Volume 1

REPORT OF THE ADVISORY COMMITTEE FOR THE LAND MOBILE RADIO SERVICES

Federal Communications Commission

TO: The Commission

FROM: Commissioner Kenneth A. Cox

RE: Final Report of The Advisory Committee for the Land Mobile Radio Services

I am pleased to submit herewith the final report of the Advisory Committee for the Land Mobile Radio Services. Since its establishment by the Commission on March 26, 1964, the Committee has planned and executed a far ranging study of the matters originally outlined by the Commission, as well as others which seemed worthy of consideration -- all limited, of course, to the better utilization of the frequencies already allocated to the land mobile services. This work has led to a number of recommendations to the Commission. Two of these are of substantial significance, while the others are of more limited scope and impact. The Committee is hopeful that the Commission can act promptly on all of them.

It has been a pleasure to work with the many representatives of user groups, individual companies and public safety organizations, manufacturers, members of the Commission's staff, and other interested individuals who made up the Executive Committee, the three standing committees, and the numerous working groups, task forces and project coordinating groups through which the Advisory Committee's work has been carried out. These men are identified in Appendix E, Part 2, Volume 2 of the report, and I want to express my personal appreciation for their contributions to the end results reflected in this report. I think they have greatly assisted the Commission in its efforts to reach sound decisions as to the future development of land mobile radio. It should be noted, of course, that their service was in addition to the already demanding duties of their regular employment, involving substantial personal sacrifice on their part. Beyond that, I think credit must be given to their companies and organizations for making them available for this work and for assuming the travel and other costs incidental thereto, since the Commission had no funds for these purposes. In order that the reader of this report may quickly realize the caliber of the organizations who have thus supported the activities of The Advisory Committee, I am appending a list which I sincerely hope is complete, omitting only the Commission itself, whose staff members had a significant part in our labors.

Finally, I want to pay a personal tribute to Victor G. Reis, who served on the Executive Committee until his death on August 13, 1965. Representing the Bethlehem Steel Company, Vic Reis worked ceaselessly for the cause of mobile radio. He contributed materially to the establishment of the Manufacturers' Radio Service, helped make the Committee on Manufacturers Radio Use of the National Association of Manufacturers one of the strongest spokesmen for improved treatment of the mobile services, played a substantial role in the planning for the Commission's inspection of land mobile operations in Los Angeles in the fall of 1963, and in general did all he could to advance the use of radio to promote public safety and to improve the efficiency of American business. His efforts typified those which led to the creation of the Advisory Committee, in whose work he shared fully until his untimely death. I think the land mobile radio industry, the Commission, and the public are in his debt, as I am.

The Advisory Committee's work is now finished, and the next step is up to the Commission.

Kenneth A. Cox

Kenneth A. Cox

PARTICIPATING ORGANIZATIONS

A. D. Ring and Associates

Aeronautical Radio, Inc.

Aerospace Flight Test Radio Coordinating Council

Air Transport Association of America

American Airlines

American Association of State Highway Officials

American Automobile Association

American Electric Power Corporation

American Newspaper Publishers Association

American Petroleum Institute

American Taxicab Association

American Telephone and Telegraph Company

American Transit Association

American Trucking Associations

Associated Public-Safety Communications Officers, Inc.

Association of American Railroads

Atchison, Topeka and Santa Fe Railroad

Atlantic-Richfield Company

Auto Club of Maryland

Automobile Manufacturers Association

Baltimore and Ohio Railroad

Baltimore Gas and Electric Company

Bell Telephone Laboratories

Bethlehem Steel Company

Boston Edison Company

Bureau of Public Roads

Burlington Railroad

California Division of Highways

California State Auto Association

Cambridge, Massachusetts, Fire Department

C. A. Rypinski Company

Champion Papers, Inc.

Checker Cab Company (Omaha, Neb.)

Chevron Oil Company

Chicago, Rock Island and Pacific Railroad Company

City of Burbank, California

City of Los Angeles, California

City of New York Municipal Broadcasting System

Clear Channel Broadcast Service

Cleveland Electric Illuminating Company

Columbia Gas Company

Communications Company, Inc.

Consolidated Edison

Detroit Municipal Communication Systems

Diamond Cab Company of Long Beach, California

Eastern Airlines

Electronic Industries Association

Florida Fish and Game Commission

Forest Industries Radio Communications

Forestry Conservation Communications Association

General Electric Company

General Motors Corporation

General Telephone and Electronics Corporation

Gulf Oil Communications, Inc.

Halliburton Company

Humble Oil and Refining Company

Illinois Division of Highways

Illinois State Police

Industrial Communications

International Association of Chiefs of Police

International Municipal Signal Association

Institute for Telecommunication Sciences and Aeronomy, Environmental Science Services Administration, United States Department of Commerce

Institute of Electrical and Electronics Engineers

Iowa Power and Light Company

Joint Technical Advisory Committee

Kahn Research Labs, Inc.

Kaiser Steel Corporation

Kear and Kennedy

Keller and Heckman

Liberty Communications, Inc.

Lockheed Aircraft Corporation

Los Angeles Department of Water and Power

Los Angeles County Department of Communications

Los Angeles County Flood Control District

Magnolia Pipe Line Company

Marathon Pipe Line Company

Martin-Marietta Company

McDonnell-Douglas Corporation

Michigan Citizens Band Association

Michigan Department of Conservation

Michigan State Police

Minnkota Power Cooperative

Minute Maid Company

Missouri and Pacific Railroad

Missouri State Highway Patrol

Mobile Communications Services

Modern Communications

Motorola

National Airlines

National Association of Broadcasters

National Association of Business and Educational Radio

National Association of Manufacturers

National Association of Motor Bus Owners

National Association of Radiotelephone Systems

National Association of Taxicab Owners

National Committee for Utilities Radio

National Liquid Petroleum Gas Association

National Science Foundation

National Steel Corporation

Natural Gas Pipe Line Company of America

Naval Research Laboratory

New York Central Railroad

New York World's Fair Fire Department

Niagara Mohawk Power Corporation

Norfolk and Western Railroad

North American Aviation, Inc.

Ohio Power Company

Oregon Department of Forestry

Outercom Electronics Corporation

Panhandle Eastern Pipe Line Company

Potlatch Forests, Inc.

Radio Corporation of America

Raytheon

Rochester Gas and Electric Corporation

Shell Oil Company

Southern California Edison Company

Southern Pacific Company

Special Industrial Radio Services Association, Inc.

Standard Oil Company of California

State of California

Sun Oil Company

Technical Communications Corporation

Telecommunications Reports

Telcom, Inc.

Transcontinental Gas Pipe Line Corporation

Trans World Airlines

Union Oil Company of California

United Air Lines

United States Army Electronics Laboratory

United States Independent Telephone Association

United States Steel

University of Pennsylvania

Virginia Electric Cooperative

Virginia State Police

Washington (State) Department of Natural Resources

Washington State University

Western Maryland Railroad

Westinghouse, Inc.

Wisconsin Department of Conservation

Yellow Cab Company of Delaware County (Pa.)

TABLE OF CONTENTS
LIST OF TABLES
LIST OF FIGURES

Volume 1

Contents

Table

Figures

REPORT OF THE ADVISORY COMMITTEE FOR THE LAND MOBILE RADIO SERVICES

DIGEST

DIGEST

1. INTRODUCTION

The Federal Communications Commission established this Advisory Committee on March 26, 1964, with the following statement:

> "...there are serious frequency problems affecting the land mobile services that must be resolved...
>
> "To explore various possibilities for resolving these problems, and to mobilize effectively the best available talent for that purpose, the Commission, as of this date, in accordance with Section 3(b) of Executive Order 11007, is establishing an advisory committee to be known as the Advisory Committee for the Land Mobile Radio Services..."

Working under the guidance of Commissioner Kenneth A. Cox, as Chairman, and James E. Barr, Chief of the Commission's Safety and Special Services Bureau, as Vice Chairman, some 200 members of the Advisory Committee, including Commission personnel and representatives from equipment manufacturers and user groups, explored those steps which could be taken singly or in combination to resolve the serious frequency congestion problem affecting the Land Mobile Radio Services without involving the allocation of additional spectrum space to the land mobile services.

The work of the Advisory Committee required three years to complete, and ranged from theoretical studies of the interrelationships of factors affecting the design of communications systems, to actual construction of experimental equipment to test proposed technological improvements. At the conclusion of the studies and experiments conducted by the various working groups and task forces created within the Advisory Committee, each was evaluated with respect to the contribution which it could make toward resolving the land mobile radio channel congestion problem.

2. HOW LAND MOBILE RADIO SERVES THE PUBLIC

Land mobile radio is a term used to describe radio communication between a fixed place and a moving vehicle or person, or between two or more moving vehicles or persons. Because of the mobile nature of the vehicles or persons served by land mobile radio systems, there is generally no means other than radio which can meet their communications needs. It is used extensively by doctors, law enforcement personnel, firemen, utility crews, truckers, ambulances and taxis, railroads, newspapermen, foresters, repairmen, manufacturers, roadbuilders, small businessmen and countless others to maintain and improve the well being and prosperity of the nation. Because of it:

-- Police, fire and other emergency vehicles are alerted and arrive at their destinations more promptly.

-- Public utilities' vehicles respond quickly to trouble calls.

-- State guard units can be mobilized more effectively.

-- Forest crews can put out forest fires with less personal danger and reduced loss of valuable timber.

-- Business establishments can respond more quickly and economically to service calls from homeowners.

-- Snowplows and other highway equipment can be utilized more effectively.

-- Manufacturers can produce higher quality products at lower cost.

-- Construction activities can be better coordinated.

In short, land mobile radio has become a part of almost every facet of our daily lives. It gets the taxi to our door, the doctor to our bedside, the furnace man to the basement when there is no heat. It plays a key role in the war on crime, enables firemen to communicate from inside burning buildings to the main force outside, is at the heart of the fight against air pollution and has saved the lives of our school children whose buses have been marooned in blizzards. Because it does perform such valuable services, its use has grown tremendously in recent years, and this growth has presented the nation with a most serious frequency congestion problem.

3. THE PROBLEM -- LAND MOBILE RADIO FREQUENCY CHANNEL SHORTAGE

The results of this congestion and its impact have been experienced by all types of users.

> "...When we started using radio, we did not have much trouble reaching our trucks. Now the congestion on the channel is becoming a problem. It is busy so often when we need to use it to call one of our trucks. This is because of the number of users on the channel. There are more users than when we went on the channel and everybody is also probably using his radio more. We ourselves have almost tripled our number of radio-equipped trucks, and we are only one user. When we started the company, we hoped to be able to grow to 15 service trucks...but I do not know if we can do that unless the radio congestion problem is improved..."
>
> Testimony before House Select Committee on Small Business, Subcommittee on Regulatory and Enforcement Agencies, May,1966

> Today, in almost all the major metropolitan areas, there is considerable interference. In Los Angeles, for example, frequencies may be shared by as many as 50 to 60 users, operating 500 or 600 mobile units, all in the same geographical area. A recent FCC inspection trip to New York City confirmed intense congestion there.
>
> The Silent Crisis
> Telecommunications Science Panel, Department of Commerce
> October, 1966

> It can be concluded from the facts contained in this report that many of the presently available frequency channels in the land mobile bands studied are becoming saturated.
>
> FCC Report,F-6701, Analysis of New York City Monitoring Survey, February, 1967

> Unless steps are taken to provide more operating frequencies, said Burton H. Dougherty, General Manager of the Department of Electricity of the City of San Francisco, a major disaster could find policemen and firemen without adequate radio communications.
>
> Fire Engineering, February, 1967.

> According to Los Angeles Police Chief, Thomas Reddin, tapes taken from police transmissions at the height of the Watts riot had no pauses at all and calls from officers requesting help were going unanswered because of lack of air time to transmit calls for assistance.
>
> Industrial Communications, March 25, 1966.

> "A study of the communications system showed that some field units had only a 25 per cent chance of establishing immediate communication with the communications center because of the volume of air traffic. The Commission regards this as a serious matter..."
>
> President's Commission on Crime in the District of Columbia.

> Our need for additional frequencies is most urgent, and our entire program for improved law enforcement is dependent upon obtaining additional radio frequencies.
>
> The Police Commissioner of New York City to the FCC, November 4, 1965.

