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ABSTRACT

This report of the Science and Technology Telecommunications Task Force consists of analyses of diverse issues, along with recommended actions. The project had two objectives: (1) to identify actions that will pave the way for the application of a few promising technologies to the benefit of users of telecommunications, and (2) to suggest actions as a basis for Government program development, for industry initiatives, and for joint government and industry activities. Four major technologies are addressed: (1) direct satellite communications, (2) land mobile radio, (3) broadband communications networks, and (4) fiber optic communications. Each is discussed relative to its current status, the issues affecting its growth, actions designed to address these issues, and the impact of the proposed actions. The discussion is organized under four general categories: (1) needs and the market, (2) system developments and performance, (3) policy and regulation, and (4) spectrum management. Conclusions, recommendations, and suggestions relating to the process of formulating a national draft agenda are presented in a final chapter. (DAG)

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LOWERING BARRIERS TO TELECOMMUNICATIONS GROWTH

Science and Technology
Telecommunications
Task Force

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November 1976

UNITED STATES DEPARTMENT OF COMMERCE
OFFICE OF TELECOMMUNICATIONS
STATEMENT OF MISSION

The mission of the Office of Telecommunications in the Department of Commerce is to assist the Department in fostering, serving, and promoting the nation's economic development and technological advancement by improving man's comprehension of telecommunication science and by assuring effective use and growth of the nation's telecommunication resources.

In carrying out this mission, the Office

- Conducts research needed in the evaluation and development of policy as required by the Department of Commerce.
- Assists other government agencies in the use of telecommunications
- Conducts research, engineering, and analysis in the general field of telecommunication science to meet government needs
- Acquires, analyzes, synthesizes, and disseminates information for the efficient use of the nation's telecommunication resources.
- Performs analysis, engineering, and related administrative functions responsive to the needs of the Director of the Office of Telecommunications Policy, Executive Office of the President, in the performance of his responsibilities for the management of the radio spectrum
- Conducts research needed in the evaluation and development of telecommunication policy as required by the Office of Telecommunications Policy, pursuant to Executive Order 11556

PREFACE

This report contains the findings and recommendations of the Science and Technology Telecommunications Task Force of the U. S. Department of Commerce. The Task Force was formed to explore how barriers to the application of telecommunication technology might be lowered so that new domestic products and services would become more widely and more rapidly available.

To begin their work, and to give it direction, the Task Force members undertook a thorough research of the recent literature. Over 100 publications were reviewed. Along with this, they consulted with industry and association officers -- 17 industrial firms took part -- to isolate salient industry problems and opportunities.

Task Force members visited 39 companies, which were selected to provide a blend of a number of varied elements: large and small companies; equipment manufacturers and service providers; and exporters and companies serving the domestic market. Taken as a whole, the interviews and visits covered the major elements of the U. S. telecommunication industry.

In the fall of 1975, upon completion of the visits, a draft report was submitted to many of the participating firms, selected Government agencies, and other interested parties. A substantial body of comment was collected on the draft. These views were considered during the preparation of this final report, which is believed to be up-to-date as of July 1976.

This report has also benefitted from the criticism offered by several industrial organizations of intermediate drafts of the chapters dealing with specific technologies.

ACKNOWLEDGMENTS

The Task Force effort was originally managed by Paul Polishuk and subsequently by Charles Wilk. The preparation of the final report was monitored by a steering group consisting of David Chang, John M. Richardson, and Douglass D. Crombié.

The four chapters dealing with specific technologies were prepared by: Direct Satellite Communications, Peter McManamon; Land Mobile Radio, John Murray; Broadband Communications Networks, Bernard Wieder; and Fiber Optic Communications, Joseph Hull. Appendix F on "Developing Techniques and the Vitality of the Electronics Industry" was prepared by Robert I. Scace, National Bureau of Standards.

Others making major contributions to the report include Kenneth Gordon, Lois Adams, Richard Harland, and groups under their supervision.

Special acknowledgment for assistance during the field interviews is owed to Hans Oser, of the National Bureau of Standards; Robert Baldwin, John Martin, and Richard Lazarus, of the Patent and Trademark Office; and Harold Handerson, formerly with the U. S. Department of Commerce. These individuals, all former participants in the Department of Commerce Science and Technology Fellowship Program, volunteered their services to this Task Force effort. This was in keeping with the stated purpose of the ComSci Council (to which all graduates of the Program belong) of offering further service to the Federal Government of these highly-motivated, uniquely-experienced professionals.

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EXECUTIVE SUMMARY

This report is based on the work of a Telecommunications Task Force formed in August 1975 under the direction of the Assistant Secretary of Commerce for Science and Technology, Dr. Betsy Ancker-Johnson.

The objective of the report is twofold:

- o To identify actions that will pave the way for the application of a few promising technologies to the benefit of users of telecommunications.
- o To suggest any such actions as a basis for Government program development, for industry initiatives, and for joint Government and industry activities.

The heart of this report consists of analyses of diverse telecommunication issues, along with recommended actions. These analyses and recommendations should be read as a contribution to the drafting of an agenda of national telecommunication concerns. Such a national agenda would presumably serve first as a vehicle for discussion and ultimately as a basis for action. The process of writing it, moreover, should help us establish priorities for this vital field. To be an effective instrument, however, the agenda will have to represent far more than just Government thinking; it will, rather, have to reflect a common effort by <u>all</u> the institutions of our national telecommunication community.

Although there is no question that U. S. telecommunication systems as a whole are the most pervasive and reliable in the world, it is possible to discern some barriers that are impeding the long-term growth of the field. An effort to lower these barriers would surely be a desirable national goal. Two major reasons support this view:

- o First, the United States is increasingly engaging in information-related activities -- to the point where productivity gains in many parts of our services sector may come to depend on improved access to and management of information. Clearly these information activities rely heavily on telecommunications; furthermore, advance in information handling will require a steady infusion of new telecommunication technology.

- Second, with present national decisionmaking processes, we may not be deriving the fullest possible benefit from a variety of attractive technological choices. Prime examples of such choices are satellites, solid state technology, lightwave communications, and new regions of the electromagnetic spectrum for expanded communications use.

The long-range importance of telecommunications as well as the complexity of the issues may well bring increased Government participation in communications affairs. So far some of the results of this participation have been less than encouraging: conflict over new policies, confusion over the question of appropriate Government and industry roles, and delay in national decisionmaking.

Such delays on the part of Government may cause -- or be causing -- similar delays in the developments of new services or products. When such a commercial delay occurs -- especially when it affects a technology or a service that reduces costs -- the public is deprived of the benefits during the period of the delay. The public interest, therefore, calls for corrective action.

It is understood that any such corrective action will require cooperation among three parties: Government, industry, and users. Government activities must be evaluated in terms of six of the roles it may play: policymaker, regulator, spectrum manager, user and purchaser, coordinator of public sector requirements, and supporter of key technological development. Industry's role, however, is vital: assembling the factors of production and bringing the product or service to the marketplace. Users, or customers, have to make known what they need. In many cases this is done in cooperation with industry; the result is "market pull." In other cases, such as the specifying of public sector requirements, much has to be done to identify user communication needs, to consolidate them, and to translate them into system requirements.

In setting about its assignment, the Task Force tried to identify those technologies and services holding the most promise for future application while, at the same time, seeming to be most inhibited by current barriers.

More specifically, the Task Force asked five questions about each technology and service it considered: How much will it benefit the public? How significant is technology as a barrier to its growth? How detrimental to its application would be the effects of no action? Has it reached a relatively advanced level of maturation? And, how appropriate would Federal involvement be?

After screening a long list of "candidates" according to these criteria, the Task Force decided to concentrate on four major technologies: Direct Satellite Communications, Land Mobile Radio, Broadband Communications Networks, and Fiber Optic Communications. This report accords each a separate section.

With each technology, the report discusses its current status, the issues affecting its growth, actions designed to address these issues, and the impact of the proposed actions. The discussion is organized under four general categories as follows: needs and the market, system development and performance, policy and regulation, and spectrum management. Those issues and actions we believe to be most urgent and feasible are restated in our conclusions and recommendations, the final chapter of the report. At the end of that chapter -- and at the end of this Executive Summary -- will be found a suggestion relating to the process of formulating a national draft agenda.

NEEDS AND THE MARKET

Here we must consider the choices for providing new services and the relative cost of the choices. An additional consideration is the services' potential for increasing national productivity.

The use of satellites for the transmission of public sector services may hold great promise. This possibility, as well as concern about future U. S. plans for the employment of this band and others, generates the following recommendation:

o. *Government and user organizations should accelerate the process by which the basic communication needs to be met by public service satellites will be defined. They should also determine the most economic way of using such satellites and who will pay for them.*

Because of the growing pressure on the radio spectrum to provide different services, all of which can claim appreciable economic value:

- *Spectrum administrators should encourage further research on the economic and social values of services that are provided through the use of the spectrum in order to achieve optimum allocation of this resource in the light of the associated needs and markets.*

With respect to nonentertainment broadband communication services, we recommend that:

- *Industry should establish a group composed of industry, institutional users, and providers of public sector services to plan and finance a demonstration designed to reduce the present uncertainties about market demand for and economic viability of aggregated broadband nonentertainment services.*

Fiber optic communications promises a great deal in the way of lowered costs and expanded capacity. The challenge is to accelerate its nonmilitary applications. To do this, we should identify those applications for which it will be most competitive.

In addition, a demonstration of fiber optic communication capabilities would do much to increase the market for its systems and components; a demonstration of sufficient size would also reduce the cost of these systems and increase their availability.

Our recommendations are two:

- *OTP should establish a Federal interagency group to identify a significant broadband communications need, the satisfaction of which will advance the solution to an important public service problem (e.g., health care delivery). The group should then compose a statement of the necessary communication requirements as a basis for a fiber optic demonstration project.*

- *The Department of Commerce should establish an advisory committee on commercial implications of fiber optics.*

SYSTEM DEVELOPMENT AND PERFORMANCE

This category focuses on systems planning and research, performance criteria and measurement, and standards of practice and of equipment operation. The elements that compose this category play important roles in determining whether new services or equipment can be provided economically and without foreclosing future opportunities for better resource use.

Are additional standards or performance criteria needed for small earth terminal satellite systems in order to foster their early application and to ensure their orderly development? This question is of particular importance.

The evolution of satellite systems operating at frequencies above 14.5 GHz is making slow progress, partly due to technology limitations. At the same time, however, demands for orbit/spectrum space below 14.5 GHz are growing significantly. These demands could be eased if the higher frequencies could be used as reliably as the lower frequencies.

The recommendations are that:

- o *Industry should take the initiative, in cooperation with users and Government, to explore the need for criteria and standards for small earth terminal satellite systems operating in the 2.5, 4, 6, 12, and 14 GHz bands. It should also assess the effect of these standards on future technological development, and, if appropriate, define and recommend performance criteria or standards for FCC adoption.*
- o *NASA should undertake, in conjunction with industry, to identify the hardware and other reliability barriers that limit the use of frequencies above 14.5 GHz for satellite communications and to recommend a program for lowering these barriers.*

Land mobile radio systems are totally dependent on the spectrum. Already, the spectrum allocated to these systems is being used intensively. Substantial growth in the demand for their services is expected. To ensure that the spectrum will be used in the most efficient way, it is desirable to have better quantitative information about the performance, spectrum utilization, and capacity of land mobile systems.

In addition, several Federal agencies support the development of better land mobile and other communications systems for use by public safety services. However, the objectives of Government support often differ, a situation that can lead to inefficient employment of the spectrum and insufficient long-range planning.

To meet these land mobile radio issues, we have three recommendations:

- *Telecommunication authorities should foster research to develop better criteria for describing and measuring land mobile service performance.*

- *Telecommunication authorities should foster research to develop better methods for describing and measuring spectrum capacity and utilization for land mobile radio systems.*

- *One Government agency should be responsible for coordinating Federal support of local land mobile radio programs. This Federal effort should support local agency attempts to achieve better spectrum use and lower costs through the development of integrated local communication systems serving several functions or user groups.*

The design techniques of current CATV systems may affect the potential growth of broadband nonentertainment services. The question is: Are these techniques adequate to provide systems that will be capable of handling additional nonentertainment services? Therefore:

- *Industry and users should seek early resolution of certain problems of system performance associated with delivery of broadband communication services. These problem areas include: (1) frequency management in broadband systems, (2) interface standards or specifications, (3) security and privacy, and (4) terminal equipment characteristics.*

To help fiber optic communications fulfill its promise as promptly as possible, the development of appropriate standards should begin soon. It is therefore recommended that:

- *The informal Optical Communications Task Force initiated by the Office of Telecommunications should identify what specifications (or voluntary standards) and codes are desirable to ensure rapid and orderly implementation of fiber optic technology in the commercial and public sectors.*

POLICY AND REGULATION

Although current regulations restrict the permanent use of satellite small earth terminals, some users wish to develop systems with terminals as soon as possible. In spite of the possible benefits to be derived from these systems, our future freedom of choice ought not to be precluded by premature approval of proposals for systems that inordinately "consume" available spectrum and orbit positions.

Moreover, it is imperative that we better understand and describe the resources that will determine how many -- and in what form -- satellite services can be provided.

In view of these concerns, we recommend that:

- *Government -- through the OTP, FCC, and other agencies -- should reexamine its policy and regulations with respect to use of domestic and international small earth terminal satellite systems. In the process, it should intensify its search for advice from interested parties.*

- *The FCC and OTP should give priority to obtaining additional and more comprehensive descriptions of the spectrum/orbit and spectrum/geography resources and the dependence of these on technical parameters of satellite systems.*

Regulatory delay is a matter of widespread concern to the telecommunications community. To reduce the delays incurred by full hearings, the FCC has from time to time brought interested parties together for informal gatherings prior to formal proceedings. Accordingly, we recommend that:

- *Consideration should be given to the desirability, feasibility, and legality of making greater use of open, informal discussions between interested parties prior to the start of FCC formal proceedings, particularly those that are to consider largely technical matters.*

CATV regulation may be a barrier to the implementation of nonentertainment broadband services. Partial deregulation of CATV services is being addressed by the Domestic Council, the FCC, and Congress. The Domestic Council regulatory group, however, concluded that not enough data were available on the effects of deregulation to support a decision, which might influence the general availability of nonentertainment services. It is recommended that:

- *The Domestic Council Working Group should arrange to obtain necessary research to establish the probable consequences of partial deregulation of CATV.*

SPECTRUM MANAGEMENT

In the next three years, two World Administrative Radio Conferences (WARC's) dealing with matters germane to this report will be held. The first, in 1977, is primarily concerned with satellite broadcasting in the 11/12 GHz band. The second, scheduled for 1979, will review the Radio Regulations, including the Table of Frequency Allocations. These WARC's will establish the pattern of worldwide spectrum use for many years to come. Moreover, their decisions will affect the rules and regulations of the United States, which are based on the international agreements. It is therefore important that the United States meticulously prepare its conference positions in all areas.

The evolution of public service satellite systems in the 2.5 GHz band is likely to be inhibited by the limited variety of services that can be provided in the narrow bandwidth available. Expanding the bandwidth would increase the number of services that might employ it. This would distribute the cost of the satellite over a greater number of users.

It is recommended that:

- *U.S. preparation for the 1979 World Administrative Radio Conference should place emphasis on:*

  (1) Provision of spectrum space for small earth terminal satellite systems.

  (2) Optimization of orbital spacing of satellites sharing the same frequencies.

  (3) Imbalance of spectrum/orbit utilization above and below 14.5 GHz.

  (4) Need for greater bandwidth allocations at 2.5 GHz for public service satellites.

o Public service satellite users should determine the cost advantages that could result from increasing the bandwidth available to them at 2.5 GHz and use the information as the basis for requesting the FCC to negotiate for an increase in the available bandwidth.

For land mobile services, we recommend that:

o U. S. preparation for the 1979 World Administrative Radio Conference should emphasize the resolution of differences between the planned use of the 900 MHz band by the United States for land mobile systems and the international frequency allocations.

COMPOSING A NATIONAL TELECOMMUNICATIONS AGENDA

As was discussed above, the recommendations of this report should be thought of as a contribution to the composition of a national draft agenda. The final agenda, of course, must be the product of an extensive dialogue among Government, industry, and users. A question arises: What is the best way to begin this process of joint discussion? Possible answers abound: Congressional hearings, industry and professional association workshops, academic seminars, and Federal Executive Branch initiatives.

However, all the best intentions will most likely be rendered futile if at the outset some agency does not assume the responsibility of receiving and processing the ideas and proposals regarding the agenda. Therefore:

o The services of the Office of Telecommunications will be available for initial coordination of reactions to this report and, by extension, of all suggestions pertaining to the formulation of a national telecommunication draft agenda. This tenure will last only until a permanent "Keeper of the Agenda" is named.

In conclusion, implementation of all the recommendations should foster the long-term growth of telecommunication technology in the United States. This growth will benefit not only service users but also industry, which will profit from the creation of new markets.

CHAPTER 1

INTRODUCTION

1. PURPOSE

Can the growth of telecommunication services be appreciably enhanced by detecting and lowering the barriers currently impeding a robust demand and an innovative supply?

Stated in its simplest terms, the purpose of this report is to explore that question.

However, the scope of telecommunications is so great, the kinds of barriers so varied, and the interested parties so numerous that we must immediately refine this general purpose by formulating more precise objectives, namely:

- o To identify actions that will pave the way for the application of a few particularly promising technologies to the benefit of users of telecommunications.
- o To suggest any such actions as a basis for Government program development, for industry initiatives, and for joint Government and industry activities -- in short, to begin to compose a truly national "telecommunications agenda."

On the one hand, it should be easy enough to accept the desirability of achieving a wider range of services and of pressing for their greater availability to the general public. There is no lack of testimony from prominent public officials about the central importance of these services to the public interest. Typical -- and as relevant now as in 1951 -- is the comment of President Harry S. Truman:

> Communications services represent a vital resource in our modern society. They make possible the smooth functioning of our complex economy. They can assist in promoting international understanding

> and good will; they constitute an important requirement for our national security. There is, accordingly, a major public interest in assuring the adequacy and efficiency of these services. 1/

On the other hand, it must be acknowledged that, to the great credit of American industry, existing telecommunications services are in good order. Our telephone system is already the most pervasive and reliable in the world. Television reaches fully 97 percent of American homes. And, more to the point, no great crisis is in sight.

REASONS TO MOVE

Why, then, in view of this impressive record of telecommunication achievement, is any special effort needed? At least two reasons bear examination.

First, this country is increasingly engaging in information-related activities. Recent studies show that today one worker in two is occupied with the production of goods and services that relate to the generation, processing, and dissemination of information. As this trend continues, productivity gains in many parts of the services sector of the economy -- such as retailing, shipping, banking, education, health management, and Government itself -- will depend on improved access to and management and exchange of information.

Crucial to our discussion here are two closely related realities:

- o The progress of the "information sector" even now relies heavily on telecommunication facilities.

- o If in the future that sector is to continue its advance, it will require a steady infusion of new telecommunication technology.

Second, with present national decisionmaking processes, we may not be deriving the fullest possible benefit from a variety of technological choices. The following are examples of such choices:

1/ Telecommunications: A Program for Progress -- A Report by the President's Communications Policy Board, United States Government Printing Office, March 1951, p. 1.

- Satellites, which offer advantages in cost over terrestrial facilities whenever long distances, extended networks, wide bandwidths, or a combination of these are involved.

- Solid state technology, which, by virtue of its low energy consumption and high degree of miniaturization, makes feasible the addition of memory, logic, switching, and computation power to millions of remote communications terminals. (See appendix F.)

- Lightwave communications, which offers an abundance of capacity and a manyfold reduction in cable size.

- New regions of spectrum use, which offer some relief to presently congested services.

These sophisticated technologies assume an added significance when their development is placed in the context of a rapidly-expanding international marketplace. Arthur D. Little, Inc., has predicted an annual world telecommunication equipment market totalling $40 to $80 billion by 1980, up from a $15 billion market in 1975. American inventive genius deserves to participate to the fullest extent in the markets it helped to create.

As this technological advance has been taking place, Government has been greatly increasing its participation in communication issues. Some of the results have been less than what might be hoped for: we refer to conflict over new policies, confusion over the question of appropriate Government and industry roles, and delay in national decisionmaking.

One might contend that, given the nature of the situation and the pace of the change, this conflict, confusion, and delay were inevitable. But this line of reasoning only highlights the wisdom of actively trying to improve the situation.

ONE WAY TO IMPROVE THE PICTURE: A DRAFT AGENDA

How, then, might we as a nation go about systematically achieving this improvement? The central task, it seems to us, is to compose a broad "draft agenda" for telecommunications. The agenda would represent a listing of the important issues of the day, together with a selection of alternative actions. It could be employed immediately as a vehicle for discussion and ultimately as a basis for action. Any such action, to be effective, would have to reflect a joint effort by all segments of the national telecommunication community.

In the end, the scope of a national draft agenda may be as broad as the field of telecommunications itself. But it is possible to specify some of the topics that the agenda will have to consider. For example, three general subjects that no agenda should ignore are:

- o Numerous problems demand our attention.
- o Interaction between Government and industry is necessary if growth is to be achieved in some areas.
- o There is a division of responsibility in Government's own ranks.

What follows are fuller -- albeit admittedly brief -- discussions of these three points.

Pending Problems

Current problem areas include the following: crowding of the electromagnetic spectrum in current land mobile, terrestrial microwave, and communication satellite bands; increased competitiveness of foreign industry; lengthening of the time needed to get through the regulatory process in spite of the best efforts of regulatory authorities; lag in technology transfer; and difficulty in achieving cooperation between Government and industry when the demonstration of combined public and private sector services is involved.

All of these problem areas will be discussed in detail in the body of this report.

It might be worth noting that if, given economic demand, the appearance of a cheaper item of equipment or an innovative service is needlessly delayed by any of these problems, then its benefits are denied to the public for that period. The public interest, therefore, calls for corrective action.

Government and Industry: Their Interaction

Even if Government succeeds in lowering a barrier -- say, by demonstrating the practicability of a new service or by removing a regulatory restraint -- this will not in and of itself automatically produce growth. For economic growth occurs only when supply or demand increases. Thus, growth will depend on whether that lowered barrier in turn stimulates market forces; that is, creates products at lower cost or motivates customers to buy more.

Although market identification and stimulation are in large part the concern of industry, Government can occasionally take part. Government might, for example, provide a threshold market for a new product, thereby allowing manufacturers to attain economies of scale.

These considerations illustrate that actions taken to enhance growth in communications often involve both Government and industry.

And this is not the only justification for close interaction between the two sectors. Another would be industry's own conspicuous role in the research and development of new telecommunication technology.

In truth, such Government and industry interaction would not represent anything all that novel. It would, rather, be an extension of the long-standing close relationship between the two in telecommunications.

However, no consensus exists on precise Government and industry roles in attacking these issues. A case in point: it is still unclear whether Government needs to be involved in the research and development of satellite technology to be employed in nonmilitary applications. But Government involvement is appropriate in certain other situations. As an example, joint Government and industry activity may be in order in demonstrating the use of various two-way, interactive, broadband services that lie in both the commercial and the public service sectors.

Also, we must keep in mind the implications of the significant interaction that takes place among the Government's several telecommunication roles: policymaker, regulator, spectrum manager, user, coordinator, and supporter of development. With this interaction, activity in any one area may have serious impact on the others as well as on nongovernmental institutions. If the activity is undertaken to accelerate an application in the name of some overriding public interest, there is all the more reason for taking pains to elicit industry's views about the probable consequences of a Government action.

Within the Government Itself

Finally, as was brought out by the hearings of the House Subcommittee on Communications in July 1975, there is within the Federal Government a dispersal of responsibility in policy research and formulation. This situation argues still more forcibly for the development of a national telecommunication agenda.

THIS REPORT AND THE DRAFT AGENDA

Already the Congress and Government agencies are preparing items that would quite likely appear on a national draft agenda. For example, the 94th Congress announced that the next Congress will address two principal issues in communications: monopoly and competition, and updating the Communications Act of 1934. Additionally, spectrum management issues will be treated in a comprehensive way at three WARCs scheduled within the next three years. Government agencies are working together with industry groups to define the issues and to draw up our national positions on them.

This Task Force Report is a further attempt to put some items on just such a national draft agenda. Its writing involved a number of steps. Above all, it was necessary to slim down to manageable size the number of telecommunication services to be considered. Simultaneously with this came a sharpening of focus on the technologies that would provide the services.

To accomplish this "whittling down," a review was made of the status of many services, ranging from electronic funds transfer to the automated office. Part of the review involved estimating potential benefits of a particular service in areas such as cost savings, innovative services, and the extent of additional contribution to our Gross National Product. The review further entailed identifying unresolved issues that constitute barriers blocking the full realization of each service.

Most importantly, the review concluded with, first, a listing of the actions that might lower or remove the barriers and, then, with an identification of who, among the many participants in U. S. Communication affairs, might do what.

This itemization of actions -- which includes evaluation of probable impact -- with respect to a select few of our most significant services and the technologies to provide them, represents our contribution to a "draft agenda."

Finally, we emphasize that the purpose of this report is not to define a national program -- or, for that matter, a program for any one Government agency. To the contrary, its objective is to stimulate joint discussion among all relevant institutions in Government and industry. Our hope is that out of this discussion will emerge a final national telecommunication agenda that will lead to fruitful and agreeable action.

But with this call to action, questions arise: How best can these joint discussions actually be made to happen? What might be the next step? Here are some suggestions.

- The relevant Congressional committees might hold hearings on certain issues of national scope; examples might be the public service uses of satellites or cable services in rural areas. Such hearings serve as an ideal forum for the voicing of a variety of opinions and guarantee a truly national audience.
- Industry and professional associations whose interests embrace telecommunications might schedule topical workshops with representatives of Government and users in attendance.
- Academic institutions might take the first step, possibly by sponsoring seminars on the topic of the national draft agenda. We have in mind primarily several graduate schools specializing in the study of telecommunication management and policy.
- And of course the Executive Branch of the Federal Government could take the responsibility. OTP and FCC suggest themselves as prime candidates for the role of initiators, thanks to their central policymaking function. And, as the prosperity of the U. S. business community is so obviously involved in the success of a draft agenda, the Department of Commerce might start things moving.

A less attractive choice would be the formation of yet another Government committee -- or, still worse, other committees -- to ponder the matter. We hope that, in the end, it does not come down to this.

It should be clear, then, that anything reasonable can be done. But nothing at all will occur without the endorsement of all those who would be involved -- Government, industry, and users. If these groups wish to express this endorsement, they must make themselves heard. And the more specific the recommendations, the better. It may be that each segment of the whole of telecommunications will have to be taken up in turn; this poses no special difficulty, so long as at the end the Nation does indeed possess a comprehensive agenda to which it can refer, and which results in action.

But if there is to be action, there must be a definite point of departure. The "good offices" of the Office of Telecommunications are available to serve as a focal point for reactions to this report. We have accordingly included a suggestion to this effect in the report. Our expectation is that, if the suggestion is acceptable, OT will stimulate initial meetings along the lines suggested by the reaction. OT would probably service this function until an official "Keeper of the Agenda" is decided upon.

2. Government and Industry Roles

Any effort to identify barriers to communication growth, to isolate the issues that are associated with those barriers, and to suggest action to ameliorate them ought also to contain a point of view about the appropriate roles of Government and industry in communications. This section expresses that point of view. It will be helpful in staking out the limits of Government responsibility and in judging whether a given action falls in the Government sphere, the industry sphere, or some region of overlap.

Before turning to specifics, we can say in a very general sense that complementary actions by the Executive Branch and industry are needed to support the national and the public interest. Government and industry should avoid policies which put them in adversary roles which compromise those interests.

GOVERNMENT ROLES

In telecommunications, as in all other fields, the Government's overall function is to provide for the national and public interest. To carry out this complex responsibility, Government must assume a number of subsidiary roles, among them the six on which we shall concentrate our attention:

- Policymaker.
- Regulator.
- Spectrum manager.
- User and purchaser.
- Coordinator of public sector requirements.
- Supporter of key technological developments.

These six roles are considered below.

Policymaker

For understandable reasons, framing national goals and priorities for any field is far from easy. But it seems to be singularly difficult to discern and to agree upon national needs in telecommunications. Perhaps the very pervasiveness of telecommunications is at fault. Because it is ubiquitous, paradoxically, it remains inconspicuous. Also, for decades, "telecommunications" for most Americans meant just the telephone and telegraph systems, the affairs of which were ably handled by the regulated common carriers without recourse to continual national policy development.

Although there have been relatively few formal policy statements in telecommunications, there are some legislative and executive signposts to mark the Government's goals: the Communications Act of 1934, the Communications Satellite Act of 1962, the Public Broadcasting Act of 1967, the Public Broadcasting Financing Act of 1970, and the various Executive Orders delegating Presidential authority vested by the Communications Act. Other actions -- such as the Federal Communications Commission's "Carterfone" decision -- also represent important, albeit de facto, policy statements.

Nevertheless, our national telecommunication policy remains imperfectly crystallized. Some contend that it is made too slowly and is insufficiently responsive to public needs. Yet, others criticize our major regulatory agency, which is perhaps trying to fill this void, for usurping Congressional prerogatives.

Regulator

The regulatory function is intended to ensure that the industry is performing in accordance with national policy. Government regulation is today a central characteristic of the telecommunication industry. The amount of trade, the degree of competition allowed, and the rate at which the industry can apply new technology all depend upon regulatory action. The extent of the dependence, of course, varies from sector to sector; in some, even industry structure and revenues are regulated.

The regulatory apparatus functions to oversee:

- Profits and rate-bases of so-called "natural" monopoly common carriers.
- Licensing and use of the "airwaves".
- Adjudication of conflicts among private interests.

In addition, the regulatory apparatus has found it necessary to:

- Establish technical standards.

It has done this by promulgating some mandatory standards and by encouraging the private (operating) sector to develop voluntary standards of its own.

The telecommunication industry, as well as other industries, is affected by many general regulatory requirements such as those imposed by the Department of the Treasury, Equal Employment Opportunity Commission, Occupational Safety and Health Administration, Environmental Protection Agency, and Federal Energy Administration. Regulation specific to telecommunications is performed by independent regulatory commissions. At the Federal level this is done by the Federal Communications Commission (FCC). The strength of Commission regulation is its inclusion of complex social and political issues that are difficult to resolve in other ways. An indispensible feature of the process is its ability to serve as a control mechanism that substitutes for competition where competition does not and cannot work.

An example of interaction between policy and regulation is President Ford's recently formed Domestic Council Review Group for Regulatory Reform. The President asked the Commissioners of all the independent regulatory commissions to concentrate on four areas: better representation of consumer interests, elimination of outdated regulation, reduction of regulatory delays, and better analysis of economic costs and benefits of regulatory actions. In addition, the Administration has sought to restore partial competition within the regulated sectors of the economy. Of these topics, the reduction of regulatory delays and the restoration of competition would lower some barriers to communications growth.

Spectrum Manager

Much of our long- and short-distance communications travels on radio waves using a limited natural resource -- the electromagnetic spectrum. It falls to Government to manage this resource in the national and public interest because without orderly use by all it will be denied to all.

Unlike other natural resources, the spectrum is not consumed by use -- although use by one may at that moment prevent use by others. And spectrum use is free. Thus the individual user gains nothing by conserving it and, in fact, may have to pay more for conservation. "Conserving" is employed here in the sense of avoiding waste, not in the sense of foregoing productive use. As examples of waste one can cite the use of unnecessarily wide antenna beams in point-to-point services or the use of signalling methods that are unnecessarily susceptible to interference, but which are required by regulation.

Over the past couple of decades, owing to the application of new technology, we have witnessed a dramatic intensification of spectrum use. The number of individual land mobile channels in a given band has increased by a factor of four or five. And microwave channels that carried 2,400 voice signals in 1950 now can carry over 6 times that many in the same bandwidth. But we should not confuse intensive use with efficient use. Intensive use of the spectrum results in increasing the amount of communication which can be achieved by individual use of radio channels. Efficient use results in increasing the total amount of communication by multiple users of the same channel in conditions where mutual interference between these users can occur. The distinction becomes critical for the spectrum manager who has to maximize the number of independent users. Such maximization is important in both land mobile radio and in services subject to policies that encourage increased competition.

The foundation of Federal Government regulation of telecommunications -- the Communications Act of 1934 -- does not explicitly consider wise and fair management of the radio spectrum or of the geostationary orbit. (The latter became a matter of concern with the advent of satellite communications.) However, this function is clearly essential to the public convenience, interest, or necessity.

User and Purchaser

The Federal Government is the biggest single user of telecommunication equipment and services in the United States; at last estimate, its telecommunication inventory totaled $50 billion. Use, of course, implies procurement; and the Government's annual bill for these purchases is about $10 billion. Naturally, all this accords the Government enormous potential marketplace leverage. This leverage might be used to advance the state of the art and to reduce costs. Furthermore, its use might result in the development of standards, even if these standards turn out to be of the de facto variety.

Coordinator of Public Sector Requirements

By its nature, government at all levels constitutes what is called the "public sector" -- that is, those activities that expend tax dollars. It is only logical, then, that when institutions that compose this sector -- public health, public safety, and education are examples -- need to enter the technology market with Federal funds, the Government might aggregate needs, pull together similar programs, and lend some unity to their requirements.

Also, many public sector agencies cannot call upon their own staffs for the technical expertise necessary to judge or define their telecommunication need. Federal agencies, therefore, that do possess such specialized knowledge, could clearly provide invaluable help to them. This represents yet another facet of the coordinating role.

Supporter of Key Technological Developments

The Government -- due to its central marketplace position and its need for the most sophisticated of equipment -- will sometimes take steps to insure that the development of a key item of technology will be hurried along when the market is not providing it. One technology that was a direct beneficiary of Government interest was the satellite, the evolution of which was immeasurably hastened by space and defense funding. Another example of this role is funding of basic research by the National Science Foundation.

INDUSTRY'S PERVASIVE ROLE

All discussion about Governmental activity in telecommunications loses much of its meaning if it lacks a recognition of the prominence of industry and the fundamental role of the marketplace which drives most development. Indeed, no matter which way the observer turns -- towards civilian research and development, product development, market identification, pursuit of overseas trade -- private industry's contribution is the major one. It is industry's role to assemble the factors of production and to bring the product to market.

LOWERING BARRIERS FOR NEW APPLICATIONS

In the real world, the complexity of the interaction among the various governmental and industrial telecommunication roles that we have just pigeonholed so neatly is well illustrated by the problems that may accompany the lowering of barriers to the application of a new technology.

There may, in fact, be many ways by which the path of a promising application to the marketplace can be cleared.

Industry Initiative

If the purpose of an application is clear and useful and the market for it exists, there is no problem. Industry -- on its own -- will feel the "pull" of the market and respond with appropriate vigor.

There are instances where the market is of secondary importance. This may be the case in a service industry which has an imperative economic need to increase its productivity through application of technologies that reduce operating costs. Development of electronic switching equipment in the telephone industry is one example.

Government Involvement

Other situations involve Government action. Sometimes a market demand will arise but the "established" industry will not react with sufficient zeal, possibly because the incentives do not truly exist or because the available solutions or products are inadequate. The easy connection of computer terminals to telecommunication lines, before the interconnection issue was settled, was such a case. Some commentators insist that an application lag is becoming all too commonplace in telecommunications nowadays. The following quotation represents a forceful -- perhaps too forceful -- expression of this opinion:

> Holding back the tide of technological advancement is virtually impossible, as Bell Laboratories demonstrates year after year with its myriad patents.

> Holding back the useful application of new technology, however, is something else. AT&T has demonstrated its ability to do this many times before the FCC. In a sense, the company has brought competition upon itself. And at the Federal level, at least, AT&T cannot legislate that away. 1/

Although the quotation is certainly relevant to this point in general, we believe that this particular statement is overly critical of the telephone industry. It can be countered by remembering one fact of economic life: the cost of telephone and similar "established" services is in part determined by the rate at which the massive existing plant is replaced and extended. If new services were allowed to force either hasty plant replacement or dramatic addition of a new plant, then the cost to the consumer would increase.

Nonetheless, even after giving the established carriers the substantial credit due to them, there have been instances in recent memory when they have not met new market needs as perceived by some. Predictably, entrepreneurs proposing to provide the new and innovative services have appeared; Telenet and Microwave Communications Inc. (MCI) spring to mind.

Whenever such a situation occurs, the challengers quickly find themselves squared off against their older competitors in ways that inevitably demand that Government -- acting through its regulatory agencies and the courts -- assume the task of moderator between the competing parties.

Another situation calls for Government intervention. On occasion, concern for the national or public interest requires Government to take actions in the absence of market forces or even in opposition to existing market forces. As well known illustrations outside the field of telecommunications, we point to research on alternative energy sources, actions to protect the natural environment, and regulation of highway safety.

Limitations on Government Action

When Government contemplates intervening in a forceful manner, it faces a problem of economic philosophy:

1/ Electronics, March 18, 1976. p. 60.

reconciling this Government action with our commitment to the operation of a mixed market. (A "mixed" market is a generally free market modified by some regulation.) The theory of the mixed market dictates that in most cases the development of technology and applications should be left to private firms. Government must weigh this option whenever considerations of national need impel it toward guiding or initiating selected applications.

The difference between the telecommunication problem and the examples of firm Government intervention cited above -- alternative energy research, environmental protection, and highway safety -- is that actions in the latter areas are in accordance with clearly articulated legislation that established national policy. In the telecommunication field no such clear legislative policy statements exist. Thus, actions by Government to direct telecommunication development in the national or public interest may meet substantial resistance if not mandated by specific legislation.

If, nevertheless, Government concludes that it can appropriately take action along these lines, then its activity may well draw from any or all the roles discussed above, namely:

> As policymaker, Government would construct the larger framework of law and policy within which the application takes shape.
>
> As regulator, Government would resolve whatever conflicts arise from the relationship of the application to other services and establish performance standards for it.
>
> As spectrum manager, Government would assure that, if need be, sufficient spectrum is allocated to new applicants and that their frequency assignments are compatible with those of "neighboring" services.
>
> As user and purchaser, Government might provide the initial market demand for the application, thereby stimulating its general availability.
>
> As coordinator of public sector requirements, Government might canvass the pertinent public institutions to determine their needs and their interest as well as the possibilities for their cooperation in demonstration programs.

Finally, as supporter of key technological developments, Government might subsidize demonstration programs or finance additional research.

In the chapters that follow, addressing particular technologies, the reader will discern examples of such actions.

AND IN CONCLUSION

Anyone who possesses even a rudimentary grasp of the realities of the American telecommunication marketplace will understand that the Federal Government is surely not going to adopt an aggressive stance in all the areas allowed it on all the issues that are placed before it. Private industry is ready, willing, and able to handle most of the problems presented by telecommunications' billowing technology. But, in spite of this, it is equally true that on some issues, Government, in one way or another, must have some voice. We believe that the several roles stated at the beginning of this chapter and summarized immediately above, taken together, constitute the irreducible base on which Government's interest in telecommunication rests.

3. ORGANIZATION OF THE REPORT

Chapter 2 deals with the technical areas chosen for consideration. The basis for final selection of these technical areas is discussed in Section 2.1. The remaining sections deal with each subject area in turn. For each technical subject, the discussion addresses its current status, the issues affecting its growth, actions designed to address some of the issues, and the impact of the proposed actions. It will be recognized by the reader that the discussion of issues and actions can be put into four very general categories:

- Needs and the market.
- System development and performance.
- Policy and regulation.
- Spectrum management.

Chapter 3, Conclusions and Recommendations, collects the principal issues identified in Chapter 2 and the actions proposed for Government, industry, and user groups for resolution of the issues. These recommendations are organized under the general categories just mentioned.

Appendix A summarizes external reactions to the draft version of the report and the resolution of these views. Appendix B summarizes data obtained during the visits to industry on international trade problems as seen by industry. Appendix C provides further technical detail about worldwide activities in direct satellite communications. Appendix D reproduces tables that list possible broadband communications network services. Appendix E gives additional technical detail on the worldwide status of fiber optic communications. Appendix F deals with recent developments in semiconductor devices technology. Appendix G lists the companies and organizations interviewed during the initial activity of the Task Force. Finally, appendix H explains the abbreviations and acronyms used in the report.

CHAPTER 2

SELECTED TECHNOLOGIES

1. <u>CHOICE OF TECHNOLOGIES</u>

CRITERIA

From its inception, the Task Force membership found no shortage of candidate topics. Based on the dozens of companies that advised the Task Force in mid-1975 -- more than 50 interviews with industry across the United States during that fall -- and the members' own perceptions, the list of candidate topics grew rapidly.1/

Many of the early discussions centered on export and domestic sales potential or on trade problems, factors which were subsequently removed as prominent considerations.2/ In time, suitable selection criteria were developed. These resulted in the choice of Direct Satellite Communications, Land Mobile Radio, Broadband Communications Networks, and Fiber Optic Communications as key technologies most worthy of national focus.

The criteria used for the selection process were:

- <u>Potential for Public Benefit</u> -- There had to be clear indications that, with lowered barriers, significant public benefits would be realizable in terms of economic gains, improvement in the quality of life, and conservation of scarce national resources.

- <u>Significance of Technology as a Barrier to Progress</u> -- The primary barriers had to include technological factors believed to be significantly remediable.

- <u>Consequences of Business-as-Usual</u> -- There had to be evidence that the projected normal course of events would not enable full application of the technology.

1/ See appendix F for a brief discussion on solid state device technology.

2/ See appendices A and B.

Or alternatively, there had to be an appreciable contrast in projected results between taking no action and making an effort to surmount barriers.

- Timeliness -- The state of development of the technology and public demand had to be sufficiently mature to warrant attention.

- Appropriateness of Federal Involvement -- There had to be good positive reason for Federal involvement, as it affects public interest, the use of limited natural resources, and the efficacy of properly targeted Federal R&D expenditures.

Concern over reasonable roles of the Federal Government acted as a continual check on suggestions for Federal involvement. Considerable recognition was given to the need for industry participation as well as the need for coalescing the Federal viewpoint.

TECHNOLOGIES THAT WERE NOT SELECTED

A number of candidates did not survive the test of the five criteria. Among the unsuccessful candidates were: the automated electronic office, electronic funds transfer systems, video teleconferencing, consumer electronics, and data communications. Here are the reasons why these admittedly important topics did not qualify.

(1) The electronic office was removed from the list because the telecommunications component involved is not very significant. Moreover, there are no persuasive reasons at present for Government involvement.

(2) Electronic funds transfer was removed from the list because the major problem at present concerns banking regulations rather than telecommunication technology.

(3) Video teleconferencing was removed because it was believed that it will be some time before significant public demand arises, despite its potential as a substitute for travel and the many interesting technological problems which will need to be solved.

(4) Consumer electronics was removed because industry has the technological problems well in hand. In addition, international trade questions, which appear to be the remaining industry problem, fell outside the scope of this report. 3/

(5) Data communications was not selected for attention because it is a service which is making rapid strides, and most of the technological problems are being resolved by industry. No great barriers to its growth were visible, despite growing confusion about the differences between data communication and data processing.

TECHNOLOGIES THAT QUALIFIED

The technologies that survived did so for diverse reasons. All, of course, satisfied the five basic criteria for selection. In each case, however, there were considerations of special significance; these are stated below.

Direct satellite communications, especially for services involving small earth terminals, was included because of its potential public benefit, the presence of significant technical barriers (i.e., hardware availability and criteria for spectrum/orbit utilization), timeliness, and potential regulatory or policy barriers to their early utilization. This subject was included also because of the danger that early ad hoc decisions might foreclose future opportunities for beneficial use of the spectrum/orbit resource.

Land mobile radio, a well established and steadily growing service, was included because of its importance to business, public safety, and government operations and because of the likelihood that there will not be sufficient spectrum available to sustain the growth of conventional privately owned systems.

Broadband communication networks was chosen as an example of a service "whose time is yet to come." Despite many persuasive arguments concerning the benefits such services, they are not becoming available

3/ See appendix B.

because the necessary networks have not been developed. Moreover, techniques appropriate to satellite and fiber optic communication modes may play an important role in providing such networks.

<u>Fiber optic communications</u> was included because it represents a new communications mode for the future, because of its potential for providing inexpensive high capacity communications, and because of its potential for development into a significant new manufacturing industry.

In summary, every effort was made to assure careful selection of those technologies that warrant Federal attention and to solicit various viewpoints, regardless of probable support or lack of it. Those technologies viewed as having high potential for public and private benefit are accordingly highlighted and proposed for further discussion.

2. DIRECT SATELLITE COMMUNICATIONS

STATUS OF THE FIELD

The communication satellite is having a strong stimulative effect on telecommunications growth. And, as this technology evolves, its maturation is marked by the emergence of different satellite systems. Diverse studies -- in and out of Government -- have indicated that, among the satellite systems displaying impressive growth potential, the direct satellite communication more than holds its own.

A direct satellite communication (DSC) system is characterized by the use of small, inexpensive earth station terminals; by "small," we mean terminals whose antenna diameter might vary from 0.5 to 3 meters. The terminals would be located on, or close to, the user's premises. DSC systems also would have satellites with high-powered transmitters and narrow antenna beams.

These features are just the opposite of those observable in most of the Fixed-Satellite Service systems currently in operation.

DSC systems could operate in either the Fixed-Satellite Service or the Broadcasting-Satellite Service. The latter includes both Community and Individual Reception. Considerable ambiguity exists -- both nationally and internationally --as to the use of these terms. In this report, we refer to DSC on the basis of technological characteristics. The expression DSC has no domestic or international regulatory service definition. On the other hand, the ITU service definitions for the Fixed-Satellite and Broadcasting-Satellite Services appear to be ambiguous in technological classification based on very broad interpretation of service characteristics. This ambiguity has been intentionally agreed upon internationally.

As an example of the ambiguity, the Fixed-Satellite Service embraces all point-to-point transmission with both points fixed. In television network relay, however, such point-to-point relay via satellite can be made to a local TV broadcast station, which then rebroadcasts the signal within a local area. The same point-to-point satellite relay with terrestrial broadcast might be included under either the Fixed-Satellite Service or the Broadcasting-Satellite Service/Community Reception definitions. The final decision about which definition is correct rests with each country.

In this section, we shall state some of the issues that are raised by the evolution of DSC systems. Our expectation is that this issue definition will speed the process by which Government and industry -- acting sometimes individually and sometimes in concert -- might identify and lower the technical, regulatory, and economic barriers that now impede our achieving lower cost delivery of satellite telecommunication services.

As the reader will appreciate, Government has a stake in the cost and availability of telecommunication services to public service sector users. Thanks largely to satellite communication costs being relatively independent of geographic distance, all communication satellite systems potentially offer these users services that terrestrial communication facilities are not now -- and perhaps never will be -- able to provide, at least at realistic prices. Owing to their potentially inexpensive earth stations, DSC systems ought to be just that much more useful to the institutions of the public sector.

It is clear that the future of DSC systems will be strongly influenced by future developments in all the satellite services, especially the Fixed-Satellite service. To comprehend the DSC issues, therefore, it is helpful to understand first the status of the Fixed-Satellite Service. A more complete discussion of this status is provided in appendix C; certain aspects of the situation, however, are summarized immediately below.

Satellite Communication Systems

Both satellites and their earth stations come in a variety of sizes. To illustrate an extreme, one proposed earth station, which is studied from time to time, would be the size of a paging radio; it is a receive-only, portable severe storm-warning receiver.

Earth station costs also vary considerably. For example, the receive-only version of the small Data Collection Platform Radio Set -- part of the SMS/GOES weather satellite system -- costs about $1,500. A large INTELSAT earth station, however, falls in the $2.5 to $5 million range.

Satellites are now in orbit for a multitude of services: international (the INTELSAT series); domestic in the United States (WESTAR, SATCOM I, COMSTAR); domestic in other countries (ANIK, Symphonie); maritime (MARISAT); and military (FLTSATCOM). In addition, experimental communications are being investigated by the Applications Technology Satellite-6 (ATS-6) and the Communications Technology Satellite (CTS).

Domestic satellite development is moving ahead swiftly in a number of other countries; for example, Japan, France, Indonesia, the United Kingdom, Italy, Brazil, Iran, India, and West Germany. And the USSR continues to be active with both geostationary and low altitude satellites.

Turning our attention to frequency bands, most of the present activity, worldwide, is concentrated in the 4/6 GHz band and the Government 7/8 GHz band. INTELSAT V will use both the 4/6 GHz and 11/14 GHz band. Satellite Business Systems (SBS) has filed with the FCC to develop a digital system for application in the 12/14 GHz band; but aside from it and the CTS, no other plans exist for that band. At 19/28 GHz, the only activities in evidence in the United States are test transmissions planned by AT&T and COMSAT. Foreign governments, however, are developing systems at 12/14 GHz and 19/28 GHz, with U. S. firms as active participants.

Frequency Resources

The presently allocated frequency spectrum extends to 275 GHz. Satellite services are allocated about 153 GHz -- or 55.6 percent -- of the spectrum from 7 MHz to 275 GHz, but must share all except 11 GHz of it with terrestrial services. Only 1.[illegible] percent of the allocated 153 GHz is set aside exclusively for the Fixed-Satellite Service.

Of the 153 GHz permitted Fixed-Satellites, 51 GHz is reserved for intersatellite activities, most of which will begin only in the future. This leaves 102 GHz for Fixed-Satellite services other than intersatellite. It is on this 102 GHz that we shall briefly concentrate our attention.

Fully 95 percent of this 102 GHz lies above 14.5 GHz. Yet, most of the current activity in satellite communications occurs below 14.5 GHz, which is to say, in merely 5 percent of the 102 GHz allocation.

Satellite communication use of frequencies above 14.5 GHz is considered to be limited by technology, while corresponding use of frequencies below 14.5 GHz is restricted more by market and regulatory factors.

On the subject of international frequency management, preparations are well under way for the 1977 and 1979 World Administrative Radio Conferences (WARCs). These will have a major impact on the direction and development of satellite communications, on both national and international scenes. The 1977 WARC will deal with the 11.7 to 12.2 GHz downlink band and the sharing between Fixed- (point-to-point) and Broadcasting-Satellite Services. The 1979 WARC will review the entire allocated spectrum in the light of the needs of 1980 and beyond.

Orbit Resources

A geostationary satellite must be positioned in orbit over the equator in such a way that it does not cause radio interference with other satellites and with other telecommunication systems in general. At present it appears that the United States will share with the other nations of North and South America between 75 and 88 degrees of the orbital arc. Just how much of the arc will be available to the United States is an issue that has not yet been resolved by the international community. At any rate, to apportion whatever orbital space the United States will have at its disposal, we shall have to reexamine our "open skies" policy.

According to this policy, any U. S. organization with the economic resources, technical capabilities, and customer market demand can apply to the FCC for use of the satellite communications frequency and orbit resources. But to insure that the orbital arc remains as accessible as possible, each satellite is allowed to use only a prescribed portion of it. Under present U. S. policy, the stipulation is 4 degrees of arc to each satellite at a given frequency; i.e., satellites for the 4/6 GHz and 12/14 GHz bands must require no more than 4 to 5 degrees orbital separation for noninterfering operation. This restriction forces a minimum ground antenna size, sets a minimum earth station cost, and influences the type -- as well as the cost -- of services that can be offered. These requirements appear to represent a "minimum entry constraint."

