A Technical Analysis of the Common Carrier/User Interconnections Area

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A Technical Analysis

of

THE COMMON CARRIER/USER INTERCONNECTIONS AREA

A Report of the

PANEL ON COMMON CARRIER/USER INTERCONNECTIONS

COMPUTER SCIENCE AND ENGINEERING BOARD
NATIONAL ACADEMY OF SCIENCES

to the

Common Carrier Bureau
Federal Communications Commission
Washington, D. C.

June 1970

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NATIONAL ACADEMY OF SCIENCES
2101 CONSTITUTION AVENUE
WASHINGTON, D. C., 20418

10 June 1970

ANTHONY G. OETTINGER, CHAIRMAN
COMPUTER SCIENCE & ENGINEERING BOARD
AIKEN COMPUTATION LABORATORY
HARVARD UNIVERSITY
CAMBRIDGE, MASSACHUSETTS 02138

Mr. Bernard Strassburg, Chief
Common Carrier Bureau
Federal Communications Commission
Washington, D. C.

Dear Mr. Strassburg,

I take pleasure in submitting this report of the Computer Science and Engineering Board's Panel on Communications/Interconnection.

This Panel was asked to make an assessment of the technical factors affecting the common carrier/user interconnection area of public communications. It was asked to develop technical and background information that might be useful to the Commission, common carriers, users and equipment manufacturers in reaching and implementing solutions to immediate problems, including a technical evaluation of various contending points of view regarding the common carrier/user interconnection area, of the various problems to which these views relate and of the various technical and policy alternatives for responding to these problems in the near future.

You stated on September 25, 1969 that "the essential technical questions to be considered by the NAS Panel now appear to be (1) the propriety of the telephone company-provided network control signalling requirements and various alternatives to the provision thereof by the telephone company, (2) the necessity and characteristics of telephone company-provided connecting arrangements and various alternatives to the provision thereof by the telephone company, and (3) basic standards and specifications for interconnection and the appropriate method to administer them".

The Computer Science and Engineering Board selected Mr. Lewis Billig, Technical Director - Communications, The MITRE Corporation, Bedford, Mass. to chair the Panel. After extensive consultations to identify the most competent people available with the required technical specialties, Mr. Billig nominated the fourteen people listed following this letter for appointment by the Board.

COMPUTER SCIENCE & ENGINEERING BOARD, JOSEPH HENRY BUILDING, 21ST & PENNSYLVANIA AVENUE, N.W., WASHINGTON, D. C. 20418

The Board hereby commends to you these principal technical findings of the study:

1. Uncontrolled interconnection to the common carrier network as it now exists would be harmful.

2. The requirements of the tariff criteria limiting characteristics of interconnected lines are technically based and in accord with the operational limits of the common carrier network as it now exists.

3. The nature of potential harm, criteria for protection against such harm and the performance of various components of the telephone system can be specified explicitly enough to be understood and acted upon properly by people with normal technical competencies.

Having found that harm of various kinds can occur and that technical limitations on interconnection are therefore necessary, the Panel studied protective measures. On the technical basis of the third set of findings, the study concluded that the following two approaches -- used either alone or in parallel in such proportions as non-technical factors might determine -- can supply the required degrees of protection for the network, including network control signalling:

1. Protective arrangements as required by the tariffs

2. A properly authorized program of standardization and properly enforced certification of equipment, installation, and maintenance.

Analysis of potential harm and protection capabilities revealed no technical reasons why innovation would be significantly restricted by either of the two approaches alone or in combination. The choice clearly impinges on economic and social problems and on questions of industrial structure which are beyond the purview of the study.

Sincerely yours,

Anthony G. Oettinger
Chairman
Computer Science and Engineering Board

AGO:chm

PANEL

PANEL CHAIRMAN

Lewis S. Billig
Technical Director
Communications
The MITRE Corporation
Bedford, Mass. 01730

Raymond M. Alden
Executive Vice President - Operations
United Utilities, Inc.
Kansas City, Missouri 64112

James D. Babcock
Chairman of the Board
Allen-Babcock Computing, Inc.
Los Angeles, California 90067

Jack A. Baird
Vice President
Bell Telephone Laboratories, Inc.
Holmdel, New Jersey 07733

Ralph L. Clark
Associate Director
International Communications
Office of Telecommunications Policy
Washington, D. C. 20504

Charles H. Elmendorf
Assistant Vice President
American Telephone & Telegraph Company
New York, New York 10007

Ronald Enticknap
Associate Group Leader
M.I.T. Lincoln Laboratory
Lexington, Mass. 02173

Charles L. Hutchinson
Hutchinson Associates
Wilmington, Delaware 19809

Robert C. Karvwatt
Director of Communications Services
Penn Central Company
Philadelphia, Pennsylvania

Jordan Kassan
President
Dynelec Systems Corporation
Glen Rock, New Jersey 07452

Herman Lukoff
Director of Research and Advanced Techniques
Univac Division of Sperry-Rand
Blue Bell, Pennsylvania 19422

Bernard Rider
President
American Communications Corp.
Arlington, Virginia 22209

John L. Wheeler
Engineering Manager
Xerox Corporation
Rochester, New York 14604

Elmer B. Shapiro
Senior Research Engineer
Stanford Research Institute
Menlo Park, California 94025

Harry S. White, Jr.
Chairman, American National Standards Institute (ANSI)
National Bureau of Standards
Washington, D. C. 20234

PANEL AIDES

George W. Gilman
Senior Consultant
The MITRE Corporation
Bedford, Mass. 01730

Victor Evans
Consultant
Office of Telecommunications Policy
Washington, D. C. 20504

NATIONAL ACADEMY OF SCIENCES

COMPUTER SCIENCE & ENGINEERING BOARD
2101 CONSTITUTION AVENUE
WASHINGTON, D. C. 20418

15 April 1970

Professor Anthony G. Oettinger
Chairman
Computer Science and Engineering Board
National Academy of Sciences
Washington, D. C. 20418

Dear Professor Oettinger:

The Special Panel on the Common Carrier/Interconnection area of the Computer Science and Engineering Board was established to perform a technical analysis of certain factors in the common/carrier/user interconnections area in accordance with the terms of Contract No. RC-10091, dated 27 June 1969. It is a pleasure to transmit this report which represents the judgments of that Panel.

Both the timeliness of the report and its content reflect a high level of dedication and professional objectivity of the entire Panel throughout all phases of the study. The work of the Panel was possible only because of the cooperation of the many organizations and individuals in producing technical papers and presenting supplemental briefings which provided the basic information on which the Panel based its judgments. Many of the papers reflect special research undertaken in response to the request of the Panel for technical support. In addition to contributing to the report, the papers submitted constitute the bulk of the existing literature of the field for the common carrier/user interconnections area.

From the start, it was our aim to produce a report which reflected the best technical competence and experience available on the various aspects of this problem area. I believe that we have succeeded in this, and am pleased to commend this report to the Computer Science and Engineering Board.

This has been a rewarding experience for me, personally and professionally, and I believe the same is true for the members of the Panel.

Sincerely,

Lewis S. Billig

Lewis S. Billig
Chairman
Special Panel on
Common Carrier/Interconnections

ABSTRACT

This report represents the result of a study of the technical issues involved in the interconnection of user-owned terminal equipment to the regulated common carrier network. The pertinent characteristics of the network were analyzed to determine its susceptibility of harm to personnel, equipment, network performance, and degradation of service to other users. It was determined that such susceptibility does exist and that uncontrolled interconnection would indeed be harmful. The requirements of the tariff criteria limiting signal amplitude, waveform, and frequency distribution of interconnected lines were found to be in accord with the operational limits of the network and to be technically based. Several methods of protecting the network -- when interconnected to user-owned equipment -- from hazardous voltages, line unbalance, excessive signal levels, and improper network control signaling were investigated. The Panel concluded that the protective arrangements required by the tariffs can provide the basis for the required degree of protection. A properly-authorized program of standardization and enforced certification of equipment, installation and maintenance can be developed to provide the desired protection. The Panel concluded that innovation by carriers need not be significantly impeded by this program, while opportunities for innovation by users would be increased. The poor information exchange among carriers, users, and manufacturers has resulted in considerable misunderstanding and the Panel concludes that mechanisms are needed to address this problem.

SECTION 1

BACKGROUND, SUMMARY, AND CONCLUSIONS

BACKGROUND

The "Carterphone Decision" was widely recognized as potentially leading to a fundamental change in communications carrier/user relationships.

By this decision, the FCC ordered the American Telephone and Telegraph Company to delete general prohibitions against interconnection and customer attachments from its interstate message toll tariffs. In compliance, the AT&T, after consultation with representatives of the independent telephone companies, filed the following revised tariffs: #259 - "Wide Area Telecommunications Service"; #260 - "Private Line Service"; #263 - "Long Distance Message Telecommunications Service." These revised tariffs specify and define certain key limiting signal characteristics and "access arrangements" believed necessary by AT&T to protect telephone service and the telephone system, as well as those who come in contact with the system as employees or users.[1]

The FCC allowed these proposed tariffs to go into effect and requested comments from interested parties. It received a considerable number and range of responses. The technical portions of these responses ranged from complete acceptance, through challenges as to the basis of determination of the protection requirements, to complete rejection.

The FCC decided that a study should be made of the technical factors involving interconnection and user-provided attachments. The National Academy of Sciences, through its Computer Science and Engineering Board, agreed to undertake such a study.

The objective was to evaluate and report on the issues of "harm," and protection of the telephone network from "harm," under conditions of user-interconnection. The approach involved the following considerations:

(a) Susceptibility of the network of "harm" in terms of hazards to personnel and equipment, network performance, and degradation of service to other users

(b) Evaluation of the tariff criteria limiting signal amplitude, waveform, and frequency distribution of interconnected lines

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[1] Section 3

(c) Evaluation of the effectiveness of several methods of protecting the network

(d) Evaluation of the impact of interconnection on innovation by carriers and user-manufacturers.

The charter of the Panel and the urgency of the problems of voice-band interconnection required that this report concentrate on the technical aspects of those problems, to the exclusion of other significant considerations involved in interconnection, such as:

(a) Distribution of costs of interconnection among carriers, the general non-interconnected user, and the interconnected user

(b) Reliability or adequacy of service obtained by a user from his own interconnected equipment

(c) Effect on service when one party has carrier-provided equipment and the other party has his own interconnected equipment

(d) Validity of the criteria for acoustic or inductive coupling

Final judgment by the FCC as to courses of action must, of course, include, in addition to the technical factors, such matters as rates, costs, legal implications, and basic economic policy. In this connection, it should be noted that future changes in costs or rates by the carriers for interconnection devices could have a significant impact on the interconnection situation.[2] This factor was not evaluated by the Panel. The principles that underlie the conclusions in this report may be applicable to other types and circumstances of interconnection.

Principal Conclusions

The principal conclusions arrived at by the Panel follow. Further detailed conclusions are included in the body of this section.

(a) Uncontrolled interconnection can cause harm to personnel, network performance, and property.[3]

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[2] Section 6

[3] Sections 3, 4, and 8

(b) The signal criteria in tariffs 260 and 263 relating to signal amplitude, waveform, and spectrum are technically based and valid and, if exceeded, can cause harm by interfering with service to other users.

(c) Present tariff criteria together with carrier-provided connecting arrangements are an acceptable basis for assuring protection.[4]

(d) Present tariff criteria together with a properly authorized and enforced program of standards development, equipment certification, and controlled installation and maintenance are an acceptable basis for achieving direct user interconnection.[5]

(e) Innovation by carriers need not be significantly impeded by a certification program. Opportunities for innovation by users would be increased.[6]

(f) Mechanisms are needed to promote the exchange of information among carriers, users, and suppliers.[7]

STUDY PLAN

Organization

An initial analysis indicated that a broad range of experience should be represented in the membership of the Panel. The technical coverage included the following subjects:

Switching Systems
Transmission Systems
Standards - Development and Use
Equipment Manufacturing
Privately Owned and Operated Communications Systems
Communications-Oriented Computer Systems

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[4]Section 5

[5]Sections 3, 4, and 5

[6]Section 7

[7]Section 9

Procedures

The Panel first reviewed the FCC files concerning interconnection and determined what additional data were necessary. Facts and opinions were accumulated from those who expressed their interest to the FCC and directly to the NAS Panel as a result of announcements, publicity, and direct solicitations. Organizations and individuals with knowledge of and experience in subjects of particular interest to the Panel were also contacted directly.[8] Among the organizations providing data were:

Communication Common Carriers
Telephone Equipment Manufacturers
Computer Manufacturers
Terminal Equipment Manufacturers
Organizations with Private Communications Networks
Regulatory Agencies
U. S. Government Agencies
Standards Agencies
Foreign Communications Agencies
Testing Laboratories
Computer Service Organizations
Installation and Service Organizations
Trade Associations

In all, over fifty written technical communications were submitted, and over twenty-five organizational representatives, by Panel invitation, made supplemental oral presentations and responded to intensive questioning at closed panel sessions.

This study makes clear the need for improved communications between the carriers, users, manufacturers, and other members of the community in this field. On a number of occasions what were considered to be significant problems raised were apparently a matter of lack of, or poor, information.

EFFECTS OF INTERCONNECTION ON THE PERFORMANCE OF THE NETWORK

The objective of the Panel has been to determine how

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[8] Section 8

interconnection can be achieved without impairment of service to users of the network, generally, and hazards to employees of the carriers. In its approach to this objective, the Panel has analyzed the appropriate portions of the carrier network to determine how harm can be caused and has then considered how this harm can be prevented.

Harmful Effects

Harm may arise through the introduction into the network of (a) voltages dangerous to human life, (b) signals of excessive amplitude or improper spectrum, (c) improper line balance, or (d) improper control signals.[9]

INCREASED EXPOSURE TO HAZARDOUS VOLTAGES CAN RESULT FROM UNCONTROLLED INTERCONNECTION[10]

Uncontrolled installation of user-owned terminal devices involving the use of 115 v AC and other hazardous voltages can introduce risks to telephone company installation and maintenance personnel. For maintenance and expansion of telephone service to be carried on without interruption of existing service, it is standard and efficient practice for cable and exchange plant workers to work bare-handed on pairs and junctions in the immediate proximity of hundreds of other pairs in normal use. To avoid increasing the hazard, it is mandatory that stringent measures be taken to ensure that hazardous voltages will not be applied at points of interconnection.

SIGNALS THAT VIOLATE THE CRITERIA RELATING TO SIGNAL AMPLITUDE, WAVEFORM, AND SPECTRUM IN TARIFFS 260 AND 263 CAN CAUSE HARM BY INTERFERING WITH SERVICE TO OTHER USERS[11]

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[9] Section 2

[10] Section 3

[11] Section 3

The non-linear characteristics of transmission components, which are widely used in the telephone plant, require that inband signal power be limited to avoid deterioration of service to others due to cross-talk or overload. The signal-limiting characteristics of voice-frequency and carrier-transmission systems do not provide the required restraints on signal power. The signal powers specified in the tariffs represent reasonably optimized values for voice and data usage.

The limits on the inband signal-power spectrum are specified to avoid the possibility of interference with internal network signaling. The out-of-band power limits are based upon limitations of local cable plant and requirements for minimum interference with present and expected greater-than-voice-band services. The telephone plant does not supply this protection.

Signal criteria specified in the tariff must be observed for both voice and data services. Data services present the more serious problem, since, when transmitting data, the user has an incentive to exceed the signal-power criteria in order to reduce his error rate with possible degradation of service to others.

LINE BALANCE IS IMPORTANT TO NETWORK PERFORMANCE[12]

Imbalance in line terminations will render ineffective the careful electrical balance built into the pairs in the cables connecting users and the telephone company central offices. The resultant imbalances can cause loss of privacy and increased interference, not only to the unbalanced pair, but to other pairs in the cable as well. Terminal imbalance can occur due to poorly built equipment, improper installation, or inadequate maintenance.