This congestion has been steadily growing ever since the basic division of the limited part of the radio frequency spectrum suitable to land mobile radio was made by the Commission in 1949. The land mobile services were allocated only 4.7% of this part of the spectrum "based on estimates of projected need for the services in existence at that time. With the possible exception of a few unavailing voices, no one then envisioned the birth of so many more diverse services and the astonishing growth pattern of the entire group." (1966 FCC Annual Report)

As early as 1951, one FCC Commissioner noted in a speech that in spite of his early experience in the field of communications,

> "...my imagination did not permit me to completely envisage the colossal and rapid growth of these services and the terrific impact which they would have on the lives of the American people. And I have talked with no one who claims to have foreseen that which has come to pass in connection with such services."

The following quotations from Annual Reports of the Commission show the steadily deepening nature of the frequency congestion crisis.

1958 - "congestion"

1962 - "extreme congestion"

1964 - "acute frequency shortage"

1966 - "Into this very limited space are packed over 2 1/4 million transmitters, with applications for new ones pouring in at the rate of 15,000 per month."

4. THE COMMISSION RESPONDS TO THE PROBLEM

In view of the unquestioned direct benefit of the land mobile services to the public at large, and the heavy usage of the private land mobile frequency space, and recognizing the urgency of the problem, the Commission set about resolving the frequency shortage affecting the private land mobile services. It began this inquiry as to whether there were any steps which "taken singly or in combination" might resolve the problem "without the re-allocation of spectrum space between 25 and 890 MHz* from other non-government radio services to the land mobile service for exclusive use."

To carry on this inquiry, the Commission established this Advisory Committee on March 24, 1964, and mobilized the best available talent for the purpose. Members of the Committee include radio users, radio equipment manufacturers, consultants, legal counsel, frequency coordinators and representatives of users, user groups, industry organizations and engineering associations.

---

*"MHz" is a recently adopted international standard abbreviation for the measure of frequency. It stands for "megahertz"; one megahertz is one megacycle per second, 1000 kilocycles per second, or one million cycles per second. It supersedes the term megacycles per second (Mc/s).

5. THE WORK AND RECOMMENDATIONS OF THE COMMITTEE

Pooling their collective knowledge and understanding of the problems, the members of the Advisory Committee first divided themselves into three major committees and then into working committees and task forces to conduct the required exploration and study. The Advisory Committee examined the possible use of multiple access systems, application of computer techniques, multiple low-power systems instead of single high-power systems, one-way radio systems, a cooperative or shared use of stations, piggy-backing on broadcast channels, relay techniques and operational procedures in order to determine whether any of them could contribute to easing the frequency congestion problems. The dimensions of the problems resulting from the explosive growth of land mobile radio and the contributions of private land mobile radio to the national economy were also explored.

With equal care, the Advisory Committee examined frequency utilization, including aspects arising from the operations of the Commission, to determine whether additional frequency coordination procedures or new FCC procedures could contribute to a solution of the frequency problems.

In short, an attempt was made to investigate any technical, operational or administrative change or idea that might offer hope for relief to the crowded mobile frequency situation. Each possibility was examined and evaluated for technical, operational and administrative feasibility. Many recommendations for change emerged from the studies and are detailed in Volume II of this report. Of these recommendations, two promise limited improvement in the utilization of the land mobile radio spectrum. These are:

1. That the Commission should give favorable consideration to reducing the channel spacing in the 450 MHz band.

2. That the Commission should give favorable consideration to relaxing the block allocation system to permit, under appropriate conditions,* a service suffering frequency channel overcrowding in a given locale to share the frequency channels of another service which is making less intensive use of its channels in that area.

---

*See discussion of conditions in Section 14, Volume 2.

The Advisory Committee was unable to find further steps which could be taken to reduce land mobile spectrum congestion within the existing land mobile frequency allocations. However, in the course of its studies it made findings which can result in slightly improved mobile usage, practices, and procedures. These findings resulted in the following additional recommendations.

1. Except for control stations operating on the same frequency as mobile units, the licensing of stations for fixed operations in the 450-470 MHz band within 75 miles of Urbanized Areas of more than 200,000 population should be suspended.

2. For those services where multiple users cannot be assigned to a single channel, such as public mobile telephone services, random access through trunking of channels should be encouraged.

3. New applications of low power should be encouraged to see if needs for service can be met in the existing exclusive low-power channels before seeking authorization to use higher power channels.

4. Use of one-way and non-voice systems should also be encouraged in the limited operations in which they can be successfully employed.

5. A detailed analysis confirmed the wisdom of leaving the decision as to whether a system should use one or two frequencies to a case-by-case determination based on the particular circumstances; no spectrum saving can be achieved by requiring all systems to operate in either of these two modes.

6. In those services where effective frequency coordination exists, the Commission should consider initiating a procedure for simple transmitter power-antenna height calculations for selecting a system configuration to meet given coverage needs, as a preliminary step to a long-range plan to develop a data base which would permit more closely approximating optimum spectrum utilization through the use of a computer-oriented frequency assignment program.

7. To assist in this long-range effort, the Advisory Committee recommends the formation of an Ad Hoc Committee consisting of FCC personnel, experts from the computer industry and advisers from the land mobile services to prepare a recommendation of the information flow which would be required to effectively utilize a computer assignment program.

8. Lastly, the Committee recommends that the Commission revise its policies and procedures so as to shorten the interval between the filing of various requests and Commission action, simplify the language of the Rules, improve the dissemination of information, and improve the overall effeciency of the regulatory process.

6. CONCLUSION

At the present time over two and one-half million transmitters are packed into only 4.7% of that portion of the spectrum considered useful for land mobile communications. Licenses for new transmitters are being requested at the rate of about 15,000 transmitters a month.

Although adoption of the recommendations of the Advisory Committee will result in a small degree of improvement in spectrum utilization, it will not provide the relief to the land mobile congestion problem that is necessary to assure continued benefits to the public which can be provided only by land mobile radio. Genuine relief, which is needed immediately, can only be achieved by the allocation of additional frequency spectrum to these services.

REPORT OF THE ADVISORY COMMITTEE

FOR THE LAND MOBILE RADIO SERVICES

SUMMARY

This is an expanded discussion of the matters treated very briefly in the Digest. Some of the material appearing there is repeated. All topics touched on here are dealt with much more thoroughly in Volume 2.

SUMMARY

1. INTRODUCTION

> "...there are serious frequency problems affecting the land mobile services that must be resolved..."
>
> "To explore various possibilities for resolving these problems, and to mobilize effectively the best available talent for that purpose, the Commission, as of this date, in accordance with Section 3(b) of Executive Order 11007, is establishing an advisory committee to be known as the Advisory Committee for the Land Mobile Radio Services..."

With this statement, the Federal Communications Commission established this Advisory Committee on March 26, 1964.

2. WHAT LAND MOBILE RADIO IS

Land mobile radio is a generic term that describes the use of both one-way and two-way radio communication between a fixed place and a moving vehicle or person or between moving vehicles or persons. It can generally be said that the uses to which land mobile radio are applied cannot be served in any other way than by radio because of the moving nature of the vehicle or person.

2.1 Illustrations

Land Mobile Radio in Law Enforcement

* * * * * * * * * * *

LATEST MOVES AGAINST CRIME IN THE STREETS

All across the country, in one city after another, police departments are being strengthened, reorganized, and modernized -- put on a war footing. Almost everywhere, the emphasis is on new techniques for fighting crime ..One of the most popular (new techniques)...is a two-way radio... light enough to be carried easily by a patrolman on foot. With this radio, an officer walking a beat can keep in constant touch with police headquarters and with officers riding in radio-equipped patrol cars. If the patrolman needs help, he can get it in a hurry.

U. S. News & World Report,
April 11, 1966

* * * * * * * * * *

Walkie-Talkies Score Big in Deterring Shop Lifters.

Mobile, Alabama Press,
March 24, 1966

* * * * * * * * * *

State, county and municipal police departments today use many types of land mobile radios...some almost as small as the imaginary wrist radio. These radios add to the effectiveness of their users, enabling quicker response in emergencies and most productive use of their time.

* * * * * * * * * *

Communications must be maintained with foot patrolmen and with police officers who have left their cars. Police officials are unanimous in their desire for small portable radios so that patrolmen can call for assistance in any emergency and so that supervisors can maintain closer contact with those they supervise and make more effective use of the entire police force.

The Challenge of Crime in a Free Society.
A Report of the President's Commission
on Law Enforcement and Administration
of Justice

* * * * * * * * * *

Without land mobile radio, police departments would be forced to add more personnel to provide the same amount of protection. This would require millions of dollars in added annual expenses for police services. But the worth of land mobile radio cannot be measured solely in dollars and cents. Rather, one must note an increased ability to capture criminals and limit highway accidents; to bring aid minutes sooner to accident victims; to move traffic; to send law officers where they're needed in time to prevent crimes and accidents.

* * * * * * * * * *

About 5:00 p.m., January 14, 1966, police officers in the Ninth Precinct arrested two subjects at 24th and Benning Rd., N.E. A crowd of three hundred to four hundred persons who were leaving a high school basketball game gathered and started

throwing rocks and bricks at the officers. Traffic Car No. 4 radioed for additional help. Several additional police vehicles were dispatched to the scene and the crowd was brought under control at 5:08 p.m.

District of Columbia
Police Records

* * * * * * * * * *

Mushrooming, congested populations generate equally mushrooming demands on all law agencies. Land mobile radio helps meet this demand efficiently and economically.

Land Mobile Radio Saving Life and Property

* * * * * * * * * *

On January 18, 1965, while fighting a very stubborn and smoking fire in an automobile sales and service building, we had two men trapped inside the building, after the ceiling of the main showroom collapsed. Fortunately, the captain who was trapped inside had a handie-talkie and radioed his situation...(to) the assistant Chief...who...located the men...and quickly rescued (them)...the written report(s)...credit the handie-talkie for saving the lives of these firefighters.

Odell Benton, Chief
Fire Department
Portsmouth, Virginia

* * * * * * * * * *

The essence of fire protection is speed - speed of communication followed by speed of reaction. Land mobile radio provides the fastest means of communications yet devised for a fire department. Modern fire departments use radio to call out the volunteers; to call for reinforcements from the scene of the blaze; to communicate with men inside burning buildings; to turn back vehicles on the way to false alarms; to reroute men and vehicles to new disasters...to keep in touch with men making fire inspections. Thus, radio means lower insurance rates for a community...it means lower fire department operation costs...it means the difference between a fire in a single building and an entire block or neighborhood devastated, and for those in peril, it can mean life.

Land Mobile Radio for Public Works and Local Government Agencies

* * * * * * * * * * *

It sounds crazy, but what saves the money for the city is a revolutionary system of using two-way radio along with an automatic billing machine for reading water meters.

The Everett, Washington Herald,
June 2, 1966.

* * * * * * * * * * *

TWO-WAY RADIOS HELP AIR POLLUTION DRIVE: SUMMONSES RISE

The use of two-way radios by inspectors has nearly quadrupled the number of smoke violation summonses issued by the City's Department of Air Pollution Control.

Arthur J. Benline, Commissioner of the Department, said yesterday that since Jan. 1, when 18 cars used by his inspectors were outfitted with surplus two-way radios, 390 summonses were issued. He said that 100 summonses was the previous average for a similar period.

The New York Times
February 4, 1966.

* * * * * * * * * * *

From gigantic state highway maintenance departments to the smallest rural school districts, every conceivable type of local government entity is using radio in an effort to improve service to its citizens and yet hold down expenses. Highway departments find that radio communications enables more efficient use of men and machines - enables repair jobs and snow removal to be accomplished more quickly and less expensively. Sewer and water departments are able to maintain better service. Safety and efficiency are added to radio equipped school buses. In short, the citizen receives more service for his tax dollar.

Land Mobile Radio Fights Disaster

* * * * * * * * * *

Report of Tornado that Struck Topeka, Kansas in June of 1966

> Topeka outshines many a larger city in its elaborate preparations for disasters. ...Topeka's storm-warning system is second to none. "Weather watchers', mostly volunteers are posted around the city in radio equipped cars whenever tornado conditions exist... (T)he loss of life was relatively small because of the repeated visual sightings of the tornado and other warnings...
>
> The Wall Street Journal,
> June 15, 1966.

