TASK FINAL REPORT

on

POTENTIAL MARKETS FOR A SATELLITE-BASED MOBILE COMMUNICATIONS SYSTEM

(Report No. BCL-OA-TFR-76-4)

by

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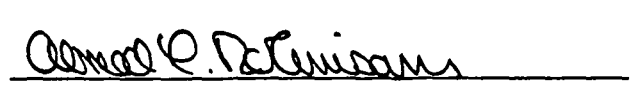

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FOREWORD

This report covers work performed on Task 2 under contract NASw-2800 with the Office of Applications, NASA Headquarters. The Battelle Project Manager for the overall contract is Dr. A. C. Robinson, and the NASA Technical Director is Mr. Forrest Waller, Code EP.

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to

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
OFFICE OF APPLICATIONS

from

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SUMMARY - APPROACH, FINDINGS AND CONCLUSIONS

Approach

This study task addresses the nature and characteristics of land mobile communication uses and users. It further seeks to identify potential needs and markets up to 1985 for improved land mobile communications based on a satellite system.

The "satellite system" was not initially defined as to its technical characteristics, performance or cost. As a basis for discussion, we therefore postulated some general performance characteristics; (1) the satellite would be "high-powered" and offer the potential for using small earth antennas, (2) the geographic range of communication capability could extend from an area as small as 100-150 miles in radius up to the continental U.S. in area, (3) the system would probably operate in gigahertz frequencies, perhaps allowing additional spectrum for land mobile uses. We ventured no estimates on cost - simply stating, if asked, that it would probably cost more than conventional land mobile systems since satellites aren't free.

The market study was therefore "needs" oriented as opposed to being the study of specific systems configurations. We sought to determine whether any one or more of the general performance characteristics postulated would provide a means of fulfilling land mobile communication needs not now being met.

Interviews were conducted among land mobile users, user representatives, equipment producers, knowledgeable experts and governmental authorities. We did not undertake to invent new classes of users where no current market nor recognized need exists, since the ten-year developmental time span of interest almost precludes totally new uses. Our findings are therefore reflective of the best opinions we could gather from a knowledgeable cross section of sources concerned with land mobile uses - some 75-80 in number.

Findings

The very great majority of land mobile communications are of a dispatch and control nature. Such communications are needed to efficiently and rapidly control the deployment of people and equipment. That is the regulatory rationale and the economic justification for such communication systems.

Typically dispatch communications are local area oriented - perhaps within a 50-mile range of a base. If the area of coverage is more than local it is usually well bounded and defined, and the area can be covered by towers and repeaters of some kind. Consequently, it became apparent that extended range of communication is not a motivating need for the great majority of users.

Frequency crowding is a common complaint among nearly all classes of users. However, recent FCC decisions concerning allocations of additional spectrum in the 900-MHz band for land mobile uses promise to provide considerable relief for probably 10 to 20 years. Therefore additional useable spectrum that could be provided by a satellite is not a motivating factor - at least for the next 10 years.

For most land mobile users, any significant increase in costs would be a severe deterrent to the acceptance of any new forms of land mobile service since their use of the spectrum is now essentially free.

The total volume of potential traffic for an improved system identified in the study is not very large and the user's needs are rather specialized. These include paging for long distance household goods movers, operation of petroleum drilling ships and off-shore petroleum production platforms, operation of new pipelines in remote areas, regional disaster operations, and land management in remote areas. These needs are summarized in Table 2 at the end of the report. These various users have indicated a willingness to discuss potential experimentation with ATS-6.

Conclusions

A commercial enterprise probably would not find the present market potential sufficient to justify investment in a satellite dedicated to land mobile uses. However, we believe experimentation at the present time is warranted. Market development under the best circumstances is a slow process. In this case feasibility must be established, demonstrations carried out, system designs developed, costs established, potential users must be broadly informed, investors must be found, and regulatory rules and arrangements would need to be developed. This chain of events will take many years.

Despite the fact that some relief from congestion for land mobile users is occurring in the immediate time frame, it seems likely that the nation will need much more land mobile spectrum within 10 to 25 years from now. Satellite systems would seem to offer a logical and perhaps the only solution. Therefore, experimental programs should be considered now so as to initiate the very long chain of events that must occur before such systems could be commercialized.

INTRODUCTION

This study was initiated under NASA Contract NASw-2800, "NASA Applications Studies - New Initiatives". The objective of the study was to define the market needs for improved mobile communications systems. Within the context of this objective, Battelle-Columbus Laboratories (BCL) was to:

- Characterize the present mobile communications industry
- Determine the market for an improved system for mobile communications
- Define the system requirements as seen from the potential customer's viewpoint.

The scope of the study was defined by the following parameters:

- Markets were confined to U.S. and Canada
- Range of operation generally exceeded 20 miles, but this was not restrictive
- The classes of potential users considered included all private sector users, and non-military public sector users
- The time span examined was 1975 to 1985
- Highly localized users were generally excluded - e.g., taxicabs, and local paging.

While never specifically stated the implied thrust of the study was land-mobile communications - this in view of major systems developments that are occurring in maritime communications (MARISAT) and aeronautical communications (AEROSAT). BCL examined these latter systems only in the context of their potential relationship to land mobile systems.

OVERVIEW

This section of the report will present an overview of the present situation in land-mobile communications. It will then present a perspective on new technical and institutional developments that are impacting the present situation.

The Present Situation

The present situation will be dealt with here in terms of the nature and organization of land-mobile communications, general magnitude of users (markets), user costs, and investments, user attitudes, user problems and existing infrastructure.

Land mobile communications can be viewed as consisting of two major classes; private dispatch and public correspondence. Paging may be considered a subclass of public correspondence but will be treated separately.

Private Dispatch

Nature and Organization

Dispatch radio communications are used to direct and coordinate the movement of people, vehicles, products, and equipment. As the term implies, private dispatch is characterized by very short messages that last an average of about 15 seconds. Indeed there are FCC restrictions on the nature of communication that can be transmitted in the dispatch mode.

By far the bulk of land mobile users and investment lies in the area of private dispatch. These include the public safety services, the industrial services and land transportation services. These services fall under the jurisdiction of the Safety and Special Radio Services Bureau of the FCC. The FCC allocates blocks of radio frequencies to these service classes and subclasses of users. Specific local frequency assignment coordination is achieved through recommendations by Frequency Advisory Committees representing each of the various subclasses of services.

Each service and its various subclasses includes:

- Public Safety Services
  - Police
  - Fire
  - Local government
  - Highway maintenance

Forestry conservation
Special emergency
State guard

- Industrial Services
  - Special industrial
  - Business
  - Power
  - Petroleum
  - Manufacturers
  - Forest products
  - Industrial radio location
  - Motion picture
  - Relay press
  - Telephone maintenance
- Land Transportation Services
  - Railroad
  - Taxicab
  - Automobile emergency
  - Interurban passenger (motor carrier)
  - Interurban property (motor carrier)
  - Urban passenger (motor carrier)
  - Urban property (motor carrier).

In general these users provide their own equipment, typically a fixed base station and transceivers in several mobile vehicles. They are assigned private channels in frequencies between 25 and 50 MHz, 150 and 160 MHz, and 450 and 470 MHz. Many of these users will also have access to channels in the recently allocated portions of the 900-MHz band.

Numbers of User Units (Markets)

The FCC reports the total number of transmitters authorized for use in each of the major user categories. Table 1 presents data for 1973. Authorized transmitters do not equate to transmitters in actual use. Some

license applicants inflate their requirements in hope of attaining a more favorable frequency allocation or perhaps to inhibit assignment of others to their frequency. Hence, while authorizations do not represent actual use, they are a reasonable proxy with perhaps a one to one and one-half year lead ahead of actual installation and use. The total annual market for private dispatch systems in the U.S. would currently approximate $650,000,000 - with Industrial representing about 50 percent, Land Transportation about 30 percent, and Public Safety about 20 percent.

User Costs and Investment

Many modes of use and maintenance are practiced today. These modes depend upon the desires of the individual user. Some prefer sophisticated multiple-function systems; others prefer a simple one-function system. Some owners do all their own maintenance; others contract for part of their service; others contract for all maintenance. Cost of money is also a variable depending upon whether financing of the system comes from federal funds, local government funds, or private capital. Detailed data on costs and investment are difficult to obtain. However, some indicators are available as discussed in the following paragraphs.

Equipment Cost. Equipment costs vary moderately depending upon the sophistication of the system. Examples of equipment cost are tabulated below.

Equipment	Unit Cost, $
Mobile unit	500 - 800
Mobile unit with repeater capability	1500
Hand-held mobile	300
Base stations	1400 - 4000
Repeaters	1000 - 1500
Mobile antennas	135 - 225
Antenna tower	5000 - 25,000
Microwave system (24 channel) (per link)	40,000
Modulators ($1,000/channel) (per link)	25,000
UHF branches	3,000 - 4,000

TABLE 1. AUTHORIZED PRIVATE DISPATCH TRANSMITTERS IN THE UNITED STATES - 1973

	Base or Fixed	Mobile	Total
Public Safety			
Police	47,401	1,114,904	1,162,305
Fire	25,487	340,521	366,008
Local government	29,489	307,939	337,428
Highway maintenance	24,531	208,688	233,199
Forestry conservation	40,093	104,849	144,942
Special emergency	8,458	61,852	70,310
State guard	388	1,114	1,502
Operational fixed public safety services	2,659	--	2,659
Total public safety services	178,506	2,139,867	2,318,373
Industrial			
Special industrial	37.290	371,444	408,734
Business	100,176	877,539	977,715
Power	16,718	285,844	302,562
Petroleum	11,986	98,667	110,653
Manufacturers	3,731	68,422	72,153
Forest products	3,079	40,249	43,328
Industrial radiolocation	18,209	107	18,316
Motion picture	246	1,598	1,844
Relay press	349	8,360	8,709
Telephone maintenance	2,393	89,898	92,291
Operational fixed industrial services	14,729	--	14,729
Total industrial services	208,906	1,842,128	2,051,034
Land Transportation			
Railroad	14,887	1,145,721	1,160,608
Taxicab	3,722	126,166	129,888
Automobile emergency	2,437	23,102	25,539
Interurban-passenger (motor carrier)	108	10,121	10,229
Interurban property (motor carrier)	2,138	45,362	47,500
Urban passenger (motor carrier)	683	18,873	19,556
Urban property (motor carrier)	2,376	53,244	55,620
Operational fixed land transportation services	2,509	--	2,509
Total land transportation services	28,860	1,422,589	1,451,449
Total Land Mobile - Dispatch	416,272	5,404,584	5,820,856

39th Annual Report/Fiscal Year 1973, Federal Communications Commission.