IMPROPER NETWORK-CONTROL SIGNALING CAN IMPAIR TELEPHONE SERVICE AND INCREASE COSTS[13]

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[12]Sections 1 and 3

[13]Sections 1 and 4

Network-control signaling must be properly performed for correct system operation and message accounting. For example, in a telephone set, these signals are produced by the switchhook and the rotary dial or the touch-tone pad. Mechanisms for producing these signals, if not carefully designed, manufactured, installed, and maintained, can, in conjunction with the varying characteristics of the telephone loops, cause improper signals to be received at the central offices. Central offices vary in their tolerance to distorted control signals and in their ability to correct such signals before re-transmission into the network. In particular, dial-pulse signaling of poor quality can cause significant harm by the generation of wrong numbers, causing annoyance to others, wasteful use of central office equipment and transmission facilities, and improper billing. On the other hand, improper signals generated by touch-tone pads are inherently less harmful since, if a signal is out of tolerance, the central office equipment will not complete the call. Network-control signaling on multiparty lines is particularly difficult to define because of different practices with respect to ringing and line identification.

Protecting the Network

Several approaches for protecting the public telephone network were considered. Two which the Panel considers acceptable are:

(a) Operation under present tariffs that call for common-carrier ownership, installation, and maintenance of connecting arrangements and adherence to tariff-specified signal criteria.

(b) A program of enforced certification of equipment and personnel, with appropriate standards for safety and network protection. This approach would allow user ownership, installation, and maintenance of protective coupling units or complete terminal equipment.

PRESENT TARIFF CRITERIA AND CARRIER-PROVIDED CONNECTING ARRANGEMENTS ARE AN ACCEPTABLE WAY OF ASSURING NETWORK PROTECTION[14]

The present tariffs specify signal criteria for electrical, acoustic, and inductive coupling, and specify that the carrier provide

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[14] Sections 3 and 5

connecting arrangements and network-control signaling. The signal criteria limit the signal inputs to the network to those considered to be harmless. The carriers, under the tariffs, assume responsibility for installation and maintenance of the connecting arrangements and for protection of carrier personnel and of the network itself. Technically, the Panel considers this to be an acceptable approach.

Carrier-provided connecting arrangements involve addition by the carrier of components between the user's terminal and the carrier's facilities. In some situations, these may duplicate components of the users' equipment; this redundancy in components and functions may, in principle, cause some loss in performance and some reduction in reliability. However, the Panel's analysis indicates that the added components, if well designed, should not significantly affect overall reliability or performance.

Concerning the need for some of the protective features, analyses of the presently available connecting arrangements indicate that they provide a degree of protection of voice-signal limiting that, in some cases, is unnecessary. Present carrier-provided coupling units are, in some instances, complicated and marginally effective and may degrade performance,[15] particularly in net-control signaling. According to AT&T, the problems relating to present protective equipment can be attributed to the rapid introduction of the connecting arrangements and lack of experience on which to base judgments. Further development should produce more effective units. Additionally, the sudden demand for interconnection and the need for time to determine the features required by a large number of users is a cause for present delays. Desired connecting arrangements are not yet available according to some users.

THE ESTABLISHMENT OF STANDARDS AND ENFORCED CERTIFICATION OF USER-SUPPLIED EQUIPMENT AND PERSONNEL CONSTITUTE AN ACCEPTABLE WAY OF ASSURING NETWORK PROTECTION[16]

It is important to note that the standards to be established cover only network-protection considerations such as personnel safety, signal levels, transmission, and network-control signaling, and do not include standards for user-equipment performance.

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[15]Section 5

[16]Section 16

Despite some variability from installation to installation, there has been enough experience with the telephone network to provide a basis for standards for network protection. A standards-development program requires the resources of a qualified standards organization. The purpose here is to provide coordination, structural guidance, and staff services to those preparing the standards. Such organizations exist in both the private sector and government. Standards can be prepared by qualified representatives of the carriers, suppliers, and users. A definition of the interface between the user-owned equipment and the network, so far as protection is concerned, is part of the basis for standardization.

Finally, although general standards can be written to cover interconnection with various types of central offices and loops, each individual installation will be, to some extent, customized due to varying loop characteristics and other factors. Therefore, interconnected equipment should be provided with proper adjustment features to deal with individual case-by-case variations. Necessary adjustments can be worked out cooperatively at the time of installation between carrier and user. Cooperative guideline procedures should be formalized.

Type certification of equipment could be accomplished by government or by independent testing laboratories. It must include evaluating and monitoring each manufacturer and his specific products. Government and independent test laboratories exist which are capable of performing these functions in related fields. They could expand their resources to qualify for the program envisaged here. With a significant volume of work, costs of this program should not be prohibitive. Certification can be applied to couplers, to protective sections of larger equipment, or to the protective characteristics of entire units of equipment.

Equipment-type certification alone is not sufficient to protect the telephone network. The equipment must be installed and maintained by certified technicians. In addition, standards must make provisions for assurance that the network protection is maintained by documented periodic inspection.

Certification of the installation and maintenance of interconnected equipment will require a program of personnel training, development of tests and test equipment, and licensing of installation and maintenance personnel. On the last point, the Panel believes that a nucleus of support personnel exists in the servicemen and organizations who now install and service communications and computer equipment. They can be certified (or licensed) by examination, following procedures included in the overall certification program. Each certification (or license) would be endorsed as applicable to equipment of one or more classes.

Requirements for an Enforced Certification Program

AUTHORITY FOR A NATION-WIDE CERTIFICATION PROGRAM MUST RESIDE WITH THE FEDERAL AGENCY RESPONSIBLE FOR THE TARIFFS[17]

To be effective, a certification program must be recognized in the tariffs and the federal agency that approves these tariffs must assume responsibility for authorizing implementation of the overall certification program. This agency should develop and publish rules and procedures and propose timetables and sequence of applications.

Plans should be developed under control of the federal agency for the selection of the organization or organizations that will coordinate the preparation of standards, the procedures for the qualification of technicians, and the organizations to be given the authority to certify equipment.

Uniformity in standards and certification procedures for equipment and in personnel qualifications throughout the country is desirable, since installation and maintenance may be supervised and inspected locally. Therefore, coordination by federal and state agencies in necessary to establish policies which will permit the nationwide use of certified equipment and procedures for the certification of technicians.[18]

ENFORCED CERTIFICATION PROCEDURES MUST BE TAKEN AS A WHOLE

The Panel emphasizes that the development of standards and a program of certification requires a complete system of control, which will not be effective unless all elements of the system, as described in this report, are adopted. For example, the development of standards alone is inadequate. Certification of equipment without certification of installation, testing, and maintenance will be ineffective in protecting personnel, facilities, services, etc.

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[17]Section 6

[18]Section 6

A CAREFULLY PLANNED
STEP-BY-STEP EFFORT IS
NECESSARY TO ENSURE THE
SUCCESSFUL IMPLEMENTATION
OF A CERTIFICATION PROGRAM[19]

Experience with interconnection is limited and has, for the most part, been with users with extensive experience and resources.[20] There is little applicable experience involving smaller, less sophisticated users or with large-scale public interconnection. A certification program is new to the telephone industry and to many of the major user industries.

Existing laboratories are not equipped to test and certify communications equipment in the quantities envisioned. The personnel needed by all parties for this kind of operation are in short supply.

There is much to be learned. If a start is made promptly, and if all concerned assign the task a high priority, the necessary certification programs and guidelines for qualifying personnel should be produced in reasonable time. The same effort should produce both standards for equipment and guidelines for qualifying personnel. Thereafter, when the personnel program has started to function, the certification of interface devices and equipment will permit their installation and operation by users according to the new standards.

The Panel believes that the certification program should be undertaken on an incremental basis in order to develop a meaningful base of knowledge and experience. The first implementation should be in an area with high probability of success and sufficient complexity to test the validity of the certification program. The first application should be to equipment with limited distribution and for which a knowledgeable technical base for manufacture, installation, and maintenance now exists (such as PBX). Application of the standards to one service can proceed while standards are set for others. Since the standards program is an iterative process, requiring procedures for continuous reconsideration and renegotiation of specifications, it is important that an organizational mechanism be set up to gather data and evaluate the progress of the program.

SELF-CERTIFICATION BY
MANUFACTURERS OR USERS
WILL NOT ENSURE AN ACCEPTABLE DEGREE OF NETWORK
PROTECTION[21]

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[19] Section 6

[21] Section 6

[20] Section 8

A self-certification program allows the manufacturer or user to test and approve his own equipment, installation, and maintenance. On the other hand, an enforced certification program separates the responsibility for certification from the organizations having direct financial involvement in the production or use of interconnected equipment.

Self-certification requires the user to procure and use equipment considered harmless and to operate in accordance with the tariffs. In the absence of some control system, it is inevitable that marginal equipment will make its way to the market and that there will be usage outside of the rules.

WE FIND NO PERSUASIVE ARGUMENTS FAVORING THE EXEMPTION OF WHOLE CLASSES OF USERS

The Panel endeavored to classify users, including utilities, right-of-way companies, agencies of the federal government, etc., in an effort to show that one or more classes might be permitted unrestricted interconnection without risk of impairment to the operation of the network. An analysis of information in the Applicable Experience section[22] and other information presented to the Panel led to a firm conclusion that this was not possible.

In a certification program that enables any user to qualify on reasonable terms, there is no reasonable basis, in the opinion of the Panel, for any class or group of users to be exempted from conforming.

EFFECTS OF INTERCONNECTION ON INNOVATION

THE PROPOSED CERTIFICATION PROGRAM SHOULD NOT SIGNIFICANTLY IMPEDE INNOVATION BY THE CARRIERS AND MAY PROMOTE INNOVATION BY USERS

Several opinions have been expressed to the Panel regarding the potential impact of interconnection on innovation.

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[22]Section 8

The carriers have said that widespread interconnection will tend to impede innovation in the network, because, among other things, users will tend to oppose changes by the carriers that make the users' equipment obsolete or require it to be modified. They have also said that direct interconnection without carrier-owned interconnecting arrangement will further impede their innovation because it removes the carrier-controlled buffer with known characteristics between the network and the interconnected equipment.

Some users, especially the large ones and those in rapidly developing fields such as computer time-sharing, have expressed the opinion that, with the necessarily deliberate rate of innovation expected in the network, there will be no major problems in keeping up with the network innovation. They do not agree with the carriers' concerns regarding the need for a carrier-controlled buffer.

Some suppliers of equipment and services have expressed the opinion that the presence of the carrier-owned interconnecting arrangement will impede innovation on the user side of the interface where the goal is to optimize the users' system or use of equipment. Further, and perhaps more importantly, they question the ability of the carrier to respond rapidly enough to new situations in which new interconnection arrangements are required.

While data on which to base conclusions are limited, it is the opinion of the Panel that:

(a) The advent of widespread interconnection itself, regardless of how it is implemented and controlled, will indeed have some effect on the rate of innovation by carriers, suppliers, and users. In some cases, it may impede innovation in the network; in others, it could conceivably promote innovation because of competition and the pressures of demand from users. It will certainly tend to increase the rate of innovation by suppliers and users.

(b) The introduction of a certification program permitting direct interconnection should not significantly restrict carrier innovation if there is effective information exchange between carriers, suppliers, and users. On the other hand, the suppliers and users will have more freedom to innovate.

(c) On balance, under the certification program, innovation in the overall system of carriers and users of interconnected equipment is likely to increase.

INFORMATION INTERCHANGE

THE PANEL BELIEVES THAT MECHANISMS SHOULD BE ESTABLISHED TO PROMOTE THE EXCHANGE OF INFORMATION AMONG CARRIERS, USERS, AND SUPPLIERS[23]

As stated earlier, the Panel was continually reminded of the need for improved exchange of information among the parties concerned. There were instances of incorrect interpretations of conditions of use of the network by user and manufacturers, causing unnecessary confusion at both the technical and administrative levels. The carriers expressed strongly the need for more direct information exchange and a more comprehensive picture of user requirements. With the aniticipated acceleration in innovation affecting data systems and telecommunications, the requirement for this improved exchange is even more pronounced. At present, no mechanism exists that adequately serves this function; such a mechanism should be established.

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[23] Section 9

SECTION 2

COMMUNICATIONS BACKGROUND

TELEPHONE SYSTEM

In discussions of the interconnection situation, it is convenient to consider separately the exchange and long-distance parts of the telephone plant.

Exchange System

In its very simplest form this consists of a telephone, a "loop" to the central office, the automatic telephone exchange, and, perhaps, trunks running from the nearest central office either (a) to other central offices nearby; or (b) extending into the toll-telephone network.

The Telephone

The user interfaces with the telephone system at the telephone instrument. From the network-control viewpoint, the user performs as a highly adaptable logic and memory system that responds to incoming calls, initiates calls, and reacts reasonably predictably to a variety of situations encountered in using the telephone. The mechanisms he uses to exert this control in the simplest form of telephone are the switch hook and the dial. Lifting the handset closes electrical contacts in the switch hook to signal the central office. These switch-hook signals play an important role in subsequent operations. (One of them is establishing, for charging purposes, the times at which the call was initiated and terminated.) On receiving dial tone (which the user distinguishes from several other tones produced for his use), the user responds by operating the rotary dial or set of push buttons to correspond to the number he desires to reach, as read from the telephone directory or taken out of his memory (not always accurately). The user takes certain actions depending on whether, subsequently, he hears the voice of the wanted party, receives busy tone, continues to hear an unanswered audible ringing signal, reaches the wrong telephone, etc. At times he may hear a voice-recorded announcement and react accordingly, or he may reach an intercept operator with whom he converses. The user, in short, by manipulating the telephone instrument, plays a crucial role in the network-control signaling function of the telephone system. The telephone instrument, its controls, and the various signals from the system beyond the instrument to which the user responds are chosen in recognition of experience with the user's capabilities, limitations, and behavior patterns. The same is true of the quantity of switching equipment at the central office, which is chosen to fit traffic patterns as to calling frequency, duration of message, etc.

The various systems' solutions arrived at for the user/telephone combination at the point of access to the network may not necessarily be the same and certainly are not necessarily optimal where the combination is replaced in part or completely by machine or computer. Such a machine or computer, with or without interface devices, must reproduce most or all of the logical and memory operations now performed by the user. It may be conjectured that the machine is more accurate and more rapid, though not necessarily as versatile.

The primary function of the telephone instrument, of course, is to transmit and receive speech. The statistical distributions of levels and waveforms sent into the telephone system depend on the characteristics of both the user and the telephone instrument. The loops and long-distance trunks are designed to handle the range of levels encountered, without introducing crosstalk between pairs in multi-paired cable, or overloading the long-distance multiplexed system with its common amplifiers. To this end, there are limits both as to the output at the user station and the input to the trunks.

The telephone instrument is being used with increasing frequency to handle signals other than human voice, the telephone user's voice and ear being replaced by an acoustically or inductively coupled data set, cardiograph machine, facsimile machine, etc. Again, replacement of the user by a machine implies compromises. Specifically, the machine-generated signal levels and waveforms must be chosen to be both effective and non-interfering. This is accomplished in part by specification in the appropriate tariffs. In acoustic coupling, the signals are first converted to specified audible sounds and the telephone handset is fitted into a specified holder where these sounds are picked up. In inductive coupling, the electrical circuits within the handset pick up electromagnetic signals from the attached device. In both cases, the exact details of telephone-instrument design are important. Small changes in the telephone instrument may take obsolete acoustic and inductive coupling arrangements. Coordination between the designers of telephone instruments and the designers of acoustic and inductive couplers is required to avoid this.

A third function of the user's telephone installation is to protect the user, telephone employees, and the rest of the telephone system against harm. The telephone instrument and installation are insulated against contact with electric power sources. The telephone instrument contains a "click reducer" to eliminate the hazard of acoustic shock (a dangerously high level acoustic impulse to the listener's ear) etc. It is designed to maintain careful balance to ground on both sides of the telephone line, avoiding noise and cross-talk effects. It contains non-linear devices that limit energy levels, particularly on short loops to the central office.

Where the user telephone system is replaced by a machine, with or without interfacing equipment, the three basic functions of network control, transmission, and protection must all be preserved.

Finally, these basic functions must be handled without mutual interference. Specifically, the network-control signaling function must be protected against interference from speech or other signals. As will be pointed out later, this consideration sets additional limits on the level and waveform of signals that can be transmitted throughout the system from the telephone.

The Loop

The "loop" connecting the telephone to the central office (or "trunk" connecting the PBX to the central office) is one of the major elements of total telephone-plant investment. The loop, for our purposes, includes the interior wiring in the users' premises, the "drop" from the premises to the point of attachment to the cable running to the central office, and a selected pair of wires in that cable, either assigned wholly for the use of a single user or shared with other users. Important characteristics of the loop are its length and the size of the copper conductors. Since a minimum of direct current, at least, must be drawn over these conductors to supply the microphone in the telephone and 20-cycle alternating current must be fed over them to ring the telephone bell, there are upper limits on length of loop and fineness of conductor gauge. Similarly, there are limits connected with the attenuation of voice signals, and the distortion to the direct-current signals used for switch-hook supervision and the detection at the central office of the fact that the called party has answered so that ringing may be "tripped." If considerations of limiting loop length and gauge are identical when the user/telephone subsystem is replaced by a machine, there need be no changes in loop design and layout. If not, some changes may eventually be indicated.