Owing to the 4 degree orbital arc limitation, minimum earth station antenna diameters are restricted to about 10 meters for the 4/6 GHz band. Furthermore, the same policy applied to the 12/14 GHz band would limit earth station antenna diameters for that band to no less than 5 meters. However, it should be recognized that a precise calculation of orbital spacing and antenna size must include details of the relative equivalent isotropic radiated power in each direction from all satellites sharing the band, as well as the modulation and bandwidth they use. It should also take into account the corresponding parameters of the earth stations and their locations.

Geographic Resources

Earth stations must be located so that no interference results to or from other systems using the same frequency band. Finding an acceptable site for operation in the 4/6 GHz band is more involved than for the 12 GHz band, since the latter band is shared only by the Fixed- and Broadcasting-Satellite Services. Coordination rules exist for the 4/6 GHz band, and are being developed for the 12 GHz band.

DSC Consumption of Resources

It has been argued that DSC systems require a disproportionate share of the three natural resources discussed above; i.e., frequencies, orbit space, and ground space for earth stations. The validity of this argument, however, is open to question. The state of the art, regulatory policies, and economic realities seem to limit DSC use of the frequency resource -- by which is meant the allocated spectrum -- to about 5 percent of the total of the spectrum allocated nationally for the Fixed-Satellite Service. As to orbit resources, the same constraints limit utilization of them to about 4 to 11 percent of what is ideally, but not practically, available for the 4/6 GHz and 12/14 GHz orbits. With regard to the geographic area resource, it is even more difficult to estimate either availability or possible usage. This will be discussed in greater detail under "Issues" below.

ISSUES AFFECTING GROWTH

Unresolved issues that are affecting the growth and development of direct satellite communications are grouped under the following subheadings.

Needs and the Market

<u>Public Service Sector Users</u>: By the term "public service sector users," we have in mind such institutions as the Department of Health, Education, and Welfare -- with its medical, education, and welfare programs -- or the U. S. Postal Service -- with its possible electronic message service -- or the Department of Commerce National Weather Service -- with its weather and disaster warning services.

An important issue relating to this category of users is:

- Their telecommunication needs are not yet well-defined and therefore must be the object of continuing attention.

Public service sector telecommunication needs, after all, will be met efficiently only when they have been more fully defined and have been pulled together so as to form a coherent market force. All of which brings us to another issue:

- Can this sector's telecommunication needs be met -- or even fully defined -- without a demonstration program that goes beyond the present and continuing demonstrations of CTS?

Should it be decided that such a demonstration is advisable, it might serve the dual purpose of revealing how to meet public service sector needs and of helping to further the definition of those needs in terms of telecommunications.

And, any research performed in connection with such a public service demonstration might well result in our pushing past the state of technological evolution where even our contemporary commercial sector is situated.

The point is that this research will have to come to grips with what at the moment appear to be the requirements of this sector's communications. Here we will state four of these possible requirements: low station capital costs, low individual transmission costs, a high degree of "connectivity" (a term that refers to the ease with which a user can be connected directly to the other stations in the network), and high data rates or bandwidths during short transmissions. These requirements result from the necessity of keeping individual user costs low by spreading total system costs widely, as well as from the need to accommodate high speed data and different forms of video.

It might be instructive to glance at industry's record as regards the rate of digital data transmission by satellite.

Each of the proposed AT&T COMSTAR satellites will be able to transmit an aggregate of 1,073 Mb/s; to achieve this, these satellites will use 30 meter antennas in the 4/6 GHz band and Atlas-Centaur launch vehicles. The SBS proposal, on the other hand, indicates a lesser total digital transmission capacity for each satellite -- 328 Mb/s; this system is based on 5 and 7 meter antennas in the 12/14 GHz band and an advanced Delta launch vehicle.

Much of the difference between the capacities of these two systems is attributable to the smaller SBS earth station antennas and the higher parametric amplifier noise figures at 12 GHz as opposed to the figures present at 4/6 GHz. Also, the SBS's Delta launch vehicle carries less weight than does COMSTAR's Atlas-Centaur.

But it would be incorrect to assume from the example cited above that the use of small earth stations inevitably implies a diminished data transmission capacity. A more advanced satellite, launched by the Atlas-Centaur, can more than compensate for the reduction in earth station antenna diameter and the higher amplifier noise figure. It is in fact possible to show that a system employing 5 meter earth station antennas and a satellite antenna mechanism that covers the United States with 11 narrow-beam patterns could yield a total digital transmission capacity of 2000 Mb/s per satellite; this would be with the use of about 80 watts total satellite downlink transponder power output. The data rate at each earth station, however, may not be more than 1 to 10 percent of the satellite's capacity.

So, if greater power and narrow-beam antennas can be built into the satellite, it will be possible to use small earth station antennas and still achieve data rates sufficiently high for efficient public service sector use.

It would be decidedly advantageous for public service sector systems to be able to utilize small earth stations. This sort of earth station may well turn out to be relatively inexpensive. Its use, therefore, would then permit many more individual institutions to join the system than would otherwise be the case. Further, thinking in terms of economic demand, greater total system revenues could in principle flow from large numbers of users at low cost than from few users at high cost. With this greater system investment, a more elaborate space segment could be programmed.

A related point: what has so far been learned about public service telecommunication requirements suggests that one technique able to satisfy them may be a variation of packet radio, which might be called "satellite packet switching." This technique, when employed in satellite communications, imposes demands on its systems similar to those that the public service sector may require for its communication networks. However, the evidence of the applicability of modified packet radio techniques to the needs of this sector is still inconclusive and it may be that only an advanced demonstration will clarify the issue.

If it is demonstrated that the way to meet public service sector needs in a cost effective manner is via a satellite network of hundreds -- or thousands -- of small, inexpensive, unattended earth stations, we shall most likely be placed in a difficult regulatory situation. For such a system would require a larger orbital arc segment than present policy permits. Allowing the public service sector to use more than its "fair share" of the arc would mean that it would be in effect receiving a resource allocation subsidy.

The question is:

- Would a decision favorable to the public service sector be in the broader public interest? Or, put another way: Do we wish to sanction this exception to present policy regarding orbital arc deployment?

<u>International Competitive Position of the United States:</u> Focusing on international trade, we find that one issue stands out:

- Should the United States act to assure its continued place as technical leader in the world market in view of the progress other countries are making in satellite research?

A refinement of this question might read: Should the United States take steps to insure that advanced satellite research is conducted in the United States -- even if this means that the Government itself must underwrite the task?

The National Academy of Engineering -- in a 1973 report prepared by S. Metzger of COMSAT -- has addressed this issue in the following words:

Thus at the time when all major countries are engaged in breaking new ground in this field in order to insure a place for the future, the U. S., already in the lead, has cancelled the ATS-G, H, and I. The effects of this cancellation should appear in the second half of the 1970's because of the anticipated need for advanced aeronautical, maritime, domestic, regional, and international satellites.

Commercial satellite ventures must, because of the high costs of satellites and rockets, take a conservative design approach. Radically new approaches involving expenditures of many tens of million dollars, can't be funded by today's satellite business.

Several other countries are developing entire satellites, including communications packages. I recommend that the detailed design of satellites for operational commercial purposes (communications, broadcast, aeronautical, and maritime) be funded by nongovernment entities; but the U. S. Government should continue to sponsor the advanced satellite techniques and components useful to all satellites, Government and nongovernment, in addition to its sponsorship of new satellites for specific noncommercial purposes, i.e., Government, military, and scientific applications, and demonstrations of satellite technology for systems having no early commercial potential.

This excerpt serves well to crystallize the issue of the right division of support between industry and the Government for advanced satellite research.

It might add some perspective to the statement of this issue to consider briefly what the competitors of U. S. industries are doing in this area. The Canadians, Japanese, and Europeans have small earth station demonstrations under way. Thanks to the delay in the United States in the use of this technology, they have taken the ~~lead in its~~ development. They, therefore, may exert substantial influence at the 1977 and 1979 WARCs. In addition, they have begun to occupy a favorable position in international sales. If small earth terminals become more widely used in the United States, these foreign countries may carve out for themselves a formidable initial sales position here as well.

System Development and Performance

The issue accompanying this topic is:

- Inasmuch as the extremely wide range of allocated frequencies above 14.5 GHz is not being rapidly exploited, should we investigate more thoroughly the technological outlook for using it and perhaps reevaluate the allocations in this light?

Of the spectrum bandwidth currently agreed upon internationally and in the United States for all satellite services, excluding the intersatellite service, 5 percent is allocated below 14.5 GHz. There appears to be general agreement among Government and industry that the major technical problems have been resolved and technology is available for international and domestic satellite communications below 14.5 GHz, with some isolated exceptions.

Very little attention is being paid to the development of technology to use the 95 percent of the spectrum above 14.5 GHZ and the corresponding orbit and geographic resources.

Even the first major step towards use of 95 percent of the Fixed-Satellite Service spectrum above 14.5 GHz has not been taken, although the preliminary step of providing 19/28 GHz beacons for experimental purposes on the COMSTAR satellite has occurred. No thorough assessment has been performed to determine the technology presently available and the associated performance limitations. The limitations of the channel are only known in general and not in sufficient detail in the frequency geographic dimensions. Even the problems of antenna beamwidth and pointing, for both satellite and earth station antennas, are not well defined as the frequency increases to 275 GHz. Equally important, no system assessments have been made for the various allocations. The existing allocations may not be the best choice and may make future system implementations more costly than they need to be. Some attention should be given to this resource imbalance.

Policy and Regulation

Frequency Resource Utilization: On the subject of international radio frequency regulations, a central issue seems to be:

- In preparation for the 1979 WARC, should the Government once again review its current satellite policy with special emphasis on the issue of small earth stations?

The 1977 WARC will consider, for the 11.7 to 12.2 GHz downlink frequency allocation, the development of rules for sharing between the Fixed- and Broadcasting-Satellite services internationally as well as in the United States. The final FCC position for the United States at the 1977 WARC is given in the Report and Order of Docket Number 20468.

In its position, the United States expresses the desire to maintain a flexible position through the use of "evolutionary planning" within an orbit division approach without power flux density limits in the 11.7 to 12.2 GHz band. The "evolutionary planning" policy requires that satellites be capable of modest, one-time repositioning ($\pm$ 10 degrees in orbit position), that earth station antennas can be repointed to the new satellite position, that earth station receivers be capable of retuning over the entire operating frequency range of the satellite network, that satellite antenna pointing angles be maintained within 0.2 degrees, and that satellite positions be maintained within $\pm$ 0.1 degree.

However, current policy seems to preclude use of more than 4 degree orbital arc satellite spacing, thus restricting earth station antennas to 5 meters and greater. This is the minimum entry constraint introduced previously. Other countries appear to favor antennas as small as 0.9 meters.

The 1979 WARC will review the frequency allocations over the entire allocated spectrum, including all satellite frequency allocations. Preparations for U. S. positions are well under way by the Office of Telecommunications Policy (OTP), the Interdepartment Radio Advisory Committee (IRAC), the Federal Communications Commission (FCC), and the International Radio Consultative Committee (CCIR), with Government and industry support.

Orbit Resource Utilization: With regard to use of the orbit resource, one issue stands out:

o Should the United States reexamine its policies governing use of the orbital arc with the intent of increasing technical efficiency where possible and allowing greater liberality of satellite small earth station network use where economically desirable?

Geostationary satellite orbital slots are limited by interference among the satellites in orbit using the same frequency band. If certain technology limitations characteristic of today's state of the art could be removed, this might increase the number of orbital slots available and expand the overall use of the band.

The regulatory questions associated with small earth stations focus on our orbit use policies. Should such small earth stations be allowed? If so, in what bands? And under what rules? (On this subject, note that MARISAT will use a 1.2 meter antenna in the 1.5/1.6 GHz bands; this will involve more than 12 degree orbital arc spacing between adjacent satellites.)

Perhaps some flexibility might be introduced into our regulatory policies. It might be appropriate to consider use of small earth terminals in a given band for a fixed interval of time, say 10 years. During this period, the subject should be periodically reexamined in the light of new technology and needs.

Geographic Resource Utilization: We define this issue as follows:

- Should we take steps to define more clearly the capacity of our geographic areas to contain earth stations that share the spectrum with other services?

Earth stations must be placed at sites that afford them compatibility with existing terrestrial and satellite systems. To determine this compatibility for each earth station application, procedures have been established at both the national level -- through the FCC and the OTP -- and the international level -- through the ITU.

When combined with the frequency spectrum, these geographic sites represent a national resource. Both the geographic and the orbit resource derive their significance from the satellites and earth stations they service. It is therefore difficult to think of them independent of the technical characteristics of the systems that put them to use. Perhaps this is one reason why the amount of the geographic resource available has not been determined. In fact, even the current use of this resource is identified only in scattered documents.

Spectrum Management

An issue concerning utilization of the 2.5 GHz band is:

- Should we make more bandwidth available in the 2.5 GHz band so as to accommodate more public services, thus spreading the cost of the space segment over more users?

At present, the Fixed-Satellite Service is allocated 70 MHz in this band and the Broadcasting-Satellite Service 196 MHz. These bandwidths are effectively reserved for the public service sector. But this restricted bandwidth limits the number of services that can be offered within it. In turn, relatively few institutions are able to partake of these services. This situation will keep the individual user cost high. What is needed is bandwidth sufficient to allow more public service agencies to offer a greater variety of services. This should make the services of this band more cost effective and therefore more attractive to public service users.

A similar issue concerning other frequency allocations below 14.5 GHz is:

- o Should we reevaluate our domestic spectrum allocations below 14.5 GHz in view of the fact that parts of it are not being used and that other parts -- in particular the 4/6 GHz band -- are in great demand?

The ITU has allocated a total of 600 MHz to the Fixed-Satellite Service in ITU Region 2 (North and South America) that is not being used within the United States, perhaps because the presence of radar and other radio location systems in bands 3.4 to 3.7 GHz and 4.4 to 4.7 GHz introduce questions of technical feasibility and discourage potential users.

Another 500 MHz has been allocated -- both within the United States and in ITU Region 2 -- to international communications in the bands 10.95 to 11.2 GHz and 11.45 to 11.7 GHz. These frequencies are now slated to be part of the INTELSAT V system. The question here is why they could not be used on a limited basis for domestic purposes with small earth stations.

Finally, yet another 750 MHz -- which is noted in appendix C and which is also allocated both in ITU Region 2 and in the United States -- does not appear to be in use at all. In the United States, the 6.627-7.125 GHz band is available on a secondary basis for downlink purposes and the 12.5-12.75 GHz band has been allocated for uplink operations in the Fixed-Satellites services. The reasons for these allocations are not clear.

In view of the regulatory limitations associated with the use of the 4/6 and 12/14 GHz bands, it would seem to be appropriate for Government and industry to review these allocations -- especially as part of the preparations for the 1979 WARC.

ACTIONS THAT ADDRESS THE ISSUES

The preceding section has identified what appear to be technical, economic, and regulatory barriers inhibiting the growth of direct satellite systems. The next step is for Government and industry to get together to study the situation outlined in this section and determine whether these alleged barriers are indeed authentic.

But that is admittedly a very general suggestion. The issues listed above also point to a number of more specific recommendations for action, which are found below.

The timetable of the two imminent WARCs -- in 1977 and 1979 -- effectively establishes a deadline schedule for coming to grips with many of the issues pertaining to satellite communications. These WARCs, then, invest these recommendations with a sense of immediacy.

Additionally, possible domestic applications of direct satellite communications raise questions of technical requirements and institutional readiness.

These factors and the issues we have stated above lead us to propose the following actions under the headings indicated:

Needs and the Market

- Public service sector users of communications must develop a definition of their technical requirements to see if, upon aggregation, satellite telecommunications can be cost effective.

Government might also investigate the need for a demonstration program in satellite telecommunications for public service sector users. The role of Government and industry, in any demonstrations beyond CTS that are considered appropriate, must be identified.

System Development and Performance

Government must determine if a need exists for NASA to resume its former place in the development of advanced satellite telecommunication technology. This review, however, must recognize that the fundamental needs of the public service sector user may differ from the needs that NASA addressed in satellite telecommunications during the 1960's.

In view of the current trend toward greater use of small earth terminals, both domestically and abroad, as described more fully in appendix C:

- Industry should take the initiative, in cooperation with users and Government, to explore the need for criteria and standards for small earth terminal satellite systems operating in the 2.5, 4, 6, 12, and 14 GHz bands. It should also assess the effect of these standards on future technological development, and, if appropriate, define and recommend performance criteria or standards for FCC adoption.

Also:

- Government and industry must evaluate the research and development activity currently centering on satellite telecommunications above 14.5 GHz. This review must include a system assessment of the potential uses, capacities, and limitations of technology applied to the spectrum from 14.5 GHz to 275 GHz.

It was mentioned above -- in the discussion of the issue relating to America's competitive position -- that some confusion exists as to what role Government and industry ought to be playing in the conduct of advanced satellite research. The private sector will have to recognize that the Government ought not to have to bear the entire burden of satellite communications development.

One ingredient now missing must be added: a "systems organization," which will be responsible not just for the space segment but for delivery of the service to the user and for the quality of the service as well. Moreover, each demonstration might benefit from separate Government and industry "systems organizations" working in coordination with each other; the former could be relatively small. For Federal user agencies, the systems responsibility might best be delegated to a nonuser agency.

Policy and Regulation

- Policymakers and regulators must address the spectrum/orbit questions associated with the use of small earth stations (0.5 to 3 meters), particularly in the 2.5 GHz and 12/14 GHz bands. Consideration should be given to the use of one or more bands with orbit spacings more than 4 degrees in order to accommodate small earth station systems. In the 12/14 GHz band, special attention must be given to the first application for a satellite system. The technical characteristics of the first system may establish de facto power flux density limits for future systems, and thereby exclude small earth station applications.

Spectrum Management

- Spectrum allocators must review the use of the frequency spectrum from 1 GHz to 14.5 GHz for satellite telecommunications, giving special attention to: the 2.5 GHz allocations, the orbital arc allocation policies, the use of multiple band satellites, unused frequency allocations for satellites, and the impact of 10,000 or more earth stations in the United States by 1990 on the terrestrial spectrum and geographic resource.

- The organizations dealing with public service sector user requirements must seek better representation in preparation of U. S. positions for the 1979 WARC.

IMPACT OF THE PROPOSED ACTIONS

When considering the current situation in which direct satellite systems find themselves, it is perhaps more enlightening to speak of the "impact of <u>nonaction</u>." The measure of any such negative impact is always difficult. But the effects of U. S. nonaction in this field have been discernible since at least 1973.

First, we seem to be observing a trend towards the loss of U. S. technological leadership in satellite telecommunications and particularly in systems applications involving small earth terminals. There is not universal agreement on this -- either in Government or in industry. However, there are a number of disquieting points. Except for the proposed SBS system, U. S. industry does not have an overall systems operation in the frequency bands of 12 GHz and higher; U. S. industries do serve as suppliers of space and ground equipment, however, sometimes providing entire satellites. Also, Government policies are either insufficient, conflicting, or fragmented. And the development of advanced satellite technology -- as has been mentioned in two places above -- appears to be slowing in this country.

If the issue of small earth terminals is resolved in such a way as to exclude earth stations with less than 10 meter diameter at 4/6 GHz and 5 meter diameter at 12/14 GHz, the application of small earth terminals and high power, narrow antenna-beam satellite technology may be denied to public service sector users for at least the next decade. The outcome of the issue resides in the determination of the public interest.

The lack of representation of small earth terminal proponents and public service sector users in committee activities for the 1979 WARC -- in FCC, OTP, IRAC, and CCIR discussions -- may result in ITU agreements which could have a long-term, unfavorable impact on U. S. domestic satellite telecommunications.

Finally, it is argued that the past productivity gains in the service sector of the economy have been assisted by the technological advances of telecommunications. If these gains are to continue, the cost of advanced telecommunication technology and services in the United States must continue to decrease and their availability must increase. Satellite telecommunications with small earth terminals may take its place among our most sophisticated technologies in contributing in a substantial way to our continued productivity growth.

3. LAND MOBILE RADIO

STATUS OF THE FIELD

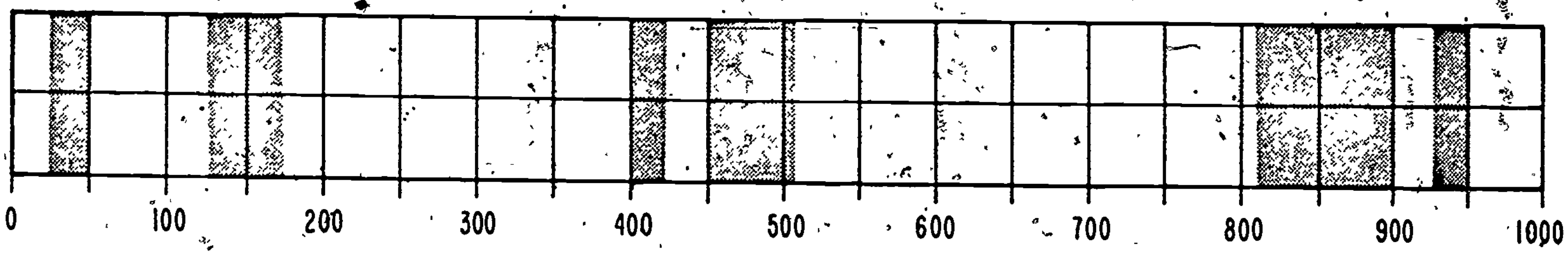
The term "land mobile radio" (LMR) originally described a radio service which provided voice communications between a fixed location and one or more vehicles and between vehicles. Since that time the industry has evolved to provide service to hand-held units (walkie talkies); to small, personal signalling devices (pagers); and to data terminals. In addition, vehicle location and some point-to-point (fixed) services are also provided. It is important to distinguish between the broad class of radio operations described by the term "land mobile radio" and the narrower class encompassed by the technical and legal scope of the FCC rules and regulations. While many types of radio operations occur between vehicles and field stations on land, only some of these operations are technically included in the term "land mobile radio." Other services have developed which are not technically "land mobile" but which appear to perform similar functions. The ubiquitous Citizen's Band service and radio amateur operation of mobile radio equipment are the best examples of the latter. The majority of land mobile operations occurs in the frequency bands shown in figure 1.

The domestic market for LMR and selected equipment (including Citizen's Band radio) is presently estimated at $783 million per year and is growing at an annual rate of 11 percent to reach over $2 billion by 1985.

Problems of market potential, diversification of new services offerings, future service demand, adequate imports and exports, administration and regulation, and many other nontechnical issues play a predominant role in the future growth of LMR in the United States.

This section focuses on those fundamental considerations which may contribute not only to LMR technology but to a better understanding of the nontechnical issues affecting growth. Many similar issues occur in the provision of service to aeronautical and maritime mobile users, but these are not discussed here.

LAND MOBILE RADIO, NOMINAL FREQUENCY BANDS



Frequency, Megahertz

Figure 1

Land Mobile Services

LMR provides a wide range of services to many distinct groups of users as shown in table 1. These distinctions have evolved partially as a result of different ways in which LMR has been used and partly as a consequence of frequency allocations made to the separate user groups.

The Land Mobile Community

In broad terms, the land mobile community consists of manufacturers, operators, users, and regulators. In some cases, single organizations may be manufacturer and operator, or operator and user, at the same time.

The Manufacturers: The U. S. market is served by a number of domestic and foreign manufacturers. Motorola, General Electric, RCA, and E. F. Johnson account for most of the domestic supply, with Motorola serving a major share of the market. This balance may shift toward foreign supply if one includes Citizen's Band as a part of LMR. Principal foreign manufacturers include Phillips, Pye, Siemens, Thomson-CSF, OKI Company, and Nippon Electric.

The Bell System represents something of a special case. In the past, Bell operating companies provided conventional radio-telephone service in various parts of the United States. Now this organization has embarked on an extensive development program to establish a new, sophisticated form of radiotelephone service in the 900 MHz frequency band. While the Bell System may not produce equipment for this use, it is expected to do the R&D and much of the system design and equipment specification that have been associated with equipment manufacturers in the past.

The Operators: LMR operators are here defined as those organizations that physically operate LMR base stations and associated equipment to provide mobile radio service. Organizational character ranges widely within two main categories: internal use and general use operators.

Internal use operators are organizations which own and operate equipment for their own proprietary use. The

Table 1. Land Mobile Radio Service and User Groups

A number of user groups are accommodated in sections of the Land Mobile Radio bands set aside for six different services, as shown below.

Category 1
Public Safety Service
- Police
- Forestry Conservation
- Highway Maintenance
- Special Emergency - provides mobile communications for emergency medical and disaster needs
- Fire
- State Guard
- Local Government

Category 2
Land Transportation Service
- Motor Carrier
- Railroad
- Taxicab
- Automobile Emergency

Category 3
Maritime Mobile & Aeronautical Mobile Service
While these groups are not truly "Land" mobile users, similar equipment operating in the adjacent frequency bands is used to provide radio communications for ships and aircrafts.

Category 4
Industrial Service
- Power (Electric Utility)
- Petroleum
- Forest Products
- Motion Picture
- Relay Press
- Special Industrial
- Business
- Manufacturers
- Telephone Maintenance

Category 5
Domestic Public Radio Service
(furnished by Wireline and Radio Common Carriers)
- Domestic Public at large - for air and land mobile and paging service
- Rural subscribers

Category 6
Government
This category includes the Federal Government agencies, many of which make extensive use of Land Mobile Radio. The Departments of the Interior, Agriculture, Justice, Treasury, and Defense all use LMR services to meet an extremely diverse set of requirements.

large local taxicab company, department stores, police departments, and the U. S. Forest Service all fall into this category.

General use operators are organizations which operate LMR equipment for the benefit of others, usually as a regulated common carrier. Included are both Radio Common Carriers and Wireline Common Carriers who provide mobile telephone service interconnected with the telephone network. The Radio Common Carriers may also provide dispatch services.

A third class of operators also exists, who operate "community repeaters." Here, a central repeater is provided for the shared use of several other licensees, who are private operators.

In the new 900 MHz band, another class of operator emerges as the Special Mobile Radio (SMR) system. The exact character of the SMRs has yet to evolved; but in concept a single, licensed operator provides base stations and repeater service to a group of users, each of whom must be eligible for licensing in the band but who is not actually licensed. Unlike operators of community repeaters, SMR operators would be recognized by the FCC through the licensing process.

The Users: In this report, users (see table 1) are those corporations and individuals who actually employ the communications service. In the case of internal use operators, the operator and users are one and the same. Sears Roebuck, for example, may operate an LMR base station to dispatch its own repair vehicles. General users, on the other hand, subscribe to services provided by others, such as common carriers. In practice, most such service is used by business and professional people. Citizen's Band users are a class in themselves -- usually private citizens who own and operate their own equipment. Such general use is sometimes put to commercial purpose.

This broad collection of users, segregated by their many different interests and requirements or by isolation between industries, does not have a common meeting ground on which to identify common problems and work toward their solutions. Many user groups are quite small or are well removed from the technology of telecommunications. Even many of the large corporate users employ LMR in simple forms, much like the smaller organizations.

The Regulators: LMR is universally regulated as to its use of the radio spectrum. Nongovernment users are regulated by the FCC; Government users by the Office of Telecommunications Policy (OTP) through the Interdepartment Radio Advisory Committee (IRAC). Market entry for Radio Common Carriers is regulated by the FCC. Their rates are regulated by the States and/or other jurisdictions.

ISSUES AFFECTING GROWTH

A wide range of concerns exists within the LMR community. The extent to which they are perceived to affect the future growth and development of LMR services varies widely. In this section, those subjects which have been mentioned in the course of numerous interviews with users and industry are discussed. They are: spectrum congestion, channel sharing, performance measures, regulatory matters, the 900 MHz band, international questions, and need for improved long-range planning. They are discussed within the more general heading below.

Needs and the Market

The most fundamental and long-standing LMR issue is spectrum congestion, namely:

- How to deal with the lack of adequate radio spectrum capacity to meet existing and expected needs.

The simplicity of this statement is deceptive, however, since no comprehensive, accepted measures of spectrum need for land mobile systems are available.

The Relative Nature of Spectrum Congestion: In the currently used bands (below 500 MHz), several cities in the United States are cited as being saturated. New York is generally accepted as the region where congestion is most intense. Radio channels in other cities, such as Los Angeles and Chicago, while heavily used, are not as congested as New York and, therefore, by one measure of performance, must offer some reserve capacity. Even so, some users in these other areas find the quality of service unacceptable or at least in need of improvement. To provide a more objective evaluation of congestion, an improved measure of channel capacity and overall radio system performance is needed.

Congestion Fixes: Traditionally, the LMR community has mitigated its congestion problems in two ways. First, it has made more effective use of existing spectrum by technical improvements to the hardware. Tone-coded squelch, in which a receiver is quiet until a call intended for it is received, is one example. Channel splitting, which reduces the bandwidth of each channel, is another. But there is a limit to the degree of channel splitting which can occur and still provide effective communications. There is evidence to suggest that this limit is reached in some cases with channel widths that are wider than the minimum required to permit intelligible reception of speech. However, the trade-offs involved in determining the channel width which produces the maximum spectrum capacity are not well understood. As a result, frequency managers still tend to assign channels of minimum bandwidth.

A second approach to congestion has been to acquire more channel space. As an example, 115 MHz of new spectrum has recently been made available for LMR in the band 806-947 MHz. However, fundamental to the question of providing more channels for LMR or other services is the need to assure "best" use of the radio spectrum as a natural resource. But in LMR, as elsewhere, "best" is not rigorously defined either micro- or macroscopically. Limited definitions exist in purely technical terms; but it is clear that "best" use must also consider short and long-term economics, social values, and other nontechnical or nonengineering factors. Lacking a rigorous definition of "best," a more general definition still does not exist that is widely accepted.

Cost as a Barrier to Congestion Fixes: In both of the above cases, the user faces higher equipment costs and added uncertainty, or risk, as to how his new systems will perform. These factors, coupled with a natural tendency to stay with the familiar, still exert great pressures to stay with the older, lower-frequency bands. Even with large amounts of new spectrum available, the older bands remain congested and are likely to continue so for the indefinite future. Effective administration of the use of the older, "traditional" bands continues as a major concern for the future.

Channel Sharing: Traditionally, most LMR services have always required users to share the radio channel assigned to them. In the early stages of sharing, however, users grow accustomed to the comparatively light loading on a shared channel. As demand increases and more users are required to share a common resource, channel loading increases and perceived service quality diminishes. Early users object to the incursions.

In other situations, users cite pressing operational needs as reasons why sharing a channel is not feasible. Consequently, numerous factors foster a reluctance on the part of LMR users to share the radio channel. Among them are:

(1) Apparent need for independent operations, free of conflicts with other agencies or adjacent area users.

(2) Clear channel experience of early users and its attendant interference-free service (in the shared bands).

(3) Proprietary interest the users acquire in their assigned channels -- an attitude deriving in part from their ownership of radio equipment.

(4) The fact that the channel appears to cost nothing and therefore the user cannot reduce his cost through sharing "his" channel with others.

(5) Increase in cost that is inherent in some forms of sharing (the use of tone-coded squelch to eliminate reception of unwanted signals, the use of computer controlled trunking systems, etc.).

(6) Natural reluctance of competitors to share facilities that may freely disclose business information. (Consider two real estate agencies on the same channel.)

The traditional approach to sharing simply adds base stations and mobile units to an already assigned channel. Both old and new listeners must listen before they speak to insure that the channel is not in use. To each user the channel is busier, access is more difficult and time-consuming, and monitoring for a message becomes bothersome.

Technical innovations have reduced these drawbacks. Some examples follow:

Tone-Coded Squelch: Tone-coded squelch can, with a modest additional investment, insure that each listener hears only those messages intended for him. However, he cannot be assured that he will hear all such messages when the channel use is high.

Trunked Systems: Another technical innovation is the use of trunked systems. Trunking is a concept in which a substantial group of channel pairs is assigned to a single system. Through the use of a central computer and remotely-controlled, multichannel mobile transceivers, channels are scanned each time a user attempts to communicate. The first unused channel is made available. This approach is expected to allow much higher usage of each channel in some applications.

The major constraints on the growth of trunked systems are:

(1) High initial cost of a trunked system relative to conventional systems.

(2) Lack of operating systems to generate practical experience in the technical, operational, and economic aspects of trunked system operation.

(3) Lack of understanding of, or confidence in, practical systems by potential buyers.

(4) Lack of remotely-tunable, multichannel transceivers. (Only one has been type accepted by the FCC. This constraint is expected to be eased, however.)

Note that the trunking concept is not limited to use in the 900 MHz band. Indeed, it is presently used in the Improved Mobile Telephone System in the very-high and ultra-high frequency bands. However, the requirement for large groups of frequencies makes the new band the only practical place to get the trunked dispatch systems started.

Paging: A third technical innovation which has been developed to provide a specialized service at low cost to the user is paging. It is mentioned here because its future widespread use may help to reduce pressure for two-way LMR channels.

Paging allows simple signalling of a large number of users, each of whom carries a small radio receiver. Typically, physicians, repairmen, and other mobile people use such a service to allow a central office to advise them of a need to call some particular telephone.

Paging is a dynamic, high growth segment of the land mobile activity. However, the constraints on its growth appear to be almost exclusively in the marketplace. With the potential for serving up to one hundred thousand subscribers on a single channel, even the limited channels presently assigned appear to offer substantial capacity. The more favorable economics of paging may drive out two-way mobile uses in some markets. Issues prominent in the field include the potential for more elaborate paging services including digital paging with message delivery, wide area services, the role of foreign manufacturers in supplying the U. S. market, and the cost of the individual pager. Bringing pager costs below one hundred dollars (some say $50) is expected to make the service attractive to the popular consumer market and so create a demand even beyond that enjoyed by present Citizen's Band radio. Some estimates put such costs 6 to 8 years in the future.

Cellular Systems: A fourth technical development which has great promise for conserving spectrum and allowing its reuse in the same area is the cellular system being developed by the Bell System for use in the 900 MHz band. The cellular concept divides the area in which mobile telephone service is provided into small cellular areas, each with a central transmitter and receiver. Mobile telephones communicate indirectly via the central installations of the cells in which they are located. By making the cells sufficiently small (e.g., half a mile in diameter) a single channel can accommodate all the traffic originating in the cell or directed towards it. Since the same frequencies can be reused at a distance of a few cell diameters, the LMR channels can be reused frequently in a large city. However, because this development involves massive computing and interconnection facilities it may, like trunking, be expensive.

Trunking and cellular systems may be major steps towards reducing spectrum congestion. However, they may not necessarily be the best. As noted earlier, the land mobile market is projected to grow at a rate of 11 percent per year. This represents a potential doubling of the demand for land mobile communications in 7 years. If this increase is to be provided with the present service quality, it represents a potential doubling of the amount of spectrum in use at present in approximately 7 years. It is unlikely that developments such as trunking and cellular systems alone will alleviate this incipient demand for spectrum. This conclusion arises because of the inherent increase in costs associated with new technical developments, particularly at 900 MHz (where they are most likely to be made available), and because of the loss of control of the facilities by individual users.

Thus the issues associated with channel sharing are:

- How to overcome user reluctance to greater shared use;
- How to recover the cost of new technical developments that facilitate sharing.

<u>The 900 MHz Band</u>: LMR operation in this band involves new concepts of operation, new equipment, and new aspects of natural influences such as radio noise and propagation. Most significant are the new concepts of operation embodied in cellular and trunked systems. Both approaches achieve greater spectral efficiency. Unlike traditional systems, these two approaches require high <u>initial</u> investment and frequency allocation despite the expected light initial demand. Return on investment (both financially and spectrally) is deferred well beyond that experienced with traditional systems.

The questions facing the community with respect to the growth of the 900 MHz band are summarized as:

(1) What is the economic viability of the new concepts?

(2) When and at what cost will equipment be available with which to establish initial systems?

(3) How can the market be encouraged in its initial phases dealing with demonstration and proof of concepts?

(4) What will be the role of community repeaters and how will they affect the market for other, more costly services?

(5) How will natural phenomena such as noise and radio propagation affect system performance in operation?

These questions, until resolved, constitute barriers to development because of the uncertainties they impose on both the users and suppliers.

System Development and Performance

Performance Measures: As stated at the beginning of this section, the fundamental issue is how to deal with the apparent lack of adequate spectrum capacity to meet existing and expected LMR needs.

The technical innovations noted above may help resolve this issue. But they can only help. More is needed. Basic to the issue is the need for better understanding of the "capacity" of a radio channel for multiple use, the extent to which the capacity is being used, and the availability of additional capacity for use by others. But an adequate definition of "capacity" has yet to be found.

Before "capacity" can be defined, a definition of system "performance" is required. How can "performance" of LMR systems be described and measured? How does performance depend on the number of users, the operating range required, and the time for which service is necessary? Again there is no adequate definition of "performance".

Lack of the definitions and subsequent means of estimating "capacity" and "performance" has the following consequences:

(1) It creates confusion, disagreement, and disappointment among users in everyday operations.

(2) It inhibits attempts to improve sharing among users.

(3) It denies the opportunity to evaluate alternative system concepts objectively.

(4) It makes rational planning for efficient spectrum use difficult.

The FCC Spectrum Management Task Force has adopted "channel occupancy", the percentage of time a channel is in use, as a measure of performance for the user. Questions still exist as to the adequacy of this approach since it does not directly determine the delay in obtaining access to a given channel. Neither does it portray the true situation unless simultaneous measurements are made at a sufficient number of points in the area where the "channel occupancy" is to be determined.

Other measures of performance are presently in use, but users and planners alike agree that they do not fully meet the practical need. The most common measure of performance presently in use is the "number of mobiles" per channel. In the Safety and Special radio channels, the "number of mobiles" performance measure for parts of the 900 MHz and 470-512 MHz bands is as follows:

Type of service	Number of mobiles which are considered to saturate a channel
Business	90
Public safety	50
Other users	70

Users argue that these rules are arbitrary and do not adequately account for the different character of radio used by various operators. Different businesses, for example, may have substantial differences in the length of messages, frequency of messages, and the amount of delay that is tolerable.

In certain telecommunication contexts, waiting-time has been a useful performance measure, but even in switched telephone networks it is not sufficient. In the LMR context, waiting time alone fails to take into account at least two important factors -- signal quality and area coverage requirements. Attempts to use waiting time as an LMR performance measure have not yet been successful, partly as a result of the difficulty of measuring this factor.

Availability of adequate and acceptable definitions of "performance" and "capacity" would allow more intelligent evaluation of various alternative solutions (e.g., channel splitting, bandwidth expansion, trunking, cellular systems) to the congestion and channel sharing problem.

Thus another major issue is:

- How to obtain adequate definitions of performance and channel capacity for dealing quantitatively with LMR spectrum congestion.

Resolution of this issue would do much to remove major barriers to future growth of LMR services, namely: (1) uncertainty about the best ways to use and administer the LMR spectrum and (2) scarcity of new spectrum space for expected growth.

Long-Range Planning: An issue essential to sound system performance and hence to LMR growth is:

- The implementation of long-range planning and the provision of the tools with which to do it.

Planning is increasingly recognized as a critical factor in insuring maximum benefit from both the spectrum and financial resources. Public safety users have documented their concerns for planning in a recent report, prepared under Law Enforcement Assistance Administration (LEAA) sponsorship by the Associated Public Safety Communications Officers (APSCO). At the FCC, the establishment of the Office of Plans and Policy, a study of future requirements for LMR services and potential digital applications in LMR, and the creation of the Spectrum Management Task Force all evidence a growing concern for improved planning. As to the radio spectrum allocated to the Federal Government, OTP requires rigorous planning by its Circulars 11 and 12.

At the State level one step in the direction of integrated system planning and operation has been the formation of State Planning Agencies (SPA's). Through this organizational mechanism, individual states are consolidating their communications requirements and centralizing their planning.

The combination of the indispensible nature of the spectrum and its scarcity drives the SPAs to shared systems. The high incremental cost of these systems is a barrier to their development, but a barrier that can be lowered by sharing costs as well as channels. Overcoming the proprietary interest that individual agencies retain in their dedicated radio channels is perhaps more difficult and depends on operational experience for its regulation. Thus, planning tools and demonstrated performance of new concepts are essential to SPAs to solve the problems of system design, system funding, and system acceptance.

The survey conducted as the basis for this chapter indicated that significant investments are being made in improved understanding of both the operations and technology of LMR. Some such investments are deliberate, as in General Electric studies of 900 MHz coverage in Dallas, Texas and studies of mobile antenna characteristics by Motorola. Other such investments are by-products of other concerns, such as proof of performance measurements by the State of Arizona and the development of better planning and analysis methods in Los Angeles County. Much of this information is potentially valuable to many organizations within the community and is not proprietary. Wider distribution of such information, particularly in uniform format to planning agencies, would contribute to improved understanding of the factors which affect LMR performance and would foster more cost-effective systems, increase sharing of facilities and spectrum, and thus remove significant barriers to wider use of LMR services.

Policy and Regulation

Two regulatory issues were identified by the Task Force:

- o Affirming the regulatory framework for the Special Mobile Radio systems.

o Shortening the duration of the regulatory process.

Special Mobile Radio (SMR) systems: The Special Mobile Radio systems approach appears attractive to those who are eligible because the standards of operation are less rigorous than for common carriers. The concept has been developed to encourage trunking, which is required for systems using more than 5 channels. But the extent to which trunked systems will realize their potential to conserve spectrum is clouded by the prospects of market response to systems with lower initial costs -- conventional systems, community repeaters, and SMR systems with five or fewer channels.

The regulatory framework for these developments is essentially in place, but action has awaited the results of a case pending before the Supreme Court. On May 24, 1976, a Writ of Certiorari was denied by the Supreme Court, removing one barrier to action. Thus, the regulatory barrier has given way to an economic barrier: the need to obtain initial operating experience with such systems to determine actual costs and customer demands. For example, to what extent will users of SMR systems detract from the Radio Common Carrier markets?

Regulatory Delays: Another issue affecting growth is whether the long periods to complete the regulatory process can be shortened. More than 8 years of proceedings transpired in FCC Docket 18262 regarding the 900 MHz allocation. The time required to process license applications is another concern.

As to the latter question, recent changes in FCC procedure have done much to speed up the process; but there remains the inherent responsibility of the regulator to let all parties be heard. As examples of improvements, however, note that the FCC has recently announced a 77 percent reduction in its domestic public land mobile backlog in the face of increased applications.

As to extended proceedings on major dockets such as 18262, a major cause in the past appears to have been the lack of comprehensive, continuing planning. The recent establishment of FCC's Office of Plans and Policy is certainly responsive to this need. Nevertheless, there remains dissatisfaction in the LMR community over the protracted decisionmaking process exemplified by Dockets 18261 and 18262. The regulators still need current technical knowledge with which to plan and evaluate new concepts and alternatives.

Spectrum Management

While many questions of international trade and market influences exist, the questions affecting spectrum use as controlled by international radio regulations are of particular concern here. While concern exists about the influence of current and future radio regulations on all land mobile operations, those affecting the new 900 MHz band are of particular interest. Both the international and U. S. table of frequency allocations for LMR are extremely complex in that:

(1) International mobile allocations are always on a shared basis with some other service, frequently broadcasting.

(2) Even within the United States, land mobile allocations are shared with other services.

(3) Allocations in a given frequency band vary from one world region to another.

(4) The 900 MHz operations in the United States will be in derogation of the ITU Region 2 (North and South America) allocations tables.

Thus, the burden of insuring freedom from interference to broadcast services in Canada and Mexico rests with the United States.

As a consequence, an unresolved issue is:

- How to improve the international allocations to provide a more uniform treatment of land mobile operations.

Such a change would improve the world market potential for U. S. manufacturers and foster lower cost equipment through the economies of scale available in serving an international market with common equipment. Such revisions to the international table appear difficult, partly because of the relatively low interest in or need for LMR services at the higher frequencies by third-world countries. Similarly, substantial pressure to retain the broadcast allocations seems likely.

There is also a particular need to provide effective methods for coordination of the use of LMR in the 900 MHz band along the borders with Canada and Mexico. Such methods should allow the maximum flexibility of use of 900 MHz systems consistent with protection of services in the neighboring countries. At a minimum, coordination methods used in the lower bands must be adapted to 900 MHz. Even better, methods specifically suited to the new band should be made available. A major barrier is that presently 900 MHz operations are excluded in regions within 250 miles of the two borders, thus precluding service to 35 percent of the potential U. S. market area.

ACTIONS THAT ADDRESS THE ISSUES

While no single crucial barrier to continued growth of the LMR community exists presently, there remain a number of unresolved questions that do contribute to slower progress, potentially more expensive services, and less than the most effective use of the radio spectrum. These issues have been introduced above.

Many of the actions suggested here fall within the scope of responsibility of more than one organization. In most cases, cooperative efforts are imperative.

Needs and the Market

In our view, the most important long-range barrier to the growth of LMR services is the lack of radio spectrum capacity, despite the recent provision of an additional 115 MHz.

Overcoming such a barrier may be accomplished by providing additional spectrum or by using that spectrum already available more effectively. A balanced approach to the problem requires careful consideration of both approaches.

The recent allocation of 115 MHz in the 900 MHz band provides spectrum relief for the immediate future, although Chairman Wiley of the FCC has already encouraged the industry to look to frequencies above 1000 MHz to meet long-term needs. However, substantial interest remains in providing more capacity in the lower bands also.

Thus it is recommended that:

- o Spectrum administrators at the national level should intensify research on the economic and social value of services provided through spectrum use with the objective of providing a more rational basis for spectrum allocation.

The reader should be warned, however, that it is no easy task to do this; and it may be many years before results of such work receive recognition.

System Development and Performance

Performance Measures: A second approach discussed above involves development of better understanding of the interactions between LMR systems sharing the same channels, geographic space, and costs.

While trunking and cellular systems are progressive steps toward increasing the capacity of the radio spectrum, they do not assist users of the more traditional services. A critical need is the development of effective definitions of the "capacity" of a radio channel and of "system performance" for LMR systems. With such definitions and related means of measurement the development of LMR systems could proceed more rationally. Alternative means of increasing the capacity of radio channels using new technology or alternative methods of frequency use and assignment can be evaluated and compared.

It is recommended that:

- o Telecommunications authorities should foster research aimed at providing effective definition and methods of measurement of system performance for LMR systems.

- o Telecommunications authorities should foster research aimed at providing effective definition and methods of measurement of channel capacity for LMR systems.

Such definitions and methods should be applicable to both frequency and geographic sharing situations. Results should be used to evaluate capacity and performance of current systems and to assess the benefits of alternative techniques for meeting future needs at minimum spectral cost.

Long-Range Planning: There is increasing activity at Federal and State levels of government in long-range planning for improved, more economic mobile radio communication systems. One aspect of the issue is that of insuring that Federal funding is used to encourage the development of integrated, spectrum efficient communication systems meeting the needs of several State agencies by sharing facilities. Another aspect is provision of better technical, cost, and operational data to all those active in system planning.

One way of addressing the latter aspect is through the development of a land mobile design reference guide or handbook. Such a fundamental reference covering the current state of the art, particularly in the new frequency band, is not available and does not appear likely to be in the forseeable future without Government encouragement. This handbook should include basic information about LMR technology and systems. It should also include information about planning new systems to meet specific requirements, evaluating policy alternatives as they arise for medium- and long-range planning, and preparing integrated procurement specifications.

Thus we recommend that:

- The LMR community should press for an integrated approach to Federal funding of local LMR projects with incentives to experiment with cost or spectrum saving concepts.

In addition, no formal recommendation is needed to point out that it is in the interest of the LMR community to press for improved mechanisms for the exchange of operational and technical experience among user groups.

Policy and Regulation

The major regulatory issue in LMR is the long delays which occur before decisions can be reached. It might reduce delays in decisions involving technical matters if the FCC could receive submissions of improved objectivity and quality relating to trade-offs and alternatives, including their long-range implications. Additionally, we recommend that:

- o FCC should consider making more use of informal nonadversary discussions prior to formal hearings in order to reduce the scope of issues to be decided by the formal hearings.

Spectrum Management

Most of the international questions bearing on the growth of LMR revolve around innovation, marketing, and demand. These are properly left to the operation of the marketplace for answers.

The major issue that the market cannot resolve is the disparity between international and U. S. allocations, particularly at 900 MHz. As a result, planned U. S. use of the 900 MHz band for LMR is constrained in the 35 percent of the continental United States along the Canadian and Mexican borders. Similar problems exist in other bands.

The recommended action is that:

- o The United States should formulate and present the strongest possible arguments for advantageous revisions to the international table of frequency allocations, especially in the 900 MHz band, at the 1979 WARC and in subsequent allocation actions.

IMPACT OF THE PROPOSED ACTIONS

The most general impact produced by aggressive response to the actions proposed above will be an increase in spectrum capacity achieved in a more orderly fashion and with greater economy than would otherwise be obtained. Some specific benefits to be expected from these actions include:

(1) More effective sharing of facilities and radio spectrum.

(2) Provision of 900 MHz services to more of the 35 percent of the U. S. area now included in the 250 mile coordination zone along the Mexican and Canadian borders.

(3) Greater flexibility in the use of LMR in border areas.

(4) Potentially greater markets for land mobile manufacturers as radio regulations become more uniform internationally.

(5) Improved confidence in planning at national, state, local levels.

(6) More productive use of Federal monies spent at the local level through better coordination among Federal agencies.

(7) Greater ultimate productivity of the LMR spectrum.

4. BROADBAND COMMUNICATIONS NETWORKS

STATUS OF THE FIELD

The term "broadband communications networks" -- in the sense used here -- embraces most telecommunication networks able to transmit high information rates to many users in video, audio, or digital data form. Generally, such systems have -- or potentially could have -- bi-directional capability. When the future of broadband is discussed, it is usually assumed that the many services it might offer would transcend entertainment services via CATV and over-the-air, or the services now provided by the telephone companies, while continuing to be based on these infrastructures.

Toward the end of the 1960's high hopes were held for the imminent expansion of broadband nonentertainment services. Quite a few years have gone by since those days of enthusiasm with only a few hesitant steps taken towards achieving the promise of broadband systems. In fact, the steps have amounted to little more than pay television for movies and sports in certain cities; some optional and limited public access to cable facilities for the origination of programming; very limited cable educational services; computer data transfers; an assemblage of studies; and collection of specialized, fragmented, and small-scale applications, experiments and demonstrations.

No major trend toward developing a "wired nation" is visible. The lack of progress is attributable to reasons that are diverse, complicated, and not unanimously agreed upon. These include less than conclusive results from a number of demonstrations, inadequate incentives for industry investment, uncertainties as to user demand, and regulatory constraints. In addition, it is unclear whether the telephone industry, the CATV industry, or some combination of these, will eventually furnish such services.

The CATV Industry

To most people, broadband telecommunications into the home is just about synonomous with cable television, or CATV. As CATV is perhaps the most conspicuous of the broadband systems now on the market, some statistics as to its growth and standing are in order.

