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# TELECOMMUNICATION SERVICE MARKETS THROUGH THE YEAR 2000 IN RELATION TO MILLIMETER WAVE SATELLITE SYSTEMS




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# TELECOMMUNICATION SERVICE MARKETS THROUGH THE YEAR 2000 IN RELATION TO MILLIMETER WAVE SATELLITE SYSTEMS

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## ABSTRACT

NASA is currently conducting a series of millimeter wave satellite system and market studies to develop 30/20 GHz satellite system concepts that have commercial potential. Four contractual efforts were undertaken: two parallel and independent system studies by Ford Aerospace and Hughes Aircraft, and two parallel and independent market studies by Western Union and International Telephone and Telegraph Corporation. The marketing efforts are focused on forecasting the total domestic demand for long haul telecommunication services for the 1980-2000 period. Work completed to date and reported in this paper include projections of: geographical distribution of traffic; traffic volume as a function of urban area size; and user identification and forecasted demand. Ongoing work within the market studies is concerned with the determination of the relationship of service demand to variations in service cost and reliability. In addition, a case study of the long haul traffic characteristics of a large metropolitan area is being conducted and, ultimately, the portion of the total traffic suited for 30/20 GHz systems will be determined during the study effort.

## INTRODUCTION

NASA is planning an augmented R&D technology program having direct application to commercial satellite communication systems. A five-year program has been structured to identify and develop critical technologies and conduct service experiments and demonstrations utilizing flight payloads, if necessary. The communications industry, carriers and suppliers, will be an integral part of this program. The initial phase of this effort consists of assessment and concept definition studies to characterize the markets for communications services and to identify potentially viable systems. The initial project in this program deals with 30/20 GHz satellite communications systems and this paper addresses exclusively the market analysis associated with such systems. This market analysis effort is being conducted for NASA by Western Union Telegraph Company and the International Telephone and Telegraph Corporation.

The market assessment effort is a fundamental part of the systems definition activity since the ultimate system configurations and service costs are inherently dependent on the communication service market characteristics. The final systems definition is achieved through an interaction of the market and systems efforts.

This paper addresses the initial market analysis results including communications traffic demand forecasts and user market characteristics. The traffic demand forecasts attempt to predict the growth of voice, data, and video services from 1980 to 2000, describe the distance distribution of these traffic categories, and determine traffic volume as a function of population density and geographic location. The user market characteristics describe the demand associates with four user categories: commercial, government, institutional, and private for 1980-2000 and include geographical distribution by user category.

## Traffic Demand Forecasts

Telecommunications services were classified as voice, data, and video and the magnitude of demand for these services was forecasted for 1980-2000. Two types of traffic forecasts were made: (1) a baseline forecast which is predicated on an orderly growth of present services and present visibility of future services, and (2) an impacted baseline scenario which is the baseline scenario modified by the occurrence of a number of events such as widespread adoption of fiber optics technology, changes in the regulatory environment, and socioeconomic factors such as rapid rise in energy costs. These events were combined in a probabilistic sense resulting in a high, low, and expected set of traffic forecasts.

Voice services were classified as: private line, message toll service (MTS)(public), MTS (business), and all other voice services. For the baseline forecasts, the MTS market demand was developed from two sources: (1) historical usage information for each element of the services (i.e. residential, pay phone, business, and WATS), and (2) examination of trends and comparison with other sources. These MTS forecasts were then converted to total demand expressed in half-voice circuits. The private line market demand was obtained by reviewing historical growth patterns, considering all possible competitors, evaluating user requirements and trends, and by using regression analysis. Radio program transmission and mobile radio telephone forecasts are included in the "other" category. Interaction between all applications and between voice, data, and video was also considered. The baseline forecasts for voice services for the years 1980, 1990, and 2000 are shown in Table 1. The demand is shown to increase by a factor of over 6, representing an average growth rate of 9.5 percent per annum over the twenty-year period. Currently, about 1200 half-voice circuits can be carried by a typical DOMSAT transponder. Thus, in terms of equivalent transponders, the demand is shown to grow from 2552 equivalent transponders in 1980 to 15,840 equivalent transponders in 2000. It must be pointed out, however, that this demand represents the total demand, only a portion of which would be best suited for satellite transmission.