Loops and short-haul trunks are derived from copper-wire pairs in cables carrying several hundred or several thousand pairs. To hold cross talk between services carried over these pairs to a minimum, there must be strict control in cable manufacture to avoid structural imbalance. The effect of this careful control can be destroyed if improperly designed or improperly installed equipment is connected to the ends of the pairs. One of the basic requirements for any device connected to the telephone network, therefore, is that it not introduce imbalance[1] in impedance to ground from the two wires of the pair at the point of connection.

Cross talk (undesired coupling of signals from one channel to another) can also be created if excessively high signal levels are applied. To avoid cross talk from this source, limits are set on the output levels from the user station. Finally, cross talk in cables increases with

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[1]Section 3

frequency. Since paired cables are used increasingly to handle communications involving higher frequencies (e.g., PICTUREPHONE), the limits on levels into these cables are set differently for frequency bands above the voice range.

Key Telephones and PBX's

Not all telephone instruments are connected directly to the central office over loops, particularly non-residence telephones for business, government, or professional use. In this case, additional switching systems are interposed between the telephone instrument (extension telephone) and the central office. These are manually operated key telephone systems and automatic (or sometimes manual) PBX's or PABX's (two acronyms for essentially the same thing). Some of these systems are of a size and complexity comparable to a telephone central office.

PBX's are sometimes, but not always, located on the user premises. In recent years there has been increasing use of Centrex service. In Centrex service, the PBX's switching may be done either on the customer's premises, or in the telephone central office. PBX extensions are reached directly by dialing from the telephone network (direct inward dialing). The telephone extension number becomes part of the nationwide numbering system. On outward calls from approved extensions, the called telephone is reached without the intervention of the PBX operator (direct outward dialing). The extension in some cases is identified automatically for billing purposes.

The Central Office

Dial central offices are of the step-by-step progressive-control type, or of the common control type (crossbar and most recently electronic switching). In a step-by-step office, the user more or less directly controls the switches in the central office when he operates the dial mechanism. Since these switches are mechanical devices with definite speed limitations, the dial-return mechanism is equipped with a speed governor, as a kind of buffer against an impatient user. In common-control offices, operation of the dial controls the condition of groups of relays or solid-state electronic circuits, which are made available for the user's sole use, when he gets a dial tone. These relay or electronic-circuit combinations then control the central office switches to set up the desired connection. In general, these latter arrangements are faster. In some cases this is taken advantage of by doubling the speed of the dial mechanism from 10 to 20 pulses per second.

Except for this, however, the same type of telephone instruments are used for all types of dial central offices. Push-button or Touch-Tone control will be referred to later.

Exchange and Toll Trunk Carrier Systems

Telephone switching offices are interconnected into a nationwide switching plan or hierarchy in which the local central office is at the lowest hierarchical level. The switching centers of the hierarchy are interconnected over short- and long-haul trunk circuits. These circuits are of voice-bandwidth (approximately 3,200 cycles) and handle two kinds of signals; 1) the message signal itself -- voice, data, etc.; and 2) the network control signals used in setting up and taking down connections, controlling switches, start of billing, and, in general, what is known as interoffice "handshaking," (exchange of call status information between switching offices by single-frequency [S.F.] signaling). It is important to good service that the message signals not produce false network-control signals. This can happen. For example, "talk-off" is a condition in which an unusual voice sound can be interpreted by the signaling equipment as an indication that the subscriber has hung up. When the system is used for other than voice, restrictions on energy level and waveform are imposed to avoid similar adverse effects. In certain trunk systems, a separate channel is used for network control-signals and these precautions are not required. The majority of trunks, however, use a single channel for both purposes. Restrictions on energy level and waveform are also required to avoid cross talk and noise among services sharing the same facilities.

Multi-channel carrier systems carry twelve to many thousands of voice channels through common amplifiers over paired cables, coaxial cables, microwave radio relay and (internationally) submarine cable and satellites. These common amplifiers can handle only limited signal power without overloading. The effect of overloading is to introduce noise and cross talk into many voice channels. The total available load capacity of the amplifiers are designed to be shared evenly by all the channels, whether they are handling voice or other communications. Specifications for individual channel loading have been established to be an optimum comprise between low levels where underlying system noises dominate and the higher levels where intermodulation noise and cross talk prevail.

Other Uses of the Telephone System

One of the uses of the telephone network for purposes other than switched message telephoning has been mentioned -- acoustic or inductive coupling to the telephone instrument for handling data, picture transmission, etc. This is only one of many non-telephone uses.

Private-Line Services

Uses of the telephone system fall into two broad categories: 1) private-line services, and 2) services provided on the switched network. Private-line channels may be terminated in either carrier-provided or customer-provided terminal equipment.

The loops and trunks of the telephone network have been made available to other services operated by large users of communications: Western Union, the railroads, large industries, government, etc. In some cases, these arrangements have involved interconnection between leased lines and equipment owned and maintained by the telephone companies, but operated by the user (for example, the 81-type teletype store-and-forward switching system). In other cases, Western Union for example, circuits only are provided -- the user attaches his own equipment.

Touch-Tone Services

There are over 1,000,000 telephone installations in which the rotary dial has been replaced by a 10- or 12-button "touch-tone" combination. The touch-tone signals, unlike the rotary-dial signals, can be used, not only to control the setting up of the connection, but also to transmit data once the connection has been set up.

SECTION 3

TRANSMISSION AND PROTECTION CONSIDERATIONS

INTRODUCTION

In this section we discuss the factors behind the carrier's tariff restrictions on the power and waveform of signals sent over the telephone networks (signal criteria).

THE PANEL HAS CONCLUDED THAT THE SIGNAL CRITERIA IN THE TARIFFS ARE REASONABLE. SIGNALS WHICH VIOLATE THESE CRITERIA CAN CAUSE HARM BY INTERFERING WITH SERVICE TO OTHER USERS

We discuss next the sources and effects of harmful voltages on personnel and plant, the exposures of the telephone system to these voltages, and the additional risks introduced by user-provided equipment.

THE PANEL CONCLUDES THAT INCREASED EXPOSURE TO HAZARDOUS VOLTAGES CAN RESULT FROM UNCONTROLLED INTERCONNECTION

Finally we discuss the subject of cross talk, and how this undesirable effect may be produced by unbalanced (to ground) attachments to telephone lines.

THE PANEL CONCLUDES THAT THE MAINTENANCE OF LINE BALANCE IS IMPORTANT TO GOOD SERVICE. LINE BALANCE CAN BE IMPAIRED IF POORLY DESIGNED OR IMPROPERLY INSTALLED AND MAINTAINED EQUIPMENT IS ATTACHED TO THE SYSTEM

The following paragraphs introduce the technical background appropriate to the later, more detailed discussion of signal criteria, protection criteria and line unbalance.

TECHNICAL FACTORS TO BE CONSIDERED IN THE INTERCONNECTION OF USER-OWNED TERMINALS TO THE PUBLIC NETWORK

The public telephone network has been engineered, on a statistical basis, to provide a variety of services to a large number of residential, commercial, military, and other users with different service requirements. The numbers and duration of the calls placed by these users cover a wide range.

Users are served by many types of telephone facilities at a range of distances from their serving central offices. The trunks that tie these offices into the long-distance portions of the network also vary statistically in type and length. Resultant ranges in transmission parameters of the loops and trunks produce variations in the overall end-to-end characteristics of switched connections through the network. The alternate routing of calls, which allows the automatic adjustment of traffic patterns to meet changing load requirements, can increase or decrease the number of links used in setting up successive calls between the same two locations. In short, both the service and the plant have been designed and can only be understood and treated on a statistical basis.

Because the numbers involved in telephone network are large, it is always possible to provide service to a small number of identified users whose requirements depart from the statistics in terms, for example, of the nature of signals to be transmitted. Special treatment might, for example, involve the selection of suitable pairs in local cables to minimize cross talk. It is clearly not economic, however, nor in some cases even possible, to provide special treatment to a very large portion of the total subscribers since the bulk of the service provided must match the capabilities of the bulk of the serving facilities. If, in addition, users whose signals depart from normal are not identifiable, there is no way to provide them with special treatment.

If the network is to accommodate large numbers of user-owned terminal equipment, it follows that signal amplitude, waveform, and energy distribution introduced by this equipment must continue to conform to the parameters used in the overall network design. Even a single user, whose signals are such as to cause cross talk or interference in multi-pair cable systems or cause overload in broadband carrier systems, can cause serious deterioration of service to a group of users.

Data and Voice

Motivation is one factor in the determination of the likelihood that generated signals will exceed the spectral power-handling capability of telephone facilities. Where voice transmission is involved, there is generally no motivation for exceeding design limits since the network components have been designed to accommodate the range of talker volumes and network links that will be experienced, with no advantage to excessive levels. In data communication, however, it is to the user's advantage to increase the signal-transmission level in order to improve his own error performance, albeit at the expense of degraded performance of other users. It is necessary, therefore, in this case to ensure that signals applied to the network do not exceed the transmission capabilities of the telephone facilities.

In addition to control of signal levels and waveforms, the interconnection of user-provided terminals involves other considerations. The first of these is the risk of voltages hazardous to personnel and to the network. The most important problem, of course, is the danger to telephone installation and maintenance personnel. Installation and maintenance must be carried on without interruption of existing service. It is the practice for cable and exchange plant workers to work barehanded on cable pairs and junctions in the immediate proximity of hundreds of other pairs and junctions in normal use.

There is potential hazard in this activity due to the adjacency of the telephone system to electric power systems. However, over the years the two systems have evolved effective measures to avoid injury. Similarly, effective measures must be evolved where there is interconnection of user-owned devices, to ensure that additional harmful voltages do not reach the telephone network from this source. Due to interconnection with the anticipated increase in user-owned terminal devices using 115 V AC and/or high DC voltages, the possibilities of harm due to poor initial design, improper installation, and/or inadequate maintenance are significant and must be faced in the interconnection of user-owned equipment.

Another situation in which service to other subscribers may be impaired is where the telephone line, normally well balanced, becomes unbalanced when a poorly designed, installed, or maintained device is attached to it.

Telephone cables are very carefully manufactured to minimize unwanted pickup of interference -- either from other telephone circuits or from nearby power systems. It is necessary to maintain this longitudinal balance at all times on all pairs. If this balance is degraded by some attached equipment, not only will interference be present on the unbalanced pair, but also other pairs in the same cable will be disturbed. Again, adequate provision must be made to ensure that user-owned terminals meet and maintain the longitudinal balance that is fundamental to maintaining the quality of network service, as do carrier-provided terminals.

Signal criteria, protection, and line balance are discussed in detail in the following paragraphs.

SIGNAL CRITERIA

The Panel has examined the basis of the signal criteria (as specified in the tariffs) that set limits on both "in-band" and "out-of-band" power. Criteria for in-band (below 3,995 Hz) signal-power levels are set to load the frequency-division multiplex carrier systems which furnish most long-haul voice-grade services, so as to optimize the signal-to-noise ratio for all users. The criteria for out-of-band signal-power levels are set to avoid interference to other pairs in the same cable, at frequencies above 3,995 Hz. Such cross talk between cable pairs increases at higher frequencies.

A third category of signal criteria sets limits on signal power in a specific region of the in-band range (2,450 to 2,750 Hz). These restrictions safeguard the operation of the 2,600 Hz in-band signaling system, which is almost universally used in long-distance telephone service. False operation of the in-band signaling system has serious results: improper billing, intermittent interruptions, insertion of a band-elimination filter in the transmission path, or even complete disconnection of a call.

As a part of this study, the Panel has examined the structure of the telephone-company plant and has determined that it does not provide protective mechanisms by either level limiters or filters to correct for signals exceeding criteria limits. We have also examined the operation of the telephone-company plant and have determined that the system is designed to operate in accordance with the criteria.

The derivations of the three classes of signal criteria, as set forth in the tariffs, are discussed under the following three subsections.

In-Band Signal-Power Criteria

The tariff requirements on in-band power[1] are as follows: FCC 259, FCC 263 -- the power of the signal at the central office not exceed 12 dB below one milliwatt when averaged over any three-second interval.[2] FCC 260 -- the power of the signal that may be applied by the user-provided equipment to the Telephone Company interface located on the user's premises

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[1]In-Band power is defined as the total power in the band below 3,995 Hz.

[2]There is also a requirement that the signal applied to the loop plant not exceed 0dBm.

will be specified by the Telephone Company for each application to be consistent with the signal power allowed on the telecommunications network.

The above requirements on in-band power are based on interference considerations of long-haul[3] frequency division multiplex carrier systems. These systems include cable carrier systems with capacities ranging up to 3,600 channels and microwave radio carrier systems with up to 1,800 channel capacity. Virtually all voice-grade services longer than about 200 miles use these types of facilities.

These systems are designed to handle a per-channel load of -16dBm long-term average power measured at a network reference transmission level point. This -16dBm power is the maximum average power per 4kc channel that can be permitted without incurring a noise penalty (increase in total system noise power). Below the -16dBm per channel average signal power, the noise is predominantly thermal (or random) noise. In addition to this thermal noise (which is independent of total signal power), the broadband systems are also subject to intermodulation noise due to non-linearity of the carrier amplifiers. At these low levels, this increases with signal power and at the -16dBm average signal power per channel, the intermodulation noise and thermal noise are equal. At signal power above -16dBm, the noise is predominantly intermodulation noise, this increases at a faster rate than the signal power. Maximum signal-to-noise ratio is obtained with average signal power at -16dBm.

Since both directions of transmission normally are not used simultaneously and not all channels are active at the same time, it has been determined that an average power limit of -13dBm applied to all users of a system is consistent with the long-term loading objective of -16dBm. In developing the tariff criteria, this -13dBm three-second average power limit was translated to refer to a specific physically identifiable location. The selected location was the serving central office and the usual loss between this point and the equivalent network reference transmission level point is 1dB. Thus, the maximum signal power that may be permitted at the central office is -12dBm when measured over any three-second interval.

When this power level is exceeded, the effect on other users of voice and data services is increased noise and interference. Depending upon the nature and number of the excessive signals, this noise and interference may appear in the following forms:

(a) Increased background noise or hiss on the channel

(b) Crackling or static on the channel

(c) Cross talk of other users' conversations into the channel. This cross talk may be either

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[3]Section 2, p. 19.

intelligible or merely bursts of garbled speech

(d) Increased error rates on data channels

(e) Complete loss of service caused by catastrophic overload of line facilities

The network of long-distance facilities to which the in-band power criterion is applicable is used on almost all long-distance connections (over 200 miles in length). This network provides many diverse paths over which voice and data calls may be carried. Network-management techniques plus dynamic alternate routing plans vary the specific path (and specific broadband facility) that a particular point-to-point call will use. Similar changes in routing also occur on private-line services, particularly when a facility failure requires an alternate facility for service restoration. This need for facility flexibility necessitates that all channels be operated at equal signal levels. Hence, an equal apportionment of system power-handling capability to all channels is appropriate.

Out-of-Band Signal-Power Criteria

The tariff requirements on out-of-band[4] power are as follows: FCC 259, FCC 260, FCC 263 -- the signal that is applied by the customer-provided equipment to the Telephone Company interface located on the customer's premises meet the following limits:

(a) The power in the band from 3,995 Hz to 4,005 Hz shall be at least 18dB below the stipulated maximum in-band signal power.

(b) The power in the band from 4,000 Hz to 10,000 Hz shall not exceed 16dB below one milliwatt.

(c) The power in the band from 10,000 Hz to 25,000 Hz shall not exceed 24dB below one milliwatt.

(d) The power in the band from 25,000 Hz to 40,000 Hz shall not exceed 36dB below one milliwatt.

(e) The power in the band above 40,000 Hz shall not exceed 50dB below one milliwatt.

[4]The out-of-band region is defined as those frequencies greater than 3,995 Hz.

