored and processed. A widely deployed, standard operating system is a strong, positive factor for NSEP telecommunications, and the Committee recommends consideration of UNIX for such a standard.

G. Industry Strategies and Government Positions

1. Government

The Committee believes that the NSEP planners in government should take the following into consideration as possible strategies, given the kinds of changes we expect in the telecommunications infrastructure of the U.S. and the resulting industry strategies we foresee.

One should expect an accelerating trend away from very heavy reliance upon hard-wired, private-line circuits as we know them today. Instead, there will be much greater use made of virtual private lines, software defined networks, and ISDN and other (as yet undefined) new services as they become available. But the NSEP planner must recognize that, as planned by industry, these will depend upon a relatively few central data bases. Although sufficiently redundant for normal operations and modest disasters, such centralized data could result in dangerous vulnerabilities in a nuclear war. Additionally, the trend away from traditional private lines will result from the ready availability of transmission for lease by bandwidth rather than as individual circuits.

Dedicated (i.e., government-owned) military systems designed with survivability as a foremost consideration must be retained for military command and control purposes. But the extensive diversity of commercial networks make them the only realistic asset suitable for general reconstitution in the post-attack period. Commercial systems should be extensively used to complement the government-owned networks, to improve the robustness of the command and control systems by a carefully planned mix of leased transmission (satellite, fiber and microwave) and selective access to the various networking systems of different telecommunications suppliers.

Fiber and satellites should be viewed as complementary, not competing, technologies. Each has advantages and disadvantages:

<u>Fiber</u> is much more resistant to intercept activities and EMP effects. It is also less expensive where large volumes of traffic require cross-sections of many channels of communication. It provides high-quality, essentially error-free, and highly reliable communications channels. The disadvantages are the time required to install new systems, the time required to restore major breaks, and the large number of circuits interrupted when a failure occurs.

<u>Satellites</u> have a unique advantage in broadcast applications (point-to-multipoint), permit rapid deployment to serve new areas or for restoration purposes, can provide end-to-end networks to the customer premises and thereby bypass exchange facilities, and are cost competitive on thin routes. They are easily interceptible, have some vulnerability to high-altitude electromagnetic pulse (HEMP), and depend upon earth stations which are vulnerable to varying degrees and have transmission delays that affect voice conversations to such an extent that calls transiting more than two or three hops are generally unusable. Within the continental United States, however, single-hop transmission can easily span the country.

The Committee believes that the government should examine carefully the idea of leasing transmission in units of bandwidth (e.g., 1.544 megabits/s) and use multiplexers to derive channels for voice and data circuits instead of leasing individual circuits. There appear to be four advantages: substantial cost savings; spare multiplex channel capacity, if available in the right places, for quick circuit turnup; routing (circuit, path and media) control in such a way as to provide controlled diversification of critical circuits and paths; and a sufficient number of suppliers to allow competitive acquisition of both transmission and multiplexers.

Implementation would be based upon the ability to group sufficient circuits and acquire and locate the multiplex equipment, and to do so cost-effectively. It represents a management task not unlike that presented by the earlier, very extensive TELPAK network and the present DoD Multi-plex network. Such a program would be compatible with the Communications Services Industrial Fund (CSIF) operated by the DCA. It could include Defense Digital Network (DDN) and AUTODIN circuits as well as conventional private lines--voice, data, teletype or facsimile.

With respect to carrier-supplied networking facilities of the SDN or ISDN type, the NSEP community must try to influence the suppliers to disperse or replicate the controlling data bases. An ideal solution would be for the user customer premises equipment (CPE) or nearest end office to have a capability to back up the central data bases if the central controller is interrupted.

The Committee is pleased to note that the Office of Technology and Standards, OMNCS, is concentrating a significant portion of its technical effort on participation in the work of the ECSA committee on ISDN standardization. Additionally, through periodic briefings of other government agencies, Technology and Standards has taken the lead to see that ISDN standards considerations are integrated appropriately and in timely fashion into the NSEP telecommunications of the NCS member agencies. These activities have anticipated one of our recommendations.

In addition to the need for incorporating state and local resoures into NSEP planning to support bottom-up restoration, there is a need for access to information on emergency telecommunications information across corporate boundaries to the NCC to support top-down restoration. The Committee considers it proper and necessary for the NCS to build documented arrangements into NSEP planning so that major carriers' network control centers may draw upon or interoperate with local or corporate resources to help with restoration efforts from the periphery of a disaster area. Nevertheless, the principal responsibility for organizing and overseeing such planning with city, county, and state organizations devolves upon FEMA.

- Accordingly, the Committee recommends that such planning be initiated jointly by FEMA and the OMNCS, with FEMA taking the lead in coordinating city, county, and state planning. The OMNCS should take the lead, as it has already begun to do, in coordinating planning with such national organizations as the radio amateurs and private non-carrier communications systems (e.g., those of Boeing, Citicorp, GE, GM, IBM, and oil and gas pipeline companies), with FEMA coordinating the planning for the states. Such planning activities might well be carried out with NSTAC and the recommended cognate governors' committee participating.

2. <u>Commercial carrier strategies</u>

The expected strategies listed in our Annual Report of new, potentially unregulated, service offerings; lower pricing of full service, sometimes at reduced quality; mergers and acquisitions; and (privateline) bypass of local exchange identified for the telecommunications service suppliers still appear valid with one exception. That exception has been the rapid acceleration and expansion of those service suppliers in the industry planning and installing optical fiber systems in both the intercity and local-exchange areas. (See Section III.C.1 for an overview of those companies and their plans as known at this time.) That exception reinforces the Committee's general conclusion that abundant, high-quality transmission, with potentially high redundancy for NSEP telecommunications, will be available quickly and that the effects on supplier and user alike will be revolutionary. As stated in E.2 above, the NCS may wish to take advantage of the potential for increased survivability by stimulating planning and agreements among the carriers that would facilitate easy use of the added network redundancy available.

III. DISCUSSION

A. State and Local Telecommunications

At the Committee's first meeting on March 26, 1984 John Grimes, then Deputy Manager of the NCS, identified the following as a major area for the Committee's attention:

> "Problems of interoperability are likely to be raised by independent, and possibly uncoordinated, actions of state regulatory commissions. The state regulatory commissions and their association, the National Association of Regulatory Utilities Commissioners (NARUC), chose not to join the President's National Security Telecommunications Advisory Committee (NSTAC). This seemsto indicate on the part of the NARUC a lack of awareness and/or a lack of consensus on what is being done, and what needs to be done to ensure...coherent approaches toward integration of state and local systems into NSEP telecommunications functions. How can the states be made aware of the desirability and necessity of coordinating their actions in the field of telecommunications toward the objective of national preparedness?"

Observations made by the Committee on this topic in its Annual Report* at page numbers indicated are summarized and will be addressed below.

- Because of deregulation there are substantial changes and widespread deployment of new telecommunications systems at the local level. These new and valuable resources are being deployed without any consideration of NSEP needs (p.61, #2, p. 62, #4).

- State and local emergency telecommunications agencies are remarkably dissimilar in their responses to emergency conditions. Not only is emergency planning localized and

*The Policy Planning Environment for National Security Telecommunications. Annual Report to the National Communications System. National Academy of Sciences Press, Washington, D.C., 1985.

independent but there is a strong feeling that upper levels of government -- state or Federal -- should not intrude other than supplying money and resources. There is no sense of national concern (p. 62, #5).

- The Federal government agencies have not extended their programs in the direction of bottom-up reconstitution. Local entities have therefore received little tangible support from Federal program planning for NSEP telecommunications (p. 63, #1).

- Very little integration exists within a state among its various telecommunication systems, or between states.

- In some states various entities have their own emergency task force with well developed procedures. However, each operates independently of the others. The states do not have the organizational structure nor the technical expertise to develop systems that integrate the many separate telecommunications facilities (p. 64, #2 & 4).

- New federal systems being developed should be made to interface and interoperate with in-place local systems (p. 65, #1).

- FEMA provides a central location for aid agencies but has no jurisdictional authority over state agencies (p. 65, #4).

After preparing the Annual Report, the Committee received presentations from the National Emergency Management Association (NEMA), the Associated Public Safety Communications Officers (APCO), and the National Governors Association (NGA), further enlarging its understanding of the situation with state and local telecommunications and clarifying its views.

1. <u>Expanded Scope for FEMA</u>

For the NCS to obtain coordination and integration of its NSEP planning with state and local jurisdictions it must assign responsibility for this activity to one of its participating members. A management axiom states that if a problem is the responsibility of everyone, it becomes the responsibility of no-one. The Committee recommends that the OMNCS and FEMA take action to have FEMA, which is already significantly involved in state and local affairs, be officially charged with this responsibility of achieving state and local coordination with the NSEP telecommunications program. The mandate for this activity must be spelled out as a set of intiatives in the same way that initiatives were enunciated for using NSTAC as an NSEP telecommunications resource. These initiatives, or responsibilities, would include:

- Joint planning for NSEP purposes. Lay out the main course to be followed. Describe in general terms the kinds of working relationships required among the various organizations and between them and FEMA and the NCS;

- An education program for state and local organizations regarding NSEP requirements;

- A liaison point in each organization;

- Training for emergency operations;

- Procedures to be followed in emergency situations; and

- Working at the policy level only, but covering all issues necessary to the development of practical solutions at the detail level.

Two organizational changes are necessary for FEMA to be effective in this coordination role:

- There should be a person in one of the offices (or departments) reporting to the Manager, NCS -- probably in the Joint Secretariat or Plans and Programs -- whose only responsibility is to develop approaches and procedures to assist FEMA in discharging this new responsibility.

- FEMA should have a representative on the NCC, preferably as NCC assistant deputy manager.

2. Achieving State and Local Coordination with Federal Agencies

There is no need to develop or invent new organizations to achieve the state and local integration desired by the NCS. Based on data presented, the Committee is convinced that well established and significant organizations are already are in place to achieve the desired coordination. The principal ones already in existence are the National Governors Association, the National Emergency Management Association (NEMA), the Associated Public Safety Communications Officers, Inc., (APCO), the National Association of Regulatory Utility Commissioners (NARUC), and volunteer radio organizations comprising the American Radio Relay League (ARRL), the Amateur Radio Emergency Services (ARES), the Radio Amateur Civil Emergency Service (RACES) and the Military Affiliate Radio System (MARS). The objectives of each of these organizations relate to coordination among their constituents for emergency operations and do reference integration with the Federal establishment, though not directly with NSEP; nor are they necessarily aware of NSEP requirements.

a. The National Governor's Association (NGA).

In August 1978 the NGA voted on and unanimously passed a states emergency management policy. It stated that since the president has followed the NGA recommendation and was moving to establish an independent emergency management office (FEMA, 1979) governors should undertake similar action at the state level. A premise for this new NGA policy is that an equal local-state-federal partnership is the most effective approach to a comprehensive national system of emergency management. The governors also hoped that the mayors would declare a similar policy at the local level to complete the system.

Federal Public Law 81920 directs states to establish directors of emergency management planning. Each state and all the territories have Emergency Operations Centers (EOCs) which plan for and coordinate responses to natural disasters and possible attack. The majority of governors and State Emergency Operations Office (SEO) directors consider response to natural disaster as the SEO's responsibility. All consider attack, whether nuclear or conventional, as falling within the responsibility of the adjutant-general and National Guard. An NGA study in 1978 found that many state emergency operations were fragmented and that this was encouraged to a large extent by uncoordinated Federal programs. If FEMA is assigned to state relations representing the Federal establishment, it can resolve these fragmentation problems and provide the foundation wherein Federal, state and local emergency management organizations become equal partners in a coordinated approach to the problems.

The Committee believes strongly in the NSTAC, with its Industry Executive Committee and participation in a National Coordinating Center (NCC). The government is fortunate that the private sector has recognized the pressing need for national planning and preparedness and has committed significant resources to various planning task forces. The Committee has already recommended in its Annual Report that an equivalent organization should be identified which represents the political leadership of the country. One such organization is the NGA. It may be necessary for the President to take the leadership in getting this organization identified as a major participant in NSEP as he did with the industry leaders. The Committee believes that for its part the NGA should accept the responsibility, but it might assign actual participation to the NEMA.

The FEMA, acting on behalf of the NCS, could then work with the NEMA in several necessary areas with the states, to:

- develop an awareness of the importance of and need for NSEP planning;
- assist the states to develop emergency plans and procedures for the integration of all public communications resources within a state;

- assist the states to develop emergency plans and procedures for integrating state-owned or -controlled, communications facilities with contiguous states, and interstate generally;

- assist the states to develop emergency plans and procedures for integrating state-owned, or -controlled, communications facilities with the privately owned facilities within the state. The NSTAC initiatives should include this same point; and

- identify desirable and permissive spectrum allocations during recovery from a disaster and also recommend, and perhaps procure for the states, the optimum hardware for recovery.

b. The National Emergency Management Association (NEMA)

The NEMA is an organization of state directors of emergency management. It was formed to promote the interests, serve the needs, and advance the objectives of emergency management at the state level of government, in partnership with the FEMA and local governments across the nation. In his presentation to the Committee in March 1985 the President of NEMA repeated what the Committee has heard many times, namely, that emergency telecommunications planning is the weakest element of programs that should be responsive to emergency situations. The organization wants to be informed, and consulted, on the problems and issues associated with national emergency telecommunications planning. FEMA and NEMA, in concert with state and local governments, should address the development of multijurisdictional emergency telecommunications systems that are flexible enough to be utilized for the range of hazards likely to occur.