Twenty-one data services were identified and were broadly classified into four main functional groupings: data transmission applications, electronic funds transfer/point of sale (EFT/POS) applications, electronic mail applications, and miscellaneous data services. The services associated with these four major categories are shown in Table 2.

In order to forecast data traffic, the twenty-one applications were grouped according to the forecasting method used; e.g. computer and general purpose terminal oriented applications and facsimile applications. Applications were also individually forecast considering such factors as operating speeds, usage requirements, trends, and technological developments. The applications were reassembled into the four functional groupings and the forecasts are presented in Table 3. The units are terabits per year ($10^{12}$ bits per year). The largest category is data transmission, mainly computer applications, comprising about 75 percent of

the total data service traffic. Data services are growing at 17 percent per annum; nearly twice the growth rate of voice services. However, the total voice traffic volume remains orders of magnitude greater than the data traffic volume for the forecasted period.

Video services were categorized as network and occasional video, CATV distribution, and all others, including teleconferencing. The unit of measure for video services is broadcast quality, full motion, video satellite channels. Reduced bandwidth circuits were assumed for teleconferencing and some other applications but were converted to a full motion equivalent.

A difficulty arises in determining terrestrial video traffic volume: on terrestrial multidrop lines, every drop point defines a separate channel; whereas,with satellite TV distribution, one program equals one channel, regardless of the number of receive-only points. Thus, the forecast was interpreted as satellite channels and no attempt was made to estimate the terrestrial equivalent. Table 4 shows the forecast video traffic in equivalent wideband satellite channels.

The impacted baseline forecast for voice, data, and video demand represents the baseline forecast as modified by the probabilistic events mentioned above. Each event was assessed for probability of occurrence and timing of occurrence, each affected application identified, and the potential impact quantified with high and low ranges. A computer program was developed to account for all the cross impacting relationships, assure consistency among the forecasts, and eliminate duplicate demand. A sufficient number of simulations were run to generate a distribution of scenarios from which high, low, and expected traffic demand forecasts could be selected. The resulting impacted baseline forecast (expected case) is shown in Table 5.

## Distance Distribution of Traffic

Voice and data traffic volume as a function of transmission distance was estimated. Traffic patterns associated with each service category were analyzed, with the analysis based on the impacted baseline market demand forecast (expected case). The analysis was conducted with a computerized market distribution model which was developed to determine traffic volume by specific geographic areas for distinct communications services. It distributes nationwide service forecasts to individual routes, identifies cumulative market potential for specific routes, and projects market forecast distributions drawing on multiple data bases. The coverage includes all 275 Standard Metropolitan Statistical Areas (SMSA's), all major U.S. cities, and over 37,000 possible routes. The model was utilized here to generate a traffic distribution profile as a function of distance. The traffic was classified into six mileage bands ranging from 0 to 2700 miles. Traffic with a transmission distance greater than 40 miles was designated long-haul traffic and traffic transmitted less than 40 miles was dropped from further consideration. The traffic/distance distributions for voice and data are shown in Tables 6 and 7 respectively.

## Traffic Volume As A Function of Metropolitan Area Size

The relationship of traffic demand to SMSA size was determined by classifying the 275 SMSA's into five population categories and determining the amount of traffic generated by each category. This coverage provides for 72.4 percent of the U.S. population and includes all cities with a population of at least 58,000. Table 8 shows the population categories, number of SMSA's in each category, and population per SMSA category for 1978.

Table 9 shows the relationship of traffic volume to SMSA size. Note that traffic demand is not proportional to population density but, rather, is skewed such that more traffic per capita is generated in the larger areas. The SMSA's with 72.4% of the population generate about 85 percent of the nation's communications traffic and comprise only slightly over 14 percent of the U.S. land area. Thus, only 15 percent of the traffic comes from outlying areas comprising 27.6 percent of the population and 86 percent of the land area.