The helplessness of the individual is never more apparent than in the face of a natural disaster, be it a hopscotching tornado, a week-long icy blizzard, a roaring canyon brush fire, a spring thaw swollen river, or a 125-mile-an-hour hurricane. No part of the country is safe from the rampages of nature. In such times, a primary need is for reliable communications. Civil Defense agencies throughout the country depend on land mobile radio when the chips are down, when rescues must be made and assistance rendered. Of course, the same communications ability is ready for use in any wartime disaster, should it ever occur.

Land Mobile Radio in Conservation

The Fourth Largest Fire Since 1910

> The fire started on August 20, 1966...It was the fourth largest fire in the state (of Oregon) since 1910 and was the first time that a fire this size had ever been stopped due solely to the fire control effort...At the height of the blaze some 1200 men per shift, scores of pumper trucks, bulldozers and other heavy equipment were employed in combatting the fire...It is an accepted fact that without the excellent communication provided by radio, the loss would have multipled many times... certainly, radio communication played a significant part in containing the fire.
>
> News and Views
> Forestry Conservation Communications Association
> January, 1967.

* * * * * * * * * *

The lookout spies a far-off, filmy puff of smoke and reports it to a forestry headquarters...by land mobile radio. The smoke jumper notifies the plane pilot that he has landed at the scene of the blaze safely...by land mobile radio. The call for additional equipment and manpower to stop the wind-swept, consuming fire is relayed back to headquarters...by land mobile radio. The fire is extinguished; growing forests are saved by daring men outfitted with the proper tools, a most important one being land mobile radio. The need to preserve timber resources is well established. Conservation organizations at state and local levels, including private timber owners, use land mobile radios...to help insure green forests for future generations.

Land Mobile Radio in the Public Utilities

* * * * * * * * * *

Cincinnati Gas & Electric Uses
Two-Way Radio As Operating Tool

It's the middle of winter. There's been a thaw, then some rain. Now it's cold again, below freezing, and ice is building up on the overhead lines. As the wind increases,...some of the lines go down...

(A) customer calls in wanting her gas service disconnected right away. Her family's going to move. Another customer wants a stove pilot adjusted... a contractor calls in to have the mains in a certain area located...ahead of his excavating equipment...

To help meet its many customer demands CG&E...installed a new communications system...all two hundred mobile radios in the Electrical Department's fleet are equipped for three-frequency operation so if they should be working outside their normal operating area they can be switched over to that base station which best covers their current area.

Communication News,
June, 1966.

Flick a wall switch to turn night into day; adjust a thermostat to counter a frigid north wind; or turn a faucet for an instant supply of water. These are matter-of-fact, everyday actions, the results of reliable, economical utility services. An investment of approximately $45 billion in generating and producing facilities plus transmission and distribution networks stands ready to respond at the touch

of a switch, bringing comfort and light to homes, and power to industry. Aiding the utilities in their task of striving for 100% reliability and lower rates is land mobile radio, licensed to organizations ranging from privately held transmission and distribution networks to the smallest REA cooperative. For each, land mobile radio means fast reaction in emergencies... the ability to make most efficient use of manpower and equipment. Thus, land mobile radio is one reason for the low cost and reliable electric, gas, water and steam utility services underpinning our nation's prosperity and standard of living.

Land Mobile Radio in the Petroleum and Chemical Industries

* * * * * * * * * * *

I have eight mobile radio units in my vehicles whose primary use is in the servicing of oil drilling rigs and producing oil wells in an area with a 60-mile radius, including the areas around Flora and Olney. Not long ago, for example, we were hauling water to service a well for the Alva Davis Drilling Company and Union Oil wanted us to do the same for them. We used our two-way radio to route and direct the water truck to the location of the Union Oil well after it got done taking care of Alva Davis. In this way we save 100 miles on this job alone.

Oil and Water Hauling,
Fairfield, Illinois

* * * * * * * * * * *

The gasoline pump at the corner service station represents the last step in the involved life pattern of one of many petroleum industry products. Before it came exploration, drilling, production, refining, transportation via pipeline, ship or barge, and lastly, distribution. In each one of these many steps, land mobile radio plays an important role. Finding and producing petroleum is a rugged, complex and expensive business. Communications are essential for safety in emergencies and everyday coordination of manpower to make best use of the huge investment in equipment. The efficiency brought about by land mobile radio enables the United States petroleum industry to compete in the world market; it brings inexpensive petroleum products to industry, farm and home quickly and reliably.

Land Mobile Radio In Agriculture and Mining

* * * * * * * * * *

One of Cliff Caldwell's busiest top hands at the ranch signed on in October, 1965. It's a two-way radio system that is paying off in time, labor and money-savings in operations on a 30,000-acre ranch near Albany, Texas.

Communications News,
September, 1966.

* * * * * * * * * *

The productive capability of American agriculture is the envy of the world. Land mobile radios are used to coordinate activities of huge farms, ranches, and food processors and is one reason why individual production of the American farmer far surpasses that of his overseas counterpart. Modern communications in forestry, mining and agriculture help keep these industries healthy, offering employment and less costly products to the public.

Land Mobile Radio In Transportation

* * * * * * * * * *

Kercil Schwartz, President of Division 26 of the Amalgamated Transit Union said he would ask that the bus drivers be armed if the DSR fails to buy 800 more radios.

Detroit Free Press

* * * * * * * * * *

A Radio-Controlled System Tying
Truckers Together is Helping
Cut Thefts of Trucks, Cargoes

The companies--most of which have radio-equipped vehicles--alert their drivers and salesmen. Within 15 minutes of the original alarm, nearly 5,000 truckers in the Chicago area and about 6,000 around New York are on the lookout for the vehicle and its cargo and ready to alert police.

Business Week
May 6, 1967

Call a cab, take a train, go by bus, or fly by plane; no matter which way you travel, your journey is made faster and less expensive through the coordination provided by land mobile radio. And if you ship any freight, whether by truck, train or plane, you can be certain that land mobile radio is helping it on its way.

* * * * * * * * * *

TWO-WAY RADIO HELPS BEKINS
COVER VAST SAN FERNANDO VALLEY

> ...Bekins Van & Storage Company is using a two-way radio system to help hammer down cartage and transportation-operation expense...using a two-way radio system to reduce communication time, eliminate duplicated miles, provide better customer service and wipe out 'deadheads' in the business operation...It is the first radio installation designed to link every mobile unit of a moving and storage company to a single headquarters dispatcher. In the case of Bekins' San Fernando branch, this consists of 29 vehicles, including staff cars, mobile repair shops, 'bobtail' or short-haul trucks and over-the-road tractors... The system is already saving about 20 minutes a day per van, or some $12,000 a year...The entire system has been devised to save time...because in this business time is profit. We are attempting to save minutes in the belief that the hours will take care of themselves.
>
> Communications News
> December, 1966

* * * * * * * * * *

Land mobile radio helps taxicab operators provide fast service at low cost. Truck lines have found that three radio-equipped vehicles can often do the work of four without radio. Railroads use the efficiencies provided by instant communications in their constant struggle to remain profitable. Radio in the transportation industry enables the public to eat its cake and have it too. Without land mobile radio, the public's demand for fast service would have to be met by making available increased numbers of vehicles on a standby basis. If this were done, costs and rates would rise. With land mobile radio, the transportation companies can offer the service without adding to costs.

Land Mobile Radio in Heavy Construction

* * * * * * * * * * *

> Our main objective is the sales and service of Caterpillar products in this area. Our servicemen travel all over this area fixing the big D-9 and other bulldozers and heavy equipment which break down on the job. When a big D-9 is down the whole spread is dead because it is usually the key to the whole operation...All this time progress on a road project may be slowed down or stopped, snow removal from the highway may be stopped, or work on dams, streets or water systems may be slowed or stopped.
>
> Testimony before House Select Committee on Small Business Subcommittee on Regulatory and Enforcement Agencies, May, 1966

* * * * * * * * * * *

An empty lot one week...the next, aluminum and steel brushing the clouds; prairie and mountain today...70-mile-per-hour concrete ribbon tomorrow; this is America's prolific and wondrous heavy construction industry at work. At work with it is land mobile radio, like a nerve system tying together the cranes, shovels, diggers, barges, dump-trucks, earthmovers and concrete trucks. At a hydroelectric dam site, radio-equipped men at bedrock level direct the movements of a crane operator hundreds of feet above, lowering down ton after ton of concrete and steel. The skilled mechanic on a lengthening superhighway is beckoned by land mobile radio to the side of a stalled $60,000 gargantuan earth mover; speed is essential to keep such an investment moving. The ready-mix concrete truck driver is rerouted by radio to another building construction job before his perishable product can harden to rock. These uses made of land mobile radios at work daily in heavy construction mean safety to the skilled workers, they mean profit to the industry and most important, they mean lower taxes as highways and dams can be built for less money.

Land Mobile Radio In Heavy Industry

* * * * * * * * * *

To help build this plane--it's 145 feet long, 39 feet high and has a wing span of 160 feet--Lockheed installed its first radio remote-controlled crane systems.

In operation eight sets of crane controls aid five major assembly functions at this plant...The use of portable remote controls to guide these huge overhead cranes resulted in an estimated 25% improvement in crane performance.

Lockheed - Georgia

* * * * * * * * * *

Minutes cost money - lots of money - if they're minutes a production line in a huge factory is shut down. Land mobile radios are at work in mills, factories, and shops of all types, providing the instant communications needed to keep the operations in motion. Radio is used to dispatch materials and maintenance personnel; to communicate with roving production engineers and quality control men; to coordinate security. Only by taking advantage of cost and time saving devices, such as land mobile radio, can American industry remain competitive and in business. Without profit, our industrial system would wither away, taking with it the strength of the nation. Land mobile radio is one of the many ways American industry keeps itself profitable.

Land Mobile Radio For Personal Communication

* * * * * * * * * *

Two-way radio helps realtor keep in touch with office.

Kennebec Journal
Augusta, Maine
March 30, 1966

* * * * * * * * * *

Two-way radio becoming business tool; used in Topeka by insurance adjusters.

Journal of Commerce
January 27, 1967

* * * * * * * * * *

In more than 500 cities and towns, individuals on the move can obtain telephone service in their cars by using land mobile radiotelephone, talking directly from their vehicles to any other telephone in the world. Doctors, lawyers, salesmen and other professionals use this service to make more effective use of their time. In addition, more than 500 miscellaneous common carriers offer centralized radio dispatching and radio paging service to other thousands of individuals in need of communications wherever they may be. We're a mobile, dynamic nation. Communications are essential to men-on-the-move.

Land Mobile Radio and The Small Businessman

* * * * * * * * * * *

Two-way radio communications solves pest control.

Orlando Sentinel
Orlando, Florida
February 7, 1966

* * * * * * * * * * *

Two-way radio cuts costs and speeds up R_x deliveries.

Drug Topics
July 25, 1966

* * * * * * * * * * *

The butcher, the baker, the candlestick maker now have something else in common. They all use land mobile radio. Land mobile radios are in use by such sales-service companies as appliance repair companies, insurance agencies, fuel oil delivery companies, and plumbers. Although the backbone of the American economy, the small businessman is always in a profit squeeze that threatens to drive him out of business. Hundreds of thousands of small businessmen have installed their own land mobile radio or have subscribed to common carrier radio services because it gives them a means to reduce costs, and improve service to their customers, the general public.

* * * * * * * * * * *

I am the Sinclair Oil Company bulk dealer in Belleville, Michigan. I serve an area going 7 miles West of Belleville, 12 miles East, 7 miles North and 16 miles South, an area that would amount to about 437 square miles...My 'will call' customers are usually either older people who never want to owe money and therefore want to order their oil only if they have

> money to pay cash, when the oil is delivered, or people without any credit...They are the 'little fellows' in this world. Their fuel tank is empty, their furnace is off, Grandma and the kids are getting cold and the pipes are in danger of freezing. They need oil in a hurry. They are the people who benefit most from my use of two-way radios between the office and the oil trucks.
>
> I have over 300 of these 'will call' customers' stops, serving about 1200 people. These people call me for oil because they know I have radio-equipped trucks and can answer their calls quickly. When they telephone my office and say that they need some oil in a hurry, I just pick up my radio microphone and call the truck closest to them and tell the truck to stop by their house right away.
>
> Testimony before House Select Committee on Small Business, Subcommittee on Regulatory and Enforcement Agencies, May,1966.

* * * * * * * * * * *

The man you call to come and fix your furnace or your flooded basement, the man your wife calls to fix the washing machine or refrigerator, the doctor or ambulance you need, are all able to respond much more quickly because they are equipped with land mobile radio in order to serve you better.