The cable television (CATV) industry as of January 1976 consisted of approximately 3400 local operating systems serving around 10.8 million households; this is approximately one-sixth of all U. S. television households. Estimated annual income from subscriber fees was around $770 million in 1974, mostly for retransmitted television signals. Plant investment is approximately $1.0 billion. In spite of sanquine projections of only a few years ago, the cable industry is not growing according to expectation. From 1966 to 1975, the growth rate in the number of CATV systems has dropped from about 13 percent to about 2 percent per year, while growth in subscribers has dropped from about 33 percent to about 15 percent per year. Heightened interest and opportunity in Pay TV in the last year has probably improved these growth rates, although there are insufficient data to establish trends at this time.

At this writing, the CATV industry is providing almost entirely one-way entertainment services. Entertainment, however, is not our interest here. This section will concentrate on two-way nonentertainment services to the home and to institutions, such as public service organizations or businesses. Entertainment services will be brought into the discussion only when they have a bearing on the provision of nonentertainment services.

Services to the Home

A variety of broadband nonentertainment services to the home has been envisioned; these might be provided either by the common carriers or by the CATV industry:

(1) Education (adult education, correspondence schools, computer-aided instruction).

(2) Business conducted from home via interactive terminals (paid-work-at-home, community typewriters and business machines, access to company data files).

(3) General information access (catalogs, magazines, wire services, transportation schedules, financial reports, libraries).

(4) Shopping and merchandising services.

(5) Transportation and travel (airline, bus, railroad, hotel, theater, and car rental reservations).

(6) Banking and funds transfer.

(7) Alarms and surveillance.

(8) Public services to help the handicapped and the disadvantaged.

Yet, two-way services to the home have not developed in any substantial way. CATV systems are capital intensive. As they typically emphasize entertainment services, they devote few resources to developing the other services cable can provide. The CATV industry has undertaken about a dozen pilot demonstrations of two-way interactive broadband communications services at several locations in the United States. These include, among others, Carpenterville and Crystal Lake, Illinois; Columbus, Ohio; Dennis Port, Massachusetts; El Segundo, California; Irving, Texas; Los Gatos, California; Orlando, Florida; Jonathan, Minnesota; Overland Park, Kansas; and Reston, Virginia. In addition, several manufacturers have developed, or have under develment, two-way cable systems using digital data communications to implement ancillary cable services.

Perhaps the most interesting attempts to provide two-way broadband, nonentertainment services to the home via CATV are to be found in certain new towns. In addition to conventional CATV services, these new town systems provide alarm services, including medical alert, under central computer management to members of the new town communities. In one instance, arrangements were made with the local insurance underwriter to allow significant rebates to subscribers of the alarm services. Examples of new town broadband communications systems include Rossmoor's Leisure World in Mesa, Arizona, and Coconut Creek, Florida; Flower Mound New Town near Dallas, Texas; the Woodlands at Conroe, Texas; and Gateview at Albany, California. The Japanese have been developing terminals for the new towns of Tama and Higashi-Ikoma that will be tested in 300 homes starting in 1978. The two-way pilot program in the new town of Jonathan, Minnesota, partially supported by the Department of Housing and Urban Development, is no longer in operation. The Mitre Corporation successfully operated a system called TICCIT at Reston, Virginia, which involved hybrid CATV-telephone communications.

Institutional Broadband Communications

While broadband services to the home have not developed in any significant way, they appear to be advancing for institutional and commercial use. Again, both the common carriers and CATV systems have a hand in these applications. A few examples follow:

<u>Urban Administration</u>: Applications include police, fire, traffic, and city administration. The city of Columbus, Ohio, with three active CATV franchises, has built an additional independent 12-mile cable system dedicated to traffic control and surveillance. In Philadelphia, Pennsylvania, teleconferencing via a dedicated two-way cable system is used for law enforcement and criminal justice while in Phoenix, Arizona, videophone over telephone circuits is used for similar purposes; the New York Metropolitan Regional Council operates a two-way microwave facility with 13 nodes for urban administration conferencing under the National Science Foundation sponsorship; Spartanburg, South Carolina, is training day-care workers; and Rockford, Illinois, is training firemen via two-way cable.

<u>Hospitals and Health</u>: The Veterans Administration has wired, and is continuing to wire, its hospitals for specialized broadband services (i.e., other than entertainment). Telemedicine experiments sponsored by the Department of Health, Education, and Welfare have led to continued use of two-way cable for patient care and TV consultations between hospitals and neighborhood clinics. Microwave is being used for video information transfer among hospitals and for teleconferencing among hospital staff.

<u>Industrial</u>: Two-way broadband systems have been installed in factories to provide functions such as inventory control, quality control, teleconferencing, surveillance, security alarms, and training. Examples are Chevrolet and Oldsmobile Divisions of General Motors, American Motors Corporation, Dow Chemical Company, and Rockwell International.

<u>Commercial</u>: The Mitre Corporation has developed an intramural dual cable two-way broadband system (MITRIX) to transfer high-data-rate digital information as well

as to provide capability for frequency division multiplexed "switchless" telephone and delivery of standard TV services, including local origination of programs. Commercial buildings such as the Sears Tower in Chicago, EXXON and CBS in New York, and U. S. Steel in Pittsburg have cable trunks designed into the building. Data exchange between the main office and the branches of a major New York City bank is being accomplished at high data rate over a dedicated CATV channel. The British Post Office is testing a number of information services, such as Viewdata, as adjuncts to television signals.

Wired Garrison: The Army (through Mitre Corporation) is near completion on a design for an Army Base Information Transfer System (ARBITS) for administrative, training, security, and entertainment uses on military bases. The Navy has TV distribution capability on 160 ships, 138 of which have additional broadband Shipboard Information, Training, and Entertainment (SITE) capability.

Education: A host of Closed Circuit Televison (CCTV) applications can be cited that involve selected channel viewing of video tapes. Universities and school districts are using dedicated channels on CATV for scheduling and training purposes. The National Science Foundation is sponsoring development of a TV high school course that can be taken for credit at home. The Xerox training center has a system linking 2200 outlets in classrooms and dormitories. A further example is the use of computer-aided instruction using telephone networks, as in the "PLATO" experiment.

Social Services: The National Science Foundation is sponsoring projects for teleconferencing among institutions for the elderly and among day-care centers.

Information Retrieval: A number of companies have developed remote access, computer-based information retrieval systems, mostly for abstracts of published documents. Access is via common carrier or specialized common carrier communication links.

In a recent report, Mitre Corporation cataloged a significant number of institutional and commercial applications of broadband services that are delivered by CATV, CCTV, telephone, microwave, and broadcast radio. Some of the programs cataloged have terminated. Others are still being evaluated. Many have survived. (See tables 1 through 6 in appendix D, which summarizes Mitre's findings.) 1/

In the Future?

Based on analyses he conducted in 1970 at the Institute for the Future, Paul Baran estimated that by 1990 the market of one- and two-way broadband services could produce $20 billion in revenues alone. 2/

This indicates that the market for broadband goods and services taken together could total $30 billion by that date. Baran based his estimates on projections relating to over 30 services, such as automated banking (the "cashless society"), computer-aided instruction, video library, and work-at-home centers. He predicted that little forward motion would be observed along these lines before 1980, more because of institutional than technological lags. And indeed, this seems to be the way the situation is working out. (See tables 7 and 8 in appendix D.)

Baran's projections were arrived at as part of a broader survey on the future of the telephone industry. Marketing studies on CATV by Stanford Research Institute, while not so optimistic as the Baran estimates, and limited to the CATV industry, nonetheless indicate a total market of $6 billion by 1985.

Broadband communications for nonentertainment purposes is therefore in the discouraging situation of experiencing sluggish growth after having been the object of optimistic forecasting. The situation is admittedly complex and highly resistant to quick cures. But nonetheless it is possible to identify some of the salient problems besetting the field and to suggest actions that might address them.

1/ The Mitre Corporation, "System Definition for Army Wired Garrison C-E Design," Volume III - Appendices (Fort Huachuca, Arizona, U. S. Army Communications Command, July 1974.)

2/ Baran, Paul, "Broad-Band Interactive Communication Services to the Home: Part I -- Potential Market Demand," IEEE Transactions on Communications, January, 1975.

ISSUES AFFECTING GROWTH

As noted above, nonentertainment broadband services -- both to the home and to public and commercial institutions -- represent a potentially huge market, measurable not only in telecommunication tariffs but also in equipment sales. Yet, the growth of these services has been less than impressive. This is especially the case with broadband services to the home, which are virtually nonexistent. Services to public and commercial institutions, while not moving along at a pace that some had expected, have made at least some headway.

Needs and the Market

This disappointing rate of growth in broadband services is in good part attributable to the lack of a clearly-defined market demand. It seems apparent that until this market demand is established -- in at least an initial way -- industry will not make substantial investments to provide these services.

Broadband service in general, and the CATV industry in particular, then, face the classic "chicken-and-egg" problem. The Cabinet Committee on Cable Communications assessed the situation in the following terms:

> The demand for these services depends heavily on their availability; yet few potential suppliers are willing to accept the risk of developing new services without significant evidence of a market demand for them. 3/

Two issues emerge from this situation:

- o How can it be established that a market exists for broadband nonentertainment services to the home?
- o How can the growth of broadband services to commercial and public institutions be enhanced?

3/ U. S. Cabinet Committee on Cable Communications, "Cable: Report to the President" (Washington, D. C., U. S. Government Printing Office, 1974).

The reader will note the difference between "establish" and "enhance." The two terms express the difference between the degrees to which broadband to the home and to other institutions face the "chicken-and-egg" obstacle. The problem is more intense in the case of services to the home. It does not apply so severely to services to government agencies and businesses, perhaps owing to the ability of these organizations to calculate their needs more precisely according to the criterion of cost effectiveness.

The two issues stated above raise an important question:

- Is a demonstration needed to overcome the "chicken-and-egg" problem?

This question, in turn, evokes many subsidiary considerations. For example: What would be the scope and the nature of the demonstration? Where would it be located? Who would organize it? Who would participate in it? How would it be evaluated? Would it discriminate against segments of the industry that already have heavy R&D commitments?

System Development and Performance

The present status of broadband communications raises an issue that is more technical in nature than the market issues discussed above:

- Will broadband systems have the technical performance capable of meeting the carriage requirements of these emerging services?

The technical design of a particular system is highly dependent on the nature and number of services to be supported. Systems now providing specialized services function well because they are either relatively narrow band or carefully designed to accommodate certain specified services. However, augmentation of services on those systems could lead to potential design difficulties. For example, as new services are added, it becomes increasingly difficult to accommodate them as the design limits are approached. Adding a 13th channel to a 12-channel system, or the 21st channel to a 20-channel system, may require investment in an entirely new parallel system, or a total retrofit, at a cost equivalent to the original system cost.

These engineering difficulties encountered in providing augmented services emerge because in the design of broadband systems there are a significant number of engineering trade-offs. These trade-offs involve: bandwidth requirements; amplifier linearity, noise figure, and spacing; frequency allocation of spectrum space in the system; degree of cable attenuation; the length of the cable run; dispersion and time delay; accumulation of noise; accumulation of intermodulation distortion and interference effects; system topology; and reliability.

In general, costs and design difficulties escalate rapidly with increases in bandwidth requirements and system loading. Systems are therefore designed to meet current or perceived near-term requirements. To reduce costs, the ultimate bandwidth capability is often sacrificed. For example, although cable technology will allow bandwidth of up to 300 MHz, the design of a 20-channel system will very likely be limited to a 120 MHz capability.

This point came through clearly in the report of the Cable Television Technical Advisory Committee (CTAC) to the FCC, Panel 9, which states:

> In any system the addition of new services increases not only the spectrum utilized but the total signal power carried in the system. The number of possible spurious frequency combinations increases very rapidly. The net result may be of serious consequences when there is not enough margin left in the design of the existing plant. This condition has been encountered by many systems when trying to activate the midband channels where previously only low and high VHF channels were carried. Great design care and increased system monitoring and maintenance will be necessary in proportion to the extra system loading incurred. In some cases amplifier respacing and/or replacement may be necessary. 4/

The fragmented structure of the CATV industry makes these technological issues of special significance to it. Three questions are of special concern to that industry; all of them relate to the major technical issue already discussed. The questions are: (1) Does the CATV industry need centralized R&D on common technical problems associated with broadband service delivery? (2) Are there systems design problems that will impede growth unless resolved? (3) What needs to be done to achieve long-distance interconnecting of CATV broadband systems for serving both urban and rural areas?

4/ Federal Communications Commissions, Cable Television Technical Advisory Committee Report to the Federal Communications Commission -- FCC CTB 75-01, May 1975, Vol. II, Part 3, p. 678.

Technical problems cited above are neither exhaustive nor unique to cable systems. They are common to all broadband systems involving a multiplicity of users. Other issues of equivalent proportion can be expected to require considerable attention in the coming decade. Among these are: assurance of adequate security and privacy measures for both private and business users; compatible interface standards and specifications to facilitate system interconnections; and the development of low cost, compatible user terminals. Indeed, telephone systems have had some analogous problems; and fiber optic systems, when they evolve, will have to overcome similar difficulties.

This technical issue, of course, is merely another facet of the "chicken-and-egg" predicament. It is unrealistic to expect industry to increase or to alter its present communication plant on the basis of a menu of ill-defined, tentative, "blue-sky" services that may or may not materialize at a reasonable future date. Yet the slow rate of such industry investments contributes to delaying the arrival of the very services that justify plant expansion.

Policy and Regulation

Putting aside market and performance issues that might be addressed by a demonstration, and concentrating momentarily on broadband services to public and commercial institutions, another growth-inhibiting factor is at work. This problem centers on the construction patterns of the CATV industry. The industry is reluctant to place its cables anywhere but in residential areas; i.e., where the entertainment market is. It is not eager to build cable systems downtown -- where most public and commercial organizations are located -- because there entertainment subscription would be low and cable construction costs high. Cable networks designed to serve these institutions, therefore, might have to develop apart from the traditional entertainment networks.

A study of the cable needs of New Orleans is pertinent to this topic. The analysis concluded that the city would require two systems. One would provide entertainment and other services to homes and would feature little home-to-source capability. The other would allow for full two-way capability and would serve institutional, urban government, and commercial services. The study indicated that while the former would not be financially viable the latter would be.

A recent decision by the U. S. Court of Appeals for the District of Columbia Circuit also relates to this subject. In the case NARUC vs. the FCC and U. S. (February 1976), the court ruled that FCC preemption of jurisdiction over intrastate, point-to-point, nonvideo, leased channel use of cable was invalid. With this decision, carriers other than the CATV industry may decide to provide local broadband services.

It is clear, then, that the issue of what combination of services broadband systems ideally should offer is still undecided. This situation poses a question: Would development toward separate entertainment and commercial or institutional networks be a sound direction to take?

Turning to the sphere of regulation, two additional issues arise. The first has to do with the relationship between the two major categories of broadband services to the home: entertainment and nonentertainment.

When both entertainment and nonentertainment services are carried on a common CATV system, the result is economies in capital investment and operating costs. A further result is savings for operators and users. In fact, it may not be economically feasible to try to bring nonentertainment services to the home without entertainment services present to serve as an economic base.

On the other hand there are signs that suggest that if nonentertainment services are to grow, they must prove their worth independent of entertainment offerings. For despite the apparent economies of scale, nonentertainment broadband services are not developing even on profitable cable entertainment systems. One analyst put it this way:

> The argument developed in much of the literature -- that as systems become profitable they will naturally develop public service programs -- simply has not held true. Many profitable systems have never instituted such programs. Other systems that have penetrations well above the expected profit-generating point of 40 percent, discontinued their programs (e.g., Wilmington, Delaware at over 60 percent, Santa Rosa at over 80 percent). It is clear that if natural experimentation in social and/or public service delivery is to develop -- even in a technologically limited mode -- it will have to be developed by agencies other than cable systems. 5/

5/ Kay, Peg, "Social Services and Cable TV," Cable Television Information Center, NSF/RA-760161, Report to the National Science Foundation, under Grant No. APR 75-18714, July 1976, p. II-35.

Thus, the question of whether CATV entertainment services are potentially valuable to the development of nonentertainment services must be left unanswered, as the evidence is inconclusive and, in a way, contradictory. As a result, it is impossible to say with any confidence that the current regulatory restrictions on CATV represent a significant barrier to the provision of nonentertainment broadband. But the question remains as an issue that might be stated as follows:

- To what extent -- if any -- would CATV deregulation aid the growth of nonetertainment broadband services to the home?

The second regulatory issue stems from the fact that a number of nonentertainment services -- especially those involving audio or low-data-rate digital communications -- can readily be transmitted over telephone circuits. The issue is:

- Which of the broadband services should be encouraged to grow on the basis of the common carrier telephone infrastructure, the CATV infrastructure, or some combination of these?

ACTIONS THAT ADDRESS THE ISSUES

The proposed actions are divided into three categories: the need for a demonstration, regulation, and technical areas. These correspond to the breakdown of the issues discussed in the preceding section.

It is worth reemphasizing that these actions are put forth as subjects for discussion among Government, industry, and users. This dialogue should be considered part of the process of composing a national telecommunication agenda.

Needs and the Market

A demonstration of broadband services to business, public institutions, and homes is needed. We strongly believe that industry should take the initiative in this and, moreover, should manage the project. To begin the process:

- Industry should establish a group composed of industry, institutional users, and providers of public sector services to plan and finance a demonstration designed to reduce the present uncertainties of market demand and economic viability.

Although industry should be the "prime mover" in this matter, economic wisdom would seem to dictate that many services -- not just those relevant to business -- should be demonstrated in combination. Only together are these services likely to prove their economic viability. Together, they could display the economic advantages of shared costs and would permit a demonstration larger in scope than has been customary in Government and industry.

But what does "in combination" mean in this context? First, as regards services to the home, it implies that the demonstration should incorporate a large number of varied services. Since current assessments contend that potential home-owner demands are likely to be diverse, any demonstration that does not reflect this diversity is probably destined to be a failure. Many previous demonstrations may have suffered from exactly this defect.

"In combination" also suggests that the demonstration would encompass both services to the home and to public and commerical institutions.

Finally, it might be advisable to combine public sector and private sector services. Commercial purveyors of services -- such as developers of information banks, specialized news service companies, merchandizing and advertising agencies, computer service companies, and airline or travel agencies -- might invest some of the venture capital necessary to develop new broadband services. So might those government agencies -- from the local through the Federal levels -- that provide direct service to the public.

This situation of public and private cooperation, so filled with opportunity, nonetheless raises several questions. What should be the relationship among those who offer the services, those who use them, and those who carry them? What sort of services should be provided by the public sector? If Government is involved in developing services, would a government subsidy to certain elements of industry discriminate against others not so favored?

At least three alternative approaches to organizing and funding a demonstration are discernible.

Industry Managed/Industry Financed: This approach would amount to an industry consortium; Government, however, might participate as a user with the same standing as other users. As an example of the consortium approach, Arthur D. Little, Inc. brought together more than 25 firms with diverse interests in broadband communications to explore the possibility of establishing a network providing a wide variety of two-way communication services to businesses, public institutions, and homes. The first phase of the project explored the market for various services, the economics of providing them, and the technology required to make them feasible. The next phase proposed the design of a new system and the formation of a publicly-owned company -- Broadband Communications Network, Inc. -- to build and operate it.

The pilot network envisioned about 10,000 subscribers. It was to offer such services as information retrieval, programmed learning, airline and theater ticket sales, banking, real-time stock quotations, teleshopping, facsmile newspapers, fire and intrusion surveillance, opinion surveys, and perhaps first-class mail delivery. Broadband Communications Network, Inc. was particularly interested in prospects for making computerized services directly available to individuals in their homes, via television or the telephone.

The effort has been stymied in part by antitrust concerns and need for assurance of availability of CATV channels to other than system operators.

According to a report by the Department of Commerce Technical Advisory Board (CTAB), the right uses of cooperative R&D will strengthen rather than retard competition and innovation. An R&D consortium need not violate antitrust policy provided it is established in a way that indicates no threat to competition. The likelihood of antitrust litigation could be reduced even further by including Government representatives as participants in, or observers of, decisionmaking process.

Government Managed/Government Financed: Government operations, by and large, comprise administrative functions, mission-related programs, and public service roles. Virtually all of these activities are "information intensive." Federal operations, therefore, lend themselves to a demonstration of broadband services for the Government's own aggregated demand.

Government is already developing broadband applications. The ARBITS testbed program, for example, because it will pull together diverse services on a common broadband system, can serve as a prototype for further Government system development. Although tailored to military needs, ARBITS could provide guidance as to the costs and the feasibility of universally applicable broadband services, thereby reducing investment risks by other agencies and by industry.

Of relevance to this question is the Cabinet Committee on Cable Communications assertion "... that Federal Government has a responsibility to help identify the public services that can best be provided via cable communications and to evaluate appropriate privacy safeguards ... (and) that the most effective way to achieve these objectives would be through a Federally supported (demonstration) effort." Such research could also provide a basis for specifications for procurement of services from the private sector and provide measures of performance for these services.

Industry Managed/Government Financed: This approach, in which Government would absorb all the risk, would require a policy decision at the highest level of Government or a legislative mandate or both. Some might defend it on the grounds that Government investment is appropriate when used to further the public interest. For example, the public might derive benefits in the form of an increased Gross National Product, improvement in national productivity, enhanced energy conservation, and a strengthened world trade position.

Several Federal agencies possess legislative mandates that allow them to support broadband service enterprises. A recent investigation by the General Accounting Office found that at least 18 Federal agencies have funded cable television development -- either through subsidies or grants -- over the past ten years. The study uncovered certain problems: there appear to be few guidelines for such expenditures as well as little coordination among the funding agencies.

In spite of all this, it appears doubtful that this approach really conforms to the Government roles as discussed in Chapter One. Therefore, it seems the least appealing of these alternatives discussed here.

System Development and Performance

The broadband communication industry would benefit from an exploration of certain technical problems that, unless solved, might inhibit the application of new services. Physical constraints and engineering trade-offs built into present systems could conceivably limit their actual realized bandwidth capability and hinder their broader use. Technical performance areas of special concern are frequency management, security, interface standards, and terminal equipment characteristics.

Although to be sure Government has a logical role in some of the areas -- security and privacy is a good example -- in large part, technical problems are in industry's domain. We therefore suggest that:

- Industry and users should seek prompt resolution of the system performance problems associated with the delivery of broadband telecommunication services.

Policy and Regulation

Two actions center on issues within the field of regulation. The first has to do with the thorny topic of CATV deregulation. As was explained above, the available evidence does not permit a confident judgment as to whether the provision of nonentertainment broadband services to the home might be aided by the expansion of entertainment services. A number of Government institutions are studying the issue of partial CATV deregulation: a working group of the Domestic Council, the FCC, and the Congress. The Domestic Council concluded that the data on the impact of deregulation were insufficient to allow a decision to be made at this time. But as the issue remains, it is recommended that:

- The Domestic Council Working Group should arrange to obtain necessary research to establish the probable consequences of partial deregulation of CATV.

Second, nonentertainment broadband services might be transmitted by the common carriers, by the CATV industry, or by some combination of these.

Any FCC position -- ranging from no guidance to clear direction -- will influence or even determine the industry's future. For this reason, we expect that the FCC will wish to increase its research into this matter, to be in the strongest possible position when the time for decision arrives. No specific action recommendation seems to be needed immediately.

IMPACT OF THE PROPOSED ACTIONS

This section has suggested that a large-scale demonstration of a wide variety of broadband nonentertainment services be undertaken. If the demonstration achieves the breadth of services envisioned above, then economies of scale will be within reach. This in turn will permit a number of observations to be made about the various broadband nonentertainment markets; i.e, about services to the home and those to public and commercial institutions.

With this demonstration, both those offering services and those transmitting them should have a far clearer picture of the economic viability of the services. Also the home market should be stimulated. As to the public service and business markets, these would be verified and expanded.

The stimulation, verification, and possible expansion of the market demand would go a long way towards achieving the only realistic goal of any such broadband communications demonstration: to inspire private enterprise to make the investments necessary to bring the services to the market place with maximum speed and efficiency.

Thinking in terms of the future, the demonstration would provide data for better system design; and it would give us system performance specification to serve as a basis for broadband services procurement.

Speaking more specifically, a demonstration on the scale suggested above would permit participants and observers to evaluate many facets of broadband communications -- and their effects. To begin, it would reveal how well the services and the technology work in an operational environment.

Also, human reactions to new applications -- many of which contain almost revolutionary implications for our lifestyle -- could be observed. Government agencies might discern innovative ways to increase public sector productivity and to conserve energy. And, finally, if planned properly, it could offer a case study in Government-business cooperation in the sharing of telecommunication facilities.

5. FIBER OPTIC COMMUNICATIONS

STATUS OF THE FIELD

Following the discovery of lasers in 1960, researchers recognized the potential of transmitting huge amounts of information on a light beam through the atmosphere or in protected optical waveguides. This potential is based on the extremely high frequency of the light wave as carrier compared with radio frequency carriers currently in use. Rapid progress was made to develop a large variety of lasers which could emit over selected frequencies in the visible, ultraviolet, and infrared spectrum.

Survey of Developments

Highly efficient laser diodes were developed which could be modulated directly over large bandwidths or at very high pulse rates. External modulators (devices that modulate a laser beam after it emerges from the laser) became quite sophisticated; and one could modulate optical carriers using amplitude (AM), phase (PM), or frequency (FM) modulation at bandwidths sufficient to impress the entire very-high-frequency television band simultaneously onto a single laser beam. Bit rates for pulsed operation reached into the gigabit per second range. The sensitivity and efficiency of the detectors also kept pace to the point that detector sensitivity was limited only by the irreducible physical phenomenon called quantum noise. Thus, the detector thresholds were reduced to the point where a light pulse consisting of a few tens of photons, or less, could be detected.

In spite of the development of this large variety of components and the tremendous potential capacity of optical communication systems, the enthusiasm of workers in the field, or their sponsors, dwindled. Guided optical systems such as sheltered pipes or lensing systems were complex and costly. Glass fibers had losses measuring in excess of 1000 decibels per kilometer (dB/km) -- too lossy.

So, owing to the unsatisfactory qualities of fiber waveguides, the only available transmission medium for optical communications was the atmosphere. But to achieve reliable transmission in the atmosphere -- now as well as in the early and mid-1960's -- one has to overcome such obstacles as clear air turbulence, aerosols in the form of fog and smog, and large scatterers such as rain and snow. Furthermore, one requires an unobstructed path between the transmitter and receiver. Through-the-atmosphere technology cannot, therefore, meet the requirements for highly reliable and wide bandwidth transmission under all conditions. There are, however, undoubtedly many applications where lower reliability requirements might be adequately met in this manner.

Kao and Hockman (1966) published a theoretical paper which demonstrated the conditions under which optical fibers could be made to transmit light energy with very low loss. In 1970, Maurer (Kapron, et al 1970) demonstrated in his laboratory the feasibility of producing fibers with equivalent loss of 20 dB/km. Now, only 5 years later several companies have commercial cables available with losses approximating 10 dB/km; and laboratory demonstrations have reached very close to the theoretical limit of about 1.6 dB/km. The production engineering and processing technologies have progressed to a point where fiber cables with strength properties approaching that of standard coaxial cable can be produced and fiber breakage is minimized. The costs of the cable have dropped to about $2.00 per meter/fiber, which is comparable to wideband coaxial cable. The costs are projected to go much lower than this and should be comparable to the costs of the twisted copper pair currently used in the local distribution segment of telephone networks. Only an assured market is needed to permit the production levels to meet the economy of scale required to achieve this lower cost.

Applications

Current fiber optic communications (FOC) systems are relatively unsophisticated pulse code modulated systems which depend only on the presence or absence of light energy at the receiver and therefore do not require advanced laser sources or modulators. These applications are developing in areas that require special physical and environmental factors: lightness of weight, imperviousness to electrical interference, electrical isolation, small cross section, resistance to nuclear radiation and to chemical corrosion, and ease of deployment. Many of these applications are in military requirements where these special properties provide unique or cost-effective solutions. Pilot studies of field applications of FOC hybrid installations in telephone networks are under way in the United States and abroad.

In all cases cited above, FOC systems are being used to solve special problems; perform in a hybrid, transparent mode with existing telecommunication subsystem components; and are being evaluated on the basis of reliability, feasibility of installation, maintenance, etc., rather than on the potential basis of providing new and different capabilities. In addition, however, the applicability of FOC to provide new or innovative services is being explored by many workers.

Long-range applications of FOC may include alternatives to spectrum utilization for wideband communications trunking both for undersea cables, as an alternative to international satellite communications, and for point-to-point terrestrial networks. Also, the use of fiber optic local distribution systems may require changes in industry structure, policy, and regulatory procedures. Questions revolve around the combination of communication services to homes and businesses in order to provide cost effective delivery of voice, video, and data services supporting educational, entertainment, commercial, and public functions.

FOC, moreover, is especially well suited to handle digital communications, a mode of increasing importance. The services of DOD and the "common carriers," as well as the specialized private data communications industry, are all implementing digital communications. The advantages of digital or pulse transmission include high accuracy in transmission (bit-error-rates as low as one bit error in 10^8 or 10^9 bits), ability to reshape and regenerate pulse trains, and also provision for forward error correction at the receiver through special coding formats and are as applicable to fiber optic systems as they are to conventional transmissions. Multichannel digital systems can provide considerable flexibility in switching or routing of messages.

The computer industries and services are particularly interested in FOC transmission in such areas as computer-to-computer and computer-to-terminal interfaces. It is attractive to be able to transmit information in the same language format as generated at the source and required at the receiver without the necessity for translating into special codes for transmission. The computer industry has utilized optical (including fiber optic) card readers for a considerable time. The use of FOC for computer-to-computer and interpanel connections is logically the next significant industrial application. The compatibility of large scale integration and FOC terminal requirements made the integration of these technologies very promising. The potential application of integrated optical technology to provide high-speed switching, optical processing, and multiplexing appears likely to bring about new inter- and intra-building networking concepts which can greatly expand the types of teleservices described in Chapter 2.4, Broadband Communications Networks.

One source, Gnostic Concepts, Inc., predicts industry growth from about $15 million in 1976 to $833 million in 1990.

Domestic FOC Research Efforts and Pilot System Demonstrations

The domestic research and development (R&D) efforts are categorized here by (1) the major common carriers, (2) the industrial hardware-supplier sector, (3) the university community, and (4) DOD.

The major carriers are deeply involved in FOC technology development to augment their own growing network requirements. Their major in-house efforts have typically relied upon outside industrial manufacturers only for commercially-available, discrete components (for example, fibers and detectors) when they meet specific systems requirements and are cost effective compared to in-house development.

The industrial sector (including established telecommunication equipment suppliers and manufacturers of optoelectronic devices and optical fibers and cables) is committed to R&D for devices and fibers, to testing of state-of-the-art systems, and to marketing of moderate bandwidth systems. Contractual DOD and NASA support (approximately $10 million per year) has assisted in this effort; but much private capital (an estimated $100 million per year) is being invested, aimed toward commercial product lines. For a more complete summary of domestic activities and a listing of prototype demonstrations or experiments, see appendix E.

The National Science Foundation supports a grantee research program in optical communications at several major universities. These grants are directed at fundamental research aspects of device technology and generally produce extensions of knowledge and understanding of the physics, material sciences, and mathematics necessary for advancement of the field.

DOD has developed in-house capabilities within all three services (Army, Navy, and Air Force, coordinated by a Tri-Servioe Committee) for component and systems performance analysis relative to specific military applications. Major developmental work has been contracted out to the civilian sector.

Foreign Research and Development

A detailed discussion, of the status of FOC technology in major foreign developed countries based upon best current information derived from U. S. Government-sponsored industry surveys, the open literature, and recent visits by OT engineering personnel to major European laboratories appears in appendix E. It is recognized that any evaluation of foreign work is subject to inherent limits imposed by proprietary restrictions of manufacturers and nationalistic trade concerns.

Foreign leaders in FOC technology, listed in approximate order of hardware maturity, are: Japan, the United Kingdom, West Germany, France, and Canada. None of these countries is now a clear-cut leader in all aspects of the technology. Japan, however, appears to be second only to the United States in development of prototype civilian-application systems, is gaining ground rapidly, and could conceivably overtake the United States within the next 5 years.

ISSUES AFFECTING GROWTH

Needs and the Market

FOC technology was selected for examination because it is a prime example of an innovative process in telecommunications where a technological invention (breakthrough) promises many advantages over conventional technology in a broad range of commercial applications. The FOC industry is struggling through a market acceptance process, common to all new technological inventions, characterized by the need to:

(1) Establish proof of claimed advantages (for example, performance, cost, and ease of maintenance).

(2) Show advantage of new equipment acquisitions over continued acquisition of old technology.

(3) Be competitive in the cost of changes in logistics systems to support or utilize new items.

(4) Demonstrate advantages or be readily acceptable in terms of transactional or interface changes required of the users. (For example, fiber optics should make possible fast, high-resolution facsimile transmission in hospital or office buildings obviating the need for messenger services.)

(5) Provide significant advantage in choice of many auxiliary items (for example, terminal devices and services) for user's applications.

(6) Have mechanisms for implementation of technology in production, public relations effort to stimulate market, customer service organizations that can solve training problems, and modification of the new technology to respond when improved understanding of customer needs is available.

Most customers procure telecommunication services on the basis of performance measures such as bit-rate, accuracy (probability of error), and time availability. Consequently, the technological makeup of the system is not of interest to the user. Therefore, the introduction of FOC technology faces at least two additional barriers, namely:

(1) No system designer or procurer will risk a new technology without high probability of success. Such probability is enhanced, of course, by demonstrated performance, without which it is difficult to sell even the first commercial system.

(2) Without a clear estimate of potential sales volume, it is difficult for industry suppliers to develop realistic cost projections or indeed to secure adequate financing to establish the necessary production capabilities, with adequate economies of scale, to reach the expected cost competitive levels.

These two barriers represent a classic "chicken-and-egg" problem. Upon recognition of these barriers, decisionmakers in Government and industry can take steps to accelerate the initial commercial application of FOC technology and make its utility and effectiveness visible to potential users at an early stage. Thus, delay in the implementation of this new technology can be significantly reduced and the benefits made available several years earlier than they would be otherwise.

Many of the following issues (and subsequent proposed actions) may already be recognized and under control, especially in the mainstream of telephone and military applications. This list is not necessarily complete but is intended for stimulation of discussion among Government, industry, and users.

- Needs -- What important communication needs are best met by FOC? Should there be Government support and/or public demonstration of the use of this technology for meeting these needs?

- Costs and Reliability -- Will the FOC wideband communication technology be competitive in cost and reliability with other technologies such as coaxial cable for a broad range of applications?

- International Trade -- Are foreign competitors likely to penetrate the U. S. domestic FOC markets to the detriment of U. S. suppliers? Conversely, what might be done to help U. S. suppliers to participate effectively in foreign markets?

System Development and Performance

- Interfaces -- Will FOC interfaces with existing systems be effective, convenient, and inexpensive?

- Standards -- What commercial standards need development? Do existing rules, regulations, or codes that may inhibit early applications of FOC need revision?

Policy and Regulation

- Local Distribution -- What consideration of the economic and institutional impact on existing modes of the local distribution of communications to homes and businesses must be given before FOC technology is extensively applied to this function?

Barriers to the emergence of FOC technology to meet Government and public telecommunication needs may be lowered by appropriate Government and industry actions. The following recommended actions are grouped according to the above issues, and no priority order is intended.

Needs and the Market

Needs: The issue of the extent of the communication needs that can be well met by FOC can be resolved by a systematic identification of the classes and volume of broadband service demanded by commercial and Government users and an analysis of the applicability of FOC to these services. Such applications would include the advantageous substitution of FOC for existing communication systems and the establishment of new systems based on unique FOC characteristics.

By way of illustration, the special properties of FOC technology tend to point its applications toward broadband, short-haul (avoiding the necessity for repeaters), and high-user-density networks. It will replace many existing modes of communications (for example, coaxial cable and twisted-wire pair) when its special properties result in significant advantages such as lower cost, immunity to cross-talk, freedom from radio frequency interference, and so forth. New modes of communications resulting from superior performance characteristics -- wide bandwidth, low loss, small size, flexibility -- may result in the aggregation within large building complexes of communication services which are not economically feasible with current communication technology. This aggregation of services may permit the widespread acceptance and use of marginally cost effective services which cannot be sustained as individual services requiring a distinct and independent communications facility.

Various efforts are under way to identify applications for FOC. The Government supports continuing FOC research in several in-house laboratories primarily to meet national defense needs and supports research through grants to universities to extend basic knowledge and understanding. It supports applied research and development through contracts and through the DOD Independent Research and Development program with industry. Industry, of course, is investing its own capital and funding to provide products and services for both domestic and international needs.

As to the development of a market, the Federal Government is the largest single procurer of telecommunication products and services and, therefore, has a profound influence on shaping the domestic market. To date, however, there exists virtually no domestic systems market in fiber optic communications.

An FOC network demonstration ought to be planned and undertaken if attractive. To this end:

- o A Federal interagency group might identify a significant broadband communications need that advances the solution to an important public service problem, such as health care delivery in a hospital complex, and compose a statement of the necessary communications requirements as a basis for a fiber optic demonstration project.

The planning and definition phase of such a demonstration may be a logical candidate for funding under the DOC Experimental Technology Incentives Program.

<u>Cost and Reliability</u>: FOC is currently a glamour technology and is receiving much public attention through the technical and trade press as well as through advertising on television and in the popular press. However, there are only a few domestic and foreign experimental/prototype FOC systems (tabulated in tables 1 and 2, appendix E) that have been or are currently being evaluated to demonstrate the feasibility and claims for this technology. After satisfactory demonstration of technical feasibility, cost and reliability for both components and systems become extremely important in lowering barriers to widespread use.

Cost can be lowered and reliability improved only through extensive development, costly in itself. So far these development costs are not well defined. Thus, the industry needs to estimate them more precisely. Once the costs are identified, workable funding methods need to be sought. For example, the permissible development cost loading of future sales should be estimated. The extent to which contracts for advanced Government applications can meet some of these development costs also needs to be considered.

International Trade: Intensive foreign R&D activity, as detailed in appendix E, constitutes strong competition to U. S. manufacturers in both domestic and foreign markets. The emergence of competitively priced FOC systems utilizing the expected advantages of integrated optic technology for switching, coupling, interfacing, driving, repeating, detecting, processing, etc., along with the integration of computer storage, processing, control, billing, maintenance, etc., in advanced telecommunication networks may well stimulate large international markets. The centralized planning and Government support of the telecommunication industries in certain foreign countries may result in proven operational systems in the near future. Such systems may well be adaptable to U. S. domestic commercial applications. The petro-dollar nations may tend to leapfrog over conventional telecommunication technology to go directly to more sophisticated optical transmission systems since they are not faced with extensive amortization costs of existing plant.

It therefore seems to be important for some institution -- perhaps the Department of Commerce -- to keep in touch with international technological developments and trade trends and to disseminate information useful to U. S. industries and users. This action would help to insure that U. S. manufacturers are kept aware of the availability of foreign markets. In addition, it would help these manufacturers to maximize their technological lead over foreign competitors in U. S. and foreign markets.

Accordingly, in order to monitor both the domestic and international market aspects of the technology:

- o The Department of Commerce should establish an advisory committee on commercial implications of fiber optics.

It will be useful to draw upon the experience of the Ad Hoc Optical Communications Task Force mentioned below in establishing both the functions and membership of this committee.

System Development and Performance

Interfaces: Several pilot demonstrations, identified in tables 1 and 2 of appendix E, are directed toward proving the compatibility and transparency of fiber optic technology with existing systems and terminal devices. The ultimate success of retrofitted systems is measured by the extent to which the user is not aware of the presence of the FOC network or interpanel connection instead of conventional hard-wire system. Thus, action to define interface requirements between existing and new terminal devices and appropriate coupling, multiplexing and operational protocols will have to be taken.

The Office of Telecommunications has organized an Ad Hoc Optical Communications Task Force (distinct from the Science and Technology Task Force that authored this report). The purpose is to serve Government, university, and industrial interests by bringing together key persons from the workers in the FOC field, marketing representatives, and potential telecommunication users. The group will explore technological readiness, nonmilitary applications, and needs of various user communities where FOC may provide optimum solutions. It is expected that conclusions and recommendations reached by this Task Force will stimulate the early delineation of many typical interface requirements.

Standards: The issue of when to introduce the development of standards in a new technology is always a controversial subject. Standards should result from agreements between major telecommunication system designers and industrial suppliers and, therefore, should generally be left to the industry for development. The establishment of standards too early may stifle innovation, but the establishment of standards too late results in costly retrofitting or "grandfather" exceptions.

The largest coordination program currently under way for components is that which is being developed by the Tri-Service Committee for fiber optic communications in DOD. This committee was formed to coordinate the activities within DOD for fiber optical components and systems. They are developing military specifications for fiber cables, sources, detectors, connectors, and couplers. These include mechanical strength, moisture and fungus resistance, nuclear hardening, and other environmental and electrical specifications which must be achieved to meet their system performance requirements.

The military program, however, does not address commercial standards nor those of the non-DOD Government agencies in which many military specification requirements would be unnecessary and often too costly. Thus, standards for commercial applications are needed to assist in the lowering of costs and to assure compatibility.

Action is needed, therefore, from a nonmilitary Government agency to encourage and assist industry in the development of voluntary standardization for commercial applications. This includes for example, cable (sizes, channels, lengths, attenuations, dispersions), hardware (sources, detectors, switches), modules (transmit-receive, multiplexers, hybrid interface), measurements (optoelectronic performance, strength characteristics, figure(s) of merit), and terminology.

FOC applications are envisioned for many inter- and intra-building communication applications in the public sector. Therefore

- o Some group with appropriate interest and membership should identify what specifications (or voluntary standards) and codes are desirable to ensure rapid and orderly implementation of fiber optic technology in the commercial and public sectors.

Policy and Regulation

The possibility that FOC technology can provide a single, high-capacity communications "pipe" into homes and businesses has been widely noted. This single conduit can, in principle, carry telephone, television, and other teleservices yet to be offered. This very fact of such multiple uses raises important policy and regulatory questions of ownership, control, quality of service, responsibility for maintenance, economies of scale, and investment.

Such questions are beginning to be investigated by FCC, OTP, and industry. Although much more research and reconciliation of diverse interests are needed, it is too early to make a specific action recommendation.

IMPACT OF THE PROPOSED ACTIONS

Except for the laboratory efforts supported by the mainstream telephone common carriers for upgrading their own internal plant, the U. S. industry prepared to supply FOC technology is largely fragmented. Many companies are anxious to supply components and are searching for guidance regarding future expected needs and expenditures of the Federal Government as a major user of telecommunication services. Traditionally, DOD has been the primary Federal agency to provide such leadership and to make initial Government procurement a significant factor in the development and emergence of new technology. Actions are well under way in DOD to define future requirements, specifications, and standards for military needs. Briefings to industry are held periodically for purposes of feedback from industry. Much of this action will produce spin-off for commercial markets.

Against this background, the actions proposed represent an agenda for discussion between decisionmaking authorities in both Government and industry on lowering barriers to the growth of this promising new technology. Their impact should be to improve industry cohesion and to hasten the sound application of FOC technology.

CHAPTER 3

CONCLUSIONS AND RECOMMENDATIONS

1. CONTRIBUTIONS TO A NATIONAL TELECOMMUNICATIONS AGENDA

This chapter summarizes the most important of the issues discussed above and presents our accompanying recommendations. The subject headings, under which the issues and recommendations are grouped, are identical to those used in the technology chapter; i.e., Needs and the Market, System Development and Performance, Policy and Regulation, and Spectrum Management.

These conclusions and recommendations should be regarded as an OT contribution to what is hoped will become a far-reaching dialogue among all the members of the U. S. telecommunication community on the content of a national telecommunications agenda. And, near the end of this chapter, the reader will find a suggestion relating to the first steps toward the preparation of such an agenda.

NEEDS AND THE MARKET

When considering this subject, one faces a number of questions. What choices are available to provide new telecommunication services? How much will each choice cost? How much weight should be assigned a given service's potential for boosting national productivity? Our productivity, after all, has in the past been substantially increased by telecommunication service developments.

As regards satellite communications, our present policy of allowing competition in the development of domestic satellites constitutes an area of concern in at least one important respect. The purpose of the policy is to encourage as many innovative approaches as possible. However, thanks to the technical regulations governing orbit/spectrum use, prospective users face a minimum entry constraint. These regulations may effectively prohibit the use of all but relatively large earth terminal stations. The point is that these regulations may thereby be hindering the development of new services for both commercial and public service sector institutions. For it appears that these new services may benefit most from small, inexpensive earth terminals located on or close by the customer's premises.

Policymakers should therefore first verify that small earth terminals systems will indeed be singularly beneficial to the public service sector and that the telecommunication needs of this sector cannot be met as well by other facilities. To do this, they will have to assess the impact that these new services will have on existing services and the costs to be borne by the general public using the new services.

A major obstacle impeding the immediate advance of public sector telecommunication services is the lack of a clear definition of their technical requirements. For example, it appears that this sector's users require systems that allow customers the use of megabit data rates transmitted infrequently. But this has not been conclusively demonstrated.

Additionally, there is some question whether public service sector telecommunication needs -- as they relate to small earth station technology -- can be met without demonstrations that go beyond those of the Communications Technology Satellite.

There are other satellite-related issues: future U.S. plans for the 2.5 GHz band (dedicated to educational broadcasting and other public services) is one; the availability of these services via ATS-6 when it returns to the United States is another. These issues include the question of cost of the services; this involves concern about the need for regional coverage (and how it can be best provided) so as to spread the cost of the space segment over as many users as possible. Consistent with Government's role as policymaker, the recommended actions are:

- *Government and user organizations should accelerate the process by which the basic communication needs to be met by public service satellites will be defined. They should also determine the most economic way of using such satellites and who will pay for them.*

Issues germane to land mobile radio include the following: the economic viability of the new concepts being proposed for use at 900 MHz, the encouragement of market interest during demonstration phases of these new services, the relative cost of these services, the cost of conventional services at 900 MHz compared with such services at lower frequencies, and the availability of equipment for use at 900 MHz. We believe these issues are being addressed by normal market forces; Government's role should be limited to monitoring the progress made toward their resolution.

Further research is needed on the social and economic value of differing uses of the radio spectrum. The objective would be to develop a rational basis for future allocation of scarce regions of the spectrum so as to maximize the public benefit arising from the allocations. The question of the relative social and economic values of radio spectrum use, of course, encompasses far more than just land mobile applications. Moreover, it will involve value judgements.

Nevertheless, this is no cause for ignoring the issues. We therefore recommend that:

- o *Spectrum administrators should encourage further research on the economic and social values of services that are provided through the use of the spectrum in order to achieve optimum allocation of this resource in the light of the associated needs and markets.*

Turning to the issues posed by broadband nonentertainment communications, we must determine the real demand for such services and estimate when this demand is likely to occur. This raises questions about demonstration programs: Could a program be designed so as better to show and to develop whatever latent demand might exist? What basic requirements should such a program meet? Who should manage it -- and who should pay for it? Could -- or should -- the services be provided by common carriers, cable operators, or hybrid arrangements? An ancillary issue: What will be the impact of having available low cost modular terminal and interface equipment? And what will be the necessary characteristics of this equipment? Thus:

- o *Industry should establish a group composed of industry, institutional users, and providers of public sector services to plan and finance a demonstration designed to reduce the present uncertainties about market demand for and economic viability of aggregated broadband nonentertainment services.*

With respect to fiber optic communications, we must identify the nonmilitary application areas for which this technology is most competitive and suitable. Distribution networks either within large buildings or between buildings in large complexes seem to be among the more promising of these possible applications.

We should also ponder the advisability of Government support for a public demonstration of the use of fiber optic technology for meeting institutional needs. For example, fiber optics might permit the communication requirements of a large hospital to be unified, with a resultant improvement in its communication system. Such a demonstration might serve to illustrate to a wide audience the advantages of these new techniques.

Another question should be addressed: is it true that fiber optics will constitute a large future market, both at home and abroad? If it is, then it may be desirable for the United States to accelerate the use of this technology so as to increase the likelihood that U. S. manufacturers will be able to win a fair share of the developing domestic and foreign markets.

The following recommendations are responsive to the above two points:

- *OTP should establish a Federal interagency group to identify a significant broadband communications need, the satisfaction of which will advance the solution to an important public service problem (e.g., health care delivery). The group should then compose a statement of the necessary communication requirements as a basis for a fiber optic demonstration project.*

- *The Department of Commerce should establish an advisory committee on commercial implications of fiber optics.*

As mentioned earlier, the Department of Commerce, through its Office of Telecommunications, has initiated an informal Optical Communications Task Force. Composed of Government, industry, and university representatives, the Task Force is designed to explore the readiness, needs, and applications of fiber optic communications. The group includes technical experts, marketing specialists, and potential users from both private and public sectors. It will be useful for the Department to draw upon this group as needed in establishing the committee.

SYSTEM DEVELOPMENT AND PERFORMANCE

This category focuses on systems planning and research, performance criteria and measurement, and standards of practice and of equipment operation. These standards are discussed here rather than under Policy and Regulations.

The elements that compose this category are present in many of the stages through which an item of equipment of a telecommunication service passes from inception to marketing.

In the early phases of the process, a market is delineated and its telecommunication needs identified. Later steps involve, among other things, the determination of performance requirements for the systems that are designed to meet the needs of the new service. Also, performance specifications for the hardware must be stated. This process allows prospective suppliers to estimate the cost of the proposed system. It therefore contributes in an important way to the decisionmaking as to whether the service -- or item -- will be wanted and whether it should be provided. Finally, the interested parties must develop means to measure the degree to which the performance criteria or standards are indeed being met.

In two instances in the past, closer attention to these concerns might have been beneficial. First recall this country's casual attitude towards the ability of ultra-high frequency television receivers to reject interference from neighboring television stations. Now we are in a situation where receiver behavior restricts our choice as to the location of new ultra-high frequency television stations. The other example involves the susceptibility of many Citizen's Band receivers to types of interference involving two or more nearby transmitters. Because of this feature, the expansion of the Class D Citizen's Bands was delayed and limited; this might have potentially adverse effects on the market for this growing service.

A word of caution: once set, standards may actually inhibit progress. It is therefore important to establish standards in such a way that they foster, rather than prevent, innovation. This general caveat applies, to a greater or lesser extent, to virtually all the issues outlined below.

The development of small earth terminal satellite systems in the 4/6 GHz and 12/14 GHz bands is currently inhibited by a number of factors, among them the need for technical standards for their operations; FCC Petition RM-2614 is relevant to this situation. The situation is complex. Some parties oppose the establishment of these systems, fearing potential incompatibility between them and other current or planned terrestrial and satellite systems; the availability of effective regulations governing system performance might allay these anxieties. At the same time, other parties, who wish to begin operating small earth station systems, claim that it will take too long to write such regulations; the result would be a delay in the establishment of desirable services, which in turn would discourage manufacturers and service providers.

Another regulatory/standards issue currently before the FCC (Docket 20468) has to do with preparations for the 1977 World Administrative Radio Conference. The issue concerns out-of-band (11.7 - 12.2 GHz) emissions from broadcast satellite transmitters. These emissions might interfere with adjacent band terrestrial services. A closely related problem is the lack of standards for selectivity of terrestrial receivers designed for use with the broadcast satellites.