Criterion (3,995-4,005 Hz)

The limitation on power in the band from 3,995 Hz to 4,005 Hz is based on potential interference in N3 carrier systems. This is an intermediate-range cable carrier system used to provide intercity circuits of 50 to 200 miles in length. By the end of 1968, there were almost 4,000,000 circuit miles of N3 carrier in the Bell System, which accounted for about 15 percent of all intercity circuits in the 50-200 mile distance range.

The interfering effect caused by power in excess of the criteria is a gain variation or flutter in another user's channel. In order to meet the overall system-flutter objective, it is necessary that the power of the interfering signal be 56dB below the power of the 4kHz carrier at the input to the carrier system's gain regulator. Based upon this reuqirement, the criterion for the 3,995 Hz to 4,005 Hz band is calculated as follows:

Spurious signal-to-carrier ration	-56dB
Carrier to maximum signal	+ 8dB
Average 4kHz suppression in channel filters	+30dB
Allowable 4kHz to in-band power ratio	-18dB

Criterion (4-10kHz)

The criterion for power in the band from 4,000 to 10,000 Hz is based on interference considerations in audio braodcast (radio and television) services. The most critical of these services, from a noise standpoint, is FM broadcast, which has an overall peak signal-to-noise requirement of 60dB. In order to meet this overall requirement, the studio-to-transmitter allocation of peak signal-to-noise is 65dB. Based on this signal-to-noise requirement and a peak transmitting level of +18dBm, the maximum channel noise permitted is -47dBm. Using this limit, the 4 to 10kHz criterion is calculated as follows:

Maximum noise	-47dBm
Correction for measuring techniques[5] and allowance for maintaining margin	-10dBm
Correction for multiple disturbers	- 3dB
System equalization	-25dB
Cross-talk coupling loss at 8kHz	69dB
Allowable 4 to 10kHz power on disturbing pair	-16dBm

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[5]Broadcasters normally use nonweighted noise measurements and align their equipment at 400Hz, while the Telephone Company uses weighted noise measurements and aligns audio channels at 1,000 Hz.

The interference mechanism in the case of these channels is cable cross talk. The resulting user effect is noise or tones heard in the channel. Due to the large number of ultimate users affected by interference with audio broadcast services, it is very important to avoid such effects.

Criterion (10-25kHz)

The criterion for the 10 to 25kHz band is based on considerations of interference into the U1 carrier system, which uses the 14 to 22kHz band for transmission from the user to the central office.

The U1 subscriber carrier system is a relatively new system and is not widely used at present. However, looking ahead to increased copper costs and reduced electronic costs, it is expected that loop systems operating in this frequency range will likely be used to an increased extent.

To meet noise objectives for this system, the minimum carrier-to-interference ratio in this band is set at 75dB. Based upon this requirement, a maximum signal of 21dB below a milliwatt would be permissible on a single disturbing pair based upon cable cross-talk coupling characteristics alone. Because other noise and cross-talk sources can exist in a given cable, the criterion was set 3dB lower than the limit for a single disturbing source. This provides assurance that the system-noise objective will be met under most conditions. The criterion is computed, as follows:

Interference-to-carrier (18kHz) ratio for 15dBm noise at subscriber terminals	-75dB
Carrier level	-29dBm
Correction for multiple disturbers	- 3dB
Cross-talk coupling loss at 18kHz	83dB
Allowable 10-to-25kHz power on disturbing pair	-24dBm

Criterion (25-40kHz)

The criterion for the 25-to-40kHz band is also based on interference into the U1 carrier system. The U1 system uses the 26-to-34kHz band for transmission from the central office to the user.

The required carrier-to-interference ratio for this band is 77dB. To meet this requirement the criterion of 36dB below one milliwatt was established. It reflects consideration of both the increased cable cross-talk coupling and the greater transmission loss at these higher frequencies and also makes allowance for other noise and cross talk in the cable. The criterion is calculated as follows:

Interference-to-carrier (30kHz) ratio for 15dBm noise at subscriber terminals	-77dB
Carrier level	-34dBm
Correction for multiple disturbers	- 3dB
Cross-talk coupling loss at 30kHz	78dB
Allowable 25-to-40kHz power on disturbing pair	-36dBm

Criterion (Above 40kHz)

The criterion for power in the band above 40kHz is based on potential interference into PICTUREPHONE service and into cable carrier systems operating in that frequency range.

The effect of interference to PICTUREPHONE service on the user is snow in the picture or herringbone patterns superimposed on the desired picture, due again to cable cross talk.

Signal Criteria (Criteria for Distribution of In-Band Power)

The tariff requirements concerning distribution of power within the transmission band are: FCC 259, FCC 260, FCC 263 -- to prevent the interruption or disconnection of a call, or interference with network control signaling, it is necessary that the signal applied by the user-provided equipment to the Telephone Company interface located on the user's premises at no time have energy solely in the 2,450-to-2,750 Hz band. If signal power is in the 2,450-to-2,750 Hz band, it must not exceed the power present at the same time in the 800 to 2,450 Hz band.

In the 2,600 Hz single-frequency (SF)[6] signaling system, the SF receivers respond to signal power in a relatively narrow band nominally centered on 2,600 Hz. However, factors such as manufacturing tolerances, aging of components and ambient-temperature differences produce some variation in both the nominal bandwidth and the center frequency of the receiver-response band. In addition, a form of distortion termed "carrier shift," which may be encountered on certain types of transmission systems, causes small frequency changes in the signal and is another source of variation. When factors such as these are taken into account, we find that the effective SF response band lies between 2,450 and 2,750 Hz. The receivers are designed, however, not to respond to power in this band when an equal or greater amount of power is present at the same time in the 800-2,450 Hz portion of the voice band. This criterion applies at the user's terminal and includes allowances for the sources of variation cited before as well as differences in transmission loss for different frequencies in the voice band, over regular telephone connections.

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[6] Section 2, p. 19.

Harmful Voltages

In this section we discuss sources of harmful voltages appropriate to the interconnection issue network, exposures to these voltages, and effects produced by them. The major hazard of significance is to maintenance personnel. Equipment hazards are considered minor since only the single termination associated with each loop would be harmed in case of excessive voltage.

Hazard to Personnel

This involves: (1) the effects of electric shock on human beings and (2) the extent to which network personnel may be exposed to such shock as a result of the connection of user-provided equipment and/or systems.

1. Effects of Electric Shock. Harmful effects are determined by the amount of current passing through the human body. The amount of current depends on several factors: the voltage on the electric conductor to which the body is exposed, the source impedance of the voltage, and the highly variable body resistance.

   In many ways, the most dangerous source of potentially fatal currents is 110 or 220 volt AC. The major danger of this source stems from its ubiquity around users' premises and the fact that the protective devices that are presently connected to telephone lines will usually not operate if the line is exposed to 110 volts. Yet the presence of the voltage is potentially lethal to personnel who come in contact with that line.

2. Extent of Personnel Exposure. As explained, the telephone companies provide service to customers by means of physical conductors in the exchange plant. Each time service is installed, removed or repaired, telephone servicemen make physical contact with wire pairs and terminals at one or more points in the station equipment or at the terminal appearances of the wire pairs on customer premises in outside manholes or on poles, and in the central office building.

   In general, the work operations require a hands-on type contact. The size of the wires, the terminal sizes and spacings, and the dexterity required, generally preclude the use of protective clothing or devices such as rubber gloves. This is not to say that rubber gloves are never worn. They are prescribed for many construction operations, particularly when working on joint-use poles shared with power companies. But they are inappropriate for such tasks as splicing together multi-conductor, fine-gauge cables.

The conductors that fan out from a wire center (or central office building are carried in densely packed cables, ranging from as few as 6 to 2,700 pairs of conductors per cable, and they are spliced together and terminated on closely spaced terminals in cross-connection boxes and in sealed splices along the routes. Therefore, servicemen working on a single pair are exposed not only to that one pair at terminal field appearances, but also to additional pairs that are connected to adjacent terminals.

Effects of Interconnection on the Harmful-Voltage Problem

The direct electrical connection of user-provided equipment and communications systems to telephone company lines adds an additional source for the introduction of potentially harmful voltages into the telephone plant. This can come about by a faulty equipment design or manufacture, or a faulty installation, both of which could cause 110 V AC or higher to appear on the loop. This potential hazard is also unique in that it is perhaps the easiest source to protect against in that the telephone-line exposure occurs specifically at the point of interface with the user equipment. Assured protection at the interface can provide suitable protection in both directions, i.e., protect the user from possible voltages on telephone lines and protect the telephone personnel from high voltages introduced by user-provided equipment or systems. In Section 5 we discuss protective mechanisms for this need.

Loop Balance

Connections between customer premises and central offices are normally made by individual wire pairs in multi-paired cables. The wires, because of the close proximity to each other, have mutual capacitive and inductive coupling effects. Mutual coupling results in cross talk between adjacent pairs, which, if not controlled, increases the noise level on all circuits concerned. Cross talk, in aggravated instances, can produce interfering signals of an intelligible nature, which violates, or appears to violate, the privacy of one or more users.

Cross Talk in Cables

To minimize electrical interactions among individual wire pairs within the cable, the pairs are twisted and balanced to ground. Twisting of the wire pairs reduces the effects of magnetic coupling to an insignificant factor. Capacitive coupling is, however, still a factor and has to be carefully controlled.

The longitudinal balance in cables is controlled in manufacturing so that the coupling loss between pairs is generally well over 100dB with about one percent of pairs having coupling losses of 80dB or less at 1,000 Hz. Since this coupling is primarily capacitive, the coupling loss will decrease (hence cross talk will increase) with increasing frequency at the rate of 6dB per octave. Tests have shown that if one conductor of one pair is grounded, cross talk will be worsened by 20dB, and if one conductor of each of two pairs is grounded, it will be worsened by as much as 60 dB. Therefore central-office circuits and telephone-station equipment and wiring in the telephone network are designed, installed, and maintained to ensure a high degree of balance to ground.

While cables are designed and controlled in manufacture to maintain balance and reduce cross talk, these controls become ineffective if equipment attached to the cable pairs is itself improperly designed, installed, or maintained. Cross talk will result if user-provided equipment is unbalanced to ground. This can occur if:

(a) Equipment is poorly designed initially. Terminating the telephone pair in an unbalanced circuit is a common error.

(b) Equipment is improperly installed so as to apply a ground to one side of the line. This may occur accidentally through insulation being scraped away or with nails or staples cutting through wires.

(c) Equipment can fail in service. A component can break down and cause unbalance on the line.

Cross talk can be insidious and difficult to locate because the malfunction is partial rather than total. The user may or may not be aware that he is causing trouble to other parties, especially if his service appears normal. Thus, the deteriorated performance can exist for a long period before diagnosis and correction. It should be noted that, with multiple party-line operation, one side of the line is grounded through the ringer. However, the ringer impedance is high enough to avoid unbalance at voice frequencies.

SECTION 4

NETWORK-CONTROL SIGNALING

INTRODUCTION

The network-control signaling functions are associated with the initiation, placing, answering, and charging of calls over the switched network.

Malfunctions can cause incompleted calls, or calls completed to other than the intended terminal. Processing such calls reduces the capacity of the network to serve "normal" calls. The effects of these malfunctions may be felt by all users of the system, not just those originating and answering imperfect calls.

The present state of the switched telephone network does not permit easy identification of the source of this kind of malfunction; that is, to locate it as occuring in the subscriber's station or in the central office. Carrier-maintenance personnel, tests, and administrative procedures become involved in the attempt to localize these malfunctions as they come to light.

Consequences of Improper Network-Control Signaling

The consequences of improper network signaling pervade the entire network and can be grouped into the following categories:

(a) Wasteful use of central office and transmission facilities

(b) Annoyance to other users

(c) Incorrect billing

(d) Wasted testing and maintenance effort

(e) Added administrative expense

Following are examples of each category:

1. Wasteful Use of Central Office and Transmission Facilities. Wrong numbers caused by a faulty network-control signaling unit represent a waste of switching equipment and a source of annoyance to those who are wrongly called.

Furthermore, a wrong number resulting from faulty signaling can cause a call to end up in the wrong city. In the near future, a wrong number may tie up, for a time, a transatlantic cable or satellite trunk connection. There are other sources of faulty control signaling. If, when a call is completed, the switch hook contacts fail to open properly, or some extraneous impedance remains bridged across the line, it is arranged that the connection will release after a time-out of thirty seconds. This is thirty seconds during which the circuits are not available to other users.

2. Annoyance to Other Users. In the example mentioned above, in which the call is not released properly, the user himself will be unable to place calls during this interval and others trying to reach him will receive busy signals.

3. Incorrect Billing. On a two-party line, the billing equipment at the central office recognizes which party is making a call because there is a high-impedance DC connection to ground on one side of the line. If the connection is not made in the telephone, or if the telephone is installed or maintained improperly, the wrong party will be charged for some calls. On lines with more than two parties, more complex party identification schemes are used, which depend upon the telephone instrument having particular identifying characteristics that differ from the instruments on the same line.

4. Added Testing and Maintenance Effort. When excessive wrong numbers occur, action must be taken to identify the source. It might be on the loops, in the line circuit, or in the central office. On the other hand, it might be in the network-control signaling unit. The user unable himself to determine where the problem is located will normally call the telephone company. Faulty network contact signaling often shows up as an intermittent trouble. These are the hardest to trace and to diagnose.

5. Added Administrative Effort. Improper network-control signaling can result in customer demands for credit against his telephone bill due to false charges. Since the source of the trouble, as previously mentioned, is difficult to trace and correct, the added administrative effort required can be considerable.

Conclusions

Improper network-control signaling leads to inaccurate billing, wasteful use of the telephone plant and administrative effort, as well as annoyance to other users. In planning for the use of user-owned network-control signaling devices, the quality of network-control signaling must be preserved.

AT&T Company Experience with Network-Control Signaling

The only available reliable source of information to the Panel on network-control signaling is experience with this function in the operation of the switched telephone network. In this section, information and data furnished by AT&T are summarized.

Dial-Pulse Signaling

Network-control signaling failures are largely related to the familiar rotary dial. Sources of trouble here are:

(a) Finger wheel and stop

(b) Contact

(c) Mechanism

(d) Noise

(e) Other

The dial mechanism itself was the most frequent source of difficulty. The mechanism is required to operate at speeds nominally between 9.5 and 10.5 pulses per second and with a percentage break between 58 and 64 percent. Generally, the units used by the Bell System fail in such a manner as to fall outside the percentage-break tolerances. This type of failure can lead to dialing wrong numbers.

Data on units supplied by others is sketchy. AT&T and Bell Laboratories, however, had reported experience with some equipment they have tested and found deficient. For example, one unit tested had a low-priced "antique" telephone with these two faults:

(a) Low ringer impedance

(b) Percentage break 67 percent outside allowable range of 58 - 64 percent

The first fault is attributable to poor design. The second may indicate either poor design or maladjustment. Bell has also tested commercial answering machines and repertory dialers. Some answering machines had the characteristic of failing to disconnect promptly. One repertory dialer tested exhibited improper percentage break as a function of line voltage, missed digits on low line voltage, and had inadequate interdigital time. A second repertory dialer exhibited dial speed and percentage-break characteristics that aged beyond specified limits.

On the other hand, general experience with telephones made by reputable manufacturers of telephonic equipment has indicated that the quality of network-control signaling units is on a par with those supplied by Bell. No comparative statistics are available.

Based upon the statistics provided AT&T, the mean time between failures for Bell station sets is 8.5 years. The mean time between failures for rotary dials is 46 years and for ringers 59 years. The combination of rotary dial and ringer has a mean time between failures of 26 years.

It is this kind of performance, or better, that must be realized where new devices and systems are attached to the telephone system if present network-control performance levels are not to be degraded.

Touch-Tone Signaling

Touch-tone signaling uses two tones per digit generated by pushing buttons on the telephone. One tone is selected from four frequencies between 697 and 941 Hz. The second tone is selected from four frequencies between 1,209 and 1,633 Hz. Both tones must be received by the central office for it to be accepted as a valid digit. Frequencies have a ± 1.5 percent tolerance. Output power is made a function of line current to regulate the received power at the central office for various loop lengths. Other tolerances are specified to hold the two sets of tones at appropriate power levels. The unit must operate within tolerance over a -30°C to +55°C temperature range and during its service life.

Reliable statistics on types and frequency of failures are not available on touch-tone dialers. Failure of the multi-frequency dialer due to improper frequency or power level, for example, will not be interpreted by the central office as a wrong number. The more likely condition is a register time-out due to its failure to recognize all the transmitted digits. This use of central office facilities is considered relatively insignificant as a harmful effect when compared to harmful effects due to malfunctioning rotary dials.

