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# SATELLITE PROVIDED FIXED COMMUNICATIONS SERVICES: A FORECAST OF POTENTIAL DOMESTIC DEMAND THROUGH THE YEAR 2000

## FINAL REPORT - VOLUME I - EXECUTIVE SUMMARY

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16. Abstract


The overall purpose of this study was to forecast the potential United States domestic telecommunications demand for satellite provided fixed communications voice, data and video services through the year 2000.

To accomplish this purpose the following objectives were achieved:

a. Development of a forecast of the total domestic telecommunications demand

b. Identification of that portion of the total demand suitable for transmission by satellite provided fixed communications systems

c. Estimation of the actual amount of traffic that could be captured by Ka-band systems.

The approach employed included the use of a variety of forecasting models, a parametric cost model, a market distribution model and a network optimization model. Forecasts were developed for: 1980, 1990, and 2000; voice, data and video services; terrestrial and satellite delivery modes; and C, Ku and Ka-bands.


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# SECTION 1
# INTRODUCTION

## 1.1 BACKGROUND

In 1979 Western Union published the results of a NASA-sponsored study entitled "18/30 GHz Fixed Communications System Service Demand Assessment." That study was done as part of a broader communications program to define the telecommunications needs of the U.S. to the year 2000, to determine how space communication systems would best address these telecommunication needs, and to define where advanced technologies would be required. During the interim three years, significant changes have occurred in the satellite communications industry, (e.g., service mixes and service offerings have changed) that led to the need for an updated set of forecasts. Consequently, the present demand assessment study was commissioned. This study represents a fresh look at the demand for voice, data and video services to the year 2000. Forecasts were developed for the total telecommunications traffic demand of the U.S., that portion generated by the 313 Standard Metropolitan Statistical Areas, and that portion that could be potentially transmitted by satellite. In addition, that portion of the potential satellite traffic that could be captured by Ka-band systems was estimated. The final results are presented in terms of equivalent 36 MHz transponders for the satellite candidate traffic, the estimated geostationary arc capacity of the C- and Ku-bands, and an estimate of the actual C- and Ku-band transponders likely to be available over the timeframe of interest.

## 1.2 PURPOSE AND OBJECTIVES

The overall purpose of this study was:

> To forecast the potential United States domestic telecommunications demand for satellite provided fixed communications voice, data and video services through the year 2000, so that this information on service demand would be available to aid in NASA communications program planning.

To accomplish this purpose the following objectives were achieved:

a. Development of a forecast of the total domestic telecommunications demand

b. Identification of that portion of the total demand suitable for transmission by satellite provided fixed communications systems

c. Estimation of the actual amount of traffic that could be captured by Ka-band systems.

## SECTION 2
## APPROACH

Six major tasks were conducted to accomplish the overall purpose and objectives of this study. These tasks, which were grouped under the two headings of "Demand Forecasts for Telecommunications Services for the Period 1980-2000" and the "Ka-band Net Accessible Market," were:

- Task 1.0 - Demand Forecasts for Telecommunications Services for the Period 1980-2000.
  - Task 1.1 - Telecommunications Service Demand
  - Task 1.2 - Net Addressable Forecasts
  - Task 1.3 - Capacity Requirements
  - Task 1.4 - Satellite System Market Development
- Task 2.0 - Ka-band Net Accessible Forecasts
  - Task 2.1 - Specialized Carrier Ka-band Net Accessible Forecasts
  - Task 2.2 - Established Carrier Ka-band Net Accessible Forecasts

The purpose and activities for each of the six major tasks are briefly described. The overall approach and activity flow for the study are depicted in Figure 2-1. Throughout all of the study tasks and activities, consideration was given to technological, economic and political-social events and trends. Telecommunications literature, and user and provider information were continually obtained and reviewed.

### 2.1 TASK 1.1 - TELECOMMUNICATIONS SERVICE DEMAND

The purpose of this task was to forecast the telecommunications services demand for voice, data and video services for the years 1980, 1990 and 2000. Potential satellite-provided fixed communications services were identified and characterized, and baseline, impacted baseline and net long haul forecasts were developed. To describe potential services, market studies and the telecommunications literature were reviewed, input was collected from users and

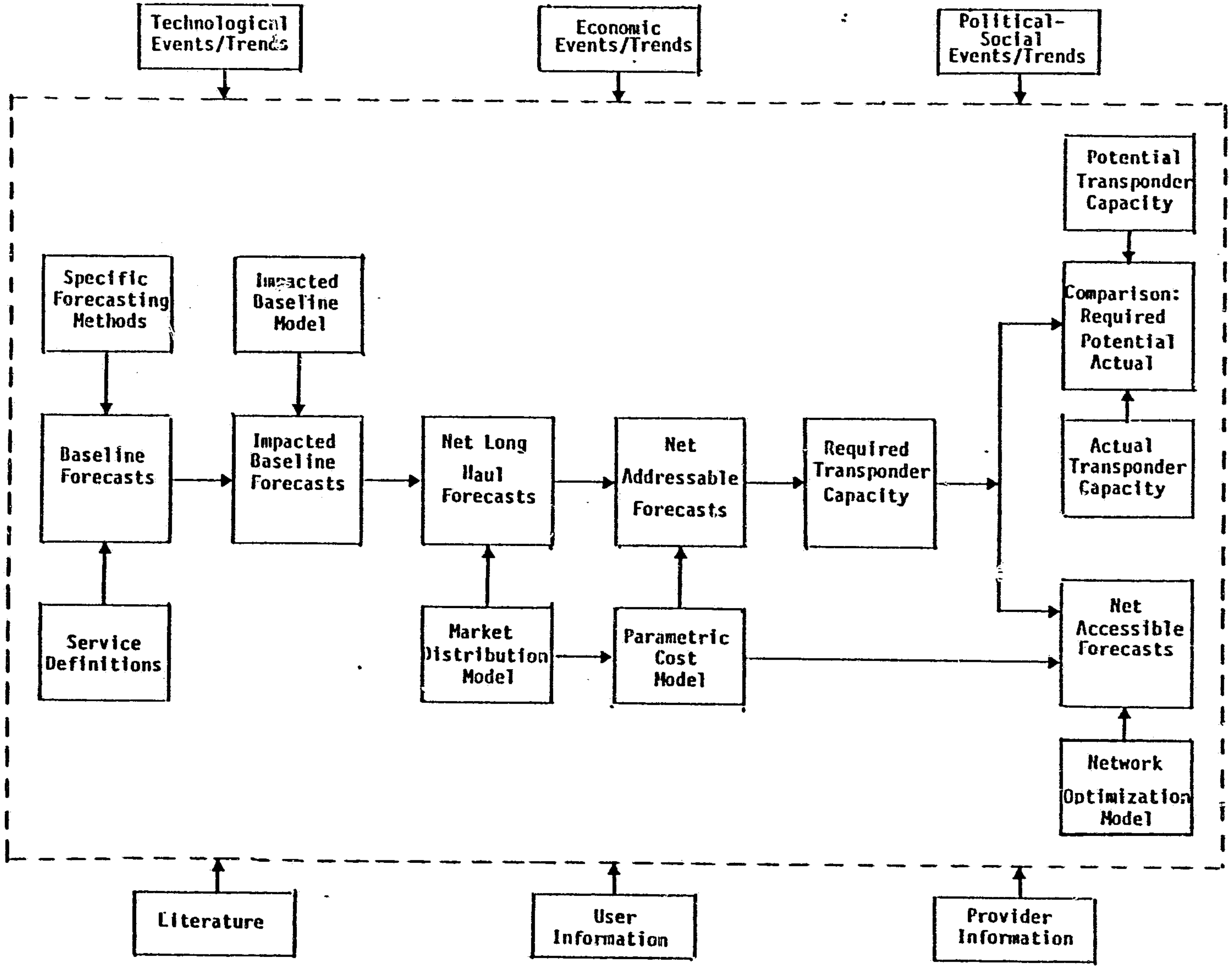


FIGURE 2-1. OVERALL ACTIVITY FLOW FOR THE STUDY

providers, lists of potential services were developed and a final list of services was defined and characterized. To develop the baseline forecasts, which were estimates of the current and future volumes of traffic and which reflected the occurrence of expected events and orderly growth, a specific forecasting methodology was identified and used to forecast each service. The baseline forecasts were then modified by considering the impact of events less predictable than those already considered; this modification, which required the development and use of a trend-cross-impact model, resulted in the impacted baseline forecasts. Next, a market distribution model was developed, traffic which was not considered long haul (i.e., long distance traffic, such as message toll) was removed, data efficiency factors were considered and traffic estimates were converted to peak hour estimates; the product from these activities was the net long haul forecast.