Also important are the recognition and evaluation of technological -- i.e., hardware -- and reliability factors, such as propagation, that currently limit the use of frequencies above 14.5 GHz for communication satellite purposes.

In view of these issues, we recommend that:

- *Industry should take the initiative, in cooperation with users and Government, to explore the need for criteria and standards for small earth terminal satellite systems operating in the 2.5, 4, 6, 12, and 14 GHz bands. It should also assess the effect* *of these standards on future technological development, and, if appropriate, define performance criteria or standards for FCC adoption.*

- *NASA should undertake, in conjunction with industry, to identify the hardware and other reliability barriers that limit the use of frequencies above 14.5 GHz for satellite communications and to recommend a program for lowering these barriers.*

The land mobile radio service is totally dependent on the radio spectrum. Its share of the spectrum, however, is experiencing very intensive use. This increases the importance of our improving the criteria by which we describe and measure this service's performance; it might be possible to develop criteria similar to the telephone industry's "Grade of Service." We also need some improvement in the way we assess these systems in terms of spectrum capacity and use.

Actions along these lines could be undertaken by the Institute of Electrical and Electronics Engineers, by U.S. Study Groups 1 and 8 of the International Radio Consultative Committee, and by Government agencies./ These groups should also investigate the trade-offs between system performance and spectrum utilization in order to guide the development of future land mobile systems.

In view of the recent allocation of substantial amounts of spectrum at 900 MHz, some may regard these issues as irrelevant. However, coverage at 900 MHz comparable to that available at the lower frequencies will be more expensive to obtain; pressures to provide conventional services at the lower frequencies will therefore persist. Without such actions as those recommended here, the congestion currently experienced in New York and Chicago may eventually spread to other cities. Moreover, if we do not obtain a better understanding of these issues, it is likely that a situation similar to that which now exists in the lower bands will, in time, develop in parts of the 900 MHz band as well.

Another issue emerges from the desirability of coordinating Federal grants to local organizations for the support of land mobile radio. Federal coordination is especially valuable when individual local users are eligible for support from two or more Federal agencies or programs. The objective should be to encourage comprehensive long-range planning and spectrum-efficient system design.

The recommendations are that:

- *Telecommunications authorities should foster research to develop better criteria for describing and measuring land mobile service performance.*

- *Telecommunication authorities should foster research to develop better methods for describing and measuring spectrum capacity and utilization for land mobile radio systems.*

- *One Government agency should be responsible for coordinating Federal support of local land mobile radio programs; owing to its central role, the OTP is a likely candidate. This Federal effort should support local agency attempts to achieve better spectrum use and lower costs through the development of integrated local communication systems serving several functions or user groups.*

The technical aspects of broadband communication services present some problems. It is, for example, an open question whether present CATV engineering design practices will be adequate to handle nonentertainment services as the demand for these arises. Will expensive reconstruction be required? Other issues center on the provision of modular terminal equipments and on questions of security and privacy. We recommend that:

- *Industry and users should seek early resolution of certain problems of system performance associated with delivery of broadband communication services. These problem areas include: (1) frequency management in broadband systems, (2) interface standards or specifications, (3) security and privacy, and (4) terminal equipment characteristics.*

The commercial application of fiber optic communication depends on the development of adequate standards to ensure that the components of fiber optic systems are compatible and that these systems can be interconnected with other systems. We conclude that industry should take the lead in devising the necessary performance specifications and voluntary standards. As to the public sector, here also action is required to compose standards of practice or codes as well as other rules necessary for orderly employment of the technology.

Our recommended action is:

- *The informal Optical Communications Task Force initiated by the Office of Telecommunications should identify what specifications (or voluntary standards) and codes are desirable to ensure rapid and orderly implementation of fiber optic technology in the commercial and public sectors.*

With appropriate action, the above recommendations should provide a more favorable climate for new technology applications.

POLICY AND REGULATION

Turning to satellite communications, current regulations restrict the permanent use of small earth terminals; i.e., terminals having antenna diameters less than 5 meters at 12 GHz or 10 meters at 4 GHz. Some users wish to proceed with the development of such systems as soon as possible. Future freedom of choice, however, must not be precluded by premature approval of proposals for systems that may inordinately "consume" available spectrum and orbit positions.

In addition, we should strive to achieve a more comprehensive understanding of the spectrum/orbit and spectrum/geography resources. This means describing these resources more thoroughly, assessing their dependence on technical system parameters, and studying the trade-offs between them. The recommended actions are:

- *Government -- through the OTP, FCC, and other agencies -- should reexamine its policy and regulations with respect to use of domestic and international small earth terminal satellite systems. In the process, it should intensify its search for advice from interested parties.*

- *The FCC and OTP should give priority to obtaining additional and more comprehensive descriptions of the spectrum/orbit and spectrum/geography resources and the dependence of these on technical parameters of satellite systems.*

The regulatory process has proved in many cases to be time-consuming; consider the lengthy decisionmaking process on the use of 900 MHz for land mobile services. Consequently, the delivery of new or improved services to the public has lagged. In fact, the importance of regulatory delays was frequently emphasized by industry during the Task Force visits. Yet, the natural desire to speed up the system must be balanced by the recognition of the need to preserve the right of all interested parties to be heard.

The FCC has, from time to time, brought interested parties together for informal hearings prior to formal proceedings. These informal gatherings, while having no formal standing, could reduce the number of adversary proceedings and accelerate the formulation of constructive solutions. They therefore might reduce the delays incurred by full hearings. It is recommended that:

- *Consideration should be given to the desirability, feasibility, and legality of making greater use of open, informal discussions between interested parties prior to the start of FCC formal proceedings, particularly those that are to consider largely technical matters.*

Nonentertainment broadband communication services might be provided by common carriers or as a part of CATV services. This situation raises a regulatory issue. In many instances, it may not be economically feasible to provide public nonentertainment services alone; i.e., in the absence of CATV entertainment services as a financial base. But the regulatory problems associated with CATV appear to be holding it back and this, in turn, may be a barrier to the development of nonentertainment services. The subject of partial deregulation of CATV is being addressed by the Domestic Council regulatory group, the FCC, and Congress. The Domestic Council reached the conclusion that not enough data were available on effects of deregulation to support a decision. The question is therefore dangling at present. Because of the potential of cable systems as an infrastructure for the additional nonentertainment services to the home, we recommend the following action:

- *The Domestic Council Working Group should arrange to obtain necessary research to establish the probable consequences of partial deregulation of CATV.*

SPECTRUM MANAGEMENT

Over the next three years, the International Telecommunication Union (ITU) will sponsor two WARC's dealing with matters germane to this Task Report report. The first will take place in 1977 and will center on satellite broadcasting services in the 11/12 GHz band. The second, scheduled for 1979, will revise the Radio Regulations; these include the Table of Frequency Allocations.

These WARC's will establish the pattern of worldwide spectrum utilization for many years to come. Moreover, their decisions may affect our own rules and regulations. It is thus imperative that the United States present its needs eloquently and persuasively. And it is equally important that the views both of our industry and of our users continue to be heard and considered during the preparatory period. This is particularly true as regards satellite communications and land mobile radio, as regulations favorable to U. S. equipment manufacturers will help them to become or remain competitive in the international marketplace.

In the chapter devoted to the selected technologies, a number of WARC-related issues were developed. For example, the 1977 WARC will consider the 11.7 - 12.2 GHz downlink frequency allocation and the establishment of rules for frequency sharing between the Fixed-Satellite and Broadcasting-Satellite Services internationally as well as in the United States. Current U. S. policy is to maintain a flexible position and not to develop any inhibiting rules. At the same time, U. S. policy favors orbital spacings of 4 degrees or less; this restriction means that earth station antenna sizes must be greater than 5 meters in the 11/12 GHz band. This is not consistent with a fully flexible policy, especially with other countries favoring antenna diameters as small as 0.9 meters.

Additionally, there is at the moment an imbalance in our use of those portions of the spectrum allocated to the satellite services. What can or should be done to encourage early employment of the presently-unused spectrum above 14.5 GHz so as to reduce pressure on the heavily used portion below 14.5 GHz? The latter represents merely 5 percent of the total earth-space frequency allocation. Similarly, we should review our use of the 1850 MHz of bandwidth that the ITU has allocated to satellite services in its Region 2 (North and South America) but that the United States is not yet utilizing for this purpose.

The allocations at 2.5 GHz also pose problems. We lack a firm position about use of this band for delivery of public services. Moreover, only 35 MHz of the band are set aside for the Fixed-Satellite Service and 190 MHz for the Broadcasting-Satellite Service. These relatively small allocations do not allow systems to extend their operations to enough terminals to make the services reasonably cost effective, in view of the high cost of the satellite. And, as the 2.5 GHz band is limited to public service use, the cost of its services cannot be reduced by commercial exploitation.

With regard to satellite services, as they relate both to the 1979 WARC and to domestic allocations, our recommendations are that:

- *U. S. preparation for the 1979 World Administrative Radio Conference should place emphasis on:*

  (1) *Provision of spectrum space for small earth terminal satellite systems.*

  (2) *Optimization of orbital spacing of satellites sharing the same frequencies.*

  (3) *Imbalance of spectrum/orbit utilization above and below 14.5 GHz.*

  (4) *Need for greater bandwidth allocations at 2.5 GHz for public service satellites.*

- *Public service satellite users should determine the cost advantages that could result from increasing the bandwidth available to them at 2.5 GHz and use the information as the basis for requesting the FCC to negotiate for an increase in the available bandwidth.*

Another WARC-related issue revolves around the planned use of the 900 MHz band for land mobile radio services by the United States. Our use of this band conflicts with international allocations; as a result, restrictions have been placed on its use along the Canadian and Mexican borders. About 35 percent of the U. S. land area -- in strips 250 miles wide along the northern and southern borders -- is affected. It is therefore recommended that:

- *U. S. preparation for the 1979 World Administrative Radio Conference should emphasize the resolution of differences between planned use of the 900 MHz band by the United States for land mobile systems and international frequency allocations.*

2. COMPOSING A NATIONAL TELECOMMUNICATIONS AGENDA

The recommendations stated above are intended to be a contribution to the formulation of a national draft agenda for telecommunications. It is hoped that this agenda will stimulate discussions among all relevant institutions in Government and industry and help in establishing priorities for action.

Who might take the first step in making these joint discussions happen? There are many possibilities: the Congress might hold hearings on issues clearly of national import, industry and professional associations might arrange topical workshops, the academic community might sponsor pertinent seminars, and the Executive Branch might assume the leadership in a variety of ways.

Until an official "Keeper of the Agenda" is named, some organization should collect and process all responses to this report as well as proposals relating to the agenda. Therefore:

- *The services of the Office of Telecommunications will be available for initial coordination of reactions to this report and, by extension, of all suggestions pertaining to the formulation of a national telecommunication draft agenda. This tenure will last only until a permanent "Keeper of the Agenda" is named.*

To sum up, implementation of these recommendations should enhance the long-term growth of land mobile radio services, permit faster emergence of satellite communications and nonentertainment broadband services, and facilitate the application of fiber optics. The resultant telecommunication growth will benefit not only the public and the Government, who are users, but also industry, which will profit from the creation of domestic and overseas markets.

To emphasize the complexity of "lowering barriers to telecommunications growth," we believe it is worthwhile to conclude with the following quotation:

> In an area as complex and dynamic as telecommunications, policy making can be difficult, even hazardous, because of conflicting public interest considerations. Legislation in the area of telecommunications raises another set of problems because its scale, its scope, its inter-relatedness, its pervasiveness, its dollar investment, its rapid turnover, its high quality, its impact on almost every aspect of our daily lives, give telecommunications technology a unique position in society. Furthermore, telecommunications technology overrides all the traditional boundaries of governmental authority.
>
> Many of the effects of telecommunications technology, because of political resistance, economics or status quo thinking, are delayed, slow-moving, accumulative, and outside the chain of responsibility of buyer, seller, and individual government agencies. In other words, no one has either overall authority or mapping responsibility with regard to what telecommunications technology has been doing, is doing, and will undoubtedly continue to do on a greater scale in the future.
>
> All of this places a very heavy burden on the legislators, the bureaucracy, the telecommunications industry itself, the public interest groups, and the academic and research community. Some very difficult decisions lie ahead; let's hope that these decisions will be as innovative, as flexible, and as far reaching as the technology they hope to implement. 1/

1/ Alan Pearce, "A Survey of Telecommunications Technologies and Services," Subcommittee on Communications of the Committee on Interstate and Foreign Commerce of the U. S. House of Representatives (GPO 63-552, 1976).

APPENDIX A

REACTIONS TO THE DRAFT VERSION

1. ANALYSIS OF REVIEWER COMMENTS

INTRODUCTION

A draft version of this report was reviewed by a number of organizations. As a part of the process of reviewing and verifying the draft, it was sent (November 1975) to approximately 40 industrial firms interviewed during the actual Task Force effort. As the existence of the draft became known outside the Department of Commerce, requests for copies were received from additional organizations; and it was decided to satisfy all such requests. Eventually, the draft was sent to a total of 70 nongovernmental organizations (64 industrial firms or trade associations and 6 academic institutions). Additional copies were provided to Congressional Committee staffs and Executive Branch agencies having close involvement in one or more of the topics covered in the report.

Comments (mostly written, but some by telephone) were received from 30 organizations. The scope of these comments varied greatly -- from a simple statement of full agreement to an item-by-item listing of disagreements or extensions. A great diversity of opinion was obtained on many of the significant issues and assessments.

An internal review, along with consideration of all comments received, led to a final report having a somewhat different purpose and structure (as has been discussed previously). However, it still seems valuable to provide an analysis of the outside comments received and the ways in which they were acted upon. This appendix fulfills that purpose. In addition, the four individual technical sections include resolution of comments specific to those areas.

SUMMARY OF ANALYSIS OF COMMENTS

The comments vary widely, both in their content and their support of or disagreement with the draft. This diversity of views is not surprising in light of the several industry topics addressed in the draft and the widely varying profiles of market and technological leadership represented by the respondents.

A general observation can be made about the comments from many industrial and trade association organizations: their views reflected an apparent self-interest. Common carriers expressed great concern about statements that eventually might influence competition in their regulated operations. Large manufacturers took issue with possible Government actions they believed might interfere with the private market in which they had already established a dominant position. Small or new firms welcomed Government actions because they believe their less than dominant market position would be helped. In contrast, the comments from reviewers in academic, nonprofit research, or governmental organizations were more supportive of the draft concepts and more anxious for the Government to take action. As a result, interpretation and judgments about specific comments must also consider the type and possible biases of the respondent.

While it might be tempting to "count" the mix of favorable and unfavorable comments on particular parts of the draft report, this approach would not produce meaningful results because: (a) classification of many comments as favorable or unfavorable would be highly subjective, (b) the actual respondents may not be representative of the views of all industry sectors or Government agencies, and (c) the comments of many individual respondents covered a variety of topics at the same time and were difficult to separate and/or assess individually. This final report follows the alternative approach of analyzing each of the approximately 100 identifiable comments. A subsequent section of this Appendix presents these comments (organized into nine groups of similar topics) and briefly discusses how the final report responds to each point. The following paragraphs briefly summarize the main issues raised in the comments and how they influenced the final report content. In general, it is seen that all comments were seriously considered; and the final report is in essential agreement with most of them.

GENERAL COMMENTS

In this category are several comments, general in nature, not appropriately classified in the subsequent eight sections. The significant comments in this group either supported the general thrust of the report or took issue with one or more of the underlying premises of the Task Force. Several reviewers said the report raised the right issues and particularly stressed the importance of not isolating the consideration of policy from the technology.

One of the underlying premises that was disputed is that it is possible or desirable to accelerate applications of technology in telecommunications (or elsewhere). A similar point was often made when questioning the proper role of Government, which is discussed in the succeeding sections. This argument was accompanied by the statement that applications of technology will be made when an entrepreneur believes it is economically worthwhile for him to do so; he takes a risk and sometimes he wins and sometimes he loses. The Task Force recognized this point, and the actions it proposed were meant to enable a better defined and more complete basis for new technologies/services to compete in that decisionmaking process and in the marketplace. No actions were suggested that would involve the Government in developing or operating telecommunication services. However, the final report is still built upon the premise that there are useful actions that can be taken by someone (probably Government and industry jointly) that would ensure or accelerate realization of benefits to the United States from the application of certain telecommunication technologies.

Another premise identified and rejected by some reviewers was that one agency, the Department of Commerce, could do anything in this area, where other agencies of the Government also had jurisdiction and responsibilities. This concern is valid, but should not be a basis for inattention or inaction. The thrust of the final report is different from the draft in that it focuses on useful actions that should be taken by someone, but does not worry about what person or what organization that should be.

Several reviewers did not feel comfortable with the premise that the telecommunication industry and/or technology is not moving forward in the United States. As the final report discusses, the situation is one of unrealized potential in which the United States may not retain its present superior position unless the rate of progress is increased in certain applied areas. In many areas, such as domestic satellite systems and digital communications, other nations are catching up very rapidly. Admittedly, the relative position of the United States in technology applications and technological innovations remains a controversial topic. 1/ Government, industry, and academic circles have been actively discussing this subject in recent months; and how real these concerns are can only be determined as time passes or more information becomes available.

A few reviewers attacked a premise they perceived in the draft that telecommunication applications should be established that would duplicate the existing U. S. common carrier system. The final report clarifies that this premise was not intended to be conveyed and also states that applications of certain new technologies need not be limited to common carriers.

ROLE OF THE FEDERAL GOVERNMENT

A very large proportion (almost a quarter) of the comments of the reviewers are focused around the issue of what is a proper and acceptable role of Government. This unexpected reaction appears to be a combination of overstatements or misstatements in the draft report and overreaction on the part of some organizations who foresaw a move toward greatly expanded Federal regulation or other interference in the market they serve.

Most industrial firms stated there was a valid justification for the Government fulfilling certain functions relative to the telecommunication industry, but there were several strong pleas that this Government role should be severely limited and constrained. However, almost all reviewers from academic institutions, nonprofit research organizations, and Government agencies argued for a strong Government role as the basis for protecting the "public interest" or in order to achieve specific national goals. Undoubtedly, there will be continual, perhaps perpetual, discussion and controversy about the preferable role of the Federal Government in telecommunications in the United States.

1/ The recently released Seventh Annual Report of the National Science Board, Science Indicators 1974, includes considerable data and discussion echoing these concerns on the present state of U. S. science and technology.

Because of these comments and because this issue underlies most of the study recommendations, the final report includes discussion on the rationale and alternatives for the Federal Government role. The final report continues to operate under the premise, as did the draft, that Government has a valid concern for advancing the beneficial application of present and future telecommunication technology. At the same time, it recognizes there is no need for the Federal Government to be in the telecommunication operations business or to otherwise undertake development activities where the private sector is able and willing to do so. Moreover, the final report emphasis is on identifying a national agenda of actions with the assumption that these will probably be carried out jointly by Government and industry.

Several comments focused on the particular role of the Office of Telecommunications (OT) and how active or neutral it should be in actions that might result from the Task Force. Further discussion on this question is not necessary since the final report does not include discussion of any specific OT future programs.

INTERNATIONAL TRADE

Several comments were received which expressed disappointment that the draft did not address international trade matters in telecommunications, even though significant issues in that area were raised during the Task Force interviews with industry organizations. Some comments specifically stated that the U. S. Government should take certain actions that would facilitate and assist U. S. telecommunication firms doing business abroad.

By a high level decision in the Department of Commerce subsequent to the interviews, international trade was deleted as a subject of concern midway through the Task Force effort on the basis that it would be pursued by the Domestic and International Business Administration, which has primary responsibility in the export promotion area. Therefore, the draft and the final report do not include discussion or action recommendations in this area. However, a summary of the comments obtained by the Task Force during industry interviews on the area of international trade barriers was added to the final report in order that this information would be available to those pursuing these issues.

REGULATORY ACTION

Several comments concerning telecommunication regulation stated that regulation by the Federal Government often inhibits the application of technological innovations. While recognizing that some regulation by Government in telecommunications was necessary, the comments from industry showed concern about inadequate efficiency or speed of the process in the past.

The other main concern expressed by the reviewers was that OT would interject itself into the regulatory process and thereby cause additional regulatory delays. While the primary action on OT's part contemplated the filing of regulatory comments to the FCC when there was a valid technological issue and need, the final report does not discuss this area since the purpose of the report is not directly related to OT program plans.

DIRECT SATELLITE COMMUNICATIONS

Reviewers from both large and small manufacturers disagreed with the draft implications that (1) U. S. technology for the next generation small earth stations is not advancing adequately, and (2) there is a need for demonstrations of such satellite technology. These comments are correct in that satellite technology is advancing rapidly in the United States; but, as the final report discusses, there are still concerns that other nations are catching up rapidly (or even excelling) in certain areas important to next generation direct communication satellites. The comments are correct that demonstrations of satellite technology, including small earth stations, are not needed since all necessary components have been tested in operational or experimental satellite systems. However, there are unresolved technical and nontechnical issues related to future communications that must be investigated before significant applications are feasible. These issues particularly affect the many proposals for public sector applications that involve large networks of interconnected earth stations via satellite. The final report discusses these issues in detail.

Several reviewers commented favorably on the concerns and objectives of the draft in the satellite communications area. It was concluded that the Government had to play an important role in development of next generation network systems and that a network demonstration may be needed to gain user support and interest. The final report identifies the issues that need to be addressed in considering, planning, or conducting such a network demonstration project with joint Government and industry participation.

LAND MOBILE RADIO

A sizable number of comments were received relative to the land mobile radio discussion. Several equipment manufacturers and trade associations active in this industry felt the industry was in better shape and making more technical progress than was implied by the draft discussion. Some thought that the characterization of the industry as fragmented was particularly harsh. The large manufacturers in a dominant position in the industry stated the industry had made, and was continuing to make, great progress in squeezing more users into a limited spectrum and that little if any action was needed on the part of Government (except to allocate more frequency spectrum and to reduce regulation). Several reviewers disavowed the present existence of spectrum shortage, except in two major cities. Several reviewers felt the draft did not fully reflect the considerable equipment and systems developments industry was pursuing for application in the new 900 MHz band.

As the final report discusses, land mobile radio is an area where slow, steady evolution has been the rule (and will continue), rather than any great particular barrier or great leap forward being involved. The final report presents a more complete description of the industry's past progress and present position than the draft. Despite a steady improvement in spectrum utilization, there is still a concern that improved integration and extension of knowledge about the planning and performance of land mobile communication systems are required if the necessary spectrum utilization improvements are to continue.

BROADBAND COMMUNICATIONS NETWORKS

A considerable number of comments were received concerning broadband distribution, which was one of the four technology areas discussed at length in the draft. Although the written discussion was concerned with a wide range of telecommunication services for home, industry, and Government that could be provided over new, broadband systems (including two-way services utilizing facsimile, data, or video), almost all the comments spoke in terms of the difficulties the cable television industry continues to encounter. The comments agreed that market uncertainty and financial weakness of the industry were the main problems causing the lack of predicted growth in the cable television industry. The need to expand into nonentertainment functions is recognized as a necessary source of additional revenue. The on-going issue of deregulation of the cable industry and competition with existing common carriers was also raised. The reviewers supported the concept of a demonstration as a way of advancing applications, although they identified uncertainties as to the source of funding for such a demonstration. The final report identifies the issues and alternatives involved in such a demonstration.

Three common carrier organizations pointed out that existing common carrier networks could form a distribution structure for future broadband distribution systems. They particularly objected to language in the draft that appeared to exclude common carriers from a demonstration of future broadband distribution systems. There was no intent to exclude the common carrier network from this application area; but at the same time the report did not mean to limit broadband distribution to common carrier systems. As the final report discusses, one of the issues requiring investigation concerns the most appropriate distribution mode or modes for broadband services.

FIBER OPTIC COMMUNICATIONS

Five reviewers commented specifically on the discussion of fiber optics as one of the communication technology areas having potential for future applications if barriers are overcome. In general, the reviewers agreed on the beneficial potential of fiber optics for broadband communication distribution. They echo some of the concerns and issues that still surround applications in this area and the final report presents an expanded discussion which incorporates these comments. Comments emphasized the uncertainty about the point at which fiber optics is economically equal or better than other wideband distribution methods, such as coaxial cable or waveguides. The need and value of an application demonstration remains a question and the final report addresses this question.

Three common carrier organizations objected to the fiber optics discussion of the draft which talked about applications in the context of noncommon carrier functions, since they felt that optical fibers used within a building for distribution would be a common carrier function. The use of the term noncommon carrier in the optics section in the draft was unclear and was not meant to exclude the common carriers from this application area. What was meant was to characterize some areas of fiber optic communications that could possibly be served by other than common carriers. For example, it is not clear that only common carriers should be able to utilize fiber optics for distribution purposes, including the intrabuilding use.

This issue remains an open question and involves many of the same issues as the interconnection of other terminal equipment and telephone lines. The final report also recognizes either possibility and identifies this as an open question.

CONSUMER ELECTRONICS

Five reviewers made comments about the draft discussion on barriers to recapturing the U. S. consumer electronics market. All of them felt that this problem was different from the other areas discussed because technology had less of a part to play.

The Office of Telecommunications Policy also commented upon the consumer electronics issue, as follows:

> "[T]he telecommunications balance of trade issue is indivisible and necessarily involves consideration of both exports and imports. This matter is of primary concern to the interagency trade balance task force, established at the behest of Congressman Torbert Macdonald, Chairman of the House Communications Subcommittee. Its members, which include the Department of Commerce (DIBA), the Office of the Special Trade Representative, OMB and the State Department, have yet to determine whether or not any such problem indeed exists. I hope that any specific action by the Department in this area will await the completion of at least the initial work of this task force, and will be coordinated with the other task force members through the Department of Commerce's representative".

Following receipt of OTP's views as set forth above, the Telecommunications Task Force agreed to terminate its consideration of the consumer electronics issue. Accordingly, this subject is not addressed in the final report.

2. DETAILED RESPONSE TO REVIEWER COMMENTS

This major section presents a detailed response to all reviewer comments received. The comments are grouped into sections dealing with similar topics. The left-hand column summarizes the substance of each item of comment, as much as possible in the words of the reviewer. The right-hand column briefly evaluates the comment substance and describes how the final report achieves a disposition of that point.

The following sections are used for grouping purposes:

- *Section 1. General Comments*
- *Section 2. Role of the Federal Government*
- *Section 3. International Trade*
- *Section 4. Regulatory Action*
- *Section 5. Direct Satellite Communications*
- *Section 6. Land Mobile Radio*
- *Section 7. Broadband Communications Networks*
- *Section 8. Fiber Optic Communications*
- *Section 9. Consumer Electronics*

Section 1 -- General Comments

Substance of Comment	Response to Comment
A. The Director of International Projects for an international common carrier and equipment manufacturer took issue with fundamental factors which make any action program from the Task Force incomplete. Restricting the study report to domestic elements is incomplete, since the telecommunication industry is very internationally minded. Secondly, the main study attention to the technical and regulatory aspects of the problem, to the exclusion of many financial and market considerations affecting the introduction of new telecommunication technology to the marketplace, leaves out an important area. An expanded base of the study is necessary to produce a reasonable action program (i.e., includes tax rates, depreciation rates, and availability of needed investment capital). The third fundamental factor concerns the proliferation of U. S. Government agencies involved. He criticizes the implied assumption of the report that expert guidance or recommendations by DOC would be accepted by other agencies, particularly those areas where those agencies have primary authority. He indicates such is not the nature of Government agencies.	His points are well taken and have been considered, although DOC can do little now to change the approach. The first two are outside the scope of the Task Force final report. The third factor of uncoordinated Government agencies is recognized as a difficulty in the final report discussion even though Government reorganization is beyond the scope of the Task Force.
B. The question of application of new technology is said to be primarily economic by a major equipment manufacturer. A company doesn't make investments (even new products are capital investment) unless the pay-back period is very short, normally less than two years (since there usually are many more economically rational candidates than there is capital to finance them).	The final report recognizes the necessity for expected economic returns before private firms will invest significant capital for new applications. However, there may still be a valuable Federal role in clarifying the technical issues or in arranging initial trials with groups of users in order that private firms gain sufficient confidence and experience to convince themselves the pay-back period will be sufficiently short. There is not necessarily a conflict between these two views.
C. The director of an academic-based policy center stated the subject matter and problems addressed by the draft report are among the right ones and the technical or economic questions that were raised are certainly worthy of note. However, he found questions of administration, responsibility, and overall policymaking structure so thoroughly intertwined with the substantive matter that controversies over the former inevitably becloud the latter. This is unfortunate since the problems must be addressed whatever instrument might eventually develop to do so. His <u>recommendation</u> is that the future draft separate findings and analysis from structural recommendations, in order to help focus substantive discussion in a more productive way.	This criticism is justified, since the treatment of the draft made it very difficult for the reader to separate premises from analysis. The final report follows a much different format and organization that should go a long way toward responding to this recommendation.

Substance of Comment	Response to Comment
D. The point is made by an equipment manufacturer that technological development, even when successful, does not automatically result in public demand for the product. Each company takes a slightly different tack as how to utilize advances in the state of the art -- some win and some do not.	This situation is true and is recognized in the final report. Nothing in the report meant to claim otherwise and the planned programs were only meant to enable a better defined and more complete basis for these products to compete in the marketplace.
E. A manufacturer felt that the telecommunication industry was indeed presently moving technology forward, although the draft report asserts otherwise.	The final report recognizes the progress being made in certain technical areas but still talks about some areas where faster progress is possible.
F. An academic-based reviewer gave a very strong recommendation for OT addressing policy aspects of telecommunications, particularly since policy analysis does not often enough address the interplay between technology and policy.	This reinforcement of subject importance and Federal role is accepted as support for the relevant portion of the report.
G. A large common carrier strongly disagrees that the United States is no longer in the forefront of innovation in telecommunications and argues that the United States continues to be the leader in this area.	The final report continues to recognize mounting concerns in the available data and the conclusions of others about the U. S. technological positions. In many areas of telecommunications, this leadership position is apparently becoming eroded. This is not to say the United States is still not Number One in most areas; the Task Force was concerned about trends that must be modified or reversed. These concerns are becoming increasingly evident in other studies and assessments as well as in the public media.
H. An industrial reviewer comments that tables 3.1 and 3.2 of the draft report are <u>not</u> a good representation of what exists. As an alternative, we should just put an "X" in <u>one</u> box in each column, because indicating a problem can really only indicate the most severe problem, and that if that problem was overcome, then another one would become the most severe. He uses broadband networks for local distribution as an example and states that only the regulatory impact issue deserves an "X" at the present time. The reviewer suggests an alternative framework for the table and presents a revised version of one table.	The content of tables 3.1 and 3.2 represented the combined judgments of Task Force members and industry respondents at the time the draft report was prepared. As the comments illustrate, it is difficult to represent a multidimension situation in a simplified way. This presentation device is not used in the final report.
I. A common carrier disagrees with numerous entries in the matrix tables of 3.1 and 3.2, which present summaries of the barriers to applications of technology and the perceived reasons why industry is not overcoming the barriers.	See response H above.
J. A large systems-engineering company found the draft report very interesting. The overall observation was that the report is more applicable to hardware producers than a systems-engineering company.	These comments are correct.

Substance of Comment	Response to Comment
K. A senior representative of the U. S. Postal Service dealing with advanced mail systems development stated "the programs proposed in the draft report are important, imperative to the domestic economy, doable, and should be done.	This comment is accepted as support for the general purpose of the report.
L. A large common carrier stated that the draft report proposed programs that would involve noncommon carrier applications, but felt that there is no economic or technical support for the need for a duplicate system similar to the existing common carrier system.	The reviewer is correct in this concern. There is no intent to establish a duplicate common carrier system and the final report makes this clear. At the same time, it is not the intent to prevent noncommon carrier alternatives from being established in some areas if such action presents clear economic or technical advantages.
M. A senior representative of DOD supported the four technology thrusts proposed, although he was not in total agreement with all the comments, conclusions, or findings. He particularly supported the idea of technology demonstration programs to put technology pieces together in a system and user application sense. He felt there were various levels of maturing technologies coming along, but no one with resolve or funds to put it all together into a system.	This comment is accepted as supportive of the concept and need for technology demonstration in certain areas.

Section 2 -- Role of the Federal Government

A. The director of a DOD advanced research agency commented that the draft report did indeed identify a number of major problem areas in telecommunications which are in need of attention at the Federal level. He feels that OT can and should play a leading role in lowering the barriers to telecommunications growth in the area of tariff and regulatory policy by stimulating new capabilities and service offerings. Technological change can be encouraged in areas that were previously subject to domination by one or a few large enterprises. This agency stated a willingness to work with OT in improving the technical and economic basis for regulatory decisions.	The comments are supportive of the concerns and recommendations of the draft and final reports. However, the final report covers the regulatory and trade areas in very limited ways. The offer of this key advanced research defense agency to cooperate in improving the technical and economic basis for regulatory decisions will be utilized as needed.
B. A representative of a very large equipment manufacturer takes issue with the premise of the report that unusual barriers to telecommunications growth exist. He says normal barriers exist in any market and concern should arise only if there are factors that distort the growth of the total national corporate body. Distortion would be evidenced by internal awareness of the retardation, which would take the form of constant public outcry for some aspect of telecommunications that is unfulfilled. He did not see such outcry in the United States. That private enterprise wants a more open-door policy with regard to what it envisions to be new opportunities for return on capital should not be automati-	The final report discusses the need and justification for a Federal role more extensively, since this is a basic premise underlying the rest of the report. The final report still concludes there is a need for Federal action in some of the areas studied and therefore will not completely satisfy those inside or outside Government who argue on ideological grounds that the Federal Government do nothing that might interfere with the free market process (which in turn excludes any centralized planning or strong guidance in the area of technology). The final report fully supports the principle that any new product or service must eventually compete on economic grounds with alternatives, but that, for the public interest,

Substance of Comment	Response to Comment
cally assumed to be a public outcry for new services. The role of Government in a free economy is to see that the doors are kept open (except where in fact a natural monopoly is judged to exist) and let the free market interplay determine which new products or services win or fail.	the Federal Government may stimulate investigation or development of a new technology to the point that a fair market test is feasible. The justification is that there are significant benefits that could accrue to the nation if the new technology passes the economic and utility tests. While everyone agrees with the principle that the Federal Government should protect the public interest, the disagreements occur when defining what is in the public interest.
C. The general comments of this large supplier of telephone equipment and services applauded the intent of the study but disagreed with its perceived underlying philosophy. It wants the Department of Commerce to carry out its mission through cooperative and supportive programs rather than through active interjection of the Department into the free market process. It agrees industry cannot do the job alone in many areas but does not want the Government to attempt to inject itself into the stream of product design and market development. It references present administration policy to emphasize less rather than more Government participation in business affairs.	The heart of this issue is the role of the Federal Government in relation to private industry. The final report discusses this issue directly and explores the types of Federal activities that are justified. The thrust of the argument is that some Federal role is justified in the public interest. The Government does not intend to inject itself into product design or market development although some of its actions taken in the public interest may have impacts on market results. The report seeks to avoid distorting the free market process, even though it is recognized any Government process (including already existing actions) may have some differential effects on firms or industry sectors.
D. A large common carrier stated that the draft report appeared to recommend a substantial move toward added Government involvement in industry matters. This could be counterproductive. It alluded to President Ford's policy for less Government <u>participation</u> in the affairs of industry.	Certainly telecommunications is an area where there is already considerable Government involvement, for a variety of justifiable reasons. The purpose of the Task Force was not to add to this but to make it more effective. It sought the positive role of facilitating market activity, not restricting it. The final report clarifies these objectives and the recommended actions. We do not believe that the result of the program will be counterproductive to existing public objectives. Indeed, one of the conclusions of the report is that more extensive discussion between Government and industry is desirable in order to avoid any counterproductive actions. There never was any intent to supplant industry activities, so there is no conflict with President Ford's policies.
E. A large equipment manufacturer opposed "more Government," but encouraged "better Government," such as less restrictive trade policies and more support for U. S. exporters.	The final report discusses the Federal role that should be compatible with better Government rather than more Government.
F. The reviewer, from a consulting/research organization, points out that new telecommunication business developments often can be accelerated significantly provided that a missing ingredient or catalyst is introduced. In many situations, this ingredient can best be provided by the private sector; in others it is essential that some arm of the Government play this role. The draft report identifies some of these areas where the Government catalyst role seems appropriate and the reviewer concurred with that general thrust as it comes through in the draft.	This distinction is recognized and the final report continues to identify this as a useful Government role.

Substance of Comment	Response to Comment
G. A large common carrier stated it preferred to free common carriers (supposedly from regulation) for development with private funds, rather than committing public funds to technological development.	As the final report clarifies, the Task Force never contemplated the commitment of public monies to technological development or implementation; this is admittedly better carried out by private industry wherever such will be done. At the same time, however, a role is seen for Government efforts to identify the critical issues, define user needs (especially in the public sector) and other related actions that serve to reduce the uncertainty/risk, and therefore encourage private organizations to undertake application and operation of worthwhile technologies.
H. A representative from a large common carrier firm states that Department of Commerce action could lead to restricted application of new technologies and remove the incentives for private R&D in telecommunications.	Neither the Task Force nor the Department of Commerce propose restricting application of new technologies. In fact, fulfilling the perceived needs to reduce uncertainties about potential applications and market would increase incentives for investment in further development and applications. Any restrictions on applications of these technologies would conceivably come from the legislative or regulatory process, both of which are outside the control of the Department of Commerce.
I. Although an electronic industry trade group wanted several months to completely analyze the draft report, its initial comment from members states that technology was moving fast enough into the marketplace and did not need to be accelerated. In elaboration, some member firms contend that technology cannot be pushed into the marketplace; the marketplace is the pertinent factor in determining the use of technology. Others state that Government involvement in pushing technology will only serve to complicate the free market concept. The commenter stated that there is some gray area where Government should be involved but its boundaries are not clear.	These trade association's views are consistent with the comments received from individual firms. Responses to the individual comments describe the ways the final report covers the points.
J. A large common carrier questions the assumption that technology can be driven to the marketplace irrespective of the needs and demands of the user of the communications.	Certainly the reviewer is right in that there is a high probability that product services will be unused if no market exists. At the same time, certain advance work is necessary to properly structure and present to potential users the full dimension of what services are available to them. In some cases that market demand must be cultivated and aggregated to the point where it is economic to supply it. This is particularly true in the case of public organizations and users where limited understanding and sophistication exists for complex telecommunications. As the final report explains further, there may be a need and value for governmental assistance to potential users for certain new technologies at the Federal, State and local level.

Substance of Comment	Response to Comment
K. A large manufacturer and common carrier stated the draft report did not distinguish between the pull of demand in contrast with the push of Government. He felt Government as a user of technology would be more effective than through demonstration or development contracts. He also took issue with table 3.2 in the column headed "Lack of Industry Concern for Development of Telecommunications Issues," in that it was not supported by discussion.	These comments identify key concerns which are considered in the final report. The technology push concern is discussed in comment "J" above.
L. Comments by a large common carrier stated Government involvement to force the premature implementation of new technologies could only result in higher costs and degraded service.	The draft report was not intended to force premature implementation, but only where demand exists. If demand is not there, then there would be no investors to rush forward to serve a nonexistent need.
M. A specialized common carrier providing data transmission networks was concerned that the draft report did not focus on the inability of the Government to assist the specialized common carriers by providing Government business to use their wideband capability (9.6 kb/s).	Although this specific comment is primarily one of specialized interest, it highlights the issue of the ability of the Federal Government as a large user of communications services to utilize that role to facilitate or accelerate the applications of new communications services. The final report includes discussion of this issue.
N. A small trade association of manufacturers was doubtful about the draft report recommendations for widespread governmental action that might usurp the activities of profit-seeking firms. The reviewer felt that there was a role for the U.S. Government and stressed the financing and trade area.	These comments are reflected in the discussion and recommendations of the final report. There is no intent or desire to usurp the activities of profit-seeking firms. Further elaboration is provided by comment responses "B" and "C" above.
O. A large equipment manufacturer commented that the objectives of the draft report were commendable. While the concept of demonstration projects was generally okay, the specific proposals seemed to be far too small to be effective. A more direct Government role was recommended in the form of actual subsidy of full scale systems through tax breaks, loans, or R&D grants. Once economic viability is demonstrated, the subsidy could be reduced. However, operation by civil servants was not necessarily contemplated. Government specifications and financing with competitive contract execution by industry was suggested. The premise for the recommendations was that the user-shared portion of all telecommunication systems was a valid role for direct Government subsidy and regulation, as in the case of telephone systems and interstate highways, etc. Extending the concept to broadband, wired cities was not considered any different.	The final report discusses the Federal role in advancing telecommunication technology applications. While such direct Government subsidy is identified as one alternative, it is not one that is pursued or recommended since it is not compatible with present financial or political realities. Moreover, the Federal role related to any type of technology demonstration would be that of catalyst-coordinator or broker rather than as complete financier.

Substance of Comment	Response to Comment
P. A reviewer from a consulting/broker organization serving the cable industry suggests that the objective of helping the business community and private individuals to benefit from improved communication services could be best achieved through an immediate and practical task. This task, of an immediate time frame (say, three years), would be to reduce Government communication costs, reduce delay in message delivery, improve access to information at point of use, and increase Government communication efficiency by a significant factor. Ancillary taxpayer savings would come from more efficient and lower cost public services and would be of at least an order of magnitude greater than the communication cost saving itself. The author does not say exactly how the Government would achieve lower communication costs and other benefits.	Utilization of the Government communication system itself as a lever to stimulate applications of new telecommunication technology and benefits is a valid one and is pursued in the final report. Unfortunately, the problem of how to carry out such an achievement remains the critical element. Jurisdictional differences and varying objectives within the various governmental user organizations provide practical problems.
Q. A representative of DOD comments the draft report is interesting and highlights an area of significant importance to the national economy. He concurs in the concept of Government support of the transfer of telecommunication technology in the private sector. However, he points out that the Government should carefully select those technologies that are to be exploited since premature attempts at exploitation could result in wasted Government resources and false starts by private industry. He suggests helping the Department of Commerce by making available unclassified technical information resulting from DOD-funded research.	These comments are supportive of analysis and recommendations of both the draft and final reports. The offer for DOD to support the Department of Commerce in facilitating technology transfer in telecommunications is particularly noteworthy.
R. A large law firm specializing in representing communication industry clients commented that from their experience, the report is well done and all too accurate. The reviewer further agrees that the Government has an essential role to play in eliminating the barriers to telecommunication growth, and that without such governmental assistance, these barriers will have the adverse consequences that are cited throughout the report.	These supportive comments have been considered in the preparation of the final report.
S. It was stated by a Government representative that OT should not involve itself in advocacy for special interests, but rather should concentrate on eliciting technical facts and data within its competence. However, he recognized that there are governmental functions which the private sector cannot afford to carry out. It was said that due process was needed to resolve interactions between technical, social, economic, and regulatory factors and that good, relevant technical inputs might shorten the process. It was further stated that many Federal agencies submit inputs to the FCC apparently without clearance by OTP (e.g., DOD on rate cases, Justice on very high frequency television drop-ins and cable).	It was never considered that OT would be an advocate for any particular special interest. The final report states the objective is to offer formal comment on FCC dockets only where objective presentation of relevant technical issues is perceived to be useful.

Substance of Comment	Response to Comment
T. The reviewer from a large consulting firm questioned whether it is a desirable role for OT to try to serve as a voice for industry. It seems more appropriate for OT comments to regulatory agencies to be based on objective technical analysis.	The latter point was the intent of the draft report and the final report stresses this more strongly. There is no chance that OT can serve as a voice for the land mobile industry, for example.
U. A large common carrier questions the need for Government to establish communication standards and states that standards can better be set by industry without Government involvement.	The draft report meant to show the need for the preparation of measures of performance in certain areas, not necessarily standards for communication transmission. Such measures of performance are more tied to user needs and should serve to assist in market aggregation, facilitate potential user selection of communication services, and in other ways help to create a timely market for the benefit of industry. The final report clarifies this area.
V. A large common carrier questioned why the Department of Commerce would undertake performance evaluations of competitive data services for users of services provided by common carriers, since this is the responsibility of State and Federal regulatory commissions.	The draft report did not mean to suggest the evaluation of common carrier services since there is no intent to interfere with such responsibilities of State and Federal regulatory commissions. However, there is a need for establishing performance specifications for new technologies applicable to the delivery of public services as a way of assisting public agencies to evaluate the applicability of such technology or services to their responsibilities.
W. A reviewer from a large common carrier sees no difficulty in the transfer of technology from Government to private industry. It sees the need for no new programs in the Department of Commerce in this area.	The critical factor is not the dissemination of technology from Government to industry, but the application thereof. There is considerable evidence that this aspect could be considerably more successful. We recognize the preference for private organizations to apply proprietary-based technology because of its exclusive features. Moreover, the problem of application of Government-developed technology may be much more severe for medium- and smaller-sized organizations than it is for the large one making the comment.

Section 3 -- International Trade

Substance of Comment	Response to Comment
A. An equipment manufacturer was disappointed that trade matters mentioned during the Task Force interviews were not treated in the draft report, since these are of primary importance.	The final report does not deal with the international trade subject, although the comments of the industrial representatives are summarized and presented. The international trade area is being pursued by another agency of the Department of Commerce.
B. A manufacturer of telephone equipment for the independent market was disappointed that the telecommunication trade imbalance was not mentioned in the draft report, although admittedly there was considerable mention of trade imbalance in the electronic consumer area. The discussion of the four technical areas (broadband, satellite, etc.) was said to be covered in excellent detail.	The final report does not cover the international trade issue (for the stated reasons) but does include a summary of the comments and recommendations on this subject received during the industrial interviews.

Substance of Comment	Response to Comment
C. The reviewer commented on the export expansion area and problems posed by export controls. Clarification and coordination of rules under which export business is conducted is stated to be an important need.	The final report does not include programs in international trade and its barriers.
D. An operator of network information services commented that the draft report recommendations contained little which benefited network information services such as himself interested in international expansion. He recommended that the final report request the Department of State to work toward improving the regulatory climate with European PTT's so that network information services might find this less of a barrier.	The final report does not address the issue of international trade and therefore is not in a position to implement this recommendation.
E. The Chief Engineer of a medium-sized electronic equipment manufacturer reviewed the draft report and stated it was good to see official Federal Government concern expressed on this subject. He provided data to indicate the U. S. civilian telecommunication industry and DOD spend large amounts on R&D for communications. He pointed out both DOD and the Department of Commerce have similar interests in telecommunications in that both wish to increase foreign sales. DOD has the special interest in increasing compatibility of telecommunication equipment among the Allies. Both agencies would desire similar national telecommunication policy in privacy, interconnect, domestic satellite, and other matters.	These points are correct but have their effect primarily in the international trade issue, which the final report does not address in any major way.

Section 4 -- Regulatory Action

A. The president of a medium-sized manufacturer of land mobile equipment stated the draft report was a comprehensive compilation of key factors that influence the application of technology to the telecommunication needs of the nation and can be safely used as guidance for most of the indicated program proposals. He agreed that the two main barriers were demonstration of technology applications and inhibitions posed by Government regulations and overwhelmingly indicated the most fruitful area for corrective action was in the area of Government regulation. Three varieties of Government regulation were specifically reinforced by his comments: (1) regulation by taxation and its curtailment of capital formation, (2) regulation of supporting functions through excessive Government reports requirements, and (3) regulation of direct program activity in telecommunications administered by the FCC. The statement did clearly acknowledge that Government regulation was justified where the forces of the free market are either not appropriate or inadequate to fully protect the public interest.	The final report includes identification of regulation as an inhibiting force, although there is little discussion of regulation of the first and second categories identified in this comment.

Substance of Comment	Response to Comment
B. While a reviewer from an equipment manufacturer had no problem with OT participation in rule-making proposals by the submission of appropriate comments to FCC, he believes that its role should assume no greater importance than that of any other party. He sees no utility in OT holding itself out as a repository of the objective overview. This is worse if OT participated in proceedings involving an application for license, which are usually adjudicatory in nature.	This comment is well taken. The draft report was only assuming that OT's comments in the regulatory process would be considered along with those of other parties.
C. A large common carrier questions the value of OT being involved in Federal regulatory proceedings since this activity would most likely be counterproductive and cause added regulatory delays.	It is only conjecture that any assistance in this area would be likely to cause added regulatory delay. In most cases, assistance would take the form of comments in FCC dockets that are open for just that purpose from all interested parties. This is not considered counterproductive since regulatory comments would only be offered where there was a technological basis and need. Such has been the case of the limited effort thus far and assistance has been welcome by the regulatory agencies.
D. A large common carrier stated that Government action had inhibited technological innovation and application in a number of instances and cited domestic satellites and mobile radio as examples, presumably with respect to slow regulatory decisions.	While there may be examples where Government action has been inhibiting, there are also several examples where development (e.g., communication satellites) has been greatly stimulated by U. S. R&D and application experiments (such as ATS and CTS). While it is undoubtedly true that regulatory actions contributed to the great delay in domestic satellite and mobile radio applications, these are events in the past and represent a similar concern to the Task Force. The final report is based upon the premise that certain Government actions can be useful on balance.
E. A large common carrier is concerned that the Department of Commerce would inject itself into civil sector spectrum management activities and therefore add to the delays in that process. These are reserved by statute to the FCC.	The Department of Commerce does not intend to interfere with that FCC process, except to the point of offering engineering-based comments where considered appropriate during the solicitation of such comments. Since this action would only be taken where expertise can be considered useful, this action is expected to clarify issues rather than extend delays.
F. A large equipment manufacturer reinforced the draft report's statement that excessive prolongation of regulatory action can have severe negative economic impact on the industry segments concerned. It was suggested that the Department of Commerce could profitably implement its charter through objective historical analysis of the actual impact of major regulatory decisions; for example, FCC docket 18509, where common carriers were denied participation in the development of broadband distribution networks. Presenting such analysis ~~to appropriate regulatory agencies~~ and making other filings would thus encourage and facilitate agency consideration of the possible long-term impacts of its decisions.	The suggestions have been taken into account in the final report preparation. However, little discussion of specific regulatory program needs is included in the final report.