The microwave equipment costs are included because of petroleum companies' need for communications with offshore platforms and drilling ships and extensive use by pipe line operators and railroads.

Maintenance Costs. Maintenance costs can be highly variable depending upon the service to which the mobile radio system is subjected. A few examples of maintenance costs for larger systems are shown in the following tabulation.

System Size No. of Mobiles	Service Type	Total Annual Maintenance	How	Cost/Mobile/ Year
1900	Severe	$2,000,000	Contract	$1,050
270	Moderate	66,000	Self	245
2800	Severe	1,200,000	Self	445

Other data sources indicate that maintenance costs fall between 10 percent and 50 percent of original equipment cost per year. Maintenance costs include labor, labor overhead, replacement parts, parts inventory costs, and profit, if the service is contracted for.

At the lowest end of the cost and investment scale, the simplest user system might consist of single-channel UHF equipment for a base station costing about $1,200, and perhaps 10 mobile units costing about $700 each. The total investment would, therefore, approximate $8,200. Fifteen year life is very reasonable. Maintenance costs might be estimated at 10 percent of investment annually for limited use systems and the cost of money estimated at 10 percent annually. On this basis the total system would cost about $2,200/year or $184/month or about $18 per mobile/per month. The simple system is representative of a small industrial or commercial dispatch system.

Larger systems are more complex and can include multiple transmitter stations and repeaters. Examples of users could be a small city police department or a state recreation department. A typical system would have 5 to 10 transmitters and 200 to 400 mobile units. These mobile units may have provisions for acting as repeaters, i.e., rebroadcasting hand-held portable messages to the base station. Equipment cost would be in the range of $1500 for base station and $800 for mobile units for a capital investment of $175,000 to $350,000, if no antenna towers are needed. If antenna

towers are required, the cost can be $5,000 to $25,000 per tower. Again, equipment life of 15 years is reasonable. For more severe use and complicated systems maintenance costs might be 20 percent of investment annually. If 10 percent money costs are assumed, then cost per month per mobile is approximately $27.

Very large networks such as used by interstate gas utilities, large electric utilities or state police, have systems with several towers, many repeaters, several types of radio service, mobile units with repeater capability and hand-held mobiles. These systems cost as much as several millions of dollars. Maintenance costs are high because of severe service. Total system cost per mobile can reach $30 per month.

User Attitudes

Private dispatch users view the spectrum as "free". They are generally very "possessive" about their systems and jealously guard their frequency assignments. Large system owners in particular develop a sense of security from complete control of their system performance - with no dependence on intermediate services provided by others. Most large organizations also maintain their own equipment.

Sharing of frequencies or sharing of facilities are often last-ditch options. The primary example of sharing is that which occurs among smaller, newer users in the business/industrial services sharing community repeater station service in an urban area. Large users develop their own repeater networks.

Attitudes about communication security vary with the perceived sensitivity of the information being transmitted. The most security sensitive systems are law enforcement operations and petroleum company exploratory data communication.

Among smaller users, there is not a great deal of quality sensitivity when purchasing equipment. Price is a dominant motivator. Among large system operators, quality is much more important. These larger organizations tend to take more of a life cycle cost point of view on

capital expenditures. Police organizations for reasons of reliability and performance tend to buy the top of the line.

User Problems

The almost universal complaint among private dispatch users is frequency crowding. Some of the wide area operators (e.g., state police, utilities, etc.) do have occasional problems of skip with lower frequency transmissions or terrain problems with higher frequencies. Most of them, however, have repeater station infrastructures and the problem is not viewed as being critical.

Frequency congestion has stimulated interest in various digital systems to promote more efficient uses of available frequencies. These systems, however, are very costly and the primary area of market penetration (still limited) has been in police communications. Without the stimulus of LEAA funding to law enforcement agencies, it is doubtful that local police systems could seriously consider such systems.

Existing Infrastructure and Investment

While no actual figures exist, based upon the last four years of sales in private dispatch radio equipment (mobiles and base stations) of about 2 billion dollars, the value of the existing stock of equipment in this sector should approximate 2.5 to 3.0 billion dollars.

There is also a substantial infrastructure existing of repeater networks for the larger urban areas and wide area system operators such as state police, utilities, highway maintenance and the like. Major microwave systems are maintained by users such as railroads and pipelines.

The whole telephone infrastructure is also an important adjunct to mobile communications in providing direct land line interconnects to the base stations and repeaters. Without conventional telephone services, most dispatch systems would be seriously deficient.

Public Correspondence

Nature and Organization

This class of mobile radio is formally referred to in the U.S. as "domestic public land mobile". These systems are operated by the common carriers, i.e., the telephone companies and the radio common carriers (RCCs). They are under jurisdiction of the Common Carrier Bureau of the FCC. Radio base stations are interfaced with the telephone network and provide switching for mobile telephone calls. Transmission is duplex and conversations typically last two to three minutes. These systems operate in assigned frequencies within 34-45 MHz, 152-158 MHz, 454-460 MHz, and UHF channels 14-20. Also recent allocations in the 900-MHz band provide an additional 40 MHz in that region.

Number of User Units (Markets)

Public land mobile services are provided by a network of approximately 380 telephone companies and 475 radio common carriers. As many as 1200 base stations may be involved in providing service. There are presently about 100,000 subscribers, about one-half serviced by RCCs. While the service is offered "nationwide", there are substantial areas of the country - particularly in the West - that are outside the typical 20-mile range of a radio base station. For obvious reasons the service is city oriented.

The service has grown rapidly in recent years. In most major metropolitan areas the service is essentially saturated and potential subscribers are wait-listed. The estimated total annual market for domestic public land mobile equipment is about $38,000,000.

User Costs and Investment

Subscriber costs in the U.S. for service fee, mobile service air-time charges and rental of equipment typically run about $100-$120 per

month. If equipment is purchased a mobile telephone unit costs about $2,000 to $2,500 depending upon its specific features.

User Attitudes

Since the service is near saturation in many metropolitan areas, it is obviously popular despite its substantial cost. It is most popular among business users, doctors, public officials and health and safety officers.

User Problems

The most difficult problem beyond high cost is channel congestion. In major urban areas the number of subscribers per available channel well exceeds 1,000. This produces queueing at peak service hours.

Also as previously discussed there are major land areas in the U.S. not within the range of common carrier base stations. However, since this service is highly local urban area oriented, this situation presents no problem to the vast bulk of users.

Existing Infrastructure

The value of the current 100,000 user investment in mobile telephones would probably be about $100,000,000.

Of course, that is miniscule compared to the total common carrier investment in land lines and base stations that makes the service possible.

Paging

Nature and Organization

Radio-paging is probably the fastest growing segment of mobile radio. Current growth estimates are 25 percent annually. Subscriber

services are provided by telephone common carriers and RCCs. About 30 percent of current pagers are accounted for by private systems, e.g., hospitals, office equipment manufacturers, utilities. Services offered are of two basic types, (1) one-way tone only where the subscriber answers back by telephone to a predetermined number, and (2) one-way tone and voice by which the subscriber can also receive a 10- to 15-second verbal message. So called "wide-area" paging service usually ranges to a maximum of about 50 miles from the base station. Frequency assignments fall between 27-50 MHz, 135-174 MHz, and 450-470 MHz.

Numbers of User Units (Markets)

The number of paging receivers in use in 1975 is estimated at about 500,000 units. The telephone companies - principally the Bell System and four major independents - serve about 10 percent and the RCCs serve about 60 percent. There are more than 1,000 RCC operators in the U.S. and perhaps 25 percent to 30 percent of them have more than 100 pagers in use.

The value of annual pager shipments is currently estimated at about $20,000,000.

Private systems tend to be local systems (5-mile radius) while common carrier systems are very predominantly wide area (50-mile radius).

User Costs and Investments

Currently, paging receivers cost about $200.00 and tone-only paging services cost about $20.00/month. Tone and voice services cost about $5.00 more.

Transmitters cost about $2,000 to $5,000. Sophisticated control terminals for a high-volume station are in the $20,000 to $40,000 range.

User Attitudes

The current annual growth rate of 25 percent in the pager market attests to the positive attitude of users. Users generally see paging

as a way to increase their personal or corporate productivity. Their positive attitudes encourage others to enter the market. Some organizations view paging as a low-cost way to enter into the mobile field. The "mass" market individual user still regards the cost as too high.

Tone only receivers represent about 60 percent of the total pager population. Wide area service (out to 50 miles) accounts for better than 90 percent of the service and local service (out to 5 miles) is less than 10 percent.

Multicity paging systems have been considered by some of the common carriers. In general they have found only limited demand for this type of service.

User Problems

Frequency congestion is becoming apparent in some urban areas, and the availability of additional frequencies is not yet on the horizon. A large pent-up demand exists in some urban areas awaiting adequate channel space.

The relatively high cost of pager units and pager service restricts the market primarily to business and professional use.

The major technical problem is the lack of acknowledgement capability on the part of the person paged. This often results in multiple transmission of the tone alert. In terms of required power output, an answer-back acknowledgement signal is currently beyond the technical capability of a pocket-size pager.

Existing Infrastructure and Investment

The value of the present pager population in use is probably about 40 to 50 million dollars.