## 2.2 NET ADDRESSABLE FORECAST

The purpose of this task was to determine the net addressable traffic or that portion of the net long haul market that could be served by satellites considering pertinent technical, institutional and cost factors. Some traffic was removed from the net long haul forecasts, a detailed cost analysis was conducted, and addressable and net addressable forecasts were developed. First, traffic not suitable for satellite transmission, due to technical and usage factors, was removed. Then, current and projected service costs to users of various delivery systems were developed. Space segments, earth stations and terrestrial links were defined and costed, future trends were considered, and end-to-end user costs were developed for 1982, 1990 and 2000. Then, these costs were compared and the satellite service cost crossover distances with terrestrial tariffs were calculated for the same benchmark years. Next, traffic corresponding to distances less than the crossover distance was removed to determine the satellite addressable traffic for C, Ku-and Ka-bands. The maximum satellite addressable traffic was developed by selecting the highest forecast for each service for each year across the three bands. Then high, expected and low estimates of the maximum net addressable traffic were developed by removing high, expected and low estimates of the amount of traffic that should be removed due to plant-in-place (existing transmission facilities that will not be phased out immediately for economic reasons).

## 2.3 CAPACITY REQUIREMENTS

The purpose of this task was to convert the net addressable forecasts from peak hour half voice circuits (voice), Mbps (data), and transponders (video) to equivalent 36 MHz transponders. This conversion enabled a comparison to be made among required capacity (i.e., the capacity equivalent, in 36 MHz transponders, of the satellite net addressable traffic), potential capacity (i.e., the possible capacity, in equivalent 36 MHz transponders, of the geostationary arc for C-plus Ku-bands) and actual capacity (i.e., the number of equivalent 36 MHz transponders expected to be provided). In making these conversions, the following technological changes were considered: percent of voice on analog, frequency/amplitude modulation improvements, coding technique improvements, and digital modulation improvements. Based on assumptions concerning these changes, high, expected and low estimates of the maximum net addressable and estimates of the net addressable by frequency band were developed in units of 36 MHz transponders. The conversion process resulted in the capacity equivalent (in 36 MHz transponders) of the satellite net addressable traffic or the capacity that would be required if all of this traffic were carried by satellite systems.

## 2.4 SATELLITE SYSTEM MARKET DEVELOPMENT

The purpose of this task was to compare required, potential and actual capacities so that estimates of when Ka-band will be needed could be made. First, the potential capacity, or the capacity expected to be possible, and the actual capacity, or the capacity expected to be available or provided, were developed. To develop the potential capacity forecasts, the following factors were considered: spacing (C- and Ku-bands), frequency reuse (Ku-band); and fill percentage (C- and Ku-transponders). In developing the actual capacity forecasts, these factors were considered: fill percentage (C- and Ku-transponders) and growth beyond scheduled satellite systems. Based on assumptions concerning these factors, high, expected and low estimates of potential capacity and actual capacity were developed. Then, required, potential and actual capacity forecasts (in equivalent 36 MHz transponders) were compared to determine when Ka-band would be needed.

## 2.5 SPECIALIZED CARRIER KA-BAND NET ACCESSIBLE FORECASTS

The purpose of this task was to develop the specialized carrier net accessible Ka-band market (i.e., that portion of the net addressable Ka-band traffic likely to be implemented on a Ka-band system) for the minimum network (defined as 30 percent of the market), maximum network (i.e., the largest network possible considering economic trade-offs) and most efficient network (i.e., the largest network economically justified within a competitive environment). The specialized carrier was defined, hubbing distances (i.e., the terrestrial-satellite crossover distances) were established and the Ka-band required capacity was determined. A network optimization model was developed and minimum, maximum, and most efficient network scenarios were developed.

## 2.6 ESTABLISHED CARRIER KA-BAND NET ACCESSIBLE FORECASTS

The purpose of this task was to develop the established carrier net accessible Ka-band market for 10 and 20 earth station networks. The established carrier was defined, hubbing distances were established, the Ka-band required capacity was determined, a network optimization model was developed and scenarios were developed for 10 and 20 earth station networks.

# SECTION 3
# RESULTS

The study results are described briefly by highlighting the major findings for each of the six study tasks.

## 3.1 TELECOMMUNICATIONS SERVICE DEMAND

The results of this task include the characterization of the potential satellite-provided fixed communications services and the baseline, impacted baseline and net long haul forecasts.

### 3.1.1 Potential Satellite-Provided Fixed Communication Services

The potential satellite-provided fixed communications services are listed in Table 3-1. Thirty-four unique services were identified and grouped under the major categories of voice, data and video. Subgroups, for example, broadcast and limited broadcast for the video category, were developed to facilitate selection and use of forecasting methods. While 34 services were described, forecasts were prepared for only 31 of these services; voice store-and-forward, DBS (Direct Broadcast Satellite) and HDTV (high definition television) were treated as market determinant factors when developing the impacted baseline forecasts.

### 3.1.2 Baseline Forecasts

Baseline forecasts are estimates of the current and future volumes of traffic and reflect the occurrence of expected events and orderly growth. These forecasts were developed for 31 voice, data and video services for the year 1980 through 2000. In Table 3-2 the voice, data and video baseline forecasts are indicated, respectively, in thousands of half voice circuits, terabits per year ($10^{12}$ bits per year), and transponders. The baseline growth rates in Table 3-3 show that data traffic will be growing the fastest and at about 14 percent per year from 1980 to 2000 and that voice and video will each be growing at slightly less than 10 percent per year.

## TABLE 3-1. POTENTIAL FIXED COMMUNICATIONS SERVICES

| | GROUPING | SERVICE |
|---|---|---|
| VOICE | Message Toll Service | Residential<br>Business |
| | Other Telephone | Private Line<br>Mobile Radio<br>*Voice Store-and-Forward |
| | Radio | Public<br>Commercial and Religious<br>Occasional<br>CATV Music<br>Recording Channel |
| DATA | Terminal Operations | Data Transfer<br>Batch Processing<br>Data Entry<br>Remote Job Entry<br>Inquiry Response<br>Timesharing |
| | Electronic Mail | USPS EMSS<br>Mailbox Services<br>Administrative Message Traffic<br>Facsimile<br>Communicating Word Processors |
| | Record Services | TWX/Telex<br>Mailgram/Telegram/Money Order |
| | Other Terminal Services | Point of Sale<br>Videotex/Teletext<br>Telemonitoring<br>Secure Voice |
| VIDEO | Broadcast | Network Video<br>CATV Video<br>Occasional Video<br>Recording Channel |
| | Limited Broadcast | Teleconferencing<br>*DBS<br>*HDTV |

*Forecasts were not prepared for those services which were considered as market determinant factors.

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## TABLE 3-2. SUMMARY OF FORECASTS

| FORECAST | YEAR 1980 | 1990 | 2000 |
|---|---|---|---|
| **Baseline** | | | |
| Voice (1000s HVCs) | 2,829 | 8,045 | 18,405 |
| Data (Terabits/Year) | 1,892 | 9,084 | 26,879 |
| Video (Transponders) | 66 | 309 | 312 |
| **Impacted Baseline** | | | |
| Voice (1000s HVCs) | 2,829 | 8,227 | 19,876 |
| Data (Terabits/Year) | 1,892 | 9,840 | 31,103 |
| Video (Transponders) | 66 | 337 | 406 |
| **Net Long Haul** | | | |
| Voice (1000s HVCs) | 2,057 | 6,220 | 15,220 |
| Data (Mbps) | 12,045 | 24,873 | 32,117 |
| Video (Transponders) | 61 | 323 | 393 |
| **Net Addressable-Maximum** | | | |
| High | | | |
| Voice (1000s HVCs) | 227 | 1,902 | 9,036 |
| Data (Mbps) | 674 | 10,624 | 23,300 |
| Video (Transponders) | 61 | 323 | 393 |
| Expected | | | |
| Voice (1000s HVCs) | 227 | 1,724 | 7,800 |
| Data (Mbps) | 674 | 9,755 | 21,860 |
| Video (Transponders) | 61 | 323 | 393 |
| Low | | | |
| Voice (1000s HVCs) | 227 | 1,594 | 6,564 |
| Data (Mbps) | 674 | 8,886 | 20,420 |
| Video (Transponders) | 61 | 323 | 393 |
| **Required Capacity (Transponders)** | | | |
| High | | | |
| Voice | 189 | 782 | 2,280 |
| Data | 13 | 131 | 288 |
| Video | 61 | 323 | 393 |
| Total | 263 | 1,236 | 2,961 |
| Expected | | | |
| Voice | 189 | 601 | 1,806 |
| Data | 13 | 120 | 270 |
| Video | 61 | 323 | 393 |
| Total | 263 | 1,044 | 2,469 |
| Low | | | |
| Voice | 189 | 490 | 1,428 |
| Data | 13 | 110 | 252 |
| Video | 61 | 323 | 393 |
| Total | 263 | 923 | 2,073 |

## TABLE 3-2. SUMMARY OF FORECASTS (CONTINUED)

| | 1980 | 1990 | 2000 |
|---|---|---|---|
| Potential C + Ku Capacity (Transponders) | | | |
| High | 681 | 1,282 | 1,455 |
| Expected | 605 | 960 | 1,140* |
| Low | 529 | 756 | 840* |
| Actual C + Ku Capacity (Transponders) | | | |
| High | 140 | 921 | 1,455 |
| Expected | 125 | 818 | 1,293* |
| Low | 109 | 716 | 1,131* |

*See Paragraph 3.4 for an explanation of why actual is greater than potential capacity.