2.2 Impact on the Economy

Tangible and intangible benefits result to the public from the use of land mobile radio. Tangible benefits can be measured by the economic value of communications. Intangible ones, however, are impossible to measure; no one can place a "value" on a human life saved as the result of prevention of a crime, prevention of an accident, rescue from a hazardous situation, or direct summoning of medical assistance to the scene of an accident.

The economic contribution of radio communications results from improved availability and utilization of productive resources. Communications pays for itself when its use returns more to the economy, in terms of increased production efficiency, than the communications costs, whether it is a business or public safety use.

In the case of land mobile communications, improvements in "availability" of resources are notably obtained by those users who must maintain a high degree of readiness to respond to an emergency situation. Typical users in this category are Police, Fire, Forestry Conservation, Highway Maintenance, Highway Emergency, Auto Emergency, and Utilities.

The benefits accruing to these users are not limited to improvements in "availability." All users also experience savings through better utilization of resources. For the above users, however, the benefits of radio are often dramatically illustrated in terms of savings in property or human life through application of their resources to situations of the moment.

For these users, it is difficult to measure economic benefit directly, since there are usually no alternative means whereby the same results could be obtained. Also, the value of lives or property saved is difficult to estimate.

When we talk of "savings," "contributions to the economy," and "benefits," in terms of land mobile communications, we mean the following:

1. Improved level of service with no increase in prices

2. Same level of service with lower prices

3. Combinations of the above

The savings from using land mobile radio in a business result from the fact that three radio-equipped vehicles can do the work of four not so equipped in most situations, or that people can be reached when otherwise unavailable. In a radio system of 100 units, a savings of over $200,000 can be realized over the life of the vehicles.*

As an example of an economic consideration in the public safety service, a modern patrol car equipped with mobile radio performs two basic functions: (1) patrol, and (2) assignment to specific incidents. Without radio, the police officer on patrol could not be contacted for assignment to specific incidents. Officers reserved for assignment to incidents could not be assigned to patrol. Accordingly, police officials

*See Section 9, Volume 2.

believe it might be necessary to double the number of cars in use if mobile radio were not available. Working Group A-8 found that the savings that can be obtained from the elimination of a single patrol car is approximately $50,000 per year. The President's Commission on Law Enforcement and Administration of Justice confirmed this estimate for a one-man patrol car and estimated $100,000 for each two-man patrol car per year.

When you add other serious negative factors that would affect both these officers if they did not have mobile radio -- such as the inability to call for additional assistance or an ambulance, tow truck, or fire equipment, or to call for identification checks, or to call for advice or instruction, to name but a few -- it is already evident that two police vehicles lacking mobile radios could not provide the same level of police service as one police vehicle equipped with two-way radio.

This analysis brings out the following facts and conclusions:

1. Land mobile radio users are spending $1.6 billions annually for radio communications.

2. Savings to the national economy resulting from the use of land mobile radio units, over and above the costs of ownership, probably exceed $8 billion annually and may well be as much as $13 billion annually. (These figures also represent a good approximation of what the added annual costs to the economy would be of providing present services without mobile radio.)

3. The analysis does not attempt to take into account the value to the nation of the contribution of land mobile radio to safety of life, to prevention of injury, and to ameliorating the effects of disaster. Land mobile radio also makes a very important contribution to the economy in terms of saving property, a contribution which also is omitted in the analysis.

4. Two-way radio is an essential tool of business, particularly of "small business." It is vital to public safety services. Its contribution to the national economy is large enough to constitute a significant element in American industry's competition with foreign firms and in maintaining the American standard of living.

2.3 Growth of Land Mobile Radio

Here are the actual cumulative numbers of transmitters licensed by the Federal Communications Commission (FCC) for past years and the estimates thru 1975:

Year	Transmitters*
1950	180,000
1955	520,000
1960	1,300,000
1965	2,280,000
1970	3,500,000
1975	5,200,000

These figures show average annual percentage increases of 10% or more (37% in the first period, when the base figure for comparison was relatively small and growth was greatest).

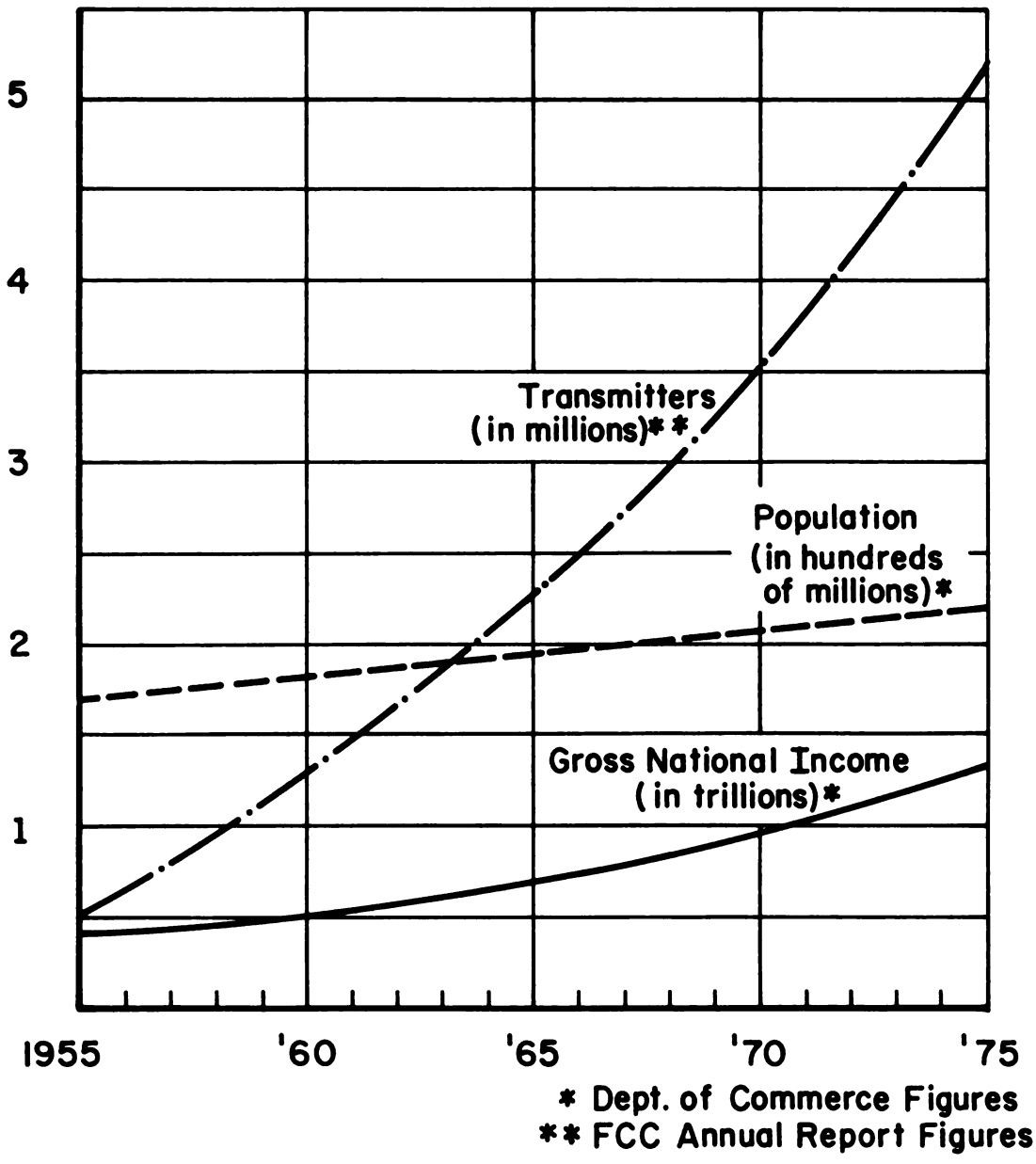
For comparison, here are some other growth rates:

U. S. Gross National Product, 1960-1965, average annually	6%
U. S. population, 1950 - 1960, average annually	1.9%
U. S. passenger car registration, 1966 increase over 1965	4%
U. S. digital computer installations current average annual increase	20%

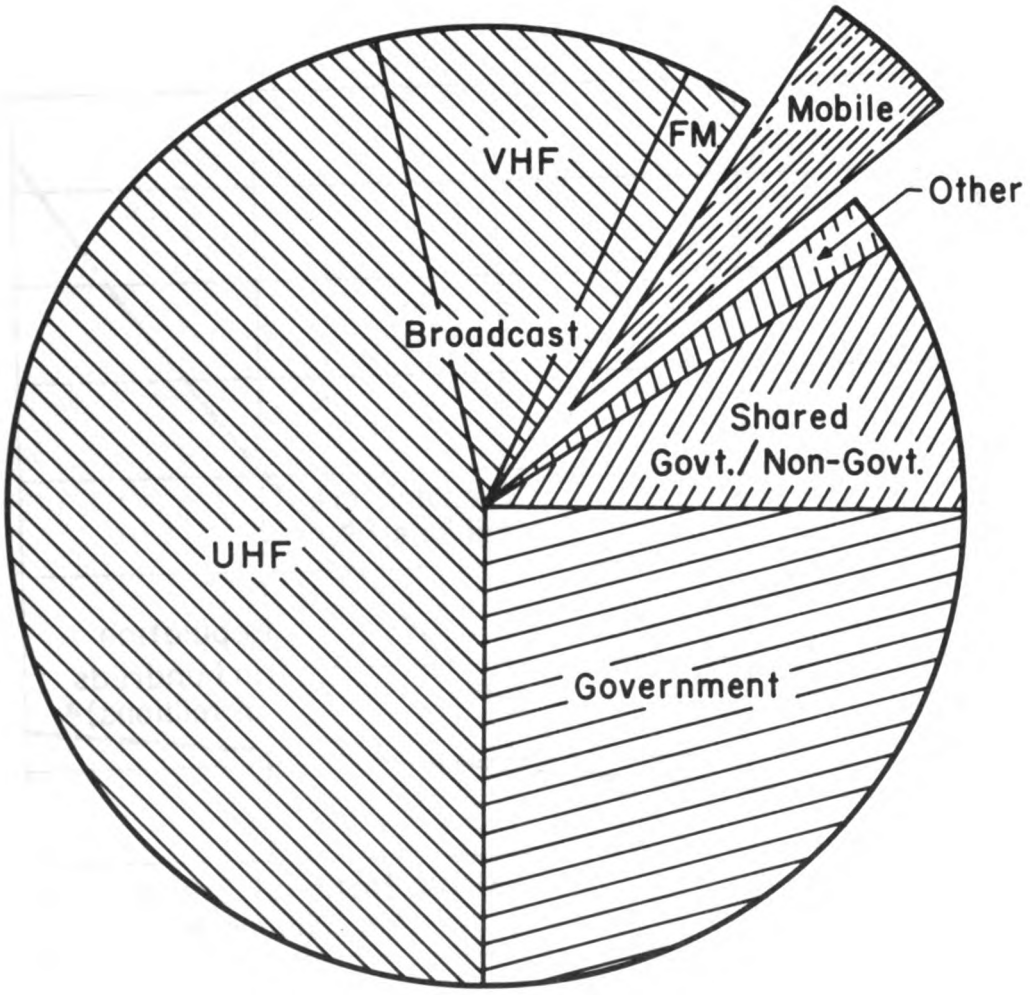
Some of these trends are illustrated in Figure 1.

The growth in land mobile radio has taken place entirely within spectrum bands fixed by FCC decisions prior to 1950. About 41 MHz in all are allocated for land mobile radio use. By comparison, AM, FM and TV broadcasting occupy 513 MHz. Of this, 72 MHz encompass the older VHF TV channels, 2-13; and 420 MHz encompass UHF TV, channels 14-83. The division of the spectrum from 25 to 890 MHz is shown in Figure 2.

*These figures are exclusive of land mobile radio equipment used by the Federal Government, as is the entire discussion herein. 1970 and 1975 figures are projections made during the study reported here, using techniques tested on data from earlier years. The 1950, 1955, 1960 and 1965 figures are from FCC annual reports.