## Geographical Distribution of Traffic

The geographical distribution pattern of voice, data, and video traffic within the United States was determined. Nine geographical regions were designated and are shown in Figure 1. The market distribution model was used to determine traffic demand by region for each service category. The forecasted traffic distributions for 1990 are shown in Table 10. This analysis and all subsequent analyses were based on the impacted baseline forecast (expected case) and long-haul traffic (transmission greater than 40 miles).

## User Market Analysis

The market for communications services was divided into four user categories: business, government, institutional, and private, and demand for voice, data, and video services was forecast for each group. The business category includes all business enterprises; government: all federal, state, and local agencies; institutional: hospitals, schools, associations, labor unions, religious groups, others; and private: all U.S. households. The forecasts for each user category were conducted by reviewing pertinent source material for user needs, and discussing these needs with source organizations (e.g., market consultants and associations). Also, analysis of information on users' expenditures for communication services of each type, and the projection of average annual growth rates for each type service by user category was utilized. The forecasts for voice, data, and video, for each user category, are shown for 1980, 1990, and 2000 in Tables 11-13.

## Geographical Distribution of User Demand

The market distribution model was used, with the user category forecasts as data, to determine the geographical distribution of user demand, classified into the nine geographic regions discussed above. The geographic distribution of user demand for voice and data services by region is listed in Tables 14 and 15 for 1990.

## CONCLUDING REMARKS

Market forecasts and distributions are critical to the design of satellite systems as they permit optimum systems to be configured; e.g., they determine capacity requirements, influence antenna design, transponder and array power levels. This paper discusses the results of the market studies to date which have focused on the overall demand forecasts and distributions of demand by geographic location, distance, and user category. These results are of general interest to communication system designers.

In the future, the market studies will address the price elasticity of demand, reliability requirements of future services, and amount of real-time vs. non-

real-time services. Also, case studies of the communications requirements of two major metropolitan areas will be conducted. The total market and system activity will be influential in determining: the potential role of millimeter wave systems in the overall transmission needs of the nation; amount of the total forecasted traffic suitable for millimeter wave systems; and how to proceed to efficiently develop the spectrum resource available at millimeter wave frequencies.

TABLE 1 - BASELINE MARKET FORECAST

VOICE SERVICES

(HALF VOICE CIRCUITS) (THOUSANDS)

| APPLICATION | 1980 | 1990 | 2000 | % |
|---|---|---|---|---|
| PRIVATE LINE | 1246 | 2895 | 6368 | 8.5 |
| MTS (PUBLIC) | 1033 | 2442 | 5244 | 8.5 |
| MTS (BUSINESS) | 776 | 2280 | 7308 | 11.9 |
| ALL OTHER | 8 | 44 | 88 | 12.7 |
| TOTAL | 3063 | 7661 | 19008 | 9.5 |

TABLE 2 - DATA SERVICE CATEGORY

- DATA TRANSMISSION APPLICATIONS (8)
  - DATA TRANSFER
  - BATCH PROCESSING
  - DATA ENTRY
  - REMOTE JOB ENTRY
  - INQUIRY/RESPONSE
  - PRIVATE TIME SHARING
  - COMMERCIAL TIME SHARING
  - PACKET SWITCHING
- EFTS/POS APPLICATIONS (2)
  - INQUIRY/RESPONSE
  - DATA ENTRY/DATA TRANSFER
- ELECTRONIC MAIL APPLICATIONS (8)
  - ADMINISTRATIVE MESSAGE TRAFFIC
  - OPERATIONAL FACSIMILE
  - COMMUNICATING WORD PROCESSORS
  - CONVENIENCE FACSIMILE
  - MAILBOX SERVICES
  - TWX & TELEX
  - MAILGRAM AND TELEGRAM
  - USPS EMSS
- MISCELLANEOUS APPLICATIONS (3)
  - SPECIAL PURPOSE FACSIMILE
  - SECURE VOICE
  - MONITORING SERVICES