## TABLE 3-3. SUMMARY OF GROWTH RATES (%)

| FORECAST | TIME PERIOD 1980-1990 | 1990-2000 | 1980-2000 |
|---|---|---|---|
| Baseline | | | |
| Voice | 11.0 | 8.6 | 9.8 |
| Data | 17.0 | 11.5 | 14.2 |
| Video | 16.7 | .1 | 8.1 |
| Impacted Baseline | | | |
| Voice | 11.3 | 9.2 | 10.2 |
| Data | 17.9 | 12.2 | 15.0 |
| Video | 17.7 | 1.9 | 9.5 |
| Net Long Haul | | | |
| Voice | 11.7 | 9.4 | 10.5 |
| Data | 7.5 | 2.6 | 5.0 |
| Video | 18.1 | 2.0 | 9.7 |
| Net Addressable-Maximum | | | |
| High | | | |
| Voice | 23.7 | 16.9 | 20.2 |
| Data | 31.8 | 8.2 | 19.4 |
| Video | 18.1 | 2.0 | 9.7 |
| Expected | | | |
| Voice | 22.5 | 16.3 | 19.3 |
| Data | 30.6 | 8.4 | 19.0 |
| Video | 18.1 | 2.0 | 9.7 |
| Low | | | |
| Voice | 21.5 | 15.2 | 18.3 |
| Data | 29.4 | 8.7 | 18.6 |
| Video | 18.1 | 2.0 | 9.7 |
| Required Capacity | | | |
| High | | | |
| Voice | 15.3 | 11.3 | 13.3 |
| Data | 23.0 | 8.2 | 16.8 |
| Video | 18.1 | 2.0 | 9.7 |
| Total | 16.7 | 9.1 | 12.9 |
| Expected | | | |
| Voice | 12.3 | 11.6 | 11.9 |
| Data | 24.9 | 8.4 | 16.8 |
| Video | 18.1 | 2.0 | 9.7 |
| Total | 14.8 | 9.0 | 11.8 |
| Low | | | |
| Voice | 10.0 | 11.3 | 10.6 |
| Data | 23.8 | 8.6 | 16.0 |
| Video | 18.1 | 2.0 | 9.7 |
| Total | 13.4 | 8.4 | 10.9 |

## TABLE 3-3. SUMMARY OF GROWTH RATES (%) (CONTINUED)

| | 1980-1990 | 1990-2000 | 1980-2000 |
|---|---|---|---|
| Potential C + Ku Capacity | | | |
| High | 6.5 | 1.3 | 3.9 |
| Expected | 4.7 | 1.7 | 3.2 |
| Low | 3.6 | 1.1 | 2.3 |
| Actual C + Ku Capacity | | | |
| High | 20.7 | 4.7 | 12.4 |
| Expected | 20.7 | 4.7 | 12.4 |
| Low | 20.7 | 4.7 | 12.4 |

### 3.1.3 Impacted Baseline Forecasts

The impacted baseline forecasts were developed by considering the impact of less predictable events or market determinant factors on the baseline forecasts. As shown in Table 3-4, leaders in the telecommunications industry estimated that half of the events considered in the study would very likely occur by 1995, and all but one, biochips, would very likely occur by 2005. The expected impact of these events is indicated in Table 3-2 where the voice, data and video impacted baseline forecasts are again presented, respectively, in thousands of half voice circuits, terabits per year, and transponders. The impact varied from -1.5 percent to 27 percent across services. As shown in Table 3-3, the growth rates for the impacted baseline were very similar to those for the baseline.

### 3.1.4 Net Long Haul Forecasts

The net long haul forecasts were developed by removing several traffic elements from the impacted baseline forecasts, considering data efficiency factors, and converting traffic estimates to peak hour estimates. The net long haul forecasts are presented in Table 3-2 where voice, data and video forecasts are indicated, respectively, in thousands of half voice circuits, megabits per second (Mbps) and transponders. As shown in Table 3-3, the growth rates for the voice and video net long haul forecasts are about 10 percent per year from 1980 to 2000, while the growth rate for data for the same period is only about five percent.

## 3.2 NET ADDRESSABLE FORECASTS

The net addressable forecasts represent the amount of traffic addressable by a fixed communications services system considering pertinent technical, institutional and cost factors. The major outputs of this task are the results of comprehensive cost analysis and the addressable and net addressable forecasts.

### 3.2.1 Cost Analysis Results

The key findings from the cost analyses are presented in Tables 3-5 through 3-7. These tables include summary information taken from the over 50 tables and

## TABLE 3-4. MARKET DETERMINANT FACTORS THAT ARE VERY LIKELY TO OCCUR BY 1995 AND 2005.

| | MARKET DETERMINANT FACTORS (MDFs) | VERY CERTAIN OR 100% CHANCE OF OCCURRING BY: 1995 | 2005 |
|---|---|---|---|
| 1 | TOUCH INPUT DEVICES | X | |
| 2 | SMART CARDS | X | |
| 3 | VOICE RECOGNITION | | X |
| 4 | HAND HELD TERMINALS | X | |
| 5 | NON-IMPACT PRINTING | | X |
| 6 | FLAT OUTPUT PANELS | | X |
| 7 | MICROPROCESSOR IMPROVEMENT | X | |
| 8 | MICROMEMORIES IMPROVEMENT | X | |
| 9 | BIOCHIPS | | |
| 10 | FIFTH GENERATION COMPUTERS | | X |
| 11 | ARTIF. INTEL. EXP. MACHINES | | X |
| 12 | SELF-PROGRAMMING COMPUTERS | | X |
| 13 | UNIVERSAL PROGRAMMING LANGUAGE | | X |
| 14 | TERMINAL/COMPUTER COMPATIBILITY | X | |
| 15 | STANDARDIZATION OF SOFTWARE | | X |
| 16 | DIRECT BROADCAST SERVICE | X | |
| 17 | HIGH DEFINITION TELEVISION | X | |
| 18 | VOICE STORE AND FORWARD | X | |
| 19 | WRIST RADIO | | X |
| 20 | ANTENNA MATERIAL IMPROVEMENT | X | |
| 21 | SATELLITE MATERIAL IMPROVEMENT | | X |
| 22 | FIBER OPTICS | X | |
| 23 | GEO-STATIONARY PLATFORM | | X |
| 24 | PROSPERITY | X | |
| 25 | RECESSION/DEPRESSION | X | |
| 26 | COMMUNICATIONS BUSINESS SHAKEDOWN | X | |
| 27 | RESOURCES - CRITICAL NEED | X | |
| 28 | GLOBAL ECONOMY | | X |
| 29 | INDUSTRIES IN SPACE | | X |
| 30 | DOMESTIC INTERNATIONAL SATELLITE | | X |
| 31 | LIMITED WARS | X | |
| 32 | ORBIT SHARE CONFLICT | X | |
| 33 | ACCEPTANCE OF TECHNOLOGY | X | |
| 34 | WORK AT HOME | | X |
| 35 | SATELLITE IMPORTATION OF WORKERS | | X |
| 36 | SELF-HELP | | X |

figures included in the cost analyses sections of the Main Text and Appendices. The key assumptions that were made are discussed in the Main Text.

The current and projected earth station costs, in thousands of 1982 dollars, are presented in Table 3-5. Costs are presented by frequency band, approach (i.e., TDMA or FDMA), capacity, and year. Presently, for both C- and Ku-bands, an earth station using a TDM/TDMA terminal is the more costly. For the year 2000, for both C- and Ku-bands, the TDM/TDMA earth station is less costly than the FDM/FDMA earth station. This is due to the fact that the technology for digital processing is progressing at a faster rate and a TDM/TDMA terminal uses digital technology. The cost of a Ka-band earth station is much higher than the cost of a C- or Ku-band earth station. The reason is that the Ka-band earth station is much larger in terms of the burst rate it can support.

The current satellite investment costs, in millions of 1982 dollars, are indicated in Table 3-6. Costs are noted by element by frequency band; elements include development, satellite recurring, launch, insurance, TT&C and ground spare costs. The cost of C-band satellites are expected to stay at the same level as they are today since these satellites have been used for over a decade and technology seems to have matured. Since the Ku-band technology is not mature, the cost of a Ku-band satellite is expected to decline at a rate of 3.5% per year until the year 2000. For Ka-band, it is expected that the satellite cost in year 2000 will remain the same as in year 1990 (i.e., the costs indicated for Ka-band in Table 3-6).