The Committee recommends that NEMA be brought into the planning framework immediately, with FEMA acting as the leader.

c. Associated Public Safety Communications Officers, Inc. (APCO)

APCO, which has been in existence for 50 years, is an organization with over 6,000 members representing all aspects of public safety communications. Although it is a strictly volunteer organization with a permanent staff of only 12, its members are all employed at local, state or federal level in communications systems. These systems include telephone and microwave systems as well as mobile radio. One of APCO's most important functions involves the coordination of radio frequencies. It is formally recognized by the FCC as the sole coordinator for the Police Service, but it also operates in law enforcement, fire, local government service, special emergency civil defense and emergency preparedness, forestry, and conservation and highway maintenance.

APCO is concerned almost entirely with public safety and its dependence on good communications. In keeping with this concern it has identified four key needs which it believes should be addressed:

- the need for national leadership. "We need to know who our leader is and begin joint planning with that leader. Some one agency must be recognized as the leader of this Federal, state and local planning partnership;"

- the development of a comprehensive long range plan. This will probably cost $500,000 even though APCO members will participate at no cost to the government;

- a requirement for suitable and adequate radio frequency spectrum; and

- the need for adequate financial resources.

These four points are closely related.

The Committee sees in APCO, a non-profit organization with an excellent reputation based on 50 years of public service, a remarkable resource which should be formally recognized by the NCS and made a partner in planning under the leadership of FEMA. APCO and FEMA are already in the process of drafting a memorandum of understanding in support of FEMA's concept of an Integrated Emergency Managament System (IEMS). The National Emergency Management Association (NEMA) strongly supports APCO -- the work it is doing and its objectives for the future.

APCO had directed its efforts largely to the FCC because that agency makes the decisions that affect the public safety allocations of the radio-frequency spectrum. A more formal association with FEMA can direct APCO's efforts also into those areas so important to NSEP which, of course, are also concerned with public safety.

d. Spectrum Management

Over the last two years, the Committee has heard extremely discouraging examples of the way the radio-frequency spectrum is planned and allocated. Some examples:

- A state trooper going north on an interstate highway cannot communicate with a trooper going east;

- In one county in Florida there are 39 frequencies used in law enforcement but only one common frequency between law enforcement and drug abuse agencies statewide. Local governments work at 57 different frequencies. In many cases police cannot communicate with firemen;

- Other than teletype there is only the telephone system providing communications between states and the Federal government.

Incremental release of frequencies by the FCC and the ensuing scramble for allocations has created this chaotic condition. It has led directly to the inability to communicate across services or jurisdictions because of incompatible and somewhat random frequency allocations. Cooperative planning by FEMA, NEMA and APCO is a first step toward resolving this major problem.

3. NSEP Awareness and National Purpose

The predecessor committee endorsed the concept of bottom-up recovery and reconstitution in its final report. This committee also endorses that concept. The OMNCS and FEMA seem to support it as well.

The bottom-up concept means that disaster recovery and communications reconstitution will occur from local islands outward. Reconstitution cannot occur from Washington downward to the states and local communities. After a severe disaster, islands of varying sizes having significant resources will survive. These resources, however, will either be rapidly consumed, as in the cases of food and fuel, or will be isolated from neighboring areas, as in the case of communications. Actions initiated or managed from the seat of government, Washington, can do nothing to bridge these surviving islands. The bridging actions must be taken at the surviving island level.

At this time all programs ostensibly oriented toward the NSEP problem have been initiated at the federal level and have as their underlying concept top-down management and control. This philosophy must change if any meaningful progress is to be made toward the creation of a viable national plan for NSEP communications restoral and reconstitution.

The committee has heard from several state and local government entities. We are convinced that the local entities (towns, parishes, counties, political subdivisions, and states) are capable of executing the actions necessary to reconstitute. It is our observation that with the help of volunteers, such as amateur radio operators, these entities have done remarkably well with the resources at their disposal. However, there is 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 agencies' top-down requirements. As a result, the local entities have received little or no tangible, useful benefit from these Federal programs.

Federal programs may support the provision of hardware such as radio equipment and emergency generators. A suggested channel for provision of equipment is through the Department of Defense to National Guard units. The National Guard invariably is employed during disasters and the equipment would always be present, 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 an urgently required resource, currently poorly applied. We offer two examples of possible improvements for emergency preparedness. The Park Service mobile and fixed radio equipment and the radio spectrum it uses should be directed to the local Emergency Coordinator for the period of the disaster. Citizens' Band frequencies with restricted-use power amplifiers for overcoming interference and ensuring contact with citizens in their vehicles should be permitted.

Many other resources involving personnel, spectrum and hardware could be made available at the local level. The barriers that now exist at the Federal level must be eliminated first. This, we suggest, must begin by declaring a national purpose from which these and other actions would flow. We would anticipate in response a surge of ideas and suggestions for evaluation that eventually could be stitched together as the fabric of a genuinely nationwide plan for NSEP communications.

4. Need for Federal and State Integration

States and local entities have extensive resources in communications facilities usually associated with their service agencies such as police, fire, public works, and the National Guard. The amateur radio network is both a local and a national resource of major importance. The Committee has not found any great degree of integration among the various systems within the states or on a multi-state basis. There is information that such integration can be and is being accomplished on a local basis, driven by concerns peculiar to particular areas. This is manifested in the procedures and practices evolving from the ingenious application of tools that happen to be available to local planners by identifying what will be accessible to them during a disaster.

Local and state governments have shown that they are capable of planning for the emergencies they foresee or have been exposed to. They routinely exercise and execute their plans with great success. When the new dimension of NSEP is added they will need technical and financial support to be equally effective. In the absence of such support it is not surprising that states planning to configure a state-owned and -operated system would ignore NSEP factors. However, there are considerations that can work to favor NSEP. These factors common to NSEP and other drivers, if applied, could make state networks valuable, national NSEP assets. Because of classical funding constraints at the state level, their funds would probably need to be supplemented to achieve such goals. This offers FEMA an opportunity to coordinate state and local emergency communicatons planning with its own in ways that advance NSEP objectives.

NSEP considerations could lead to commingling of projects between the states and other government agencies, thereby supplementing state funds. An example is the FEMA underground facilities in some states. These sites need to be interconnected with comparable state facilities.

In at least one case a state and FEMA had plans to put in a fiber-optic cable along identical routes to the same places. A commingling of the FEMA and state projects would be highly desirable. The aims of the two coincide in many key areas. The result of such combined planning and engineering would be systems capable of providing increased survivability and reconstitutability of communications among Federal, state, and local government agencies.

Mobilization is a key problem that must be addressed in any plan involving joint federal and state planning for reconstitution. The NSTAC and the NCS have created a joint industry/government task force to examine this issue. Some corporations, for example, continue to draw upon retired people for use during disaster recovery periods. This concept should be extended to the entire nation. Available, qualified people should be drawn upon to assist in the reconstitution efforts. Similarly, the assets that may be drawn upon for use during recovery need to be inventory-controlled for earmarking and distribution during disaster-recovery operations. These assets should be integrated with those already earmarked, such as amateur radio, and molded into a viable package. As soon as feasible, the telecommunications assets of private systems such as the Citicorp, railroads, oil and gas pipelines, and other similar systems would be consolidated and prioritized within the framework of local, state and national reconstitution plans.

In general, the states have neither the organizational structure nor the technical expertise to initiate and maintain systems to integrate the many separate telecommunications facilities that they own. They have no capability today to integrate and manage privately owned systems within their jurisdictions. They are even less capable when it comes to the operations planning of the use of communications service supplier resources to recover from disasters. They need planning to help on a very large scale. This help can only come from the OMNCS and FEMA.

5. The Role of FEMA

FEMA is chartered 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 FY 1984 budget is about $1 billion, with $169 million earmarked for civil defense. It has a staff of 2500, 1500 of whom are in Washington, D.C.

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 or locations for aid agencies. This is an example of the top-down concept, based on collecting data to be sent to Washington, where decisions are made for the state or local entities. This cumbersome Federal response to emergency or disaster is all the nation has because the bottom-up concept has not been adopted as national policy. The Committee is convinced that FEMA resources now in existence and those currently under procurement could be reoriented to produce significant advances toward achievement of the national NSEP objectives. The Committee believes that such advances would take place if FEMA were officially assigned responsibility for integrating state and local organizations into the NSEP process and coordinating its activities and theirs in responding to emergencies or disasters.

The National Governor's Association's (NGA) Office of State Services has published documents addressing Comprehensive Emergency Management (CEM) in substantial detail from the state and local government viewpoint. 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. The state also cooperates at multi-state levels when appropriate and is responsible for requesting supplemental federal assistance for major emergencies. Planning to date is deficient because of constraints imposed by the top-down philosophy of management and restricted availability of resources permitted to state and local entities in their planning process. The Committee feels that the states are ready to cooperate with FEMA should it be given the integration and coordination responsibility described above. FEMA must carry out that responsibility in ways that take advantage of and do not interfere with the autonomy of the states.

6. 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 frequency 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 the Emergency Broadcasting System (EBS)] at the FCC. Indeed, although the Nuclear Regulatory Commission has passed regulations requiring that the nuclear power industry install alarm systems for the area within 12 to 14 miles of a nuclear plant, neither it 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.

The Committee has already strongly recommended in its Annual Report that a national policy be adopted mandating interconnection and interoperability of emergency communications systems nationwide. In implememting such a policy, the Committee believes that the assistance of APCO should be sought. One major area of immediate importance should be the integration of 800MHz trunking systems into national NSEP reconstitution planning. APCO has developed a Public Safety Communications Standard Operating Procedures Manual which would seem a key element in any national scheme.

The Committee urges that the OMNCS identify or establish one organization to work on a nationwide basis to coordinate spectrum needs, equip ment standards and practice planning of all existing emergency communication systems and to identify areas where no, or inadequate, provision has been made for such a system. 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. The Technology and Standards Division of the OMNCS strikes us as a good candidate.

7. Integrated State NSEP Networks

Some states have conducted studies which show that state-owned and -operated systems would be cost-effective over their life cycles. As a result, some states have already moved to implement state-owned and -operated systems. These are supplementary to the existing MTS and substitute for special construction performed by the carriers.

The Committee considers it urgent to involve the states in the NSEP process to permit them to consider NSEP needs early in their planning. We assume that all of the national resources including state networks are candidates for inclusion in NSEP planning. Preparation of an NSEP plan is a major problem. State entities do not have experience with large-scale planning nor with operating systems of such magnitude and complexity. One critical element that affects the cost in place and 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 NSEP design criteria solutions.

In many cases the actual transmission equipment costs are overshadowed by the cost of land involved. This may be a high-cost item, particularly where cable transmission is involved. State taxpayers' funds may be hard to justify for a "hard" system without consideration of national need and would likely result in the construction of "soft" systems. In their future efforts to bring state and local entities into the NSEP planning process, the OMNCS and FEMA should give serious thought to the need for hardened systems and the extent to which they would be prepared to fund the hardening.

B. Technology and Standards

1. Integrated, Customer-Configurable Networks

Underlying the expected evolution of the world's telecommunications in the next decade is the complete integration of voice and data traffic over a standardized "bit pipe," the Integrated Services Digital Network (ISDN). At the very minimum, this service provides switched, digital, customer-premises interfaces to circuit-switched connectivity on the two 64kbs "B" channels and possibly packet-switched service on the 16 kbs "D" (or signaling) channel. At most it provides a great deal more, namely, a repertoire of network and data-processing services to be provided within the network by the network provider. The various carriers of the world differ in their views of how much of this function a particular ISDN should provide: whether it is to provide only standardized interfaces and switchable bit pipes or whether it is an "intelligent" network to which the user attaches "dumb" machines and telephones.

This dichotomy is also visible in the larger class of "software-defined networks" evolving today, of which ISDN is a particular standard subclass. The fasionable and much-abused term "software-defined network" can mean anything from a specific set of AT&T offerings under the trade-marked name "Software Defined Network" to the generic notion of any network within which the hardware configuration evolves only slowly over time, while its connectivity in the overall system can be redefined rapidly by program reloads. In this report we shall adopt a convention much nearer the latter approach and refer to all such modern systems, whether obeying the ISDN standardization or not, as "customerconfigurable networks."

As a particular example of a typical service from a customer-configurable network, consider the customer-controlled, private-line reconfiguration capability being made available by AT&T. The first step was to make it possible for a single operator within the network to set up a series of switched connections at successive switches remotely, on a path to constitute a private leased-line connection for a customer. These connections were latched into place at each node by commanding the Digital Access and Crossconnect (DACS) System switch at that node remotely from the operator position, thus setting up an entire point-to-point leased connection simply and quickly, sometimes over very large distances. The process is seen to exploit software control rather than the more expensive hard-wiring and rewiring by technicians. It was an obvious next step from operator control to subscriber control, and this step is now being implemented by some carriers.

One may look at this trend in customer-configurability as extending common channel interoffice signaling (CCIS) from its former place entirely within the network out to the customer's premises. First the bit pipe is extended to customer premises and then the signaling. The "D" channel of ISDN can play the role not only of a 16kbs packet-switched channel for user data, but as an order wire or out-of-band signaling channel exactly analogous to that used in CCIS.

The availability of customer definition of network configuration parameters is not limited to telephone networks. Several satellite offerings have the "bandwidth on demand" character, and this capability has long been one of the reasons for the attractiveness of packet switching.

There is a spectrum of flexibility of customer-definable functions and services. The most inflexible, difficult to change, and one requiring the highest skill levels for recovery, would be that of hardwired functions requiring some system element to be changed physically. Somewhat more flexible are those that require a new system program load for a new configuration. The most flexible are those termed "dynamic," in which the software is designed to change itself without a reload. Examples of the last category are dynamic route selection and dynamic capacity allocation.

The wide adoption of ISDN has a number of NSEP implications. At the very minimum the standardization of all attachments will facilitate recoverability by easing today's incompatibility of interfaces, making it possible to rebuild damaged end-user environments and reconfiguring whole networks more easily than today. The network functions are all carried out in software, whether network control (the routine signalling), network management (for example, problem determination), or user applications. Those networks that are today not dependent on computer software will soon become so. Thus the recovery of an individual system will involve having high skill levels, sizable program loads and sometimes large supporting databases immediately at hand, even if the system has not been damaged. The time taken to restart an undamaged computer system from scratch can sometimes be significant in NSEP terms (minutes to tens of minutes). To reconfigure a damaged system often requires configuration data about lines, spare parts, and other details that can only be gotten from remote sources, most likely over the very network that one is trying to recover.