We conclude failure of touch-tone (multifrequency) signaling to be considerably less harmful to the network than failure of dial-pulse signaling.

Maintenance Data

In the switched telephone network, network-control signaling is exercised by the customer through the telephone instrument and over his wire loop to the central office. It is pertinent, therefore, to examine available data on station troubles and the costs associated with maintenance and trouble clearing. The following data were supplied to the Panel by representatives of AT&T.

In 1967, Bell had 42,586,551 customer-trouble reports - 27,392,760 troubles were found as a result. These troubles broke down as follows:

Station set	8,608,962	30.8%
Other station equipment	4,302,696	15.4%
Station wiring	4,802,760	17.2%
Outside plant	5,390,924	19.3%
Central office	2,485,913	8.9%
Customer action	1,801,505	6.4%

A Bell System study of station troubles made in 1966 showed the following breakdown:

	Trouble rate/100 stations/month
Cord	0.21
Dial	0.18
Ringer	0.14
Key and lamp	0.12
Mounting and plastic	0.12
Circuit	0.08
Receiver	0.03
Transmitter	0.03
Other	0.03

Whether these data reflecting carrier experience would be valid for customer-furnished station equipment, would depend on the performance of this equipment relative to that furnished by the common carrier. It would also depend on the extent of use of touch-tone control instead of rotary dial.

FAULTY NETWORK-CONTROL SIGNALING WITH USER-OWNED EQUIPMENT

It is difficult to evaluate the effect of interconnection on network-control signaling, since it is not known at present what precise instrumentalities users will employ for this function. Network-control signaling performance is closely related to the very detailed design and performance of the device used (switch hook, rotary dial, touch-tone pad).

The best that can be done, therefore, is to cite present experience of the carriers using their own devices. Starting from this as a reference point, it may be postulated that devices owned and used by customers will be either (a) as good as, or (b) poorer than, these carrier-furnished devices. The consequences of these assumptions are drawn in the following section.

ECONOMIC PENALTIES OF NET CONTROL SIGNAL-DEVICE FAILURES

Data on Bell System rotary dial and ringer units show a mean time between failures (MTBF) of 26 years. This is equivalent to a failure rate of 0.0385 per year.

Except for the special case in which competent maintenance personnel are continually at hand, trouble visits will be required and costs will be incurred and must be paid for.

Some vendors and users might be satisfied with a seemingly reasonable, though lower, MTBF. Reliability, however, has a profound impact on network operation and cost. Based on a large volume and using the Bell System experience of $15 per maintenance visit, Table 1 shows the annual average per phone cost for maintenance alone as a function of MTBF. The distribution of this cost between the user and the carrier cannot be determined at this time; however, it represents a substantial factor to be considered in specifying the performance of network-control signaling units.

TABLE 1

MTBF	Annual Maintenance Cost Allocated to Each Phone
26 years	$ .57
20 years	.75
15 years	1.00
10 years	1.50
5 years	3.00
1 year	15.00

Another cost (to the carrier) associated with improper network-control signaling failures is that attributed to wrong numbers, wrong toll charges, etc. It is difficult to estimate the frequency of such occurrences as a function of MTBF.

A third cost associated with network-control signal-unit failures is that due to false calls for assistance by the user. Where limited free interconnection has been permitted in the past, it has been the experience of the carrier that he is frequently called to perform the maintenance when, in fact, the interconnected equipment is at fault. This phenomenon can be expected to persist with any form of interconnection in which a specific interface between vendor equipment and the telephone company is not clearly defined.

The three types of costs described are a function of the MTBF of the net-control signal unit. The costs are very significant when evaluated in terms of a large number of subscribers. These costs will be borne by both users and the carrier, since some costs cannot be easily allocated.

CONCLUSIONS

Net-control signaling is a critical element, and a high order of reliability is necessary to avoid loss of net performance and excessive costs to both carrier and user.

SECTION 5

PROTECTIVE DEVICES

TARIFFS AND PROTECTIVE DEVICES

Unrestricted interconnection of user-owned communications devices or of privately owned unregulated communications systems to the public telephone network, as discussed in detail in Section 3, introduces the possibility of harm to the users of the networks in the form of degraded performance or an increase in the hazards of exposure of carrier personnel to dangerous voltages and currents.

As a safeguard against these potentially harmful effects, AT&T has incorporated in FCC tariffs 259, 260, and 263 not only protective criteria relating to levels, bandwidth, and signaling frequencies, but, in some cases, a requirement for carrier-furnished and installed protective and coupling arrangements to be placed between the telephone network and customer-owned and customer-maintained equipment and systems. Private-line customers obtaining service under FCC tariff 260 are not, in all cases, required to obtain protective devices.

This Section discusses this concept of protection along with alternative arrangements. At the present time, the selection of devices and priority of design and manufacture rests with the carrier. The number of different types of coupling devices available is limited and are intended to fill immediately-known requirements. They are to be followed by additional types as needs are identified, economics are justified, and as development is completed. Systems innovation and development of user-owned devices may be influenced by the willingness of the carrier to produce specialized interface units. This approach will be discussed in depth in later portions of this section.

PROTECTION AFFORDED BY PRESENT CARRIER-FURNISHED DEVICES

It is not intended here to provide a detailed description of every available coupler. Each is described in detail in a Bell System Technical Reference. The couplers are similar in their basic functions, which are:

(a) To isolate the line from hazardous voltages

(b) To limit signal levels

(c) To preserve longitudinal balance

(d) To protect the network control and signaling functions

In its simplest form, the coupler is designed around an isolation transformer that interfaces directly, via a jack, with the user-owned equipment. This transformer serves three functions:

(a) It ensures longitudinal balance on the loop regardless of any unbalance in the customer's equipment

(b) It isolates DC currents in the customer's equipment from the loop

(c) It prevents hazardous A.C. voltages from being impressed on the loop by virtue of its saturation capability

Varistors, shunted across the line side of the transformer, limit peak signal voltages. A capacitor in one side of the line blocks line current from saturating the transformer core.

Some of the more complex forms of coupler include a more sophisticated signal limiter designed to reduce distortion of data signals that exceed the allowable limits. Others include arrangements for signaling and supervision, either manual or automatic, answering only, or answering and calling. Coupler for interfacing customer-owned PBX equipment are much more complex units.

Degree of Protection

1. Hazardous Voltages. The major hazard is that involving personnel and the protection provided here is excellent in the carrier-furnished units. A saturable transformer is an effective method of protection. Fuses and circuit breakers rated for equipment protection do not provide personnel protection.

2. Signal Amplitude. The protection provided here also is excellent. The various types of limiter all ensure that proper levels are not exceeded.

3. Spectrum Limitations. No attempt is made in any of the couplers to limit signal spectrum. The couplers provide no protection against unwanted frequencies.

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[1]Section 3

4. Longitudinal Unbalance. The isolation transformer provides excellent protection against any defects in the customer's equipment or installation that could cause unbalance on the user loop and consequent hazard of cross talk and noise.

4. Improper Network Control Signaling. The subject of network-control signaling and the consequences of improper control are dealt with in some detail in Section 4. In this section, conclusions are reached as to the effectiveness of the current carrier-provided interface arrangements in preventing improper network-control signaling.

   The degree of protection afforded to customer-generated network-control signals is minimal. DC isolation is indeed provided between the customer's equipment and the loop, but since signals are usually merely repeated, there is no protection against dial-pulse speed variation, make-break ratio (in most cases), or repetitive dialing from a malfunctioning auto-calling device. In certain cases, particularly with relays that repeat dial pulses, the coupling device can, in fact, degrade the dial pulses by inferior timing characteristics of the relay. In another instance, the dial repeating function in one of the protective devices was less tolerant to dial pulse variation than if no protective device were used. In this latter case, AT&T is redesigning the unit.

IDENTIFIED ISSUES

Reliability

The protective arrangement or coupler introduce another electronic box into the system. What are the chances of failure occurring in a coupler with an attendant reduction in reliability? The answer, of course, depends on the complexity and soundness of design of the coupler. In the very simplest type of voice coupler, several solid-state diodes and an isolation transformer are all that is involved. Since all elements are solid-state, life under normal operating conditions is indefinitely long. Transformer-insulation failure at telephone-line voltage is extremely rare unless the quality of the insulation is initially poor.

At the next higher level of coupler complexity, the diodes are replaced by amplifiers and an AGC circuit with power supply. Additional resistors, capacitors, transistors, and diodes are introduced. Under normal conditions, the life of this sort of coupler should be comparable to the life of the attachment. Certain of these couplers use relays for dial-pulse repeating. Relays are notably poorer in reliability than solid-state devices and can, therefore, be expected to have a somewhat higher, but still acceptable, failure rate.

Redundancy

Redundancy, for purposes of this discussion, means that essential functions are duplicated in the coupler and in the devices attached to it and the requirement for protection, in many cases, can cause such a redundant condition. For example, redundancy occurs in some of the couplers provided for use with PBX's. In these cases, all functions of the coupler are repeated within the PBX itself from transformer isolation to regeneration of subset dial pulses which themselves may meet the dial criteria.

One approach would be to delete the redundant features from the user equipment designed for interconnection to the common carrier network. A manufacturer, on the other hand, would then be required to supply two types of equipment -- one to interface with the carrier provided coupling unit and another where a coupler is not required. Another approach would be to allow interconnection under the provisions of a Certification Program.[2]

Transparency

Ideally, the protective device should be "transparent"; that is, its presence should have no effect upon normal system functions. In this connection, the present coupling units are not transparent in that they do not pass DC due to the transformer provided for line balance.

"Transparency" has another, and somewhat different, meaning to the designer of equipment attached to the telephone network. The ideal protective device to him is one that does not require that he make design changes in his equipment. For example, the AT&T CDH coupler for PBX's presents a manufacturer of PBX's with a ten-terminal interface, whereas a PBX is designed for a two-terminal connection direct to the carrier's line.

Certainly, the greater the transparency of the protective device, the fewer the problems presented to the designer and manufacturer of terminal equipment. As with the redundancy case, transparency can be improved by cooperative action by the carrier and the supplier of attachments to produce improved couplers or by incorporating the protection into a unit built under an enforced certification program.

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[2] Section 6

Availability

Certain types of protective devices are said not to be available. AT&T states that the most frequently required types are available and the carrier is proceeding with the development of other varieties. They further state that the suddenness of the tariff filing created problems with regard to the supply of protective devices. A minimum number of types were ready for distribution at the time of, and shortly after, the filing. Nevertheless, a number of users have complained about lack of availability of announced units. Some have complained that, due to the difficulty in defining all protective requirements in advance, design and production of devices by the carrier could unduly delay installation of systems. There is also concern on the part of manufacturers that their desire and ability to innovate will be limited by the decisions of the carriers. At this time, availability is further complicated by a lack of a firm interpretation of tariff language. A lack of uniform interpretation among the many telephone companies and the various state Public Service Commissions is also a factor.

Power Supply Dependence

Protective arrangements (above the simplest level) require a source of power and typically commercial AC power is used. In the event of a power-line failure, therefore, the protective arrangement becomes inoperative. Communications within the customer's site can continue if the customer has provided emergency power for his own equipment, but communications with the outside world, where it is most needed, is cut off. This problem can be resolved and, fortunately, many solutions exist. Automatic means for bypassing the coupler in the event of an emergency is one possiblity. The problem disappears, of course, if the protection is incorporated into the design of the user's equipment.

Glare

"Glare" is a condition that occurs on trunks or lines when the circuit is seized at both ends at, or nearly at, the same time (or during what is called the "unguarded interval"). When this happens, the switching machines at each end of the circuit are confused, each fruitlessly waiting for an answer from the other end. Early-type protective couplers were designed to a 1.5 second unguarded interval. The addition of this coupler introduced a three-fold increase in potential glare with customer-provided PBX's over normal operation. However, a field change order for all CDH units, which reduces their unguarded interval from 1.5 to .5 seconds, has been issued. The risks of glare with this change are no different with the protective coupler and user-provided PBX equipment than that with carrier-provided PBX's. The increase in glare incurred by the addition of the protective arrangement would, therefore, appear to be a minimal problem at this stage.

Transmission Degradation

Although the ideal protective arrangement should be without loss, coupler losses amounting to 2 db to 3 db are practically achieved. Normal variations of attenuation in the received signal of the line can vary over 10's of dB's due to differences of loop length and other circuit variables. Therefore, losses induced by the coupler are small compared to normal circuit variations. There is usually no problem in compensating for this additional loss. Most modems and other attachments have adjustments or taps by which these losses may be fully compensated.

Packaging

The carrier-supplied protective device now appears as a separate entity in its own cabinet or box. While clean-cut from the carrier's point of view, it represents to the user just another box that has to be put somewhere. Presently, the protective device cannot be physically located in the customer's equipment, although the carrier indicates it is willing to discuss this issue.

Integrated Protection

Assuming a Certification Program[3] to allow direct connection between carrier and users, the following are some factors involved in the inclusion of the protective arrangement within the equipment cabinet.

1. Redundancies can be removed in various ways; one way is through repackaging. A manufacturer, having complete control over both the protective device and his own attachment, will tend to eliminate all redundancies in order to get the best cost advantage.

2. There may be small maintenance advantages. An interface of two wires is easier to maintain than the interface of eight or more wires of the more complex couplers.

3. There are fewer hardware variations. Manufacturers of the user's equipment will build the protective arrangement from the same hardware building blocks that are used in the rest of this equipment. The number of types of spare assemblies needed for maintenance is consequently reduced.

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[3]Section 6

4. The appearance of the installation is enhanced if there is one less box to contend with. The space occupied by the protective arrangement within the user equipment should be considerably less than as a free-standing box. The sharing of common facilities (power supplies, framework, etc.) will contribute to the better packaging efficiency.

5. No conclusions can be drawn with regard to manufacturing-cost advantages. It appears that a large-volume manufacturer would have a manufacturing-cost advantage through elimination of redundancies and the sharing of common facilities (as discussed in 1 and 3).

6. A built-in protective device has greater potential for mobility where that feature is important. Carrier-supplied protective devices would otherwise be required at each point of use of the portable attachment.

PROTECTION AT THE TELEPHONE CENTRAL OFFICE

This section discusses the feasibility of transferring the protection function to the telephone central office itself.

Perhaps the most significant observation to make about providing protection in the central office compared to protection of the customer's station is that no protection can be provided in the central office for certain effects. Protection at the central office cannot affect high-level signals that cause cross talk in exchange cables, high voltages that may be hazardous to those working on the loops, or unbalance which destroys the inherent balance of cables. Protection in the central office could, in principle, prevent excessive levels on carrier systems in the trunk plant. Present central-office designs, however, do not provide facilities to limit signals to the levels required to prevent overloading carrier systems or to prevent cross talk in loops or on voice-frequency intertrunks. In any case, such facilities, if provided, would also have to be provided on a per-loop basis or switched into service as required. At this writing, the Panel does not have enough information to make recommendations.

OTHER PROPOSED PROTECTION ARRANGEMENTS

Although the present coupling arrangements provide an acceptable way of providing protection from the hazards discussed in Sections 3 and 4, there may well be other and better ways of accomplishing it. An approach proposed by one manufacturer provides partial protection. The exact nature of the protective device, which uses solid-state elements, is not disclosed by the manufacturer. Its virtue is apparently low cost. The device does not use transformer isolation, yet appears to guard against hazardous voltages and out-of-limit signals. The protection, however, is not complete in that capacitive unbalance can still exist.

CONCLUSIONS

The need for some forms of protection is well established. The questions are: How much? Where? and In what form? Clearly, there must be protection against harmful voltages, excessive signal amplitudes and longitudinal unbalance introduced by attached equipment. We draw the following conclusions:

1. Existing carrier-provided protective devices are indeed effective in providing protection for hazardous voltages, excessive signal amplitudes, and longitudinal unbalance from users.

2. Existing carrier-provided protective devices provide, on the whole, minimal protection against faulty network control and signaling.

3. A protective device obviously introduces another potential point of failure. Reliability of the protective devices under normal operating conditions, however, should be comparable to the attachment and should, therefore, present no great concern.

4. There are redundancies between the functions of the protective devices and those of certain user-provided equipments; e.g., PBX's.