Using estimates of the earth station and satellite costs and Western Union's financial packages, payoff requirements and crossover distances were developed for C, Ku- and Ka-bands by year and by operating speed. These service cost crossover distances (based on a comparison of terrestrial and satellite systems) are presented in Table 3-7. The crossover distances for Ka-band 1982 are not presented since domestic Ka-band satellite systems are not in existence. The first experimental Ka-band system is being planned for near the end of this decade. In 1982 the C-band crossover is lower than the Ku-band crossover for all operating speeds. In 1990 the ranking of the crossover distances across bands is variable across operating speed; no one band is expected to have the lowest or

**TABLE 3-5. CURRENT AND PROJECTED EARTH STATION COSTS INCLUDING TRANSPONDER HOPPING*****

**(Thousands of 1982 Dollars)**

| BAND | APPROACH | CAPACITY | YEAR 1982 | 1990 | 2000 |
|---|---|---|---|---|---|
| C | TDM/TDMA | 60 Mbps | 1746 | 1002 | 628 |
| | FDM/FDMA | 1200 VF Channels | 1219 | 927 | 638 |
| Ku | TDM/TDMA | 60 Mbps | 1868 | 841 | 549 |
| | FDM/FDMA | 1500 VF Channels | 1111 | 843 | 579 |
| Ka | TDMA* | 512 Mbps | -- | 4905 | 3803 |
| | TDMA** | 512 Mbps | -- | 2836 | 1831 |

*Dollar estimates provided by NASA
**Dollar estimates developed by Western Union

***Transponder hopping refers to the capability of accessing more than one transponder when necessary.

## TABLE 3-6. INVESTMENT COST OF C-, KU- AND KA-BAND SATELLITES*
(in millions of dollars)

| | BAND | | |
|---|---|---|---|
| COST ELEMENTS | C | Ku | Ka |
| Development (NR) | 0 | 34 | 160 |
| 2 x (R + L + IN) | 156 | 164 | -- |
| 1 x (R + L + IN) | -- | -- | 109 |
| 1 x R | 30 | 36 | 45 |
| TT + C | 15 | 15 | 40 |
| TOTAL | 201 | 249 | 354 |

R = Satellite Recurring Cost
L = Launch Cost
IN = Insurance Cost

*Costs for C- and Ku-bands are current 1982 costs, while those for Ka-band are estimated costs for 1990 when the first Ka-band system is expected to be operational.

TABLE 3-7. BREAKEVEN DISTANCE IN MILES FOR TRUNKING NETWORKS

| YEAR | BAND AND APPROACH | OPERATING SPEEDS 2.4 | 4.8 | 9.6 | 56 | T1 | SCHEDULE 1 | VF SCHEDULE 2 | SCHEDULE 3 |
|---|---|---|---|---|---|---|---|---|---|
| 1982 | C-BAND | 95 | 158 | 307 | 112 | 92 | 566 | 479 | 395 |
| | KU-BAND | 380 | 410 | 469 | 204 | 158 | 778 | 691 | 600 |
| | KA-BAND | --- | --- | --- | --- | --- | --- | --- | --- |
| 1990 | C-BAND | 94 | 142 | 291 | 98 | 62 | 449 | 335 | 235 |
| | KU-BAND | 117 | 134 | 170 | 104 | 74 | 485 | 371 | 270 |
| | KA-BAND | 112 | 124 | 155 | 102 | 75 | 480 | 366 | 265 |
| | KA-BAND | 110 | 121 | 149 | 98 | 64 | 436 | 322 | 222 |
| 2000 | C-BAND | 94 | 131 | 277 | 90 | 61 | 489 | 367 | 249 |
| | KU-BAND | 71 | 76 | 87 | 74 | 21 | 230 | 117 | 70 |
| | KA-AND | 72 | 83 | 104 | 96 | 76 | 462 | 340 | 233 |
| | KA-BAND | 71 | 81 | 100 | 91 | 65 | 417 | 295 | 189 |

highest crossover distance. In 2000, it is expected that Ku-band will have the lowest crossover distance, with the crossovers for C- and Ka-bands being similar.

### 3.2.2 Addressable Forecasts

The crossover distances were used to develop the addressable and maximum addressable forecasts. High, expected and low estimates of the maximum net addressable were developed based on the estimates of the amount of traffic removed, due to plant-in-place, from the maximum addressable forecasts. These estimates are presented in Table 3-2 and the corresponding growth rates appear in Table 3-3.

Forecasts for voice, data and video, respectively, are in thousands of half-voice circuits, megabits per second and transponders. As indicated in Table 3-3, the growth rates for voice and data are expected to be about twice that for video for the 1980 to 2000 time period.

## 3.3 CAPACITY REQUIREMENTS

The specification of capacity requirements involved the conversion of the maximum net addressable forecasts from peak hour half voice circuits (voice), Mbps (data) and transponders (video) to equivalent transponders. The results of this conversion process are indicated in Tables 3-2 and 3-3 and Figure 3-1. The high, expected and low forecasts reflect variations in the assumptions concerning technological changes as well as differences in the high, expected and low maximum net addressable forecast. As shown in Table 3-2 the estimates, in equivalent transponders, for the year 2000 vary from about 2000 to about 3000 transponders with voice requiring a majority of the capacity and video requiring slightly more capacity than data. The growth rates for these capacity requirements are listed in Table 3-3 and are diagramed in Figure 3-1. For the 1980 to 2000 time period, data required capacity is expected to grow about 17 percent per year, while voice and video will grow at about 10 percent per year.