2. Centralization and Decentralization of Intelligence

Efficiency in computer-controlled networks clearly favors centralized network control at the present time. This, of course, makes the network more vulnerable to catastrophic failure in case the control center is destroyed than would be the case with distributed control. Two thoughts about this may be worth pursuing.

- Continuity of service is an important attribute of commercial networks, so one should not assume that a high degree of vulnerability will be allowed to exist even in the absence of NSEP considerations. Designers of new software-defined-type networks, or of digital networks generally, might provide interesting insights about how they are dealing with this challenge.

- History may be repeating itself. Ten years ago there was a pattern of large, time-shared, computer centers, but then economically viable distributed processing came along. It is not clear that the same trend is now occurring in network control, but there are nevertheless good reasons to avoid excessive concentrations of control and it may be that the means to do so economically are approaching.

There are obvious NSEP implications of the placement of functions in a few easily disrupted facilities compared with distribution of that same function over many geographically separated facilities. Much of the software behind the customer-defined networks is distributed across multiple, interconnected systems, and the number, mutual proximity, and multiplicity of paths between nodes in these systems have a lot to do with their robustness and recoverability. In addition to these geometric survivability issues there is also the closely related issue of whether the function is to be placed within the network itself or around its periphery in customer-attached systems and terminals.

The push by carriers toward intelligent networks with unintelligent attachments goes in the opposite direction from that of the computer and PBX industries, which have for years been successfully placing ever richer communications functions in their attached machines, requiring from the carrier only a reliable web of interconnected, leased facilities. An example of competition between the carrier and computer cultures is the question of Centrex versus PBXs for simple call-support functions.

Telephone operating companies are anxious to maximize the opportunities for service and profit with offerings dependent upon centralized equipment and data bases. The contrary approach, in which intelligence and storage reside in terminal equipment, is open to competition. This difference in cultures will not disappear; and hence, the carriers' greater vulnerability because of that concentration must be taken into account.

Out-of-band signaling using CCIS was originally motivated by the recognition that multiplexing and centralization of signaling devices would be more economical than having individual signaling for every trunk. Out-of-band signaling soon proved to be the ideal base on which to build the new user-defined services, starting with "800" service. This has led to considerable centralization of function with negative NSEP implications: for example, the concentration into a small number of implemented and planned Switching Transfer Points greatly increases vulnerability.

Decentralization of function is also taking place, with positive effects on the recoverability of the network. Packet switching was originally used in "datagram" mode so that packets find their way to their destinations without a redial, even if a path is cut. Circuit switching, burst switching, and modern forms of packet switching require a reinitiation of the call over a new route at the initiating signaling center when the chosen path cannot be traversed because a node is down.

AT&T's Dynamic Non-Hierarchical Routing (DNHR), already implemented on 16 out of 96 Number 4ESS toll offices for reasons of trunk efficiency, is a step in the same direction and is typical of carrier-configured networks. As presently implemented, the former five-level hierarchy is replaced by a topologically unconstrained mesh whose connections are recomputed every four hours using data from previous days at the same time of day. The reconfiguration is today based on historical data and entered by hand, because it is said to capture 80 to 90 percent of the theoretically available economic benefits in reduction of trunks required. However, there is no inherent reason why this technique could not in principle be extended to use control based on current traffic conditions and entered by machine, thus gaining much better responsiveness to emergency conditions.

3. Operational Telecommunications Automated Information Processing (AIP) Support

a. Current Architecture and Capability

AIP support in the national telecommunications industry today consists of two basic configurations of hardware, software, and environment. The first configuration is used primarily for large, nationwide inventory and administrative functions. The second configuration is used for locally focussed and real-time functions.

Major service inventories and administrative data are generally processed and stored in very large, commercial, mainframe computers in commercial office buildings dedicated to data processing. These applications are accessed by complex, private, data networks. A well-known example of this type of system is the AT&T Trunks Integrated Record Keeping System (TIRKS), which maintains inventories of facilities, equipment, customer circuits, and network trunks. It also "designs circuits, assigns facilities and equipment, and issues work orders for the installation people."[1] Major service inventories are required for a top-down restoration of the type that would be desirable and effective under less severe threat conditions. Some site relocation and restoration planning is part of the normal, operational, emergency planning for these systems, primarily as a protection against damage to or loss of a specific computer center. For the most part, however, such plans have not been coordinated with local or national emergency preparedness initiatives. Since the user locations for these inventories are nationwide, there is generally significant diversity of communications access. However, the access networks have been designed primarily for cost-effectiveness and not for threat resistance.

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[1]Bell Laboratories Record, September 1982.

Large mainframe computers require special environments and are susceptible to high or low temperatures, poor air quality, power fluctuations, and other environmental disruptions. Some require complex water cooling systems. Many AIP sites containing large inventory systems are not blast-hardened, although most have uninterruptible power and auxiliary power generation. However, as telephonic equipment becomes smaller due to modern solid-state technology, "telephone equipment" building space is being reused to house mainframe computer operations in the traditional telephone companies (the BOCs and such established local exchange carriers as GTE and United Telecom). A number of these buildings are shielded; many are built without windows to gain a measure of blast-resistance; and all are equipped for emergency operations at a level not found in commercial office space. This re-use of such buildings strengthens the NSEP capabilities of telecommunications AIP.

Local-service inventories and analysis of service status and quality, as well as active control of service-providing equipment, is generally performed by minicomputer-based systems colocated with telecommunications equipment. Users may be at the same location or remotely located. The Network Service Center System (NSCS) is a system of this type. An NSCS performs trouble analysis and service monitoring for Network Service Centers in a specific geographic area.

Local-service inventories, analysis of service status and quality, and equipment control would all be required for effective "bottom-up" service restoration as appropriate to threat models of differing severity. Site relocation and restoration is frequently not appropriate for these systems, since they are location-specific. However, they are generally located in secure, blast-hardened and shielded "telephone" buildings. Hardware for these systems is selected for both reliability and compatibility (interoperability) within a site. Compatibility of applications at a given site allows cost-effective redundancy of hardware capability and has significant advantages for NSEP. It allows degraded or partially disabled processing capability to be used for the highest priority tasks at any specific point in a restoration effort. Some, if not all, of the user communities for this type of AIP are colocated with the computer hardware, providing knowledgeable users on site and reducing dependency on the telecommunications network. All of these characteristics enhance the ability of these systems applications to support NSEP.

b. New Directions in AIP Technology

Current trends in AIP technology are driven by technological capabilities, by new concepts of computing, and by new user needs. The key technological trend is increasing computer power available at decreasing costs in radically smaller spaces. This trend is the basis of office environment processing and more powerful mainframes, as well as making possible current applications of artifical intelligence and many applications of specialized processors, and making fault-tolerant processors economically feasible. New ideas about what computers can do and how they can do it have led to advances in artifical intelligence and to database machines, "super-computers," and other specialized processors. Finally, the wide availability of computer power has generated the need for widely accepted standards and for complex data networks.

Office-environment processing can be seen most clearly in the number of personal computers deployed in a vast variety of work places. Greater processing and data storage capability is moving closer and closer to the end user. Generally, this capability is far less environment-sensitive than older and larger machines. Besides personal computers, telecommunications offices abound with terminals and controllers with some internal data-processing capabilities, as well as local area networks (LANs) with data-processing and storage capability, and office environment processors for multiple users.

Local, office-environment data processing and storage makes possible local storage, retrieval, and use of larger and more sophisticated databases than is possible in an environment where all local records are on paper or microfiche. Of course, it also tends to replace all paper record-keeping, thus increasing dependency on system survivability. However, wide-ranging data access and analysis may be critical to any extensive "bottom up" reconstitution efforts. This widespread deployment of computing power supports the NSTAC AIP architecture recommendation of avoiding single critical nodes. Office-environment computers are also designed to require much less power than conventional minicomputers and mainframes. In addition, the office-environment machines require less stringent heating and cooling controls, which may result in additional savings in power consumption. This is a clear value to NSEP.

Increasingly powerful mainframes can handle larger and more complex single programs and/or more transactions or more simultaneous programs. Larger programs are of concern for NSEP because they cannot be readily moved to smaller-capacity machines with similar software environments. On the other hand, capacity designed to provide some level of response under heavy load may not be stressed by the data requests in a disaster mode. Such functions could be moved to smaller-capacity processors with little difficulty. Most telecommunications AIP use of large mainframes is to provide response under load, making this trend neutral for NSEP.

Operating system standards are becoming available across many hardware environments. A good example of this trend is UNIX software, which is designed and implemented for a wide variety of hardware environments provided by many manufacturers. UNIX is being implemented experimentally on "reduced instruction set computers" (RISCs) and has been hailed as the commerical environment for this technology because existing programs could easily be ported to a RISC-hardware architecture. Programs and data files are readily portable from any UNIX system to any other. Of course, porting from a mainframe downward has the potential risk of overflowing processor capacity, as discussed above. Overall, a widely deployed, standard operating system is a very positive factor in NSEP. It is significant here that the most widely deployed operating system in telecommunications local processing is UNIX. The Committee recommends its consideration as the likely standard for NSEP telecommunications. The large mainframe environment is dominated by a variety of IBM operating systems products including MVS, VM/CMS, and TSO.

Artifical intelligence is a term for a collection of disciplines that include "expert systems," image processing, and natural language processing. These disciplines attempt to process information in ways more similar to human thinking processes than traditional linear program logic. In general, these applications require large amounts of specially configured processing power. However, they also make it possible for users to perform highly technical or specialized tasks such as troubleshooting highly complex equipment with little specialized training. This could be of advantage in a disaster situation when skilled personnel may be unavailable or in short supply. The disadvantage here is that artificial intelligence applications may reduce the required skill level in the normal work force and cause greater disruption if the system capability is destroyed or impaired.

In the professional workforce, however, increasing reliance on software systems to maintain, manage, and reconfigure the telecommunications assets of the common carriers bring a potential negative value to NSEP, namely, the high skill levels needed to run such systems. Nevertheless, they carry several positive values. They lend themselves to distributed control, increasing redundancy and survivability. They are, in consequence, naturally robust, and thus could be made more responsive to NSEP needs. The OMNCS may wish to consider an initiative focusing on this area as potentially fruitful for NSEP telecommunications.

Fault-tolerant systems provide significant advantages for NSEP. The disadvantages include significant overhead in specialized operating system environments and increased cost per system. Operating systems for these environments which are look-alikes for standard operating systems and which support software portability from non-fault-tolerant environments reduce much of the survivability risk of these systems and of compatible non-fault-tolerant systems. Currently, a number of firms manufacture large, fault-tolerant minicomputers. As hardware becomes even smaller and cheaper, this concept will probably proliferate downward into office-environment computing. This technology supports the eliminations of single critical nodes and links as noted by the NSTAC AIP task force and also provides for the usage of some backup capabilities in normal operations, also as noted by NSTAC.

Database machines and other specialized processors can provide high efficiency for specialized computing functions at a reasonable cost. The disadvantage for NSEP is that this is truly specialized hardware, requiring specialized spare parts and maintenance, possibly specialized interfaces, and specialized skills in the operating personnel. These computers are generally not interchangeable with general-purpose computers.

Complex data networks support most inventory and administrative AIP for telecommunications. As data is required outside the boundaries of local databases, it would be accessed by increasingly complex networks and networking equipment which may be more vulnerable than the systems themselves. At the same time, networking may provide a variety of paths from the user to the data location, reducing overall vulnerability.

c. AIP Impacts of Industry Strategies

The post-divestiture telecommunications industry is characterized by technical and managerial diversity and by increasing technical complexity. Competition in all telecommunications markets has greatly increased the variety of proprietary technical solutions to telecommunications needs. AT&T's divestiture of local-exchange companies has removed the traditional management structure for emergency telecommunications support. Finally, the technical capabilities of software controlled digital networks have allowed the development of highly complex, highly customized services.

The diversity and complexity of this environment suggests a need for emergency telecommunications information management across corporate boundaries to support any possibility of top-down restoration after disaster. Specific areas of information management concern are inventories of service-providing capabilities and the technical specifications for connectivity, compatibility, and emergency capabilities. Long-term AIP support for NSEP should be the responsibility of a government agency, as NSTAC recommended to the President. This agency should inventory industries' critical AIP capabilities and requirements and develop restoration plans that respond to specific disaster and/or national security scenarios. Near-term technology and practical coordination dictate an information-management approach here -- providing access to existing information in the form used for day-to-day support of various networks. This is in contrast to a stand-alone information-systems approach and may be made practical through new, intelligent workstation technologies that can coordinate access to many existing databases and process information from many sources within the workstation.

Technical support information for use with specific inventories could be maintained and distributed by emergency coordination organizations as appropriate. As a rule of thumb, the more technologically complex telecommunications capabilities are least likely to be interoperable between vendors, even if the service delivered is very similar. Emergency management support should include information about "stripping out" complex functionality to provide basic telecommunications connectivity. "Expert systems" would provide an excellent vehicle for this type of information.

Generally, new AIP technology can solve many of the telecommunications emergency management problems created by the new environment. However, this requires a fresh view of existing AIP capabilities and their applications. It also requires active commitment by the responsible government agencies and by segments of industry not previously concerned with telecommunications for the public sector. The NSEP awareness program recommended by the NSTAC could address some of these issues.

d. Characteristics Contributing to NSEP Objectives

(1) Invulnerability or fault resistance is the traditional approach to environmental threats, consisting primarily of design for reliability. It includes use of highly reliable components with wider environmental tolerances, protection against external forces such as shielding and surge protection, and assembly techniques for increased durability.

