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A Comparison of Domestic Satellite Communications Forecasts to the Year 2000

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ABS:  The methodologies and results of three NASA-sponsored market demand
        assessment studies are presented and compared. Forecasts of future
        satellite addressable traffic (both trunking and customer premises
        services) were developed for the three main service categories of voice,
        data and video and subcategories thereof for the benchmark years of 1980,
        1990 and 2000. The contractor results are presented on a service by
        service basis in two formats: equivalent 36 MHz transponders and basic
        transmission units (voice: half-voice circuits, data: megabits per second
        and video: video channels). It is shown that while considerable
        differences exist at the service category level, the overall forecasts by
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A COMPARISON OF DOMESTIC SATELLITE COMMUNICATIONS

FORECASTS TO THE YEAR 2000

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SUMMARY

The methodologies and results of three recently completed NASA-sponsored market demand assessment studies for U.S. domestic fixed telecommunications services are summarized and presented. Two studies addressing the forecast of satellite-provided customer premises services (CPS) were performed by the Western Union Telegraph Company (WU) and the U.S. Transmission Systems subsidiary of the International Telephone and Telegraph Corp. (ITT). A single effort to forecast the demand for satellite-provided trunking communications services was performed concurrently by WU. The emphasis of the studies was to provide estimates of future satellite addressable traffic; that is, forecasts of telecommunications traffic which can be competitively carried by satellite. Each study consisted of a series of sequential traffic forecasts, leading from the overall domestic telecommunications market to the potential satellite market (trunking or CPS). The interim steps in the development of these succeeding forecasts included the application of economic models, traffic distribution models, constraints on traffic utilizing satellites, and the like. Also, in deriving the various forecasts, technological improvements in transponder capacity and competition with terrestrial delivery systems are taken into account.

All these studies focused on the major service categories of voice, data and video and several subcategories thereof. WU and ITT utilized different methodologies and assumptions which subsequently led to different results in many instances. However, while considerable differences exist at the service subcategory level, the overall forecasts by the two contractors are quite similar.

The purpose of this paper is to summarize the methodologies employed and present the results of the studies in common units. Each forecast is presented on a service by service basis in two formats: (1) equivalent 36 MHz transponders; and (2) basic transmission units (voice: half-voice circuits, data: megabits per second and video: video channels).

The major results include forecasts of the total future potential transponder demand for which in the years 1990 and 2000 ITT envisions growth from 1370 to 3594 transponders and WU estimates an increase from 1141 to 2779 transponders. ITT predicts the data component of the demand to be the largest contributor (54 percent) with 1941 transponders in the year 2000. This data estimate is approximately three and one-half times as large as that of WU. The WU forecast is dominated by voice services (66 percent) which represent 1824 transponders and is almost twice the ITT voice forecast. Video forecasts of ITT and WU as percent of the total transponder forecast are comparable

(19 percent and 15 percent), but the magnitude of the transponder demand differs; ITT: 676 transponders and WU: 413 transponders.

The CPS satellite addressable market is forecasted to approximately triple in size in the time frame of 1990 to 2000. ITT estimates this CPS demand for the year 2000 to total 699 transponders and WU predicts a total of 739 transponders. ITT indicates a larger contribution of voice services to the total than does WU (44 percent versus 14 percent). WU in turn predicts that data services will dominate this CPS market and represent 72 percent of the total. Both contractors foresee videoconferencing to be the sole component of the CPS video demand.

INTRODUCTION

Three fixed service telecommunications demand assessment studies were recently completed for NASA by the Western Union Telegraph Company (WU) and the U.S. Transmission Systems subsidiary of the International Telephone and Telegraph Corp. (ITT). Parallel contracts regarding the forecasts of satellite-provided Customer Premises Services were performed by both Contractors, and a single contract regarding the forecasts of satellite-provided Trunking Communication Services was performed by WU. Results of these efforts are contained in references 1 to 3.

The prime focus of the studies was to provide estimates of future satellite addressable traffic, that is, forecasts of telecommunications traffic which can be competitively carried by satellites. Such forecasts are required by NASA to provide guidance for the NASA Communications Program. A knowledge of the requirements for advanced satellite communications systems needed by the end of the century provides an understanding of the corresponding enabling technologies required. From this understanding, appropriate NASA-sponsored advanced communications technology development programs can then be structured.