GROWTH IN NUMBER OF LAND MOBILE RADIO TRANSMITTERS AS COMPARED TO GROWTH IN U.S. POPULATION AND GROSS YEARLY NATIONAL INCOME. FIG. 1



Legend

Broadcast			**Government**	**25.0%**	
FM	2.3%		**Shared**	**9.1%**	
VHF TV	9.5%		**Other**	**2.0%**	
UHF TV	47.4%				
	59.2%				
Land Mobile	**4.7%**				

APPORTIONMENT OF THE FREQUENCY SPECTRUM IN THE RANGE FROM 25 TO 890 MHz -- FIG. 2

3. THE CRISIS OF LAND MOBILE FREQUENCY CONGESTION

This growth of the land mobile services and the critical frequency congestion existing in these services point to the urgency of finding a solution in the near future.

3.1 What is the Problem

Although land mobile radio is vital to the safety and economic well being of all, the amount of radio spectrum allocated to its use has remained constant through the years and is now very badly overcrowded in most major metropolitan areas. Communications are not only poor, slow and difficult but in many cases impossible, because of this overcrowding.

For example, in many metropolitan areas, such as New York, all of the available police frequencies are in use. This means that these areas have reached the limit of their communications growth potentiality and must "make do" with less than the most efficient radio communications networks. It also places very real limits and restrictions on new and growing communities.

* * * * * * * * * * *

> According to Los Angeles Police Chief, Thomas Reddin, tapes taken from police transmissions at the height of the Watts riot had no pauses at all and calls from officers requesting help were going unanswered because of lack of air time to transmit calls for assistance.
>
> Industrial Communications, March 25, 1966.

* * * * * * * * * * *

> "A study of the communications system showed that some field units had only a 25 per cent chance of establishing immediate communication with the communications center because of the volume of air traffic. The Commission regards this as a serious matter..."
>
> President's Commission on Crime in the District of Columbia.

* * * * * * * * * * *

> Our need for additional frequencies is most urgent, and our entire program for improved law enforcement is dependent upon obtaining additional radio frequencies.
>
> The Police Commissioner of New York City to the FCC, November 4, 1965.

It means that new police techniques, requiring additional radio channels, may never be utilized with resultant loss in overall police protection. For businesses, the severe channel congestion in such areas as Los Angeles, Chicago and New York virtually prohibits many classes of business and industry from using radio to achieve lower overall operating costs and thus lower cost service to the public.

The result of this congestion and its impact is confirmed for all types of users.

* * * * * * * * * * *

> "...When we started using radio, we did not have much trouble reaching our trucks. Now the congestion on the channel is becoming a problem. It is busy so often when we need to use it to call one of our trucks. This is because of the number of users on the channel. There are more users than when we went on the channel and everybody is also probably using his radio more. We ourselves have almost tripled our number of radio-equipped trucks, and we are only one user. When we started the company, we hoped to be able to grow to 15 service trucks...but I do not know if we can do that unless the radio congestion problem is improved..."
>
> Testimony before House Select Committee on Small Business, Subcommittee on Regulatory and Enforcement Agencies, May, 1966.

* * * * * * * * * * *

The overall value of land mobile radio to this nation is such that provision for continued growth is extremely important.

Today, the use of radio by the land mobile services is such an integral part of our daily life that if these services are not given spectrum relief, the public will suffer substantial losses in safety, protection, and in increased costs for goods and services. This is not something of future concern. The interference and havoc caused by channel overcrowding is being experienced in most large metropolitan areas today, and the public is suffering right now.

A major result to the public of land mobile frequency congestion is a loss in police and fire protection and a consequent rise in the cost of these services to the taxpayer.

* * * * * * * * * * *

Radio Frequencies Crowded, Crises in Big Cities Feared.

Unless steps are taken to provide more operating frequencies, said Burton H. Dougherty, General Manager of the Department of Electricity of the City of San Francisco, a major disaster could find policemen and firemen without adequate radio communications.

Fire Engineering,
February, 1967.

* * * * * * * * * * *

The plight of the land mobile services in the metropolitan areas was brought out in a study of the FCC frequency assignment cards.* Over 50% of all licensed transmitters are concentrated in less than 8% of the land area of the Continental United States.

This geographic concentration is also true of our country's population. 2.18 per cent of the nation's land area accounts for slightly more than 50 per cent of the nation's total population.

Since for the most part the land mobile services provide communications for activities that in turn exist to serve people, the close correspondence between the geographic distribution of population and transmitters is not really surprising. It does mean, however, that channel requirements for most of the land mobile services will be affected by the long-term trend towards increased urbanization of the nation's growing population, which will continue to reinforce the population growth of the nation's metropolitan areas.

---

*EIA Study dated November 9, 1964.

The close correspondence in the geographical distribution of population and the number of licensed transmitters is matched by a high correlation between the growth of population and the increase in the number of licensed transmitters since 1950.

Forecasts of land mobile service growth both by EIA and this Advisory Committee's Working Group A-9 indicate that heavy congestion will turn into a major catastrophe in the metropolitan areas if spectrum relief is not provided soon.

The extent of the "explosive growth" of the land mobile radio services and the resulting congestion have been reported and commented upon by other independent government studies.

For example, a report by the Telecommunications Science Panel of the Department of Commerce, prepared with the cooperation of the Office of the Director of Telecommunications Management, the FCC, the Department of Defense, and the Department of Commerce, was issued earlier this year. It is entitled "Electro-magnetic Spectrum Utilization -- The Silent Crisis" and states:

> "Today in almost all the major metropolitan areas, there is considerable interference. In Los Angeles, for example, frequencies may be shared by as many as 50 to 60 users, operating 500 or 600 mobile units, all in the same geographical area. A recent FCC inspection trip to New York City confirmed intense congestion there."

Further evidence of the serious congestion is contained in a report issued by the FCC in February, 1967, analyzing its monitoring of the land mobile services in New York City during December, 1966. The report showed almost total saturation of the frequency channels assigned to the business, taxi cab and motor carrier radio services by messages during periods of peak use. The report states that "it can be concluded from the facts contained in this report that many of the presently available frequency channels in the (spectrum area studied) are becoming saturated."

The problem of finding additional frequency spectrum to take care of this rapidly increasing use of land mobile radio to better serve the public is a difficult one. As noted above, the FCC described it in its 1966 Annual Report as "one of the thorniest confronting the Commission." The difficulty arises from the fact that:

> "The laws of physics dictate that the frequency spectrum portion best suited for mobile communication lies in the range between 25 and 890 Megacycles.
>
> "The basic apportionment of this part of the spectrum was begun in 1944 in a lengthy allocations proceeding and more or less fixed in its present form in a 1949 decision of the Commission based on estimates of projected need for the services in existence at that time. With the possible exception of a few unavailing voices, no one then envisioned the birth of so many more diverse services and the astonishing growth pattern of the entire group." (1966 FCC Annual Report)

In commenting on the extent of the crisis at the time that the 1966 Annual Report was prepared, the FCC stated:

> "Only 4.7 per cent (of the spectrum between 25 and 890 MHz) is apportioned to the mobile services. Into this very limited space are packed over 2 1/4 million transmitters, with applications for new ones pouring in at the rate of 15,000 per month.
>
> "The underlying reason, then, behind this apparent imbalance in allocations is simply that the unusual growth in the Nation's economy and its resulting impact on the Land Mobile Radio Services was not foreseen by those concerned." (Emphasis supplied)

Although the unusual growth in the nation's economy and its resulting impact on the Land Mobile Radio Services "was not foreseen by those concerned" in 1949 when that 4.7 per cent of the spectrum currently suitable for land mobile purposes was allocated to the Land Mobile Radio Services, the problem was already becoming apparent two years later. On October 25, 1951, FCC Commissioner E. M. Webster commented:

> "It logically follows that, because of my early experience in this field, I came to the Commission with more than the average insight into the potentialities of marine and vehicular radio communications. Even so, my imagination did not permit me to completely envisage the colossal and rapid growth of these services and the terrific impact which they would have on the lives of the American people. And I have talked with no one who claims to have foreseen that which has come to pass in connection with such services."

In the brief period of those two years, the number of transmitters in the Safety and Special Services, of which land mobile services comprise about one half, had increased over 50 per cent.

This rapid growth continued unabated. By 1957, it had reached such a point that the FCC adopted an Order stating that:

> "The Commission has determined that it is necessary to institute an inquiry, on its own motion, pursuant to section 403 of the Communications Act of 1934, as amended for the purpose of obtaining the data necessary to carry out its statutory responsibilities, as set forth in section 303 of the Act in connection with the allocation of frequencies to non-governmental services and the radio spectrum between 25 Mc/s and 890 Mc/s." (Docket 11997)

The following quotations from subsequent Annual Reports of the FCC show the steadily deepening nature of the frequency congestion crisis.

1958 - "congestion" -

> "...the Commission's objective (is)...to relieve, to the greatest extent possible, the frequency congestion which prevails in most of these services."

1962 - "extreme congestion" -

> "The various industrial services grow within the confines of a very small portion of the usable radio spectrum. This situation has led to extremely congested operating conditions in many areas."

1964 - "acute frequency shortage" -

> "One of the most pressing problems faced by the Commission is to find frequency relief for the Public Safety, Industrial and Land Transportation Radio Services. These land mobile radio operations have grown rapidly in the past few years and frequency shortage has become acute in many geographic areas."

1966 - "major problem...one of the thorniest...intensively populated services" -

> "The major problem facing the Land Mobile Radio Services, as well as one of the thorniest confronting the Commission, is the congestion in the limited spectrum space available to these intensively populated services."

The Inquiry in Docket 11997 begun in 1957 lasted for seven years. The FCC gathered a vast amount of material and concluded that:

> "It is clear that the use of radio by the private land mobile services has been interwoven into the economic and social fiber of our society. Unquestionably, its use renders vital service and direct benefit not only to the users, but to the public at large. The record of the proceeding showed a picture of the Land Mobile Services not only making extensive use of then available frequencies for various purposes beneficial to the nation involving commerce, industry, public safety and protection of life and property, but also looking forward to a continuation and vast expansion of such uses."

While this Report and Order did not culminate in spectrum reallocation to provide the needed frequency relief to the land mobile services, the Commission's recognition of the seriousness of their plight did result in the initiation of a first step intended hopefully to provide some limited improvement in the situation. This step was the formation of the Advisory Committee for Land Mobile Radio Services.

3.2 The Commission Responds To The Problem

In view of the unquestioned direct benefit to the public at large, and the heavy usage of the private land mobile frequency space, the Commission recognized the urgency of the problem and set about resolving the frequency shortage affecting the private land mobile services. It began by asking whether there were any steps which "taken singly or in combination" might resolve the problem "without the re-allocation of spectrum space between 25 MHz and 890 MHz from other non-government radio services to the land mobile service for exclusive use."

To pursue this inquiry, the Commission established this Advisory Committee to mobilize the best available talent for the purpose. Members of the Committee, numbering over 200, included radio users, radio equipment manufacturers, consultants, legal counsel, frequency coordinators and

representatives of users and user groups, industry organizations and engineering associations as well as members of the Commission staff.

This was not the first time that the users and suppliers in the land mobile radio community responded to the need for a study of ways to improve utilization of the spectrum allocated for these services. Following is a list of Commission actions, each of which triggered a substantial effort, and of other notable undertakings:

July 1951 - December 1954 -- At FCC request, a Joint Technical Advisory Committee Subcommittee was formed to study the feasibility of splitting channels in the 152 - 162 MHz band;

January 1955 -- FCC issued Notice of Proposed Rule-Making proposing to split these channels (Docket 11523);

September 1956 -- FCC's First Report and Order splitting these channels and specifying that old equipment be modified or replaced by 1963;

April 1957 -- FCC issued an Order of Inquiry concerning the allocation of frequencies in the various non-Government services in the spectrum between 25 and 890 MHz (Docket 11997);

September 1957 -- FCC issued Notice of Proposed Rule-Making proposing to split the channels in the 42 - 50 MHz band (Docket 12169);

December 1957 -- FCC issued First Report and Order splitting these channels;

November 1960 -- FCC instituted Docket 13847 proposing to split the channels in the 450 - 470 MHz band;

February 1962 -- FCC issued Notice of Proposed Rule-Making proposing to split channels in the 30 - 40 MHz band (Docket 14503);

October 1963 -- FCC issued First Report and Order splitting these channels;

September 1963 -- FCC Commissioners visited Los Angeles for on-the-spot investigation of congestion in land mobile radio channels and to attend demonstrations prepared by Southern California users and suppliers;

March 1963 - November 1964 -- Extensive computer study by The Electronic Industries Association of land mobile radio as reflected by FCC's license file data;

March 1964 - November 1967 -- Study of this Advisory Committee.