(2) Recoverability is the ability of a technology to contribute to the recovery of AIP functions after a disaster. Ease of repair and minimal spare parts requirements enhance recoverability, as does some diversity. Diversity here is the "Don't-put-all-your eggs-in-one-basket" concept. Fault tolerance, the designed capability to continue operating when partially damaged, is generally achieved by redundancy of hardware -- at the component, circuit board or total computer level -- and by software that manages the redundant hardware.

(3) Low power requirements are as critical for information processing equipment as for telecommunications service-providing equipment in a disaster environment. In addition, superior tolerance of power fluctuations and the ability to use battery power without major modifications is also critical.

(4) Privacy and security issues are much the same in support information systems as for the telecommunications network. The ability to restrict access and/or protect meaningful data is critical.

(5) Interoperability of computing hardware is generally only guaranteed by identical or nearly identical hardware configurations. To a significant degree, "plug-compatible" equipment can be considered to be interoperable. However, that does not necessarily mean that no modifications would be required to movable media such as disk packs, in order to use them in a plug-compatible environment. Interoperability of application functions may affect the ease by which a less than highly trained or skilled user of the system can obtain and use information.

(6) Portability is the ability to move software and data from one hardware environment to another. Portability can be served in several ways. First, portability can be from one hardware environment to a similar or identical environment in a different location if the environment is widely deployed. Second, portability can be

from one environment to a very different hardware environment deployed in the same or different locations. Generally, this enhanced capability is brought about by the use of a standard operating system environment which masks the hardware differences from the software.

4. Microwave and Radio Technology

a. Microwave Links

New terrestrial microwave links are still being installed and many existing links will remain active in the system for at least a few decades. The current wisdom is, however, that the rate of installation will greatly decrease as fiber systems are selected instead. The NSEP implications of this change are difficult to assess. For some kinds of disasters (for example, flooding), microwave terminals located on hilltops would be more survivable than cables of any kind strung across bridges. On the other hand, brush fires are more likely to take out microwave terminals than they are buried cable. If necessary, microwave terminals could easily be shielded from EMP by paying special attention to the receiver front end, although the Committee has not seen evidence that this step need be taken. Moreover, terminals in microwave systems are not as geographically spread as a cable network, but their physical structure would be more susceptible to direct damage from a nuclear blast. A good NSEP strategy might be to have a mix of microwave and fiber cable on key routes, with the expectation that a redundant mix would survive a wider variety of possible disasters than one or the other alone. However, unless something is done to encourage the installation of new, perhaps hardened, microwave systems, the mix will gradually disappear in favor of the all-fiber system.

b. Millimeter Waves

Although there appears to be little interest in the telecommunications industry, higher-frequency microwave and millimeter-wave devices and systems are becoming much more practical and economical than in the past, primarily driven by military technology needs (20-100 GHz). Low-noise, field-effect transistor (FET) amplifiers and higher-power, solid-state sources (Gunn, IMPATT) continue to be developed for these frequency ranges. It should be possible in the near future to build very-high-bandwidth (e.g., 1GHz) links for short-range application that could be economically competitive with the more expensive fiber installations (for example, drilling through the concrete base of a freeway to install the fiber). Intracity (roof-top to roof-top) links for private-business networks could become cheaper than obtaining the necessary right of way to pull cable under the streets. It is unlikely that such links will continue to be installed in the lower microwave bands because of spectrum crowding, antenna size, and the problem of eavesdropping. However, the millimeter-wave region offers at least an order of magnitude larger spectrum, substantially smaller antennas, and greatly enhanced privacy through narrower beamwidths and atmospheric attenuation. For example, at

55 GHz the atmospheric attenuation is 10 dB/km due to oxygen; a 1 km roof-to-roof link with 30dB S/N would have less than -10dB S/N for an eavesdropper 5 km from the transmitter. The problems of interference among users would also be greatly relieved by the narrower beamwidths and attenuating atmosphere, perhaps so much so that the FCC could forgo individual link licensing in favor of a "citizens' band" system. Freedom from interference could not be guaranteed, but the high bandwidths available would make error-free coding much more practical, and the greatly reduced FCC paperwork could make such mm-wave systems attractive to businesses. The Committee does not, however, foresee such applications becoming widespread before the year 2000.

Perhaps the greatest NSEP leverage to be gained from a proliferation of short mm-wave links is the possibility of rapid replacement or relocation of such equipment following a disaster. Additional leverage is, of course, that proliferation in the private sector would add diversity to the fiber links of the telephone operating companies, providing a suitable plan can be worked out to use such facilities in time of disaster. Wide-spread commercial usage of mm-wave equipment by business would also likely bring down the cost of strictly emergency equipment purchased for stockpile.

c. Synthesized Radio

The development of low-power-consumption microprocessors and memory has made a great change in the design of radio communications equipment. In less than a decade analog tuning and crystal control have almost disappeared in favor of digitally synthesized tuning. The current generation of amateur radio equipment, almost exclusively of Japanese design and manufacture, provides quasi-continuous tuning (10Hz steps) by digital synthesis, with a digital display of the same accuracy. Likewise, equipment designed for traditionally channelized amateur radio bands, for example the 144-148 MHz (2meter) band, is typically fully synthesized in 5kHz steps with numeric key-pad entry and digital display to match. The cost of such equipment is amazingly low: a 2- to 30-MHz, single-sideband (ssb) transceiver with 100W output can be obtained for less than $700; a 144MHz, 2W, handheld unit, for less than $300. Handheld units at 432 and 1296 MHz are not much more expensive.

The public service radio system and Federal agencies could benefit greatly from the development of a common set of digitally synthesized equipment, capable of operation on all the service frequencies: fire, police, hospital, public works, etc., both state and federal. The actual access to channels could still be restricted by agency during normal times, for example, with a "normal/emergency" switch, but quickly reconfigured for interagency use during times of emergency when such operation is needed. This is a radio analogue of the "software-defined network." The advantages are manifold: two examples are cost savings in purchase, maintenance, and spares when all agencies use the same equipments; and commonality in training personnel in equipment operation -- in an emergency situation, any officer should be able to use any radio available to make contact with any system.

A system allowing flexible interagency operations has been developed for the 800MHz band and is currently undergoing field trials. Consideration should be given to the development of other common-equipment systems for the lower-frequency public service bands as well, with the hope of improving the usefulness of these bands. Action by the FCC will be required to permit cross-agency operations on the 30-50, 150-170, and 460MHz bands. It would take a decade or more for user agencies to convert to the new common-equipment system, since existing government procurement and budget procedures would likely dictate a slow retrofit policy (governmental budgeting does not recognize depreciation, so there is no natural way to "turn over" obsolete equipment). Maximum compatibility with existing crystal-controlled, single-agency equipment should be sought. The goal should be a single standard equipment that all emergency personnel could use flexibly in time of emergencies.

5. Switching

Emerging technologies for telecommunications switching may have significant NSEP implications. We will consider separately near-term and long-term technological trends.

a. Modular Digital Switches

For the next five years, the dominant trend in telecommunications switching will be the introduction of digital offices. The percentage of subscriber lines served by digital end offices is projected to grow from 8% at the end of 1984 to 26% by the end of 1986, and to continue at that rate through the decade.[1] Besides facilitating the introduction of the Integrated Services Digital Network, new digital switches are both smaller and more modular than previous switch generations.

One consequence is the increasing use of remote switching modules (RSM), typically in units of 256 or more lines, which provide wire termination in a local neighborhood and are linked by (typically optical fiber) trunks to a central control unit, which itself can be several miles away. Where the remote modules maintain some switching capability even when the fiber link to the central control unit is severed, the increased dispersion makes the system more robust. However, for some switch designs, loss of the link means loss of all switch capability. Under these circumstances, vulnerability may be seen to be increased. Moreover, because they reduce wire runs the use of RSMs may lead to larger numbers of lines controlled by a single central office. This also

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[1] Telephony, Jan 16, 1985, p. 46

leads to increased vulnerability. RSMs are not, typically, individually equipped with backup generators, nor are they always powered from the central office. Thus, their use may increase vulnerability to power outages even when the RSMs themselves may still be functional.

Not only RSM's but entire Class 5 switches are increasingly being installed in remotely monitored, unmanned buildings, with attendant reduction in the carrier maintenance work force. As a consequence, there is less total manpower in a region to bring to bear in an emergency, and service restoral may be delayed until skilled personnel can get to the scene. Unmanned switches also pose problems of vulnerability to sabotage.

b. Statistical Switching Architectures

In the longer term (10-20 years), current switch technology may give way to various forms of integrated voice and data switches. Two approaches have received the most research attention: burst switching and fast packet switching.

(1) Burst Switching

Developed largely by GTE, burst switching is based on the recognition that speech consists of alternating bursts of speech and periods of silence with the bursts generally ranging in length from 0.1 to 0.5 second. Silence, while listening or between words, can account for up to two-thirds of the total time of a conversation. Burst switching accommodates buffered data traffic during the intervals of silence between speech bursts.[2] Speech is sent in real time; data may be delayed.

Burst switching operates on existing-wire, local-loop voice channels encoded at the standard rate of 64 kbps. A speech burst is preceded by a 4-byte header which contains address and control information. Upon receipt of a header, a burst switch finds a free 64kbps channel from among the 24 channels in a T1 carrier, and begins to foward the burst down the channel. No attempt is made to buffer the burst before transmission, as is typical of packet switching; thus, required delays are kept to a minimum. Where there is contention between a speech burst and data for an available channel, speech bursts have priority and the data is buffered, as queuing delays for data are more acceptable than for speech.

The GTE design is based on a hierarchy of elements with 16 64kbps channels served by a remote link switch, with as many as 16 link switches distributed along a T1 link. As many as 256 T1 links would terminate at a central hub switch, providing an overall switching capability for up to 60,000 lines. Thus, in addition to providing for the integration of voice

[2]Amstutz, Stanford R., "Burst Switching -- An Introduction," IEEE Communications Magazine, Nov 1983, pp 1-7)

and data, the design is highly decentralized. As a consequence, wire runs are greatly reduced, with a reduction of as much as 80% in the outside plant requirement as compared to conventional wire-pair distribution.

From an NSEP perspective, the distribution of call-switching logic appears to increase the survivability of the overall system. In practice, however, a centralized database is required during call setup to map call requests into logical channel numbers for burst headers. For convenience in database maintenance, it is unlikely that this data will be distributed down to the link level. Consequently, call processing is still dependent upon availability of centralized facilities. On the other hand, data sufficient to process local calls within a link switch might be kept locally. In addition, links could be connected to more than one hub switch; this would eliminate the dependency on a single central hub and allow the network to continue to function even if a hub switch is knocked out. Because much of the switching function has been distributed to the links, replication of hub switches is far less costly, and thus easier to justify, than replication of a conventional central office. Power requirements at any one location are also greatly reduced. Indeed it is possible to construct a hub switch reduced to a size which could fit onboard a satellite.

From a strictly economic perspective, the transmission-line efficiencies promised by making use of the silences between speech bursts and realized in one way by time-assignment speech interpolation (TASI) are rendered increasingly superfluous by the rapidly declining costs of fiber-based transmission. Similarly, the promised savings in local-loop costs are being achieved already through the use of RSMs in the current generation of switches. Finally, the promised savings in transmission materialize only when both ends of a long-haul link are served by burst switches. Thus, much of the benefit will be delayed until and unless such switches can be widely deployed in the network.

As a consequence, the successful commercial introduction of burst switching is far from assured. GTE conducted a field trial in a local switching office in Indiana in late 1985, and will conduct further local trials and a long-distance trial in the Sprint network in 1986. Without external impetus, the Committee thinks this technology is unlikely to be employed outside of GTE even if these tests prove successful, and thus the anticipated NSEP impact will be small.

(2) Fast Packet Switching

An alternative to burst switching which is being promoted by Bell Laboratories is fast packet switching.[3] In burst switching, the actual transmission rate on a channel remains 64 kbps. The absence of any speed

[3]Kulzer, J.J. and W.A. Montgomery, "Statistical Switching Architectures for Future Services," Proceedings of the International Switching Symposium 1984, IEEE, May 1984

change minimizes the need for buffering and allows bursts to be forwarded as they are received. The association of a long burst with each header keeps control overhead to a minimum. However, data packets are also restricted to a maximum 64kbps rate.

By contrast, fast packet switching allocates the entire capacity of a high-speed channel to single voice or data packets in turn. The effective data rate is then determined by the arrival rate of packets, and notby any subdivided rate of the transmission facility. As a result, a fast packet switch could equally well provide a burst rate of several megabits per second to a file transfer request while servicing voice calls which generated packets at an average rate of 64kbps or less.

The need to buffer an entire packet before sending requires that packets be kept short, to minimize the delay associated with accumulating bits for any packet. In turn, short packets increase the percentage of capacity devoted to control overhead. Packet switching also introduces a statistically varying delay into each connection because of the need to buffer packets in the switch. However, if very-high-speed trunks are used, then queuing delays can readily be kept to at most a few milliseconds at each switch.

Conventional packet switching architectures use a single processor to move packets from inbound to outbound trunks, thus greatly limiting their overall throughput. In the Bell Laboratories design, a VLSI-based, shuffle-exchange network provides multiple paths through the switch, allowing throughputs of gigabits per second. Each stage in a shuffle exchange network consists of a row of elements having two inputs and two outputs. An arriving packet is routed to the correct output link according to successive bits in the packet header. The rows of elements are interconnected so that this sequence of binary choices results in routing a packet arriving at any input of the first stage to the final output designated by the packet header. Because of the multiple paths, overall switch throughput is high.

Unlike burst switches, fast packet switches do not lend themselves as well to highly decentralized arrangements. In order to provide multimegabit rates to data users on demand, the switch must interface to high-speed trunks (e.g., DS2 or DS3). In turn, this suggests switches constructed to handle perhaps 50,000 calls at a time. Moreover, as with burst switches, call setup would require communication with a centralized address-to-logical-channel database.