5. Carrier-provided couplers are not inherently transparent.

6. The present dependence of some couplers on commercial power is a significant and probably unnecessary disadvantage.

7. Protective arrangements do not contribute to any significant performance degradation. Increase in glare is minimal. Transmission loss is a small effect.

8. Central-office protection cannot provide the same degree of protection as customer-site protection.

SECTION 6

CERTIFICATION PROGRAM

Certification procedures in the interest of safety are customary in areas where safety to personnel and equipment depends critically upon engineering design, installation, maintenance and inspection. The Federal Aviation Agency regulates private flying under such a program. The Federal Communications Commission regulates the operation of radio and television broadcasting stations through the issuing of station and personnel licenses. A certification of satisfactory inspection by an inspector, who is himself certified as competent, is required before an electric power utility will permit the connection of its power lines to a new home, office building or factory. There are other familiar examples in which certification procedures are in daily operation.

It is natural to inquire whether similar procedures can be applied to the interconnection of user-owned equipment with the telephone network. The Panel has studied this question and has concluded that:

> ALTHOUGH EACH TELEPHONE INSTALLATION IS, TO SOME EXTENT, CUSTOMIZED BECAUSE OF DIFFERENCES IN LOOP AND SWITCH CHARACTERISTICS, NEVERTHELESS, THERE IS SUFFICIENT COMMONALITY TO ALLOW STANDARDIZATION

> THE PANEL CONCLUDES THAT THE STATE OF KNOWLEDGE AS TO THE CHARACTERISTICS OF THE TELEPHONE PLANT AND THE DEMONSTRATED CAPABILITY OF REPUTABLE MANUFACTURERS AND USERS WILL ALLOW THE DEVELOPMENT AND CAREFULLY PHASED-IN IMPLEMENTATION OF A CERTIFICATION PROGRAM

A successful certification program for telephone interconnection must be made up of three principal functions. These cover the areas of:

(a) Standards development

(b) Equipment certification

(c) Certification of installation and maintenance

STANDARDS

No certification program, whether it be for equipment or for services, will work unless proper standards have been established. In the case of telephone interconnection, standards must be developed to cover certification for installation and maintenance of equipment and facilities, as well as for equipment manufacture, since all of these combine to determine the net effectiveness of the program.

The standards, as defined for this effort, cover those factors relating to protection of the telephone network and to personnel safety.

These limited performance and safety standards would not guarantee the performance that the use of user-owned and maintained equipment would receive. Programs for this area could be developed. However, they are not within the realm of this study, which is limited to the technical issues that have evolved from the Carterphone decision.

Since enforcement will require that the standards be referred to in the tariffs, final authority for the entire program should remain with the governmental agency having jurisdiction over the tariffs.

Standards Development

A standards-development program requires the resources of a qualified standards organization to provide coordination, structural guidance, and staff services to those writing standards. Such organizations exist within both the private sector and government. In addition, a standards-development program in this area requires the work of knowledgeable people with sufficient training and experience in the design, manufacture, installation, operation, and maintenance of modern complex communication equipment and systems. Without this depth of practical technical knowledge, the resulting standards will fall short of the requirements for a workable certification program. The technical expertise in this area resides with the carriers, users, and manufacturers, and these must all be involved in this program. In this connection, several organizations representing such expertise are now active in the United States in the preparation of standards for communication equipment, systems, and interfaces. They can contribute knowledge and experience toward the establishment of the program being considered.

Assuming federal government participation in the establishment and conduct of standards-development activity for telephone-interconnection certification programs, this participation should take several forms:

(a) Establish the line of authority that gives weight to the enforcement of the standards. Cooperation between federal and state governments will be most important in this area.

(b) As a large user of communications facilities and services, it should participate in the committees developing new standards.

(c) Establish priorities and schedules to ensure that an orderly and expeditious development program proceeds.

Development of proper standards will take time. Even with qualified personnel working on their preparation, some standards have required more than a year before agreement could be achieved. If the program is recognized to be sufficiently urgent, the time required for development will be shortened. The importance of each standard influences the manner in which necessary qualified personnel are made available and the willingness of affected organizations to work out compromise agreements, and this, in turn, determines the time needed to arrive at an approved standard. In the opinion of the Panel such a standardization program can be successfully implemented.

EQUIPMENT CERTIFICATION

In addition to standards, procedures must be established and enforced to ensure that equipment meets those standards. The degree of inspection performed as a part of equipment certification determines the probability that the equipment will meet the standards.

An enforced equipment-certification program requires not only an evaluation of equipment samples but evaluation of the manufacturing organization to establish that procedures for quality of component procurement, manufacturing, testing, personnel training, and quality control ensure that there is a consistency of production quality.

In setting up an enforced certification program, overall organization responsibilities and relationships, therefore, need to be considered. One approach involves separating central management and administration of the certification and standards program from the day-to-day operation of test and inspection facilities. A central management organization might be continuously responsible to the government agency granting its authority. At the same time, performance of equipment testing and manufacturer inspection could be handled by government facilities or by many competing firms looking for more cost-effective methods of performing their tasks. There are a number of independent test laboratory companies in the United States today.

Certification of Installation and Maintenance

After a user obtains his certified terminals or other equipment, he must assume responsibility for their operation. As discussed earlier in this report, it is essential that the equipment be installed and connected to the telephone facilities correctly, and it must be maintained in a way which will not cause future harm to the telephone network. A complete certification program must, therefore, cover installation and maintenance, as well as manufacture, of the user-owned equipment.

An installation- and maintenance-certification program must include standards for, and inspection of, the equipment connection to each telephone line. In addition, consideration must be given to the qualifications and responsibility of the personnel who do the work. Minimum standard requirements will specify whether a given individual is authorized to carry out installation and maintenance of the equipment and to certify that the work has been properly completed.

A certification program for installation and maintenance would require that testing and licensing procedures be specified. In this case, licensing would follow examination under rules developed in the standards program with every license certificate endorsed to indicate its applicability to equipment of one or more classes.

The procedure for installing user-owned equipment will require close cooperation with telephone company personnel, since each case will require some degree of customer adjusting or fitting. This cooperative action will need to be recognized in a standard through the establishment of guideline procedures for installation and checkout.

In its simplest form, installation and maintenance certification would apply to a protective coupling unit designed to prevent harm to the public telephone network. If the protective features are not in a separate unit, but are incorporated into the user's equipment, then these procedures must apply to pertinent parts of equipment and facilities in the user system connected to the telephone line.

Inspection at the time of installation will not certify the installed user equipment indefinitely. Periodic inspection with appropriate documentation by licensed personnel must also be required by the standards for installation and maintenance.

Another area requiring careful consideration is the certification of equipment for resale to a second user. After connection and use at one installation and subsequent removal, it must be serviced and inspected by authorized personnel before it can be sold to a second user.

Maintenance requirements will include both routine and emergency service of the user's equipment. The correct type of routine or preventive maintenance can protect the network by preventing trouble before it starts. After trouble has been observed or suspected, optimum methods for fault isolation will help greatly in reducing the time needed to correct the trouble and to return the system to satisfactory operation. Responsibility and duties of those on each side of the common carrier-user interface must be spelled out in sufficient detail.

A maintenance organization, in order to secure certification, should carry the necessary stock of replacement units, spare parts, and other material needed for service of the equipment. Training programs for service personnel should also be implemented in a way that meets or exceeds minimum standard requirements.

PHASE-IN PROGRAM

In the Applicable Experience Section (Section 8) of this report, we point out that there has been considerable successful experience of U.S. carrier interconnection of large-scale organizations -- such as "right-of-way" companies. However, this experience is limited in scale relative to the overall telephone plant, and detailed data on the degree and specifics of this interconnection was not gathered. The past experience has been with large and technically capable organizations. There is no such equivalent experience with the larger-volume/smaller-user type of customer on a direct interconnection basis. As a matter of fact, since this whole area is so new, there is no large-scale experience of interconnection using the carrier-supplied connecting arrangements. As discussed earlier in this report, those elements are also new, relatively untried, and already some deficiencies are evident. All this leads to the caution that if a program for direct interconnection by the customer via a certification program is to be carried out, it should be done carefully and in a way planned to minimize risk to the success of the program. This program must be set up to gather data to provide feedback to the standards organization for further development of the program.

Therefore, the Panel feels that, as a first step of implementation, configurations involving smaller numbers of installations (such as PBX) should be certified. A ready technical base of servicemen exists, which could be certified. The equipment manufacturers and users are already familiar with telephone practices. This application would not represent a significant volume impact, so that if errors are made and lessons are learned they can be remedied. Following this, the next most widespread area can develop (probably data terminals), and then proceed to the remainder of the field. It must be emphasized that the development of the certification program for both equipment and personnel must proceed apace.

A number of installations, primarily the "right-of-way" companies, are presently directly interconnected with the carrier system. Over a period of time, these existing interconnections should be certified or access arrangements used. The Panel has not investigated a schedule for this, but it could be considered as an element in the overall certification program.

SELF-CERTIFICATION

If a user-manufacturer sets up his own program for equipment certification and verifies that he, in fact, meets all the stated requirements of a producer of specific products, and that the finished product has been installed and inspected according to published standards, the resulting program would be called self-certification.

Limited self-certification has proved to be satisfactory in several areas. The FCC requires that manufacturers of radio transmitting equipment mark all such products in a way that certifies that particular standards are met. Although the units are not tested by a third party, provision is made for monitoring in case of interference and inspection when required. In a similar way, the U.S. Coast Guard requires that standards be met in the manufacture of equipment and accessories for small craft used in specified areas. Again, the manufacturers' own certification is sufficient. However, annual inspection of small craft equipment is required.

An enforced certification program formally separates the responsibility for inspection from the manufacturing, distributing, and using organizations that have a direct financial involvement in the outcome. In the case of direct electrical interconnection where intractable harm can be done, it is the considered opinion of the Panel that this risk cannot be avoided by self-certification. This is particularly so in the case where a large group of small users with little technical knowledge might buy lower-quality equipments (new or used) and cause serious harm to the rest of the using community. Faults in equipment quality, installation, maintenance, and operating procedures will have a high likelihood of occurrence in the absence of the controls of an enforced certification program.

Responsibility

It was pointed out that the allocation of responsibility for protection of personnel, equipment, and service is important to the success of a certification program.

At present the carriers are responsible for the safety of their personnel, equipment, and the services they provide, and the regulatory agencies (both federal and state) exert authority over these carriers.

The widespread interconnection of user-owned terminals and systems, without isolating protective interface devices (which assign responsibility to the carriers), would cause the dispersal of responsibility for service to include, in addition to the carriers, one or more of the following:

(a) Users who own their own equipment

(b) Manufacturers who assure that standards are met

(c) Those who prepare standards

(d) Those who test or certify products

(e) The source of certifying authority

(f) Those who certify the competence of individuals or organizations for installation and maintenance

(g) Inspectors

(h) Commission (directly, in contrast to present back-up responsibility) for system design

The Panel also believes that any significant dispersal of responsibility for service and cost would ultimately jeopardize the performance of the telephone network. The Panel also believes that this can be prevented by so structuring a program of standards and certification that the final authority for each segment of the program rests with the federal regulatory commission having jurisdiction over the carriers.

Installation and maintenance work will usually be performed at the request or direction of the user. The user therefore should be required to acknowledge his responsibility for abiding by rules he understands. The Panel believes that the vast majority of users will accept such responsibility if care is taken to be certain that each one is aware of the rules and limitations. Users who wish to interconnect directly with the network should be required, in the process of applying for such privilege, to affirm their acceptance and understanding of the provisions of the tariffs governing such interconnection. If the evidence of such awareness is provided in the form of an application for service, then the carriers and the commissions will have the necessary tools and authority to deal with problems on a case-by-case basis.

The question of jurisdiction among the several commissions, federal and state, must be considered. Equipment manufacturers cannot deal with a multiplicity of standards, and centralized authority is thus essential. Minimum standards for the certification of servicemen will be a parallel effort with the setting of standards for equipment, and the same uniformity is needed. Nationwide service considerations would seem to require that practices be uniform, or nearly so, and certainly, certified equipment will be shipped from state-to-state. To retain the greatest practicable degree of centralized responsibility, the Panel recommends, therefore, that all standards and certifying organizations cooperating in the program derive their authority from the same federal regulatory agency having jurisdiction over the services of the common carrier. The tariffs would contain the provisions governing interconnections.

COSTS

The Panel has been requested to consider the technical aspects of interconnection with the telephone network, and of making recommendations on the basis of those considerations. At this time there is no available cost-data base for analysis. Nevertheless, every technical conclusion is associated with costs, and some general comments in this area would be worthwhile.

Many of the presentations made to this Panel have included protestations that this or that solution entailed an unnecessary cost burden. Consideration of any one cost by itself is easily transformed into a debate about who should bear the cost, or of how costs should be distributed among users and suppliers of telephone service. Such a debate is beyond the scope of the assignment given to this Panel.

What matters is that all costs that result from interconnection be recognized, and that they be held to a level that is reasonable in relation to the benefits expected to follow. While the directly connected user will have expenses for equipment purchase, installation and maintenance, the carriers will also have costs associated with direct connection. These will be primarily associated with changed maintenance and installation procedures and administrative tasks.

The apparent waste involved in requiring the use of protective interface devices in <u>all</u> cases, may be offset more or less by the reduction or elimination of other costs that are less visible, but just as real. The overall standardization-certification program will also entail costs. In this connection, a figure of $1,000 has been suggested for test and evaluation of the production run for one manufacturer's small product. Final figures will depend upon volume as well as details of the equipment configuration.

It should be noted that the whole subject of rates has been outside the scope of this Panel's consideration. Nevertheless, rates are basic to this entire issue, as they will determine the degree of interest among users in any interconnection method beyond that presently authorized by the tariffs. Since there is as yet no experience with direct interconnection, no conclusions in the area of rates are possible.

CONCLUSIONS

(a) The establishment of standards and the enforced certification of user-supplied equipment and personnel form an acceptable way of ensuring network protection.

(b) Authority for a nationwide certification program should reside with a federal regulatory agency responsible for the tariffs.

(c) A carefully planned and timed step-by-step effort is necessary to ensure the successful implementation of a certification program.

(d) Self-certification by manufacturers or users will not ensure an acceptable degree of protection.

SECTION 7

INNOVATION

INTRODUCTION

For the purpose of this section, the term "innovation" will be taken to mean the introduction and use of new equipment, new uses of equipment, or new services. We are not concerned here with inventions or ideas per se, but rather with the ability to put inventions or ideas to practical use by the telephone companies or those who wish to interconnect.

The principal consideration here is interconnection with the Direct Distance Dial (DDD) network, although some of what is discussed is obviously applicable to the question of interconnection with private lines as well.

The impact of innovation has not been presented as a major issue before the Panel, but some concerns have been expressed. It is clear that many of those concerns are the result of interconnection itself and the fact that interconnecting parties and the carriers will have to cooperate in some way to reach solutions to problems when their interests do not coincide. The amount and kind of protection required for the network and the method of providing it tend to change the nature and degree of the problems, but do not solve them. Few, if any, of the problems are entirely technical in nature, although technical factors should be considered in any policy decision.

Although the discussions before the Panel have been addressed primarily to problems that might limit innovation, it seems clear that interconnection will have a positive influence on innovation in some cases. The Panel has made no systematic attempt to survey new technology and potential new developments. For our purposes, the material presented to the Panel in response to our inquiries seems adequate. For this reason, the references to new technology and new developments cited below should be considered only as examples of things that are reasonably well understood and which may have some impact in the not too distant future.

The incentive to innovate is usually economic, either directly or indirectly, whether it be to provide an existing service at lower cost or to provide a new service. The increasing dependence of the business community on communications in a variety of forms will provide ample incentive for continuing innovation in an era in which technology is likely to advance rapidly.

It seems likely that business will want fast response to its communication needs and will want customized services to optimize its own operation. To the extent possible, no technical barriers in the interconnection policy should prevent such innovation so long as new things are not allowed to interfere with other uses. Neither should technical barriers prevent telecommunication carriers from innovation in the network, where it is in the public interest.

BACKGROUND

New Technology

The development of integrated circuits to the point where cost and reliability expectations are realized will certainly have an impact on innovation. Existing functions will be performed at lower cost and new functions not practical with older technology will become economically attractive. In addition, it seems likely that in attempts to optimize overall systems (common carrier systems, user systems, or a combination of the two) there may be a tendency to shift functions between different parts of the system. For example, with low cost, small size, and high reliability, there may be future tradeoffs that suggest putting more functions in terminal equipment or changing the characteristics of terminal equipment in order to make savings elsewhere in the system.