The investment in common carrier and private system base stations is a vital part of the infrastructure. There doesn't seem to be any

reasonable way to estimate its present value since individual systems range from simple manual systems to sophisticated computer controlled systems. If we assume $10,000 as an average value of individual system investment, the total value might approximate 10 to 15 million dollars.

Finally the whole telephone system infrastructure is of course critical to access to, and response from, paging systems.

Suppliers

Three companies dominate the market for land mobile radio equipment. Estimated market shares are shown in the following tabulation.

Company	Share of Market, 1975
Motorola	65%
General Electric	20%
RCA	8%
Others	7%
Total	100%

The minor suppliers of equipment include at least five other companies who supply limited lines or specialty equipment.

Motorola. Motorola dominates the mobile radio market with an estimated $1.4 billion sales in 1973. It maintains this position by virtue of quality equipment and aggressive marketing practices. Motorola markets through its own direct sales and service organization. Included in this organization are:

800 authorized service stations
100 service managers
Technical training centers
7 day - 24-hour national parts depot
Field technical representatives
7 metropolitan full-service field support offices
30 branch offices.

A major strength of Motorola is its ability to identify new programs and needs early so products can be introduced early in the product cycle.

In addition to the U.S., Motorola markets products world-wide. Also products are manufactured in seven foreign countries.

General Electric. General Electric Mobile Communications Department (GE) is the second largest producer of mobile radio equipment in the United States. In addition to U.S. factories (headquartered at Lynchburg, Virginia), GE manufactures equipment in Mexico and Spain and assembles in Canada. Current production covers most of the types of mobile radio equipment.

General Electric markets both through direct sales and through manufacturing representatives. The U.S. is divided into eight sales regions. Each region has major account managers and managers for major user groups. This marketing can be focused on critical areas as needed.

Like Motorola, GE expends significant amounts in research and development. Equipment has been developed for the 900-MHz band.

Radio Corporation of America. Mobile radio is only one small part of the total RCA product line. Production of mobile radio equipment is in Meadows, Pennsylvania.

The sales and distribution network of RCA is similar to GE's. The United States is divided into sales regions with direct sales personnel in each region. Manufacturers' representatives are also used in some regions. Service is provided by nationwide RCA Service Corporations and by independent dealers.

Other Producers. Other manufacturers of mobile radio include the following:

E. F. Johnson Company
Martin Marietta
Standard Communications
REPCO, Incorporated.

These companies have only a small market share each, probably less than $10 million sales each in 1973. Sales are mostly by a combination of dealers, manufacturing representatives, and direct salesmen.

New Institutional and Technical Developments

Major events have occurred in the recent past that will have very pronounced impacts on the future development of land mobile communications in the U.S. In character these events center on more availability of spectrum, more efficient use of spectrum and more frequency reuse.

To accommodate the rapid growth that has been occurring in land mobile communications, the FCC has undertaken two major rule-making proceedings. These are known as FCC Dockets 18261 and 18262.

Docket 18261

The first of these, Docket 18261, allows land mobile use of UHF TV channels 14 through 20 (470 to 512 MHz) in the 13 largest metropolitan areas in the U.S. However, these allocated channels are becoming rapidly occupied. Also additional large cities are requesting similar allocations.

Docket 18262

Docket 18262 is far more sweeping in its potential impact. It deals with reallocation of frequencies in the 806 to 947-MHz band for primary use by land mobile services. Originally FCC suggested allocation of 115 MHz to land mobiles services; 75 MHz for cellular system development by wireline carriers and 40 MHz for private dispatch (26 MHz were allocated to Industrial Scientific and Medical band - ISM). Additionally FCC requested further market and technical studies covering utilization of the band.

On May 1, 1974 FCC adopted its second report changing the wireline common carrier cellular system allocation to 40 MHz and private

allocation to 30 MHz. 45 MHz were reserved. It also was very noteworthy in that it suggested creation of a new class of unregulated commercial service for shared use, now referred to as Specialized Mobile Radio Systems (SMRS).

Cellular Systems

This system employs "space division" multiplexing. The same channel can be used in different locations in the same general geographic area. Specifically a major urban area would be subdivided into a large number of adjoining hexagonal cells from perhaps 1 to 8 miles in radius. The individual cells would be served by low-power-base stations each with a group of independent frequencies. Proper spacing of the cells allows the frequencies to be reused many times in the same telephone service area. The system would be computer controlled, fully automated and allow multiple access and hand-off from cell to cell for moving vehicles.

AT&T has been authorized by the FCC to construct a developmental pilot system in Chicago. FCC estimates that in its fully developed form a cellular system could serve up to 500,000 mobile telephone subscribers in an urban area. Construction should get underway within the next year and the system hopefully proven by 1980-1981. The pilot system is estimated to cost about $20,000,000. If successful the system will be expanded into several urban areas during the 1980's and beyond. An additional 20 MHz is held in reserve by FCC for future needed expansion of the system.

Within certain restrictions, the AT&T cellular system will also be permitted to offer dispatch services. Some observers believe the dispatch service will be most beneficial to small fleet operators (1 to 5 mobiles).

The target for the cost of this form of mobile service is $50-$60 per month. The target for the cost of mobile equipment is $1,000.

Specialized Mobile Radio Systems

This FCC proposal has generated the most controversy of any of the allocations dealt with in Docket 18262. Briefly the report established

guidelines for the development of common-user multichannel trunked systems. Many duplex channels would be made available through trunked, computer controlled, channel access. For each proposed service area (at least 70 miles apart) 300 duplex channels would be provided. They would include 200 trunked channels and 100 single channels for individual private dispatch users. An additional 300 channels would be held in reserve.

The point of controversy is not the technical worthiness of the concept, but rather the institutional arrangement that FCC proposed. They proposed that the system operators/service providers not be treated as common carriers, that is that they not be regulated. Also within certain limits, system operators could come from any responsible part of the private sector - including equipment manufacturers.

This proposed arrangement brought strong legal protest from state utility regulators and the RCCs. In June of 1975 the U.S. Court of Appeals forbade the operation of SMRS in the 900-MHz region. This stay will remain in effect until appeals are adjudicated. This may take another 3-4 years. Most expert observers believe that SMRS trunked service will eventually be approved, but probably in some regulated configuration.

Private Systems

While the court stayed SMRS development, FCC was permitted to proceed with the implementation of private dispatch systems in the 900-MHz region.

Spectrum Management

Through Docket 19150 the FCC created the Regional Spectrum Management Center in Chicago. This Center was established as an experiment in regional spectrum management and importantly to study spectrum utilization within a specific geographic area.

Previous studies have shown that block allocation of spectrum, as heretofore practiced by the FCC, can result in maldistribution and unbalanced use of channels. There is often no correlation between numbers of transmitters assigned to a channel and channel occupancy. The Chicago center is gathering data on channel use which might suggest other approaches to spectrum management. In addition the FCC's position in Docket 18262 would suggest that they would like to move away from block allocation and toward high-capacity shared, trunked systems.

Impact of New Institutional and Technical Developments

The developments discussed in the previous section add up to some definite relief from land mobile spectrum congestion. Various experts suggest that the relief will last till the time period 1985 to 2000.

The successful development of the very high capacity cellular system has obvious major impact on land mobile telephone service. It will provide relief from congestion where it is badly needed - the metropolitan areas. Through the telephone infrastructure, these areas can also be fully interconnected. In terms of markets, forecasts suggest that the development of the cellular system will bring about a 200 percent growth in mobile telephone within the next decade, and there would still be huge capacity for further growth. It should be noted that the system will also provide dispatch services. These services should be particularly applicable to small fleet operators.

With respect to the utilization of the 100 private channels in the 900-MHz region, propagation characteristics and costs will be major influences. The propagation characteristics of 900-MHz transmissions limit mobile transceivers in an urban area to a maximum talk-back range of about 10 miles. Wide area dispatch systems will need multiple satellite receivers. Therefore, private 900-MHz systems might be most cost effective for users operating in a limited geographic range. These would include manufacturers, construction projects, mines, airports, warehouses and the like. Wide area urban users would probably need to rely increasingly on community repeater-satellite receiver systems. Large public safety users might develop their own.

Equipment in the 900-MHz band will probably cost about 20-25 percent more than 460-MHz equipment. Market projections for private 900-MHz systems suggest that by 1985 total equipment sales could reach $340,000,000 annually. This would imply about 1,200,000 mobiles in use at that time and perhaps 100,000 operating base stations.

Shared trunked systems (SMRS) might perhaps offer the greatest interest to the average smaller users. Because of the previously discussed legal complications, significant system development for actual use will probably not occur for another 3 or 4 years. After that, system subscribers could grow very rapidly, perhaps reaching well over 1 million by 1985-1986.

Perhaps more importantly in the longer run, SMRS would firmly establish shared use of land mobile channels and facilities. The wide acceptance of the concept of shared facility and channel use would probably be critical to the eventual introduction of satellite-based systems serving land mobile users.

IMPLICATIONS OF THE OVERVIEW TO BATTELLE'S STUDY

In reviewing and summarizing the information presented in the Overview, certain statements and conclusions can be drawn about the existing and medium term development (5 to 10 years) of land mobile communications.

(1) By far the bulk of land mobile communications is local and urban oriented.

(2) Further, the overwhelming majority of users operate in the dispatch mode. By nature dispatch communications are local phenomena oriented at quick organizational response.

(3) Land mobile frequencies are currently congested. This is largely a U.S. phenomenon. The U.S. has 23 transceivers per 1,000 population, whereas a country like West Germany has 3.3.

(4) Current land mobile users view their spectrum use as "free". Their equipment is simple and relatively low cost.

(5) Larger land mobile users are very possessive about their private systems and their channel assignments.

(6) Compared to other countries, the U.S. has a very large "sunk" investment in infrastructures related to land mobile communications. This includes investment in mobiles and base stations, repeater stations and community antennae, microwave systems, telephone systems and even Citizen's Band equipment. This infrastructure is "competitive" to new system development.