From an NSEP point of view, the adaptability of fast packet switching to varying traffic demands would allow great flexibility during an emergency. Moreover, the necessities of implementing the switch with custom VLSI and of interfacing directly with a few high-speed, fiberoptic trunks result in a physically small configuration with low power requirements. Thus, backup switching equipment could be transported to a damaged site more readily than, and power requirements are reduced compared to, conventional equipment.

The principal advantage of fast packet switching over burst switching is the greater speed range it can handle, including computer-to-computer transfers or even digitized video. It does so at the price of introducing increased average delay into all traffic, including speech. By reducing call setup times to fractions of a second, both systems have the potential to reroute a call around a failed link in an interval short enough that a caller does not perceive a signficant break in the conversation (conventional switches may produce a similar result). Of the two, improvements in call set-up time using CCIS fast packet switching is the more advanced and is also more likely to be widely used in future networks.

AT&T Communications has indicated it is planning to introduce fast packet switching in its network in the 1990s.

c. Standardization and Interconnection

The major impact of introducing either burst switching or packet switching arises from problems of standardization and the need for interfaces to conventional switching architectures. Taking full advantage of fast packet switching would require major revisions to current thinking about the ISDN. While AT&T is in a position to benefit from transmission efficiencies even if implementation is restricted to AT&T Communications (ATT-COMM), users can employ fast packet switching for data only by providing appropriate links to ATT-COMM facilities. Much, though not all, of the benefit of either technology will be lost if compatible switches are restricted only to the ATT-COMM or Sprint networks. Note that both of these interexchange carriers could choose to introduce new switches in their networks even if the interfaces provided at the network boundary were restricted to conventional voice or ISDN standards. If this were to happen, the ability to reconstruct the network by piecing together facilities from several interexchange carriers may be diminished, because intranetwork conventions would differ radically. Nor do we believe it likely that the interexchange carriers could be persuaded to adopt common standards for intranetwork, interswitch communication, especially where they control captive switch manufacturers. By contrast, the Bell Operating Companies, led by BellCore, have every reason to adopt standards for intranetwork, interswitch traffic in order to be able to purchase switches competitively from several manufacturers. Should the Bell Operating Companies be allowed to engage in manufacturing as contemplated in recent proposed legislation, their incentives too would diminish.

d. Other NSEP Considerations

Both burst and fast-packet switching architectures result in physically smaller switches with reduced power consumption. The division of speech into packets with sequential packets from a conversation potentially following different routes results in an inherent increase in the difficulty of evesdropping. Both systems have the potential for assigning different priorities to particular packet sources.

The need in both systems for central databases to provide physical-to-logical address mapping suggests that restoral of switching services following a nuclear exchange cannot proceed readily from the bottom up. If the network map is decentralized and dynamically derived, as described by Baratz, et. al.[4] this problem would be greatly reduced.

e. Recommendations

As intranetwork architectures continue to diverge because of changes in switch design, the NCS will be able to rely less and less on piecing together facilities from separate carriers in the event of an emergency. Only if carriers provide routine, widespread, external access to standardized transmission links (e.g., DS3 or DS4), and themselves use such interfaces internally, will it be possible to make use of links from one carrier with transmission facilities of another. The NCS should encourage the development of standards for such facilities. The Committee does not believe the NCS can be successful in encouraging switch standardization within carriers' networks, with the possible exception of the BOCs.

The NCS should also attempt to influence the development of networks based on the new switching architectures to insure that NSEP considerations affect decisions about 1) priority capabilities, and 2) database replication and recoverability of the network map.

f. Stand-Alone Restarting at Conventional, Digital Switching Sites

A digital switching site has the built-in capability to recover from a failed condition as long as there is power to the switch. After a failure of call-processing functions, the system recovery programs within the switch will attempt to find a working configuration by switching active equipment and initializing. The level of initialization will escalate if the attempts are within specific periods of time. If the automatic initializations do not recover the machine, manual capabilities are provided that will allow maintenance personnel to attempt machine recovery procedures. This manual recovery can be done at the office or remotely from the Switching Control Center.

It is not necessary to have commercial a-c power restored to the building in order to recover the switches. The central offices are equipped with batteries and emergency power sources that, given sufficient fuel, will allow the switch to function until the commercial power is restored. The power demand, and hence the fuel requirement, to support restoration varies with the type of switching installation.

Since the ratio of equipped lines to working lines is subject to a number of local variations (e.g., engineering intervals), the following

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[4]Baratz, A., et.al., "Low Entry Networking", IEEE Journal of Selected Issues in Communications, April, 1985

BUSY-HOUR POWER	SWITCHING SYSTEM
(Base kw + watts/line)	
SXS	2 w/l.
#5 Crossbar	1.1kw + 2.1 w/l.
#5 Crossbar w/ Electronic Control	3.97kw + 2.1 w/l.
Electronic Analog	
Large (over 10k lines)	10kw + 0.75 w/l.
Small (under 10k lines)	3kw + 0.6 w/l.
Electronic Digital	
Large (over 10k lines)	8.5kw + 1.25 w/l.
Small (under 10k lines)	2.5kw + 0.9 w/l.

data is provided on the basis of the number of working lines. Further, all data is based on busy-hour traffic at medium rates [3 or 4 customer calls per second (ccs) per working line]. The power needs of several systems have been combined to provide an average of the power requirements for the system type. The table below shows d-c power requirements. The power from an a-c source will be about 15% above the listed figures because of rectifier losses.

A typical battery plant provides three or four hours of reserve and an engine alternator plant is commonly supplied with about three days' fuel. However, very small systems (less than 3000 lines) may have eight hours of battery and be supported by a portable engine-alternator. The portable systems are frequently shared by two or more such locations. he Committee considers this a severe limitation to recovery in any general outage. As in our Annual Report, we recommend standby generating facilities at every installation, supported with a fuel reserve good for at least weeks, and perhaps months, if recovery from a Threat Model 3 incident (or even Model 2) is to be ensured.

If the switch memory is lost, the back-up tape or disc that contains the database will be loaded as described in III.C.6. No external device is required to reload and initialize the office. All capabilities are contained within the switch to perform these functions.

The major problem encountered by the switch after a restart would be the condition of the outside facilities. Line and trunk seizures caused by shorts, crosses or actual requests for service could cause the machine to overload while attempting to process these requests. Distributed processing used by most digital switches would lessen this effect, and overload programs contained within the switch would prevent the condition from halting call processing. Maintenance personnel would remove these conditions from the switch by opening lines at the protector frame and removing bad trunks from service. Since digital switches are virtually non-blocking, any new originating calls at this time would be switched by the machine.

6. Enhancing Reliability with Deployable Satellite Earth Stations

In just the last few years several new additions to the satellite earth station technology have appeared that now make it possible to install wideband voice or data connectivity nationwide in a matter of minutes or hours so long as the satellite is in place to support it.

The most immediately available of these technologies is the "small aperture earth station" or "personal earth station" technology introduced within the last two years by M/A-COM, Scientific Atlanta, Equatorial Communications, and others. The earth stations use small antennas, often on simple tripod mounts, with lightweight, portable electronics running from house current or battery power, and employ a two-hop path geometry. In this arrangement one small station communicates with another by going up to the satellite; down to a large-diameter, high-power, low-noise "hub" station; then back up to the satellite again, sometimes on a different frequency or transponder, and then down to the receiving station. This strategem allows the stations to be small (4-foot diameter antennas) and of low power (1-2 watts). Low-skill-level personnel have been able to set up such a station, acquire the satellite, and start exchanging 100-500 kbps data streams in 30 to 60 minutes. While this allows small, transportable, low-power earth stations to be distributed, the scheme depends upon the large hub stations for message routing and traffic control. This suggests a level of vulnerability determined by the number of hub stations such a system requires. That may still be less than the vulnerability of conventional satellite communication systems that depend on earth station antennas of 15-, 30-, and 85-foot diameter.

Next on the horizon is the "Mobilsat" technology, operating at 800 MHz. Ultimately, there is the very ambitious plan of NASA to provide an 800-MHz service to very small, personal, portable and mobile earth stations using spot beams from a 60-foot antenna mounted on the Space Station. Inasmuch as the launch of the Space Station is not scheduled to occur until 1992, this technology will not be a useful component in the NSEP repertoire for a long time, but because satellites intrinsically provide "instantaneous any-to-any station reachability" when they are launched and activated, a large NSEP capability could come on line over a very short time period in the mid 1990s.

7. Optical Fiber Link Capacity

a. Introduction

Developments in optical technology in the past two decades will result in major changes in the topology of telecommunications systems. In the mid-1960s it was accepted that satellites would play a major role in long haul links, supplanting terrestrial, atmospheric microwave and buried coaxial cables. It was also anticipated that businesses would own or lease channels on private satellites to form private, corporate networks as the satellite technology developed and costs decreased. The strongest advocates envisioned that all telecommunications, even short-haul, site-to-site, and building-to-building links, would go via satellite. The objections raised early by AT&T on the degradation of the quality of two-way voice service caused by the 0.5sec round-trip delay were ignored in this early enthusiasm. Indeed, the public seems to have accommodated somewhat (or become resigned) to the "push-to-talk" nature of satellite connections. Undersea cables were also clearly rendered noncompetitive by satellites.

b. Near-term Optical-Fiber Links

The dramatic year-by-year reduction in the attenuation exhibited by glass fibers during the past two decades has resulted in a turn-about in this situation. Today's fibers exhibit attenuation less than 0.2dB/km at 1.5 m and less than 0.7 at 7 m,with link route-bandwidths well in excess of 10 GHz-km or route-data rates in excess of 10 Gbit-km at cable costs less than $1000 per km for single mode fiber, exclusive of installation and rights-of-way costs. Losses one or two orders of magnitude lower still are projected for fluoride glasses at longer infrared wavelengths. With these parameters, optical fibers are now likely to supplant satellites for most high-density telecommunications routes between fixed points, including overseas traffic. Satellites will still be a major means of broadcast-type traffic, traffic between mobile or relocatable terminals, and low-density, fixed-point routes, but fibers will most likely take the rest on sheer economics. And the 0.5-sec delay problem will largely disappear in the bargain.

Optical-fiber links for land-based installation will remain simple in their terminal equipment and repeater structures. A typical gigabit, long-haul link for the next decade will likely consist of a single-mode fiber operating at 1.3 to 1.8 micrometers (μm) wavelength, an appropriate quaternary-alloy diode laser source with the bit stream directly modulating the laser current, and a simple diode detector. If repeaters are required, they will contain the same detector and laser combination, with amplification or pulse regeneration done electronically at baseband or some intermediate-frequency range. Optical amplification or other optical signal processing will not be employed. Likewide, switching will continue to be an electronic process rather than become an optical one. Trunking between central offices will also be all optical fiber, with many parallel fibers, and no repeaters for distances shorter than about 20 km. These trunks could have, and likely will have, a great deal of excess capacity, since the cost of the extra fiber links will be substantially cheaper than present day costs for the same capacity. The excess capacity will likely be used to simplify the trunk rerouting problem greatly.

Another change that could be brought about even by today's optical-fiber technology is the connection of every telephone subscriber to an end office with a high-bandwidth link, say 100 MHz. If it becomes at all economically feasible to use fiber connections directly to the end user, then the high-bandwidth capability could be added at little cost for a cable-TV-like system. Of course, switching each line at this bandwidth would be another matter entirely, but a broadcast system would be relatively inexpensive. Such systems may be proposed by the operating companies, but their future use may well be dictated by FCC action rather than the marketplace. If the telephone operating companies are excluded from the cable TV (CATV) market, it is still likely that the CATV companies themselves will use optical fiber systems. Indeed, one of the major attractions of fiber for the CATV companies should be their freedom from pickup and radiation and the resulting interference now commonly caused by corroded and loosened cable joints. Although recent tests have shown replacment of metallic strength members with nonmetallic ones in optical-fiber cables unnecessary for EMP protection, it is quite important to protect repeater and terminal electronics from pulses that could come through the power supplies. That can easily be accomplished with simple, inexpensive, penetrator protection: e.g., gas tubes or zener diodes. A surviving CATV broadcast system with emergency power capability would be a valuable redundant asset to the standard TV and FM broadcast systems.

c. Longer-term Optical-Fiber Links

Undersea cables place a higher premium on longer repeater spacing and will likely drive the development of the lower-loss, longer wavelength, fluoride fibers. Very recent results in several laboratories indicate near-ideal behavior (Rayleigh scattering losses alone) is possible. This would result in one or two orders of magnitude lower transmission loss and may make possible undersea cables of 1000 km without repeaters. Of course, satisfactory lasers and detectors would have to be developed for this wavelength range, 2-7 μm. The most promising approach for such devices is to use multiple-quantum-well materials. Such materials, made of many very thin (100 Å) layers of semiconductor materials, can have properties tailored to a specific wavelength range. Actual devices are currently at a very primitive laboratory stage. Once these fibers, lasers, and detectors are developed for the premium, undersea-cable application, their costs will likely decrease, and they will find applications in future, land-based, optical-fiber links. Eventually, the vulnerabilities of these components will have to be determined for the NSEP environments.

d. Optical Switching and Signal Conditioning

The recent history of developments in optical communications technology has, indeed, been spectacular, but not necessarily along the lines first predicted for it. In the earlier days, the development of optical communication systems was anticipated to take the same course as earlier microwave development; the 1969 article by Miller[1] on integrated optics

[1] S.E. Miller. Bell Systems Technical Journal, Vol. 48, p. 2059, 1969.

illustrated how most of the optical elements analogous to existing microwave communications hardware could be realized in optical waveguides near the surface of a two-dimensional substrate. Most of Miller's device illustrations (e.g., directional couplers, band-dropping filters, switches), have by now been demonstrated in the laboratory. However none have found their way into operational fiber systems because the system economics have driven optical-fiber link design in directions quite different from microwave systems. Likewise, optical amplifiers have been demonstrated in the laboratory for two decades, but none have found their way into low-level, low-noise signal amplification.