## TABLE 3 - BASELINE MARKET FORECAST

### DATA SERVICES

(TERABITS PER YEAR)

| APPLICATIONS | 1980 | 1990 | 2000 | % |
|---|---|---|---|---|
| DATA TRANSMISSION | 1358 | 6040 | 25,564 | 15.8 |
| ELECTRONIC MAIL | 120 | 2120 | 5,402 | 21.0 |
| EFT/POS | 32 | 476 | 2,742 | 24.9 |
| ALL OTHER | 43 | 247 | 1,105 | 17.6 |
| TOTAL | 1553 | 8883 | 34,813 | 16.8 |

## TABLE 4 - BASELINE MARKET FORECAST

### VIDEO SERVICES

(WIDEBAND CHANNELS)*

| APPLICATIONS | 1980 | 1990 | 2000 |
|---|---|---|---|
| NETWORK AND OCCASIONAL VIDEO | 69 | 89 | 96 |
| CATV DISTRIBUTION | 69 | 81 | 81 |
| ALL OTHER | 23 | 33 | 47 |
| TOTAL | 161 | 203 | 224 |

* EQUIVALENT WIDEBAND

## TABLE 5 - IMPACTED BASELINE FORECAST

(EXPECTED CASE)

| SERVICES | UNITS OF VOLUME | 1980 | 1990 | 2000 |
|---|---|---|---|---|
| VOICE | HALF CIRCUITS (THOUSANDS) | 3068 | 8050 | 20371 |
| VIDEO | WIDEBAND CHANNELS | 161 | 222 | 274 |
| DATA | TERABITS/YEAR | 1678 | 10559 | 42834 |

## TABLE 6 - TRAFFIC/DISTANCE DISTRIBUTION

VOICE SERVICES

(LONG HAUL)

| MILEAGE BAND | NO. ROUTES | PERCENT DISTRIBUTION 1980 | 1990 | 2000 |
|---|---|---|---|---|
| 0 - 40 | 163 | NOT APPLICABLE | | |
| 41 - 150 | 1477 | 11.9 | 11.4 | 10.7 |
| 151 - 500 | 7716 | 29.3 | 28.8 | 28.2 |
| 501 - 1000 | 13340 | 25.4 | 25.7 | 26.0 |
| 1001 - 2100 | 12258 | 23.7 | 24.2 | 24.9 |
| 2101 - 2700 | 2721 | 9.7 | 9.9 | 10.2 |
| | 37675 | 100.0 | 100.0 | 100.0 |

## TABLE 7 - TRAFFIC/DISTANCE DISTRIBUTION

DATA SERVICES

(LONG HAUL)

| MILEAGE BAND | NO. OF ROUTES | PERCENT DISTRIBUTION | | |
|---|---|---|---|---|
| | | 1980 | 1990 | 2000 |
| 0 - 40 | 163 | NOT APPLICABLE | | |
| 41 - 150 | 1477 | 7.8 | 7.8 | 7.8 |
| 151 - 500 | 7716 | 27.0 | 26.9 | 27.0 |
| 501 - 1000 | 13340 | 29.8 | 29.6 | 29.8 |
| 1001 - 2100 | 12258 | 25.9 | 26.0 | 25.9 |
| 2101 - 2700 | 2721 | 9.5 | 9.7 | 9.5 |
| | 37675 | 100.0 | 100.0 | 100.0 |

## TABLE 8 - SMSA CLASSIFICATION, 1978

| POPULATION CATEGORIES | NUMBER OF SMSA's REPRESENTED | CATEGORY POPULATION |
|---|---|---|
| 4 MILLION AND GREATER | 5 | 32.8 MILLION |
| 1.5 MILLION - 4 MILLION | 15 | 35.0 |
| 0.8 MILLION - 1.5 MILLION | 25 | 28.4 |
| 350,000 - 800,000 | 61 | 31.3 |
| 58,000 - 350,000 | 169 | 29.8 |
| | 275 | 157.3 |