Substance of Comment	Response to Comment
A. The director of a nonprofit public service organization concerned with satellite communications stated the concerns and objectives of the draft report in the satellite communication area were completely compatible with his beliefs. He saw important needs and opportunities in utilizing present and next generation satellite communication systems in the provision of public service. It was felt that the Federal Government had an important role to play in promoting and/or supporting both demonstrations and operations in this area.	These observations and objectives about public service needs are fully consistent with the discussion in the final report.
B. Although he thought the draft report was good in the areas it discussed, a small satellite equipment manufacturer did not feel the need for heavy Federal technical involvement. This firm rather identified problems needing resolution in FCC regulation, export licensing clarification, and Export-Import Bank loan assistance.	The final report does not recommend <u>heavy</u> Federal involvement (such as funding R&D or establishing a Federal communication system) but recommends a Federal role as catalyst, coordinator, and analyst. The report identifies limited needs in regulation assistance but does not address the issue of exports at all.
C. A large space systems firm stated that the data gathered from industry was consistent with its opinion and felt it accurately reflected the situation as it saw it today. It gave particular attention to the section dealing with communication satellites since it was active in developing such hardware.	This comment is accepted as supportive of the satellite section of the draft and final reports.
D. A reviewer from a large multinational manufacturer claims the need for demonstrations in the area of small earth stations for satellite communications as proposed in the draft report is not really necessary since sufficient work has already been done in this area by U. S. firms. He also states technical information has been readily available through the NASA Technology Utilization program and other sources. He further states sales by U. S. industry in foreign markets for satellite earth stations depend primarily on competitive financing and other export assistance.	It is correct that technology for the next generation satellite area does exist and has been demonstrated in component form for limited uses. The final report acknowledges that a demonstration of technology does not appear necessary, although demonstrations of large scale networks and related user problems may be useful in reducing the aggregation and investor/user uncertainty about viable applications. The related comment about selling in international markets depending primarily on financing is probably true, but outside the scope of the final report.
E. A small satellite equipment manufacturer said that U. S. technology is well in hand and demonstrations are not needed for the satellite earth station area.	The final report states that the technology for next generation satellite applications <u>does</u> exist at present, but the problem is to assist and facilitate applications through market identification, aggregation, etc.
F. A senior official of the U. S. Postal Service (USPS) commented that in the satellite communication area the studies USPS had commissioned did not reflect the same degree of concern as the draft report on the state of technology or the ability of the U. S. industry to compete in the small earth station market. In other words, USPS had a more favorable interpretation of available satellite technology.	The final report acknowledges that the necessary technology for the next generation satellite systems does exist at present, but has not yet been tested in complete form. As a result, the final report does not recommend a demonstration of technology <u>per se</u>. However concerns are expressed about the need for a demonstration of procedures and user benefits. The comment about the ability of the U. S. industry to compete in this market is not of direct concern given the lack of attention to international trade in the final report.

Substance of Comment	Response to Comment
G. A reviewer from a multinational carrier and manufacturer took issue with the draft report claim that the cost of mail delivery could be 30 percent lower in the discussion under electronic mail in the satellite section; this is said to be an unsupported claim. He also questioned the report's statement that the U. S. Postal Service might purchase small earth stations from foreign suppliers. He says U.S. Postal Service is precluded from buying from foreign suppliers if less than 51 percent of the item is manufactured in the United States.	The relative cost of electronic mail by satellite remains an issue. Initial inquiries with the U.S. Postal Service obtained the response that they have the ability to buy wherever they wish.
H. A senior technical staff member in a large record common carrier encouraged development of the 12/14 GHz band in the satellite communication area since he believes this frequency band will be needed to satisfy many future communication needs.	This recommendation is completely compatible with the satellite communication area as discussed in the draft and final reports.
I. A vice president of COMSAT provided corrected or more recent information for several technical statements about satellite communications, including the number of active INTELSAT stations, estimated cost of future SBS earth stations, feasible data rates, etc.	This improved technical information is used in the final report.
J. A vice president of COMSAT questioned the statement of the draft report that U. S. development of small earth stations in the 4/6 GHz band is not taking place. He pointed out that American firms were manufacturing 150 stations (5 meter) for Alaska use, about a dozen stations (10 meter) for Algeria (by GTE) and 40 stations (8 meter) for India, all for the 4/6 GHz band.	This information is correct and is reflected in the final report. However, the concern was meant to apply primarily to the 12/14 GHz band, which is the band expected to see the eventual development of large numbers of small, low cost earth stations. In this area, development by U. S. firms is more limited and by Japanese firms more active.
K. A vice president of COMSAT commented that since the size of the antenna of an earth station should be selected in order to minimize the overall costs (earth station plus satellite), it will not always be best to make the "smallest" earth station possible. If all the capacity possible is needed, it would be poor economics to use a small antenna. For example, in one recent large satellite, they found reducing the antenna from 47 feet to 42 feet would cut the cost about 2.5 percent, but would cut capacity by about 20 percent. Of course, in other systems, small antennas may indeed be most economical. He stated that the use of large antennas is not exclusively due to their low technical risk as the draft report asserts.	The trade-offs described are correct and relevant, as the discussion of the final report recognizes.

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Section 6 -- Land Mobile Radio

Substance of Comment	Response to Comment
A. Although recognizing the advantage of the draft report to open a dialogue between Government and industry to work cooperatively, a vice president of a large manufacturer of communication equipment took strong issue with several statements in the land mobile area. He does not acknowledge the existence of the particular problems the report identified in the land mobile sector. He is not aware of any loss of technological leadership to other countries and states the U. S. land mobile technology has out stepped the available spectrum.	The final report clarifies and justifies this area. It discusses in greater detail the problems and issues identified, although these problems and issues are somewhat different than those in the draft report.
B. A vice president of a large equipment manufacturer took issue with the draft report's statement that the land mobile radio industry was exceptionally fragmented and believes this to be a misunderstanding. On the contrary, except for Class D Citizen's Band, the industry is characterized by relatively few major competitors, who through the Electronic Industries Association have developed comprehensive industry technical standards and have worked closely with the FCC in resolving industry technical problems. It is further characterized by well organized and highly competent user organizations and an overall industry/user group organization.	The final report recognizes this structure of manufacturers and user organizations.
C. A vice president of a large equipment manufacturer takes issue with the draft report's statement about spectrum shortage. He states that right now there are only two cities in which businesses have trouble obtaining adequate spectrum. He emphasizes this relates to the present and further states the FCC is working out spectrum additions for the needs of the world of tomorrow. He believes all organizations, not just Bell Labs, are working now to make the best technical and business structure arrangements for making efficient and low cost use of the new spectrum (900 MHz band). In summary the reviewer felt the resolution of the issues was not impeded for lack of a Government regulatory framework or for lack of adequate inputs, both economic and technological. The remaining issues in land mobile for the new frequency bands are being resolved in due course by the participation of all concerned parties in the normal regulatory process.	The final report reflects this additional information and viewpoint.
D. The president of a manufacturer of land mobile radio equipment took exception to the description of the industry as exceptionally fragmented and the subsequent statement that no industrial R&D is being undertaken in the competitive development of new 900 MHz band. He claims that the industry was dominated by the three largest firms and this could hardly be described as a fragmented industry. It was further claimed that considerable industrial R&D in the 900 MHz area was being undertaken while awaiting final resolution of the FCC docket in this area.	The final report more specifically describes the structure of the land mobile industry and acknowledges industry R&D in the new 900 MHz frequency band.

Substance of Comment	Response to Comment
E. Although the mobile radio user community is highly fragmented, a reviewer observed from his consulting contracts with user groups and radio common carriers that there is a strong incentive to conserve spectrum. The problem lies with the manufacturing sector and the industry standard developed. To achieve any kind of meaningful results, a land mobile program would require industry participation and commitment, not just dissemination of information.	The final report recognizes past efforts and present incentives to conserve spectrum, while still identifying remaining problems in this area. The final report also acknowledges the necessity of industry participation and commitment to any land mobile program action.
F. A vice president of a large equipment manufacturer takes issue with the draft report's statement that the land mobile radio industry has no incentive for conserving spectrum nor that it has not taken means to do so in the past. He claims that the land mobile industry has utilized spectrum more intensively and more effectively than in probably any other portion of the radio spectrum. Equipment developers have produced highly sophisticated equipment utilizing channel splitting procedures that operate with a high density of interfering signals. He also takes issue with reference to needed investigation in the areas of ambient noise, interference effects, and coverage prediction methods, since the industry has published a large volume of excellent technical material on these subjects. He claimed the industry has already funded significant investment in the development of advanced, computer controlled, spectrally efficient systems in addition to the development of hardware for the 900 MHz band. The comments include an offer to review the work done by that specific company for the benefit of the Task Force staff.	The final report recognizes these industry accomplishments although concerns are still expressed about future developments and incentives, which may be different than past accomplishments.
G. A vice president of a large equipment manufacturer takes issue with the draft report description that the land mobile industry and users have virtually no means or incentive for conserving spectrum space or for undertaking engineering development of high performance/low cost mobile receivers. Several examples are given that show land mobile users have greatly increased activities within a very confined spectrum sector and that manufacturers have developed new methods for increased utilization of the spectrum.	The track record of the users and manufacturers in the land mobile industry is impressive and the final report reflects this. However, concerns still exist about the future.
H. A vice president of a large equipment manufacturer expresses strong disagreement with the program proposed to deal with land mobile barriers. The recommendation that OT should become the focal point for R&D to provide the technical basis for the design of complete systems is not needed since industry R&D is substantial in this field. Moreover, he states past history demonstrates that U. S. R&D in commercial areas has been the responsibility of competitive enterprise and has worked exceedingly well. If OT took over this function and were to make its results public, there would be no incentive for domestic manufacturers to develop systems. The potential	The draft report did not intend to suggest the Government take over R&D in the land mobile area and this is clarified in the final report. Additional research in areas that can improve the ability to predict impacts and spectrum utilization was recommended, not research in hardware design or production. The intent was to assist industry R&D and not to replace it. The draft report should not have said performance standard, but should have said a <u>measure</u> of performance is needed that allows a consumer or regulator to judge alternatives.

Substance of Comment	Response to Comment
negative impact would be escalated if it were accompanied by performace standards imposed by Government.	
I. A vice president from a large manufacturer of land mobile equipment takes issue with the doubt expressed by the draft report that industry can respond to the challenge of the 900 MHz allocation. The interpretation is that without an R&D program under OT sponsorship, the innovative systems needed at 900 MHz will not come into being. He says the report assumption that the cellular system is the end-all of 900 MHz utilization is not valid, spectrum can be used for a variety of systems, and a variety of manufacturers have made systems proposals for such use. He claims that all reliable market forecasts indicate that the bulk of the needs for communications will come from the private dispatch sector. (These comments are from a major competitor of AT&T.) While admitting the AT&T cellular concept has promise for providing high capacity mobile telephone service, it is pointed out that it is only one of many proposals that will have an opportunity to be proven in the marketplace in the coming years. For perspective, it is pointed out that, between 1970 and 1979, AT&T will have spent about $23 million on R&D for the cellular concept, while the land mobile industry will have spent in excess of $300 million on R&D.	The referenced material was an overstatement by the draft report and it is revised. Cellular is not the end-all, and this new band offers new opportunities for many firms and systems. The final report places all these contributions in proper perspective. It agrees that many concepts will be able to compete in the marketplace, but most will be relatively complex, and thus it will be even more difficult for the user or regulator to evaluate their effectiveness.
J. The draft report states the Japanese enjoy a substantial competitive edge in the 900 MHz land mobile band. The largest non-Bell manufacturer in the land mobile area takes issue with this claim. He points out Japanese success has been due to low price, not superior technology. This is true for both the paging area and the recent large award to OKI Company.	There remains some uncertainty about the size and source of the Japanese relative position in this area. Doubts still exist about the reasons for the OKI Company award.
K. The vice president of a large equipment manufacturer took issue with the technical feasibility of the 900 MHz land mobile communication discussion. He stated extensive past experimental projects have been done at Bell Labs and in Japan.	This is correct and the final report accommodates this comment.
L. The vice president of a large equipment manufacturer takes issue with the report statement that AT&T's plan for the Chicago Prototype System for 900 MHz is now being challenged on technical grounds. The comments point out the petitions were predicated mainly on economic grounds.	The final report clarifies this statement. Since spectrum capacity is or must eventually be involved, the issue is also dependent on technical factors.

Substance of Comment	Response to Comment
M. A reviewer from a large consulting firm recommended that a land mobile radio program should include a demand and user requirements analysis to identify the needed product features and to provide justification or incentive for new product development by the manufacturing sector of the economy.	The final report includes recommendations for long-range planning, which would embrace such a demand and user requirements analysis.
N. An association of radiotelephone system operators stated the draft report exhibited a good understanding of the problems and prospects of the telecommunication industry and demonstrated a commendable concern for the overall public interest. The association hopes the final report would acknowledge the substantial and continuing contribution which the independent Radio Common Carriers (RCC) have made in mobile communications. They felt the report would be incomplete if it merely dismissed the land mobile radio industry as fragmented and failed to take into account the contribution which individual RCC's have made to the industry.	These suggestions were considered in the preparation of the final report. Radio Common Carriers represent a significant segment of the land mobile communication sector, but their importance and needs must be balanced with other sectors of the industry.

Section 7 -- Broadband Communications Networks

Substance of Comment	Response to Comment
A. An association of cable operators strongly supports the draft report's reasonings and recommendations concerning broadband communication. The reviewer believes the cable industry must expand nonentertainment functions for sources of additional revenue if the industry is to grow out of its present traditional posture of community antenna service. The association feels large common carriers will contain the cable industry in its present posture if at all possible. The industry does not now have an effective development program large enough to be effective and therefore the draft report recommendation for a demonstration program is fully supported by this association.	Although the final report is not as strong as the material in the draft report which this association supported, it is assumed the association would also support the modified discussion.
B. A partner in a small consulting firm serving the cable industry agrees with the problems the draft report identifies as responsible for the lack of predicted growth in the broadband distribution area up to this point of time. His comments affirm the observed delays in development of new and necessary communication aids to serve Government, business, and individual needs. He foresees lower costs for services and greater efficiency (in time and accuracy) can be provided by nonentertainment communication on a national scale. He agrees with the proposed constructive Government leadership in helping to establish basic hardware and techniques necessary to realize broadband communication benefits.	This comment is accepted as support for the relevant portion of the report.

Substance of Comment	Response to Comment
C. The director of a research center on cable communications read the draft report and agreed with the findings on broadband network services.	These supportive comments are reflected in the final report.
D. An academic-based reviewer accepts the need and value of demonstration sites for broadband communication. However, he questions limiting a demonstration to Boulder, Colorado. He states an experiment in Boulder would not be considered as representative by many. He suggests the alternative of installing several small-scale demonstration experiments in carefully selected cities throughout the country. One possibility is to establish an experimental demonstration in a large office building where related businesses require considerable communications and information transfer.	The final report discusses in greater length the demonstration needs in broadband communications and these comments about demonstration sites are reflected in that discussion.
E. An association of cable operators fully supports the concept of a demonstration or test bed for broadband distribution. However, it states multiple and flexible test-beds are needed; and Boulder, Colorado may be too limited. Emphasis should be on the human factors involved in market testing as opposed to more technology development. Equipment evaluation, generation of equipment compatability specifications, system evaluation, and related factors are probably the best payoffs from a technical standpoint. Another example is the trade-offs in home terminal characteristics, examined in an experimental testing approach.	The final report discusses the value and needs of a demonstration. The suggestions of this reviewer about specific objectives and methods are more relevant later when and if a demonstration is being designed.
F. An association of cable operators sees a growing need for advanced telecommunication services for the administering of Government in metropolitan areas as well. They believe the Government as a user should help by aggregating some of its own needs, applying some advance systems to prove out productivity and efficiency improvements, lowering cost of service, and making an initial determination how best to use broadband communication systems. One of the expected impacts would be to stimulate industrial interests. They believe the final report should emphasize this view.	These suggestions are realistic and correct. The final report is fully compatible with these suggestions.
G. A professor suggests broadband demonstrations should be selected with a view toward maximizing the "freeway effect" in communications, which he defines as the tendency for a communication channel to pick up users usually not considered in the initial installation (and usually at a rate that soon overloads the channel). He believes this freeway effect would occur when broadband communications are established and it would not take long for the channel to be overloaded and require additional capacity.	This freeway effect is an interesting concept and verifying its existence could be an element of a broadband demonstration project. The issues and actions discussed in the final report reflect consideration of this concept.

Substance of Comment	Response to Comment
H. An academic-based researcher made specific comments about the broadband distribution area. He feels one big advantage of the research demonstration efforts recommended in the draft report might be that the FCC would be discouraged from taking regulatory actions that raise additional barriers. He feels the actions at the FCC have had an extremely dramatic effect on the domestic economy and industry. Although not stated implicitly, his bias appeared to be against FCC actions that inhibited growth of cable. He also points out that OT activities as recommended would raise interesting and difficult regulatory issues that could have large impacts on common carrier rules and regulations. Broadband demonstration networks for local distribution communications will stir up the telephone companies; this could lead to some major changes in the present concept of common carrier regulation.	This comment about raising important regulatory issues and reaction is fully correct. These concerns are recognized even though no particular regulatory action program by OT is initiated or discussed in the final report. It should be clear that such drastic reform of common carrier regulation is not an objective of this broadband communications section, even though there might be some future impacts in the regulatory area from progress in this industrial sector.
I. A large law firm specializing in communications issues (particularly representing broadcast and cable clients) supports the demonstrations and other programs recommended by the draft report in the area of broadband communications. However, they are also frustrated on how to start the wheels of implementation into motion. The reviewer reinforces market uncertainty and the financial weakness of the industry as impediments to growth of broadband communication services of a nonentertainment nature. His clients state the problems of lack of markets and financial inability to engage in extensive research have not been overcome and thus things are not moving toward more prompt development of two-way systems and other broadband services.	The final report reflects recognition of these factors and observations. However, these impediments must be considered in conjunction with an appropriate role for the Federal Government when designing programs.
J. The question is raised by a large law firm as to the availability and source of funding for underwriting the broadband communication experiments or actual installation in a Government facility. It is pointed out that if there was some funding available, it would be much easier to interest a manufacturer in undertaking significant additional research and demonstration projects. Moreover, the benefits of broadband communication cannot be developed and demonstrated to public policymakers without such industry support.	The draft report did not intend for OT to obtain or pass out funds for underwriting a broadband demonstration, although it is recognized that governmental assistance of some kind will probably be needed. The immediate task is to identify those needs and attempt to put together a joint industry-governmental demonstration activity. The final report identifies actions that could be taken by industry and Government to move in this direction. Some parts of those activities will require some cost sharing from governmental agencies and the specific source and amounts of such funding must be the subject for future consideration.
K. An academic-based researcher recognizes that cost-sharing among Government agencies and industries would be necessary to carry out a desirable program in broadband communications, and he suggests a way that might encourage a high degree of cost sharing. He states that city and state governments, institutions, and businesses exploring broadband communications services are usually not able to identify what these services will do to their costs and	The recognition of the necessity of cost sharing is correct and is reflected in the final report.

Substance of Comment	Response to Comment
operations. In the main, they cannot perform necessary analysis to identify benefits resulting from increased operating efficiencies and cost reduction on their operations (and therefore have difficulty obtaining funds to carry out the initial inquiry). The reviewer suggests OT could perform such operational analyses in carefully-selected locations prior to embarking on a demonstration. Successful conclusion of such a study would encourage the agency as well as a terminal manufacturer or other beneficiaries of the adaption of broadband services to become cost-sharers. He believes a more-or-less standard procedure could be developed for analyzing operations to determine the impact of improved communications in a way that attracts the attention of the purse-string holders.	
L. A reviewer from a non-Bell common carrier states there is absolutely no reason to tie broadband distribution to the existing CATV industry nor even to the coaxial cable which is currently used as a medium. He states the existing common carrier network could form a distribution structure for tomorrow's broadband distribution systems. He specifically objects to the language in the report that ties all future activity in broadband distribution to other entities without mention of the common carrier industry.	There was no intent to exclude the common carrier network from this area. But at the same time, we did not mean to limit broadband distribution to using the common carrier system. Moreover, broadband distribution of TV by common carriers is not imminent because (a) cable TV is regulated as ancillary to broadcasting, and (b) such action would raise concerns of excessive concentration of economic power in the common carriers.
M. A large common carrier questions development of two-way interactive system services for broadband communication services completely independent of the community of communication common carriers.	The intent was not to say that development/ of such systems must be completely independent of existing common carrier services, but that such a possibility exists. The final report clarifies this issue.
N. An association of independent/ small common carriers raises a question concerning the draft report description of broadband distribution networks. The main criticism of the draft report discussion is that it fails to include the common carrier when it identifies industries to participate in future broadband distribution systems. It is pointed out that broadband distribution systems have been utilized by the telephone common carriers for many years in providing all types of communication services. It is stated that the text following the heading, "Broadband Distribution Systems" focuses on cable television only.	The draft report did not mean to exclude common carriers (telephone or otherwise) from the use of future broadband distribution systems. The final report clarifies this situation.
O. An individual from a large manufacturer of communication equipment was concerned with the draft report's concept of revitalizing analog CATV equipment as a broadband subscriber drop. He believes the emerging fiber optic technology is likely to come into being too soon for CATV to be a viable competitor. He suggests that the large telephone common carriers might add optical fiber lines to the subscriber loop and utilize their existing poles and copper subscriber loops to supply dc power for trunk	The final report allows for the possibility of various media distributing broadband communication services. Many of the potentia barriers are more in the software or user service segment. Utilization of existing plant by telephone common carriers to power fiber optic transmission trunks and subscribe terminals can only be speculative at present. That possibility is open and the future marke process (as influenced by the regulatory process) will determine applications in this area.

Substance of Comment	Response to Comment
repeaters and subscriber terminals, thus retaining traditional freedom from dependency on ac supplies, and at the same time keeping the broadband drop firmly in their own hands.	

Section 8 -- Fiber Optic Communications

A. A large research and consulting firm agreed with the draft report emphasis on the fiber optic distribution network area for intra- and inter-building use because it is simply not clear yet that there is adequate high speed data or other wideband traffic demand to justify large-scale investments by the common carriers to replace existing long haul transmission plant. However, the building services area looks like a real possibility with appropriate stimulation for both common carriers and private operating entrepreneurs.	This comment reinforces our conclusion; it remains as a part of the final report discussion.
B. The reviewer, who is from a non-Bell common carrier firm, objected to the fiber optic discussion which talked about intra- and inter-building use in the context of noncommon carriers. The reviewer found it inappropriate to expend large sums of Federal money for exploration and earmark it for use in the noncommon carrier market. It was said that, in today's environment, these fiber optic distribution systems would be owned and maintained by the common carriers and therefore the proposal seems to invite needless duplication.	The use of the term noncommon carrier in the optic section was unclear as OT did not mean to exclude the common carriers from this application area. What was meant was to characterize some areas of fiber optic communications that could possibly be served by other than common carriers. For example, it is not clear that only common carriers should be able to utilize fiber optics for distribution purposes, particularly in the intra-building use (which might be interpreted as an interconnect application and therefore, open to noncommon carriers). The use of fiber optics for distribution purposes in new buildings would clearly not be duplicative. The final report clarifies this issue along these lines.
C. A large common carrier questioned that optical fibers within a building would be a noncommon carrier function.	While the final report does not state that fibers must be provided within a building as a noncommon carrier function, it also concludes that it is not clear at present that the common carrier must necessarily provide this function. This remains an open question and involves many of the same issues as the interconnection of other terminal equipment to telephone lines. It should be noted that the internal wiring of new buildings with optical fibers would not be duplicative of existing common carrier distribution facilities. Moreover, FCC has established policies that encourage competition in the area of interconnect equipment.

Substance of Comment	Response to Comment
D. An equipment manufacturer commented that small scale intra-building use was not well adapted to optical fiber distribution networks. This is because the total data flow envisioned is well within the capabilities of economic closed-circuit cable systems already available. Since 300 to 400 MHz can be provided now with cable, fiber optics is considered attractive only for long distance, higher capacity trunks rather than short range nets. Eventually large scale production would be expected to lower costs such that small local systems using optical components would have a cost advantage, but it would take extensive use on long distance trunks to drive this production cost down.	While it is true that data flows from terminal equipment presently available can be accommodated by available coaxial cable, there are reasons why optical fibers may be more advantageous in the future. We anticipate that future terminals would make possible new intra- or inter-building communication uses that need and benefit from the inherently higher capacity of fiber optics, at equal or less cost. Furthermore, fiber optics appear to have the potential to be significantly less expensive than cable within the next few years. The final report discusses this issue in detail.
E. A large common carrier commented there would be continued optical fiber research and use by common carriers, contrary to statements in the draft report.	The draft report did not say that large common carriers were not expected to continue their research and development in this technology; it is expected. Although the reviewer says R&D in optical fiber technology is proceeding well under the hand of private industry, other information indicates the United States is not maintaining a comfortable lead in this area, relative to other countries. The final report discusses this issue directly.

Section 9 -- Consumer Electronics

A. The director of a technical DOD agency expressed concerns in the consumer electronics area about the merits of using existing R&D findings as a tool in reducing imports. Since low cost foreign labor is a major consideration in the flow of this industry overseas, increased research into industrial automation may be a partial answer in recovering a portion of the consumer electronics market. He suggested this subject should be dealt with at the level of providing incentives to business or possibly in the political or diplomatic arena.	The final report does not address the consumer electronics issue.
B. A reviewer from a large consulting firm raised the question of consumer electronics being a proper area for OT since it involves a different sector of the U. S. industry and a different set of problems. (It may not even fit within the definition of telecommunications.) To devote resources to this sector at the expense of other areas may be diversionary.	The final report does not address the consumer electronics issue.
C. A reviewer from a large manufacturer warns that the draft report did not successfully make the case that we must recapture domestic markets lost to lower cost overseas sources in the consumer electronics market. He doesn't believe that we must pursue a positive balance of payments in every product area, especially if it might cost us dearly to get there.	The final report does not address the consumer electronics issue.

Substance of Comment	Response to Comment
D. A large multinational manufacturer stated the consumer electronics industry would be better served by a strong Government program to implement anti-dumping statutes rather than by Government intervention in the R&D process (which in the past has been counterproductive). A desirable appropriate role for the Department of Commerce was identified as data gathering and a program to more rapidly and effectively implement Government agency regulations.	The final report does not address the consumer electronics issue.
E. A large manufacturer recommended that more flexible tax and depreciation formulae would motivate the kinds of innovative technology in products and in production automation that are required in the U. S. consumer electronics industry.	The final report does not address the consumer electronics issue.

APPENDIX B

SUMMARY OF INTERNATIONAL TRADE PROBLEMS AS IDENTIFIED BY THE INDUSTRY

1. ORIGIN OF THE VIEWS

Earlier, in appendix A, we mentioned that the trips made to industrial firms sounded out their opinions on various aspects of international trade in telecommunications. More specifically, the interview teams sought to identify the obstacles that might be hindering U. S. industry's claim to its fair share of the international market. This appendix summarizes the major points made by industry in the course of these interviews.

The reader should be aware that: (1) what follows is industry speaking, as heard by the Task Force reporters, and (2) when the word "industry" is used, it refers merely to the sample of the industry that the interview teams canvassed during their survey.

2. SUMMARY OF THE VIEWS

The basic barrier, as viewed by industry, seems to be the lack of a unified national telecommunication trade policy. Closely related to this is the absence of a well-defined Government commitment to an increase in telecommunication exports.

At the moment, no single Federal agency is responsible for establishing and giving voice to U. S. policy as regards telecommunication trade. Export control is decentralized; as a result, there is a general diffusion of responsibility throughout the Government. Industry, therefore, often experiences confusion and frustration when it tries to elicit a response from Government. Sometimes it ends up with no response at all.

It was pointed out that most other developed countries have telecommunication ministers with cabinet rank to determine their national policies.

The exact composition of unified national policy was not stated. But the following problems would surely be alleviated, and thus could be considered as candidates for improved policy formulation:

- Insufficient financing of export sales.
- Unfavorable tax laws and regulatory processes.
- Federal delays in export processes.
- Inadequate U. S. embassy assistance.
- Multiplicity of Federal agencies responsible for telecommunications trade.
- Differences between U. S. standards and standards of the International Telecommunication Union (ITU).
- Narrow base of U. S. participation in ITU.
- Barriers erected by other countries.

Each of these will be treated in a separate section below.

Focusing on Network Information Services, there is a clear need for a coherent Government policy on privacy. "Privacy" in this context refers generally to the protection of personal or business information placed in computer storage facilities. America's concern with such "privacy" may take differing forms. In the matter of sensitive personal data -- such as credit records -- that might find their way into overseas computer storage centers, Government should act vigorously to assure that carefully specified "due process" is observed. But, as regards the flow of economic information from country to country, industry would like to see this Government speak out forcefully for more open policies; some companies fear that, in the international sphere, restrictive measures along these lines may be in the offing.

THE NEED FOR BETTER FINANCING

The inadequacy of Government financing of telecommunication exports is considered by 70 percent of the companies interviewed as a serious, and in many cases the most serious, obstacle to successful competition for contracts worth more than $100,000. Industry seems to believe that, although the United States ranks first in technology, Japan is capturing the world's telecommunication market thanks to its vastly superior financing plans.

(Japan, for example, will offer a prospective client 100 percent financing at 5 percent interest for 20 years, often with no payment for the first 2 years.)

Industry thinks that the Export-Import Bank (ExIm) provides a number of examples of poor financing policy. ExIm has offered to reduce its rates to meet the lower rates of foreign lending institutions; but, speaking realistically, it is often impossible in the short time the bid is open to determine what those foreign rates might be.

Also, ExIm will not get involved early enough in the contract negotiations. It is unwilling to discuss financing until the contract is signed, in spite of the fact that no prospective buyer will sign until he is assured of his financing.

There are other aspects of ExIm's operations that industry views as nonsupportive. ExIm's main interest is in very large contracts. Its rates are no longer truly competitive. And its response time to financing requests -- from 2 to 6 weeks -- is too long.

Turning to the World Bank, industry criticizes its unwillingness to take into account the whole life cycle of a telecommunication system, which may total 40 years. Industry thinks that the bank should therefore engage in more long-term financing.

THE NEED FOR BETTER TAX INCENTIVES AND REGULATORY PROCESSES

Industry considers present U. S. tax laws to be discouragements to aggressive exporting especially in the light of the supportive tax programs and heavy export subsidization of foreign competitors; chief among these are Brazil and Japan. Smaller firms in particular think this way.

As to the Domestic International Sales Corporation program, which allows for some deferral of taxes on export income, it was suggested that it not be cancelled (as Congress is now considering), but rather modified to provide still greater incentives to the telecommunication industry. As things now stand, many companies are ignoring it as being not worth the effort.

Another unsettling phenomenon is Congress's apparent intent to phase out the Western Hemisphere Trading Corporation, whose tax provisions are generally regarded with favor.

With regard to regulation, firms pointed to regulatory delays causing uncertainty among prospective buyers of protective coupling devices for interconnection equipment. Industry was also unhappy with the FCC's delay in deciding Class D and Class E cases that permitted Japan to introduce its radio into the market before U. S. firms could. Industry generally recommended that a thorough review of the effect of the regulatory process on exports and imports be conducted, with the goals of reducing the delays and simplifying the procedures.

SHOULD WE REEXAMINE THE FREE WORLD COORDINATING COMMITTEE LIST?

Companies doing business with Eastern Bloc nations are concerned with a lack of clarity in the pertinent sales guidelines. They say there is no way to find out in advance what can and cannot be licensed for export; this is especially true for nonmilitary goods. Also, the delay in licensing can be appalling, some firms reporting that approval might consume up to 18 months; sometimes letters of credit expire before shipments can be made. In one case, it took 13 months to replace a burned-out minicomputer in Poland.

Moreover, the process of the Free World Coordinating Committee (CoCom) has the effect of providing market tips to competitor nations. Worse yet, the United States may well be the only nation that takes this list very seriously.

Some companies contend that the use of the CoCom list is an inefficient way to control these exports. It was suggested that DOD, which administers the CoCom list, concentrate its energies on a core area of critical items where control is still advisable, and free the remaining items.

HELP NEEDED FROM U. S. EMBASSIES

The majority of the companies interviewed expressed discontent with the assistance given the U. S. telecommunication industry by our embassies abroad. This was especially true in the case of small companies; i.e., those with annual revenues under $50 million.

No one characterized the embassy staffs as being particularly helpful. It was thought that commercial attaches and other embassy staff members have overly broad areas of responsibility and generally lack either background or interest in telecommunications.

The U. S. telecommunication exporter faces two problems that our commercial attaches could help lessen:

- Identifying key telecommunication policymakers in foreign countries and arranging introductions.
- Locating and evaluating the potential markets for telecommunication products.

"ONE STOP" CENTRAL AGENCY

Industry gave wide support to the idea of a small, central Federal agency that would serve as both a coordinating group and as a central information service. Also, it would be empowered to represent U. S. telecommunication export interests before other Federal agencies. In doing this, such an agency would be a further expression of a unified, "one-voice" national telecommunication policy.

The minimal activities of this proposed agency were seen to include the following:

(1) Consolidating the Government's telecommunication export control processes in order to simplify and to speed up regulatory decisionmaking, export licensing, and other such Government concerns.

(2) Maintaining a central information agency where telecommunication executives might obtain data and guidance relevant to their interests. This information library would contain such things as translations of foreign standards and specifications, an up-to-date log of bidding results on foreign contracts, a compilation of the latest regulatory decisions, and a World Directory of Telecommunications.

(3) Serving as a forum that would fulfill two closely related purposes: first, it would be an institution at which industry could present its views, thus allowing Government and industry to interact as the need arises; second, it would provide an easily accessible meeting ground for representatives of the U. S. Government, foreign governments, and American industry.

DIVERSITY OF INTERNATIONAL STANDARDS

Differences between the standards of the United States and those of the ITU sometimes make American telecommunication goods unsuitable for overseas use. This situation of differing standards also means that U. S. firms find it difficult to practice economies of scale as regards production for foreign markets. Foreign firms producing for the U. S. market do not face this problem in quite the same way, as our market is so vast.

The firms interviewed did name some specific areas where standards might be harmonized: optical communications, needed for development of fiber optic systems; modulation equipment as used in the MARISAT program; and access codes for Telex equipment.

Conversion to the metric system primarily affects design and construction drawings, cabinetry, and similar concerns; these difficulties are considered to be roughly equivalent to language barriers.

Industry's proposals for Government help in this matter include:

(1) An analysis of U. S. telecommunication standards penetration into the world market.

(2) Preparation of a log of foreign standards and of countries using common standards. This might aid smaller companies, some of which reported that they periodically had trouble finding out what the relevant foreign standards were in time to meet tenders of short duration.

(3) More effective participation in the international organizations that establish standards. This gets us back to the ITU, which is discussed in some detail below.

A MORE EFFECTIVE VOICE IN THE ITU?

Government activity in the ITU's major committees -- the International Radio Consultative Committee (CCIR) and its opposite number for telephone and telegraph (the CCITT) -- was the subject of some industry comment. Many companies criticized the United States for not developing positions and objectives before these committees and then following through on them; the lack of American performance at the CCITT seemed to be emphasized.

Many firms believe that they have no voice -- or at best a weak voice -- in the deliberations of the CCIR and CCITT. They point out that most companies cannot afford the time and expense demanded by representation on these committees. And, they contend, the Government's positions do not always incorporate their views. So they are interested in seeing some mechanism developed that would permit manufacturers' voices to be heard by the Government as it frames the statements it places before these ITU institutions.

NATIONAL TRADE BARRIERS

Foreign governments often restrict imports from the United States for a variety of reasons: military preparedness; the wish to protect local industries, a wish that is particularly strong in less developed countries; political considerations; and lingering ties of former colonial nations to their prior rulers.

The restrictions take diverse forms, including the following: discriminatory tariffs; "dumping" practices; bilateral trade agreements; long-standing traditions of corruption, which erect barriers by necessitating graft payments; and the often dilatory methods of central PTT's.

How should the Government attack these problems? The interviewed firms suggested a number of approaches:

(1) Increased U. S. participation in the committees of the International Telecommunication Union.

(2) Government support for work-study programs designed to educate engineers from emerging countries in U. S. technology and its applications.

(3) Federal Government encouragement to American firms to combine efforts in international trade so as to reduce internal competition and to compete with greater strength against foreign consortia.

(4) Joint Government and industry studies of problems relating to balance of payments, barter (in which goods are exchanged for goods), and offset (in which countries agree to buy specified items from each other on a reciprocal basis).

APPENDIX C

ADDITIONAL TECHNICAL DETAILS ON THE STATUS OF DIRECT SATELLITE COMMUNICATIONS

1. PERSPECTIVE

Satellite communications are a major part of satellite technology application. Applications to date have been as diversified as weather, space, and environmental observations, telecommunications, earth resource assessments, position location, and military applications.

The satellites have ranged from small (such as SYNCOM in 1963) to large (such as the NASA ATS-6 experimental satellite in 1974). The corresponding earth stations also come in a variety of sizes, for example, the small Data Collection Platform Radio Set (DCPRS) of the SMS/GOES weather satellite system of NASA/NOAA as opposed to the large INTELSAT earth stations. The smallest earth station may be the receive-only, portable, severe storm warning receiver of the paging radio size, proposed and studied from time to time. Costs of earth stations vary considerably, as indicated by comparing the SMS/GOES radio set, DCPRS, for around $1,500 (receive-only version), to the large INTELSAT earth station in the $2.5 to $5 million range.

FREQUENCY RESOURCES

Internationally, the variety of satellite technology applications is demonstrated by the number of "satellite services" for which frequency allocations have been made. The list includes the satellite services in table 1. The 18 satellite services shown each have a corresponding set of numbers, describing the number of allocations and the total number of megahertz (MHz) assigned to that satellite service in ITU Region 2 (North and South America). Of those, the number of allocations and megahertz not shared with other satellite or terrestrial services are also shown. The four numbers are split into two parts, referring to frequency allocations at or below 14.5 GHz, and, separately, those above 14.5 GHz.

Table 1. ITU Region 2 Satellite Services[1]

Satellite Service[2]	Frequency Allocations: Number[3]	Frequency Allocations: Number Shared[3]	Number of Megahertz Allocated: Total[3]	Number of Megahertz Allocated: Not Shared[3]
Aeronautical Mobile -	4/6	2/6	32.0/49,000	30.0/0
Aeronautical Radionavigation -	[4]N.A./6	N.A./6	N.A./49,000	N.A./49,000
Amateur -	5/1	5/1	4.5/50	0/0
Broadcasting -	4/2	4/0	690/4000	0/4000
(a) Individual Reception	N.A./[5]	N.A./[5]	N.A./[5]	N.A./[5]
(b) Community Reception	3/[5]	3/[5]	190/[5]	0/[5]
Earth Exploration -	4/3	4/3	385/2800	0/0
Fixed -	23/12	21/2	4420/34,825	100/33,500
Inter- -	N.A./4	N.A./0	N.A./50,950	N.A./50,950
Land Mobile -		Not Allocated		
Maritime Mobile -	4/6	2/6	17/49,000	15/0
Maritime Radionavigation -	N.A./6	N.A./6	N.A./49,000	N.A./49,000
Meteorological -	10/N.A.	10/N.A.	203.85/N.A.	0/N.A.
Mobile -	1/N.A.	0/N.A.	0.10/N.A.	0.10/N.A.
Radiodetermination -		Not Allocated.		
Radionavigation -	3/N.A.	1/N.A.	100.3/N.A.	0.30/N.A.
Space Research -	11/14	10/11	188.871/38,150	1.0/11,050
Space Operation -	6/N.A.	6/N.A.	20.005/N.A.	0/N.A.
Standard Frequency -	1/N.A.	0/N.A.	0.10/N.A.	0.10/N.A.

[1]U.S. Satellite Services and Allocations are consistent with, but not the same as, those of ITU Region 2.

[2]For example, Aeronautical Mobile-Satellite Service, and Inter-Satellite Service.

[3]The first number, A, of the pair, A/B, applies to frequency allocations at or below 14.5 GHz while the second number applies to those above 14.5 GHz.

[4]N.A. - Not Allocated.

[5]Broadcasting-Satellite allocations for individual or community reception have not been decided above 10 GHz.

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These allocations are distributed across the frequency spectrum from the lowest at 7.0 to 7.1 MHz (Amateur-Satellite) to the highest at 265 to 275 GHz (Fixed-Satellite).

Sharing with other satellite services and terrestrial services is the rule rather than the exception. Performance can be limited by interference, in addition to noise, which fact has led to limits of power flux density in many of the allocations to satellite services.

For table 1, the dividing frequency of 14.5 GHz was chosen. It appears to represent the upper limit, in frequency, of off-the-shelf technology which has been tested for system application.

Frequency allocations above 14.5 GHz are characterized, at the present time, by needs for development of selected technology, studies of system applications, identification of technology and channel limitations, economic studies, and demonstration links and systems. While allocations have been made, the major allocation and regulatory implications are not clearly defined yet. This is an issue itself, in view of the forthcoming WARC in 1979.

From the viewpoint of resource allocation and utilization, within ITU Region 2 covering North and South America, one quickly calculates the difference between 275 GHz and 7 MHz to arrive at a total bandwidth of 274,993 MHz. The satellite services have 152,860.855 MHz, or 55.6 percent of this total bandwidth, allocated under conditions of both sharing and nonsharing with terrestrial service allocations. Hence, the satellite services are well recognized, in terms of frequency allocation resources, as equally important as terrestrial services. However, the satellite services appear to have a nonequitable burden in sharing with terrestrial services. While the satellite services are allocated 55.6 percent of the total, only 11,098.5 MHz are exclusive to the satellite services, which is 4 percent of the total. Thus, while the terrestrial services have 43.2 percent of the allocations exclusively (not shared with the satellite services), the satellite services have exclusive use of only 4 percent of the allocations (not shared with terrestrial service). Further, only 1.1 percent of the allocations is reserved exclusively for the Fixed-Satellite Service.

The dividing line of 14.5 GHz between the technology limited (above 14.5 GHz) region and the market and regulation limited (below 14.5 GHz) region can be used to illustrate a fundamental imbalance in resource utilization. Between 7 MHz and

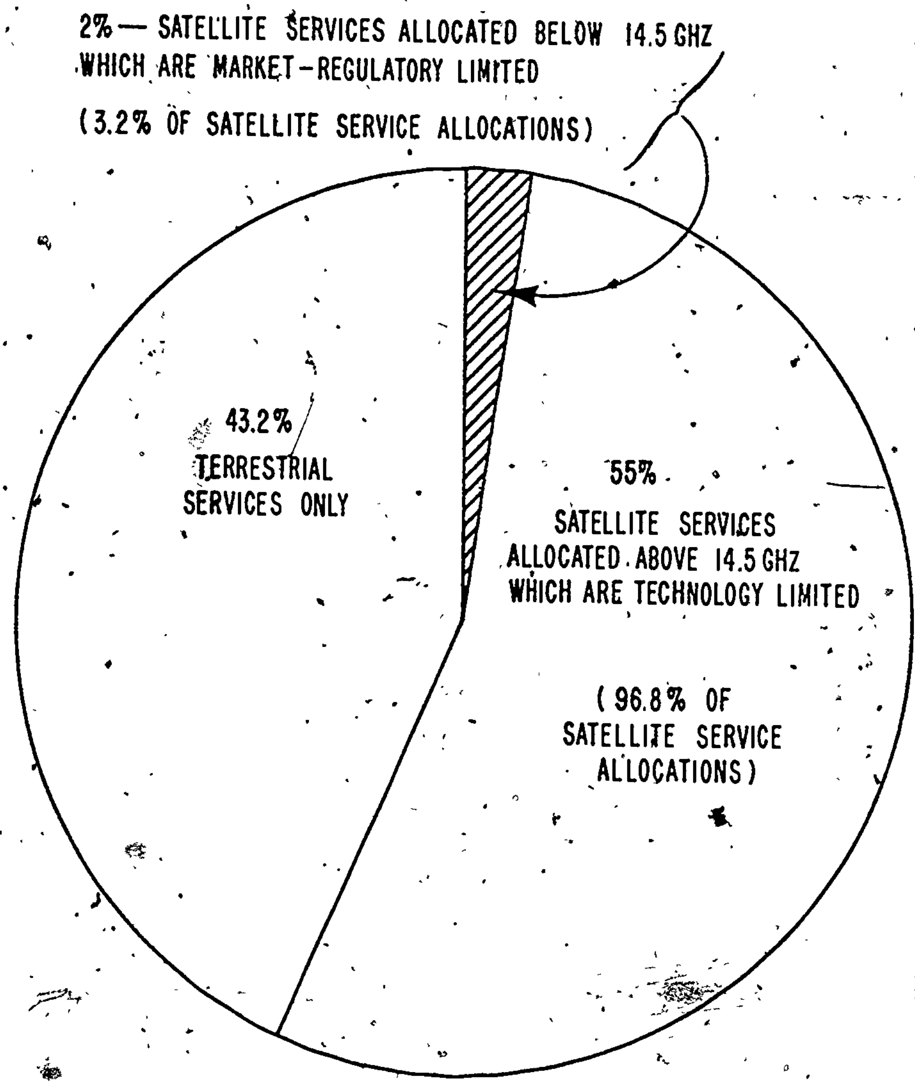
14.5 GHz, one has 14,493 MHz bandwidth of which 4960.855 MHz, or 34.2 percent, are allocated to the satellite services (shared - 85 percent and nonshared - 15 percent). Above 14.5 GHz, the 260,500 MHz allocated (up to 275 GHz) has 56.8 percent, or 147,900 MHz bandwidth allocated to satellite services (shared - 93 percent and nonshared - 7 percent). The 4960.855 MHz, however, is only 3.2 percent of the total bandwidth allocations to the satellite services (152,860.855 MHz). These numbers were not rounded off because some allocations are in kHz, or fractions of a MHz. Above 14.5 GHz, 50,950 MHz are allocated to the intersatellite service, which is included in the aforementioned. A better comparison would exclude this 50,950 MHz from the 147,900 MHz. Doing this, the total satellite service allocation is 101,910.855 MHz, between 7 MHz and 275 GHz, excluding the intersatellite service allocation. Above 14.5 GHz, then, 95 percent of 101,910.855 MHz is allocated to all other satellite services.

This appendix will focus on the 5 percent of the allocations below 14.5 GHz and the problems which exist today. From a resource utilization viewpoint, it is reasonable to pursue another investigation into the technology limitations of the other 95 percent bandwidth of the satellite service frequency allocations which have been made to date. This is also a major potential issue for the forthcoming 1979 General WARC. Figure 1 illustrates this division of the frequency spectrum from 7 MHz to 275 GHz.

Of the 4960.855 MHz allocated to the satellite services below 14.5 GHz, in ITU Region 2, 89.1 percent, or 4420 MHz bandwidth, is allocated to the Fixed-Satellite Service. The next largest allocation, 690 MHz, has been made to the Broadcasting-Satellite Service. However, these 690 MHz allocations are shared with the Fixed-Satellite Service and are included in the 89.1 percent given above.

OTP and FCC, acting in concert, determine the application of the ITU Region 2 frequency allocations within the United States. National frequency allocations are divided into two parts -- one for nongovernment use and the other for government use. The allocations to the Fixed-Satellite Service in the United States, which include the Broadcasting-Satellite Service because of sharing, total 12,040 MHz for the allocations between 2.5 GHz (the lowest) and 31 GHz. This allocation represents 42.2 percent of the spectrum between the above limits.

Below 14.5 GHz, 4440 MHz are allocated to the Fixed-Satellite Service in the United States. An additional 600 MHz



NOTE: SATELLITE SERVICES INCLUDE ALLOCATIONS SHARED AND NOT SHARED WITH TERRESTRIAL SERVICES

Figure 1. Frequency allocation division for the 7 MHz-275 GHz interval of 274,993 MHz (ITU Region 2). Only 4% of the Satellite Service allocations are not shared with terrestrial services.

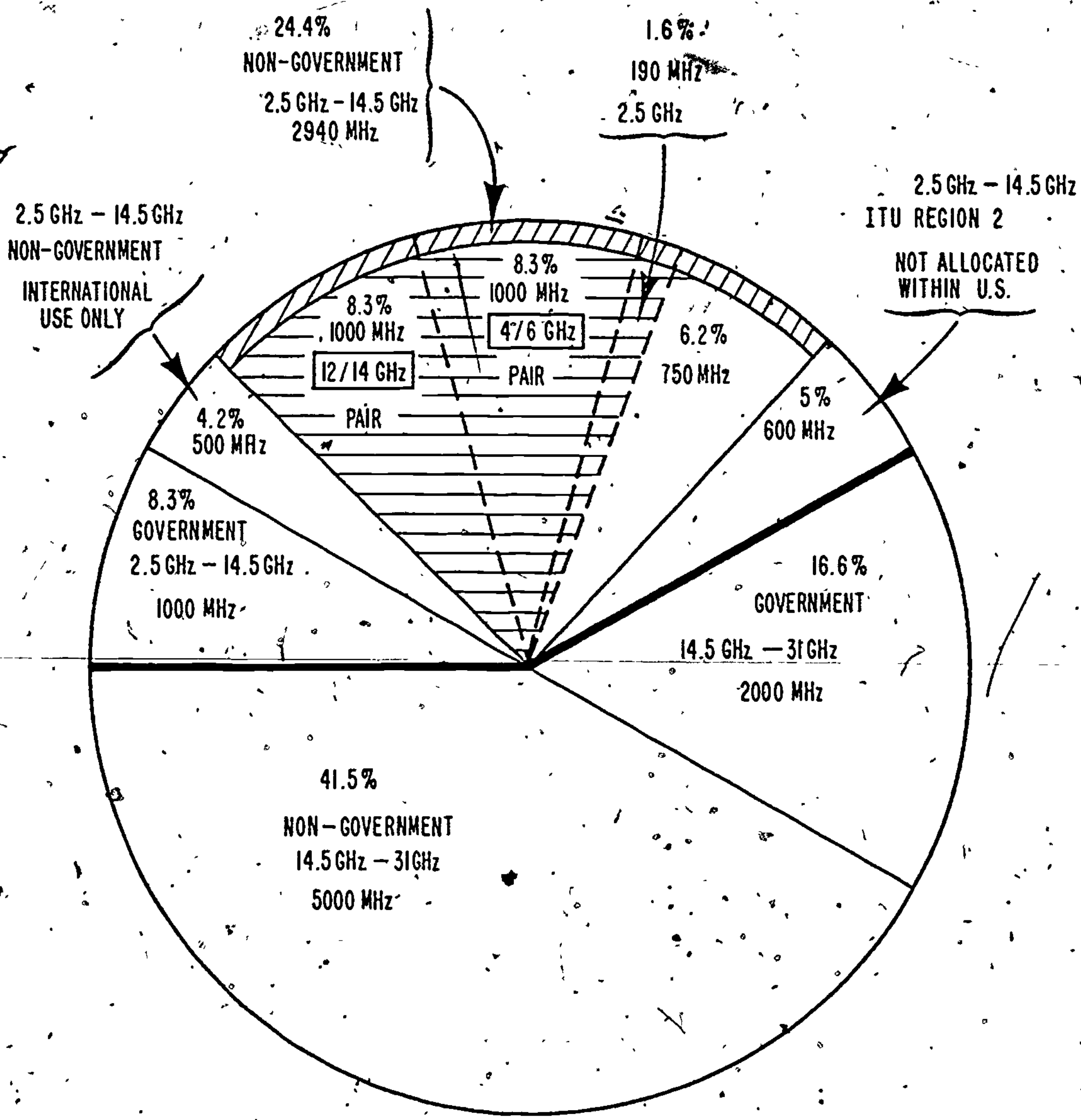
allocated for ITU Region 2 has not been so allocated for use in the United States. This totals 5040 MHz. On the other hand, an additional 500 MHz has been allocated to the Fixed-Satellite Service in Brazil, Canada, and the United States, on a secondary basis. This 500 MHz is allocated to the terrestrial Fixed and Mobile Services in ITU Region 2 (to non-government use in the United States).