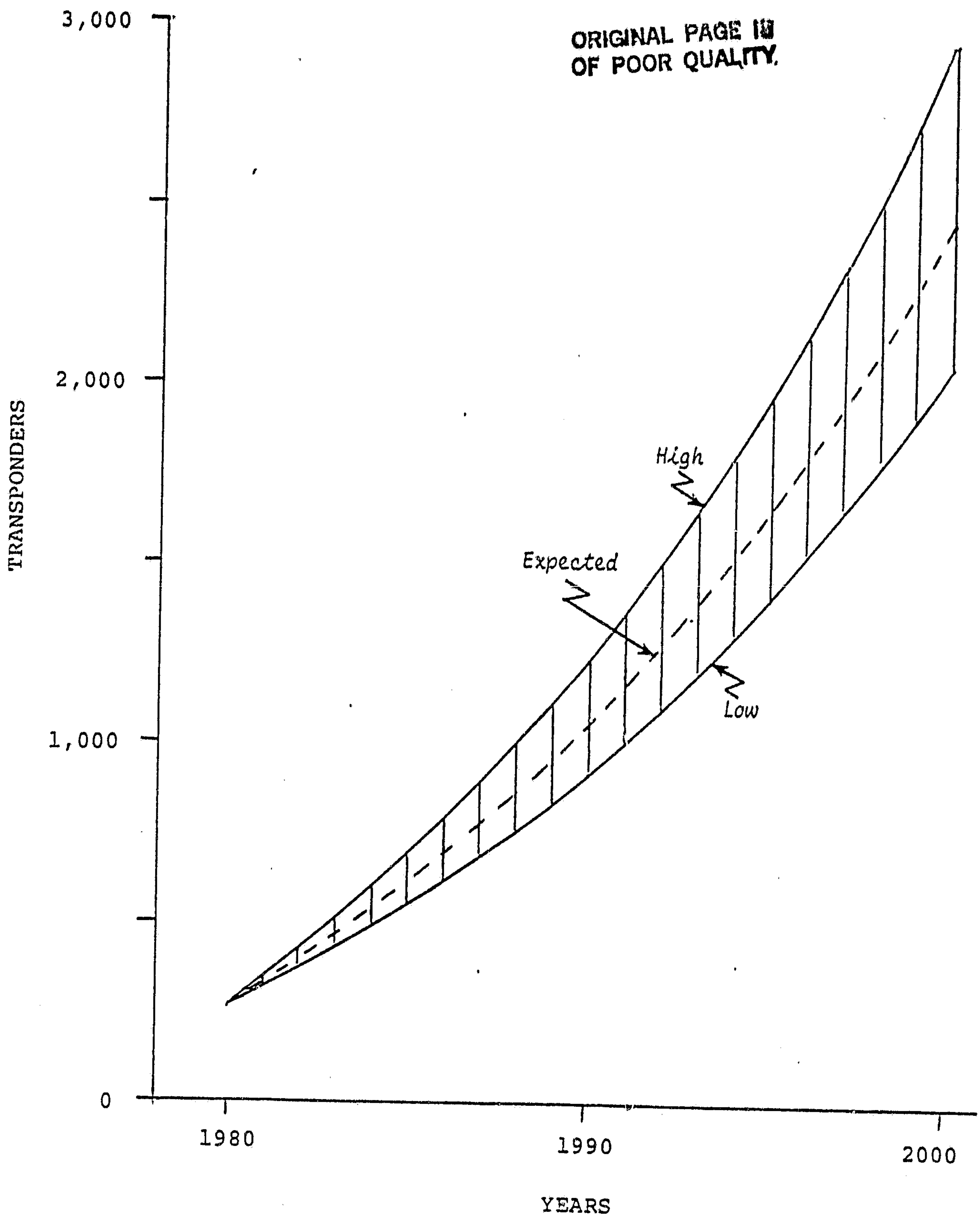


FIGURE 3-1. HIGH, EXPECTED AND LOW ESTIMATES OF REQUIRED CAPACITY

## 3.4 SATELLITE SYSTEM MARKET DEVELOPMENT

In this task the potential and actual C- plus Ku-band capacities were developed and compared with the required capacity to determine when Ka-band would be needed. The results of this task are presented in Tables 3-2, 3-3, 3-8 and 3-9 and Figures 3-2, 3-3 and 3-4. As shown in Table 3-2 potential and actual C- plus Ku-band capacity estimates vary from about 850 to 1450 transponders in the year 2000. The growth rates for actual capacity are around 12 percent, or very similar to those for required capacity and much larger than those for potential capacity. Figures 3-2 and 3-3 depict the growth rates for potential and actual capacities. The expected and low estimates of the actual forecast are higher than the expected and low estimates of the potential forecast in the year 2000 because only one growth rate was used for projecting the actual forecast; the differences among the high, expected and low estimates of the actual forecast were determined solely by the fill factor. In reality, the actual capacity would always be less than or equal to the potential capacity.

Table 3-8 summarizes the factors considered in developing the high, expected and low estimates of the required, potential and actual capacities, and Table 3-9 summarizes these estimates. These estimates are presented in Figure 3-4 and two possible scenarios, based on the following assumptions, are indicated:

a. Assuming expected-required and expected-potential capacities with actual equaling potential, Ka-band will be needed around 1990.

b. Assuming low required and high potential capacities with actual equaling potential, Ka-band will be needed around 1995.

The following are the major areas of uncertainty where sensitivity analyses could be conducted to determine the impact on the forecasts.

Economic Factors

a. National - International economic conditions (reflected in impacted baseline forecasts)