The WU Trunking Services study (ref. 3) represents an update of a previous NASA-sponsored study entitled, "18/30 GHz Fixed Communications System Service Demand Assessment" (ref. 4). This 1979 study provided the service requirements subsequently used to define many elements of the NASA Communications Program. During the years following the completion of this study, significant changes have occurred in the satellite communications industry including: technological advances, a wave of new satellite service suppliers, a rapid increase in the demand for Cable TV channels, different service mixes than earlier anticipated, different service offerings, etc. These and other events and their corresponding effects on the satellite services market created the need for updated satellite traffic forecasts. Thus, the WU Trunking Services study was undertaken to provide a fresh look at the satellite demand for domestic services provided by trunking systems.

As in the 1979 study, forecasts were developed for the total telecommunications traffic demand of the U.S., that portion transmitted between the 313 Standard Metropolitan Statistical Areas (SMSA), and that portion that potentially could be transmitted by satellite. This satellite addressable traffic took into consideration economic competition with terrestrial delivery systems and the impact of the existing terrestrial plant-in-place. The final results were standardized in terms of equivalent 36 MHz transponders after projected improvements in transponder throughput capability were considered.

The Customer Premises Services (CPS) studies by both WU and ITT (refs. 1 and 2) focused on satellite communications traffic that could be supplied directly to the customer through earth terminals located on his premises or through a local customer-shared earth station. Customer premises services were not directly considered in the previous market studies (refs. 4 to 7), but the provision of CPS has since been identified as an important offering which could significantly impact the future growth of satellite communications and its advanced technology requirements. The purpose of the CPS studies, therefore, was to assess and characterize the future market for CPS and determine the volume of CPS traffic that could be supplied by advanced satellite systems through the year 2000. To accomplish these objectives, the following traffic demand forecasts were derived: the overall telecommunications market; the overall satellite addressable telecommunications market; that portion of the satellite market addressable by CPS systems; and that portion of the CPS market addressable by Ka-band CPS systems. The WU final results were presented as equivalent 36 MHz transponders and ITT final results were presented as peak hour megabits per second (Mbps).

All three studies considered the major service categories of voice, data and video and several subcategories thereof, and produced forecasts for the same benchmark years of 1980 (an estimate of actual traffic), 1990 and 2000. However, in deriving their results, WU and ITT utilized different approaches and assumptions which in some cases resulted in quite different results.

The purpose of this report is to present a summary of the major results of the three studies together with an outline of the methodologies and assumptions which were used. To allow comparisons, the results of the contracts are presented on a common basis. Results of all three studies are presented in terms of 36 MHz equivalent transponders based on WU transponder assumptions, and in terms of the basic transmission units for each service (voice, video, data) to allow the reader to make his own assumptions regarding potential numbers of transponders needed.

This report is intended as a summary of the respective studies. The reader is referred to the contractors' final reports for more explicit details. An analysis of the differences between the contractors' results is currently in progress and will be reported on at a later date.

The report is organized into two main sections. First, the methodologies are described for the WU Trunking Services and CPS studies and the ITT CPS study. This is followed by a section summarizing the contractors' results. Tabular data are presented for voice, video and data services for the years 1980, 1990 and 2000 for the net long haul, satellite addressable, CPS satellite addressable and the Ka-band CPS satellite addressable forecasts. Forecasts on a service subcategory level are presented when appropriate. Finally, the total satellite and CPS satellite transponder demand as predicted by each contractor is presented. Included is the percent contribution to this total demand by each of the three major services.

FORECASTING METHODOLOGIES

WU Trunking Services Study

The forecasting methodology utilized for the determination of the demand for satellite-provided trunking communications services is briefly summarized in this section and depicted in figure 1. Initially, candidate communications services comprised of voice, data and video and subcategories thereof were defined and characterized. The 31 services which were selected are listed in table I. A series of sequential traffic forecasts, leading from overall telecommunications traffic to satellite candidate traffic, were then derived with each succeeding forecast being created by applying various constraints, models and other variables to each respective preceeding forecast.

A baseline forecast was first determined for each of the 31 services reflecting the occurrence of expected future events and orderly growth in demand. Significant effort was required in this step as it formed the basis for the rest of the study. It involved a detailed literature survey, interviews with industry vendors, suppliers and experts and an in-depth analysis by WU. Other factors utilized in this procedure included historical trend data, revenue data, terminal populations, video-teleconferencing room projections, etc. Baseline forecasts were expressed in terms of half voice circuits for voice, terabits/year for data and transponders for video. These baseline forecasts were then refined by considering the impact of future events (technological, economic and social-political) that are less predictable than those already considered. A cross-impact model was utilized to determine the effects of these factors on the baseline forecasts. The resulting modified forecasts were defined as impacted baseline forecasts.