The difference between the previously mentioned 4960.855 MHz for ITU Region 2 and the 5040 MHz, cited above, for the United States between 2.5 GHz and 14.5 GHz is accounted for by:

- Subtracting from 4960.855 MHz the 160.855 MHz of allocations below 2.5 GHz.
- Subtracting from 4960.855 MHz the 260 MHz of allocations to other than the Fixed-Satellite Service.
- Adding to 4960.855 MHz the 500 MHz, cited above, which is not allocated to a satellite service in ITU Region 2.

Between 14.5 GHz and 31 GHz, within the United States, 7000 MHz (58 percent of the 12,040 MHz satellite allocations between 2.5 and 31 GHz) are allocated to the Fixed-Satellite Service. Of this, 2000 MHz (16.6 percent of 12,040 MHz) are allocated for Government use, with the other 5000 MHz reserved for nongovernment applications. Figure 2 illustrates these numbers. This is the next region of the spectrum for commercial progress in satellite communications to be made. However, this progress will be slow until technology limitations, to be discussed subsequently, are overcome.

The most well known Fixed-Satellite and Broadcasting-Satellite Service allocations below 14.5 GHz are between 2.5 and 2.69 GHz (downlink), the downlink-uplink pair of 3.7 to 4.2 GHz and 5.925 to 6.425 GHz for domestic public use, and the downlink-uplink pair of 11.7 to 12.2 GHz and 14.0 to 14.5 GHz. These allocations are designated in this report as 2.5 GHz, 4/6 GHz, and 12/14 GHz, respectively. As noted from figure 2, these nongovernment allocations account for only 2190 MHz of the 5040 MHz allocated below 14.5 GHz, which is 18.2 percent of the Fixed- and Broadcasting-Satellite allocations below 31 GHz. Another 8.3 percent is allocated (1000 MHz) to Government purposes in the 7/8 GHz allocation downlink-uplink pair. This particular Government allocation is often claimed to have reached the saturation level in terms of sharing between terrestrial and satellite stations.



NOTE: A TOTAL OF 12,040 MHZ IS ALLOCATED TO THE FIXED-SATELLITE SERVICE IN THE UNITED STATES BETWEEN 2.5 GHZ AND 31 GHZ (SHARED AND NON-SHARED).

Figure 2. Division of fixed-satellite and broadcasting-satellite service frequency allocations within the U.S. from 2.5 GHz to 31 GHz.

One notes that 500 MHz (4.2 percent) are reserved for international applications, and another 600 MHz (5 percent) are not allocated within the United States. Further, of the U. S. allocations, 750 MHz (6.2 percent) are not yet in common use by the private sector. The following section 2 concentrates on the use and present status of activity in the 2.5 GHz, 4/6 GHz, and 12/14 GHz allocations within the United States.

ORBIT RESOURCES

Low- and medium-altitude satellites were used for telecommunications until SYNCOM I was launched into a geosynchronous altitude orbit over the equator in 1962. A satellite, at geosynchronous altitude, positioned over the equator, has the advantage of maintaining a fixed position relative to points on the earth's surface. Earth station tracking of the satellite is eliminated and earth station costs are considerably reduced. The satellite is in view of the earth stations for 24 hours a day, as long as the satellite orbital position, as viewed from the earth station, is above the earth station's horizon.

The orbital arc above the equator at geosynchronous altitude represents an orbit resource. Within ITU Region 2 (North and South America), the orbit resource for each country differs somewhat. More precisely, for a specific country, the usable orbital arc is the part of the geostationary orbit which is visible (in the radio propagation sense) above a specified minimum elevation angle from all potential earth station sites within the country. While satellite communications are possible for earth station elevation angles below 10 degrees, the likelihood of decreased performance quality is greater for a given earth station design. The 0 to 5 degree sector has restrictions on power levels and is generally considered undesirable. Satellite-to-satellite communications could also be considered to utilize more fully the orbital arc for the United States.

Figure 3 illustrates the equatorial orbit resource for ITU Region 2 countries (approximately 25 national administrations). Mexico and Central America can use portions of the arc west of the 5 degree point for the United States, and many countries of Central and South America can use up to 55 degrees further east than the United States. Satellites could be positioned further east or west if only a portion of the country were to be covered.

earth station, within the country, with an antenna pointed at a geostationary satellite positioned above the equator at the given longitude.

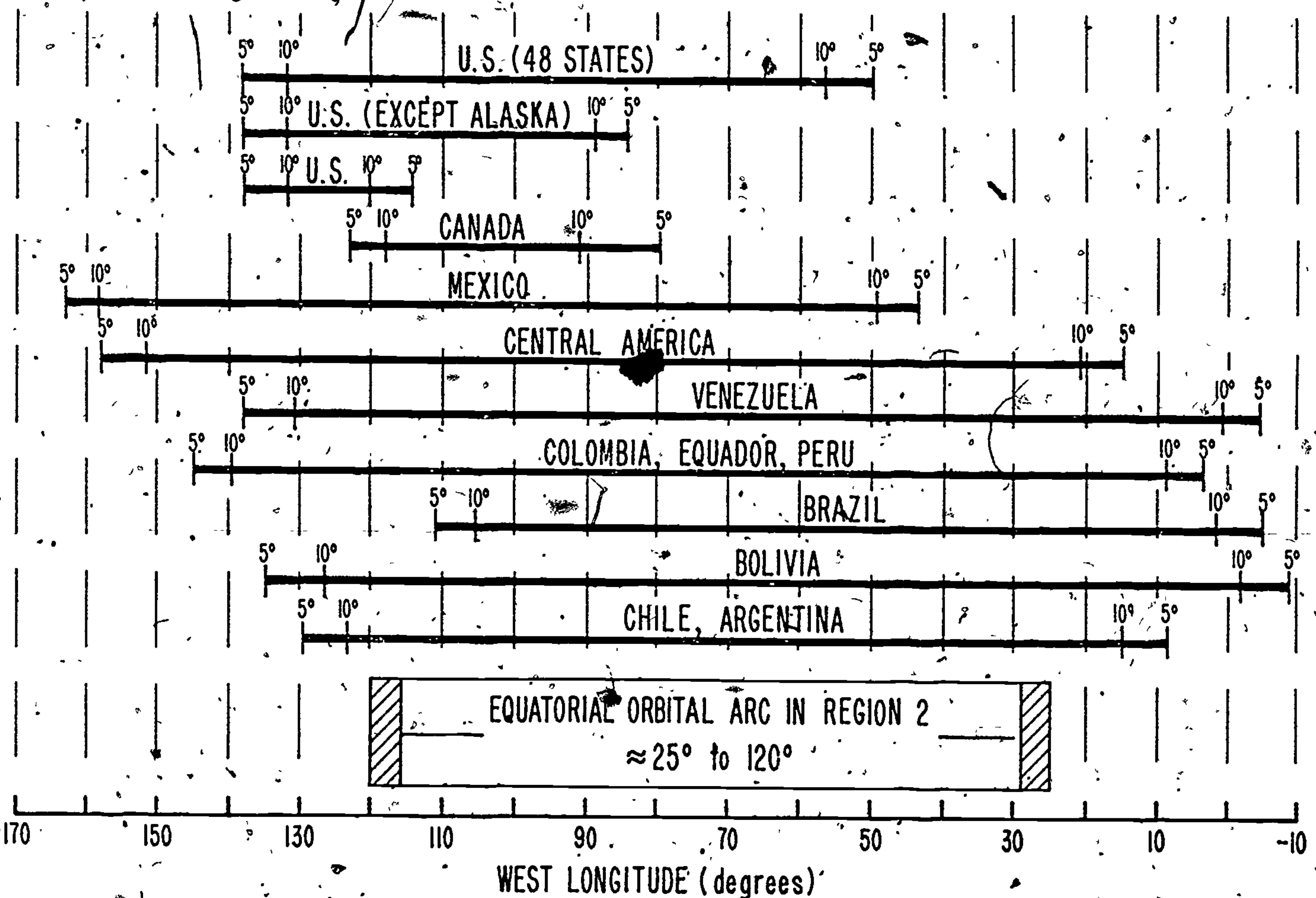


Figure 3. Usable orbital arcs for various countries in ITU Region 2 (adapted from Reinhart, E.E., Rand Report R-1463-NASA, May 1974, without verification). The 3rd line, designated U.S., applies to the 50 states.

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The figure also shows a question which arises. At the equator, the ITU Region 2 boundaries extend from about 25 to 120 degrees West longitude, a considerably smaller arc than 10 degrees East to 165 degrees West longitude. Do the ITU Region 2 boundaries limit the available orbital arc resource to within Region 2, or can the arc extend outside the boundaries into Regions 1 and 3? This question is currently an issue in association with the 1977 WARC for the 11.7-12.2 GHz band.

For the contiguous United States, between the 5 degree elevation angle limits, about 88 degrees of geostationary arc are available. If the 10 degree elevation angle limits are considered, 75 degrees are available. This 75 to 88 degree arc applies to each frequency allocation, so that 75 to 88 degrees are available at 2.5 GHz, the same is available at 4/6 GHz, and so on. Some additional analysis should be done to include the 0 to 5 degree elevation angle segments since this part of the orbit resource should not be arbitrarily discarded. The frequency and size of the earth station antennas, though, has a great deal to do with the number of satellites which can be positioned within the 75 to 88 degree arc for operation in a single downlink-uplink pair of frequency bands.

Conventional parabolic reflector antennas of diameter D in meters have a main beam of 3 dB power beamwidth, which is approximately 20.6/fD degrees, where f is the carrier frequency in GHz. To a first approximation, the segment of geostationary orbital arc, which is intersected by the terrestrial antenna main beam, is nearly the same as the beamwidth of the main beam. The intersected arc in degrees is 0.85 times the main beam beamwidth, or in terms of frequency f and antenna diameter D, about 17.5/fD. This relation is illustrated graphically in figure 4 for frequencies from 2.5 GHz to 14 GHz, and antenna diameters from 1 to 30 meters.

How close can one space satellites along the geostationary arc? How many satellites can use the same frequency resource within the orbit resource? Neither the answers to these questions, nor even the technical, economic, and social criteria to begin to analyze and answer the questions, are agreed upon. Ideally, the intersatellite spacing could be as close as the beamwidths of the earth station main beams would permit. Figure 4 suggests what that ideal spacing could be for different antennas and frequencies. Obviously,

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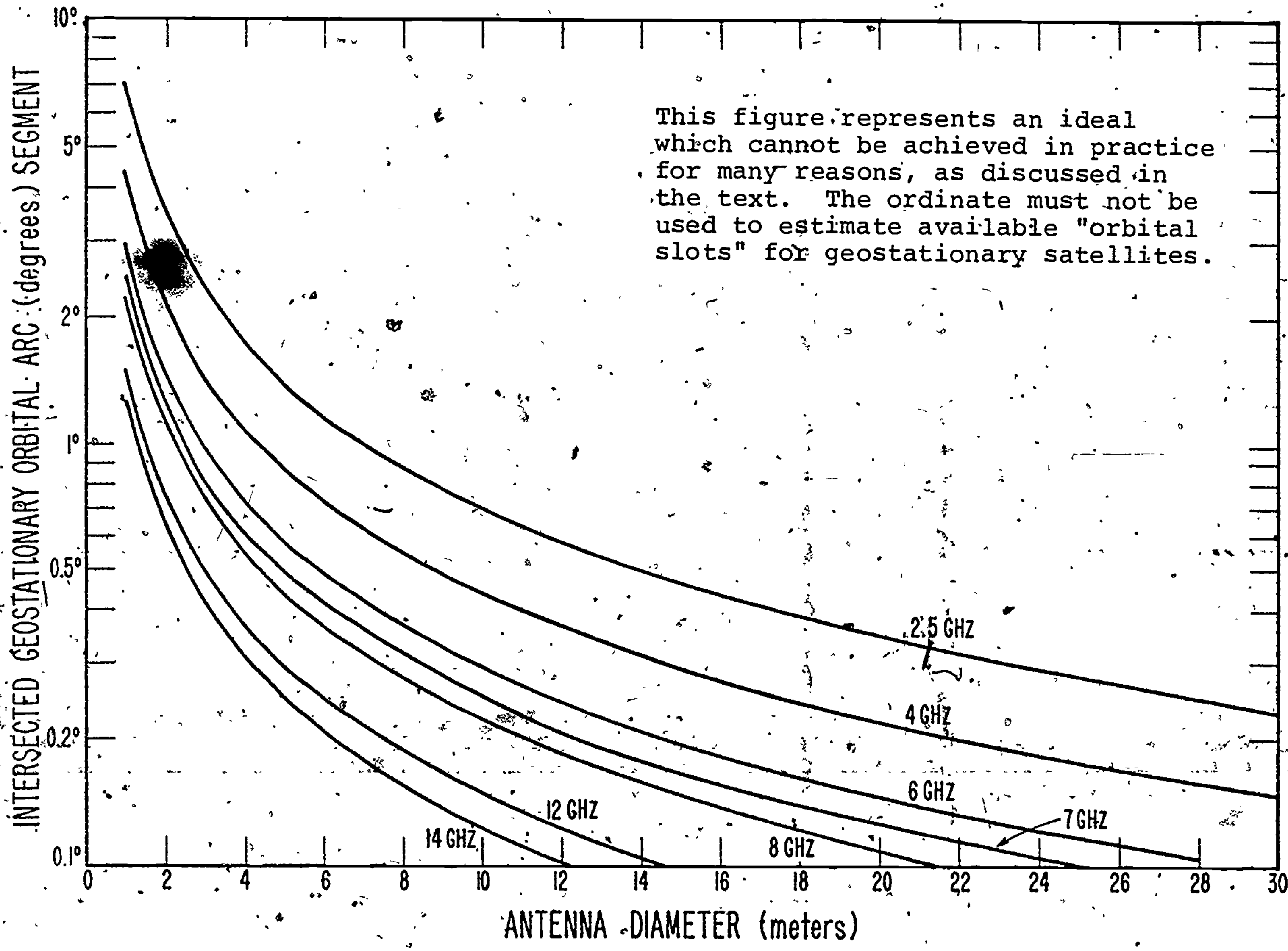


Figure 4. Geostationary orbital arc intersected ideally by circular earth station beams.

this means that the signal-to-interference ratio could be as high as 3 dB, so the practical limitations of the ideal separation are apparent. Currently, signal/interference ratios of at least 25 dB are needed.

Antenna sizes which have been used in the 4/6 GHz band vary from 10 to 30 meters in diameter. Corresponding inter-satellite spacings, ideally, vary from 0.44 to 0.15 degrees. These may be compared with the present FCC limitation of no more than 4 degree spacing.

Antenna diameters of circular reflectors suggested for applications in the 12/14 GHz bands have ranged from 3 to 9 meters, with some as small as 1 meter. The corresponding ideal intersatellite spacings of 0.48 to 0.17 degrees are nearly the same as the 4/6 GHz band. One sees that a 5 meter antenna at 12 GHz corresponds to a 15 meter antenna at 4 GHz, and a 24 meter antenna at 2.5 GHz, for the same intersatellite spacing. Limitations for intersatellite spacing in the 12 GHz band are complicated by the allocation to both the Fixed- and Broadcasting-Satellite Services for sharing. This is one of the issues being addressed in the FCC Docket 20468 in preparation for the 1977 WARC. Inter-satellite spacing will also be a major issue addressed by the FCC Fixed-Satellite Advisory Committee for the 1979 WARC.

The number of satellites in orbit corresponding to the aforementioned intersatellite spacings, if all the ideal earth stations and satellites were identical, is illustrated in figure 5 for the popular 4/6 GHz and 12/14 GHz bands. At 4/6 GHz, the percentage of the optimum orbit resource under consideration due to present technology controlled limits varies from 3.8 to 11 percent when expressed in terms of the number of satellite systems. Economic and market factors are a separate issue, most obviously expressed by the question of the cost of 585 satellite systems in orbit, each having a number of earth stations with 30 meter diameter antennas.

The corresponding situation for the 12/14 GHz bands is comparable, although the options are more difficult to express because of Fixed- and Broadcasting-Satellite Service sharing. Reinhart's analysis provided the numbers in figure 5. The percentages are in the 4 to 8 percent range, although the number of satellite systems could vary from extremes of 9 to about 87.

The reasons for such small percentages of utilization form a long list of technical limitations, among the more important being:

- Satellite station keeping accuracy. Present ITU rules require ±1 degree of longitude with ±0.5 degrees of longitude encouraged. The Canadian domestic satellite ANIK was reported to have maintained ±0.05 degrees of longitude.

- Earth station pointing accuracy. Without adaptive, automatic position sensing and corrections, limitations are imposed by the pointing techniques, antenna size and design, etc. The ANIK satellite system was reported to have earth station pointing accuracy of ±0.013 degrees rms.

- Satellite antenna pointing accuracy.

- Earth station and satellite antenna patterns. Actual antenna patterns for the main beam, and even more so for the sidelobes, differ considerably from the ideal. CCIR recommendations currently exist for "standard" patterns to use for antenna sidelobes in interference limitations. However, considerable difference of opinion exists here, including the question of overly restrictive CCIR requirements.

- Noise figure limits of receivers.

- Interference power limits. The lack of ideal antennas forces consideration of how much interference can be tolerated between and among satellite systems which share the same orbit and frequency resources. The limits depend on factors such as modulation, power, bandwidth, application (telephone, television, data), digital encoding if used, error control coding, etc. Unfortunately, many of the existing limits are based on subjective rather than objective performance measurements, and are not widely agreed upon.

- Bandwidth limits of receivers and transmitters. These are not very sharp and lead to vulnerability to or sources of interference signals which otherwise could be rejected.

- Atmospheric limitations. The signals from the earth stations and satellites must pass through the earth's atmosphere and weather conditions. The most serious

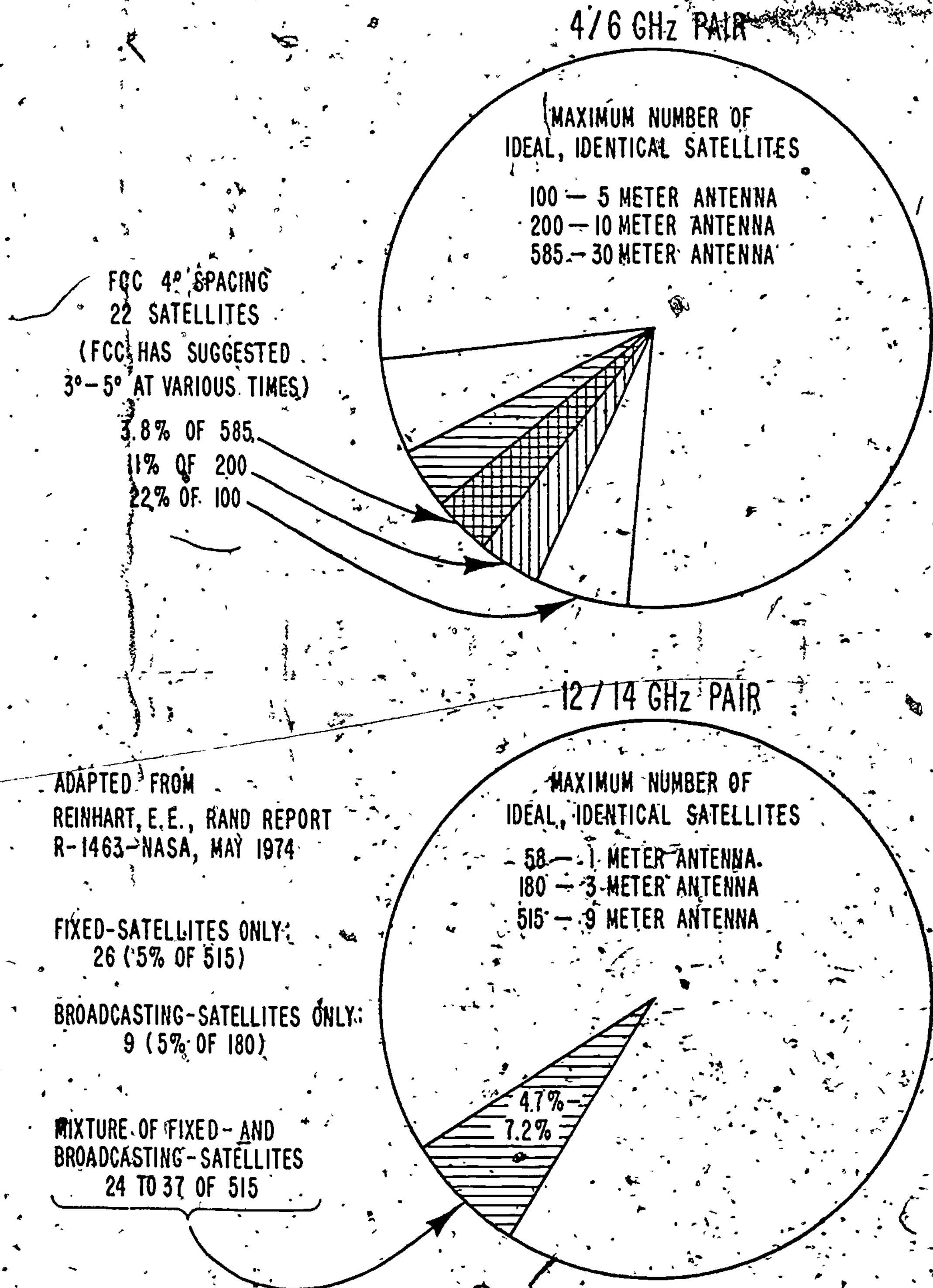


Figure 5. Contiguous U.S. orbital resource of 88° (earth station antenna elevation angles greater than 5°). The ideal cases shown here cannot be achieved in practice. The shaded areas represent the state of the art.

limitations arise from rain, which can attenuate and scatter, in different directions, the signals. Rain also increases receiver noise for earth station antennas and reduces the effectiveness of interference discrimination techniques such as cross-polarization. While not overly serious at 2.5 GHz and 4/6 GHz, atmospheric limitations cannot be ignored at 12/14 GHz and above.

Obviously, the situation illustrated in figure 5 is misleading in the sense that the optimum use of the resource cannot really be expected. The closer one gets to 100 percent utilization, the higher the costs become. It is fair to observe, though, that figure 5 illustrates perhaps the maturity of the technology and places into perspective the statement that "the technology at 2.5 GHz, 4/6 GHz, and 12/14 GHz is available for satellite telecommunications." Numerous system tactics (frequency interleaving, crossed-polarization, crossed-beam, etc.) and equipment techniques (modulation design, coding, sidelobe reduction on antennas) are known, but it is questionable as to whether the technologies have advanced to be of much help without large increases in cost.

GEOGRAPHIC RESOURCES

Often overlooked, the limitations of earth station sites caused by the physical proximity of antennas operating on the same frequencies cannot be ignored. In the frequency allocations shared with terrestrial radio services, antennas for both satellite and terrestrial stations are involved. This is the case in the 4/6 GHz bands. The 12/14 GHz band involves only stations for satellite service. At the present time, U. S. domestic satellite common carrier earth station sites exist near locations such as New York, Chicago, Dallas, Los Angeles, and San Francisco. The actual earth station locations, however, are somewhat removed from the center of each metropolitan area. The Western Union earth station for the Chicago area is actually at Lake Geneva, Wisconsin, about 65 miles northwest of the city center. The proposed earth station site for the AT&T domestic satellite in the Chicago area is at Hanover, Illinois, about 135 miles west of the city center.

The aspect of sharing deserves additional comment at this point. Satellite communications have always had to share the frequency resource with terrestrial stations. While sharing does lead to practical problems, it provides a greater utilization of the resource. The magnitude of the problems of sharing, however, must not be taken lightly. Numbers for 1974, for example, indicated that 16,620 terrestrial microwave radio-relay frequency assignments had been made in the United States for the 3.7-4.2 GHz band, with 11,820 in the 5.925-6.425 GHz band, shared with satellites in the popular 4/6 GHz band. The number of such assignments has increased considerable since then and continues to increase.

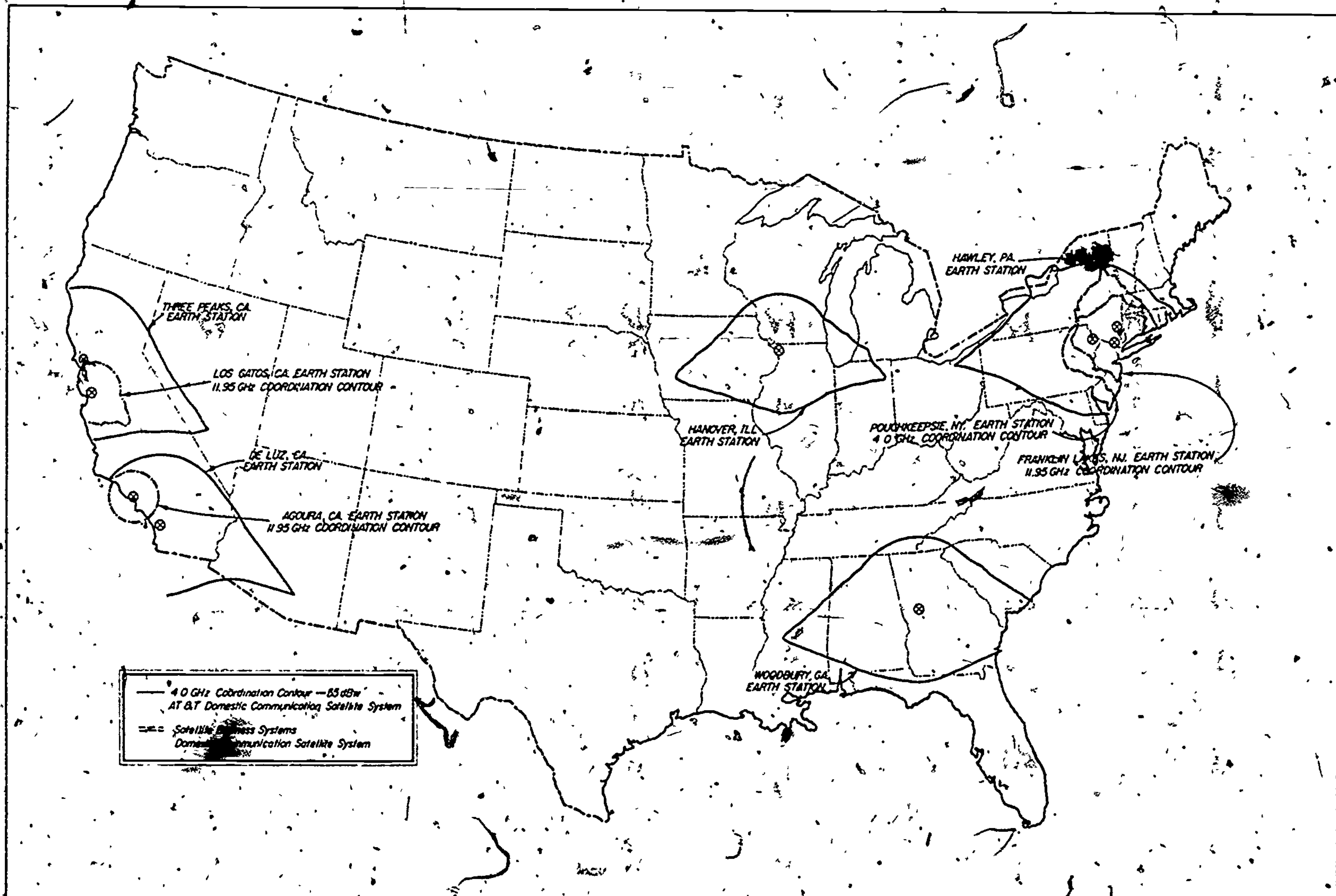
Applicants for earth station sites in the 4/6 GHz and 12/14 GHz bands are required by Part 25 of the FCC Rules to submit with their applications the contours of coordination distances for each earth station site. The coordination contours bound the geographical area within which microwave facilities should be analyzed in detail with respect to interference. The size of some of these contours, can be substantial. Figure 6 was prepared from the AT&T Application for a Domestic Communications Satellite System as amended June 8, 1973, and the Satellite Business Systems (SBS) Application for a Domestic Communications Satellite System, December, 1975. The areas involved are not small. The AT&T sites involve 30 meter diameter antennas whereas the SBS sites will have 5 and 7 meter diameter antennas for 12/14 GHz communications.

The existing and available earth station sites in the U. S., as in any country, represent a resource. This resource is not independent of the frequency and orbit resources previously discussed. The earth station geographical site resource also depends upon the technical characteristics of the satellites and earth station, both within a system and for other systems. Unfortunately, it is an expensive and time-consuming endeavor to select an earth station site just for proposed systems. To do it from the point of view of defining the national resource which might be available, even ideally, in each frequency allocation, may not even be feasible. One may never know what percentage of the resource is not in use because of technical, economic, and regulatory limitations.

SPACE APPLICATIONS BOARD

In 1972 the Space Applications Board (SAB), National Research Council of the National Academy of Sciences, was formed to

Figure 6. Earth Station Coordination Contours for the AT&T (30-meter antennas) and the SBS (5- and 7-meter antenna) Domestic Communication Satellite Systems.



consider how the Nation's space capability might be put to work on a much broader basis to help solve some of mankind's truly great and pressing problems. With their most recent report in 1975, Practical Applications of Space Systems, the Board brought up-to-date their earlier report (1969) on satellite telecommunications.

The Space Applications Board observes:

> It may be expected that many of the next important applications of satellite communications will be in the public area --- applications that would see the provision of new public services or of important cost reductions or cost avoidances in the delivery of present public services. Adequate technical and economic exploration and testing of such services, however, will take considerable time and money, perhaps will require markedly different technological approaches than those now in hand or being developed, and may not be easily accommodated in all cases by the Nation's present common carrier network. Further important progress will take place at an early moment only if certain difficulties that now ~~inhibit~~ broadened uses of satellite communications are appreciated and steps taken to minimize them.
>
> The extraordinary commercial success of satellite communications in the past decade has led some to conclude recently that all further required progress can be left to private industry alone. Certainly, the private sector will exploit and refine the present technology, and will improve the efficiency and, in time, the quality of services currently provided. But the private sector can do so only at a pace dictated by its own perception of the character and size of the markets and in a manner consistent with present investments, capital resources, and the present character of the aerospace and communications common carrier industries. Consequently, the private sector will find it difficult -- perhaps even impossible in the near term -- to support major sophisticated technological advances, especially when the technological risks are great, when the eventual markets are not clear, when only the broad public good is involved, or when the present institutional and regulatory framework does not easily respond to new service needs or new technological approaches.
>
> Many of the telecommunications services envisioned for the future would be enhanced, expedited, and made more generally available if user terminal equipment were small, lightweight, and easily operated and maintained by non-technical people, and the service costs were low. Achieving these ends may well require the development of much more sophisticated spacecraft than the ones now envisioned, operation in electromagnetic spectrum regions significantly higher in

frequency than 10 GHz, innovative techniques for transmission and dynamic circuit allocation, and cost-conscious terminal design. Federal research and development in these fields should complement that of industry.

It appears to the SAB that much of the next decade's activities in the satellite communications area will be aimed at the provision of new domestic services and that a great deal of research and development will be required -- not only of a technological nature but of a market- and-service-related nature as well. COMSAT's experience has demonstrated that satellite telecommunications technology can provide circuits of great reliability, range, capacity, and flexibility. If the market for public service communications is large enough, circuits could be provided at relatively low cost. To establish whether there is a large market for public service communications, however, will require that telecommunications scientists and engineers work closely with potential telecommunications users such as teachers, public officials, doctors, and city planners, over long enough periods of time and with enough thoughtful imagination so that all can ascertain how, to what extent, and under what circumstances, telecommunications could be used to assist in the provision of public and private services in a demonstrably sound, economic and acceptable fashion.

The Board recommends:

> that greater support be given by all of the federal departments and agencies to those research, development and other activities required to explore new ways of using satellite telecommunications to improve, to allow increased access to, and to reduce the cost of providing public services. The Office of Telecommunications Policy should lead in defining and establishing such support and in encouraging innovative private initiatives (as it has in the recent past for a public service satellite consortium) as well.

Because such research and development activities will involve detailed study of complex social, economic, organizational and institutional arrangements, the Board suggests that they be planned with great care and involve all of the professional disciplines and governmental, commercial and industrial skills needed for their satisfactory conduct.

To avoid such difficulties as attended the move of the ATS-6 satellite to serve India, satellite telecommunications circuits should be made available for the relatively long periods of time inherently required for public-use experiments. 1/.

The Committee on Satellite Communications of the Space Applications Board, National Research Council, has recently been meeting to consider the role that the Federal Government should have in development of satellite communications. A report is planned to be available toward the end of 1976. It is our assessment that industry and user groups can play an important role here.

1/ National Academy of Sciences, Practical Applications of Space Systems, 1975.

2. PRESENT STATUS

In 1962, the Communications Satellite Act established COMSAT. In 1965, the American Broadcasting Co. requested FCC permission to launch a domestic satellite for TV broadcast purposes. During 1968-1969, the President's Task Force on Communications Policy recommended a cautious approach to satellite communications development, centered on COMSAT. This was reversed in 1970, with a policy of open entry in the domestic satellite communications field. The FCC, in its Second Report and Order of June 1972, approved the beginning of domestic satellite communications for the United States.

For contrast, one must note that there are over 1785 terrestrial communication telephone companies in the United States with plant assets in excess of $84 billion, operating revenues greater than $35 billion, and over 1 million employees. AT&T and its operating companies serve about 82 percent of the telephone subscribers in the United States, but only about one-third of the geographical area. GTE and its operating companies serve about 8 percent of the telephone subscribers, and 11 other holding companies and independents serve another 6 percent.

The domestic and international telecommunication satellite industry has emerged from demonstrations led by NASA, DOD, and industry. These programs established the potential of satellites to provide conventional voice telephone service and television relay when operations are imbedded in common carrier systems. The Government R&D investments have helped bring about the INTELSAT/COMSAT system and the U. S. Domestic Satellite Common Carrier Industry (U. S. DOMSATs reviewed below) in addition to U. S. industries which supply satellites, earth stations, modems, multiplexers, etc., both domestically and internationally. This research and development, and the resulting industries and products, are uniquely based upon a technology of large earth stations, and broad antenna beam satellites with low power transmitters which operate in the 4 GHz and 6 GHz frequency allocations (4/6 GHz band).

NASA sponsored the SYNCOM Program to demonstrate the first use of communication satellites in geostationary orbit. These satellites quickly replaced lower altitude communication satellite techniques. As a recent (1975) NASA Task Team report has observed:

Prior to the demonstration of Syncom II in 1963 there was concern expressed by prestigious communications organizations that the 260 millisecond time delay inherent in communications via synchronous satellite would be unacceptable to telephone users. Although early experiments with simulated time delays were conducted, a demonstration of a working satellite was necessary to convince skeptics of the superiority of synchronous satellites.

Many other technical doubts were expressed about the ability of maintaining a satellite precisely in its orbital position; accurate pointing or attitude control; building a satellite lightweight enough for the available launch vehicles; and on the reliability and lifetime in orbit.

For perspective, it should be noted that tests were made on the RELAY satellite with added delay to stimulate a geo-stationary satellite path. These tests were not conclusive. In 1965, tests were made on the Early Bird satellite, listening tests with call-back interviews, which showed that customer acceptance was not negative. These tests were under the steering committee direction of the FCC, DTM (Director of Telecommunications Management), AT&T, NASA, COMSAT, and various European organizations.

International frequency allocations for communications satellites also exist in the 11/14 GHz band and the 19/28 GHz band as noted in section 1. There are no operational systems in these bands now, but experimental satellites and some plans for use of the bands currently exist (INTELSAT V and European satellites).

Table 2 was prepared to summarize as best as can be determined, the current status as of July 1976. Long-range research programs involving satellites, such as the Lincoln Labs, MIT, LES-8 through LES-10 satellites, have not been included. The ATS-6 backup satellite, which was in "flyable storage," is being transferred from NASA to the Air Force and Lincoln Labs for conversion to LES-10.

1.5/1.6 GHz

The first commercial satellite serving merchant ships is COMSAT General's Marisat, which is now in orbit. More than 200 ship terminals have been built by Scientific Atlanta and Digital Communication Corporation for COMSAT General. The 1.5/1.6 GHz pair will provide uplink (ship-to-satellite) and

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Table 2. Fixed-Satellite Service Systems as of July 1976

Uplink Frequency GHz	1.5		5.9-6.4	7.9-8.4	14-14.5	14-14.5	27.5-30	30-31
Downlink Frequency GHz	1.6	2.5-2.69	3.7-4.2	7.25-7.75	10.95-11.2 11.45-11.7	11.7-12.2	17.7-20.2	20.2-21.2
Present Satellite Systems	Marisat (Maritime Satellite: COMSAT General)	ATS-6	ATS-6 Intelsat (IV and IVA) ANIK WU WESTAR RCA SATCOM Indonesia Symphonie **	DSCS II Skynet		CTS		
Satellite Systems in Development	Marots		Marisat Italy Japan Intelsat V Telesat-2	DSCS III FLTSATCOM	Intelsat V European - (Orbiting Test Satellite)	SBS Japan - (Broadcast Satellite) Telesat-2	Japan AT&T - (Beacon Test)	
Satellite Systems - Future Plans	Aerosat		Arabian Brazil Iranian	AFSATCOM				U.S. DoD

** Marisat, AT&T COMSTAR

The USSR Statsionar satellite operates with uplink frequencies 5732-6225 MHz and downlink frequencies of 3407-3900 MHz. Satellites for Indonesia, Italy, Japan, and other countries outside region 2 may operate on different frequencies than those shown above.

downlink (satellite-to-ship) communications. The satellite-shore station communications will use the 4/6 GHz band. The shipboard equipment consists of a 1.22 meter diameter antenna, receiver, transmitter, and platform stabilizer to compensate for ship motion. Including other terminal equipment and modems, the terminals cost $37,000 with a $3,000 installation charge. This 1.22 meter antenna has an ideal beamwidth of about 11.2 degrees and its main beam would ideally intersect a geostationary orbital arc segment of about 9.6 degrees.

2.5 GHz

Operation in this band is characterized by well-developed technology and relatively little interference from propagation anomalies -- specifically, rain attenuation. The last NASA Advanced Technology Satellite (ATS-6) provided a satellite technology demonstration which had the following goals:

- To demonstrate the feasibility of deploying a 30-foot diameter parabolic antenna in space.
- To provide a satellite with advanced pointing, tilting, and tracking capabilities.
- To provide an oriented, stable spacecraft platform at synchronous altitude for advanced technological experiments (approximately 20 such experiments).

Included in the experiments was a Satellite Technology Demonstration which utilized approximately 130 low-cost ($5,000) ground stations for receive-only downconverters and antennas distributed across 23 states (including Alaskan and Appalachian experiments). The antennas built for the Westinghouse earth stations were 3 meters in diameter. The programming was limited to health and educational experiments.

The ATS-6 satellite was moved over India to demonstrate the effectiveness of such a system to provide means for educational programming to be delivered to some 5000 villages. The primary attribute of this satellite system is the relatively high satellite power available at the ground terminals, resulting from the moderate (15 watt per channel) power, and the large satellite antenna, resulting in the use of the low-cost ground terminals. The satellite is scheduled to be returned to this country in the fall of 1976. A consortium of user (non common carrier) groups, the Public Service Satellite Consortium, has been formed to plan for the effective use of this and other satellite services. The design lifetime of the satellite is two years; however, experience with other (ATS-1 and ATS-3) satellites launched several years ago shows that a longer lifetime has been experienced, but is not to be expected.

At present, advanced concept studies are under way which might identify this band for satellite disaster warning as a public service. Preliminary studies of satellite communications for mobile services are in progress. Alternative experiments are planned for the 12/14 GHz bands for education and health-care services on the Communications Technology Satellite (CTS) discussed below.

4/6 GHz

This is the downlink/uplink pair of bands in which the INTELSAT satellite series (I to IV-A), the Canadian ANIK, and the U. S. domestic satellite common carriers have begun operations. Power flux density limits restrict satellite powers. Within the United States, use of the 4/6 GHz band has necessitated location of earth stations away from urban areas because the 4/6 GHz allocations are shared with terrestrial common carrier microwave systems, which concentrate in the urban areas. While this separation distance solves the interference problems, the satellite terminals require terrestrial networks to connect to customers with resultant increased costs. Further, the expensive 30 meter diameter earth stations must operate at sufficient traffic capacity in order to be economically feasible, thus limiting the market applications to common carriers who can aggregate and concentrate customer traffic.

Many of the current and planned systems are listed in table 2. The INTELSAT IV and Canadian ANIK satellites have 12 active transponders (40 MHz bandwidth each, of which about 34 MHz or 85 percent is used). The ANIK and WESTAR satellites are nearly identical and are versions of the INTELSAT IV reduced in size for a smaller launch vehicle.

INTELSAT

This global system has four operational satellites located over the Atlantic, Pacific, and Indian Oceans with a spare at each location. As of July 1976, they provide international communication service to over 136 ground antennas at about 108 ground station sites in 73 countries. These stations represent an investment of at least $0.5 billion. By 1978, there will be about 200 such ground antennas ranging in size from the standard 29.5 meters down to 9 meters.

INTELSAT also provides communications between points within a country. They are now providing domestic service, or soon will be, to Brazil, Algeria, Norway, Nigeria, Zaire, Malaysia, Spain, Mexico, and the United States (Hawaii-mainland).

In 1975, INTELSAT and COMSAT gross revenues were on the order of $100 million and $145 million, respectively. Investments in new satellites, which involve on the order of at least $270 million for just the space segment (6 INTELSAT IV-A satellites), must be made consistent with expected revenues. Experimental satellites to explore the viability of new services for which future revenues are not clearly identifiable are not economically feasible.

INTELSAT and COMSAT have used narrow satellite antenna beams (IV) and frequency re-use (IV-A) on the same satellite. Digital Time Division Multiple Access technology; Single channel per carrier, Pulse code modulation, multiple-Acess Demand assignment Equipment; and single channel per carrier techniques were developed by INTELSAT member countries. The number of transponders was increased from 12 on INTELSAT IV to 20 on INTELSAT IV-A.

The INTELSAT V satellite series is now in procurement. It will use both the 4/6 GHz and the 11/14 GHz bands, but not the 12 GHz band, with both dual polarization and frequency reuse.

TELESAT

This organization with the ANIK satellites has provided domestic communications service to Canada since early 1973. The space segment has two operating satellites, and one spare, transmitting to 3 manned stations, 7 supervised stations, and over 60 remote earth stations. Antennas range in size from 30 meters for heavy route stations to 4.7 meters for remote television reception stations. TELESAT-2, the next generation satellite, will be a multiple band satellite with transponders for both 4/6 GHz and 12/14 GHz operations. The Canadian Government has guaranteed to TELESAT, that it will purchase the 12/14 GHz capacity. RCA is the satellite contractor.

Western Union

WESTAR became the first U. S. domestic communications satellite in 1974. Two satellites in orbit, with one ground spare, provide data, voice, and video leased private line service through 5 earth stations with 15.5 meter antennas. Earth stations are located near New York, Chicago, Dallas, Los Angeles, and San Francisco.

RCA GLOBECOM/ALASCOM

This organization has 9 existing earth stations, which have been operating with transponders leased from existing satellites. SATCOM I has now achieved geostationary orbit and will soon provide the space segment. RCA plans to add 12 standard and up to 60 small earth stations in 1976. Recently, a new wholly-owned subsidiary called the RCA American Communications Company was established to own and operate the RCA domestic satellite system. It is a parallel activity to RCA Global Communications, which will continue to be responsible for overseas communications, and RCA Alaska Communications, which provides RCA communication services to Alaska.

American Satellite Corporation

American Satellite Corporation leases its space segment from Western Union. It operates 3 common carrier and 5 dedicated service earth stations with 10 meter antennas. In addition it built 2 stations for Dow Jones and Company, which transmit data from Masssachusetts to Florida. Eight more earth stations to serve 20 cities are planned.

USSR

The Soviet Union, because of its Northern location and 11 time zones, employed an elliptical 12-hour synchronized orbit for the Molniya satellite system. The orbit allows three times more satellite weight for a given launch vehicle and gives about 20 hours coverage per day. The Statsionar, the first Soviet synchronous satellite, is used for domestic television distribution service to small terminals.

AT&T, COMSAT, GTE

A U. S. domestic satellite communication system is planned to provide message telecommunications service (MTS), wide area telecommunications service (WATS), and service to the U. S. Government. Private line services are excluded by the FCC for the present. Three geostationary satellites operating at 4/6 GHz are planned to serve the 50 states, Puerto Rico, and the Virgin Islands. Each satellite would have 24 transponders of 40 MHz bands, with +33 dBW effective isotropic radiated power at beam edge. A single antenna beam would cover the contiguous United States. Satellite positions at 93 degrees, 119 degrees, and 128 degrees West Longitude were requested. The information presented here is based on the original AT&T 1973 briefing to the FCC with some minor additions. COMSAT General will provide the space segment (3 satellites in orbit, 1 ground spare) and lease to AT&T and GTE. The first COMSTAR satellite was successfully launched in May 1976.

Each satellite has the capacity of 14,400 two-way telephone channels (1200 channel frequency division multiplex frequency modulation per transponder), or 24 one-way television channels (1 FM channel per transponder), or 1,072.8 Mb/s digital capacity (24 channels of time division multiplex-phase shift keying) at T-3 rates of 44.7 Mb/s each). Cross-polarization will be used. Reliability objectives are uninterrupted service for 99.9 percent of the time. Satellite station keeping goals are 0.1 degree in both longitude and latitude.

Seven earth stations are planned with 30 meter diameter antennas (steerable). The 3 dB beamwidths are 0.18 degrees at 4 GHz and 0.16 degrees at 6 GHz. The planned locations are:

New York (Hawley, Pa.)	3 antennas (AT&T)
Atlanta (Woodbury, Ga.)	2 antennas "
Chicago (Hanover, Ill.)	2 antennas "
San Francisco (Three Peaks, Cal.)	2 antennas "

Los Angeles (Triunfo Pass, Cal.)	3 antennas (GSAT)
Tampa (Homosassa, Fla.)	2 antennas "
Honolulu (Sunset, Hawaii)	1 antenna "

The Los Angeles, Tampa, and Honolulu area earth stations will be built by GTE.

AT&T states in its application for its domestic satellite communication system, which it refers to as "the System,"

> In 1976 the System will have assigned to it the equivalent of 19,100 mastergroup miles of terrestrial facilities, in the contiguous states....
>
> The present worth in 1976 of the equivalent terrestrial costs for the years 1976 through 1982 is $258 million, exclusive of revenue from transponders used to connect the offshore points to the Mainland and for Alaskan intrastate services....
>
> Thus, the 1976 present worth of the System's annual charges for the period 1976 through 1982 is $230 million. Clearly then, the System will constitute an economic benefit in the provision of AT&T's telecommunications services.

The cost to COMSAT for the four satellites, launch vehicles, and associated launch costs is estimated to be $182.9 million. This is recoverable through a lease rate to AT&T of $1.3 million per satellite per month.

The installed cost of the seven earth stations (4 AT&T, 3 GSAT) including fifteen antennas and associated electronics, land, buildings, support equipment and connecting facilities is expected to be $76.7 million.

Satellite Business Systems

While initial operations are planned for the 4/6 GHz band, the Satellite Business Systems (SBS) will be discussed under the 12/14 GHz heading.

10.95-11.2 and 11.45-11.7/14.0-14.5 GHz

At present, no operations appear to exist in the 10.95-11.2 GHz and 11.45-11.7 GHz downlink bands for international telecommunications. The INTELSAT V satellite series and the European Orbiting Test Satellite are in the planning stage and will operate in these bands.

11.7-12.2/14.0-14.5 GHz

There is no power flux density limitation in this band, so that high power satellite signals may be received with small (2-3 meter) roof-top antennas at the customer's site. Direct point-to-point satellites for electronic mail, packet-switched data, facsimile, educational, health, and social services can benefit from the absence of shared terrestrial services in the 12/14 GHz band. These applications are under consideration but the technical and developmental risks of a 12/14 GHz small earth station venture are not minor.

Communications Technology Satellite

The first satellite to operate in the 12/14 GHz band is the Communications Technology Satellite (CTS), a joint project of NASA and the Canadian Department of Communications. Its 60 dBW equivalent isotropic radiated power (200 watt or 23 dBW transponder) will be the highest power transmitted so far from space, and will allow the use of 1 meter receiving antennas. The experimental satellite, with two antenna beams, is in orbit. There are 22 earth stations with antennas ranging in size from 9.1 to 0.9 meters. The 0.9 meter antenna is used for voice reception and transmission, with larger antennas for television.

The objective of the CTS project is to advance the state of the art in spacecraft and related ground-based technologies relevant to future communications and other satellite application systems. The principal technological objectives of the project are to conduct experiments with 12 GHz terminals and to test (a) a super-efficiency power tube having greater than 50 percent efficiency at a minimum output power of 200 watts and operating at approximately 12 GHz; (b) unfurlable solar power arrays of over 1.0 kW initial capability; (c) liquid metal slip rings; (d) an electrical propulsion system for spacecraft station-keeping; and (e) an accurate stabilization system for spacecraft with flexible appendages.

One-half of the available transponder time will be available to U. S. experimenters. NASA has been delegated as the U. S. agent for the Canadian Department of Communications, which operates the CTS satellite; and NASA will select U. S. experimenters for participation. Fifteen American experimenters involving approximately 160 earth stations (131 receive only, 29 transmit/receive) have been approved by NASA to access CTS. Public Service Satellite Consortium has 53 station applications. A total of 104 earth stations will be licensed to entities of the private sector and 56 will be authorized by OTP and operated by one of several Federal Government agencies. Deployment of these earth stations is to take place over the next 12 months (Order 76-74, 58 FCC 2d 345 (1976)).

Westinghouse Communications Services, Inc. has applied for authority to construct and operate an experimental earth station near Baltimore, Maryland, and Lima, Ohio. It will consist of a dual-linearly polarized 4.6 meter antenna (steerable), a 500-watt FM transmitter operating in the 14 GHz range, and a receiver in the 11.9 GHz range or 12.1 GHz range.

COMSAT filed an application to construct and operate earth stations near Clarksburg, Maryland, and elsewhere. It would consist of a 4.6 meter antenna with dual-linearly polarized feed, a 20-watt frequency modulated transmitter, and a 24-foot modified boat trailer on which the antenna, transmitter, and receiver are mounted. Subsequently, COMSAT also applied for authority to construct and operate a transportable experimental earth station at various other unspecified locations throughout the continental United States and Alaska. This proposed earth station will consist of a 1.22 meter parabolic antenna mounted on a commercial tripod and associated 20-watt FM transmitter and receivers.

NASA filed four separate applications with OTP for authority to construct and operate experimental earth stations at various locations throughout the United States.

(1) Goddard Space Flight Center -- using a 4.6 meter antenna and a 3 meter antenna with associated transmitters and receivers.

(2) Rosman Tracking Station in North Carolina -- using a 4.6 meter antenna and a 1.6 kW frequency modulated transmitter in the same 14 GHz range.