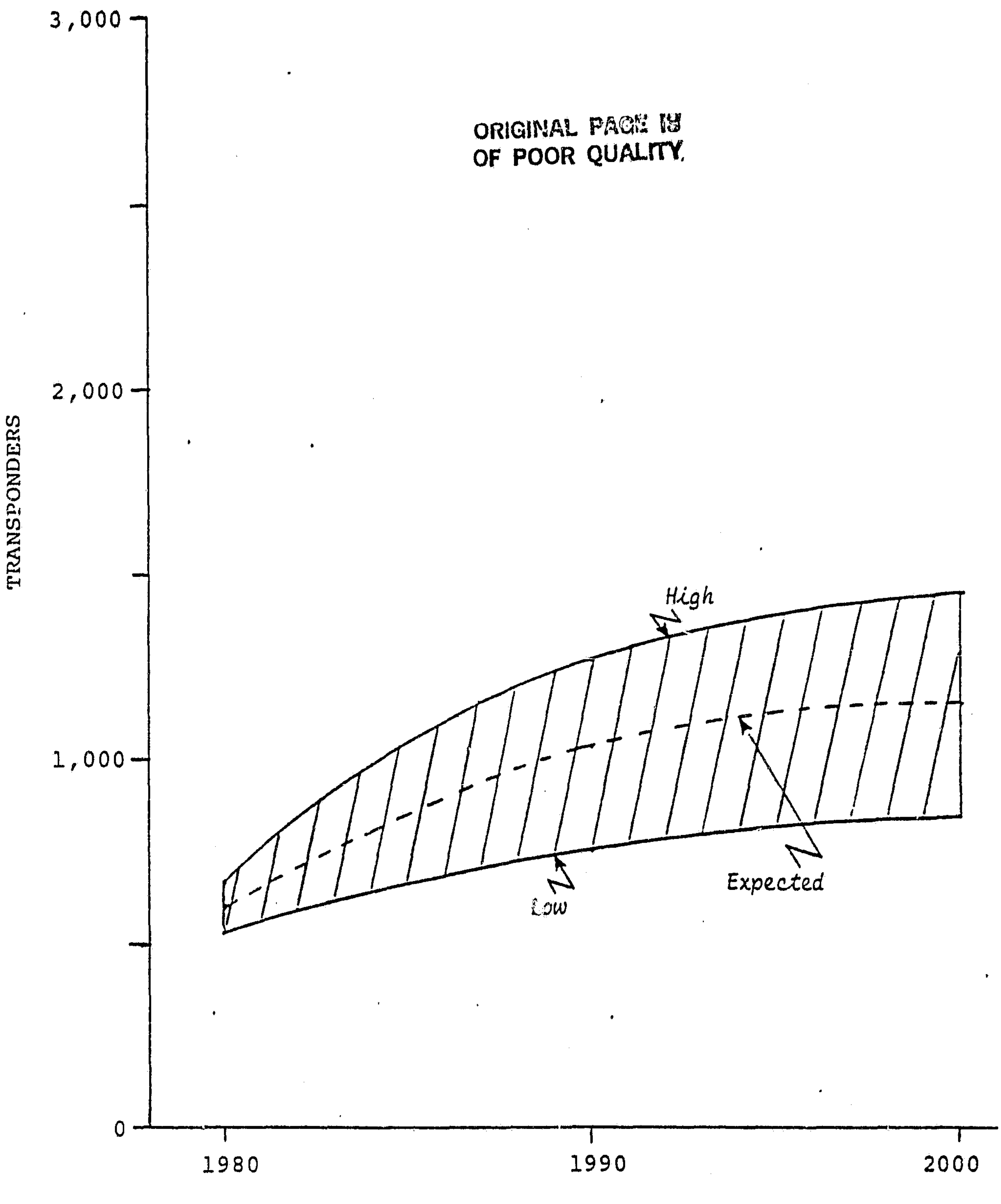


FIGURE 3-2. HIGH, EXPECTED AND LOW ESTIMATES OF POTENTIAL C- PLUS KU-BAND CAPACITY

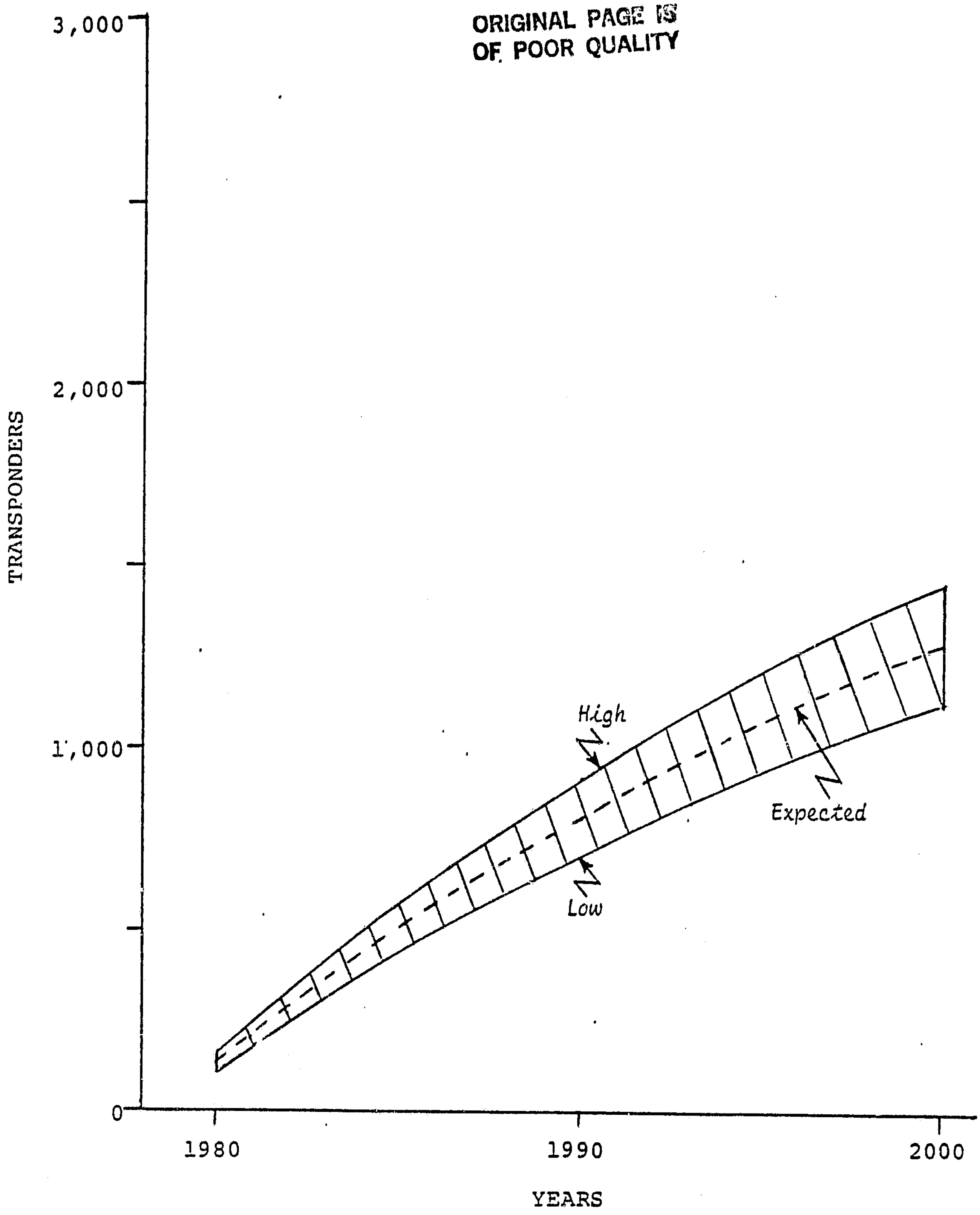



FIGURE 3-3. HIGH, EXPECTED AND LOW ESTIMATES
OF ACTUAL C- PLUS KU-BAND CAPACITY

**TABLE 3-8. SUMMARY OF FACTORS, VARIED AND HELD CONSTANT, IN DEVELOPING HIGH, EXPECTED AND LOW ESTIMATES OF REQUIRED, POTENTIAL AND ACTUAL CAPACITIES**

| FACTORS | CAPACITIES | | |
|---|---|---|---|
| | Required | Potential | Actual |
| Factors that varied | 1. Percent removed - common carrier consideration<br>2. Analog modulation techniques, #HVC/Transponders | 1. Spacing<br>2. Fill Factor | 1. Fill Factor |
| Factors Held Constant | 1. Analog coding techniques, #kbps/HVC<br>2. Digital Modulation techniques, #Mbps/Transponders<br>3. Percent voice on analog and digital | 1. Reuse | 1. Growth beyond schedules |

**TABLE 3-9. SUMMARY OF REQUIRED, POTENTIAL AND ACTUAL CAPACITIES (36 MHz Transponders)**

| | YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1980 | | | 1990 | | | 2000 | | |
| Capacity | High | Expected | Low | High | Expected | Low | High | Expected | Low |
| Required | 263 | 263 | 263 | 1236 | 1045 | 922 | 2960 | 2468 | 2073 |
| Potential | 681 | 605 | 529 | 1282 | 960 | 756 | 1455 | 1140* | 840* |
| Actual | 140 | 125 | 109 | 921 | 818 | 716 | 1455 | 1293* | 1131* |

*See Paragraph 3.4 for an explanation of why actual is greater than potential capacity.

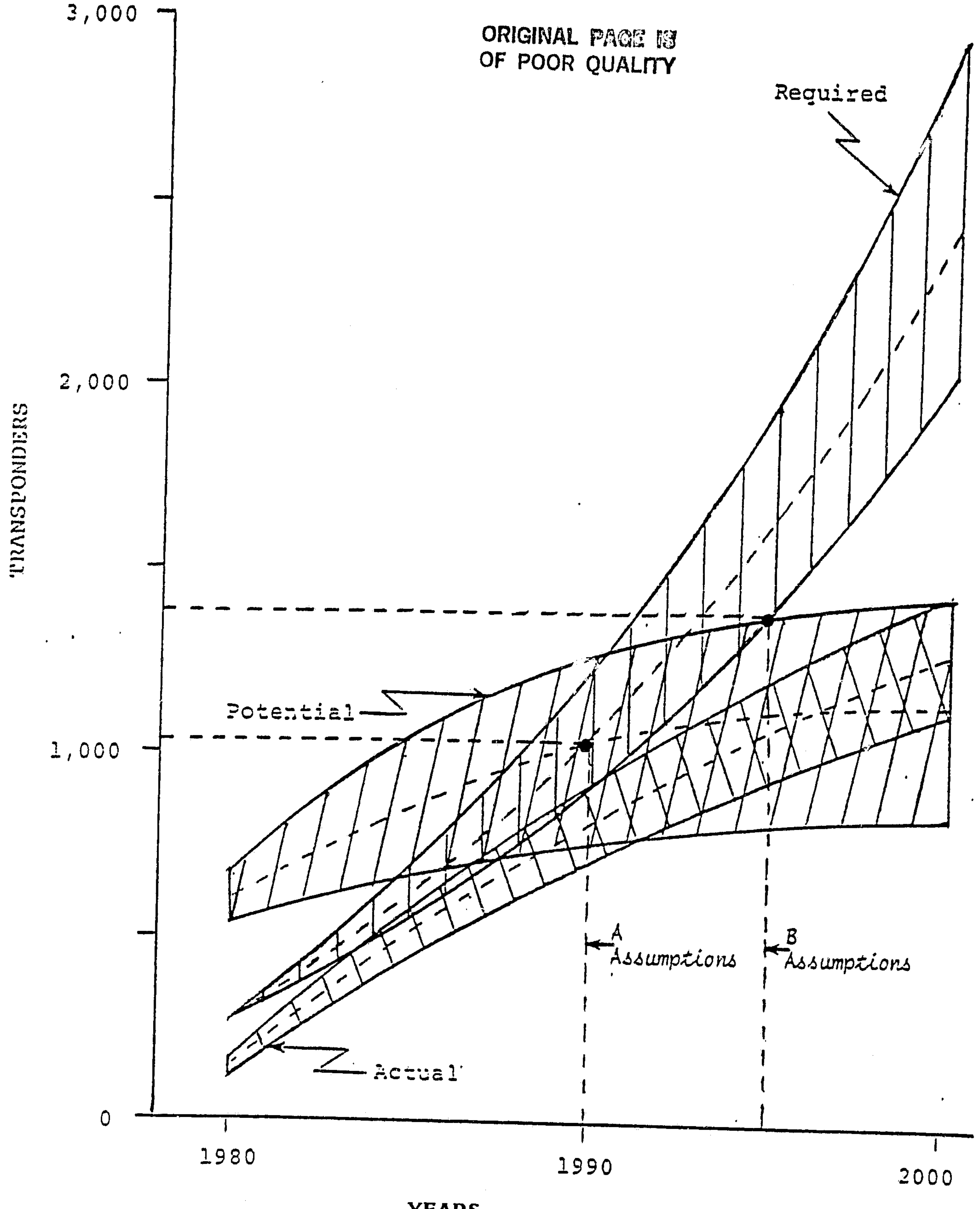


FIGURE 3-4. TWO SCENARIOS FOR SATURATION OF C- AND KU-BANDS

b. Relative costs of satellite and terrestrial systems (reflected in net addressable forecasts)

c. Provider requirements - Satellite/terrestrial differential, fill percentage (reflected in potential and actual capacity forecasts).

Technological Factors

a. Modulation and coding improvements: Number of half-voice circuits/36 MHz transponders, #Mbps/36 MHz transponders, #Kbps/HVC (reflected in required capacity forecasts)

b. Spacing and frequency reuse (reflected in potential capacity forecasts)

c. Creative integration of technological improvements (reflected in impacted baseline forecasts).

## 3.5 SPECIALIZED CARRIER KA-BAND NET ACCESSIBLE FORECASTS

The specialized carrier Ka-band net accessible forecasts are those portions of the Ka-band traffic likely to be implemented on a Ka-band specialized carrier system. In developing these forecasts the starting point was the Ka-band required capacity which was the difference between the low estimate of the maximum net addressable (i.e., 2073 transponders) and the high estimate of the potential (C- and Ku-band) capacity (i.e., 1455 transponders). Using this required capacity (i.e., 618 transponders) and a network optimization model, specialized carrier network scenarios were developed for the minimum, maximum and most efficient networks.