For many years, the trend in transmission technology has been toward larger and larger systems. In the long-haul transmission plant, each new system carries larger numbers of voice-band circuits or equivalent and at less cost per circuit mile. This trend seems certain to continue, using waveguides, perhaps within a decade, and still wider band systems, using optics in several decades. As now understood, these latter systems will likely use digital modulation techniques and will tend to promote more widespread use of digital facilities in the network feeding into those systems.

NEW DEVELOPMENTS

New Telephones

The Bell System has indicated that the next generation of telephones will use active electronic devices to improve transmission quality and to help overcome some of the technical limitations of loop characteristics.

It will also likely include tone ringing using tones in the voice band. When that telephone is used, customer equipment that is acoustically coupled to the telephone will have to be modified, and inductively coupled devices probably won't work at all. The new telephone is not expected to be in production for several years and will not be in widespread use for quite some time. It does, however, illustrate how new system tradeoffs by the carrier could impact on customer-owned equipment.

New Data Terminals

Very little has been said before the Panel about the character of future data terminal development. This is not surprising, considering the competition in this field. It seems safe to assume, however, that with the ability to interconnect, this will be an attractive field and new ideas may spring from a variety of sources. It also seems safe to assume that terminals will become increasingly sophisticated. In fact, future terminals will most likely be small "computers," in that logic will be programmable by the user. In such cases, the terminal might be able to match changes in central offices by changes in terminal "software," if a standard interface has been established.

The rate of innovation of data users will likely exceed that of the switched network with the largest and fastest-growing segment in the low and medium data rate areas.

Digital Transmission

The telephone companies are now using large quantities of PCM carriers in their exchange trunking plant. The Bell System version is called T1. A second system, T2, with more capacity and usable for short- and medium-length toll circuits is under development by Bell. This trend toward systems that carry signals in digital form seems likely to continue through larger long-haul systems. In particular, as noted earlier, the system using waveguide as the transmission medium will be a digital system. The prospect then is toward an increasing percentage of the DDD transmission plant being digital, leading eventually perhaps to a predominantly digital plant. Special digital networks will likely appear much sooner.

In an all-digital DDD long-distance plant, the loading and interference characteristics will be somewhat different from those in the present frequency division analog carrier systems. While one would expect that some of the details of the signal criteria might change, the changes are not likely to be large and, in any event, will not occur for some years to come. The availability of a substantial amount of digital transmission will very likely result in new tariff offerings for digital data services. The Panel believes that protective criteria for those services should be consistent with the need to protect the specific facilities used.

New Switching Systems

The move toward all-digital transmission in the long-distance plant will lead also to the switching of signals in digital form. Such switching already exists in special networks like that of Western Union. Since such a switch looks essentially like another digital-transmission link, it would have no additional effect on the criteria for interconnection.

In the local or exchange switching plant, the desire to go to solid-state electronic crosspoints in the switching network has been thwarted somewhat because of the need to pass the high voltages required for ringing the telephone. This is one example of a situation in which the system balance may change with integrated electronics. It may be that by putting a tone ringer and perhaps tone transmission of off-hook/on-hook signals in the telephone, even at added expense, the resulting impact on the local office, which might then make extensive use of electronics in the switching path, would more than offset the additional costs, if any, in the telephone. Such tradeoffs could, of course, have a significant impact on interconnection and the interface between user-owned and carrier-owned facilities.

New Signaling Systems

Currently, signaling in the DDD toll plant includes the use of a 2,600 Hz tone to indicate the busy or idle status of trunks. The tariff criteria are set up to protect this 2,600 Hz signaling system. The future direction of signaling appears to be toward systems that are separate from the voice-band path. Hence, with such systems, the protection of 2,600 Hz will no longer be necessary, but because of the very widespread use of the present system, it will be a significant factor for years to come.

NEW SERVICES

PICTUREPHONE

The Bell System has conducted trials of a switched see-while-you-talk service called PICTUREPHONE and has announced that a commercial service offering will be made in 1970. It has also advised the Panel that interconnection arrangements will be available at, or soon after, the introduction of the service.

This service will have, in addition to the normal audio pair in the loop, two pairs of wire for the video (one for each direction), with a transmission capability approaching 1 MHz. In the digital toll transmission plant, the voice and video will be multiplexed on a 6.4 MB/s bit stream.

The system clearly has capability for high-speed data.

Since the interconnection arrangements have not been announced, the Panel has no basis on which to make detailed comments. One observation, however, can be made. The audio pair is used for network-control signaling. The question of interconnection to the two video pairs should then be limited, in the technical sense, to transmission and physical-protection criteria.

DATA-PHONE 50

The Bell System has recently begun a 50 kilobit service called DATA-PHONE 50. No provisions have been made for interconnection and a few parties have suggested that interconnection be allowed. Although the Panel has not studied the characteristics of this service, it sees no technical reason why interconnection should not be permitted, consistent with the final decisions regarding interconnection for voice-band circuits. The use of this service will likely be primarily for computer-to-computer data transmission in load-leveling, national data banks, national network access for remote access users, etc. It will be desired to incorporate into computer communication hardware all automatic functions as opposed to manual functions most used today in voice-band data transmission.

OTHER NEW SERVICES

Other new services are likely to be offered in a way and form that can only be estimated at this time and which will depend not only on technical factors but also on actions by regulatory agencies. The offerings of the types recently proposed by MCI and the DATRAN service are examples. We have grouped such services under the general heading of customized common carriers. They will, in general, we believe, aim their offerings at the business community and perhaps especially at users of data services, where the rate of innovation will be high. In this connection, we observe that, from a technical point of view, many of them will depend on interconnection with the common carrier.

POTENTIAL RESTRICTIONS TO INNOVATION

Problems of Information Transfer

The need for more information to be exchanged between suppliers and users on the one hand and the carriers on the other was evident in the presentations before the Panel. Users suggested arrangements to the Panel that the Bell System had already provided for, but about which the user was unaware. Other cases came up in which the Bell System stated its intent to the Panel to provide for connecting arrangements, but that intent was unknown to suppliers and potential users. Regardless of the procedures finally adopted for providing protection to the network, whether by interface boxes, by standards, or some other arrangement, some method should be worked out to allow for better interchange of information. Some of this will come naturally with time as all parties gain experience with interconnection, but the problem will remain to some degree. Further, it is evident to the Panel that many customer systems have or will have terminal points in independent companies, as well as Bell System territory, and better communication with the Bell System is not sufficient. This issue will be addressed further in Section 9.

Questions of Timing

Perhaps the most significant question of timing is that of the response time of carriers to new user requirements. Users have found that arrangements that are nominally available are not actually readily available in all Bell System companies when they want them and not available at all in some independent companies. This is inevitable in the initial stages of a change as significant as interconnection. Nevertheless, many people feel that the carriers will not be able to respond rapidly enough with new protective arrangements and that they could innovate faster if they included the protection in their terminals. They could then make it available on their equipment regardless of the location or company.

A second question of timing has to do with the changes in the carriers' system that might make user equipment obsolete. The Bell System has expressed concern that if a user has just purchased new equipment, he will be reluctant to accept a change in the telephone system that would require substantial change in his equipment.

Several users, especially those in fast-moving fields like computer communications and those who have historically interconnected with the carriers' private lines, suggest that the rate of innovation in the DDD network will pose no problem to them.

Questions of Cost

An important cost question from the suppliers point of view is the cost of a new connection arrangement for some new service or use he may want to offer. If he included the protection in his own design, he would be able to determine the total cost himself. If he must wait for a carrier tariff, the total cost of his service will be uncertain until the tariff is filed.

Another criticism of the present arrangement is that suppliers fear that the carriers can compete unfairly because, in their opinion, the added protective box makes customer-owned systems more expensive and less reliable than comparable carrier-owned systems. The Panel recognizes that the question of actual overall cost is a complex one and has made no evaluation of costs, including those of administration, etc., as they relate to different approaches. Section 6 discusses some of the general cost tradeoff areas in greater detail.

Restriction of Use

Present connection arrangements are on a per line basis and are tailored to a specific terminating arrangement. Some users may want to use a line for one purpose at one time (e.g., during the day) and something else at another time (e.g., during the night). This argues, in their opinion, for an arrangement that is physically a part of the terminal rather than the line. The Bell System has agreed that this may be possible using carrier-owned protective devices integrated into the customer equipment.

In a different vein, the carriers point to a potential use of characteristics of specific designs in the network that are incidental to its normal use and that may be different in subsequent generations of equipment. An interconnecting arrangement that takes advantage of such arrangements may unknowingly be made obsolete by new designs. An example brought before the Panel involved the use of single tones produced by pressing two touch-tone buttons simultaneously. The new integrated circuit version of the touch-tone generator does not produce the single tone since that feature was only incidental to the original design.

SUMMARY OF ISSUES AND CONCLUSIONS

The carriers have said that widespread interconnection will tend to impede innovation in the network, because, among other things, users will tend to oppose changes by the carriers that make the users' equipment obsolete or require it to be modified. They have also said that direct interconnection without carrier-owned interconnecting arrangement will further impede their innovation because it removes the carrier-controlled buffer with known characteristics between the network and the interconnected equipment.

Some users, especially the large ones and those in fast-moving fields such as computer time-sharing, have expressed the opinion that, with the necessarily deliberate rate of innovation expected in the network, there will be no major problems in keeping up with network innovation. They do not agree with the carriers' concerns regarding the need for a carrier-controlled buffer.

Some suppliers of equipment and services have expressed the opinion that the presence of the carrier-owned interconnecting arrangement will impede innovation on the user side of the interface, where the goal is to optimize the users' system or use of equipment. Further, and perhaps more importantly, they question the ability of the carrier to respond rapidly enough to new situations in which new interconnection arrangements are required.

While data on which to base conclusions are limited, it is the opinion of the Panel that:

1. The advent of widespread interconnection itself, regardless of how it is implemented and controlled, may indeed have some effect on the rate of innovation by carriers, suppliers, and users. In some cases, it may impede innovation in the network and, in other cases, it could conceivably promote innovation because of the pressures of demand from users. It will certainly tend to increase the rate of innovation by suppliers and users.

2. The introduction of a certification program for direct interconnection will not significantly restrict carrier innovation <u>if</u> there is effective information exchange between carriers, suppliers, and users. On the other hand, the suppliers and users will have more freedom to innovate.

3. On balance, under the certification program, innovation in the overall system by carriers and users of interconnected equipment is likely to increase.

SECTION 8

APPLICABLE EXPERIENCE

COMMON-CARRIER APPLICABLE EXPERIENCE

The common carriers have had extensive experience with interconnection between carrier systems and with non-carrier user-owned and user-maintained equipment and systems.

Interconnecting with Each Other

Communications carriers are extensively interconnected with each other. There are approximately 1,900 independent telephone systems connected with the Bell System. The Western Union Telegraph Company is interconnected with the Bell System and many of the independent telephone companies. The international communications carriers, including COMSAT, are interconnected with the Bell System. The Bell System, the international carriers, and COMSAT are interconnected with foreign carriers.

These interconnections are all arranged on a contractual basis with standardized interface arrangements developed by extensive intercarrier committees and consultative groups. The Federal Communications Commission and forty-nine state regulatory commissions act as referees, or courts of appeal, if difficulties arise over the interconnection interface. However, the fifty or more years of experience the telephone industry has had in arranging interconnections from simple interfaces involving manual plug and jack telephone switchboard to the complex automatic systems providing for nationwide (and now international) Direct Distance Dialing (DDD) have resulted in a surprisingly small number of appeals to these commissions. Design procedures and the authority for interconnection have been formalized between the carriers and the regulatory commissions, such that these practices are well established and thoroughly understood throughout the telecommunications industry.

Equipment standards and practices are based on voluminous documentation prepared by joint industry committees. Equipments and practices developed by the Western Electric Company are widely used "standards" of reference throughout the industry and many manufacturers substantially duplicate this equipment for use by the independent telephone companies.

Standards for maintenance and repair and standard practices for installation and preventive maintenance have been established by the industry through experience with extensive analysis of equipment failures and faults. Technical equipment and system innovation promoted by both the carriers and the manufacturers of communications equipment is pursued on an industry-wide basis, with extensive consultation through the many joint committees between the Bell System and the independent carriers. New services, when requiring new technical equipment, system practices, transmission standards, etc., are developed jointly between the AT&T and the independent companies. After new services have been tested experimentally, standard operating procedures, inter-company tariff agreements, and revenue-sharing arrangements are established.

The assignment of cost burdens between the several carriers is established on the basis of the current separations formulas, or through negotiation and action with the responsible regulatory commissions.

The experience of inter-carrier interconnection arrangements has applicability to the present study to the extent that two organizations operating on the opposite side of an interconnection interface can perform successfully when both operate to compatible or the same standards and are technically and operationally qualified, and when both are similarly motivated to provide efficient, economical service with minimum disruption due to interconnection difficulties. Common regulatory authority assures a degree of common motivation of all telephone carriers.

Non-Carrier Interconnections

There has been experience with a very considerable number of non-carrier interconnection arrangements. The largest of these users are the United States Government agencies, particularly the Department of Defense, which, for many years, has made extensive use of common-carrier systems, often providing its own terminal equipment, including PBX's. Another class of users has been the so-called right-of-way organizations (railroads, pipelines, electric utilities) who have operated their own communications systems with varying degrees of interconnection with the telephone carriers. Aeronautical Radio Incorporated (ARINC), serving the air-transport industry, has operated an extensive network and many localized interconnection arrangements. Most of these are on an allocated circuit (leased-line) basis, but there has been some use of interconnection with the switched network, theoretically only on an emergency basis.

User systems are designed, in most cases, with extensive consultation with the carrier involved and often with installation of test equipment and practices to protect the network.

In many cases in the past, the equipment employed has been Western Electric-manufactured or manufactured by other concerns on the basis of Western Electric's specifications and designs. Currently, equipment is being manufactured in accordance with accepted national or international standards by competent manufacturers and many satisfactory interface arrangements have resulted.

In most cases, the organizations concerned are adequately competent technically and motivated to maintain equipment to high standards of performance, and interconnection problems have been manageable.

There is applicability to the present study in these non-carrier interconnection arrangements, both from the standpoint that several have been highly successful and trouble-free, while others have resulted in troubles. Both of these cases will be discussed in greater detail later in this section.

Experience of Right-of-Way Companies with Carrier Interconnections

The right-of-way companies, to which might be added ARINC, have had extensive experience using carrier circuits as part of their systems. In many cases, these right-of-way companies own and operate private communications systems (microwave relays being the most important, but other systems are also included) which serve their principal operational locations. These locations include railroad switchyards and terminals, pipeline pumping stations and control centers, utility generating and distribution systems, substations, and other installations. In the case of ARINC, circuits are used to interconnect transmitter and receiver or transceiver sites with communications and control centers.

Much of the equipment used by the right-of-way and similar utility companies has been developed and procured in accordance with specifications or practices developed by carriers or manufacturers who are skilled in providing equipment for the telephone utilities. Interface problems have developed from time to time, but these are generally worked out amicably between the user and the carrier with satisfactory settlement of areas of responsibility.

One submission by such a user summarizes its experience with interconnection. It has nearly 500 unattended stations controlled over Bell System circuits by operating centers sometimes located several hundred miles away. The user also has an Electronic Switching System interconnected with over 800 Bell System circuits. This user had no reports of dangerous voltages or currents having been introduced into the carrier system through its operations, and, from the user's standpoint, service has been entirely satisfactory without the necessity of interface devices between the user and the carrier facilities. The user has extensive procedures and facilities for monitoring the nature of the signals introduced by it into the carrier network. It has also established rigorous preventive maintenance procedures with about sixty maintenance men and thirty fully-equipped maintenance trucks constantly visiting and checking facilities throughout the United States.

Experience of Foreign Communications Carriers

Foreign communications carriers have been concerned with the problem of interconnection of non-carrier equipment in varying degrees. The extent of the problem depends upon the policies of the carrier, the extent to which the carrier is able to meet urgent demands for switched telephone services, and the nature of its organization.

The applicability of the experience of foreign carriers to the specific problems facing the FCC and the U.S. carriers varies, both because of the widely differing circumstances under which different foreign carriers operate and the lag in the development of pressures for the use of the carrier networks for many non-telephone purposes.