Today's fiber links are operating up to 1 Gbit/sec with simple, direct, intensity modulation of the GaAs laser and direct (incoherent) detection with a diode detector. Recent advances in both laser and detector technology make it clear that simple, digital, intensitymodulation links are practical in excess of 10 Gbit/sec. It is somewhat less clear that simple, intensity modulation of analog information with 10 GHz bandwidth and good signal-to-noise performance is as practical; the inherent noisiness of today's high-speed lasers and the additional noise caused by even minute amounts of optical feedback are much more harmful to analog links. However, it is reasonable to expect that these problems will be overcome in the future. External modulation with integrated, optical-waveguide modulators has been demonstrated with 20GHz bandwidth in ion-implanted $LiNbO_3$ and at lower rates in GaAs. The $LiNbO_3$ optical losses are to date somewhat too high for practical devices. Avalanche diode detectors have exhibited bandwidths in excess of 20 GHz.

Optical multiplexing[2] can be used to achieve more than 10-20 Gbit/sec per fiber, if that were to prove economically desirable. Waveguide/grating multiplexers have been demonstrated that combine 10 wavelengths with greater than 25 dB isolation between channels and insertion loss of under 3 dB.[3] The demonstration was accomplished with multimode fibers, and may not be as good with single-mode fibers, particularly in insertion loss. Dichroic combiners using multilayer interference filters have been proposed to combine two wavelengths.[2]

Miller's resonant-cavity, band-dropping filters have not been implemented to date because of the rather lossy nature of the basic waveguide in integrated circuits. One problem in all multiplexing schemes is the precision control of the individual laser wavelengths and the added optical complexity of coupling N lasers and N detectors to the multiplexer. The maximum limit to the number of channels thus combined is determined by the dispersion of the fiber. To minimize dispersion the core size of the single mode fiber is chosen so that the waveguide dispersion just cancels the material (glass) dispersion. However, this exact cancellation occurs at only one wavelength and a typical laser has

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2 W.J. Tomlinson. Applied Optics, Vol. 16, p. 2180, 1977.
3 R. Watanabe, K. Nosu. Applied Optics, Vol. 19, p. 3588, 1980.

a linewidth of 0.1nm (100Å). Thus, today's components limit ultimate link capacity by a residual dispersion of roughly 1 picosecond/km or hundreds of Gbit-km. Some reduction in laser linewidth and better frequency control to tune to the dispersion minimum should be possible through future technology improvements. However, 10km, 10Gbit links are feasible today with single lasers. Multiplexing additional lasers will increase this capacity, but not proportionally, since only one laser can operate at the minimum dispersion wavelength.

C. Organizational Relationships in Industry and Government

1. Fiber-Optic Networks in the Telecommunications Industry

This discussion considers the installations of fiber-optic networks and systems in the United States. It will provide an overview of the progress of the technology and identify the major players and their announced plans.

a. The Technology

The technology used in fiber-optic networks has been advancing at an astonishing rate. A couple of years ago the debate was about when single-mode fiber would replace multimode. At that time the cost of single-mode electronics and fiber was considerably higher, but it has fallen rapidly. Moreover, single-mode offers much greater repeater spacing. The two factors, declining cost of the electronics and increasing repeater spacing, indicate clearly that single-mode fiber will dominate in intercity communication systems. Multimode fiber may still have a major role to play in the local areas, where repeater spacing is not as important.

At the same time, the capacity of a fiber pair has increased dramatically. As recently as a year ago 90-megabit systems were the norm. Now, 405 megabit systems are being installed, and 560-megabit electronics are available for delivery from 14 suppliers. Rockwell promises to upgrade its 560-Mb system to 1.2 gigabits within one year, Fujitsu is showing a 1.8-gigabit system in its laboratories, and AT&T has done experiments at 4 gigabits, but plans to introduce 1.8 in 1988.

b. The Players

Someone has calculated that if all the announced fiber networks were built, there would be nine billion fiber circuit-miles installed in the U.S. alone. Compare that figure with AT&T's current network of approximately one billion circuit-miles and one has to wonder how it all could be used. A potential capacity glut of that size means that considerable agonizing must be underway on the part of the latecomers. Those simply using fiber to expand their present networks (e.g., AT&T and MCI) can adjust their plans to the growth of their own traffic. Others who are essentially new entrants to the transmission market must focus very heavily on financing and, above all, marketing if they are to have any chance of success. With all the competition for traffic by various players investing in new fiber facilities, consolidation of resources may be expected.

There are four categories of players in the game; the national networks, regional carriers, consortiums of regional and local carriers, and the local exchange carriers. Plans and the status of their implementation are sketched below for some companies in each of these categories.

(1) National Networks. These include AT&T, MCI, and the recently announced, merged networks of GTE and United Telecommunications. AT&T plans a nationwide fiber-optic system, at one time forecast to be over 150,000 circuit-miles by the end of 1986, using 405-Mbit technology with plans to upgrade to 1.8 Gbits in 1988 and have 18,000 route-miles in service by 1989. MCI, intending to build its own facilities, had acquired 7300 miles of railroad rights of way and is continuing to acquire, talking about building in all parts of the country where it has such rights of way. Unwilling to amortize its analog microwave system prematurely, MCI now seems to be planning fiber-optic construction only where the marketplace warrants: a position taken before its acquisition of SBS from IBM in exchange for IBM's 16% interest in MCI, which expected to have 2500-3000 route-miles of fiber cable installed by the end of 1985, operating at 405-Mbit rates. GTE and United Telecom, having recently announced a "partnership" of their long-distance and data-exchange subsidiaries, will share facilities. United, planning to construct a nationwide (fiber-optic) network that eventually would reach into all LATAs, has also contracted to build fiber-optics links for Lightnet (see below): it will purchase fiber-pairs from Lightnet along the routes it builds. Twenty-eight percent of United's planned, 23,000-route-mile network was planned to be in operation by the end of 1985.

(2) Regional and Local Carriers. Lightnet, a joint venture of the CSX Railroad and the Southern New England Telephone Company, has a fiber-optic network that now connects 23 cities east of the Mississippi River. Its plans envision a 5000-route-mile network serving 43 cities in 24 eastern states. In addition to its own approximately 1600 route-miles of construction, about 2000 more were expected to be completed by the end of 1985. Fibertrak, a joint venture of the Santa Fe, Southern Pacific, and Norfolk and Southern railroads, had announced plans to build an 8000-route-mile, $1-billion net- work, but suspended operations in the face of what it saw as a capacity glut. RCI Corporation, a subsidiary of the Rochester Telpehone Company,

plans to purchase capacity on the Lightnet system for access to New York, Newark, Philadelphia, Baltimore, and Washington, and expected to complete a fiber system running between Buffalo and Chicago by the end of 1985.NTN, a consortium of seven regional, fiber-network companies, has interlinked a total of 2424 route-miles of its members' independent, regional, fiber-optic networks in two separate links: LDX and Consolidated, 1525 route-miles centered on St. Louis; and Microtel and Southland Fiber Net, 899 miles centered on Tallahassee. Linking is done by cross-connecting electrical signals at fiber junction points. The table on page 60 shows the status of the consortium members' systems at the end of January 1986.[1] Litel, owned by LCI Communications, is planning its network principally in Ohio, to work at 565-Mbit rates. LDX, privately owned, plans its network to provide services in six states: Mississippi, Louisiana, Arkansas, Texas, Oklahoma, and Kansas. Microtel, owned by Centel, Allnet, M/A Com, E.F. Hutton, and private investors, plans its network largely in Florida with a northern extension to Georgia, and will operate it at 405 Mbits. SouthernNet, a venture of what had been Southern Telephone, Interstate Communications, Inc., Norfolk and Southern Railroad, and E.F. Hutton, will interconnect with Microtel in Atlanta and plans a fiber system from there to Washington, probably operating at 405 Mbits for compatibility with Microtel. Southland Fibernet, now connected with Microtel in southern Georgia, plans to extend across the Florida panhandle, across southern Alabama, and into Louisiana to connect with LDX outside New Orleans. Williams Telecom, a joint venture of Teleconnect Company and Williams Pipeline Company, plans to run fiber cables operating at 405 Mbits through the Williams Company's out-of-service, underground, petroleum pipelines. Its network is planned to run from Chicago to Kansas City via Omaha, Des Moines, and Cedar Rapids, with later extensions to Minneapolis and Tulsa. It expects to connect with LDX and Litel. An eighth venture, Norlight, has initiated negotiations to become a member of the NTN consortium. A joint venture of five electric utility com panies, it has planned a 56Mbit/sec network to link Milwaukee, Madison, La Crosse, and Eau Claire with Minneapolis and Chicago.

There are other ventures in local regions, but these suffice to indicate what is taking place.

(3) Local Carriers. The RBOCs are aggressively installing fiber cable in their respective areas. Much of this activity seems to be aimed at heading off the threat of bypass. Ameritech has 40,000 circuit-miles of fiber in the ground and plans to add about 45,000 miles in 1985. About 45% of Ameritech's capital budget for 1985 will be spent on fiber or

[1] Communications Week, January 27, 1986.

	Planned	Route-Miles Complete	Operational
Consolidated Network	731	285	0
LDX Net	2100	1240	1012
Litel	1561	905	675
Microtel	1294	663	556
Southern Net	1250	376	105
Southland Fiber Net	332	236	69
Williams Telecom	3571	304	0
Totals	10,839	4009	2417
		37%	22%

digital facilities. Principal uses are to connect downtown business areas, intercity transmission facilities and switching offices. Bell Atlantic intends to have about 50,000 circuit-miles of fiber in the ground by the end of the year. Extensive facilities around major corporate complexes are included in northern New Jersey, Wilmington, Delaware and Washington, D.C. BellSouth has started signing up customers for Lightgate, a fiber exchange service that allows customers within South Central Bell's intraLATA districts to lease capacity over optical-fiber pairs. Pacific Telesis has about 42,000 circuit-miles in the ground now and intends to build a network to interconnect the Silicon Valley complex. It also has an 819-mile system from Sacramento to San Diego under construction for its internal communications needs.

U.S. West has signed supplier agreements with Telco Systems and Northern Telecom. Southwestern Bell claims to have installed more than 160,000 miles of fiber-optic circuits.

c. Some Conclusions

1985 seemed to the Committee to be the year of peak activity in fiber-optic network planning and implementation. All plans call for single-mode fiber, with bandwidth essentially limited by available terminal electronics.

Some think there is only room for three, or at most four, national networks, and for a few regionals in areas with the heaviestcommunications traffic. But at least 10 major networks are now in various phases of implementation. In the view of some Wall Street skeptics a shakeout may be impending and only a few of the planned networks will actually be successfully completed. It is clear that some in Wall Street are nervous about what looks like a developing glut. Hence, availability of risk capital is affected.

Foreseeing a glut may also induce major system users to enter only short-term contracts, as over-capacity would inevitably produce lower prices. The early starters have a distinct advantage at this time.

d. Considerations for NSEP Planners

Multiple routes are operating, planned or under construction among several major cities. Among the more important are New York-Washington, Washington-Atlanta, Atlanta-Miami, Washington-Chicago, Houston-Dallas, New Orleans-Dallas, and San Francisco-Los Angeles. Competition should therefore be maximium along these routes. The OMNCS should seize opportunities to get the competing systems appropriately hardened and interoperable while construction is still under way.

Many other city pairs are now being connected by multiple-fiber routes, for example: Atlanta-Jacksonville, Miami-Orlando, Orlando-Tampa-Jacksonville, Dallas-Fort Worth, Baltimore- Philadelphia-Washington, and Kansas City-St. Louis-Chicago.

Note that both of the above examples show city pairs where multiple routes are available. It is still early enough in a rapidly changing scene characterized by a lot of "hype" to warrant caution about betting on the success of a sole supplier (with, of course, obvious exceptions like AT&T; but even there, some scaling back of original enthusiasm is in evidence).

While little precise informaion is generally available about pricing, it is clear that price is negotiable, volatile and dropping. The rapid growth in the capacity of the electronics (90 megabits to 1.2 gigabits in just a few years) should exert further pressure on prices, as should the multiple-carrier enviroment. For these reasons, relatively short-term leases appears to be the best near-term strategy should the government decide to lease DS-1 capacity and derive its own channels using multiplexers to save money, control routing of critical circuits, and gain the increased resistance to EMP and intercept that is characteristic of fiber-optic systems. For the longer term, tradeoff decisions will have to be made on capital expenditures portions of annual budgets and on control versus flexibility.

Several of these new ventures planning fiber-optic networks have little or no telecommunications experience. The absence of a core management team experienced in the operation and maintenance of long-haul communications systems should be a warning signal. Some problems once believed to have been solved forever in older technology (e.g., "jitter") are recurring when some fiber and radio systems are interconnected. This is not to say that such problems cannot or will not be resolved, but the Committee believes that the NCS would prefer to deal with experienced management when the unexpected arises -- as it will. This is particularly critical under emergency conditions, when NSEP recovery procedures should be in experienced hands.

2. Changing Relationships in the Communications Industry

In its Annual Report the Committee discussed the proliferation of new entities providing telecommunications services (e.g. private carriers, transmission condominiums) and the growth of private networks. We argued that current tariff policies, particularly the use of carrier common line charges (CCLC) to recover costs of non-traffic-sensitive plant, was leading many large companies to construct private networks using their own switches and leased or custom built transmission links.