A summary of the specialized carrier network is given in Table 3-10. This table shows that 100 earth stations with 203 subordinate standard metropolitan statistical areas (SMSAs) are enough to cover the entire Ka-band addressable market. This printout was key in the analysis of the accessible traffic resulting from the various specialized carrier scenarios. Using the criterion that the minimum market network must be 30 percent of the total market along with Table 3-10 revealed that 22 earth stations were needed and 116 subordinate

TABLE 3-10. SUMMARY OF SPECIALIZED CARRIER NETWORK

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OF POOR QUALITY

| | | NO. SMSA'S | GROUP MARKET VALUE | CUM GROUP MARKET VALUE |
|---|---|---|---|---|
| 1 | NEW YORK NY-NJ | 20 | | |
| 2 | CANTON OH | 9 | 1.33 | 1.33 |
| 3 | RACINE WI | 5 | 1.21 | 2.54 |
| 4 | JACKSON MI | 6 | 0.93 | 3.47 |
| 5 | SPRINGFIELD-CHICOPEE-HOLYOKE CT-MA | 12 | 1.16 | 4.63 |
| 6 | HAGERSTOWN MD | 8 | 1.81 | 6.43 |
| 7 | MUNCIE IN | 6 | 1.15 | 7.58 |
| 8 | GREENSBORO-WINSTON-SALEM-HIGH NC | 7 | 1.92 | 9.50 |
| 9 | ANNISTON AL | 5 | 1.44 | 10.94 |
| 10 | SPRINGFIELD IL | 5 | 1.36 | 12.30 |
| 11 | DUBUQUE IA | 6 | 1.18 | 13.48 |
| 12 | OXNARD-SIMI VALLEY-VENTURA CA | 4 | 1.44 | 14.92 |
| 13 | STOCKTON CA | 6 | 1.42 | 16.34 |
| 14 | PETERSBURG-COLONIAL HEIGHTS-HO VA | 5 | 1.64 | 17.97 |
| 15 | LAKELAND-WINTER HAVEN FL | 4 | 1.10 | 19.07 |
| 16 | ELMIRA NY | 6 | 1.67 | 20.74 |
| 17 | LEXINGTON-FAYETTE KY | 3 | 1.64 | 22.38 |
| 18 | ROCHESTER MN | 4 | 1.62 | 24.01 |
| 19 | ASHEVILLE NC | 5 | 1.66 | 25.67 |
| 20 | LIMA OH | 4 | 1.59 | 27.25 |
| 21 | BEAUMONT-PORT ARTHUR-ORANGE TX | 4 | 1.58 | 28.83 |
| 22 | KANSAS CITY MO-KS | 4 | 1.53 | 30.36 |
| 23 | BENTON HARBOR MI | 5 | 1.51 | 31.87 |
| 24 | BILOXI-GULFPORT MS | 4 | 1.44 | 33.31 |
| 25 | JACKSONVILLE NC | 4 | 1.45 | 34.76 |
| 26 | PARKERSBURG-MARIETTA WV-OH | 4 | 1.46 | 36.22 |
| 27 | COLUMBIA SC | 4 | 1.46 | 37.68 |
| 28 | DENVER-BOULDER CO | 4 | 1.46 | 39.14 |
| 29 | FORT LAUDERDALE-HOLLYWOOD FL | 3 | 1.48 | 40.62 |
| 30 | OCALA FL | 4 | 1.44 | 42.05 |
| 31 | COLUMBUS GA-AL | 4 | 1.41 | 43.46 |
| 32 | DALLAS-FORT WORTH TX | 2 | 1.37 | 44.83 |
| 33 | PROVIDENCE-WARWICK-PAWTUCKET RI-MA | 4 | 1.32 | 46.16 |
| 34 | TERRE HAUTE IN | 4 | 1.33 | 47.49 |
| 35 | BUFFALO NY | 2 | 1.31 | 48.80 |
| 36 | GLENS FALLS NY | 4 | 1.34 | 50.14 |
| 37 | APPLETON-OSHKOSH WI | 4 | 1.35 | 51.48 |
| 38 | BREMERTON WA | 4 | 1.17 | 52.65 |
| 39 | VINELAND-MILLVILLE-BRIDGETON NJ | 4 | 1.31 | 53.96 |
| 40 | LONGVIEW TX | 4 | 1.28 | 55.24 |
| 41 | LAWTON OK | 3 | 1.28 | 56.52 |
| 42 | AUSTIN TX | 3 | 1.29 | 57.81 |
| 43 | CLARKSVILLE-HOPKINSVILLE TN-KY | 2 | 1.25 | 59.06 |
| 44 | BAY CITY MI | 3 | 1.24 | 60.30 |
| 45 | JOPLIN MO | 3 | 1.15 | 61.45 |
| 46 | LAFAYETTE LA | 3 | 1.15 | 62.60 |
| 47 | FORT WALTON BEACH FL | 3 | 1.10 | 63.70 |
| 48 | LINCOLN NE | 2 | 1.07 | 64.77 |
| 49 | SALEM OR | 3 | 1.00 | 65.78 |
| 50 | BRADENTON FL | 3 | 0.96 | 66.74 |
| 51 | CHARLESTON-NORTH CHARLESTON SC | 2 | 0.97 | 67.70 |
| 52 | LITTLE ROCK-NORTH LITTLE ROCK AR | 2 | 0.96 | 68.66 |
| 53 | EVANSVILLE IN-KY | 2 | 0.93 | 69.59 |

TABLE 3-10. SUMMARY OF SPECIALIZED CARRIER NETWORK (CONTINUED)

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| | | NO. SMSA'S | GROUP MARKET VALUE | CUM GROUP MARKET VALUE |
|---|---|---|---|---|
| 54 | MEMPHIS TN-AR | 1 | 0.91 | 70.50 |
| 55 | PROVO-OREM UT | 2 | 0.85 | 71.35 |
| 56 | VISALIA-TULARE-PORTERVILLE CA | 3 | 0.78 | 72.13 |
| 57 | PHOENIX AZ | 1 | 0.78 | 72.91 |
| 58 | CEDAR RAPIDS IA | 2 | 0.76 | 73.67 |
| 59 | LEWISTON-AUBURN ME | 2 | 0.76 | 74.43 |
| 60 | YUBA CITY CA | 3 | 0.74 | 75.17 |
| 61 | SAN DIEGO CA | 1 | 0.75 | 75.92 |
| 62 | SIOUX CITY NE-IA | 2 | 0.74 | 76.67 |
| 63 | BANGOR ME | 2 | 0.74 | 77.40 |
| 64 | TULSA OK | 1 | 0.72 | 78.13 |
| 65 | EL PASO TX | 2 | 0.72 | 78.84 |
| 66 | FARGO-MOORHEAD ND-MN | 2 | 0.70 | 79.54 |
| 67 | MIDLAND TX | 2 | 0.68 | 80.21 |
| 68 | CORPUS CHRISTI TX | 2 | 0.67 | 80.89 |
| 69 | ALTOONA PA | 2 | 0.67 | 81.56 |
| 70 | BROWNSVILLE-HARLINGEN-SAN BENI TX | 2 | 0.67 | 82.23 |
| 71 | BRYAN-COLLEGE STATION TX | 2 | 0.66 | 82.89 |
| 72 | ABILENE TX | 2 | 0.66 | 83.55 |
| 73 | CHATTANOOGA TN-GA | 1 | 0.64 | 84.19 |
| 74 | DES MOINES IA | 1 | 0.64 | 84.83 |
| 75 | WICHITA KS | 1 | 0.59 | 85.42 |
| 76 | JACKSON MS | 1 | 0.57 | 85.99 |
| 77 | SALINAS-SEASIDE-MONTEREY CA | 2 | 0.55 | 86.54 |
| 78 | DULUTH-SUPERIOR MN-WI | 1 | 0.52 | 87.06 |
| 79 | RICHLAND-KENNEWICK WA | 2 | 0.51 | 87.57 |
| 80 | ALBUQUERQUE NM | 1 | 0.51 | 88.08 |
| 81 | RIVERSIDE-SAN BERNARDINO-ONTAR CA | 1 | 0.51 | 88.59 |
| 82 | HAMILTON-MIDDLETOWN OH | 1 | 0.50 | 89.09 |
| 83 | LORAIN-ELYRIA OH | 1 | 0.48 | 89.57 |
| 84 | LYNCHBURG VA | 1 | 0.48 | 90.05 |
| 85 | LAS VEGAS NV | 1 | 0.48 | 90.52 |
| 86 | TUCSON AZ | 1 | 0.48 | 91.00 |
| 87 | FORT SMITH AR-OK | 1 | 0.48 | 91.48 |
| 88 | ATHENS GE | 1 | 0.45 | 91.93 |
| 89 | FLORENCE AL | 1 | 0.45 | 92.38 |
| 90 | TALLAHASSEE FL | 1 | 0.45 | 92.83 |
| 91 | LUBBOCK TX | 1 | 0.44 | 93.27 |
| 92 | TUSCALOOSA AL | 1 | 0.43 | 93.71 |
| 93 | COLUMBIA MO | 1 | 0.43 | 94.14 |
| 94 | MONROE LA | 1 | 0.43 | 94.58 |
| 95 | AMARILLO TX | 1 | 0.43 | 95.00 |
| 96 | ST CLOUD MN | 1 | 0.41 | 95.42 |
| 97 | KANKAKEE IL | 1 | 0.39 | 95.80 |
| 98 | SPOKANE WA | 1 | 0.38 | 96.18 |
| 99 | ENID OK | 1 | 0.37 | 96.55 |
| 100 | PUEBLO CO | 1 | 0.36 | 96.91 |
| 101 | BOISE CITY ID | 1 | 0.36 | 97.26 |
| 102 | RENO NV | 1 | 0.34 | 97.60 |
| 103 | BISMARK ND | 1 | 0.33 | 97.93 |
| 104 | BILLINGS MT | 1 | 0.33 | 98.27 |
| 105 | LAREDO TX | 1 | 0.32 | 98.59 |
| 106 | CASPER WY | 1 | 0.31 | 98.90 |
| 107 | GREAT FALLS MT | 1 | 0.30 | 99.20 |
| 108 | MEDFORD OR | 1 | 0.29 | 99.49 |
| 109 | REDDING CA | 1 | 0.27 | 99.76 |
| 110 | BELLINGHAM WA | 1 | 0.24 | 100.00 |