The tremendous growth of the land mobile services has been the result of a real public need. But it has come about only because research was conducted, and equipment and techniques developed, that allowed continued squeezing of more users into a fixed amount of frequency space.

As a result of research, channel spacing in the 150 MHz band which started at 120 KHz was cut in half to 60 KHz, and then later again halved to 30 KHz. There are land mobile users now operating with 15 KHz separation, with coordinated geographical spacing. At 40 MHz, channel spacing has come down to 20 KHz. The industry is now preparing to split the 450 MHz channels to 25 KHz, down from 100 KHz and 50 KHz. Frequency stability has been improved from 0.01% to 0.0005%, a ratio of 20 to 1; and this Advisory Committee has, of necessity, recommended further tightening base station frequency stability to 0.00025% at 450 MHz. Receiver selectivity has been improved by several orders of magnitude. Image responses were 60 dB and are now 100 dB, an improvement by a ratio of 10,000 to 1. IF beat and intermodulation responses have been improved from the order of 40 dB to 80 and 100 dB, an improvement by a ratio of 1,000,000 to 1. Impulse noise blankers were developed to reduce the increased effects of ignition noise upon narrower and narrower bandwidth receivers. Transmitter noise spectrums were reduced, along with transmitter harmonics. Continuous tone-coded squelch systems were developed to alleviate the co-channel sharing problem.

But all these improvements of the last 20 years have not been instituted without cost. Wholesale conversions and replacement of equipment to allow closer and closer spacing of channels have cost the users, -- which are tax supported agencies, utilities, American industry, and the public, -- hundreds of millions of dollars. To allow for more and more use of the spectrum, as the art progressed, the land mobile user has had to change equipment a number of times in the last 20 years at substantial cost. He has done this because his communications are absolutely essential. He has paid not only in money but also in degraded service, due to increased noise and more and more interference occurring as channel spacings were reduced.

The present Advisory Committee has now completely studied the spectrum utilization problem and believes its report represents an objective view of the present situation and a proper analysis of all the techniques available for any increased utilization of the existing spectrum assigned to the land mobile radio services.

4. THE ADVISORY COMMITTEE FOR THE LAND MOBILE RADIO SERVICES

4.1 Organization and Method of Operation

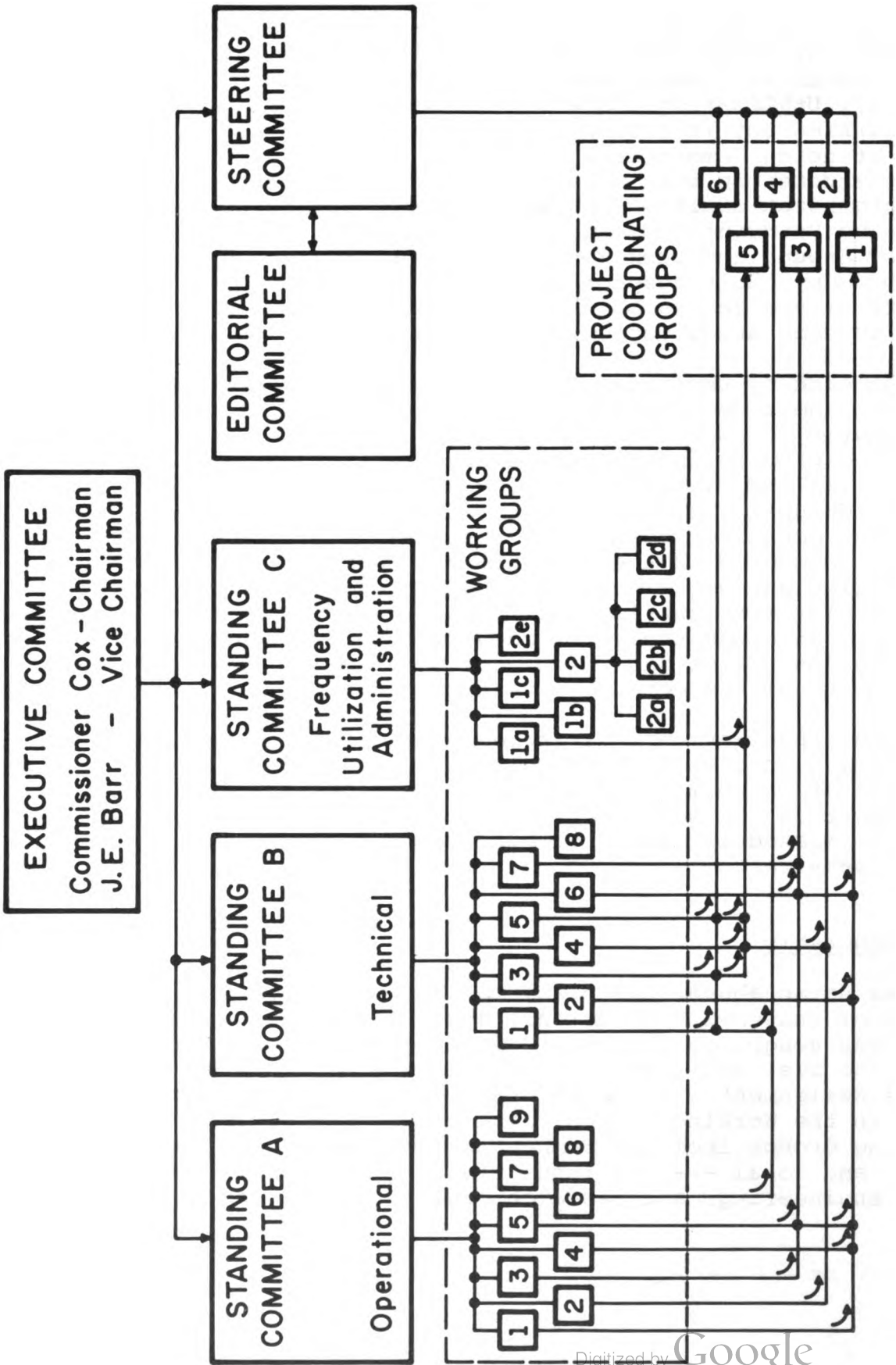
The Advisory Committee structured itself into several echelons of study activity and responsibility. An Executive Committee was formed to oversee the entire effort and provide overall guidance and direction. The study was initially organized into three major areas of investigation. (See organization chart, Figure 3.)

1. Operational - This area included study of both present practices and potentially useful new operational system concepts to determine if any might lead to improvements in frequency utilization and what degrees of improvement might be realized. This area of study also included studies of the economic aspects and growth projections of the land mobile radio services.

2. Technical - This area emphasized study of the technology of land mobile radio. The application of presently used and potentially useful equipment and system concepts were explored in terms of identifying where improvements in frequency utilization might be achieved based on technical changes or improvements.

3. Frequency Utilization and Administration - This area of study involved an examination of the administrative and management practices and policies of users and of the Federal Communications Commission. This was undertaken to determine if changes in these might contribute to amelioration of the frequency problems. Further, this study examined the possible application of computer techniques to reduce a portion of the administrative burdens.

The work of each of the three Standing Committees was carried out by Working Groups which undertook specific study assignments. For example, the Operational Standing Committee was responsible for examining the possible use of multiple access systems, multiple low-power systems in place of a single higher powered system, one-way systems in lieu of two-way systems, etc. Each of these subjects was assigned



ORGANIZATION CHART, ADVISORY COMMITTEE
FOR LAND MOBILE RADIO SERVICES -- -- FIG. 3

to a Working Group specifically formed for the study effort. In a similar manner, Working Groups were formed under the supervision of the Technical Standing Committee. Much of the study of these Working Groups involved evaluation of advanced technology and methods. The study activities of the Frequency Utilization and Administration Standing Committee were carried out in essentially the same manner as in the other Standing Committees. However, because of the nature of the studies in this area, Task Forces were formed which were organizationally comparable to the Working Groups of the other two Standing Committees. Throughout the period of the Working Groups and Task Forces' studies, reviews of progress were made by their respective Standing Committees. This was done to assure that a balanced and thorough treatment was given to each study topic.

As each of the individual study activities reached completion, their data and analyses were supplied to six Project Coordinating Groups. These Project Coordinating Groups were formed to provide an integrated treatment of matters having aspects falling within the study scopes of two or more Working Groups. Thus, these Project Coordinating Groups provided the means to interrelate the results of the individual studies conducted in the Operational, Technical, Frequency Utilization and Administration study areas. Most of the study topics were carried out in this manner. However, there were several study topics which were found suitable for separate discussion and which were not incorporated into the assignments of Project Coordinating Groups.

The organization thus formed provided for a balanced exploration into every area which appeared even remotely possible of harboring means for more effective use of that small portion of the radio frequency spectrum which is presently allocated to serve the burgeoning needs of the land mobile services.

4.2 Membership

As noted above, the participation of the entire community of those with experience and interest in land mobile radio was sought so that the Committee's results might reflect the best available thinking of the nation with respect to its assignment. The more than 200 men who took active roles in the Working Groups, Task Forces and Project Coordinating Groups included members of government --- Federal, state, and local ---, of industrial, agricultural, commercial, engineering, and research organizations, and of law

offices and academic institutions in all parts of the nation.* Many more people attended meetings and reviewed and commented on the work as it progressed.

5. APPROACHES UTILIZED TO TRY TO IMPROVE LAND MOBILE SPECTRUM USAGE

More effective use of this portion of the spectrum by more users depends, in large measure, on the extent to which it is possible to improve the methods used to separate the radio signals of one user from the radio signals of another. Technically, this can be done either by transmitting the messages: (1) on different frequencies, spaced far enough apart in frequency to preclude interference; (2) on the same frequency, but at different times; or (3) on the same frequency, but at such a geographical distance from another transmission that the signals do not interfere with each other.

In practice, this means that more messages can be crowded together by:

(1) narrowing each frequency channel to provide space for more channels,

(2) using less spectrum space in each frequency channel to transmit a message,

(3) shortening the time it takes to transmit a message,

(4) making use of all available transmission time,

(5) assigning frequency channels so that there is sufficient geographic separation between users of the same frequency channel that one user will not interfere with another user, and,

(6) developing techniques and devices which will accomplish a result similar to actual geographic separation.

6. CLASSIFICATION OF STUDIES AND RESULTS

The findings of the Advisory Committee study can be subdivided into two major areas:

---

*Persons participating are listed in Appendix E, Volume 2.

A. Findings that relate directly to spectrum utilization.

B. Findings of an important nature that do not relate to spectrum utilization as such, but which are important codifications of a technical, economic or administrative nature.

In the former area, the results of the study have been further categorized as follows:

1. Concepts affording promise of some improvement in spectrum utilization at a low enough cost to be worthy of implementation. Only two of these were discovered.

2. Concepts promising minor improvements in spectrum utilization, but at relatively high costs or under such special circumstances that their possible usefulness would be confined to special cases. Ten such items were identified.

3. Concepts offering only negligible improvement in spectrum utilization. Some of the concepts placed in this category are currently being utilized by many users; however, it appears that there is little possibility that they can be extended broadly in any way to further improve spectrum usage.

Table 1 shows how topics studied by the Committee fall into this classification scheme. Brief discussions of the topics appear in the paragraphs following.

7. SUMMARY OF RESULTS OF STUDIES

The complete reports of the six Project Coordinating Groups and the complete reports of those other studies that stand alone make up Volume 2 of this final report. In addition, there are many other reports and studies which helped make up the basic work underlying these final reports. These are far too numerous and extensive to publish, and are on file with the FCC as the working papers of the Advisory Committee. Also on file are stenographic transcripts of the meetings of the Executive Committee and of the three Standing Committees.

A brief summary of each major topic and the Advisory Committee's conclusions and recommendations with respect

TABLE 1

CLASSIFICATION OF STUDY RESULTS

Topic	A			B	Pertinent Subgroup Reference
	1	2	3		
1. Reduced Channel Spacing in the 450 MHz Band	X				WG B-8
2. Expanded Interservice Sharing	X				TF C-2
3. Broadband Multiple Access Systems		X			PCG 1
4. Geographic Separation Versus Time Shared Use of Land Mobile Channels		X			PCG 1
5. Exclusive Use of Low Power		X			PCG 2
6. Multiple Low Power Transmitter Systems		X			PCG 2
7. One-Way Base to Mobile Systems		X			PCG 3
8. One-Way Multiplexing on Broadcast Transmitters		X			PCG 3
9. Non-Voice Systems		X			PCG 3
10. Single Frequency vs. Two-Frequency Systems		X			PCG 1
11. Precise Limitation of Signal Strength		X			PCG 5
12. Fixed Point-to-Point Service		X			TF C-2e

NOTES:

Classifications

A-1: Concepts affording promise of some improvement in spectrum utilization at a low enough cost to be worthy of implementation.