The next step was the development of the net long haul forecasts. They were calculated by the removal of intra-SMSA traffic, data carried over voice lines and hinterland traffic (that traffic that originates and/or terminates outside the limit of an SMSA) from the impacted baselines. At this point all services were converted to peak hour units through the use of peaking factors on a service by service basis. Also, efficiency factors on a year to year, service by service basis were applied to the data services to account for the various inefficiencies of data transmission. These inefficiencies include idle line time, protocol overheads, call set-up and breakdown and other factors. At this point an internal WU model was utilized to determine the distribution of net long haul traffic between the 313 SMSA's.

Finally, several steps were performed to obtain the forecasts of the satellite net addressable traffic demand. A comprehensive cost analysis was used to determine the current and future crossover or break-even transmission distances between satellite and terrestrial delivery systems. This crossover distance is defined to be that distance at which the terrestrial and satellite transmission costs are the same for a given service. This effort included the definition and costing of the earth and space segments of a high volume satellite trunking system for C-, Ku- and Ka-bands, end-to-end user costs for satellite systems and user costs of various terrestrial transmission systems through the year 2000. Traffic less than the break-even distance as well as traffic unsuitable for satellite transmission was removed from the net long haul forecasts, resulting in peak hour addressable forecasts by service for

C-, Ku- and Ka-bands. After reducing this addressable forecast by considering the existing terrestrial plant-in-place (microwave, cable, etc.), the remaining potential satellite traffic was finally converted into the common unit--an equivalent 36 MHz transponder. Technological considerations utilized in this process included estimates of the analog and digital mixes of transmission systems, and improvements in modulation and coding techniques. High and low estimates of the potential satellite traffic for each service and year were arrived at by using high and low estimates of traffic removed due to the plant-in-place, and high and low estimates of technological improvements in transponder capacity. The data presented in this report are the mean values of these estimates. This procedure resulted in estimates for the potential transponder capacity that will be required in the years 1990 and 2000.

WU Customer Premises Services Study

Several components of the methodology and much of the data for the Western Union CPS study are identical to those previously discussed for the trunking study. A summary of the CPS forecast methodology used by WU is described in this section and depicted in figure 2. First, potential CPS services were defined and characterized. The same 31 services of the trunking study listed in table I were used. This step was followed by the identification and characterization of potential CPS users. A user survey was employed to obtain information (current and future volumes and mixes of services, price/demand/performance information, communication budgets, specific CPS data, etc.) that enabled Western Union to develop a compendium of potential CPS user classes and their associated needs. Two hundred and fifty-three interviews were conducted with a sample that included representatives from large, medium and small businesses, government agencies and institutions across the United States.

The CPS forecasting methodology, as in the trunking services study, began with the same baseline and impacted baseline forecasts for the 31 services. Differences between the two studies began to emerge at the net long haul forecasts. While intra-SMSA traffic and data traffic transmitted via voice lines were removed as in the trunking services study, hinterland traffic was not removed. Artificial SMSA's were created to represent that area of a state located outside of designated SMSA's. These areas represent potential sites for CPS earth stations as they are remote from areas of high volume trunking services. At this point, all services were converted to peak hour units on a service by service basis and efficiency factors were incorporated into the data forecasts as in the trunking services study. Then the WU internal model was used to route this traffic among each of the real and artificial SMSA's.

Before further developing the various components of the CPS forecasts, an extensive cost analysis was performed to determine the competitiveness of satellite and terrestrial CPS systems. This analysis determined the break-even or crossover distance by service, year and satellite band. These crossover distances were required for developing the CPS satellite, the Ka-band CPS satellite and the total or overall satellite addressable forecasts. Note that all satellite addressable forecasts were again converted to units of equivalent 36 MHz transponders utilizing expected future technologies regarding transponder capacity.

The CPS net addressable forecast was derived by removing not only that traffic less than the crossover distances, but also several other portions of the net long haul traffic which were deemed unsuitable for CPS satellite transmission. This procedure resulted in a CPS net addressable forecast for each of the 31 services. When WU derived these forecasts they assumed a stand alone system that would not be in competition with trunking satellite systems. Also, for this procedure and all subsequent refinements, WU assumed all digital transmission for CPS satellite systems.

The next component of the CPS study was the development of the Ka-band addressable forecasts. This forecast represents the total amount of traffic addressable by a Ka-band CPS satellite system. Again, WU derived these Ka-band forecasts for a stand-alone system excluding competition of other satellite delivery systems.