SMSAs were included in the top 30 percent. As discussed earlier, the development of the maximum market network required the creation of an earth station site cost model to determine the smallest amount of traffic in an SMSA location to economically justify placement of a specialized carrier earth station. From this the smallest incremental market value for the last principal SMSA was determined to be .082 percent. Using this incremental value and Table 3-10, it was possible to conclude that all earth stations could be economically justified (i.e., .24% >.082%). The most efficient specialized network was defined as one in which the smallest incremental SMSA generates sufficient communications traffic within a competitive carrier environment. The minimum market value for any SMSA was determined to be 4 x .082% or .328%. Using this value and Table 3-10, it was possible to conclude that the first 104 earth station locations, including 203 subordinate SMSAs, were economically feasible in a competitive environment.

## 3.6 ESTABLISHED CARRIER KA-BAND NET ACCESSIBLE FORECASTS

The established carrier Ka-band net accessible forecasts are those portions of the Ka-band traffic likely to be implemented on a Ka-band established carrier system. In developing these forecasts the starting point was, as with the specialized carrier forecasts, the Ka-band required capacity or 618 transponders. Using this required capacity and a network optimization model, established carrier network scenarios were developed for 10 and 20 earth station networks.

Scenarios of the 10 and 20 earth station networks are presented in Tables 3-11 and 3-12, respectively. In the 10 earth station network, a total of 178 subordinate SMSAs would be interconnected to the network. The 10 locations plus the subordinate SMSAs would provide market coverage for 42.5 percent of the addressable market. In the 20 earth station network, a total of 245 subordinated SMSAs would be interconnected to the system. The 20 locations plus the subordinate SMSAs would provide market coverage for 75 percent of the addressable market.

## TABLE 3-11. SUMMARY OF 10 EARTH STATION NETWORK

| ORDER OF SELECTION | EARTH STATION LOCATION | LARGEST SMSA IN GROUP | NUMBER OF SUBORDINATES SMSAS | GROUP MARKET VALUE | CUM GROUP MARKET VALUE |
|---|---|---|---|---|---|
| 1. | NEW YORK, NY-NJ | NEW YORK | 41 | 10.02 | 10.02 |
| 2. | FT. WAYNE, IN | CHICAGO | 32 | 8.09 | 18.11 |
| 3. | Lynchburg, VA | Washington | 18 | 4.69 | 22.80 |
| 4. | Erie, PA | Pittsburgh | 14 | 4.18 | 26.97 |
| 5. | Rockford, IL | Milwaukee | 19 | 3.31 | 30.29 |
| 6. | Athens, GE | Atlanta | 14 | 3.34 | 33.62 |
| 7. | Bryan - College Stn, TX | Dallas | 11 | 2.35 | 35.98 |
| 8. | Lakeland-Winterhaven, FL | Tampa | 12 | 2.25 | 38.23 |
| 9. | Portland, ME | Boston | 11 | 2.19 | 40.42 |
| 10. | Evansville In, KY | Indianapolis | 6 | 2.11 | 42.53 |

TABLE 3-12. SUMMARY OF 20 EARTH STATION NETWORK NETWORK

| Order of Selection | Earth Station Location | Largest SMSA in Group | Number of Subordinates SMSAs | Group Market Value | CUM Group Market Value |
|---|---|---|---|---|---|
| 1. | New York, NY-NJ | New York | 41 | 13.13 | 13.13 |
| 2. | Fort Wayen, IN | Chicago | 32 | 11.03 | 24.16 |
| 3. | Lynchburgh, VA | Washington | 18 | 5.82 | 29.98 |
| 4. | Erie, PA | Pittsburgh | 14 | 5.20 | 35.18 |
| 5. | Rockford, IL | Milwaukee | 19 | 4.53 | 39.71 |
| 6. | Athens, GE | Atlanta | 14 | 4.28 | 43.99 |
| 7. | Bryan-College Stn, TX | Dallas | 11 | 3.59 | 47.57 |
| 8. | Lakeland-Winter Haven, FL | Tampa | 12 | 2.98 | 50.56 |
| 9. | Portland, ME | Boston | 11 | 2.73 | 53.28 |
| 10. | Evansville, IN-KY | Louisville | 6 | 2.80 | 56.08 |
| 11. | Visalia-Tulare-Porterville, CA | Los Angeles | 10 | 3.07 | 59.15 |
| 12. | Lawrence, KS | Kansas City | 9 | 2.67 | 61.82 |
| 13. | Jackson, MS | New Orleans | 9 | 2.39 | 64.21 |
| 14. | Eau Claire, WI | Minneapolis | 5 | 1.93 | 66.14 |
| 15. | Montgomery, AL | Birmingham | 5 | 1.50 | 67.64 |
| 16. | Chico, CA | San Francisco | 7 | 1.59 | 69.24 |
| 17. | Yakima, WA | Seattle | 8 | 1.53 | 70.77 |
| 18. | Oklahoma City, OK | Oklahoma City | 5 | 1.45 | 72.22 |
| 19. | Fort Collins, CO | Denver | 5 | 1.39 | 73.61 |
| 20. | Little Rock-North Little Rock, AR | Memphis | 4 | 1.37 | 74.98 |

## SECTION 4
## SUMMARY AND CONCLUSIONS

- The demand for telecommunications in general and for satellite telecommunications in particular will increase significantly between now and the year 2000.

- Voice services over the period will continue, by wide margins, to account for the largest portion of the overall demand for telecommunications in general, and for satellite telecommunications in particular.

- Required capacity and actual C- plus Ku-band capacity will grow about three times as fast as will potential C- plus Ku-band capacity for the time period 1980 to 2000.

- For the year 2000, the expected estimate for required capacity will be about 2500 transponders while that for potential and actual capacity will be about half that amount or 1250 transponders.

- Ka-band capacity will be needed in the early 1990's even if actual and potential capacities reach their maximum in the early 1990's rather than the late 1990's.

- For specialized carrier Ka-band networks, a minimum network or 30 percent (i.e., 188 transponders) of the total market (i.e., 618 transponders) will require 22 earth stations with 116 subordinate SMSAs; the maximum network will include all of the network or 110 earth stations with 203 subordinate SMSAs; and the most efficient network will include 104 earth stations with 203 subordinate SMSAs (this market coverage equals about 98 percent of the market or 607 transponders).

- For established carrier Ka-band networks, a 10 earth station network will provide coverage for 42.5 percent of the addressable market while a 20 earth station network will provide coverage for 75 percent of the net addressable market.

- Major assumptions were made throughout the study and these should be carefully reviewed when examining each forecast.

- Because varying the assumptions underlying the forecasts could significantly alter the forecasts, a sensitivity analysis is needed to determine the potential impact on the forecasts of varying such assumptions.

# SECTION 5
# ORGANIZATION OF STUDY REPORT

The report for this study consists of three volumes:

a. Volume I - Executive Summary
b. Volume II - Main Text
c. Volume III - Appendices

The Main Text details the purpose, tasks and methodology, and provides major and specific findings. The Appendices present comprehensive and detailed explanations of methodologies and include specific tables of forecasts that are summarized in the Main Text.

The Main Text, Volume II, includes the following sections:

a. Section 1 - Overview
b. Section 2 - Characterization of Services
c. Section 3 - Baseline Forecasts
d. Section 4 - Impacted Baseline Forecasts
e. Section 5 - Net Long Haul Forecasts
f. Section 6 - Cost Analysis
g. Section 7 - Net Addressable Forecasts
h. Section 8 - Capacity Requirements
i. Section 9 - Satellite System Market Development
j. Section 10 - Net Accessible Forecasts

The Appendices, Volume III, include the following sections:

a. Appendix A - Baseline Forecasts
b. Appendix B - Impacted Baseline Forecasts
c. Appendix C - Market Distribution Model
d. Appendix D - Net Long Haul Forecasts
e. Appendix E - Cost Analyses
f. Appendix F - Net Addressable Forecasts

g. Appendix G - Capacity Requirements

h. Appendix H - Satellite System Market Development

i. Appendix I - Ka-band Net Accessible Forecasts