A-2: Concepts promising minor improvement in spectrum utilization but at relatively high costs or under such special circumstances that their possible usefulness would be confined to special cases.

A-3: Concepts offering only negligible improvement in spectrum utilization. Some of the concepts placed in this category are currently being utilized by many users; however, it appears that there is little possibility that they can be extended in any way to further improve spectrum utilization.

B: Findings of an important nature that do not relate to spectrum utilization as such, but are important codifications of a technical, economic or administrative nature.

Abbreviations

PCG: Project Coordinating Group

TF: Task Force

WG: Working Group

TABLE 1 (Continued)

Topic	A			B	Pertinent Subgroup Reference
	1	2	3		
13. Multiplexing			X		PCG 1
14. Variable Power Systems			X		PCG 2
15. Selective Calling			X		PCG 3
16. Mobile Relay Techniques			X		PCG 4
17. Common Base Station Siting			X		PCG 4
18. Computer Techniques for Frequency Assignment			X		TF C-1c
19. Suitability of Various Frequency Bands for Land Mobile Service				X	PCG 6
20. Radio Operating Techniques and Procedures				X	WG A-7
21. Value of Land Mobile Radio Services				X	WG A-8
22. Predictions of Land Mobile Radio Service Growth				X	WG A-9
23. Review of FCC Policies and Procedures				X	TF C-1b
24. Man-Made Noise				X	WG B-3
25. Transmitter Power, Efficiency of Communication and Interference				X	WG B-5

NOTES:

Classification

A-1: Concepts affording promise of some improvement in spectrum utilization at low enough cost to be worthy of implementation.

A-2: Concepts promising minor improvement in spectrum utilization but at relatively high costs or under such special circumstances that their possible usefulness would be confined to special cases.

A-3: Concepts offering only negligible improvement in spectrum utilization. Some of the concepts placed in this category are currently being utilized by many users; however, it appears that there is little possibility that they can be extended in any way to further improve spectrum utilization.

B: Findings of an important nature that do not relate to spectrum utilization as such, but are important codifications of a technical, economic or administrative nature.

Abbreviations

PCG: Project Coordinating Group
TF: Task Force
WG: Working Group

to that topic follow. The complete, detailed reports supporting these summaries are contained in Volume 2.

7.1 Reduced Channel Spacing in the 450 MHz Band

The study of this subject included theoretical analysis, laboratory testing and field evaluation. Details of this study are contained in the attached report, Section 11 of Volume 2, entitled "Determination of Technical Standards for Reduced Channel Spacing in the 450 MHz Band."

As a result of its study, the Advisory Committee recommends that:

> The channel spacing in the 450 MHz band be reduced and that the new channels thereby made available be immediately allocated.

In arriving at this recommendation, the Advisory Committee recognized that this step will require the expenditure of significant sums of money for modification and replacement of equipment. However, since it was found technically feasible to reduce the assigned bandwidth from 50 KHz to 25 KHz in this band, the Committee concluded that the more efficient spectrum usage occuring from such a move would justify the cost.

It was also apparent from the tests that reducing the separation between frequency channels in this band would result in increased interference from ignition noise and a larger radius of interference around a station on an adjacent channel. As the "split channels" are occupied, there will also be an increase in the interference caused by the combination of signals broadcast by different land mobile stations on separate frequencies, known as intermodulation interference. Thus "splitting" the channels will not create double the number of usable frequencies. In addition, there will be an increased indirect cost to the public as well as to the users due to the need for increased maintenance of the radio systems as a result of the more exacting technical requirements which must be placed in effect when the separation between frequency channels is reduced.

However, the problem of frequency congestion in the spectrum presently allocated to the land mobile service is of such magnitude that the Executive Committee of the Advisory Committee recommended the consideration of reduced channel spacing in the 450 MHz band to the Commission.

The Commission has already begun to implement this recommendation by an order issued on November 30, 1966, establishing new technical standards for channel spacing in the 450-470 MHz band, citing the tests and experiments of this study in support of its action. No action, however, has yet been taken to actually implement use of the new split channel frequencies.

The Advisory Committee wishes to emphasize that this reduction in the separation of assignable frequencies in the 450-470 MHz band will not solve the land mobile congestion problem. It will reduce some of the present congestion for a limited period of time, but it will not accommodate even the conservative forecast for growth of the land mobile services set forth in Section 2.3 above.

7.2 Expanded Inter-service Sharing of Mobile Channels

The study of this subject is set forth in Section 14, Volume 2 of this report. The study covered the following four areas:

1. An analysis of the existing "block service" system of allocations.

2. A characterization of each of the existing services in terms of the types of radio usage they employ and the proportion of each type.

3. A review and extension of the results of the EIA Card Study to relate usage to allocations.

4. Evaluation of alternative allocation plans including more extensive inter-service sharing and geographical reallocation.

As a result of this study, the Advisory Committee recommends that:

> Expanded inter-service sharing of land mobile channels be permitted as described in Working Group C-2's report so that there will be maximum utilization of all channels in all areas.

At the present time, the land mobile radio users are divided into basic categories, such as police, fire, taxi, relay press, business, industrial, forestry, petroleum, and railroad, with each category allocated specific groups

of frequency channels by the Commission on a nationwide basis. This is known as "block allocation" of frequencies.

It was found that some relief would be afforded if the present Commission block allocation system were relaxed to permit, under appropriate conditions, a service suffering frequency channel overcrowding in a given locale to share the frequency channels of another service which is making less intensive use of its channels in that area. To be sure, in the major metropolitan areas, this would not be of great benefit because substantially all frequency channels in all allocation blocks are already crowded. However, to the extent such sharing may be determined to be practicable, there would be an aggregate improvement in the use of the frequency channels.

THE RECOMMENDATIONS IN 7.1 AND 7.2 ABOVE CONSTITUTE THE ONLY MEANS THE COMMITTEE FOUND THAT COULD MEANINGFULLY INCREASE THE UTILIZATION OF THE EXISTING LAND MOBILE SPECTRUM. THEY WILL DO LITTLE MORE THAN TO QUITE TEMPORARILY RELIEVE CONGESTION IN LAND MOBILE RADIO.

7.3 Broadband Multiple Access Systems

Broadband multiple access systems, described more fully in Section 2 of Volume 2, are basically systems in which a number of individual users share a common base station which operates on frequencies which are the equivalent of several individual mobile channels. Although many of the techniques studied proved to have very limited application (having been developed principally to meet unique mobile needs of the military), one type had characteristics useful for specialized land mobile radio applications: namely, the frequency division multi-channel type. It is characterized by a complicated central control station which performs the necessary channel switching and assignment functions to allow each user access to more than one radio channel. Mobile units employing this system must have channel switching capability with logic control.

This system has been found to be particularly well-suited for mobile telephone service since the central location also serves as the telephone exchange providing connection to the land line network. The major advantage of this type of system is that potential access to more than one channel can minimize the delay time necessary for access to a clear channel under busy conditions.

Although extremely efficient for common carrier mobile telephone service, this technique does not offer the same advantages for today's typical non-common carrier mobile systems. The reasons for this are several. Since a commonly shared system of this type must serve users who may be widely separated in a geographic area, the transmitters used must cover the entire area to be served. Consequently, simultaneous use of a particular frequency in two or more geographically separated locations in the same metropolitan area is not practical. Under the present practices of assigning individual channels to the non-common carrier users, it is possible to take advantage of their geographic separation and thereby re-use a particular channel frequency several times in the same metropolitan area. Furthermore, under today's congested conditions, where channels are simultaneously shared by several users, there is virtually no "idle" channel time for a trunked system to take advantage of. In fact, in some instances, the geographic separation enables well over 100% channel usage since users are frequently able to be "on the air" simultaneously because the stronger local signal "captures" the desired receiver while masking out the more distant, unwanted transmissions.

As a result of the detailed investigation of the applicability of this type of system, the Advisory Committee concluded:

> Most land mobile users are presently operating on channels shared with many other users in the same local area. Under these conditions, trunking, although it can theoretically result in an improved quality of service, can actually result in fewer users served per channel. However, in those situations where applicable (see Section 2, Volume 2), particularly public mobile telephone service, trunking does conserve spectrum space, and its use in such cases should be encouraged.

7.4 Multiple Use of Conventional Channels (Geographical- vs. Time-Shared Use)

A detailed report of the investigation and findings of this study is also contained in Section 2, Volume 2, of this report. This study involved theoretical analysis and measurements made by channel-monitoring. The study revealed that multiple, separate, geographically-spaced use (shared use) of a channel results in better spectrum utilization than does time-shared geographically co-extensive use, in cases where users are communicating over a portion rather than over all of a metropolitan area. It was found, however, that

adopting multiple, separate use should be subject to case-by-case decisions (see also Section 7.7 below and Section 4, Volume 2) based on individual system communications requirements. In view of these findings, the Advisory Committee has concluded that:

> In relation to the overall land mobile communication requirements no significant improvement in spectrum utilization can be obtained through exclusive use of either system type, since both are necessary to fulfill the various needs encountered in land mobile radio use. However, in specific circumstances, particularly where users require short range mobile communications (up to ten miles), the geographically-spaced shared-frequency system concept should be encouraged.

7.5 Channels Exclusively for Low Power Use

This study analyzed the communications requirements of the land mobile services to determine if any of them could be fulfilled by operation on channels set aside exclusively for low power systems. The full report of this investigation is contained in Section 3, Volume 2 of this report. After reviewing the findings, the Advisory Committee has concluded that:

> None of the land mobile services studied could obtain operational advantages by changing over completely to low-power systems. However, there are individual users who could benefit from adopting systems using channels limited to low-power operation. The Commission should give favorable consideration to setting aside channels exclusively for use with low-power transmitters. Applicants should be encouraged to examine the prospect for satisfying their needs on such channels before making application in bands where higher powered operations are provided for. "Low-power," in this sense, would be defined in terms restricting radiation patterns to relatively small coverage areas, as described in Section 3, Volume 2.

7.6 Multiple Low-Power Transmitter Systems

The full report of this investigation is contained in Section 3 of Volume 2 of this report. The study involved analyzing the potential merits of using a number of controlled radiation base stations, all operating on the same frequency, to cover with adequate radio signal strength a defined area. This concept was contrasted with the normally used method of employing a single higher-powered base station covering the same area. As a result of this study, the Advisory Committee has concluded that:

> For most land mobile service users, properly designed single higher-powered stations offer technical advantages, definite economic advantages, operational advantages and comparable spectrum usage. There are, however, a few special cases, where long, narrow coverage areas are desired, in which low-power base station systems can conserve spectrum at the cost of increased system complexity and added auxiliary equipment.

7.7 One-Way Base-to-Mobile Systems

A complete report of this study is contained in Section 4, Volume 2 of this report. This system concept involves the potential use of a one-way communication path from the base to the mobile with the mobile units having no means for reply. Based on the findings of this study, the Advisory Committee has concluded that:

> One-way base-to-mobile systems are candidates to replace only a small fraction of the communications afforded by two-way systems because the vast majority of users also need mobile-to-base or mobile-to-mobile communications. In certain circumstances such systems can be used to advantage, as for paging, which has recently become an important new mode of communications. It is also recognized that in those limited cases where one-way base-to-mobile service can provide adequate communications it should be encouraged, since some improvement in spectrum utilization could result. However, personal paging, a new and expanding use of the spectrum, seems to demand special channels just for its own use. This is a further need, in addition to the other growing spectrum requirements of the land mobile services.

7.8 One-Way Multiplexing on Broadcast Transmitters

This study, reported in Section 4, Volume 2, centered on evaluating the feasibility of using multiplex techniques and FM broadcast transmitters (although AM and TV transmitters were also considered) to provide one-way communications for land mobile service use. Since the Committee was restricted to consideration of presently available land mobile frequencies only, the fact that the Commission authorized examination of multiplexing on broadcast channels is worthy of note. From the findings of this study, the Advisory Committee has concluded that:

Multiplex service on FM broadcast transmitters for land mobile service use was found to be technically feasible; but such use would entail greater costs as well as increased operational and maintenance complexities than are involved in comparable existing land mobile systems. Multiplexing on AM broadcast stations was found to be unfeasible. The effort required to determine the feasibility of multiplexing on TV channels was found to be beyond the resources of the Committee.