(3) Lewis Research Center in Ohio -- using a 4.9 meter antenna and a 1.6 kW FM transmitter and associated receivers.

(4) Ames Laboratories in California -- using a 3 meter parabolic antenna and a 1.6 kW FM transmitter.

Another NASA application to OTP concerns earth stations at various unspecified locations throughout the United States and Canada, using a standard horn antenna of 17 dB gain and a 250-watt FM transmitter.

Satellite Business Systems

Satellite Business Systems (SBS) -- a partnership sponsored by COMSAT General Corp., IBM, and the Aetna Casualty and Surety Company -- proposes to provide wideband, switched, all digital transmission services (voice, data, and image) using the 12/14 GHz bands with 5 and 7 meter antennas. The intention is to locate the earth station at the customer's site. The available high power satellite technology (200 watt transponders) of CTS is not planned for the SBS satellite. They plan to use 10-20 watt tubes.

The SBS system is intended to serve organizations requiring large communication networks with heavy and dynamic loads using Time Division Multiple Access (TDMA) demand assigned techniques, without interconnection to the terrestrial common carrier network. SBS has asked the FCC to authorize Phase I operations on leased transponders in the 4/6 GHz bands to help develop technology. Seven 4/6 GHz earth stations are planned, with the first two at Poughkeepsie, New York, and Los Gatos, California.

SBS plans two satellites in orbit (116 and 122 degrees West longitude) with a ground spare, estimated to cost $119 million. Each satellite will have 8 transponders (61 MHz spacing with 54 MHz or 88.5 percent useable bandwidth), each with 20 watts power output. Satellite orbital station keeping in longitude and latitude is estimated as ±0.05 degrees. Delta 3914 launch vehicles would be used. Total estimated system costs are $250.6 million to August 1979 when commercial operations are expected to begin. More recently, SBS has furnished the FCC with estimates of $235.5 million costs from January 1971 to the start of commercial operations, and total estimated costs to the end of 1986 of

$406.9 million. SBS has also stated that market demand is estimated to require about 190,000 voice circuits and 7,500 earth stations by 1985 in the United States. SBS plans a growth of their system from 78 in 1979 to 375 in 1983.

Orbital spacing between SBS and the CTS satellites is recommended as 6 degrees, with spacings of 3 degrees possible between SBS satellites. The CTS design life of 2 years is expected to expire before 1979 operations. The system capacity objectives are 328 Mb/s per satellite (41 Mb/s per transponder). Link availability objectives are 99.5 percent -- planned for a bit error rate of 1x10-4, or 1x10-7 if the higher performance option with forward error control is selected by the customer. The SBS earth stations, planned for unattended operation, would have a minimum of 16 voice-grade access ports or one high speed (56 Kb/s or greater) data port. Variable TDMA "time slots" will be assigned at each earth station. The 5 meter antennas will be used in SBS region 1. (The satellite coverage area is approximately bounded by New York to Jacksonville, Florida, to Little Rock, Arkansas, to Kansas City, Missouri, to Chicago, Illinois, to Detroit, Michigan, to New York.)

The 7 meter antennas will be in SBS region 2 (most of the remainder of the contiguous United States). Estimated costs of one typical unattended earth station were $474,000. Total system ground segment costs for 37 earth stations were estimated as $24.7 million ($668,000 average). Customers will have to make some modification to existing data communication terminals because of the SBS system characteristics and the round trip delays due to propagation time.

OTHER 12/14 GHz SATELLITE EARTH STATIONS

Inasmuch as the ATS-6, the first broadcast satellite for small antennas, gives excellent TV reception with 3 meter antennas at 2.5 GHz, many of these terminals are being modified for use with CTS with a special 12 GHz to 2.5 GHz frequency converter. CTS will use antennas as previously noted. The Japan Broadcast Company has developed an inexpensive conversion kit ($350) to enable individual TV set owners to receive directly from the Japanese Broadcasting Satellite (planned for about 1978 launch). West Germany is developing a 700 watt satellite transmitter for 12 GHz, which could broadcast to 1-meter antennas.

19/28 GHz

AT&T is investigating the 19/28 GHz band, and this step includes transmitter beacons on the 4/6 GHz COMSTAR satellite. The beacon will permit more exact measurements of frequency dispersion, rain, and propagation statistics throughout the United States. AT&T and Bell Laboratory management are seeking participation of others in these measurements since they will not operate more than a dozen test sites. Test data would be exchanged among all participants. AT&T plans to use high powered, narrow antenna beam satellites at 19/28 GHz with large earth stations to achieve 99.99 percent reliability and high channel capacity.

Japan is having a domestic communications satellite built (in the United States) which is expected to be launched near the end of 1977. In addition to operations in the 4/6 GHz band, it will have 19/28 GHz band transponders to cover the four main islands of Japan.

MILITARY SATELLITES

The satellites developed for DOD applications have requirements for operation in different frequency bands and for secure communications with high survivability in hostile environments. The Defense Satellite Communications System (DSCS) is the main program with DSCS-III under development. FLTSATCOM is another system to provide communications for ships and aircraft, with AFSATCOM to provide subsequent communications with aircraft. The DOD satellite programs are working with advanced technology which will eventually impact in the commercial satellite communication equipments. These include a multibeam, low sidelobe, electronically steerable antenna with multiple feed horns and an RF lens.

TRENDS

In any assessment of the present status of systems and technology, it is important to identify trends in the performance and costs of systems and their component parts. Such assessments exist and were available, but the scope of this effort did not permit inclusion of useful summaries here.

OTHER

It has been reported that the State of Alaska has purchased single channel per carrier FM small earth stations (on the order of 140) at a cost near $37,000 each in quantities of 100. This figure does not include installation. A 4.57 meter Andrew Corp. antenna was used with California Microwave and Hughes Aircraft terminal equipment.

The Satellite Working Group -- a user consortium which includes the Corporation for Public Broadcasting, the Public Broadcasting Service (PBS), and National Public Radio -- recently announced plans to use the Western Union WESTAR satellite for distribution of PBS television programming. Collins Radio Group was selected to provide 165 receive-only earth stations at a total capital cost of $38.4 million which includes a master origination terminal ($5 million), five regional two-way terminals for regional origination ($1.25 million), and an estimated termination payment to AT&T, which provides the current terrestrial distribution ($1.1 million). Costs for the receive-only earth stations average $188,000.

Within the United States, for CATV application as an example, video earth terminals are off-the-shelf for the 4/6 GHz band: Scientific-Atlanta and the Andrew Corp. have 10 meter video receive-only terminals for about $65,000, although the installed cost may be as high as $100,000. Smaller earth terminals with 4.8 meter antennas cost around $30,000 for the equipment. Small earth terminals are also available from other U. S. manufacturers, such as Aeronutronic-Ford and California Microwave.

APPENDIX D

TABLES ON BROADBAND COMMUNICATIONS NETWORKS

Table 1

EDUCATION AND TRAINING

Telecommunications Capability	Use	System	Findings
Local Broadcast TV			
Hagerstown, Md	offers a series of specialized courses in the sciences not otherwise available due to a lack of staff	CCTV	Student performance improved with use of television, program began in 1956 and has expanded to other disciplines.
Indiana University	presents credit courses for graduate and undergraduate students as well as continuing professional education courses	CCTV	System operational since 1967, has opened up new channels of communication to other universities and between college administrators.
University of Florida – GENESYS	keeps professionals abreast of technological advances and retrains industrial employees for industry production changes	CCTV with talkback capability	Program operational over eight years and has awarded over 200 advanced degrees, industry uses program to foster professional competence and remain competitive.
Ft Hood – Central Texas College	broadcast of sociology and business courses from Central Texas College	post CATV interconnected to CTC studio	Students can get credit for courses taken at home
British Open University	offers university level courses to adults who couldn't otherwise attend a university	broadcast television to large adult population	Pilot program currently under study
New Telephone Features			
University of Wisconsin	educational programs presented as live or taped lectures followed by questions, conferencing possible	telephone network linking hospitals, campus and courthouses	System began modestly but has expanded to include many different credit courses and professional courses
Man Machine Interaction			
Keesler AFB	basic electronics training course	Lincoln Training System; interactive computer, audio microfilm display	Basic electronics training time reduced 37%
Ft Monmouth, N J	Army basic electronics course	clustered minicomputers with 128 interactive display terminals	Initial trial demonstrated reduction in training time by 20% Prototype evaluation of new system scheduled for 1975
Ohio State University	teach economics and English to individual students	IBM computer and remote terminals	Self paced and student initiated instruction, excellent campus acceptance
USMA, West Point	assist in teaching courses such as engineering, management economics and math	Honeywell H635, time share terminals, teleprinters and CRT, CCTV	Ongoing since 1962, cadet education in problem solving and data processing applications
Univ of Illinois – PLATO	drill and practice and student directed inquiry programs on courses from elementary to post graduate levels	plasma panel interactive terminals and computer	Program has value as an educational tool, but cost per student terminal hour is higher than conventional methods Use of plasma panel aims at reducing costs
Dartmouth College	provide students at remote locations with problem solving capabilities	computer time sharing, special software language called BASIC	With an easy to learn language, students from many disciplines can use computer, slower students can also productively use computer
Stanford University	computer assisted instruction from elementary to university levels	medium-size computer, CRT and typewriter keyboard	CAI is a great aid in quality control, repetitive work and in individual learning situations
TICCIT, MITRE Corp under NSF Sponsorship	courses in freshman and remedial math and English	interactive color television and CAI courseware	To undergo evaluation at junior colleges in Ariz and Va
Ft Benning and Ft Carson Individual Learning Centers	self-paced individual instruction in most areas	slides, video cassettes and other material	Expanding to other Army troop posts

Source for Tables 1 through 6:
The Mitre Corporation, "System Definition for Army Wired Garrison C-E Design," Volume III - Appendices (Fort Huachuca, Arizona, U. S. Army Communications Command, July 1974).

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Table 2

HEALTH CARE

Telecommunications Capability	Use	System	Findings
Local Broadcast TV			
Calif Medical TV Network	transmit medical programming over educ. TV	educational TV broadcast	Program folded due to administrative, cost and scheduling difficulties.
La Hospital TV Network	educational programming for medical professions	statewide microwave and local CATV of South Central Bell	Ongoing since 1967, program has spread into many different medical institutions
Ga Regional Medical TV Network	live programming to various medical institutions in the metro Atlanta area	2 channel ITFS (Instructional TV Fixed Service) System	Limited to line of sight coverage, but relatively small costs due to use of ITFS network
Network for Continuing Medical Education (New York)	video transmission of biweekly medical journal	east coast microwave channels connected with CATV systems	Positive physician acceptance; more than 1,000 doctors receive program; in its third year.
Salem Hospital (Salem, Mass.)	instructional TV for patients, especially bed-ridden patients	CCTV	High patient acceptance for interesting programming
Nebraska Psychiatric Institute at Omaha and Norfolk State Mental Hospital	staff education and psychiatric consultation	2-way CCTV	Ongoing since 1964, program has served as a model for many subsequent efforts. Achieved greater capabilities and staff morale
Alaskan Satellite Network	transfer medical info. seven days a week	voice link through NASA ATS-I satellite	Project began in August, 1971 and is in operation today.
New Telephone Features			
La Hospital TV Network	educational programming for medical professions	improvement on telephone cable systems for broadband TV distribution	Ongoing since 1967, programs allow better exchange of information between medical professionals.
Man Machine Interaction			
Wisconsin Medical Center	immediate information on medical subjects for use in emergencies	tape library accessed by telephone	24-hour service available all over the state.
Univ. of Wisconsin Medical School	source data automation of patient medical histories	keyboard and CRT device	Saves physician time, Upgrades and standardizes medical history records.
Activated Patient (George Washington U.)	self-help and preventive medicine for people	interactive TV	Sustained student attendance indicated students perceived course as meaningful.
Army Medical Outpatient System (AMOS)	paramedic training and patient screening	on-line CRTs to interactive computer	Positive patient acceptance, more efficient treatment, paper based system being expanded Army wide.
Beth Israel Hospital, Boston, Mass.	patient interviews for primary diagnosis and dispensation	interactive terminals and computer	Computer failed to improve efficiency of diagnosis above the level of a well trained health aide. Computer has been eliminated
Desk to-Desk Paper			
N Y C. Health Services Admin.	transfer of patient records and medical tests between facilities	facsimile	Proposal would reduce unit service costs by 10 to 30 percent.
Boston City Hospital	link physician in hospital and nurse practioner at nursing home in diagnosis	telephone and facsimile transmission capability	Project reduces demand on hospital emergency room and offers 24-hour, seven-day, on-call physician service. Difficulty in measuring quality of medical care.
Multi-Media Teleconferencing			
Mass Gen Hosp. – Logan Airport	telediagnosis and teleconsultation between hospital and airport	two-way sound and picture over microwave	Working system since 1968. Picture great help in diagnosis.
Medinav (U.S. Navy)	interactive telemedicine for medically isolated units	black and white TV; alphanumerics and graphics, store and forward transmission	Program aims at solving rising medical costs, medical isolation of missions and short fall of physicians due to end of draft.

Source: MITRE Corp.

Table 2 (concluded)

Telecommunications Capability	Use	System	Findings
N Y C. Health Services Administration	telemedicine for neighborhood pediatric centers and nearby hospital	2-way CCTV facsimile	Proposal would reduce unit service costs by 10 to 30 percent.
Mt Sinai Hospital, N Y., N Y.	teleconsultation between hospitals and neighborhood clinics	2-way coaxial cables with TV terminals	Nurses can now handle 60% of patient cases as opposed to 25-30% before teleconsultation capability
NASA Telecare, Houston	full duplex communication between emergency technician	telemetry of patient vital signs — SCI Systems, Inc. Houston	Based on NASA technology, 28 rescue vehicles are equipped with units.
U. of Alabama School of Dentistry	dental surgery training conducted using monitors	interactive audio-video transmission	Economizes on instructor time, a number of procedures can be monitored concurrently, students instructed without patient knowledge.
Mass. Gen. Hosp — Bedford V.A Hosp	psychiatric diagnosis by teleconsultation	2-way sound and picture with videotape playback	System increases sharing of professional opinion. Video playback.
Vt. — N H Medical Network	medical conferencing on a variety of fields, speech, therapy, psychiatric consultation	interactive television by microwave	Conferences held 4 times weekly; well attended.

Source: MITRE Corp.

Table 3

PERSONAL COMMUNICATIONS

Telecommunications Capability	Use	System	Findings
Local Broadcast TV			
Newark, N. J.	first-run movies offered in hotel rooms at a price	CCTV with computer registering bill; converter to unscramble signal	High successful system of pay TV on CCTV or CATV, system will be expanded to other hotels.
Hartford, Conn	first run movies and sports	broadcast TV; converter	Poor consumer penetration; project closed after 7 years due to financial losses. Recent systems are more successful
Reston, Va.	tax filing assistance, electronic mail, home entertainment games, etc.	computer with microwave link, push-button phones, video tape recorder, 2-way voice & video	Technology readiness demonstrated.
New Telephone Features			
Louisville, Ky, Call-a-Mart	in-home shopping via computer	computer-telephone network with third party conferencing with keypunch	Commercially successful ongoing program, initial membership limited to 300 families; overcomes warehouse problems
Sacramento, Calif. Store-to-Door Inc.	in-home shopping via computer	computer-telephone network	System closed due to software limitations and warehouse problems.
Coral Springs, Fla	all electric home with intercom and outside telephone links	telephone and intercom switching networks	Kitchen and bedroom command post allows telephone and intercom communication throughout home and to outside telephone links.
Man-Machine Interaction			
Reston, Va	interactive game playing and tax filing assistance	push-button phone and computer	Technology is ready.
Sacramento, Calif.	in-home shopping via computer	computer-telephone network	Interaction with computer file; other project limitations closed system down.
Louisville, Ky	in home shopping via computer	computer telephone network	Commercially successful ongoing program.
Multi Media Teleconferencing			
Center for Policy Research, N.Y.C., Project Minerva	electronic town meeting	2-way conferencing by telephone and television	Greater community participation and communication.

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Source: MITRE Corp.

Table 4

COMMUNITY SERVICES

Telecommunications Capability	Use	System	Findings
Local Broadcast TV			
Ft. Hood & Ft. Polk	regularly scheduled TV information program	local CATV	Easier personnel adjustment to a new base.
Colorado Springs, Colo.	weekly TV magazine to demonstrate community organization activities	local CATV	Good audience response.
Reston, Va.	weekly "consumer interest" show	local CATV	Positive consumer acceptance warrants continued programming.
Charlottesville, Va.	monthly "consumer information" show	local CATV	Encourages registration of consumer complaints; justified continuation of program.
Man-Machine Interaction			
Reston, Va	interactive information requests on community services and news	computer, MICROWAVE CATV, push-button phone	Project led to greater interest by social-science community in the near term impact of communications-electronics.
Chattanooga, Tenn.	interactive information requests on community service agencies	12 remote video-keyboard terminals connected by telephone line to central computer.	System very helpful in streamlining operations of local human service agencies; will eliminate duplicated efforts and reduce administrative costs.
Philadelphia, Pa.	information and referral of social agency clients	remote keyboard terminals enter client info; computes searches files and makes referral	Program operates on yearly budget of $32,000. Model Cities feels the system is one of the country's best.
National Science Foundation – Stockton, Calif.	in-home retrieval of municipal services information, schedules and programs	interactive television accessing computer resource via 2-way CATV	Multimillion dollar demonstration system funded by NSF.
Jonathan/Chaska, Minn.	consumer experiences in education, home security, opinion polling, entertainment, information retrieval and data communications.	2-way interactive CATV	Pilot program currently under study.

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Table 5

SAFETY & SECURITY

Telecommunications Capability	Use	System	Findings
Local Broadcast TV			
Mt. Vernon, N.Y	round the clock surveillance of two down-town intersections	remote control, low light level, all weather TV cameras, monitor at police station	Operational since 1970, system has led to a lower crime rate and higher arrest rate in neighborhood
New Telephone Features			
Coral Springs, Fla	burglar and fire alarm	telephone and intercom switching networks	Family has ability to access emergency help through special switching from phone or intercom terminal.
Desk to Desk Paper			
Costa Mesa, Calif	dictation of reports with full editing control from a remote location	dictaphone word processing thought tanks and automatic typewriters	System successful costwise, accepted by the officers, allows security for individual officer reports.
Man Machine Interaction			
Tulsa Police Dept	computer search of microfilm files for criminal suspects	computer controlled microfilm storage and viewing system	Successfully operated; provides a more efficient and secure procedure for checking criminal records.
St. Louis Police Dept.	automatic monitor and display of police vehicle location and status	minicomputer and visual display in central dispatch, inertial navigation equipment and radio transmitters in the vehicles	Reduces elapsed time from receipt of call for help to the arrival of policeman at the scene.
Monroe, Ga	fire and burglar alarm sensors in 12 municipal buildings	transmitters and sensors in each building, computer to decode alarm signals; software	Some technical problems, system should be operational early this year.

Source: MITRE Corp.

Table 6

ADMINISTRATIVE

Telecommunications Capability	Use	System	Findings
Local Broadcast TV			
World Trade Center	in final planning stage, tenants will view film & videotaped material stored in Information Center	multi pair cable, 12-button tone generator for program selection, audio-video monitor, facsimile printer	Allows both viewer privacy or conferencing if desired; tenants have ability to prepare their own videotapes.
New Telephone Features			
Switchless Telephone	automatic rerouting, add-on conference, abbreviated dialing	frequency division multiplex on wideband 2-way cable	Recently developed by Collins Radio; no real information yet in operational situations.
Desk to Desk Paper			
U.S. Army – ATCAP	direct access to on post data processors and local Autodin terminal	variety of user data terminals connected to message center communications processor	Being implemented at 3 Army posts in first phase, eventual Army-wide implementation to achieve reduced personnel in Autodin message centers.
Graphnet	National Electronic Mail System	store and forward facsimile	Implementation awaiting approval by FCC
Man Machine Interaction			
Minnesota State Legislature	text editing for drafting bills	interactive CRT's and IBM 370 computer	Significant reduction of search and bill draft turnaround time.
U.S. Dept. of Interior, Bureau of Reclamation	prepare technical reports, publications and specification reports	IBM word processing center, IBM Magnetic Tape Selectric Typewriter & Composer	Reduced printing costs by 40% eliminated some typing and steno help.
Redstone Arsenal	prepare procurement documents	teletypewriter terminals and central computer. Automated Engineering Document Preparation System	Would reduce cost and time to prepare specification and purchase descriptions: purchase document cost estimated at $27 as opposed to $500 today.
Los Angeles County	process and store all welfare applications, payments and case histories in the county	150 remote video keyboard terminals in welfare offices and hospitals, leased telephone lines, disc storage and central computer	Program being implemented, attempts to improve overall efficiency of county welfare system.
Multi-Media Teleconferencing			
Communications Study Group, University College, London	conducting experimental and analytical studies of person-to-person telecommunications	multi-faceted standard telephone, fast facsimile and television	Person-to-person teleconferencing can be cost effective, but significant human factors problems remain
Goldmark Communications, Conn.	links separated bank facilities for conferencing	2 communication terminals, specially-connected microphone, leased lines from N.E. Telephone Co.	Pilot program saves travel time and expense.
Institute for the Future	organize and improve the collective work of experts using message entry, storage and retrieval	special computer program accessed from remote terminals over ARPA network	U.S. Geological Survey experiments show it to be a useful tool.
Picturephone, AT&T	face to face teleconferencing in offices, stores, hospitals	switched broadband network added to telephone system	Only 500 installations; system and marketing approach under review by Bell System

Source: MITRE Corp.

Table 7

SUMMARY OF MEDIAN FORECASTS

Service	Average $ Value of One Conversation: Low	Middle	High	Duration of Single Transaction (min)	Data Transmission Connect Time (%)	Avg. No. of Transactions/Mo./Home	% of Service Home Subscriber Expected to Pay	Most Likely Year of Introduction: Early	Middle	Late	% Penetration of All U.S. Households	Median Transmit Time (min)	Average Value of Service, $/Subscribing Household/Mo.: Median	High	Value of Service After 5 Years, $/Average U.S. Household/Mo. (At Penetration Rates Shown)
1. Cashless society transactions	$0.10	$0.16	$ 0.40	0.75	20%	40	25%	1975	1980	1990	20%	0.29	$ 6.4	$ 12.50	$ 1.00
2. Dedicated newspaper	0.10	0.20	0.50	10.00	95	30	75	1980	1983	1990	10	9.00	6.0	15.00	0.54
3. Computer-aided school instruction	0.50	1.50	3.50	30.00	20	20	50	1975	1982	1987	10	10.00	40.0	100.00	3.75
4. Shopping transactions (store catalogs)	0.20	0.50	1.00	6.00	40	10	25	1977	1985	1990	10	2.50	3.0	5.00	0.38
5. Person-to-person (paid work at home)	0.50	1.50	5.00	20.00	50	60	5	1980	1985	1990	5	6.50	75.0	250.00	3.20
6. Plays and movies from video library	0.60	2.00	5.00	90.00	100	10	60	1975	1980	1985	10	90.00	20.0	50.00	2.00
7. Computer tutor	1.00	2.00	5.00	30.00	20	10	80	1975	1980	1990	5	6.00	20.0	50.00	1.50
8. Message recording	0.20	0.35	1.00	3.00	75	7	90	1975	1980	1985	10	2.50	2.5	6.25	0.20
9. Secretarial assistance	0.35	1.00	3.00	10.00	60	10	100	1975	1980	1985	5	6.00	10.0	25.00	0.25
10. Household mail and messages	0.10	0.20	0.50	2.00	90	25	75	1980	1985	1990	10	1.80	5.0	12.00	0.60
11. Mass mail and direct advertising mail	0.10	0.17	0.50	3.00	90	25	0	1980	1990	1995	10	2.55	4.0	15.00	0.50
12. Answering services	0.10	0.20	0.50	2.00	80	20	100	1975	1980	1985	10	1.60	5.0	11.25	0.30
13. Grocery price list, information, and ordering	0.20	0.35	0.50	5.00	80	15	50	1975	1980	1990	10	4.25	5.0	7.50	0.26
14. Access to company files	0.30	0.60	2.00	5.00	65	10	1	1980	1985	1990	2	3.50	15.0	50.00	0.30
15. Fares and ticket reservation	0.20	0.35	0.75	5.00	50	5	40	1975	1980	1985	5	2.50	1.0	2.50	0.05
16. Past and forthcoming events	0.10	0.20	0.50	4.00	80	10	50	1975	1982	1990	5	2.70	2.0	5.00	0.11
17. Correspondence school	1.00	2.00	5.00	40.00	85	10	75	1978	1984	1990	5	30.00	20.0	50.00	0.75
18. Daily calendar and reminder of appointments	0.10	0.20	0.50	1.00	80	25	100	1980	1983	1985	5	0.95	4.0	10.00	0.20
19. Computer-assisted meetings	1.00	2.00	5.00	30.00	40	5	40	1975	1980	1985	5	6.00	15.0	91.00	0.75
20. Newspaper, electronic, general	0.20	0.50	0.75	10.00	95	30	75	1980	1985	1990	5	9.00	15.0	22.50	0.75
21. Adult evening courses on television	0.60	1.00	5.00	50.00	95	10	80	1975	1980	1985	10	45.00	10.0	25.00	0.88
22. Banking services	0.10	0.25	0.50	2.00	60	20	60	1975	1980	1985	10	0.85	4.0	10.00	0.38
23. Legal information	1.00	5.00	15.00	10.00	75	5	100	1980	1985	1990	3	7.50	6.0	25.00	0.25
24. Special sales information	0.20	0.50	1.00	4.00	70	10	80	1975	1982	1990	5	2.70	5.0	10.00	0.25
25. Consumers' advisory service	0.25	0.50	1.00	5.00	70	10	100	1975	1980	1985	5	3.50	7.5	10.00	0.40
26. Weather bureau	0.10	0.20	0.50	1.00	90	20	100	1975	1980	1980	5	0.90	2.0	5.00	0.12
27. Bus, train, and air scheduling	0.10	0.20	0.50	1.25	80	5	80	1975	1977	1980	5	1.00	0.5	1.00	0.06
28. Restaurants	0.10	0.20	0.50	3.00	80	5	60	1975	1980	1985	5	2.50	1.0	2.50	0.05
29. Library access	0.50	1.00	2.00	10.00	90	5	100	1980	1985	1990	5	9.00	5.0	10.00	0.25
30. Index, all services	0.10	0.20	0.50	3.00	80	10	50	1975	1980	1985	5	2.50	3.0	5.00	0.10
															$20.12

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Table 8

Brief Descriptions of Potential Home Information Services

1. CASHLESS-SOCIETY TRANSACTIONS. Recording of any financial transactions with a hard copy output to buyer and seller, a permanent record and updating of balance in computer memory.

2. DEDICATED NEWSPAPER. A set of pages with printed and graphic information, possibly including photographs, the organization of which has been predetermined by the user to suit his preferences.

3. COMPUTER-AIDED SCHOOL INSTRUCTION. At the very minimum, the computer determines the day's assignment for each pupil and, at the end of the day, receives the day's progress report. At its most complex, such a service would use a real-time, interactive video color display with voice input and output and an appropriate program suited to each pupil's progress and temperament.

4. SHOPPING TRANSACTIONS (STORE CATALOGS). Interactive programs, perhaps video-assisted, which describe or show goods at request of the buyer, advise him of the price, location, delivery time, etc.

5. PERSON-TO-PERSON (PAID WORK AT HOME). Switched video and facsimile service substituting for normal day's contacts of a middle class managerial personnel where daily contacts are of mostly routine nature. May also apply to contacts with the public of the receptionist, doctor, or his assistant,

6. PLAYS AND MOVIES FROM A VIDEO LIBRARY. Selection of all plays and movies. Color and good sound are required.

7. COMPUTER TUTOR. From a library of self-help programs available, a computer, in an interactive mode, will coach the pupil (typically adult) in the chosen subject.

8. MESSAGE RECORDING. Probably of currently available type, but may include video memory (a patient showing doctor the rash he has developed).

9. SECRETARIAL ASSISTANCE. Written or dictated letters can be typed by a remotely situated secretary.

10. HOUSEHOLD MAIL AND MESSAGES. Letters and notes transmitted directly to or from the house by means of home facsimile machines.

11. MASS MAIL AND DIRECT ADVERTISING MAIL. Higher output, larger-sized pages, color output may be necessary to attract the attention of the recipient -- otherwise similar to item 10, above.

12. ANSWERING SERVICES Stored incoming messages or notes whom to call -- possibly computer logic recognizing emergency situation and diverting the call

13. GROCERY PRICE LIST, INFORMATION, AND ORDERING. Grocery price list is used as an example of up-to-the-minute, updated information about perishable foodstuffs. Video color display may be needed to examine selected merchandise. Ordering follows

14. ACCESS TO COMPANY FILES. Information in files is coded for security; regularly updated files are available with cross-references indicating the code where more detailed information is stored. Synthesis also may be available.

15. FARES AND TICKET RESERVATION. As provided by travel agencies now but more comprehensive and faster. Cheapest rates, information on regarding the differences between carriers with respect to service, menus, etc. may be available.

16. PAST AND FORTHCOMING EVENTS. Events, dates of events and their brief description, short previews of future theater plays; and recordings of past events.

17. CORRESPONDENCE SCHOOL. Taped or live high school, university, and vocational courses available on request with an option to either adult or graduate. Course on TV, paper support on facsimile.

18. DAILY CALENDAR AND REMINDER ABOUT APPOINTMENTS. Prerecorded special appointments and regularly occurring appointments stored as a programmed reminder.

19. COMPUTER-ASSISTED MEETINGS. The computer participates as a partner in a meeting, answering questions of fact, deriving correlations, and extrapolating trends.

20. NEWSPAPER, ELECTRONIC, GENERAL. Daily newspaper, possibly printed during the night, available in time for breakfast. Special editions following major news breaks.

21. ADULT EVENING COURSES ON TV. Noninteractive, broadcast mode, live courses on TV -- wider choice of subjects than at present.

22. BANKING SERVICES. Money orders, transfers, advice.

23. LEGAL INFORMATION. Directory of lawyers, computerized legal counseling giving precedents, rulings in similar cases, describing jurisdiction of various courts and changes of successful suits in a particular area of litigation.

24. SPECIAL SALES INFORMATION. Any sales within the distance specified by the user and for items specified by him will be "flashed" onto the home display unit.

25. CONSUMERS' ADVISORY SERVICE. Equivalent of Consumer Reports, giving best buy, products rated "acceptable", etc.

26. WEATHER BUREAU. Country-wide, regional forecasts or special forecasts (farmers, fishermen), hurricane and tornado warnings similar to current special forecast services.

27. BUS, TRAIN, AND AIR SCHEDULING. Centrally available information with one number to call.

28. RESTAURANTS. Following a query for a type of restaurant (Japanese, for instance), reservations, menu, prices as shown. Displays of dishes, location of tables, may be included.

29. LIBRARY ACCESS. After an interactive "browsing" with a "librarian computer" and a quotation for the cost of hard copy facsimile or a slow-scan video transmission, a book or a magazine is transmitted to the home.

30. INDEX, ALL SERVICES SERVED BY THE HOME TERMINAL: Includes prices or charges of the above, or available communications services.

APPENDIX E

ADDITIONAL TECHNICAL DETAILS ON THE STATUS OF FIBER OPTIC COMMUNICATIONS

1. DOMESTIC STATUS

THE COMMON CARRIERS

Bell Laboratories, in support of the largest U. S. telephone network, has mounted the most intensive and sustained single domestic R&D program in fiber optic communication (FOC) development. The effort covers every aspect of the technology and has undoubtedly spurred the rapid worldwide acceleration in advanced R&D. An empirical measure of the readiness of their systems technology for network application is the announcement (Bell Labs, 1975; Electronics, 1976) of their first link tests under field conditions, started in early 1976 (see table 1). The purpose of the experimental systems is to evaluate feasibility of FOC for use between AT&T metropolitan switching offices. Cable will be installed in existing ducts and manholes.

GTE Laboratories, the R&D arm of the Nation's second largest carrier, is also heavily committed to state of the art R&D, targeted at potential FOC incorporation into their telephone network. Plans have been announced (Electronics, 1976) for an operational field trial, probably in late 1976. The interoffice trunking link (see table 1) will be employed by GTE Service Corporation for field environment evaluation of FOC concepts and systems components, especially the optical cable.

ITT, a major international supplier to the carrier industry, has committed a comprehensive effort to FOC technology development.

Due to the lack of extensive R&D facilities, the smaller telephone companies as well as most of the private data carriers are not expected to contribute substantially to the advanced developmental stages of the technology; but they should eventually represent an appreciable market for mature commercial hardware.

Table 1. Representative U. S. Experimental/Prototype Fiber Optical Communication Systems

FIRM/AGENCY	TRANSMISSION RATE	PATH LENGTH	DEVELOPMENTAL STATUS	DATE ANNOUN.	SPECIAL FEATURES, PROPOSED APPLICATIONS/SECOND GENERATION UP-DATING
Bell Labs.	a. 1.544 Mb/s b. 44.7 Mb/s	See special features	Operational field experiment (Atlanta, GA)	1975	Ruggedized, 100-fiber cable (600 m length; "loop" splicing of fibers will provide multi-km links); manhole and duct, installation; pluggable connectors; miniaturized transmitter, receiver, repeater module packaging. Goal: starting in early 1976, evaluation for use between Bell metropolitan switching offices.
GTE Labs. Inc.	6.3 Mb/s (T-2)	200 m (repeater at mid-point)	Laboratory test bed system	1975	Full-duplex operation using a single graded-index fiber in each direction; multiplexing of telephone, picture telephone and bit-error test signals; simulation of operating field system by interfacing with existing network terminal equipment. Modular packaging includes connectors compatible with all optical components.
GTE Service Corp.	1.544 Mb/s (T-1)	------	Operational field experiment	1975	The test will take place, using existing links, at an operating GTE facility, probably on the West Coast. The system, which will use an electronic/optical interface, is designed to prove FOC concepts and evaluate componentry, especially cables in a field environment (inter-office trunking).
USAECOM Ft. Monmouth, NJ	2.304 Mb/s (full duplex)	1 km	Exp. lab. feasibility model	1975	Determination of feasibility of replacing CS-1123 dual coaxial cable with 6-fiber ruggedized cable for Army long-haul data trunks. Goals: 2 Mb/s to 20 Mb/s, up to 8 km w/o repeaters, 2 Mb/s up to 64 km with repeaters. Replacement appears desirable from technical and cost standpoints.
	32 kb/s or 4 kHz voice (4 channels, full-duplex)	334 m	Exp. lab. feasibility model	1975	Determination of feasibility of replacing CX-4566 (26 wire-pair) cable with 6-fiber ruggedized cable for Army local distribution nets. Goal: Mixture of 4 kHz voice and 32 kb/s CVSD voice up to 300 m. Replacement appears highly desirable technically and is cost effective for paths over 75 m.
Wright-Patterson AFB Contractor: Spectronics, Inc.	10 channel - 15 Mb/s	15-53 m	Prototype multi-channel point-to-point system	1974	Performance evaluation of FOG against other transmission media under consideration for advanced military systems. Features use of connector-packaged sources and detectors and both high-loss and low-loss fibers. Path length extendable with low-loss fibers. Projected up-dating to 100-150Mb/s

FIRM/AGENCY	TRANSMISSION RATE	PATH LENGTH	DEVELOPMENTAL STATUS	DATE ANNOUN.	SPECIAL FEATURES, PROPOSED APPLICATIONS/SECOND GENERATION UP-DATING
Wright-Patterson AFB Contractor: Hughes Research Laboratories	10 MHz	30 m bus length	Exp. avionics system flight tested	1975	7-Port star coupler data bus integrated with Hughes' Fault-Tolerant-Digital-Airborne-Data System to carry flight-control signals. Goal: evaluation of FOC data bus for multiplexed signals in fly-by-wire flight control system.
NASA Kennedy Space Ctr. w/contractors: •Corning Glass Works •Harris, Inc. •EMR, Telemetry •Coherent Assoc.	40(1.5 Mb/s) Channels + mix of var. analog data, voice, and video	1.8 km	Prototype field trial (interbldg.) planned to be operational early 1976.	1975	Uses 10-fiber armoured cable, directly - buried and/or duct-pulled; overall systems design includes multiplexing on single fibers. Goal: evaluation of FOC as potential future replacement for NASA (KSC)'s 4000 km wideband cable system.
Naval Electronics Laboratory Center	---------	Total data bus cable length 68 m	Airborne avionics systems evaluation	1974 to present	Replacement of 576 m of copper wire connecting A-7 aircraft cockpit with avionics bay and tactical computer with 68 m of optical cable; multiplexing reduced number of signal channels from 118 to 13, total cable + connector weight from 14.5 kg to 1.2 kg, at lower cost.
Collins Radio (Rockwell-Internat'l Corp.)	800 kb/s (100 voice channels)	0.5 km; 30 m between regen. repeater stations	Prototype interfacility digital intercom system	1975	Full-duplex (TDM-multiplexed) operation with 2 optical cables replacing 200 copper wire pairs; design emphasis: low cost, reliability, flexibility for other digital applications: optical sources, detectors, cables built into commercial BNC connectors. Planned extension of interbldg. links to 1 km and 44.7 Mb/s.
Harris Elec. Systems Div.	80 MHz	300 m	Laboratory experiment	1975	FDM multiplexing (using 1 low-loss bundle) of three 5 MHz video channels, three 4 MHz digital channels and three 1 MHz audio channels: modified SMA connectors; compensation schemes under consideration to overcome LED nonlinearity for improved intermodulation performance.
Xerox Palo Alto Res. Ctr.	150 Mb/s	500 m	Laboratory experiment	1975	Single fiber with new-type stripe geometry laser/LED yields high coupling efficiency, low pulse dispersion; planned up-dating; interbuilding link; 360 m cable, 6 independent channels.
ITT-EO Products Division	30 Mb/s	6.8 km	Laboratory experiment	1975	Graded index ITT fiber; ITT laser transmitter; PIN detector.

Optical Fibers and Cables

Corning Glass Works marketed the first commercially-available ruggedized cable last year under the trademark CORGUIDE. In addition to its domestic market, Corning has announced international agreements with several west European cable manufacturers, involving export of low-loss fibers.

The Electro-Optics Division of ITT has developed several types of fibers and ruggedized cables aimed at military systems but potentially applicable to commercial markets. ITT has recently issued its first data sheets detailing a line of general-purpose fiber cables (Electronics, 1976).

General Cable Systems Corporation announced (in their 1974 annual report) the equipping of their laboratory with new apparatus capable of producing optical cable in quantities adequate for evaluation in future field tests. General Cable (private communication, telegram from G. H. Foot to A. G. Hanson, March 1976) is supplying the fiber cable for the upcoming GTE field test.

Established volume-manufacturers of medium- and high-loss fibers (e.g., Galileo Electro-Optics Corporation and Valtec Corporation, Electro Fiber Optics Division) are producing fibers and fiber bundles with attenuation in the 10 dB/km or less region. New, small firms devoted exclusively to production of low-loss, jacketed fibers are being formed (e.g., Fiber Communication, Inc., and Fiber Optics Corp.). Some of the optical fiber manufacturers, although not perhaps deeply involved in systems technology, offer relatively uncomplicated systems as commercial items. Various manufacturers offer fiber-termination hardware ranging from simple end-ferrules to sophisticated multiple-access couplers.

Devices

Intensive R&D continues in the development of efficient, fast-response semiconductor optical sources (LED's and injection lasers) and sources (PIN photodiodes and avalanche photodiodes) for FOC systems applications. The technological status of prototype FOC systems attests to the current success of this overall effort; and steady progress is being made in further optimization of such parameters as source/fiber coupling efficiency, device lifetimes, etc.

The R&D activities of some device manufacturers are not limited to the optoelectronic transducers but extend to development of various stages of systems hardware ranging from integral connector-packaging of fibers and sources (or detectors), transceiver modules providing compatible optical/electrical interfacing, to prototype systems. Some are planning ahead for the rapidly-growing need for test instrumentation.

Firms heavily committed to the device field include: RCA; Texas Instruments; Hewlett-Packard; Motorola; Laser Diode Labs., Inc.; Spectronics, Inc.; ITT; and EG&G. Electrical connector manufacturers who have announced developmental work in FOC connectors include ITT/Cannon; Deutsch; and AMP, Inc.

Systems

Systems R&D is evolving from laboratory breadboard circuits to experimental field trials in hostile environments and in some commercial applications. Telephone network and DOD/NASA-oriented operational prototypes are in the forefront for predictable economic reasons: well-defined future applications of sufficient size as to promote economies of scale in production. In comparison with DOD and telephone companies, the commercial market and the nonmilitary Government agency markets are not yet as clearly defined in terms of volume potential for specific applications -- a deterrent to finalized design of sophisticated systems. There are also obvious proprietary constraints inhibiting public disclosure of specifications of commercial systems prior to marketing. Technology transfer from DOD- and NASA-sponsored work will undoubtedly augment the appreciable level of privately-funded advanced R&D now under way in the private sector.

One of the most extensive corporate R&D systems efforts is being conducted by ITT in their Electro-Optical Products Division. Partially DOD-sponsored, the effort is heavily systems and component oriented, using ITT components such as lasers, connectors, fibers, and cables, as well as commercially-available components where applicable. They have recently acquired a military contract to deliver a 2 km system and have announced a product line of lasers, fibers, cables, and connectors.

Collins Radio (Rockwell International Corp.) has published details of an experimental system (see table 1) and has announced present in-house efforts including a 0.5 km interfacility link, an intercomputer feasibility link, a 100 MHz (approximately) laser receiver, and a digital receiver for a telemetry systems.

Hewlett-Packard has developed a prototype 10 Mb/s transmit-receive module, which they estimate will cost approximately $50 in production quantities. The TTL-compatible module is designed for systems operation up to 600 m or, at a lowered capacity of 2 Mb/s, up to 1 km. Hewlett-Packard is now working on a second generation system designed for 30 Mb/s over a 600 m path. Hewlett-Packard's projections are for off-the-shelf systems sales by the end of 1977. Their immediate goal is for short-haul, low-cost, high-performance medical applications (e.g., connecting some 15 medical instruments). Other perceived applications for such an optical data bus include distributed instrumentation systems, interconnecting computer remote terminals, multiple remote sensors, central processing units, programmable calculators, storage systems, and various multiplex signals. They have also examined building interconnect systems with capacities up to 100 Mb/s.

The experimental Xerox system shown in table 1 indicates their interest in development of broadband, interbuilding systems capability.

Harris Electronic Systems Division's multiplexing experiment, detailed in table 1, is an example of one approach to low-cost systems design. Commercially-available optical sources, detectors, and fibers are employed, with design emphasis upon optimized electronic circuitry.

A few moderately-high capacity, short-haul systems are beginning to appear on the commerical market from firms with DOD systems-design experience. One firm, Spectronics, Inc., (see Wright-Patterson in table 1), which formerly was exclusively a device house, has announced the availability of one analog and two digital systems, with a maximum data rate of 10 Mb/s.

Other firms, such as Hughes Research Labs (see table 1) and TRW, are involved in contractual government FOC support and have not announced commercial systems. IBM has presented analytical papers discussing FOC potential in computer interconnect. A few firms (e.g., American Laser Systems, Inc.; Quadri Corp.; Develco, Inc.; and Meret, Inc.) offer inexpensive, short-haul, moderate capacity general-purpose commercial systems for a variety of applications including use in hostile industrial environments (e.g., where high electromagnetic interference levels require heavy shielding of metallic conductors). Mergers such as the recent Valtec-Laser Diode Laboratories will create new systems capabilities.

THE UNIVERSITY COMMUNITY

A majority of U. S. colleges and universities with large electrical engineering and/or optical departments has become concerned with optical communications, usually both through-the-atmosphere and guided-fiber transmission. A significant portion of the R&D at the universities is sponsored through an on-going program of the National Science Foundation (NSF). The NSF promotes an active interchange between researchers and the broad, potential user community by means of semiannual Grantee-User meetings.

The university effort tends to be largely devoted to fundamental research areas, but covers a broad spectrum ranging from basic materials research to systems performance analysis. Some typical NSF-sponsored program areas include theoretical and experimental investigations of integrated-optics technology, development of continuous-wave dye lasers, design of high-efficiency modulators, exploration of the application of detection theory to quantum communication systems, and acousto-optical switching. Much of the impact of the university research effort will be upon the next generation of FOC systems, in which, for example, integrated optical circuitry is expected to replace at least a portion of the present electronic switching functions, pushing the optical/electronic interface further into terminal equipment.

DEPARTMENT OF DEFENSE

The potential for use of fiber optic cable for military communications (DOD) is extensive. Applications are many and may soon include: (1) long-haul time division multiplex,

(2) base distribution for telephony, (3) remote antenna connect for satellite ground stations to base terminals, (4) computer interconnects, and (5) long-haul pulse code modulation for high bit rate transmission.

Consideration is being given to substitution of fiber optic cables for the conventional hard wired communication cables and harnesses aboard ships and on aircraft.

DOD has announced its commitment to the gradual conversion of military telecommunication systems from analog to digital circuitry. These requirements for digital transmission have caused attention to be focused on FOC where the combination of directly modulated sources (semiconductor laser diodes or light emitting diodes), low attenuation fiber optic cable, and highly efficient solid state optical detectors will make possible TDM systems at 10 to 100 Mb/s over several kilometers without the necessity for repeaters.

The necessary input-output-access requirements of a telecommunication system have caused the development of a variety of coupling and distribution components, such as "STAR" and "T" couplers. This makes possible various types of radial, loop, or T-distributions and provides accessibility to the telecommunication systems with considerable flexibility in network architecture.

DOD has sizeable fiber optic communication programs in all three major branches of the services and has established a TriServices Committee to coordinate development activities in the military to prevent costly duplication of designs and systems.

Listed below are some of the major laboratories involved in extensive optical communications:

(1) U. S. Naval Electronics Laboratory Center -- concerned with shipboard communication links and services in high interference environments.

(2) U. S. Air Force Avionics Laboratory -- concerned with the development of fiber optic data bus links for onboard aircraft communications.

(3) U. S. Electronic Communications Command (Ft. Monmouth) -- concerned with a wide variety of base communication networks.

(4) U. S. Naval Electronics Systems Command -- evaluating fiber optic undersea cables for certain applications as alternatives to conventional cable systems.

(5) U. S. Army Communications Command -- concerned with the wideband communication link between satellite ground terminals and conventional digital communication links such as the DCS.

The Naval Electronics Laboratory, San Diego, has demonstrated a large number of laboratory, land transmission, aircraft, and shipboard systems in which military specifications qualified components are becoming available to meet the rigorous environment in which these systems must operate. Fiber optic computer interconnects have been established at Cheyenne Mountain, Colorado. Demonstration systems have been developed for aircraft, as for example, the ALOFT-A-7 aircraft modifications -- glass fiber cable for copper cable harness. Shipboard digital systems for intraship communications are operational.

For a variety of reasons, the Army considers fiber cable to be an attractive alternative to its existing metallic cable facilities. The Army is impressed with fiber cable's resistance to cross-talk (95 dBm), its quality of nonradiating (thus improving security), its immunity to electromagnetic interference, its relative reduction in weight and volume per unit of bandwidth, and its requiring fewer repeaters for long-haul trunking lines.

A recent review (Dworkin, et al., 1975) was given on the applications of optical waveguides to Army communications. Reproduced below is a table summarizing Army applications:

Summary of Army Applications for Fiber Optics

Short Distance 100m	Moderate Distance 100m - 1km	Long Distance 1km+
1) Intra-shelter wiring.	1) Command post distribution.	1) Down hill PCM cable.
2) Avionics data bus.	2) Special weapons system (CE SAM-D).	2) 60 km PCM cable runs.
3) Antenna connection.	3) Field computer interconnect.	3) Base information transfer system.
4) Base information transfer system.	4) Base information transfer system.	

The table gives applications for various expected lengths of links and various formats of data rate and signal modulation. Two major applications are:

- o Long-haul TDM trunking to transmit data at rates of 2-20 Mb/s at distances up to 64 kilometers with repeaters.
- o Local distribution of analog voice and 3264 kb/s continuously variable slope delta modulation voice of distances of a few hundred meters.

The extensive efforts by several DOD organizations indicate that major R&D efforts in FOC are well under way under DOD auspices.

2. INTERNATIONAL STATUS

JAPAN

Extensive R&D efforts are under way in Japan in all phases of FOC: fibers, optoelectronic devices, modulation techniques and hardware, and telephone network-compatible prototype systems. Involvement includes Japanese government facilities (e.g., the Electrotechnical Laboratory and the Electrical Communications Laboratories), major industrial firms (e.g., Nippon Electric Company, Nippon Glass Works, Fujuitsu, and Hitachi), and universities (e.g., Tohoku University and the Tokyo Institute of Technology). The programs are mostly large and generally government-funded.

Based upon the developmental level of numerous prototype systems (see table 2 for example), innovative technology transfer is quite effective.

The extent (and effectiveness) of the Japanese commitment short-term FOC involvement compared, for example, to the United States and the United Kingdom. The first reported Japanese FOC investigations began in 1970. The intervening 5 years have revealed very rapid progress. An early accomplishment was their development of the first graded-index optic fiber. Marketed under the trademark SELFOC (for "self-focusing"), the fiber minimizes optical pulse dispersion, thus permitting more favorable trade-offs of large bandwidth and long transmission paths. (Variations of this graded-index fiber design are now under development in every country heavily committed to FOC technology.) In addition to continuing refinement of fiber production, Japan has developed laser diodes, detectors, and interfacing hardware to implement experimental multikilometer FOC links with at least 123 Mb/s capacity. There has also been a government commitment to apply FOC to community communication distribution systems.

UNITED KINGDOM

The United Kingdom has a smaller R&D effort in FOC than Japan but appears to be ahead of its European competition in reported development of hardware. With the exception of the

Table 2. Representative Foreign Experimental/Prototype Fiber Optical Communication Systems.