In general, the carriers in the developed industrial countries have a monopoly of telecommunications services. This is achieved by the carriers, either being a ministry of government -- as in the case of the Bundespost and the PTT's in various countries -- or a chosen instrument government-chartered corporation, such as the Nippon Telephone and Telegraph Public Corporation or the British Post Office Corporation. The extent of the monopoly varies but, in general, it is quite complete and to challenge it is, in effect, to challenge the government.

Most of these foreign carriers are responsible for the total of domestic (and, in many cases, foreign) telecommunications services. This includes message telephone service, telegraph services including TELEX, the provision of leased lines for all services from narrow-band telegraph to television program relay. There are exceptions to the provision of television program distribution, such as the separate network of EUROVISION in Europe, but such exceptions are limited. In the case of the communications systems operated by government ministries, the ministry is, in effect, the FCC, the AT&T, the independent telephone companies, Western Union, private microwave services, etc., all incorporated in one organization. In general, the policies of such an organization can be challenged only through the national parliament. In the case of the recently established British Post Office Corporation, one of the objectives was to remove the carrier from detailed political surveillance by parliament and permit it to concentrate on the technical, operational, and business-management aspects of a major service business. In this case, to provide for customer or public influence or guidance in the operations of the carrier, several Country Councils and a National Council have been established.

In many countries, the primary orientation has been almost exclusively toward public message telephone and telegraph services and financial and plant resources have been inadequate to fulfill the demands for these services; hence, the carriers have been slow in permitting any extensive use of their facilities for other services. This has been particularly true of certain countries of Western Europe that have been loath to commit transmission facilities to private-line services when they are sorely needed for public message telephone service.

An advantage a government ministry or chosen instrument corporation has is the ability to rank order subscribers or using agencies giving preference to those adequately qualified. These include other government departments and agencies, the railroads or other right-of-way companies, and large technically qualified industries. The government department, or government-backed corporation, is in a strong position to discontinue service if established specifications, practices, or standards are not adhered to.

These "monopoly" carriers can, and do, establish and enforce rules ensuring adherence to high standards in the procurement of customer equipment. They can establish specifications, require type approval of all equipment -- even to the extent of testing it in their own laboratories -- before manufacturers are permitted to sell to prospective users for interconnection. The British Post Office, for example, has long avoided the investment in large PBX's by requiring the user to procure his own, but it has type-approved only a few models produced by manufacturers who supply equipment to the Post Office and manufacture in accordance with Post Office specifications, practices, and standards. The PBX is then installed in accordance with the Post Office-established specifications and then maintained by Post Office personnel. The Post Office permits interconnection of automatic dialers and other devices for fire, burglary, high water, and other alarm services. However, these must be connected in parallel with a standard telephone installation, the device must pass a Post Office qualification test, and be maintained in accordance with established standards.

The ministry of telecommunications or a national telecommunications corporation can make any necessary decisions as to the placement of economic burden for provision of non-standard services for any interconnection arrangements or for other costs occasioned by user-provided equipment. The British Post Office requirement that the user provide large PBX's is a good example of this.

Experience with Extra-Legal Interconnections

Prior experience with unauthorized interconnection has given some indication of problems that might develop with formal arrangements for interconnection of user-provided equipment without some protective interface between customer-owned and customer-maintained equipment and the carrier facilities.

Amateur radio operators have long used "phone patches" for connecting amateur radio telephone stations to the switched network in order to permit their friends to communicate with distant parties through amateur radio. Most of the telephone companies have countenanced this "illegal" use of the system as a service to the amateurs and the public and relatively few cases of trouble have been experienced. In general, an amateur operator is a competent technician and the amateur's carrier-provided telephone is used to perform the signaling functions, and the phone patch is only connected while the call is in progress.

There is a body of experience of difficulties with user-installed extension telephones that usually shows up only when the telephone is defective or the mismatch between the characteristics of the "foreign" telephone and the requirements of the loop are such as to result in a report of poor service or a failure of service.

A survey of state regulatory commissions indicates a limited accumulation of knowledge concerning troubles from interconnection of user-owned equipment, although a considerable number of examples were cited in which such equipment had been interconnected with telephone company facilities resulting in service calls and difficulties in clearing the trouble. One commission cited fifty-four trouble reports during a recent, but unspecified, period in which user-owned equipment was involved, of which forty-five were found to be faults in the user equipment. A second commission cited an example of computer time-sharing terminals connected through a local central office, which contributed to a serious overload condition. In this case, the holding time per call on the terminals was approximately ten times the holding time on regular business telephone lines. A number of other specific examples were cited by this commission.

The experience here is applicable to the present study to the extent that it indicates that a customer with inadequate technical and operational competence may create difficulties in the common-carrier network.

Experience in Other Areas

There is experience in other technical and service enterprises in which interconnections between systems or system components may be pertinent to the study of interconnection with telephone systems.

Computers (Main Frames and Peripheral Equipment)

A good example is the interconnection of peripheral equipment of one or several manufacturers with a computer main frame of another manufacturer.

The computing industry had to face the interconnection issue years ago. The large computer main-frame manufacturer maintained a strong sense of overall systems responsibility very similar to the common carrier's position, which has been altered by the Carterphone decision. The manufacturers maintained that they could not be responsible for the performance of the system if the customer uses other than the manufacturer's equipment and supplies. The issues are comparable in certain respects to those posed in the common-carrier interconnection case. Who is responsible for maintenance and installation? Will the attachment harm the system? The attachment may have greater capability, lower cost, etc.

The first departure from the entrenched position of the main-frame manufacturers in the computer field occurred over ten years ago in the magnetic tape area. Computer manufacturers sold their approved magnetic tape, but the users started buying from other independent suppliers. In general, the tape worked quite well and it represented an appreciable cost saving to the user. Customers were warned, however, that they had now transferred the responsibility for tape-handler performance to themselves. When there was doubt as to whether the tape handler or the tape was at fault, the manufacturer's serviceman used a "good standard" tape to prove the case one way or the other. Even though the responsibility for tape performance was thus assumed by the user, he was willing to take this responsibility judging by the amount of magnetic tape being purchased from independent manufacturers today.

Within the past few years and with the fantastic growth of the computer industry, many independent peripheral device businesses have been spawned. More are being born each day. There are now a large number of organizations providing peripheral devices like punched-card readers and punches, high-speed printers, tape handlers, and disc handlers to customers in competition with computer main-frame manufacturers.

Interconnection of these attachments raised grave concerns among the computer main-frame manufacturers. The complexity of the interface between the peripheral device and the control unit or computer is such as to make the telephone interconnection interface seem much simpler in comparison. Signal frequencies are in the megacycles rather than cycles, levels are in the milli or microvolts, cross-talk problems are fierce, and timing-control sequences are much more complex and precise than the dial pulses or tones used in the telephone network-control system. Yet, users have decided of their own volition to risk the interface problem and incur the division of responsibility to accrue cost savings.

To the Panel's knowledge, the use of such attachments, especially disc and tape units, has been successful despite the complexities of the interface. The user will undoubtedly experience greater difficulty and delay in resolving a malfunction, but he apparently feels it is worth the cost differential. In the event of malfunction, the user will, in most cases, have to call the computer main-frame maintenance man to diagnose whether the problem is in the peripheral or in the system. If the problem is in the peripheral, he then has to call the peripheral service company, thus paying a double maintenance charge and incurring extra delay. If the problems are obviously in the peripheral, he need call only the one company. The same maintenance philosophy can apply to the interconnection of foreign attachments to the telephone lines.

It appears that foreign attachments will be a way of life for the computer industry. The weakness of the analogy pointed to above is that only the user may be harmed in the case of the computer attachment while many, who are generally unknown, may be harmed with a bad telephone attachment, although, with the advent of computer time-sharing, this may become less true, but here again, it is the user or provider of the particular computer time-sharing service who accepts the degradation in service to reduce costs. Further, there is no comparable problem of hazard to personnel or property of other than the user of the computer.

Broadcast Interconnection Arrangement

There is considerable experience of some relevance in the broadcasting industry (sound as well as television) in the interconnection of user-owned equipment with the carrier facilities. These are almost exclusively leased-line situations with full-period or temporarily allocated circuits in use for broadcast purposes. These systems are operated without additional complex interface devices between the user and the carrier facilities.

Experience with Government Networks and Equipment

The largest single class of interconnected communications systems and terminals in the United States are those of U.S. Government agencies -- the largest being the Department of Defense.

Defense Communications Systems

There is a long complex history of a partnership between the Department of Defense and the U.S. domestic and international common carriers. In this connection, a wide latitude of interconnection of government-owned equipment and systems has been permitted by the common carriers as exceptions to normal tariff arrangements. Last year, the government obtained approximately one-half billion dollars of telecommunications services and facilities from these carriers. The largest single aggregation of such facilities is the Defense Communications System (DCS), which is being evolved from the systems of the three military services. When put together with systems of the other principal departments and agencies of the government, the whole becomes the National Communications System. Leased carrier facilities (particularly in the continental forty-eight states) comprise the bulk of the National Communications System (NCS). Major components of the NCS are:

1. The CONUS AUTOVON system, a leased telephone network provided by AT&T and the independent telephone companies. AUTOVON provides the backbone voice network for national security command-control communications.

2. A companion to AUTOVON is CONUS AUTODIN, a leased system provided by the Western Union

Telegraph Company, providing record communications for the Department of Defense and certain other associated activities.

DCS Specifications

The Defense Communications Agency, with the advice and assistance of other agencies, has developed DCS and NCS specifications (in many cases, substantially equivalent to those descriptive of the public telephone network) to guide the evolution of the Defense Communications System and the National Communications System. These specifications include interface specifications for interconnection of the government-owned equipment with carrier facilities.

Government Systems Other Than Those Operated by Defense

There are a number of government systems other than those operated by Defense. Principal among these are:

1. The FTS (Federal Telecommunications System), a CCSA voice network administered by the General Services Administration and providing service to all government agencies, but primarily service to agencies other than DoD.

2. The ARS (Advanced Record System), a GSA-administered record-communications system leased from Western Union, provides these services for government agencies other than the DoD.

Preferential Treatment by Common Carrier

Because of the nature of government requirements, particularly those associated with national security activities, the space program, and other critical government activities, the carriers have afforded the government special treatment in regard to interconnection, such as the use of customer-provided equipment and the provision of special telecommunications arrangements to meet unique requirements. As was demonstrated to the Panel, these arrangements have not been without cost and difficulty. Although the DoD is probably the largest technical organization in the world with extensive capabilities for procurement, installation, and operation of telecommunications-type equipment, many problems have developed as a result of interconnection arrangements without interface devices to shield the common carrier network from failure, malfunction, or deliberate misuse of user facilities.

It has been shown that DoD interconnection of user-owned and maintained equipment with the Bell System accounts for a disproportionate share of the troubles in terminal equipments and transmission arising through interconnection.

Conclusions

The review of the practices of certain foreign carriers and the experience of U.S. carriers with interconnections provides many lessons germane to the recommendations of the study Panel. The most comprehensive experience is that derived from interconnections of government-owned equipments and systems (primarily those of the U.S. Department of Defense) with systems of the common carriers.

There is also a large background of experience with interconnection of systems and equipments operated by the right-of-way companies, including the railroads, pipelines, electric utilities, etc., and with communications-service organizations such as ARINC. There is also some applicable experience with the connection of user-owned telephones and other terminal devices to carrier networks. There is, however, no experience applicable to large-scale interconnection of small, individual users, and the Panel concludes that it must be approached with great care.

The Panel also concludes that:

1. Interconnection without special interface devices is possible without service impairment or hazard to carrier personnel only under favorable conditions,

2. Such interconnections without restrictions could cause substantial service impairment,

3. Favorable conditions are necessarily associated with incentive, ability, responsibility, and user resources.

SECTION 9

INFORMATION AND ORGANIZATION

The need for improved information transfer among carriers, users, and sponsors was demonstrated on numerous occasions during the study. This lack of information is felt by all and will grow more serious as the interconnection area evolves. It exhibits itself in the improper design of equipment, confusion as to rules, rates, and procedures, and a certain rigidity in the approach to mutual problems. At present, no formal organizational mechanisms exist to provide the desired information interchange. It is the opinion of the Panel that such mechanisms should be established in this area to cope with the problems that are sure to develop.

Existing inter- and intra-industry organizations should be encouraged to assist in improving the flow of technical information not only among the carriers, manufacturers, and users, but also within manufacturing and user organizations. It is especially important to expedite the process of obtaining agreement among the groups through technical and standardization meetings.

As discussed in the section on "Certification," certain organizational steps and mechanisms should be developed if that program is to be implemented. In that connection, organizational mechanisms may be similar to others but with a major difference, i.e., that of responsibility. Since the certification program will be reflected in tariffs, the federal regulatory agency responsible should ensure that the certification program reflects that responsibility. Such a new organizational mechanism should, therefore, be formally recognized to ensure that proper weights are attributed to its recommendations.

The Panel recommends that organizational mechanisms be established to:

1. Promote a two-way exchange concerning problems of interconnection interfaces among users and suppliers and between them and the carriers. This exchange is vital to the problem of possible liberalization of interconnection and the resulting integrity of the public telephone network.

2. Promote and establish working groups that will be concerned with standards development, certification programs for equipment, licensing programs for installation and maintenance procedures, and finally, with the data gathering and analysis of technical interfacing problems. The various user groups should have a common, authoritative forum to which data are fed and reacted to in the coming decade. Other trade

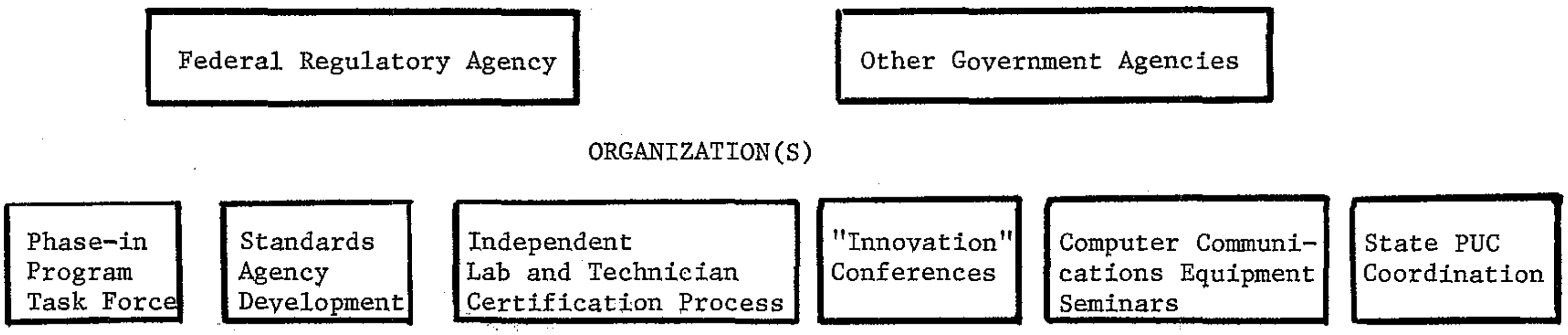
and industrial organizations would probably welcome an independent atmosphere for discussions related to their specific positions on interconnection policy from a technical standpoint.

3. Develop recommendations to a federal regulatory agency as to the timing of the elements of a phasing-in process if a certification program is established. These recommendations should specify specific changeover interim periods for certain classes of users to minimize the impact of the new standards and certification programs.

4. Promote a workable atmosphere concerned with innovation problems in interconnection on a continuing basis. There are three areas of concern: (a) interchange of ideas and information before new concepts and equipment developments are implemented; (b) interchange of ideas and new approaches before installations are made (by the carrier or user); and (c) interchange of problems data after new services are installed in which unforeseen problems sometimes arise.

A possible structure of a possible new organization is noted in Figure 1. This structure is purely an example and is by no means meant to be definitive. Various standing committees on continuing problems could be organized and short-range *ad hoc* groups would function on specific problems such as the phasing-in period for the proposed standards and certification program for direct-connection equipment. Another important area is that of coordination with the state regulatory agencies to foster a degree of uniformity on technical matters.

FIGURE 1


Federal Regulatory Agency
Other Government Agencies
ORGANIZATION(S)
Phase-in Program Task Force
Standards Agency Development
Independent Lab and Technician Certification Process
"Innovation" Conferences
Computer Communi-cations Equipment Seminars
State PUC Coordination