7.9 Non-Voice Systems

This study, reported in Section 4, Volume 2 of this report, investigated the potential use of automatic message signalling devices and teleprinters to replace, or to be used in conjunction with, voice messages. These techniques were evaluated in terms of the factors which contributed to efficiency in spectrum utilization. Based on the findings of this study, the Committee has concluded that:

The potential use of non-voice communication techniques is a possible means for improving technical efficiency in spectrum utilization; however, important gains in efficiency are presently limited by economic and operational factors. The Committee also notes that there is a growing use of non-voice systems which do not in any way replace voice, such as control signals and telemetry. These are adding to the growing requirement for suitable spectrum, rather than providing relief for older usages.

7.10 Single-Frequency Versus Two-Frequency Systems

The report of the investigations of this study is contained in Section 5, Volume 2 of this report. The study included an analysis and comparison of single-frequency and two-frequency modes of operation. The single-frequency mode utilizes a single radio channel for transmissions by both the base station and its mobiles. In contrast, the two-frequency mode uses two radio channels - one for transmissions originated by the base station, and one for transmissions originated by the mobile units of a system. Two-frequency mode operations may be simplex or duplex. Simplex implies that a particular station, whether base or mobile, cannot receive and transmit simultaneously, whereas duplex operation implies that simultaneous reception and transmission is possible. Operationally, the two-frequency simplex mode is ideally suited to a heavily-loaded channel in which a base station is in near-constant communication with a fleet of mobile units and shares the channel with other similar users suitably separated geographically. An example of this is a group of geographically

dispersed cab companies. The two-frequency duplex mode is ideally suited to the economic and operational needs of a cooperative group of small users. The single-frequency simplex mode is ideally suited to the needs of users whose mobile units must communicate with each other at locations which are remote from base stations. From the findings of this study, the Advisory Committee has concluded that:

> The overall efficiency of spectrum utilization achieved is dependent upon the degree to which each of the above system types is employed to meet operational and economic requirements. Consequently, the selection of which of the system types is to be used in a specific application should continue to be determined on a case-by-case basis.

7.11 Precise Control of Signal Radiation

The report of the investigation conducted in this study is contained in Section 6, Volume 2 of this report. This study centered on obtaining a better understanding of the extent to which spectrum utilization might be improved through more precise control of radio signal coverage to restrict radiation to the minimum required for adequate coverage of the required area of service of a given land mobile user. Based on the findings of this study, the Advisory Committee has concluded that:

> In those services where effective frequency coordination exists, the FCC should investigate the feasibility of establishing a procedure for simple transmitter power-antenna height calculations which might be used to select the system gain factors required to meet given coverage needs. For the long range, the FCC should develop a data base which might permit optimum spectrum utilization through control of permissible systems gain in the licensing process by use of a computer-oriented data processing system. The Committee cautions, however, that any such system must be simple and economical to operate, as well as flexible to allow for changing conditions.

7.12 Fixed Point-to-Point Service

This investigation is reported in Section 15, Volume 2 of this report. From a review of the point-to-point operations in the 450 MHz band, the Advisory Committee has concluded that:

> Although presently in use, in the interest of conserving spectrum, point-to-point communications systems in the 450 MHz band in major metropolitan areas, should be phased out with an appropriate amortization period. An exception to this are those control stations operating on the same frequency as the mobile units. This step will remove the additional burden of fixed service operations from this band in the heavily congested areas and free their channels for mobile use. Little additional utilization will result in the major metropolitan areas as a result of this move, but because 450 MHz frequencies are well suited for mobile operations, the Advisory Committee felt compelled to take this action to relieve the congestion problem in the larger cities. Outside these areas there are justifiable needs for point-to-point service and there is no apparent reason to restrict usage entirely to that related to mobile operations. Broader use, however, should be permitted only on a secondary non-interference basis to mobile-related operations.

7.13 Multiplexing

The complete report of this study is contained in Section 2, Volume 2 of this report. The use of the term "multiplexing" here refers to a mode of signal transmission whereby information from many independent sources is used to modulate a common RF signal carrier. Based on the findings of this study, the Advisory Committee has concluded that:

> The contribution which multiplexing could conceivably make to increased spectrum utilization is negligible in light of present and proposed techniques because of the many technical, operational and economic restrictions required for successful application.

7.14 Variable Power Systems

The study of this concept is contained in Section 3, Volume 2 of this report. This concept involves the control of base station power in accordance with the signal strength or other appropriate measure of the signal received from a mobile unit. After a review of the findings of this investigation, which included an on-site evaluation of an operating system, the Advisory Committee has concluded that:

The limited applications for this concept represent a small percentage of potential users. It is costly. Elaborate equipment is required; full duplex operation is necessary; and carriers must be transmitted continuously. No formal action should be taken to require use of the concept. It offers little toward solving the total spectrum problem.

7.15 Selective Calling Systems

This study is reported in Section 4, Volume 2 of this report. The selective calling concept involves the use of coded signals to activate a particular receiver so that more than one user may share a channel without the nuisance to operators of hearing messages originated by other users. However, selective calling only prevents nuisance interference and the resulting unnecessary operator fatigue; it does nothing to alleviate destructive interference which is the main problem in heavily congested areas. After a review of the findings of this study, the Advisory Committee has concluded that:

Such systems afford improvements in the operation of land mobile radio systems, but offer no potentiality for increasing spectrum utilization.

7.16 Mobile Relay Techniques

The complete study is contained in Section 5, Volume 2 of this report. Mobile relay techniques permit extension of the range of communication between two or more radio stations. The stations whose signals are relayed may be either fixed or mobile. This study was able to identify the varieties and many operational advantages of such techniques, but could find no benefit by further use of such techniques in improving efficiency of spectrum utilization. As a result, the Advisory Committee has concluded that:

Mobile relay techniques can provide no contribution to improving spectrum utilization.

7.17 Common Base Station Siting

This study report is contained in Section 5, Volume 2 of this report. This concept involves intentionally placing a number of base stations at a common location in order to

provide a convenient means for "engineering" for minimum interference conditions. After a review of the findings of this study, the Advisory Committee has concluded that:

> Co-channel usage of spectrum cannot be increased by such techniques. The most common reason for such practice was found to be that there are too few sites suitable for metropolitan coverage in most areas. Location of many base stations at one point forces city-wide coverage which may not be necessary. Therefore many geographically spaced stations may give better overall utilization than centrally located stations. Common locations also create major intermodulation problems in base station transmitters and receivers. Furthermore, study indicated that co-location was a more costly solution than the application of the same techniques to the situations existing at each user's location.

7.18 Computer Techniques for Frequency Assignment

The full report of this study is contained in Section 13, Volume 2 of this report. This study was conducted to determine if a computer-oriented assignment system might be achievable and of assistance to the management responsibilities of the FCC. After a review of the findings of the study, the Advisory Committee recommends that:

> An Ad Hoc Committee be formed consisting of FCC personnel, experts from the computer industry and advisors from the land mobile services to work out the details of the total system of information flow which will be required to utilize computer capabilities in the administration of frequency assignments most effectively and efficiently. It is believed that if a proper computer system can be designed, and all existing assignments put into it and carefully kept up to date, administrative improvements will result, though local competent human judgement will be necessary in the final assignment process.

7.19 Suitability of Various Frequency Bands for Land Mobile Service

This study report is contained in Section 7, Volume 2 of this report. This study examined in detail frequencies below 1000 MHz potentially useful for land mobile service.

This effort did not relate to means of reducing spectrum congestion since it considered some bands not available or not generally usable for land mobile service. After a review of the findings of this study, the Advisory Committee has concluded that:

> Operations should continue to emphasize the use of frequencies below 600 MHz. While experimentation on frequencies above this region should be encouraged, years of development effort will be needed before use of the frequencies above 600 MHz becomes practicable. Even then, these frequencies may well prove to be of limited value for general use because of their coverage characteristics.

7.20 Radio Operating Techniques and Procedures

This study report is contained in Section 8, Volume 2 of this report. This study examined techniques and procedures of operation of land mobile radio systems to determine if standardized techniques and procedures might improve the benefits derived from radio systems. After reviewing the results of this investigation, the Advisory Committee recommends that:

> The FCC consider issuing a manual, describing operating techniques and procedures which have been found to be of benefit, to all its licensees in the land mobile radio services. This should not be a mandatory replacement of existing techniques and procedures but would serve as a valuable guide to establishing effective methods.

7.21 Value of the Land Mobile Radio Services

This study report is contained in Section 9, Volume 2 of this report. This study determined that the value of the land mobile services in terms of benefit to the public-at-large is substantial and is an important section of our total economy. Based on the findings of this study, the Advisory Committee has concluded that:

> The benefit to the national economy resulting from the land mobile radio services is in excess of $8 billion annually. To this must be added the inestimable value of these services to the safety of life, prevention of injury and the amelioration of the effects of disaster.

7.22 Predictions of Land Mobile Radio Service Growth

The complete report of this study is contained in Section 10, Volume 2 of this report. This study established growth factors which permit prediction of expected future growth of the land mobile services. As a result of a review of the findings of this investigation, the Advisory Committee has concluded that:

> All available indicators show that the need and use of land mobile radio services will continue to grow at an average annual rate in excess of 10%.

7.23 Review of FCC Policies and Procedures

The report of this study of the investigation is contained in Section 12, Volume 2 of this report. This study encompassed a review of the practices used by the FCC in its administration of the land mobile services. Based on the findings of this study, the Advisory Committee recommends that:

> Certain policies and procedures be revised to provide: shorter intervals between the filing of various requests and Commission action; simplification of the language of the Rules; improvement in the dissemination of information; and improvement in the overall efficiency of the regulatory processes.

7.24 Man-Made Noise

The report of this study is contained in Appendix A, Volume 2 of this report. This study entailed analysis, laboratory testing and field measurement of the magnitude and severity of interference to land mobile channels due to electrical noise that is man-made; the study specifically excluded the effects of noise from terrestial and extra-terrestial sources. As a result of the findings of this study, the Advisory Committee recommends that:

> A program of continued study of man-made noise reduction be given serious consideration.

7.25 Transmitter Power, Efficiency of Communication and Interference

The report of this work is included as Appendix B, Volume 2 of this report. The study reviewed the technical factors determining communications range and collected and formulated analytical expressions of the relationships among the factors for use (1) in calculating the coverage or service areas of given systems and (2) in analyzing the suitability of alternative channel assignments for a given system or systems. In particular, efforts were directed to clarifying the relationships between transmitter power as it affects communications reliability on the one hand and as it causes or contributes to interference on the other hand. The study, in addition to assembling and developing useful results, provided a framework within which further experimental and analytical work may be undertaken to improve understanding in this area. It was noted that service reliability prediction is limited at present by the unavailability of critical data and by limitations in the analytical capabilities so far developed.

8. CONCLUSIONS

The Advisory Committee has found, through the extensive and costly studies reported herein, which were pursued actively for three years, that no major long-term relief of the frequency congestion crisis being experienced by the land mobile service can be achieved in the major metropolitan areas of the country by further changes in operation, techniques and procedures within the existing land mobile services. These studies have identified only two areas in which any significant improvements in spectrum utilization can be obtained, and then only through more costly equipment and increased engineering and coordination expense.

The recommendations listed above will be extremely costly to users and the FCC alike. They will require extensive modification or complete replacement of millions of dollars worth of radio equipment. Also, they will be costly in terms of additional man hours of coordination. The land mobile radio users realize that these recommendations mean still further sacrifices of time and money on their part as a price for access to the limited radio spectrum. It is a price they are willing to pay. However, at the present rate of growth of the land mobile radio services, even their willingness to accept this additional penalty will not meet the desperate need for additional land mobile radio channel space.

Therefore, the Advisory Committee concludes that if the public is to continue to receive the benefits, services and efficiencies provided to it by all areas of the land mobile services -- which can only be so provided -- benefits, services, and efficiencies which are indeed in the public interest, convenience and necessity -- additional frequency spectrum must be allocated for this use.

* U. S. GOVERNMENT PRINTING OFFICE : 1967 O - 280-469