(7) Some relief is in sight for land mobile frequency crowding. This stems from new assignments in the 900-MHz band - cellular systems, SMRS, and private dispatch.

From these statements one can conclude that the market development of land mobile satellite based systems must be based on characteristics unique to satellite systems. At present, they could perhaps offer many more useable land mobile channels in gigahertz frequencies. In the absence of the 900-MHz band allocations, more frequencies could be a potent argument for immediate development of satellite systems. Under present circumstances, however, this motivation is lacking -- at least in medium term developmental thrusts. One must therefore look to the other major unique characteristic of satellite systems -- namely more than urban area range.

Within the context of "range uniqueness" of satellites, however, we are confronted with the developmental possibilities of urban interconnected land mobile cellular systems which will offer great range potential at least among continental urban areas. Basic cellular based land mobile services are projected at $50-$60 per month for users. This fact suggests that satellite based systems, if higher in cost, would best serve remote area uses that would not be within the range of urban-oriented telephone company cellular systems.

This line of logic led the Battelle study to focus attention on potential mobile communication users with remote area communication needs -- that is that the uses were beyond the scope and range of the existing and developing telephone and land mobile system infrastructure.

The following sections therefore deal with a discussion of the various classes of land mobile services, their characteristics, and their possible needs for "remote area" land mobile communication.

CHARACTERISTICS AND NEEDS OF IMPORTANT LAND MOBILE SYSTEM USER CLASSES

Public Safety Services

State Police

Federal financing has allowed many police departments to upgrade their communications systems since the late 1960's. As a result few further major changes are contemplated for the next few years. State police tend to divide their area into regions. Each region has administrative authority and dispatch capability. Communications from headquarters to regions can be by radio, teletype or phone line. State police systems are large with many base stations and a few thousand mobile units. Regions with terrain problems may have several repeaters in order to cover the complete region. Some state police systems allow communications to adjoining states from contiguous regions.

The number of radios per car varies with the philosophy of the state police department. Some only allow one communications set per police car. All orders come from the regional office with no discretion allowed by the officer. Others have several communications sets. These can include a dispatch, citizen band, emergency network, and mobile radio extension facilities. These mobile radio extensions allow the mobile unit to act as repeaters for hand-held sets when the officer is away from the car.

The problems of state police mobile radio are primarily related to lack of frequencies and to adverse terrain problems. The frequency crowding problem is handled by multichannel systems and selectively allocating frequencies around the state to keep adjacent regions on different frequencies. The terrain problem is handled by remote repeaters.

Equipment life of 15 years for 24-hour-a-day usage is usual. Maintenance policies vary from complete subcontracting of the function to complete service within the department.

Desirable future innovations would be radio ties to county and local police systems and direct communications state-wide. Also desirable would be an accurate automatic vehicle location system. However, these needs are not great enough to motivate state financing for the facilities.

Satellite communication systems have been considered by some state police systems. However, the technology was not available at the time of the last major change. The antenna on a police car is critical. Anything more than a whip, if exposed, is not desirable.

Local Police

Within the general public safety category, police radio represents about one-half of total equipment use. Local police departments also depend upon LEAA financing for major systems improvement. Many are now changing from VHF to UHF frequencies. A new system is considered to have a 20-year life; 5 years to install, 5 years to prove, 5 years of maintenance and 5 years to phase out. The system configuration will vary with the county or city size. However, multi-transmitter, several hundred mobile unit systems are common.

A dominant required characteristic of police radio is need for very high reliability under severe service. In addition to conventional voice systems many options are available such as tone-coded squelch, selective calling, scanning receivers and secure transmission systems. The latter are usually based on scrambling or coding techniques and cost

about $1000 to $3000 per mobile. Hand-held portables have become an important adjunct.

Probably the greatest amount of technical development effort among suppliers of police radio has been directed toward digital systems to report such information as status, alphanumeric transmissions, and even vehicle location. Some of the arguments for digital systems include spectrum conservation, reduced response time, accuracy of transmission and security. However, such systems can be quite expensive. Mobile terminals typically cost $3000 and up and base station equipment can cost $70,000 and higher.

Automatic vehicle location is also a subject of police system experimentation. Probably the most popular technical approaches today are proximity techniques based on fixed location "sign post" emitters. One estimate on a system to locate 500 vehicles over a 100-square-mile area within a range of 250 feet was about $5,000,000. That represents $10,000 per vehicle.

Police departments are generally satisfied with their systems. They have many available options for increased efficiencies but usually at a very substantial cost. Their problems of range usually deal with nearby inter-city or inter-county communications. These are often institutional problems as opposed to purely technical problems.

Highway Maintenance (State)

Mobile radio finds its greatest economic pay off in the ability to rapidly mobilize and dispatch equipment and staff in emergencies such as severe snow storms, flood damage and the like. Without that kind of mobilization capability they would need much more equipment and many more employees. Low band is the commonly used frequency.

Radio is also used in such jobs as route marking, traffic control and construction. For performing these more routine functions states are usually organized into regions. At construction sites, portable base stations are common.

A typical state highway maintenance operation would include thousands of mobiles and portables, perhaps 100 fixed-base stations and 100 portable-base stations.

They do not appear to have substantial frequency crowding problems, They may encounter poor radio coverage in some areas occasionally, but if important they add base stations or repeaters. Their equipment is simple and relatively low cost.

Industrial Services

Special Industrial

Within the FCC's services designated for blocks of frequency, this category encompasses agriculture, construction, ready mix delivery, petroleum services, fuel delivery and mining. They represent the second largest user category in the industrial services. The major need in this area is more frequency. There is already some frequency sharing with other services. About 25 percent of the users are agriculture related, 25 percent heavy construction and 20 percent ready mix delivery.

The most sophisticated users are probably the large construction companies, therefore we have singled them out for further discussion.

Construction. Construction companies use mobile radio for dispatching, security, and paging in the main plant area, for crane and other equipment control in manufacturing operations and for dispatch and radio control at construction sites. As a result, many systems are in use and thousands of mobile units are typical of the large companies.

Maintenance can be any combination of internal service and contract maintenance. However, usually a few in-house technicians are maintained for emergency service and to supervise contract maintenance.

The major problem with design and construction companies is frequency crowding. Directional antennas, selective frequency use and close control of use of mobile radio are used to alleviate the problem.

Future potential new uses for mobile radio are automatic vehicle location, location of oil barges, and radio communications with foreign sites. Satellites have been mentioned only in connection with foreign data communication. A need exists to transmit many kinds of data from foreign sites to headquarters.

A major problem mentioned with satellite communications for mobile radio is the antenna problem. A distinctive antenna is detrimental in some uses. A whip would be highly desirable.

Business Radio Service

This is by far the largest industrial user service category. Business radio users are very diverse and it is almost an "all other" user category in the industrial services. Users range from very small one or two mobile systems to large organizations with many base stations and mobiles.

Despite the already large number of business users, the growth potential is still huge. About 80 percent of business fleets are five or less vehicles, yet less than 10 percent of the licensees fall in that size category, and only 25 percent of the larger truck fleets are currently licensed. Some 52 percent of the present users are service oriented businesses. Typical user cost is about $25.00 per mobile per month.

Business radio is among the larger users of community antenna systems that provide them with extended urban range. This service costs about $25.00 per month.

Small fleet operators will probably be among the early users of cellular mobile telephones. While it may be higher cost it would offer the advantage of complete two-way telephone interconnect. The present business radio rules allow only one-way telephone access, i.e., mobile to land lines.

Power

Electric, gas, and other public utilities use mobile radio for both dispatch and supervisory functions; dispatch usually on a district basis. Included are customer service, repair, and maintenance, and reporting

of information. Supervisory functions include transmitting control information to remote locations, reporting of data to central facilties, and communications between headquarters and regional stations. Some utilities have personnel paging and failure information systems.

Utility systems tend to be large, with hundreds of base stations and thousands of mobile units. The major problems appear to be with frequency crowding. Solutions to the problem include selective allocation of frequencies on a regional basis, coordinating frequencies with other users, and monitoring their own use of the system. Shifts are occurring to higher frequency bands with a subsequent increased number of channels as funds become available.

Utilities prefer to have complete control of communication systems including ownership of equipment and maintenance. Reasons given are security, versatility, more rapid repair and more favorable economics.

Satellite communications have been considered by many utilities. However, the need for such sophisticated systems is not perceived by the companies for most operations. Control of long pipelines is one of the few uses where satellite systems are looked upon favorably.

Petroleum

Petroleum company communications systems are large and sophisticated with a mixture of mobile/base, back bone microwave with VHF and UHF branches, ship-to-shore maritime radio, and leased telephone lines.

The non-leased line part of the system can be divided into three categories as follows:

Two-way mobile
Right-of-way
Offshore.

Two-way mobile is used primarily for land operations which include field exploration, dispatch, paging and supervisory functions. Right-of-way systems are point to point for transportation and pipeline monitoring and

in many cases are microwave systems. Offshore uses include communications to production platforms and to drilling platforms, and drilling ships doing exploratory work. Offshore systems are a mixture of microwave and UHF and VHF. When the platform is within line of sight of land or the next inshore platform the system uses a microwave back bone with lower frequency branches.

Satellite communications to offshore platforms and ships would be seriously considered by the petroleum companies. One system is now being experimented with by one oil company. Also, pipeline monitoring is a potential customer for a satellite system.

Exploration and Drilling Petroleum

The major petroleum company communications problem which appears to be solvable by satellite use concerns communications with offshore platforms and drilling ships. Battelle's estimates of the number of installations are given below.

Type of Installation	Location	Number
Platforms	Gulf of Mexico--oil	25
	Gulf of Mexico--gas	10
	Pacific Coast--oil	10
	Alaska	5
Drilling ships		15
	Total	65

Many of the existing platforms in the Gulf of Mexico have microwave communications links now. Those over the horizon from the next platform use UHF or VHF radio.