In the year since that Annual Report these trends have continued, with many additional companies, such as Boeing, going down this path. At the same time, other changes have occurred which may mitigate these trends. In June of 1985 customer access line charges (CALC) of $1 per month for residences were introduced, with little public outcry. These charges are scheduled to increase to $2 in June of 1986. If a CALC can be successfully substituted for the current CCLC, the incentive for private bypass networks would be reduced.

The carriers have also become more aggressive in introducing services to compete with private networks. In particular, the software defined network offerings of AT&T, United Telecom and others provide a carrier-based alternative for users requiring customized services. Similarly, the BOCs have begun introducing advanced Centrex features that allow them to compete more effectively against PBXs.

The Committee also stressed in its Annual Report the structural constraints under which AT&T and the BOCs were operating with respect to the integrated provision of various services. In the last year we have seen the FCC drop its restrictions on AT&T's joint marketing of CPE and basic services, and initiate a rule-making (Computer Inquiry III) designed to relax the constraints on the provision of enhanced services. Legislation has even been introduced that would eliminate the MFJ constraints on the RBOCs' entry into long-distance services or equipment manufacturing.

These trends confirm our belief that the choice between privately operated networks using customer-owned switches and common-carrier provided services will be a major battleground in the new, competitive, telecommunications marketplace. The choice will rarely be a simple one. The relative merits of these alternatives will continue to depend heavily on public policy decisions, foremost among them the implementation of CALCs. The government was among the first to deploy a large private network when it built the FTS system in the 1960s. The continued migration towards private networks by large firms is evidence of the value of this approach. The government should continue to monitor the trends of leading private firms in this area for signs of a shift back towards carrier-provided services such as SDN, which may serve as an early signal of the need to re-evaluate the government's approach towards networking.

a) Private networks and compatibility

In the discussion of switching technology (III.B.5.) the Committee observed that there was little incentive for standardization of inter-switch, intranetwork protocols by interexchange carriers. For similar reasons, the growth of private networks is likely to lead to increased divergence in intranetworking standards. Many private networks are being configured using equipment provided by PBX manufacturers who do not sell to the carriers, and who have little experience with carrier conventions except at the public interfaces to the network. Thus, while private networks may lead to the construction of alternative switching and transmission paths, interconnection of these resources with the public network on a piecemeal basis in an emergency will likely be difficult.

b) Identifying Private Communications Resources

The growth of private networks means that these resources will account for an ever larger fraction of the nation's total communications infrastructure. Mountain Bell Telephone already estimates that the total capacity of privately assigned microwave frequencies in Colorado is greater than the microwave capacity assigned to carriers. As a consequence, identification of such resources in an emergency should be a necessary part of NSEP preparations.

In a later section we discuss steps that local bodies might take to ensure that data about private communications resources can be obtained in an emergency.

3. The Role of the NCC

This Committee and its predecessor have both recognized the NSTAC and its creation, the National Coordinating Center (NCC), as an important means of using the resources of industry to assure continuity of service and reconstruction in emergency circumstances. The NCC has now been operational for about two years. Its objectives, as described in its charter, appear appropriate to the need, but it is too early to judge whether their achievement is a reasonable expectation in the near future.

In considering the adequacy of the NCC it is well to keep in mind certain obstacles that are inherent in the present situation:

- Among the older common carriers (e.g., AT&T and Western Union) there is a long tradition of cooperation in times of emergency. Among the carriers formed in recent years, and particularly since divestiture, there is no tradition, and competitive pressures tend to work against cooperation.

- The legal and procedural constraints on getting things done in the NCC are substantial, in part because of fears of anti-trust allegations, and also in part because of the partial staffing by representatives of potentially competing firms in a bureaucratic environment.

- Leadership within the NCC is, necessarily, supplied by the government and current practice is to do so through a military officer serving a limited tour of duty. The experience, resources and authority of this leader differ in both amount and form from that to which the commercial representatives are accustomed.

- While all of the constituent agencies of the NCS have an important interest in the success of the NCC under emergency conditions, one -- the FEMA -- also experiences a significant degree of overlap with its day-to-day responsibilities. The significance of this has not been fully developed. That must be done before working relationships will become effective. The Committee is concerned about the absence of a full-time FEMA member of the NCC.

- The current industry membership represents common carriers only, but there are others who will have contributions to make that are important to the NCC objectives. How these contributions should be secured is a question which has not yet been addressed.

Given these obstacles, it is not surprising that the performance of the NCC to date has stimulated few accolades from either participants or observers. Given both the challenges and the time spent, it would be surprising if it had done so. The Committee believes that these obstacles can and should be overcome through modifications of structure and procedure, and through experience. In particular, the government has not yet asked the NCC participants to accomplish more than that of which they appear capable. It should do so; the danger lies not in asking too much, but in asking too little.

The Committee suggests the following specific steps that might be taken now to further improve the performance of the NCC:

- The Department of Justice should convene and chair a meeting of the General Counsels of corporations that participate in the NCC, with participation by the FCC and other government agencies, to review the risks associated with cooperation among competitors in the interest of NSEP telecommunications, and to determine if these present any serious impediment to the cooperation desired.

- The Committee notes the appointment of a civilian Deputy Manager of the NCC from the OMNCS. The leadership of the NCC should be provided by a Manager from the OMNCS (as is now the case), a NCC Deputy Manager, an NCC Assistant Deputy Manager from FEMA, and a third person (possibly a second NCC assistant deputy manager, but the title is unimportant) drawn from industry. Neither of the two added leaders should come from existing NCC personnel; both should be from a higher level of management. The industry assignment need not necessarily be full-time, but the Committee feels that the FEMA assignment should be because of FEMA's very heavy role in emergency management.

  The industry's NCC assistant deputy manager should be furnished by one of the carriers represented in the NCC, and the assignment to provide such a person should change biennially, rotating among the NCC participants who are willing to make their resources available. The presence of the carriers' officer in the leadership structure will give the participating carrier representatives a spokesman of their own to ensure that they are fully utilized as an NSEP resource.

The FEMA official within the NCC leadership structure should be drawn from the state and local emergency management section of the FEMA organization, and should establish and maintain channels, or utilize existing FEMA channels, into the states' Governors' organization for emergency preparedness. This person will also ensure that planning in the NCC is supportive of planning at the state and local government levels.

- There are telecommunications resources of uncertain but possibly large proportions within the private sector of the economy exclusive of the common carriers. Some, for example, of the broadcasting industry have a recognized role in NSEP planning; others, like the railroads and petroleum pipelines, do not. Major corporations, such as Citicorp, also have resources and others, like General Motors, are considering or making acquisitions (e.g., General Motors' acquisition of Hughes Aircraft and its satellite communications and broadcasting subsidiaries).

  The NCC does not have official liaison with these private resources, which might be the only remaining link between a disaster area and surviving sources of help in an emergency. The best means for setting up a channel of communications and support to tap these resources is not clear. What does seem clear, however, is that such resources will be needed on a local scale rather than on a national scale. It may be, therefore, that efforts to identify these private resources and to establish working arrangements with their owners might be undertaken through FEMA channels to state and local officials.

4. Management and Coordination With Industry Outside the NCC

The primary channels for achieving coordination with industry in emergency circumstances are the same channels that are used to arrange for service to NCS member agencies in normal circumstances.

- Suppliers to the NCS holding contracts for telecommunications services maintain direct relationships with the NCS relating to those services. This is the most effective channel for coordination of matters that pertain to existing services and their curtailment, expansion, and modification. To the best of the Committee's knowledge this channel works well within its intended limitations, and it is the primary and initial means for restoration of NSEP services.

- Actual and would-be suppliers to the NCS maintain regular working relationships through procurement offices and procedures. This is the primary and initial means for securing new and additional NSEP services. It is also (or should be) a resource for exploring and examining new and potentially valuable opportunities in telecommunications as advancing technology drives competitors to offer new and improved services.

In addition, there are existing arrangements through which the NCS staff participates in the development of standards. In view of the many opportunities now available to influence important decisions, it appears that additional resources could be assigned to this effort with the expectation of worthwhile results. NSEP needs should be made known clearly and standards, once adopted, should be recognized and used by the federal government.

All of the above channels should be used by the NCS staff and by the NCS member agencies to make known to industry the needs of federal, state and local government with respect to NSEP. There is no single channel that is preferable to the exclusion of others, but some are better than others for a particular purpose. For example, much of the detailed planning with industry can best be performed at the state or local levels through FEMA channels.

For the examination and joint consideration of policy matters, the NSTAC is a unique resource which, like the NCC, the Committee believes has not been pressed hard enough to determine its limits. The NSTAC, its principal support group, the Industry Executive Subcommittee (IES), and the IES Working Groups, Task Forces and Committees offer the most recently developed opportunity to bring the resources of industry to a focus on NSEP issues. The breadth of its coverage of telecommunications-related industry and its high-level representation are two important characteristics of the NSTAC. A third is its independence in setting its own agenda, for its deliberations need only be related to national security/emergency preparedness and telecommunications.

The Committee has observed over the past 18 months that subject matter considered by the NSTAC has emanated largely from within the NCS staff. We feel that opportunities exist for the NSTAC to become more effective and of appreciably more value to the NCS and to the national objectives of NSDD-97 by having NSTAC agenda items come from additional sources.

It would be preferable to establish regular procedures for seeking agenda suggestions from all NCS member agencies directly and from other agencies of government, Federal, state and local, and from the NSTAC and IES members themselves. The current examination of mobilization is one, and perhaps the only, example of a topic raised by the NSTAC members independently of any government agency input.

In particular, the National Security Council should be a source of agenda items for the NSTAC, without depending upon the NCS staff to search out and present such proposals.

There is no other comparable resource available to the government in the field of telecommunications. The NCS staff has been cautious rather than bold in the way it has sought to use the NSTAC. In its final report to the NCS,[1] however, our predessor committee recommended twelve possible problems (unclassified) for NSTAC review. The Committee endorses those recommendations and repeats them here for the NCS' convenience.

"Using the NSTAC as an NSEP Telecommunications Resource.

"Since the NSTAC membership comprises Chief Executive Officers of the largest U.S. corporations having interests in telecommunications, it can be used to reach lasting agreements that will ensure industry government cooperation in NSEP activities. The Committee suggests twelve possible problems for NSTAC review, and recommends that the NCS pursue them.

> "1. Joint planning for NSEP purposes: Lay out the main course to be followed, and set limits. Describe in general terms the kinds of working relationships required among the companies represented, then between them and the NCS.
>
> "2. Establish a permanent structure, possibly within the National Coordinating Mechanism (NCM), for advising the design of commercial communications facilities and networks so as to facilitate their survivability as functional networks and their ability to interoperate or reinforce one another in reconstitution activities.
>
> "3. Delegation of authority, within limits, under emergency conditions (not just under crisis conditions!): The NCM established by NSTAC at the urging of the NCS appears to be the way the industry and government propose to replace the present working arrangement with AT&T to achieve and maintain a state of readiness for NSEP in the telecommunications industry. To what extent will they delegate authority to such an organization?"

This is a corollary to the challenges the Committee has posed for the NCS and the NSTAC in this and the preceding section. It still applies.

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[1] Telecommunications Initiatives Toward National Security and Emergency Preparedness, CONFIDENTIAL, National Academy Press, Washington, D.C., February 1984.

"4. Resources for restoration of facilities during recovery operations: their storage, sharing, allocation, etc.; and procurement and orderwire systems to ensure that all available commercial resources can be used quickly to respond to government needs.

"5. Determining the potential commercial value of the interoperability of separate networks, to provide guidelines to the NCS on what might reasonably be expected in the absence of any overt initiatives.

"6. Acceptable ground rules for funding whatever is needed beyond what has commercial value, or that might appropriately be made mandatory for all carriers.

"7. Provisions in legislation that might be desirable in order to:

a. Facilitate the degree of joint activity which NSTAC members believe to be necessary;

b. Assure recognition of priority systems established by, or in cooperation with, the NCS, and

c. Assure direct funding of resource requirements which might otherwise not be made available to fill NSEP needs.

"8. Examining the need for, and the practicality of, using non-common-carrier industry communications facilities, in emergencies, to piece out or supplement the common-carrier networks.

"9. Defining the data base problem at each of three levels:

a. Data bases and operating computers that are necessary in order to maintain communications capability;

b. Data bases and operating computers that are needed by other industries and agencies of government upon which, in turn, communications systems may be dependent in times of stress; and

c. Data bases and operating computers that are essential to the restoration of a minimum level of civil and governmental activity following disasters.

"10. Determine general guidelines which might be followed in search of solutions the problems of data bases and operating computers.

"11. A permanent structure, if necessary, to address the design of data systems and networks so as to asure their survivability.

"12. An examination of the resources and procedures which grow out of all of the above, with a view to:

a. Their exercise under normal conditions to assure their ability to function under abnormal conditions, and

b. The transition period between normal and crisis conditions, to assure a smooth changeover under stress."

With the passage of time since the recommendations were first made in 1984, the Committee anticipates that the NCS and the NSTAC will have found additional problems for their consideration.

5. Integrating Joint Management of NSEP Telecommunications with Industry and with the State and Local Entities

The national planning effort for NSEP telecommunications has thus far been limited to that represented by the NSTAC entities. These are largely the communications service suppliers and a limited set of equipment suppliers. The NSTAC has caused the creation of a National Coordinating Center (NCC) to manage the critical actions of NSEP functions. Neither the NSTAC nor the NCC staffing includes representation of privately owned (noncarrier) industrial telecommunications resources, nor does it include state and local entities.

In its Annual Report the Committee emphasized the vital role of state and local participation in NSEP activities, and is gratified to see OMNCS action. In response, the OMNCS has given a presentation on the NSEP Telecommunications Service Priority (TSP) baseline requirements to the states, specifically, to the National Association for State Information Systems (NASIS). In so doing, the OMNCS has asked the states to participate in the Telecommunications Service Priority (TSP) system. The Committee is pleased to learn that the OMNCS is now working with the National Governors Association on such participation.