COUNTRY	FIRM OR PTT	TRANSMISSION RATE	PATH LENGTH	DEVELOPMENTAL STATUS	DATE ANNOUNCED	SPECIAL FEATURES: PROPOSED APPLICATIONS/NEXT GENERATION UP-DATING
Japan	Nippon Electric	Color TV or 600 Tel. channels	--	Lab. prototype; simulated 2 km path	1975	2 km operational field test (Osaka, Japan) scheduled late 1975
Japan	Nippon Electric	7.8 Mb/s	2.8 km	Lab. experiment; total systems analysis	1975	4-fiber ruggedized cable; hardware compatible with existing 40 Mb/s digital trans. system; extendable to 20 km link using 3 repeaters; field tests in planning stages as of June 1975
Japan	Nippon Tel. and Tel./ Fujitsu Lab.	32.064 Mb/s	3 km	Lab. experiment	1975	Digital video-phone transmission using regenerative repeaters
Japan	Fujitsu Lab.	400 Mb/s	4 km	Lab. experiment	1975	Spliced 1 km length fibers
Japan	Nippon Elect. Nippon Sheet Glass	123.49 Mb/s	2 km	Lab. experiment	1975	500 m-length cables mated with low-loss connectors
U.K.	Post Office Res. Dept.	8.448 Mb/s	Goal: 2 km	Lab. prototype	1974	Lensed, demountable couplers; design goal: extension to 6 km repeater spacing with improved-transmission on fibers; future field trials dependent upon economic analysis
U.K.	Post Office Res. Dept.	139.264 Mb/s	?	Lab. experiment	Goal: Late 1975	Experimentation with their "near monomode" high-purity glass fiber (core diameter 10 μm)
U.K.	Plessy Tele. Res. LTD	8.448 Mb/s	1.48 km	Inter/intra Bldg. prototype	1975	Evaluation of multi-terminal link (pulled through existing ducts) for possible "wired city" broadband local network, incl. CATV
France	CNET	Min. 8 Mb/s	Goal: 5 km	Lab. statistical analysis of componentry		PTT field tests scheduled to be operational by late 1981
France	CGE	8 Mb/s	?	Lab. experiment	Goal: Late 1976	--
West Germany	AEG Telefunken	250 Mb/s	?	Exp. demonstration	1973	Binary work + digital TV transmission tentative schedule for PTT link demonstration: late 1977
West Germany	AEG Telefunken	100 Mb/s	200 m	Lab. experiment	1975	Simulated 3 km link; S/N ratio permits 3 km link using an equalization network
Canada	Bell Northern Research	>100 MHz	?	Lab. prototype	1975	Applications goal: wide-band analog distribution network, incl. color TV
Canada	Bell Northern Research	45 Mb/s	?	Lab. prototypes	1975	Applications goal: digital transmission of voice, video, and data

military and, particularly, avionics applications (reported to be comparable to those of the United States), the primary U.K. commitment is toward application in its PTT network. The main government center for these efforts is the British Post Office Research Development (PORD), which has been involved in a broad range of R&D, from development of fibers and devices to experimental systems testing and characterization. Major industrial efforts in fiber, device, and systems development are under way at the Standard Telecommunications Laboratory (STL) -- an ITT subsidiary. In the words of C. P. Sandbard of STL (in addressing a 1975 FOC symposium), there is "... a close interaction between basic technology and systems development". Strong emphasis is being placed upon practical systems aspects of FOC; e.g., lowered costs, cable installation, minimizing the number of repeaters, and simplifying maintenance.

FRANCE

The French may have lagged behind the United States, Japan, and the United Kingdom in the start up of FOC technology. They now appear to be strongly committed to catching up, with major emphasis upon systems applications. The lack of a domestic source of fiber production has been considered by many to be a significant hindrance to France in the international market; however, the teaming of Thomson-CSF with Pilkington of the U. K. to market small FOC links (using Thomson optoelectronic devices and hardware and Pilkington fibers) may point to at least a short-term solution to this problem.

The French PTT is also now involved in the pulling of a number of state of the art types of fibers at the Centre National d'Etudes Telecommunications (CNET) laboratories. The commercial firm, Compagnie Generale d'Electricite (CGE), is developing fibers and fiber cables and has entered into an interim agreement with Corning Glass Works (United States) for annual purchase of an appreciable volume of low-loss fibers. Cabling would be provided as their own add-on.

Most FOC work in France is directed toward long range PTT applications and is being carried out by CGE and Thomson-CSF in conjunction with the CNET, the national telecommunications research center, and the PTT. The level of effort indicates a firm commitment of the national PTT to FOC application in the French telephone system. The confidence in nongovernment markets is reflected by the fact that the CGE is funding more than 50 percent of its own FOC developmental program. (The rest is CNET-sponsored.) CGE plans to have an experimental 8 Mb/s system in operation by late 1976.

WEST GERMANY

The German FOC efforts are largely confined to the research laboratories of the industrial telecommunication giants, Siemens AG, SEL (Standard Electrik Lorenz, the ITT subsidiary) and AEG-Telefunken, one of the primary suppliers and research organizations for the German PTT.

All three companies have large programs under way in fiber development, devices, and systems characterization. Jenaer Glaswerk Schott und Sohne, one of the world's largest manufacturers of optical glass and fused silica, supplies high-purity bulk glass and quartz for fiber manufacture by the other German firms. There is every reason to expect that Germany will develop a high performance (low-loss) family of fibers for its own needs and for trade abroad.

The majority of the German effort is aimed at long-term applications to the national telephone network: long-haul, high-capacity digital transmission. AEG-Telefunken has demonstrated experimental systems with up to 250 Mb/s capacity and is currently concentrating R&D efforts upon two distinct systems, one operating at 35 Mb/s, the second at 140 Mb/s. The former may be operational in late 1977 as a prototype. In the commercial side, Telefunken has marketed (in early 1975) an FOC "data link kit" aimed at the intra-office industrial communications market.

CANADA

Canada is a relative newcomer to the FOC field. Most of the reported work is being done by Bell Northern Research (BNR), the R&D arm of Bell Canada, the major Canadian telephone utility, and Northern Electric, Bell Canada's manufacturing subsidiary. BNR has been involved since 1971 in the development of FOC components, subsystems, and systems. Strong emphasis has been placed upon optimization of sources, detectors, and connectors for use with single-fiber cables.

The wire and cable division of Northern Electric has a complementary program under way in developing low-loss fiber and multiple-fiber cables designed so that individual fibers can carry independent channels.

Feasibility and systems engineering studies at BNR have been directed toward analog systems beyond 100 MHz and digital systems up to 150 Mb/s. The analog work is directed toward distribution of wideband services, including color video in metropolitan areas, and a switchable, customer interactive broadband facility. System design analysis and market applications evaluation for digital systems are aimed at voice, video, and data transmission in the 45-150 Mb/s range. Short intercity trunks are being considered as potential markets. Time frames are not known.

APPENDIX F

DEVELOPING TECHNOLOGIES AND THE VITALITY OF THE ELECTRONICS INDUSTRY

INTRODUCTION

At the request of the Deputy Assistant Secretary for Science and Technology, a selection of significant semiconductor device technologies was examined to determine their significance to the electronics industry over the next few years. The study was part of a larger investigation to explore ways to improve the worldwide competitive position of the United States in this field.

The technological topics were chosen in consultation with a group of senior scientific staff members of the Electronic Technology Division of the National Bureau of Standards (NBS) as being the ten most significant in terms of their impact on the commercial and consumer sectors of the electronics industry. They were:

- Charge-coupled devices (CCD's).
- Surface acoustic wave (SAW) devices.
- Microprocessors and memories.
- Monolithic linear integrated circuits.
- Hybrid linear integrated circuits.
- Microwave signal devices.
- Microwave power devices.
- Silicon-on-sapphire (SOS) integrated circuits.
- Improved photolithographic technology.
- Improved component reliability.

In addition, eight application areas of present or potential significance were chosen:

- Cable television (CATV) systems.
- Electronic fund transfer systems (EFTS).
- Land mobile radio (including personal paging systems).
- TV telephones.
- Satellite communications.
- Data networks.
- Secure civilian communications (scramblers).
- TV receivers and other broadcast and Citizen's Band radio equipment.

The first six of these were subjects of study by agencies participating in the overall investigation, and the remaining two were added by the writer. Particular attention was given to the effects of the selected technologies on these applications, though other important applications of the technologies were considered where approriate.

Because only two weeks were available for this study, most of the information gathered from industry was obtained by telephone. A study of CCD technology had been made during September for another purpose, and some of this information was useful in this instance. Visits were made to three companies of particular significance. Because much of the detailed technical and financial information from the industry is proprietary, the information is not associated with its source in this report.

THE TEN TECHNOLOGIES

The following sections deal with each technology in turn, including a brief description of the device, its general utility, a more detailed discussion of its impact on the selected applications, and a summary regarding the state of the maturity of the subject and future development possibilities.

Charge-Coupled Devices

Charge-coupled devices (CCD's) use much metal-oxide-semiconductor (MOS) technology in their manufacture, and can be regarded as a subset of that class of device. They are basically linear arrangements of regions in a silicon body, each region being able to contain a packet of electric charge. By manipulating the potentials of metal regions overlying and insulated from the silicon, the charge packets can be transferred from region to neighboring region. The charges may represent the ones and zeroes of digital information or may have a continuous distribution of magnitudes representing analog (linear) information. Thus CCD's have uses as both digital and linear devices.

The packets of charge are departures from equilibrium and will decay in times of the order of seconds at most. Linear information thus must be used before it is lost. Digital information can be recirculated and regenerated. Operation is always dynamic.

CCD's are important digital memory devices. They have a desirable combination of density of storage (64 k bits/cm2 at present), data transfer rates to ∿ 100 Mb/s, and low power (0.2 pico Joule/bit transfer). In linear applications, CCD's are useful for signal processing and for optical imaging. Processing examples include variable time delays, correlators, fast Fourier transforms, and filters of various kinds. Optical imaging CCD's operate by absorption of visible light in the device, which creates electron-hole pairs. These charges are collected into packets whose magnitude depends on the local light level. The packets are then shifted serially out of the device to generate a video waveform for a variety of uses. In the laboratory it is now possible for a CCD of ∿ 1 cm^2 to generate a full 380 x 488 element array of picture elements corresponding to a complete TV picture frame. Such devices will be commercially available in one to two years. The sensitivity of these images is such that a (marginally) useful picture can be obtained at such low light levels that the brightest elements of the picture are represented by only 15 electrons per packet.

The major commercial impact of these devices in the near term (< 5 years) will be as medium-speed memories for computers, as sensors of light (certain TV cameras, for example), and in signal processing in specialized communications equipment, in the above order. Present commercially available memories are quite cost competitive at 0.01 to 0.05 ¢/bit, compared with cores at 0.1 to 0.2 ¢/bit and other semiconductor memories at 0.1 to 1.0 ¢/bit. CCD memories have greater access times, however, since they are serial devices and not truly random access as these other means are. They are also volatile, losing their stored data when power is removed, whereas cores are not.

CCD's are only now beginning to emerge as commercial products. Widespread application must await appropriate system redesign, which will require a year or two at least. Costs, as is typical in the semiconductor industry with new concepts, will drop by a factor of ten in five years and more slowly thereafter. The United States (Bell) originated the CCD and has at least a two-year technological lead in bringing it to market. Once a component is generally available, of course, any free world equipment manufacturer is able to use it; and any lead we have will depend on our ability to design and manufacture equipment competitively.

Surface Acoustic Wave Devices

Surface acoustic wave (SAW) devices make use of ultrasonic waves propagating along the surface of a piezoelectric crystalline substrate. Generation and detection of the waves is done by metallic electrode arrays in the form of interdigitated comb-like patterns. The electrode deposition and patterning is by means of standard integrated-circuit methods: vacuum deposition and photolithography. While these are not semiconductor devices, being entirely passive and using insulating substrates, their manufacture is by identical processes and thus semiconductor manufacturers are well able to make them. The valuable properties of the devices are obtained by designing the electrode patterns in particular ways which are very amenable to mathematical analysis.

SAW devices can perform filtering, transformation, convolution, and delay functions of great sophistication. In principle they are low cost (∿ $1 to $5) and straightforward to apply. SAW's are useful over the range 10 to 1000 MHz, though any given device can only operate over a 2 to 1 frequency range. Practical bandwidths range from 0.5 to 40 percent of the center frequency in filter applications. Minimum insertion losses of 0.5 dB can be achieved, though 3 dB is the minimum in simple devices. Desired attenuations of up to 80 dB are possible, with shape factors as low as 1.2 and less than 0.1 dB passband ripple. These characteristics are individually as good as can be obtained by any other available means, and can be obtained in SAW devices in combinations not available in other ways.

Applications exist in all radio communications equipment and in most wired communications systems, the exceptions being at frequencies less that 10 MHz where the increased physical size of SAW's implies a noncompetitive cost (primarily material). Since these devices are quite new, most of their development has been supported by DOD for military systems. The first large civilian application has just been made in one manufacturer's TV receiver as a replacement for IF transformers.

A cost analysis (from another source than that company) shows the present IF amplifier circuit costing $6.00, and an equivalent using SAW filtering (without the cost of the filter) costing $4.50. Thus the SAW filter must cost less than $1.50 to displace the old technique (a tuned transformer). The analysis also shows the present cost of the

SAW filter to be $3.00, reaching $1.00 after 2 million units are produced. Thus a total excess cost of $23 million must be dealt with in some way before the new technology will be in an economic position to take over this application on a large scale. This situation is commonly encountered in the application of new methods where the existing way of performing the function is satisfactory and has matured to a low cost. New technology alone is not attractive; the cost must be less.

Similar IF filter applications exist in all radio receivers, though the frequency is too low in AM broadcast receivers for use of SAW filters. (The exception is academic. Virtually no AM broadcast receivers are made in this country today.) Receivers for land and aeronautical mobile services and other commercial equipment can stand the extra initial cost of SAW filters better than consumer products such as TV or Citizen's Band radio.

Other potentially large applications exist in the telephone industry. Long-distance transmission of voice, video, and data is done by grouping individual narrow-bandwidth channels together into wideband signals and transmitting these via coaxial cable, microwave relay stations, or satellites. Each signal channel must be separated from the others at some point, and filters are required for this. SAW devices can do this function, but will do so only when the combination of cost and performance is right.

Laboratory development is being done on SAW resonators, which are essentially very narrow bandwidth filters of high Q. These permit oscillator circuits to be made, working at frequencies up to 1 GHz, with stabilities of 1 ppm over a 10°C temperature range. Conventional crystal oscillators are limited to frequencies below 100 MHz, higher frequencies requiring subsequent multiplier circuits. Thus there are good prospects for simplifying the frequency control circuits of very-high and ultra-high frequency communications equipment, but three to five years will pass before this can occur to any significant degree.

The more exotic functions of convolution, transformation, and adaptive filtration will be used in specialized systems, mostly military, and will penetrate civilian applications only slowly. Means to do such operations at low cost have not been available before, so there are no developed high-volume applications. When functions are available, ingenious circuit designers often find unexpected uses for them, so it will be interesting to see what happens. Prediction is hazardous.

SAW's are in an earlier stage of development than CCD's. Their elegant simplicity and low-cost potential are powerful stimulants, but low cost must be at hand before large-scale use will occur.

Microprocessors and Memories

A microprocessor is the data processing heart of a computer made in the form of a single integrated circuit. Of itself it is not a complete computer. At least an additional IC (memory) is required, and usually also some circuitry for communication with the user. Practical computers using microprocessors can be constructed on a single circuit board half the size of this page. They have capabilities comparable to a small minicomputer of three years ago in speed, instruction repertoire, and utility. A microcomputer on a single board can be bought today for less than $400.

Since the microprocessor requires memory, both are considered here. Microprocessors were developed for two reasons. First, as costs of computers, and later minicomputers, came down their applications grew enormously. The microprocessor is the logical next step. Second, the number of very complex specially designed integrated circuits is increasing rapidly. These are required for a variety of systems in which a unique design is cost advantageous or for which the desired functions are not otherwise available. The design cost of a large integrated circuit is substantial. If the production run is long, that cost can be distributed among a large number of pieces. But many special applications require only a small total production of the circuit, which may have no other uses. Thus the design cost per unit is intolerably high. Microprocessors offer an alternative approach. Rather than designing a special IC, a microprocessor of standard design is used in association with a special read-only memory (ROM) which programs the microprocessor to provide the functions of the special IC.

This approach has other advantages. Complex equipment designs are not always entirely right the first time, or application requirements may change with time. In either case the special IC may have to be changed and the entire design cost incurred again. The time required to redesign and to produce the first samples of the new circuit are often long enough to be a problem as well. But with the microprocessor approach only the program needs to be changed. The ROM containing the program is a standard production part which has the program permanently installed after manufacture. A modified ROM can be programmed and installed in minutes at low cost.

Applications of microprocessors are developing rapidly. In the consumer area they are already in sewing machines, washing machines, and calculators. In communications they are used in point-of-sale terminals (electronic cash registers), remote computer terminals (thus in data networks), and in test and measurement instruments used to maintain communications systems. Costs range from a few dollars upwards.

Future applications are certain to be many. One example will illustrate the possibilities. Recently announced was a tuner for a TV receiver which the set owner can program to select any channel and turn the set on and off at any time with a 5-minute time resolution. An entire week's programming cycle can be accommodated. It is a Japanese development and, while not explicitly stated in the news release, probably contains a microprocessor.

Memories useful in these applications abound. In addition to CCD memories, there are bipolar and MOS semiconductor memories. All have attributes of speed, storage density, access time, and power requirements in differing combinations which suit each to various uses. There are also many types of ROM's:

PROM	programmable ROM (only once)
REPROM	re-programmable ROM
EAROM	electrically alterable ROM
RMM	read-mostly memory (similar to EAROM)

Other types of ROM's will no doubt arise. The point is that the components are available to support the application of microprocessors to an extrordinary variety of jobs. The only limitations are economic.

Monolithic Linear Integrated Circuits

The earliest monolothic IC's were digital for two reasons: saturated logic is relatively easy to implement, and the computer industry had a need for large numbers of a very few circuit types. In contrast, linear circuits are much more difficult to design without adverse behavior over a range of temperatures and there are many different complex operations to be done. Further, those products which use linear circuitry in large enough numbers to be attractive markets are mostly consumer products and thus extremely cost-sensitive.

The technical problems have been overcome; and monolithic linear IC's are available to perform most of the functions required in TV receivers, mobile radio equipment, stereo and FM equipment, and related hardware. The limitations are in frequency (not over $\sim$ 50 MHz) and power (generally < 1 watt per package, < 5 watts with special cooling). Both of these limits will be relaxed to some degree with time but probably not beyond 100 MHz and 20 watts for lack of economic incentive as much as any other reason. Functions outside those limits or exposed to voltages over 20 volts are more economically done with discrete components.

The economic limitations are still partly with us, however. The TV receiver history illustrates this. At a time in the mid-sixties when AM and FM receivers were virtually all solid-state, the conversion of TV receivers from tubes to discrete semiconductors was only starting. A TV set is much more complex and tube designs were well matured and thus low in cost. Displacement on a cost basis was difficult and redesign for solid state was a substantial investment. The motivation for small, compact audio equipment does not apply to TV since the picture tube dictates the minimum feasible size. The transition was evolutionary and took several years. There are still sets made with vacuum tubes.

Design for integration requires the circuit to be suitably partitioned, and the approach to this varies from one manufacturer to another. Many TV manufacturers do not make semiconductors and have been reluctant to give their circuit design responsibility to their parts supplier. Yet this is required if an IC design of TV sets is to be done. One large TV manufacturer estimates that the industry is about 50 percent of the way toward the maximum feasible use of integrated circuits.

One comment was received during this study which may be of interest. Considerable circuit board assembly work for TV has gone offshore, mainly to the Far East. With the introduction of IC's into his designs, one set manufacturer has found it more economical to return this work as far as Mexico and is studying the feasibility of repatriating it altogether by addition of more automation to control the labor cost content.

In commercial telecommunications equipment the use of IC's also appears to be growing gradually. The investment in product design is substantial, and redesign will not be done solely to use new technology. There must be either a performance improvement, a cost improvement, or both. Since much of this equipment now uses discrete solid-state circuity, the advantages of better reliability and reduced power consumption are already being enjoyed.

Hybrid Linear Integrated Circuits

This technology uses a glass or ceramic substrate on which conductors are deposited and discrete parts are finally assembled. In concept a hybrid IC is a printed circuit much reduced in size. There are significant performance advantages to this approach. Operation at microwave frequencies is possible with controlled impedance transmission lines. Deposited resistors can be trimmed to close tolerances. Transistors and IC's, which are mounted directly on the substrate without previous packaging, can be tested and selected beforehand to have the desired characteristics. The additional control afforded by this approach permits hybrid circuits to have greater linearity and much better controlled electrical characteristics generally than monolithic IC's. The major disadvantages are larger size and substantially higher cost.

Hybrid circuits are used where either very high accuracy of response or operation at high frequencies is required. Important applications exist in CATV systems, UHF communications, satellite systems, and instruments used for development and maintenance work. Nearly all these applications require that the hybrid assembly be specially designed, so there are relatively few standard products on the market. Those that do exist are mainly for analog computer applications or for instrumentation systems of only peripheral importance to this study. The technology is approaching maturity, and costs are stable.

Microwave Signal Devices

Included in this category are specialty transistors, variable capacitance diodes, tunnel diodes, and related low-power devices. At frequencies much above 100 MHz, the parasitic inductances and capacitances of conventional device packages become significant uncontrolled circuit elements. Therefore, special packaging is necessary to reduce these parasitics, making the devices more expensive. The active semiconductor part of the device is also smaller to reduce capacitances and transit times. For these reasons microwave devices cost more and have quite low power dissipation capabilities.

The price must be paid for operation up to 1 GHz, needed for TV receiver tuners and for input circuits of UHF receivers in land and aeronautical mobile service. There is no other solid-state way to provide active device functions at less cost. Improvements in manufacturing processes for these devices can reduce costs and improve performance. Present photolithography is pressed to its limits to make UHF bipolar transistors with 1 μm wide lines in metalliation patterns. A substantial advance in photolithography would have a beneficial effect on both cost and performance.

Microwave Power Devices

These devices are used to generate signals of appreciable power (100 milliwatts to 100 watts or more) at frequencies over 100 MHz. Special power transistors are the most important economically, although avalanche diodes and traveling-wave vacuum tubes are useful above about 1 GHz. UHF power transistors share the problems of the signal devices mentioned above: special packaging, very finely detailed geometries, and high prices. Costs are coming down on the usual learning curve, and have finally become low enough that power transistors have displaced vacuum tubes in the high-power stages of UHF transmitters up to 50-100 watts during the last few years. This goal had also been desired for performance reasons: no warmup time and greater physical ruggedness are important attributes in mobile equipment.

The device technology is gradually maturing, extending useful performance to 1 GHz at a few watts power level. This has allowed greater design freedom in CATV systems in which it had been necessary to translate signals above channel 13 down into unused channels in the lower ranges. Since some TV sets do not reject adjacent-channel signals as well as they should, this practice often resulted in interference in the desired picture from a signal in a neighboring channel.

In satellite transmitters it is still necessary to use traveling-wave tubes for high-level signal generation. Vacuum tubes are not as rugged as transistors and they are subject to wearout mechanisms not shared by transistors. Other applications above 1 GHz, such as telephone microwave relay systems, could use transistors when they become available. Ground-based systems can have their tubes replaced. This is difficult in a satellite. The motivation for development exists and progress is being made. It will still be several years before substantial transistor power is available at, say, 5 GHz.

Silicon-On-Sapphire Integrated Circuits

Silicon-on-sapphire (SOS) is a technique for making very high-speed integrated circuits by epitaxially growing single-crystal silicon layers on sapphire (Al_2O_3) substrates. The IC is formed in the silicon layer in a conventional way, except that isolation regions between the active areas in the silicon are etched entirely away. In this way the active areas have much reduced interactions with one another and operation at higher frequencies is possible. There are some major technical problems of a detailed nature to be solved before SOS is a candidate for serious consideration in civilian applications. One company (Inselek) which intended to make this device family its raison d'etre has gone bankrupt. The major efforts to bring SOS to market are being done by RCA and Autonetics. Some military applications have been undertaken.

The major applications foreseen for SOS are in high-speed digital systems which would impact data networks and possibly satellites for digital data handling. At the moment SOS must be regarded as an unproven technology which may or may not survive. Considerable DOD support is being given to development work, and several years will pass before SOS will be widely available commercially if its problems can be solved. Even if this occurs it will be more expensive than other digital IC's because of the cost of sapphire substrates (now \$20-30 each).

Improved Photolithographic Technology

This topic has been referred to previously in several places. It is a process technology of almost universal utility in making semiconductor devices. For many purposes it is entirely satisfactory; but when one is trying to make very complex, finely detailed structures, then serious problems arise.

As a technology in itself, photolithography includes many operations. A high-precision drawing of the pattern to be created is first made at many times larger scale than the final product. This is often done by computer-controlled drafting equipment. This drawing may be as large as two meters square. It is photographically reduced to an intermediate size in special room-sized cameras with lenses designed especially for this use. The reduction ratio is typically 10 or 20 fold. The intermediate image is again reduced by 5 or 10X in another camera to a single image on a precision glass plate at the final size.

This single image is used in a step-and-repeat camera to generate a master plate, on glass, containing a multitude of exact copies. The master is used to make intermediate masters by contact printing, which in turn are used to contact print working copies on glass for use in semiconductor processing. A set of working photomasks to make an integrated circuit may be as many as five different patterns of the various kinds needed to be used in sequence. All must register precisely with one another.

In typical use, an oxidized silicon slice is coated with a photosensitive material (resist) which is exposed to light through the photomask. The pattern thus exposed is developed, leaving a patterned layer of resist on the slice. The exposed areas are etched to remove the silicon dioxide and the resist is then stripped off. The slice may then be given a diffusion treatment at high temperature to create a pattern of impurities in its surface and thus form a part of its intended structure. Subsequent patterns must register properly with the first, requiring use of very precise alignment equipment to position the mask and the slice correctly before exposure.

Problems arise in every conceivable way. Obviously any flaws in the pattern on the slice will cause diffusion to occur in unwanted areas or no diffusion in desired areas. Dirt, scratches, or emulsion failures at any point in the mask-making or wafer-processing sequence will cause trouble. Although these are not basic technological problems, they are real and they cause yield losses in manufacturing.

In practice, the limiting line width in common use today is about 5 μm. With care, this can be cut in half. A very few devices, mostly microwave transistors, are made with 1 μm lines. There are serious measurement problems in simply inspecting masks to see if the proper line width exists to begin with. To provide a point of departure, NBS is developing, as a standard reference item, a plate containing lines of 1 μm width and up. Since these dimensions are very near the theoretical resolution of optical microscopy, there are no sharp edges in the image to measure. In a high density microcircuit there may be thousands of lines in each of the several masks in a set. Verification of patterns and their fidelity to the original design is next to impossible.

The glass plates on which masks are made must be flat and smooth to within a few micrometers. Only one U. S. manufacturer makes sufficiently flat glass (Kodak). Its process is proprietary. As lines in patterns get smaller, the need for flatter plates is more pressing. For the most demanding applications (making large CCD's is an example), only one in 30 plates is flat enough.

Patterns with line widths less than 1 μm must be generated using electron-beam or x-ray exposure. This is a radical departure from existing methods. Further, the alignment of each new mask to the preceding one is impossible by optical microscopy. Therefore, any significan advance in this direction (making devices smaller and thus more of them per IC) will require a major development effort and creation of a whole new array of expensive equipment to supplement the existing expensive equipment.

Another approach to more complex IC's is to keep the minimum line width the same and use larger areas. At present, most manufacturers are limited to 6 x 6 mm devices. The limitation is imposed by the inability of existing 10X reduction lenses to resolve 2 μm lines over larger areas. An option which will allow doubling the size (4X area) to 12 x 12 mm. is to do a 5X reduction instead. This moves the problem back one step to the intermediate reduction level, where one must then maintain 10 μm lines over a 60 x 60 mm pattern. Development of better lenses is required if a larger size device is to be made.

As device area is increased, one reaches a point where the yield of good devices drops to nearly zero. The reason is that the incidence of fatal defects is random, at some number per unit area. With larger and larger devices, the probability of the device containing at least one flaw rises. With experience, the limiting size has increased as process controls have improved. Today the maximum size is about 7 to 8 mm on a side at a marginally acceptable yield.

The above discussion can only highlight the problems in photolithography. The economic loss to the semiconductor industry due to limitations in photoprocessing is in the hundreds of millions of dollars annually, it being a major source of yield loss today. There is a wealth of supporting information at NBS on this subject, and a program to address some of the problems in measurement.

Improved Component Reliability

Reliability is not a technology; it is an attribute. It is a property as much desired of systems as components; however, one cannot build reliable systems without reliable parts, so we will start there.

Reliability starts with careful design. In an integrated circuit there is more than one aspect of this. The circuit design must be right; and so must the process design, package design, and final test and evaluation designs. A design weakness in any of these areas can negate the most careful work elsewhere.

The execution of the designs must be well done. It is in this area that most weaknesses arise. Semiconductor manufacture is a long, complex sequence of operations. The requirements for cleanliness and precision in many steps are extreme. In a great many of these steps, <u>there is no way to measure</u> how well the operation has been done. How clean is a freshly cleaned surface? In many cases, a monolayer is far too much of an impurity level (MOS devices). The measurement may be destructive, or so laborious as to be far too expensive, or so imprecise or insensitive as to be worthless.

Thus most semiconductor process operations are done on faith, following instructions. Operations such as cleaning are overdone in order to be "sure." Yet yields are low at times and high at others. Even neighboring wafers in the same lot can differ radically. It is not known why.

The U. S. semiconductor industry ships about $2.5 billion worth of product annually. It is estimated that the industry average yield is around 50 percent. This does not imply that the output would be $5 billion at 100 percent yield with the same labor, since the loss is not all taken at the end of the process. Much culling of unsuitable material occurs along the way. It is probably fair to say the loss is close to $1 billion. The opportunity for saving is enormous, and so is the job of devising measurements and controls which would enable manufacturing operations to avoid the loss. The reasons for the NBS/ARPA program for improvement of in-process measurement in the industry are evident.

With the above very brief discussion as background, one has good reason to suspect that variability in manufacturing processes without adequate measurements and controls might lead to less than ideal reliability of the product. Complaints from users abound. At recent FDA/NBS symposium on cardiac pacemakers, the frustration of the manufacturers with their inability to get sufficiently reliable semiconductors was very clear.

The military and space electronics programs have for many years been struggling with the same problem. They have developed a pragmatic approach: if the devices are not inherently reliable, find testing and screening methods to weed out the unreliable ones. The approach is not altogether sucessful (the pacemaker problems occur with the best aerospace grades of devices), but it helps.

In our information gathering for this study, we were told:

> Reliability improvement is crucial to maintaining the U. S. world position in electronics. -- Texas Instruments

> Greater reliability would obviously impact the business, but it is not possible to quantize its effect. -- Jerrold Corporation

> Watkins-Johnson is most interested in seeing an improvement in reliability.

These responses are typical.

With regard to reliability of systems in the telecommunications field, the range is very wide. Here more than in components one can relate design care and conservatism to improved reliability, at least on the average. We were told by another company than Sony that Sony's TV sets are the most reliable in the U. S. market. They are also higher-priced than others. In Europe -- where owners expect their TV sets to have appreciably better quality and longer life than Americans expect of their sets -- TV sets cost more than in this country. In commercial equipment these differences in national market preferences are absent. Every manufacturer strives for some optimum balance between quality (including reliability) and cost.

Unfortunately, semiconductor devices are the least reliable electronic components (possibly excepting vacuum tubes, for which no data are at hand). The feature article in Electronics for October 2, 1975, presents evidence that component failure rate trends over the last five years are at best level, and for transistors are getting worse. This is disquieting. The article questions whether the same care is being taken in manufacture today as in former years.

The concern of the industry is obvious, but there are few sound suggestions for solutions. Experience in other product areas teaches that care and control in manufacturing is necessary to make quality products. More care and more control in semiconductor factories might do the same.

APPLICATIONS OF THE TECHNOLOGIES

In the following paragraphs, each of the applications under study is discussed briefly to bring into perspective the technologies which are useful in each application.

Cable Television (CATV) Systems

The essential technologies here are hybrid linear IC's and microwave (or at least UHF) power transistors. CATV systems transmit many TV signals by cable over entire cities. Large numbers of repeaters are required to overcome cable losses and to make up the power lost at the cable terminations in subscribers' homes. Because many repeaters are cascaded, nonlinearities are cumulative; and great care must be taken to reduce these inaccuracies to the minimum.

Development of UHF monolithic linear IC's would be a cost reduction. So would the use of broadband fiber optic transmission systems. Cable losses are 3 to 5 dB per hundred meters, whereas fiber optic losses are an order of magnitude less.

The annual electronic hardware value in this application is about $100 million. A major supplier stated that "a little more sensible" regulatory approach is needed. A potential CATV service has to deal with the Federal Communications Commission (FCC) first, then with the target community and its government, and finally, with the FCC again. At best, two sets of authorities, having different aims and outlooks, are involved. Simplification of the regulatory environment would stimulate growth of CATV systems.

Electronic Funds Transfer Systems

There are no technological barriers here at all. The necessary computers and means of digital communications all exist today. Problems in regulation, security, and lack of intersystem data transmission standards abound.

Land Mobile Radio (including personal paging systems)

While microwave power and signal devices and hybrid IC technology are needed and used, the state of these arts is adequate. SAW's and monolithic linear IC's will provide lower costs in time. There are regulatory complications here, also.

The industry is exposed to growing competitive pressure from foreign manufacturers. One U. S. manufacturer said that his creative and aggressive use of hybrid IC methods had allowed him to enlarge his domestic share of hand-held transceiver equipment (walkie-talkie) sales and to penetrate the European market significantly.

TV Telephones

One major effort to provide this service in the early 1970's failed for cost and human factors reasons. There are continuing efforts to achieve a viable cost/value ratio. Overall, this application must be regarded as technologically immature except for specialized cases which are too few in number to make the idea commercially successful at present. The entire system is being worked upon, and there seems little that the Government could do now which would be helpful.

Satellite Communication

Hardware in this service uses nearly every technology in this study. Reliability, light weight, and low power demand are overriding considerations in the satellites themselves. Except for reliability problems and microwave power transistors, the technologies are adequate. Both of these topics have been discussed.

Data Networks

These exist, are growing rapidly, and are not being limited by technology. There is no doubt that microprocessors will cause drastic changes in the architecture of data networks and in their cost and usefulness, but these effects will take place without Government intervention in the technology.

There are serious regulatory problems. Because data networks are so varied and changing rapidly, solution of the regulatory questions will require an uncommon amount of wisdom and flexibility.

Secure Civilian Communications (scramblers)

A 1972 NBS survey provided the basis for the following. There are about 170,000 police car radios and 60,000 police portable radios in the United States. Of these, 9 percent had voice scramblers on them. An additional 52 percent would have scramblers if the cost were not so high. This represents about 135,000 potential sales in police service. There are no doubt other potential sales as well, especially in telephones.

It is technically quite feasible to do voice scrambling using either CCD or SAW devices which may be cheap enough for this application. Perhaps the National Institute of Law Enforcement and Criminal Justice or another appropriate agency could encourage such a development.

TV Receivers and Other Broadcast and Citizen's Band Radio Equipment

These applications are grouped because there is one common dominant factor: as ultimate consumer products, cost is a key item in making design decisions. All the technology in the world will not be used unless it is less expensive than the present way of doing the job.

The use of SAW filters and monolithic linear IC's in these applications has been discussed above. Both of these are being introduced in TV sets as their costs come down.

BUSINESS ENVIRONMENT

The existence of new device technology does not of itself guarantee its use. Particularly in civilian applications, reduced cost is the most important factor.

U. S. industry representatives state unequivocally that their needs are for improved manufacturing methods, not technology. Our productivity is not as good as that of our foreign competitors, and they have access to new technology almost as soon as we do.

Government actions to simplify and make consistent the relations between regulatory bodies and the industry would be welcomed. Policies are desired which will encourage the industry to reinvest in more efficient production tools and to improve productivity.

We have a technological lead over the rest of the world. We can design to use this technology as well as anyone. We are not able to exploit either the technology or the designs in the world market as well as foreign producers because they can make quality products at lower costs than we do.

APPENDIX G

COMPANIES INTERVIEWED BY THE TASK FORCE

Aeronutronic Ford Corporation — September 10, 1975
Palo Alto, California

Contact: Harry J. Goett
Western Development Laboratories Division

American Telephone and Telegraph Company — September 23, 1975
Washington, D.C.

Contact: Marvin Haltom, Communications Supervisor
Richard Hake, Director of Government Communications
Ben Givens, Assistant Vice President for Federal Agencies

Avantek, Inc. — September 8, 1975
Santa Clara, California

Contact: Lawrence R. Thielen, President and Chairman
Forrest F. Fulton, Jr., Vice President, Telecom Division
Robert E. Goff, Director of Marketing, MIC and Components Division
Robert M. Bendorf, International Sales Manager

Bell Laboratories — October 10, 1975
Holmdel, New Jersey

Contact: Solomon J. Buchsbaum, Vice President - Network Planning and Customer Services
David Thomas

Boeing Computer Services, Inc. — September 11, 1975
Dover, New Jersey

Contact: John S. Gilbert, Director of International Operations

California Microwave — September 10, 1975
Sunnyvale, California

Contact: D. B. Lesson, Vice President

Collins Radio Group, Rockwell International
Richardson, Texas

September 15, 1975

Contact: Thomas A. Campobasso, Vice President and General Manager
Tariq Aziz, Manager, International Satellite Communications Marketing
Don Smith, Director, International Marketing, Microwave

Computer Sciences Corporation
Falls Church, Virginia

September 12, 1975

Contact: William A. Kuhn, Vice President, Program Development, International Programs

Comtech Laboratories, Inc.
Smithtown, New York

September 19, 1975

Contact: Donald Campbell, Vice President, Technical Planning
Jack Green, Chairman of the Board

Control Data Corporation
Arlington, Virginia

September 19, 1975

Contact: Earle L. Lerette, Special Assistant to the Chief Executive Officer

Control Data Corporation
Minneapolis, Minnesota

October 2, 1975

Contact: Wilbur D. French, General Manager, Pan Am Far East Data Services and Systems Operations
Kent H. Stow, Technical Development, Control Data Technotec, Inc.
Charles W. Bahan,* Vice President, COMSOURCE, Service Bureau Corporation

*New contact for CDC key focal point is Mr. P. C. Onstad, Service Bureau Company, Greenwich, Connecticut.

Cook Electric Company — September 11, 1975
Morton Grove, Illinois

Contact: Gerard L. Meyer, President, C-Trade, Inc.
(international marketing subsidary)

Cornell University — September 16, 1975
Ithaca, New York

Contact: Raymond Bowers, Program on Science, Technology and Society
Jeffrey Frey, School of Electrical Engineering

The Cyphernetics Corporation — September 16, 1975
Ann Arbor, Michigan

Contact: Kenneth Lochner, President
John C. Duffendack, Vice President, Telecommunications Systems

Data Resources, Inc. — September 15, 1975
Lexington, Massachusetts

Contact: Charles Warden, Vice President
Dennis O'Brien, Vice President, Marketing, Canada/Western Europe
Ralph DeMent, Manager, Telecommunications Services

Farinon Electric — September 10, 1975
San Carlos, California

Contact: Weston C. Fisher, Vice Chairman
William O. Craddock, Vice President, Operations

General Electric Company — September 19, 1975
Lynchburg, Virginia

Contact: Richard P. Gifford, Vice President, Communications Projects
H. Speight Overman, Strategic Planning Analyst
Al Giesselman, Manager, Product Planning

General Electric Company September 23, 1975
Rockville, Maryland

Contact: Gerhard Mueller, Manager, International Operation
Robert Streight, Manager, International Market Development
Peter Salisbury, Manager, Strategy Development, Strategy Planning Operation

Granger Associates September 9, 1975
Menlo Park, California

Contact: Jack L. Shephard, President
Kevin Giffen, Marketing and Sales Manager
Robert W. Berg, Director of Marketing

General Telephone and Electronics September 18, 1975
Stamford, Connecticut

Contact: James L. Clark, Vice President Communications Products and President of GTE Satellite Corp.
Lee L. Davenport, President, GTE Laboratories, Inc.
Jane Davis, Deputy Washington Representative, GTE International Inc.
John V. Hefferman, Staff Assistant to the President, GTE Service Corp.
William R. Malone, Vice President GTE Corp.
Roy C. Megargel, Senior Vice President/Telecommunications Division, GTE International Inc.
Claude E. Munsell, Vice President/Telephone Operations Staff, GTE Service Corp.

General Telephone and Electronics September 22, 1975
Stamford, Connecticut

Contact: Alexander E. Patterson, Jr., President, GTE Information Systems, Inc.

Hughes Aircraft Company September 11, 1975
El Segundo, California

Contact: R. W. Lyngren, Director of Administration and Services

IBM Corporation — September 22, 1975
Armonk, New York

Contact: Fred Warden, Director of Telecommunications Relations

ICC/Milgo — September 19, 1975
Miami, Florida

Contact: E. Bleckner, Vice President for Operations, Milgo, and President, ICC
H. Moore, Manager, ICC Export Company

ITT — September 17, 1975
New York, New York

Contact: Lynn Ellis, Director of Telecommunications

E. F. Johnson Company — September 11, 1975
Waseca, Minnesota

Contact: Richard E. Horner, President
Jim Hemans, Foreign Sales

Martin Marietta Corporation — September 15, 1975
Orlando, Florida

Contact: George F. Mansur, Vice President
Harold W. Clark, Marketing Director, Communications and Electronics

Microwave Associates, Inc. — September 17, 1975
Burlington, Massachusetts

Contact: John Van, International Marketing Manager

Motorola, Inc. — September 12, 1975
Schaumberg, Illinois

Contact: James Searle, Vice President and Manager, Latin American Distribution
Martin Cooper, Vice President, and Division Director of Systems Operations
Curtis J. Schultz, Director, International Engineering

North Electric Company
Galion, Ohio

September 12, 1975

Contact: J. A. McDavid, Vice President, Corporate Planning
Chuck Conry, Vice President, Government Products
Morris Horrell, Vice President, Product Development

Rapidata, Inc.
Fairfield, New Jersey

September 11, 1975

Contact: I. M. Auld, Vice President, International
Curt M. Huff, Assistant Vice President, Operations
Stephen Pritchard, International Sales

Raytheon Data Systems
Norwood, Massachusetts

September 13, 1975

Contact: Hugh Bannon, Marketing Manager
John Caliguire, Export Manager

RCA Corporation
New York, New York

October 16, 1975

Contact: William Webster, Vice President, Laboratories
Stephen S. Barone, Vice President, Licensing
Alan D. Gordon, Vice President, International Licensing
James Hillier, Executive Vice President, Research and Engineering

RCA Communications Systems
Meadow Lands, Pennsylvania

September 18, 1975

Contact: Ray Hamblett, Manager, International Sales, Mobile Communications Systems
Malcolm L. Stephenson, Manager, Systems Engineering, Mobile Communications Department

Rockwell International
Downey, California

September 11, 1975

Contact: Gene Freeman, Space Division

Sanders Data Systems, Inc. September 17, 1975
Nashua, New Hampshire

Contact: M. Andrew Haladej, Vice President, Business Development
Charles L. Register, Vice President, Corporate Staff

Scientific-Atlanta September 17, 1975
Atlanta, Georgia

Contact: Sid Topol, President

The Singer Company September 22, 1975
New York, New York

Contact: Clark B. Robbins, Manager, Advanced Systems

Stromberg-Carlson Corporation September 10, 1975
Rochester, New York

Contact: John Fairfield, Vice President, International
Joe Kotzin, Manager, International Programs

TRW, Inc. September 12, 1975
Redondo Beach, California

Contact: James Burnett, Senior Vice President, TRW Systems Group
Jan Roos, Systems and Energy

Texas Instruments September 26, 1975
Dallas, Texas October 7, 1975

Contact: Fred Bucy, Vice President and Chief Operating Officer
Norman Neuriter, Manager, International Business Development
Charles Phipps, Manager, Strategic Planning

Tymshare, Inc. September 17, 1975
Cupertino, California

Contact: Thomas J. O'Rourke, President
Warren Prince, Vice President, Data Services Division

Wescom, Inc.
Downers Grove, Illinois

September 11, 1975

Contact: Alan Brown, President
Roger McLain, International Marketing

Zenith Radio
Chicago, Illinois

October 8, 1975

Contact: Robert Adler, Research Vice President

APPENDIX H

ABBREVIATIONS AND ACRONYMS

ac	-	alternating current
Aerosat	-	aeronautical satellite system planned for the future
AFB	-	Air Force Base
AFSATCOM	-	name of Air Force satellite
ALASCOM	-	Alaska Communications division of RCA
ALOFT	-	name of Air Force program
AM	-	amplitude modulation
AMOS	-	Army Medical Outpatient System
AMP, Inc.	-	Amphenol, Inc.
ANIK	-	name of Canadian satellite
APCO	-	Associated Public-Safety Communications Officers
ARBITS	-	Army Base Information Transfer System
ARPA	-	Advanced Research Projects Agency
ATCAP	-	Army Telecommunications Automation Program
ATS	-	Applications Technology Satellite
AT&T	-	American Telephone and Telegraph Company
Autodin	-	Automatic Digital Network (DOD)
BNR	-	Bell Northern Research
C	-	Celsius
CAI	-	computer-aided instruction
CATV	-	community antenna television (cable television)
CBS	-	Columbia Broadcasting System
CCD	-	charge-coupled device
CCIR	-	International Radio Consultative Committee
CCITT	-	International Telephone and Telegraph Consultative Committee
CCTV	-	closed circuit television
CGE	-	Compagnie Generale d'Etudes Telecommunications
CM	-	centimeter
CNET	-	Centre National d'Etudes Telecommunications
CoCom	-	Free World Coordinating Committee
COMSAT	-	Communications Satellite Corporation
COMSTAR	-	name of COMSAT satellite

CORGUIDE	-	optical fiber trade name
CRT	-	cathode-ray tube
CTAB	-	Department of Commerce Technical Advisory Board
CTAC	-	Cable Television Technical Advisory Committee
CTC	-	Central Texas College
CTS	-	Communications Technology Satellite
CVSD	-	continuous variable slope delta
dB	-	decibel
dB/km	-	decibels per kilometer
dBm	-	decibels relative to 1 milliwatt
dBW	-	decibels relative to 1 watt
dc	-	direct current
DCPRS	-	Data Collection Platform Radio Set
DOD	-	Department of Defense
DOMSAT	-	domestic satellite
DSC	-	direct satellite communication
DSCS	-	Defense Satellite Communications System
DTM	-	Director of Telecommunications Management (obsolete)
EFTS	-	electronic fund transfer system
EAROM	-	electrically alterable read-only memory
ExIm	-	Export-Import Bank
f	-	carrier frequency
FCC	-	Federal Communications Commission
FDA	-	Food and Drug Administration
FDM	-	frequency division multiplexing
FLTSATCOM	-	Fleet Satellite Communications System
FM	-	frequency modulation
FOC	-	fiber optic communications
GENESYS	-	Graduate Engineering Education System
GHz	-	gigahertz
GLOBECOM	-	Global Communications division of RCA
GNP	-	Gross National Product
GSAT	-	General Satellite Corporation
GTE	-	General Telephone and Electronics
IBM	-	International Business Machines Corporation
IC	-	integrated circuit
IEEE	-	Institute of Electrical and Electronics Engineers
IF	-	intermediate frequency

INTELSAT	-	International Telecommunications Satellite Consortium
IRAC	-	Interdepartment Radio Advisory Committee
ITFS	-	Instructional Television Fixed Service
ITT	-	International Telephone and Telegraph Corporation
ITU	-	International Telecommunication Union
k	-	kilo
kb/s	-	kilobits per second
kHz	-	kilohertz
km	-	kilometer
KSC	-	Kennedy Space Center (NASA)
kW	-	kilowatt
LEAA	-	Law Enforcement Assistance Administration
LED	-	light-emitting diode
LES	-	name of Lincoln Labs (MIT) satellite
LMR	-	land mobile radio
m	-	meter
MARISAT	-	Maritime Satellite System
Marots	-	maritime satellite system in development
Mb/s	-	megabits per second
MOS	-	metal-oxide-semiconductor
Medinav	-	A U. S. Navy multi-media teleconferencing program to serve isolated units
MHz	-	megahertz
MIT	-	Massachusetts Institute of Technology
MITRIX	-	Mitre Corporation two-way broadband system
mm	-	millimeter
MTS	-	message telecommunications service
μm	-	micrometer
NARUC	-	National Association of Regulatory Utility Commissioners
NASA	-	National Aeronautics and Space Administration
NBS	-	National Bureau of Standards
NOAA	-	National Oceanic and Atmospheric Administration
NSF	-	National Science Foundation
OT	-	Office of Telecommunications
OTP	-	Office of Telecommunications Policy
PBS	-	Public Broadcasting Service
PCM	-	pulse code modulation

PIN	- positive-intrinsic-negative
PLATO	- Programmed Logic for Automatic Teaching Operation
PM	- phase modulation
PORD	- (British) Post Office Research Development
ppm	- part per million
PROM	- programmable read-only memory
PTT	- post, telegraph, and telephone organization
Q	- quality factor of a resonator
RCA	- Radio Corporation of America
RCC	- radio common carrier
R&D	- research and development
RELAY	- name of satellite
REPRO	- reprogrammable read-only memory
RF	- radio frequency
RMM	- read-mostly memory (similar to EAROM)
ROM	- read-only memory
SAB	- Space Applications Board
SAM	- surface-to-air missile
SATCOM	- name of RCA satellite
SAW	- surface acoustic wave (device)
SBS	- Satellite Business Systems
SEL	- Standard Electrik Lorenz
SELFOC	- trade name for "self-focusing"
SITE	- Shipboard Information, Training and Entertainment
Skynet	- A satellite system
SMR	- Special Mobile Radio
SMS/GOES	- Weather satellite system
S/N	- signal-noise (ratio)
SOS	- silicon-on-sapphire
SPAs	- State Planning Agencies
STL	- Standard Telecommunications Laboratory
Symphonie	- name of satellite
SYNCOM	- Synchronous Communication Satellite
"T"	- circuit configuration
TDM	- time division multiplexing
TDMA	- Time Division Multiple Access
TELESAT	- name of both the Canadian satellite corporation and the satellite
Telex	- Automatic Teletypewriter Exchange Service (of Western Union)

TICCIT	-	Time-Shared Interactive Computer-Controlled Information Television (System)
TTL	-	transistor-transistor logic
TV	-	television
U. K.	-	United Kingdom
UHF	-	ultra-high frequency
USAECOM	-	U. S. Army Electronics Command (obsolete)
USMA	-	U. S. Military Academy (West Point)
USSR	-	Union of the Soviet Socialist Republics
VHF	-	very-high frequency
WARC	-	World Administrative Radio Conference
WATS	-	wide area telecommunications service
WESTAR	-	name of Western Union Satellite

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15. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)

The report briefly summarizes the status of four technologies: direct satellite communications, land mobile radio, broadband communications networks, and fiber optic communications. It considers the problems that appear to be hindering the growth of these technologies, suggests some issues that stem from these problems, and recommends actions that would address these issues. The report also touches upon the problem areas in the larger field of telecommunications, discusses the desirability of a national telecommunications agenda, and analyzes the appropriate roles of Government and industry. Appendices provide a summary of comments received about an earlier draft version of this report, a summary of international trade problems as identified by the industry, additional technical details on the status of direct satellite communications, tables on broadband communications networks, additional technical details on the status of fiber optic communications, comment on the state of the technologies and the vitality of the electronics industry, a list of companies visited by the Task Force, and a list of abbreviations and acronyms used in the text.

16. Key Words (Alphabetical order, separated by semicolons)

BROADBAND COMMUNICATION NETWORKS; DIRECT SATELLITE COMMUNICATIONS; FIBER OPTIC COMMUNICATIONS; ELECTRONICS INDUSTRY; INTERNATIONAL TRADE; LAND MOBILE RADIO; TELECOMMUNICATION TECHNOLOGY.

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