The most pressing problem involves communication with drilling ships. The cost of equipment delays can exceed $2,000 per hour. It would be desirable to radio in data for processing at headquarters and radio instruction to the ship as rapidly as possible since the ship may be on location for only a week.

Drill ships operate 200 miles offshore or more. Reliable safety and emergency communications are necessary. Major need is in the Gulf of Mexico now, but the North Shore of Alaska, and the Atlantic and Pacific coast offshore areas would require many more channels.

In addition to drilling ships some offshore platforms are now beyond line of sight of the next platform. This negates use of microwave systems and forces reliance on lower frequency radio communications.

Security for exploratory data communications is a vital concern of the petroleum companies. While coding, scrambling, etc., are possible, even these may be suspect for highly confidential data messages. For normal communications, channels can be shared.

Communication needs can vary with the type of operations. Drilling operations could use 2 or 3 voice channels. However, some get by with as little as 1/3 channel in the Gulf of Mexico. The greater channel need occurs during emergencies or breakdown. Congestion is a problem during certain times of days, for example, getting orders in for the next day's operations, etc.

Cost of idle rigs can run into thousands of dollars per hour. Thus, reasonably expensive equipment can be justified. It is not unusual to spend $50,000 per platform for multichannel microwave communications systems.

As drilling and production moves further out into the Gulf of Mexico, the need for satellite systems grows. Also, if the Atlantic coast continental shelf is exploited the need for longer range systems will become evident. The Alaskan North Shore and Pacific Coast installations will be able to use a longer range system.

Data communications is desirable but at present is too expensive. 50,000 bits/sec systems would be adequate. The primary need for data systems stems from the practice of doing most processing of exploration data at a central location. After analysis of incoming data the drill ship is given further instruction. A ship is normally on stations about 1 week. It would be desirable to have faster turn around on data communications to allow more efficient use of ships.

Antennas are not a problem on ships or platforms. On platforms the antenna could be cantilevered to one side of the platform. For smaller antennas even a gun mount might suffice for the antenna mount. The need for a stabilized base on a ship, however, can be costly. One oil company has estimated a 15-foot antenna with 15° pitch and roll compensation and resistance to 80 to 100-mile-per-hour wind to cost between $200-$300 thousand.

Pipeline Transport

Pipeline companies are major users of land mobile communication systems. A typical domestic user, Columbia Gas Systems, will be briefly described.

Columbia operates in a 7-state eastern and midwestern service area. The gas transmission segment of this pipeline transport operation has over 100 base stations and thousands of mobile units. Base stations are usually located at major installations like compressor stations. The gas distribution segment of the business has base stations in some 60-80 major cities and about 6,000 mobiles.

Mobile radio transmission is presently voice only. Columbia fully service their own equipment and have strong feelings about operating their own system as opposed to relying on any forms of outside services. They purchase high quality equipment. They report no problems of range of system capacity. They are fearful, however, of future forced frequency sharing.

Columbia feels that future remote area gas transmission operations in Canada and the Arctic could probably bring about definite potential for use of satellite-based mobile systems; this primarily because of the extremely high cost of building towers for base stations. A brief discussion of the communications systems being developed by RCA for the Alyeska crude oil pipeline in Alaska will illustrate the potential for a suitable satellite-based land mobile system.

The backbone of the Alyeska system is a 41-station microwave link between Prudhoe Bay and Valdez. The microwave network will link all pump

stations and maintenance centers, and via VHF radio (with two independent channels) some 62 remotely controlled gate valves. Tied in with all this is also a mobile radio system.

Backing up the microwave system will be a satellite communication system with four earth stations. The northern and southern pipeline terminals will each have a 33-foot-diameter antenna; there will also be two 15-foot-diameter antennas at intermediate points. The satellite system is designed to handle all pipeline control data in the event of any communication breakdown along the microwave chain. The earth stations will be served by the RCA domestic satellites.

Alyeska had considered earth stations for the 62 control valves rather than conventional VHF. Because of extreme environmental requirements (150-mph winds and -60° F) the earth stations would have cost $300,000 each, which was far too costly.

The system will be owned by RCA Alascom but construction costs are being shared by Alyeska. The total system cost will be somewhere around $25-$30 million. It will have a 300-channel capacity and transmit at 1200 bps. Initially 60 channels will be leased by Alyeska and 60 channels will be public. Alyeska's lease costs could not be obtained on a direct basis, but it is estimated at about $1,000,000/year.

One can visualize that high-power satellites coupled with small earth terminals could totally provide an equivalent communication capability including mobile units. It is very possible that the consortiums that are planning the Arctic gas transmission lines may be interested in such communication experiments. Columbia Gas, for example, would probably be interested in discussions.

Manufacturers

Manufacturers mobile radio is most commonly used within limited confines of the plant premises. Uses include such functions as coordination

of materials handling, deliveries, security and process control. If these users encounter specific frequency problems, they may be early users of 900-MHz systems.

Some of the large manufacturers have been interested in teleconferencing systems. Dow Chemical and American Can are cited.

Land Transportation Services

Railroads

Railroads are by far the largest user category in land transportation. They are also one of the most mature users of mobile radio. Over the years a very comprehensive communication infrastructure has been built along their rights of way including extensive microwave links. For most large railroads, microwave is the backbone of their point-to-point and mobile systems.

A large railroad will have hundreds of microwave stations, hundreds of base stations and repeaters and thousands of mobiles and portables.

Uses for mobile radio typically include:

- End-to-end (front to rear of the train)
- Train-to-train (safety observation)
- Point-to-train
- Automatic wayside defect detectors
- Maintenance
- Yard control
- Terminal operations and switching
- Slave locomotive control.

In general, railroads feel their present systems are entirely adequate.

Automobile Emergency

Highway emergency services are provided by various affiliates of the American Automobile Association. Most clubs are urban oriented and

operate in a radio range of 50-75 mile maximum. Their most difficult problem is frequency crowding.

There are eight frequencies assigned to this service in the large urban areas. They currently receive 13-14 million emergency calls per year.

One of the largest systems in operation is in eastern Florida. That system includes two microwave stations and 5 base stations and covers nearly all of Florida.

There is a problem of providing emergency services in geographically remote areas outside the range of the operating clubs. For individuals who wish to insure themselves an extra measure of protection in those circumstances, the AAA has considered the possibility of a CB radio rental service.

A somewhat related use category are motorist aid systems which consist of fixed call boxes located strategically along a highway. Only limited use has been made of these systems because of their high cost; $2,500 per installed terminal and $120 per year for maintenance. Equally important, states that use federal highway funds for this purpose must submit definitive plans for staffing the service. This makes total costs almost prohibitively high and little further development is expected.

Interurban Passenger (Motor Carrier)

This service is composed essentially of interurban motor bus operators. They perceive no strong need for improved land mobile communications systems.

Several years ago there was a movement to promote development of an interterminal communication system. Due to the lack of sufficient economic incentives the scheme never got off the ground. The interurban bus operators see their interests closely allied to the interurban trucking industry.

Interurban Property (Motor Carrier)

Despite the fact that this category is essentially over-the-road interurban trucking companies, by far the greatest volume of radio use is within urban areas for local terminal pickup and delivery dispatching. There are a very few carriers, mostly intrastate or regional, who do employ over-the-road mobile systems. Most truckers find it impossible to justify such systems on any economic basis.

The trucking industry is fragmented and highly competitive, and any increased costs are viewed with considerable doubt. In addition, interurban truck drivers are a notoriously independent breed who resent mobile radio, viewing it as a management tool to supervise them more closely. There are numerous anecdotes of malicious destruction of equipment by drivers, or benign neglect at the least, when experimental installations have been tried.

From an economic point of view there are possibly two specialized areas of interurban trucking that might benefit from some form of over-the-road mobile communication. These would be the "specialized carriers" and the household goods movers.

The specialized carrier is an irregular route operator. Certain categories of goods movements do not follow repetitive shipping patterns. These include, for example, such commodities as certain steel products, building materials and agricultural products. These carriers do not operate over specified point-to-point routes. The drivers themselves are mostly independent contractors affiliated with a trucking company. The basic economic problem is keeping the drivers scheduled in some cost efficient way, through scheduling another paying load at the driver's destination to some other point. These arrangements are frequently ad hoc and it would be desirable to be able to contact the driver as soon as possible so that the business details can be consummated and confirmed as quickly as possible. Of course, if the dirver is strongly motivated, he can always contact his headquarters by telephone at regular intervals.

The interstate household goods moving carriers have very similar problems. Drivers are usually independent operators and are frequently on the road continuously for a year or more before ever returning to home base. Scheduling the next load is the business need, and the sooner the arrangements for the next load can be consummated, the better from a marketing viewpoint, as well as efficiency in routing.

At least one long distance mover attempted to solve the problem through utilization of a network of many radio common carriers. However, the communication traffic for any one RCC was so small that the company was plagued by many small billings, and due to the fragmented nature of the RCC business there was no way to centralize procedures, responsibilities, and services. The experiment was abandoned.

During our meeting with NASA and JPL personnel in Washington on February 26 the possible applicability of ATS-6 to one-way nationwide paging experiments for this class of carrier was discussed. BCL promised to follow up the concept with the household goods moving industry. We have since discussed the concept with the American Trucking Association and two of the largest interstate carriers, North American Van Lines and Allied Van Lines. There is a unanimous expression of interest. Since North American Van Lines has probably been the most active in attempting to solve the problem, we will elaborate their perceptions.

As an early phase development they would definitely be interested in one-way paging service to their drivers. Their fleet consists of about 2,000 vehicles. They presently maintain 197 WATS lines and have about 8,000 telephone calls in and out per day. They estimate a potential volume of 1,000 nationwide pages per day. On equipment costs they estimated they might afford $300-$400. They estimated service costs of $25-$30 per pager per month might be reasonable. Some form of digital read-out paging could be of interest assuming costs were not driven too high. If required, paging calls could be "bufferred" for perhaps one-half to one hour.