The Telecommunications Committee of NASIS has reviewed the TSP Baseline Requirements. Its review resulted in a "brief" that took exception to lack of involvement of state and local entities in the TSP process, taking strong exception to having TSP and, indeed, NSEP requirements and plans, imposed upon the states by the OMNCS and FEMA.[1] Proceeding constructively, the Telecommunications Committee has taken the opportunity offered by the OMNCS' implied request for state and local entities' participation in the TSP process to launch an effort leading to direct participation in the entire NSEP process. To get such participation it prepared a resolution for adoption by the NASIS Executive

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[1]NASIS Telecommunications Committee "Brief on 'TSP System Concept (Draft)', Prepared by the Office of the Manager, National Communications System;" October-November 1985.

Committee.[2] The resolution, like the brief, remarked on the lack of recognition of the need for bottom-up involvement in NSEP activities and, in particular, asked that further action on the TSP plan be delayed until state and local participation were ensured. The resolution was adopted on December 8, 1985, and, with the brief, will be introduced to each Governor. That action is expected to lead to a joint Governors' request to the National Security Council for direct representation of state and local entities in the NSEP process.

The states see that baseline NSEP requirements are prepared by federal agencies for federal agencies. Some of the states are responding to the OMNCS request to identify NSEP circuit requirements. They believe strongly that their role should be much larger, and contend that sections 3.(b)(2) and 3.(b)(3) of Executive Order (E.O.) 12472 do not grant authority to FEMA for planning and coordination of the state and local NSEP requirements. Nor do they concede to FEMA the capability of doing their planning and coordination for them. The states envision a more comprehensive role that will permit ultimate satisfaction of restoration and reconstitution both of their own facilities and services and those of others requiring facilities under state jurisdiction. They do not believe that FEMA can adjudicate their differing requirements.

In its Annual Report and again in this report (II.C, p. 15) this Committee has recommended that the state and local entities be made a part of the NSEP planning activities. The process that has now begun with NASIS should eventually lead to such participation, and perhaps to effective bottom-up response capability. When that issue is resolved, state and local participation in the management of NSEP actions will be a natural outcome, and the OMNCS may even expect that active participation in the NCC will follow.

Representation and participation of privately owned telecommunications resources in the NSEP structure is a complex issue that requires further study. It is not obvious who should, or could, properly plan the integrated participation of industry or institution-owned resources such as the systems owned by Citicorp, Colonial Pipeline, American Express and others. The FCC has requested that private radio licensees be represented in the NCC. It is not clear that such action covers the necessary scope of participation for all of these private-industry entities. Greater involvement, perhaps from the NSTAC level, may well be needed to ensure that all aspects of planning and management are effectively integrated into the NSEP process.

Full integration of all resources that can contribute to NSEP robustness should be an NSEP objective. Such full integration will take time. The Committee recommends that the NSEP Telecommunications Plan of

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[2]Resolution on State/Local Government Involvement in NSEP Telecommunications Service Priority; October-November 1985.

Action be amended to reflect this objective. Concurrently, the appropriate studies and tasks should begin with the participation of both the state/local and industry participants in planning for integration of their telecommunications resources into the NSEP capability.

6. Plans and Records for NSEP Management Support

The Committee and its predecessor have discussed the documentation needs of NSEP advanced planning in prior reports. Inventories of available resources, where they are, and who knows how to use them are fundamental for NSEP telecommunications support. In addition, lists of key personnel and their locations, and simple, standard procedures for restoration, reconstitution, and operation of the systems are needed at all operations centers. Records of such documentation, including information about its locations, are essential for management support. The larger interexchange and local-exchange carriers have such plans and have executed them well in emergency or disaster situations. It is not clear that smaller carriers or private systems not necessarily served by carriers' facilities do. Such telecommunications resources could be critical to successful, bottom-up efforts to establish, restore, or reconstitute telecommunications in severe disaster situations.

a. Records and their Rerouting for Restarting an Office

The records (data base) required to restart an office are kept in the form of magnetic tapes or disc packs. Several copies of the tapes or disks are maintained by the local-exchange carriers and are stored both onand off-site. The usual procedure is to update the oldest copy of the on-site media on a weekly basis after it has been verified that the resident (core) database is able to recover the machine. The off-site copy is updated much less frequently, as prescribed by practices of the local-exchange carriers. After loading the back-up copy, the data base is made current by re-applying the changes that were inserted since the last update. This is done on a mechanized basis from a centralized location that minimizes the time required for this operation. If the data link is down or the center not functioning, the changes can be manually applied at the office. Call processing would have resumed after loading the back-up copy of memory. Only those subscribers with changes will be delayed. Procedures for performing the restart are well documented and the maintenance personnel are trained for this function.

In the case of a remote switching unit, where the equipment serving the subscribers is located in a building different from the host switch, the data links between host and remote must be functional to restart the remote after a total failure. As long as the remote memory is not destroyed, the remote unit has the optional capability to switch local calls in a stand-alone mode with host or data links inoperable. Local calls include interoffice and selected, extended-area service. In this condition, the remote unit has recovery capabilities limited to the switching of active equipment and low-level initializations. Memory reloading to effect complete restoration of a remote switching unit can only be accomplished by the host machine via the data links.

Rerouting of the office trunks will be required if the far end office is out of service or the facilities between the offices are inacessable. The records for rerouting the trunks are contained in the office data base, which has information on the working trunks out of the office and how to route these trunks. Since this procedure requires translation work (data-base changes) at both the originating and terminating offices, it is usually done at the time the trunks are placed into service and pretested. When it becomes necessary to reroute trunks, a translation change at the originating office is required. In addition to the trunk records kept in the machine, paper or mechanized records are maintained in the office and other telco locations. The local office maintenance personnel have access to the records, as do the switching control center, network management center, network administration center, and the trunk provisioning center.

Network management centers have capabilities to activate and deactivate controls in an office to reroute trunks. The centers are staffed 24 hours a day and their personnel are well trained in this function. Rerouting by translation changes can be done from the local office or the switching control centers. The change procedures are documented for all switches and the personnel at these locations are in most cases the same groups that build the original translations. Some switches also have automatic reroute capabilities activiated by carrier-group alarms. If a carrier system is out of service and the translations and routes are available, the switch will automatically mark the trunks busy and reroute to a predetermined trunk group.

b. Planning for Use of Noncarrier Facilities

The proliferation of private channels that bypass the facilities of the exchange carriers will offer opportunities during a bottom-up effort at reconstitution. To take advantage of this opportunity, however, will require advance planning with respect to what is available, who knows how to use it, and where the needed documentation is located.

The needed documentation is of two kinds: (1) that which concerns the operation of the equipment and facilities, where they are located and how to make them work; and (2) that which concerns the use of resources once they are fully operational. Examples of the former are instruction manuals, site drawings and wiring diagrams; material lists and specifications; interface locations, levels and commands; power requirements and sources, fuse locations, sizes and types; locations of spare parts; and test procedures. Examples of the latter are cable and cross-connect assignments, channel assignments, routing options, number assignments, relative priority among users, and directories of personnel skilled in operations.

With respect to the last item in the second category, "who knows how to use it", selected personnel records of the carrier should be augmented by data about retired employees living in the area and having the needed skills.

The first consideration is where such information is located for the facilities and equipment of the exchange carrier itself. The second consideration is whether or not such information concerning bypassing resources can or should be located in the same place, and if not, then how the proper people can, in an emergency, have access to multiple sets of data. The third consideration is how such information can be maintained in reasonably current form over an extended period of time and who will be responsible for doing so.

It would be futile for the NCS to attempt this task, for the action required is local to an extreme degree and the training and exercising of such emergency arrangements will, as a practical matter, take place in the context of localized emergencies. This is the proper role of city, county and state organizations, supported by the FEMA. It is proper and necessary for the NCS to document such arrangements in the general sense and to build them into the NSEP planning it will perform, so that the network control centers of the major carriers are in a position to draw upon these resources when they are trying to help with restoration efforts from the periphery of a disaster area.

A practical method by which to assure the availability of needed data about bypassing facilities and other private resources would be to identify the needed information and the desired format for its organization, and then to work through state and local authorities to persuade the owners of such facilities to gather and maintain the needed information on their own premises. The information given to local authorities and to FEMA need only be the names and locations of two or more people who have access to the files.

Recommendations:

- Exchange carriers, perhaps through the United States Telephone Association (USTA), should be asked to set up a task force to examine the current record situation and trends, and be asked to recommend the general forms of answers to three questions:

  - Location of their own records of equipment, facilities, human resources, assignments and alternative uses in emergency restoration efforts; (they should, for example, be comparable to those described in III.B.3. on page 38.)

  - The feasibility of using records of bypassing resources if these can be made available in an emergency; and

  - How such information is or can be maintained current over an extended time period.

- In conjunction with a larger effort to interface the NCC with the owners of large private telecommunications systems (see Section III.B.5), a survey should be made, through the USTA or Bellcore, as to whether there are other bypassing resources that should be accounted for in devloping a complete plan of local, bottom-up, restoration.

- A plan to develop and build upon these recommendations and survey findings should be developed by or with the FEMA. This plan should thereafter be exercised by local disaster-relief agencies and be refined through experience.

- The revised plan should then be incorporated into NCC plans for the restoration of telecommunications following emergencies at all levels of stress.

7. Network Diversity and Problems of Coordination

Several years ago the intercity network was a single entity with a unified structure, its day-to-day performance coordinated in a hierarchical manner under a single command. In the future there will be many networks, each with a different structure designed to meet different objectives, and coordinated with only marginal reference to the performance of other networks. Today, we are somewhere between these extremes, moving steadily in the direction of the latter condition. Furthermore, the interrelationships that do exist between networks are largely the result of the dependency of new networks on the facilities of the old single entity while new design and construction take place; it is definitely not the result of the conscious recognition of and response to the NSEP needs of the nation.

As noted in the Committee's Annual Report, this changing environment among suppliers of services to the government will impose on the buyer a need for more well-informed procurement procedures. We quote from p.48 of that report:

> "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."

Beyond this internal requirement now imposed on the government is another need which may not be met at all unless it is planned for immediately. The many networks of the future will offer to the government greater diversity of resources than ever before possible, but taking advantage of this diversity for NSEP purposes will require more than just knowledgable purchasing. There must be the means for coordination among the carriers, and even between the carriers and the owners and operators of large private systems. Such coordination will not occur automatically or naturally, at least in the near term. If it is to happen, it will require action by the government, now, to make it either mandatory or commercially attractive, and to hold to a reasonable level the risks of antitrust allegations that are inherent in any cooperative endeavor among competitors.

The NCC offers the potential for coordinated reconstitution under the auspices of a government-directed operational center. There is no parallel activity at the design stage; no channel for assuring diversity of network control centers or compatible interfaces between networks. There is no requirement, or even a standard of reference, for developing trained personnel having a capability beyond the needs of each individual employer.

The challenge of developing policies that make such coordination possible should be placed squarely before the NSTAC. Technical interface problems should be placed before the standards-setting technical committees with the objective of having NSEP considerations receive at least equal treatment with the commercial needs of manufacturers and system operators. Beyond policy and standards, however, there is little that can be done at the national level. But given favorable policies and resonable standards there is much that can be done locally, where the people and the resources can be matched in detail against anticipated problems.

The Task Force on Telecommunications Industry Mobilization of the NSTAC, the Governors' Emergency Planning Committee and the resources of the FEMA should all be applied to this task of training and network management. If large private systems are to be counted among the nation's emergency resources, they will have to be brought into the planning process at the local level; the details would overwhelm any national effort that goes beyond policy.

Part of the dilemma faced today by the NCS and FEMA is that changes in the operating environment have been so great and so rapid that no one is sure just what, or how severe, the problems are. The most important immediate task, therefore, may be to experiment, and test the willingness and capabilities of suppliers and system owners to work cooperatively on a task which is larger than any of them.

APPENDIX

GLOSSARY OF ACRONYMS

AIP	Automated Information Processing
APCO	Associated Public Safety Communications Officers
ARES	Amateur Radio Emergency Services
ARRL	Amateur Radio Relay League
AT&T	American Telephone and Telegraph
ATT-COMM	AT&T Communications
BOCs	Bell Operating Companies
CALC	Customer Access Line Charge
CATV	Cable Television
CCIS	Common Channel Interoffice Signaling
CCLC	Carrier Common-Line Charge
CSIF	Communication Services Industrial Fund
DACS	Digital Access and Crossconnect System
DCA	Defense Communications Agency
DDN	Defense Digital Network
DNHR	Dynamic Non-Hierarchical Routing
E.O.	Executive Order
EBS	Emergency Broadcast System
ECSA	Exchange Carriers Standards Association
EMP	Electromagnetic Pulse
EOCs	Emergency Operations Centers
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FET	Field-effect Transistor
GaAs	Gallium Arsenide
HEMP	High-altitude Electromagnetic Pulse
ISDN	Integrated Services Digital Network
LAN	Local-area Network
LATAs	Local Access and Transport Areas
MARS	Military Affiliate Radio System
MFJ	Modified Final Judgment
MOS	Metal-Oxide-Semiconductor
NARUC	National Association of Regulatory Utilities Commissioners

NASA	National Aeronautics and Space Administration
NCC	National Coordinating Center
NCS	National Communications System
NEMA	National Emergency Management Association
NGA	National Governors Assocation
NSCS	Network Service Center System
NSEP	National Security/Emergency Preparedness
NSTAC	National Security Telecommunications Advisory Committee
OMNCS	Office of the Manager, National Communications System
RACES	Radio Amateur Civil Emergency Service
RBOCs	Regional Bell Operating Companies
RISCs	Reduced Instruction Set Computers
RSM	Remote Switching Modules
SDN	Software Defined Network
SEOO	State Emergency Operations Office
SOPs	Standard Operating Procedures
SSB	Single-Sideband
TIRKS	Trunks Integrated Record Keeping System