## TABLE 9 - SMSA POPULATION DENSITY AND TRAFFIC VOLUME

1990

| SMSA POPULATION CATEGORY | SMSA POPULATION % TOTAL | PROPORTION OF MARKET DEMAND | |
|---|---|---|---|
| | | VOICE SERVICES | DATA SERVICES |
| 4 MILLION & GREATER | 21.0 | 25.7% | 23.4% |
| 1.5 - 4 MILLION | 22.2 | 23.7 | 25.0 |
| 800,000 - 1.5 MILLION | 18.0 | 19.9 | 17.9 |
| 350,000 - 800,000 | 19.9 | 18.5 | 19.1 |
| 58,000 - 350,000 | 18.9 | 12.2 | 14.6 |
| | 100.0 | 100.0 | 100.0 |

## TABLE 10 - GEOGRAPHICAL DISTRIBUTION OF TRAFFIC (LONG HAUL)

1990

| REGION | TRAFFIC VOLUME DISTRIBUTION | | |
|---|---|---|---|
| | VOICE | DATA | VIDEO |
| NEW ENGLAND | 6.5 | 6.1 | 4.6 |
| MIDDLE ATLANTIC | 19.1 | 21.9 | 10.6 |
| EAST NORTH CENTRAL | 19.2 | 18.3 | 18.1 |
| WEST NORTH CENTRAL | 6.7 | 6.4 | 10.9 |
| SOUTH ATLANTIC | 16.4 | 15.3 | 16.8 |
| EAST SOUTH CENTRAL | 4.8 | 4.0 | 8.3 |
| WEST SOUTH CENTRAL | 8.8 | 9.6 | 12.1 |
| MOUNTAIN | 4.5 | 3.9 | 6.7 |
| PACIFIC | 14.0 | 14.5 | 11.9 |
| | 100.0 | 100.0 | 100.0 |

## TABLE 11 - NET LONG HAUL

## TRAFFIC VOLUME FORECASTS BY USER CATEGORY

## VOICE SERVICES

(HALF-VOICE CIRCUITS)

(THOUSANDS)

| USER CATEGORY | 1980 CIRCUITS | 1980 % | 1990 CIRCUITS | 1990 % | 2000 CIRCUITS | 2000 % |
|---|---|---|---|---|---|---|
| BUSINESS | 995 | 47.5 | 2420 | 45.5 | 6878 | 49.8 |
| GOVERNMENT | 336 | 16.0 | 1004 | 18.9 | 2629 | 19.0 |
| INSTITUTIONS | 56 | 2.7 | 125 | 2.3 | 255 | 1.9 |
| PRIVATE | 708 | 33.8 | 1771 | 33.3 | 4043 | 29.3 |
| TOTAL | 2095 | 100.0 | 5320 | 100.0 | 13805 | 100.0 |

## TABLE 12 - TRAFFIC VOLUME FORECASTS BY USER CATEGORY

## NET LONG HAUL TRAFFIC

## DATA SERVICES

(TERABITS/YR)

| USER CATEGORY | 1980 TERABITS/YR | 1980 % | 1990 TERABITS/YR | 1990 % | 2000 TERABITS/YR | 2000 % |
|---|---|---|---|---|---|---|
| BUSINESS | 847.2 | 78.6 | 5777.0 | 83.0 | 23715.0 | 86.1 |
| GOVERNMENT | 222.9 | 20.7 | 1111.1 | 16.0 | 3694.7 | 13.4 |
| INSTITUTIONS | 7.5 | .7 | 27.6 | .4 | 93.7 | .3 |
| PRIVATE | .9 | 0 | 41.6 | .6 | 50.2 | .2 |
| TOTAL | 1078.5 | 100.0 | 6957.3 | 100.0 | 27553.6 | 100.0 |

## TABLE 13 - NET LONG HAUL

## TRAFFIC VOLUME FORECASTS BY USER CATEGORY

## VIDEO SERVICES

(WIDEBAND CHANNELS)

| USER CATEGORY | 1980 CHANNELS | % | 1990 CHANNELS | % | 2000 CHANNELS | % |
|---|---|---|---|---|---|---|
| BUSINESS | 118 | 73 | 151 | 74 | 166 | 74 |
| GOVERNMENT | 3 | 2 | 6 | 3 | 6 | 3 |
| INSTITUTIONS | 40 | 25 | 46 | 23 | 47 | 21 |
| PRIVATE | 0 | 0 | 0 | 0 | 5 | 2 |
| TOTAL | 161 | 100 | 203 | 100 | 224 | 100 |