As an <u>ultimate</u> mobile system they would like complete two-way printed communications, and possibly a coordinate location system for

individual vehicles. They would not hazard guesses on allowable costs for this "ultimate" form of service but we can logically guess that the cost of mobile telephone represents an upper limit.

North American has discussed mobile telephone at length with AT&T, but the present overcrowding of this service would allow them service in only 30 of some 100 metropolitan areas of prime interest to them. With the eventual development of 900-MHz metropolitan cellular systems on a national scale, telephone companies could have ample capability to offer this service at some time in the future -- perhaps in 10-20 years.

The fleet of the five big interstate movers is about 7,000 to 10,000 vehicles. This would extrapolate to a potential 3,500 to 5,000 pages per day nationwide for the industry.

North American would be interested in discussing participation in an experimental program if NASA is interested in pursuing the concept further.

There is some feeling in the trucking industry that they must serve their customers better through improved coordination and movement of shipments that are transferred from one carrier to another. Intercompany communication among carriers is minimal. The American Trucking Association has filed a petition with FCC to form an agency to serve all the trucking industry communication needs much as Airinc does for the airline industry. The primary motivation is to gain bulk telephone rates for the industry, but such an agency (if created) could also perhaps be a focal point for future interest in broader ranging land mobile communication systems.

Urban Passenger (Motor Carrier)

This category basically includes bus and rail urban transit systems. Similar to police systems these operations have benefited in recent years from the infusion of large amounts of federal funds.

The main driving forces for improved communication systems have been security and scheduling. The simplest systems are two-way voice

communication between the driver and the dispatcher. The most sophisticated systems might include automatic vehicle location, silent alarms, digital transmission and equipment to monitor potential mechanical defects, or data on fuel consumption, mileage, etc. The communication range usually doesn't exceed 50 miles -- more commonly 25-30 miles. Underground transmissions are handled by wire. Frequency availability is always a potential problem particularly for new systems. Much recently purchased equipment has been in the UHF spectrum, but already applications are pending for 900-MHz frequencies.

Federal Agencies

General discussions were held with several staff in the Office of Telecommunications Policy. They were not specifically aware of any compelling needs among the federal agencies for improved land mobile systems. However, they urged BCL to contact certain key people among various agencies they identified that could discuss their respective needs.

Interior Department; Bureau of Land Management

BLM manages very extensive areas of land in remote areas. As would be expected they also maintain extensive mobile radio networks. They do have potential need for a satellite system in Alaska to maintain communications with survey parties or fire parties. They could visualize the value of small portable earth stations (not necessarily mobile). They currently use VHF equipment which presents problems of tower construction, spacing and reliability. They could potentially use perhaps 6-10 small terminals in a cost range up to $10,000. In terms of communication capacity they might use the equivalent of one or two channels at up to $1,000 per channel per month.

Department of Agriculture; Forest Service

Similar to BLM, Forest Service problems are associated with Alaska. Communications need to be better maintained with forest management and fire control personnel. Their needs would be nearly identical to those of BLM. There are only two national forests in Alaska but they are equivalent in extent to 10 in the U.S. There is also a distinct possibility that there may be more national forest land designated for Alaska in the next few years.

They presently use HF equipment in Alaska but are under contract for a VHF system that will involve 20 repeater stations. The repeaters will cost about $3,000 each. With the new system they will buy mobiles at about $1,000. If they did not need repeater stations they could obviously pay somewhat more for mobiles. The Forest Service would be interested in discussing experiments with NASA.

Alaska State Government

Since the State of Alaska will have vast areas of land to manage, BCL talked with a responsible communications official in Alaska.

Alaska's current developmental thrust is toward point-to-point communication with isolated communities in the state. The current plan is directed to development of a 120 earth station network to provide telephone service via the RCA domestic satellite. The earth stations will be 15' dish antenna installations providing two-channel service that will average in cost in excess of $70,000 each. There is also interest in the Alaska Air Guard for "transportable" earth stations -- transportable probably meaning transportable by helicopter.

Alaska does recognize a future "mobile" communication problem in managing their large state land domains. Despite the fact that this is not their current priority, they would possibly be interested in mobile communication experimentation with ATS-6.

Department of Transportation: Urban Mass Transit Administration

The focal point of interest here is Automatic Vehicle Monitoring Systems (AVM). The Office of Research and Development here has attempted to aggregate the interests of various agencies in this subject. Other agencies mentioned with an interest in AVM are;

DOT - Office of Transportation Security. Concern: Hijacking

Drug Enforcement - Concern: Track drug smuggling vehicles

NRC - Concern: Track nuclear material shipments

NOAH - Concern: Track location of weather ballons

GAO - Concern: Not well defined

Justice Department - Concern: Illegal immigrant control - track vehicles

LEAA - Concern: Location of police vehicles

Bureau of the Census - Concern: Audit location of rural census sources.

The best technology for vehicle location systems today seems to rest on some modification of "sign-post" technology. Fixed transmitters or receivers are strategically located in an urban area to identify vehicle location within the context of some grid system. UMTA is currently pursuing the use of such systems.

Federal Railway Administration; AMTRAK

AMTRAK provides mobile phone service on the N.Y. to Washington Metroliners. AT&T provides 12 frequencies in the 400-MHz band which are "borrowed" from other federal services. Now the other agencies want their frequencies back so the service is on a month-to-month basis until the issue is resolved. They use about 5 repeater stations along the route.

Service is provided on 30 trains per day. Total daily passenger load for the 30 trains is about 6000. Initially the service cost was $1.00 access plus the land line rate. The outgo then was about 7000 calls/month. AT&T then raised the rate to $3.00 access plus the land line rate and the telephone traffic fell to 4500 calls/month.

AMTRAK does not see general applicability of this service to the whole AMTRAK system. The northeast route presents a unique density situation and a minimum need for repeaters. A satellite system could probably technically serve this market, but costs would be the major hurdle. It is obvious that the service is very price elastic, and just guessing, the whole U.S. probably wouldn't generate more than 1000 calls/day.

Department of Transportation; Office of Transportation Security

This office is concerned with cargo security including truck hijacking. Various electronic schemes have been proposed over the years to locate or sense the "state" of vehicles - during or soon after hijacking. These have included transponders or emitters that relay vehicle position to helicopter, or signals that sense "state" such as motion or open door latches.

Cargo theft is estimated to cost the nation $1 billion per year. However, only about 10 percent of that theft is "hijacking". About 85 percent of the loss is employee theft and 5 percent is burglary of the truck or the terminal. Of the hijacking loss component, about 80-90 percent occurs in urban areas -- and not on the open road as might be the popular conception.

Vehicle locaters to be of any value during hijacking would need to detect a deviation from planned route - probably within a kilometer or less and very importantly to trigger a counter response from law enforcement authorities that would need to occur within a short space of time -- perhaps a few minutes at most.

More recently attention seems to be focusing on specific urban area systems. Reportedly Aerospace Corporation is designing an experiment for Los Angeles that would employ a "sign post" technology to sense vehicle state and location.

Department of Health, Education, and Welfare;
Office of Emergency Medical Services

This office was unable to identify need for improved or extended range mobile systems, except possibly within remote areas such as Alaska.

Emergency Medical seems to have certain parameters of use that make it "different". It responds to a person or a group that has some means of communicating a problem in the first place. If an individual man breaks his leg in a remote area and has no communication facility - then nobody knows he needs help. Therefore, the system responds to someone or some organized group that has a communication capability to begin with. This suggests that land mobile units serving remote areas would have marginal utility. Small portable units may have utility for remote base camps, remote paramedical clinics, etc., to communicate with more extensive regional medical centers. However, evacuation of a victim from remote sites is unlikely to be by land vehicle.

Department of Justice

BCL was unable to obtain much information on land mobile needs from the Department of Justice. There is a Federal Interagency Law Enforcement Telecommunications group which published a "FELT Communications Summary Plan" in August of 1975. We attempted to obtain a copy from the Justice Department but were refused on the grounds that any general dissemination of the information might invite exploitation by criminal elements.

Through Glenn Garrison of JPL we did obtain a copy of a similar August 1974 report. From that report we are able to summarize certain information on the Justic Department land mobile systems which we show in tabular form.

Justice Agency	General Nature of Equipment	Five-Year Planned Expenditures on Hardware 1975 - 1979
Drug Enforcement Administration	Base stations Repeaters Mobiles Portables Microwave	$8,500,000

Justice Agency	General Nature of Equipment	Five-Year Planned Expenditures on Hardware 1975 - 1979
FBI	Base stations Repeaters Mobiles Portables	$6,750,000
Immigrantion and Naturalization	Base stations Repeaters Mobiles Portables	$3,500,000
U.S. Marshalls Service	Base stations Repeaters Mobiles Portables Portable/Mobiles Portable base stations	$1,500,000

The various Services seem to operate on a regional basis with telephone and backup HF radio to headquarters. Nearly all the systems seem to be "dedicated". There is very little interconnection with each other. Immigration does interconnect with a few Customs Offices and local law enforcement agencies.

Notably the Drug Enforcement Administration is planning an extensive microwave network for Florida and the southern U.S. border to Los Angeles.

As one would expect all the Services are very security conscious. We can therefore guess they would look unfavorably on shared facilities or services even with each other.

Treasury Department

The major area of mobile communication activity rests within the Secret Service and their protective assignments for the president and other high U.S. officials, as well as foreign dignitaries. As with the Department of Justice, little detail could be obtained regarding their specific needs. Their mobile systems need to be highly reliable, very

flexible as to location, and secure. BCL can make no meaningful estimate of their capacity needs. Due to the high mobility and extensive geographic ranging of our U.S. officials and foreign dignitaries, one could guess that a satellite-based system could have definite utility. However, we would surmise that the communication traffic would be relatively thin -- except perhaps during election compaigns. The value assigned to these forms of security/protective communications is unknown to BCL.

Nuclear Regulatory Commission.

Since location monitoring and communication with shipments of nuclear materials would seem to have almost overwhelming public safety considerations, BCL discussed this aspect of NRC's operations with staff of the NRC Materials Protection Branch in Rockville.

We discussed a draft report covering a recent study of their various communication alternatives for safeguarding "commercial" shipments of such materials among reactors and processing facilities.

Briefly the desired system requirements are described as:

- Nationwide coverage
- Digital transmission plus voice
- Vehicle reporting at least twice an hour
- Ability to send emergency messages automatically
- Ability to authenticate communications
- Security status monitors independent of shipment personnel
- Automatic position determination.

The report reviews four major alternative systems; radiotelephone, an HF network, a satellite relay and a meteor burst network.

Radio telephone was eliminated because of incomplete geographic coverage, and meteor burst was eliminated because it lacks continuity of reliable communications.

Problems identified with satellite were the possible need for two satellites to guarantee reliable operations, and the possible susceptibility

of satellite communication to jamming by relatively low power, directional antenna emissions. The biggest deterrent, however, was time and cost. They estimate a 4-5 year lead time and $30,000,000 threshold cost for such a system. They point out this cost could be reduced significantly if the system were shared with others.

The report recommends that the best near-term solution is sharing ERDA's SECOM II HF network. SECOM II consists of five HF base stations across the continent designed to monitor shipment of government-owned nuclear materials (primarily weapons materials).

The sharing concept would cost NRC less than $500,000. An independent NRC HF network would cost nearly $2,000,000.

The report does recommend further study of a possible shared satellite system.

Volume of shipments of commercial nuclear materials is projected at a maximum of 1000 trucks per year by 1985 and 2000 by 1995. This, of course, implies very thin communication traffic.

Maritime Administration

BCL's investigation of marine mobile uses was limited to small boats and barges. For small craft operators operating in coastal waters, ship-to-shore communication is essentially free. The service is frequently very crowded and not highly reliable. On the other hand the equipment is very inexpensive ($300-$500). Most small boat operators are economically marginal, and therefore any communication system that would significantly increase their costs would not find acceptance. The FCC feels that greatest need for small craft is an inexpensive search and rescue system.

With respect to barge communications, the Maritime Administration has recently agreed to development of a prototype VHF system by Waterway Communications Systems, Inc. The prototype will consist of eight directional VHF stations to be built on the lower Mississippi between Cairo, Illinois and Baton Rouge. VHF sets would be installed on 25 towboats. The prototype

system will cost about $1.3 million with the Maritime Administration contributing up to $500,000. If the system is fully expanded to some 40 or 50 UHF stations, it could serve up to 1800 towboats using the inland waterways in central U.S.

Regional Disaster

Civil defense has a need to augment the national telephone system in case of a disaster such as tornados, earthquakes, etc. In natural disasters the telephone system soon becomes saturated because of calls seeking information on people and events. Thus, the group handling emergency problems cannot get the service needed.

Two types of service are potential satellite users. Both the military (Army and National Guard) and the Civil Defense have need of a system to augment the telephone system. Perhaps 3 to 5 normal voice channels would be required. In the U.S. there are 8 regions for supervising national disasters.

The occurrence of national disasters is such that probably no more than one region would have need for a system at any one time. Thus, nationally probably 3 to 5 channels of coverage would suffice.

The system could be portable with a steerable antenna since once put in place the equipment would not be moved until put back on stand-by.

We understand that the Red Cross and the Forest Service are cooperating on a CTS experiment.

CANADA

The large majority of Canada's population and economic activities lies within 200 miles of the U.S. border. The northern territories above the 55th parallel are almost devoid of highway and telephone infrastructure and therefore the economic development and administrations of those areas are very dependent upon radio systems and airplanes.

Within the developed and urban areas of Canada land mobile radio use follows patterns similar to those in the United States. However, the ratio of mobile units per 1000 population is close to 10, compared to a figure of over 20 for the U.S. Therefore, frequency crowding is not quite so severe. Also Canada does not make block assignments within their land mobile frequencies which probably allows better distribution of channels among the various users. Canada has not yet opened up additional land mobile frequencies in the 900-MHz band. Technically, prime emphasis at present seems to be on further development of digital systems -- particularly for public safety.

Nearly all Canadian land mobile equipment is domestically produced. Canadian Motorola is the dominant supplier with an estimated 60 percent of the market. For 1975 the estimated market for private dispatch equipment was $78 million; public land mobile telephone was about $7 million, and paging equipment about $5 million.

In 1975 there were about 225,000 dispatch mobile units in service. There were also about 18,000 to 20,000 land mobile telephones served by the common carriers, and a total of about 50,000 paging units. Mobile telephone is particularly popular in Alberta due to the influence of the petroleum industry.

In contrast to the U.S., Canada has a federal Department of Communications. Canadian communications development policy strongly leavens commercial viability with "socially desirable" criteria which makes communication with remote northern populations (perhaps a little over 1 percent of the citizenry) a primary goal.

Consequently, we see that a good deal of Canadian attention in CTS satellite experiments aims at communicating with remote populations for

educational, medical, cultural and administrative purposes. The development of the portable one-meter antenna and "transportable" 2-meter antenna systems is important to a number of their experiments.

Similar to the U.S. Canada could probably benefit from improved communication with petroleum, gas, and mineral exploration and production sites, remote construction areas, remote pipelines, land survey parties and forest management personnel.

SUMMARY OF NEEDS OF IDENTIFIED POTENTIAL USERS FOR A SATELLITE-BASED SYSTEM

The BCL searching process for identifying potential needs for improved land mobile communication systems has been sequential in nature -- eliminating major user classes as the present and future characteristics of their needs and cost limitations were identified up to 1985 - and concentrating on possibilities with the greatest economic justification.

The total volume of potential traffic identified is not very large. We do not claim to have identified all the potential users, but those identified do have predictable characteristics. Their needs are regional (or larger) in range; the regions are remote and lacking in communications infrastructure, and as such, the potential users can justify costs that might be considerably higher than conventional land mobile uses.

Some sources feel that, if such systems were actually offered, perhaps a number of other users might identify needs not yet articulated in their own minds.

The major hurdle in offering such systems by any commercial enterprises would be the threshhold cost. What is needed is one or two very large users that could in essence underwrite a major share of the traffic. MARISAT, with Navy participation, is an excellent example in the marine mobile area. BCL has not uncovered a similar major potential underwriter in the land mobile area.

CML Satellite has made a major survey of potential high volume users of domestic satellites and has not identified any significant demands for land mobile applications.

In the land mobile services, the major activity that presently might be most closely allied with land mobile needs would be the aspirations of the Public Service Satellite Consortium. Although their thrust is not toward land mobile uses per se, many of their proposed applications in health, education and the like would need small, inexpensive earth stations. If a "public service" satellite existed, it might technically serve some of the public needs for land mobile that BCL identified. The institutional arrangements that might surround the use of such a satellite might have a major influence on private use.

Table 2 summarizes the needed user/system characteristics identified in the study. We will be glad to review these in more detail with NASA. We would also be pleased to enter future arrangements to assist NASA in further examination, analysis and negotiation of possible experiments with ATS-6.

TABLE 2. SYSTEM CHARACTERISTICS SUMMARY

User Type	Type of Service	Required Channels	Potential Users	User Cost Limits	Coverage Patterns	Earth Station Characteristics	Remarks
Household goods movers	Paging	1 channel	3500-5000 per day *	Equipment - $300-$400 per pager Service - $25-$30 per month	Continental U.S.	Flat or whip	Digital paging read-out would be of interest - if not too high cost. *Potential use for the industry is 3500-5000 pages per day
Petroleum industry (a) Drilling ships	Voice	1/3 to 3 channels per ship	Approximately 15 ships	$1000-$2000 per channel per month	Regional	Could use 15-ft steerable but would prefer fixed and as small as possible	
	Data (50,000 bps)	1 channel per ship**	Approximately 15 ships	More than above, but no limits established	Regional	Same as above	**One channel per ship primarily for security reasons
(b) Production platform	Voice	2-3 channels per platform	New platforms out of line-of-sight	$1000 per channel per month	Regional	Could use 15-ft fixed but would prefer small as possible	New platforms may be in the Gulf of Mexico, Atlantic Ocean, Pacific Ocean or North Slope
(c) Pipelines	Voice and Telemeter (1,200 bps)	60 channels for 800 miles of pipeline	New pipelines, Trans Alaska or Trans Canada	$1000-$1500 per channel per month	Regional	Fixed - small as possible for control points. Whip or flat for mobiles	Characteristics are based on the only known prototype - Alyeska pipe line
Regional disaster (Civil Defense)	Voice	3-5 channels per region	8 Civil Defense regions	Unknown	Regional	Not necessarily mobile - but portable. Could be steerable	
Remote and survey and management	Voice	2-4 total for Alaska	Two federal agencies BLM and Forest Service; Possibly the State of Alaska	Earth station - $2000-$10,000 Service - $1000 per channel per month	Regional (Alaska)	Same as above	Allowable cost for earth stations would be related to the cost of repeaters using VHF

REFERENCES

Reilly, N. B., Ground Mobile Voice Communications Using Satellite Links, Jet Propulsion Laboratories (December 1, 1975).