## TABLE 14 - GEOGRAPHICAL DISTRIBUTION OF DEMAND: 1990

## LONG HAUL TRAFFIC

## VOICE SERVICES

(HALF VOICE CIRCUITS)

(THOUSANDS)

| REGION | BUSINESS CIRCUITS | % | GOVERNMENT CIRCUITS | % | INSTITUTIONS CIRCUITS | % | PRIVATE CIRCUITS | % |
|---|---|---|---|---|---|---|---|---|
| NEW ENGLAND | 181 | 7.5 | 50 | 5.0 | 9 | 6.9 | 106 | 6.0 |
| MIDDLE ATLANTIC | 501 | 20.7 | 143 | 14.2 | 27 | 21.3 | 347 | 19.6 |
| EAST NORTH CENTRAL | 508 | 21.0 | 132 | 13.1 | 28 | 22.5 | 356 | 20.1 |
| WEST NORTH CENTRAL | 157 | 6.5 | 68 | 6.8 | 8 | 6.5 | 122 | 6.9 |
| SOUTH ATLANTIC | 361 | 14.9 | 234 | 23.3 | 17 | 13.8 | 262 | 14.8 |
| EAST SOUTH CENTRAL | 97 | 4.0 | 67 | 6.7 | 6 | 4.6 | 83 | 4.7 |
| WEST SOUTH CENTRAL | 194 | 8.0 | 104 | 10.4 | 10 | 8.1 | 161 | 9.1 |
| MOUNTAIN | 94 | 3.9 | 65 | 6.5 | 4 | 3.4 | 75 | 4.2 |
| PACIFIC | 327 | 13.5 | 141 | 14.0 | 16 | 12.9 | 259 | 14.6 |
| TOTAL | 2420 | 100.0 | 1004 | 100.0 | 125 | 100.0 | 1771 | 100.0 |

TABLE 15 - GEOGRAPHICAL DISTRIBUTION OF DEMAND: 1990

LONG HAUL TRANSMIT AND RECEIVE

DATA SERVICES

(TERABITS/YR)

| | BUSINESS | | GOVERNMENT | | INSTITUTIONS | | PRIVATE | |
|---|---|---|---|---|---|---|---|---|
| REGION | TERABITS/YR | % | TERABITS/YR | % | TERABITS/YR | % | TERABITS/YR | % |
| NEW ENGLAND | 727.9 | 6.3 | 107.3 | 4.8 | 3.4 | 6.1 | 4.8 | 5.8 |
| MIDDLE ATLANTIC | 2,726.7 | 23.6 | 288.3 | 13.0 | 11.7 | 21.2 | 17.1 | 20.5 |
| EAST NORTH CENTRAL | 2,264.6 | 19.6 | 251.8 | 11.3 | 11.7 | 21.2 | 17.4 | 20.9 |
| WEST NORTH CENTRAL | 739.5 | 6.4 | 143.8 | 6.5 | 4.0 | 7.3 | 6.0 | 7.2 |
| SOUTH ATLANTIC | 1,548.2 | 13.4 | 564.2 | 25.4 | 8.0 | 14.5 | 12.1 | 14.6 |
| EAST SOUTH CENTRAL | 392.8 | 3.4 | 151.8 | 6.8 | 2.4 | 4.3 | 3.5 | 4.2 |
| WEST SOUTH CENTRAL | 1,086.1 | 9.4 | 240.8 | 10.8 | 5.5 | 9.9 | 7.9 | 9.5 |
| MOUNTAIN | 381.3 | 3.3 | 157.4 | 7.1 | 2.0 | 3.7 | 3.3 | 4.0 |
| PACIFIC | 1,686.9 | 14.6 | 316.8 | 14.3 | 6.5 | 11.8 | 11.1 | 13.3 |
| TOTAL | 11,554.0 | 100.0 | 2,222.2 | 100.0 | 55.2 | 100.0 | 83.2 | 100.0 |

# GEOGRAPHICAL TRAFFIC REGIONS

FIGURE 1