The National Research Council, Practical Applications of Space Systems, National Academy of Sciences, Washington, D. C. (1975)

National Academy of Sciences, Practical Applications of Space Systems, Supporting Paper 2, "Uses of Communications", Washington D. C. (1975)

Panel on Extractable Resources, Practical Applications of Space Systems, Supporting Paper 6, "Extractable Resources", National Academy of Sciences, Washington (1975)

Proceedings of Electronic Communications Industry Trends and Economic Directions, EIA Seminar held at the Shoreham Hotel, Washington, D.C. (March 12, 1974)

Arthur D. Little, Inc., Study Report of the U.S. Radio Paging Market National Technical Information Service, U.S. Department of Commerce, (30 April 1975)

Arthur D. Little, Cost and Technical Characteristics of Radio Paging System, National Technical Information Service, U.S. Department of Commerce (June 13, 1975)

Arthur D. Little, World Mobile Telecommunications, Vol. 1, "Technology and Worldwide Aspects" (1974),

Arthur D. Little, Inc. World Mobile Telecommunications, Vol. 2, "Country Descriptions and Glossary," (1974)

Technology Requirements for Post-1985 Communications Satellites, Lockheed Missiles & Space Company, Inc., Final Report to Ames Research Center, Mountain View, California (October, 1973),

REFERENCES (Continued)

Study of Data Collection Platform Concepts, Data Collection System User Requirements, Operations Research, Inc., Final Report to Goddard Space Flight Center, NASA, Greenbelt, Maryland (April, 1973).

FELT Communications Summary Plan, Federal Interagency Law Enforcement Telecommunications Group, Department of Justics (August 1974).

Martin Lukes, Raymond Shea, Chicago Transit Authority, An Urban Mass Transportation Demonstration Project Study of Automatic Vehicles Monitoring, Final Report to U.S. Department of Transportation, (May, 1973).

Federal Communications Commission, 39th Annual Report, for the Fiscal Year 1973, to Congress of the United States, Washington, D. C.

Communications Satellite Corporation (COMSAT), Report to the President and the Congress 1975, (1975), Washington D. C., (Auguat 31, 1975)

Interface 75, Alaska Pipeline Takes on Datacomm Monitor to Keep Oil Flowing, and Satellite Link Speeds Drilling Data from Off-Shore Rig to HQ,(February 1975).

Communications and Signal Section, Association of American Railroad, Washington, D. C., The Need for and the Use of Radio by the Railroads, Report, (February, 1973).

Y. Hirata, M. Kogoku, and E. Isomura, Koskusai Denshin Denwa Co., Ltd., Tokyo, Japan, "A Study on Satellite Communications for Mobiles", Presented as Paper 72-565 at the AIAA Communications Satellite Systems Conference, Washington, D. C. (April 24-26, 1972).

D. C. MacLellan, Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass., "Anticipated Developments in Communications Satellite Technology", Department of the Air Force, Washington, D. C. no date given.

R.P. Haviland, General Electric Company, Valley Forge, Pa., "Individual and Thin-Route Communications by Satellite", Presented as Paper 72-541 at the AIAA 4th Communications Satellite Systems Conference, Washington, D.C. (April 24-26, 1972).

REFERENCES (Continued)

R. P. Morgan, et al., "Satellites for U.S. Education: Needs, Opportunities, and Systems", Presented as Paper 72-523 at the AIAA 4th Communications Satellite Systems Conference, Washington, D. C. (April 24-26, 1972),

Burton I. Edelson, COMSAT Laboratories, "Small Earth Terminals for Satellite Communications", Astronautics & Aeronautics, (June, 1973)

Nathaniel E. Feldman, The RAND Corporation, and Charles M. Kelly, The Aerospace Corporation, "The Communication Satellite-A Perspective for the 1970s", Astronautics and Aeronautics,(September 1971)

Dr. Paul Polishuk, "Telecommunications and The Energy Crisis", Office of Telecommunications, U. S. Department of Commerce, (February, 1974)

Dr. Paul Polishuk, "Land Mobile Radio - Boom or Bust?", Office of Telecommunications, U. S. Department of Commerce, Washington, D. C. (August 1975),

Stacy V. Bearse, Associate Editor, "The Year of Giant Growth Arrives For Land-Mobile Communications", Microwaves (January 1974),

H. Rex Lee, Public Service Satellite Consortium, San Diego, California, "Today's Planning for Tomorrow's Needs", AIAA Paper No. 75-913 presented to AIAA Conference on Communication Satellites for Health/Education Applications, Denver, Colorado (July 21-23, 1975)

Daniel R. Wells, Public Broadcasting Service, Washington, D. C. "Interconnection by Satellite for PBS and Other Public Service Users", AIAA Paper No. 75-914, presented at AIAA Conference on Communication Satellites for Health/Education Applications, Denver, Colorado (July 21-23, 1975)

N. R. Helm and J. Kaiser, COMSAT Laboratories, Clarksburg, Maryland, "Small Earth Terminals for Medical/Educational Applications", AIAA Paper No. 75-917, presented at AIAA Conference on Communication Satellites for Health/Education Applications, Denver, Colorado (July 21-23, 1975)

Dr. Arthur Goldsmith, "Telecommunication--An Alternative to Travel", A paper presented by Dr. Goldsmith, Office of the Secretary of Transportation to the 1974 Government-Industry Telecommunications Conference of the

REFERENCES (Continued)

Resources and Technology Department of the National Association of Manufacturers on June 5, 1974 at Washington, D. C.

Roger Pye, et al., "Travel or Telecommunicate? The Energy Considerations", Paper presented at the one-day conference on 'Exploring the limited to growth of telecommunications - energy and materials - problems, solutions, and opportunities' Sponsored by IEEE, Washington Section and the Technology Forecasting and Assessment Project, (February 20, 1974), Washington, D. C.

J. V. Charyk, COMSAT, "Future Prospects of Satellite Telecommunications Systems", Telecommunication Journal Vol. 38,(V1971),

Communications Technology Satellite, United States Users Meeting #8, held at NASA Goddard Space Flight Center, Greenbelt, Maryland (January 28-29, 1975),

Eascon '75 Record, IEEE Electronics and Aerospace Systems Convention, Sponsors: IEEE Washington Section, IEEE Aerospace & Electronic Systems Society, Stouffer's National Center Inn, Washington, D. C. (September 29-October 1, 1975)

Experimental Evaluation of Satellite Communications and Position Fixing for Maritime Users, Joint Final Report, Exxon Corporation and General Electric Company (June, 1974)

Howard H. Hupe, HEW Office of Telecommunications Policy, "Markets for a Social Services Satellite", Astronautics and Aeronautics, (Februrary, 1975)

Axel F. Brisken, General Electric Company, Corporate Research & Development, Schenectady, New York, "L-Band Trilateration of ATS-5", Paper presented at the 31st Annual Meeting, Institute of Navigation, Washington, D. C., (June24-26, 1975)

Roy E. Anderson, General Electric Company, "Communications and Position Fixing Experiments Using the ATS Satellites", Paper presented at the Institute's Annual Meeting in St. Louis, Missour on June 20, 1973, Journal of The Institute of Navigation, Vol 20, No. 4, Winter 1973-74,

REFERENCES (Continued)

William A. Anderson, Department of Sociology, The Ohio State University, "Disaster Warning and Communication Processes in Two Communities", Reprint #24, Reprinted from The Journal of Communication 19, No. 2 (June, 1969)

Robert A. Stallings, Department of Sociology, The Ohio State University, "Communications in Natural Disasters", Disaster Research Center Report Series No. 10 for Office of Civil Defense, Office of the Secretary of the Army, Washington, D. C. (January 1971)

R. W. Huck, Space Applications Branch, "Communications Experimenters' Guide Communications Technology Satellite", Communications Research Centre, Department of Communications, Canada, CRC Technical Note No. 671 (February, 1975)

G. H. Booth, CTS Spacecraft Manager at the Communication Research Centre, Ottawa, Ontario, Canada, "The Canadian/U.S. High-Power Communications Technology Satellite", Paper, Canadian CTS Experiments (1975)

B. A. Walker, M. L. Card, and O. S. Roscoe, "A Planning Study for a Multi-Purpose Communications Satellite Serving Northern Canada", Canadian CTS Experiments, (1975),

Canadian CTS Experiments, (Rev. November 1975), 28 experiments titled and authored as shown:

J. Strickland, "Propagation Measurements"
P. P. Nuspl, "Time Division Multiple Access Synchronization Experiment"
R. J. Campbell, "FDMA Demand Assignment Experiemtn - Two-way Voice"
Peter P. Nuspl, "High-Rate Data Experiment"
R. K. Tiedemann, "Small Terminal Evaluation Experiment"
C. A. Siocos, "Technical Measurements and Demonstrations, Broadcasting Signal Reception in a Metropolitan Environment"
TBD, Canadian Broadcasting Corporation, "Applications of Radio Broadcasting"
TBD, Canadian Broadcasting Corporation, "TV Special Demonstration"
Director of Studies, Public Service Commission, "Staff Training by Satellite"
M. House, W. C. McNamara, "Telemedicine Experiments with the Communications Technology Satellite (CTS)
Jacques Jobin, "Community Communications in New Quebec"
M. Pierre Dumas, "Omnibus Network"
Michel Couillard, "Radiotelephony with Satellite Camps"
Pierre Girard, "Telephony and Data Transmission Studies"
D. I. Towers, "Multi-Ministry Administrative and Operational Experiment"
R. O'Kane, "Government Teleprocessing Network"
Dr. D. A. George and Dr. D. Lumb, "CTS Digital Video University Curriculum Sharing Experiment"

REFERENCES (Continued)

Dr. N.A. M. Mackay, "A Satellite Communications Link for Train Location"
J. L. Yen, "Satellite-Link Radio Interferometry"
Dr. Simon Haykin, "Performance Evaluation of a Digital Modem for High-Rate Data Transmission"
J. F. Hart, "Exploration of a Satellite Computer Network to Supply Computerized information to Native Peoples in Northern Canada"
Dr. Lewis S. Carey, "Telemedicine Experiment - Between a Remote Village (Kasechewan), Northern Base Hospital (Moose Factory General) and a Health Science Center (University of Western Ontario)
J. W. Mark, "Studies and Evaluations of Signal Processing Techniques for Data Communication via Satellite"
Dr. G. Vervoort, "Upgrading Mathematical Competence of Elementary School Teachers"
Dr. B. Wilhelm, "Saskquebec Education-Culture"
R. M. Lester, "Transportable Telecommunications System"
Dr. H. MacGuire, "Health Care Delivery to Remote Areas"
L. Desmeules, "Project 'Ironstar'"