In the Ka-band CPS forecasts, two types of system configurations were considered: (1) an unshared earth station located directly on (or very close to) the customer's own premises; and (2) a shared earth station arrangement. The shared configuration represents an arrangement of more than one user employing a common earth station as in an industrial park. Each user would have a dedicated link to the earth station. Availability levels of 0.995 and 0.999 (that is, acceptable service provided 99.5 percent and 99.9 percent of the time) were considered for each configuration. As in the derivation of the CPS net addressable forecasts, the Ka-band CPS net addressable forecasts were determined by modifying the net long haul forecasts considering several factors. These factors were the same as in the CPS market derivation but with the addition of removing traffic that is not suitable for Ka-band CPS transmission. Finally, a variety of Ka-band CPS forecasts (e.g., by services, users, national regions and mileage bands) were developed for the four configuration/availability schemes listed above.

The final step in the WU studies involved considering the CPS and trunking markets simultaneously (that is, not as stand-alone systems) to derive an overall satellite addressable forecast. This market represents the total amount of traffic addressable by both trunking and CPS satellite systems when they are in direct competition with each other. Based on a comparison of crossover distances considering service, service speed, year and satellite band, traffic was assigned to either the trunking or CPS segments and then the forecasts for each segment were summed to provide the overall satellite forecast.

ITT Customer Premises Services Study

Similar to the WU approach, the ITT forecasts were generated in a sequential manner, where each succeeding forecast was a subset of the one preceding. An overall telecommunications annual traffic forecast was first generated. This forecast was estimated nominally for all interurban traffic, or traffic estimated as traveling outside local service area boundaries. Derived from this was a satellite addressable forecast. As in the WU study, the satellite addressable forecast was then used to generate, in turn, a CPS satellite addressable forecast, where it was assumed the CPS systems could provide services at a 0.999 level of availability. Finally, a Ka-band CPS forecast was derived from the preceding. Here it was assumed that some versions of Ka-band systems might provide services at a lower (0.995) level of availability, but at reduced costs. Again, there were two subsets for each of the CPS forecasts: one considering dedicated CPS systems only, the other considering a combination of dedicated and shared systems.

In addition to the above forecasts of annual traffic demand, corresponding peak or busy hour forecasts were generated as well. Each forecast covered voice, video and data services and subcategories thereof. These subcategories, shown in table II, differed from those of Western Union. ITT grouped voice services into switched and dedicated (or private line) subcategories. Video services were grouped into one-way broadcast and two-way videoconferencing subcategories. Data services were split into message and computer components. All of these subcategories were themselves, in general, groupings of individual services forecast at the overall demand level. After identifying candidate CPS services, ITT performed a user survey consisting of 370 interviews to identify and characterize potential CPS users. These data served as input to the forecasting methodology.

The overall flow of the sequential ITT forecasting methodology is depicted in figure 3. As in the WU studies, the bases of the ITT forecasts are those forecasts for the overall telecommunications market in terms of annual demand on a service by service basis. These forecasts were arrived at by using such factors as historical trends, published revenue data, travel displacement by videoconferencing, number of terminals, estimated traffic per terminal, etc. Efficiency factors were applied (as in the WU studies) to the data forecasts. All forecasts at this stage were developed in terms of bits per year.

The next step involved proceeding from the overall market to the satellite market. This procedure involved estimating the distance at which satellites would be cost effective relative to terrestrial delivery systems for the year 1980 by comparing terrestrial and satellite tariffs for various services. The cost-effective distances for the remaining years were then estimated and these distances were assumed to be the same for all services. The distance distribution of voice and data traffic was estimated based on AT&T published information and first class mail delivery data. Satellite addressable traffic for the voice and data services was calculated by multiplying the overall traffic by the appropriate distance factor (defined as the fraction of service or traffic at or exceeding the cost-effective distance). Computer traffic was further reduced 25 percent in 1980 due to the adverse effect of the time delay in satellite transmission. ITT assumed this problem would be overcome by 1990. In all years, ITT assumed that the satellite addressable demand for video services was the same as the overall video demand.

The next traffic demand subset category calculated was the CPS addressable traffic. As with WU, ITT also assumed that CPS satellite systems will utilize all-digital transmission. The derivation of the CPS addressable traffic is based on distribution, connectivity, and traffic volume. With respect to distribution and connectivity, ITT assumed that initially only a minor portion of the switched traffic would be addressed by CPS systems in the early years of the forecast time frame. However, ITT assumed that, as CPS systems become more sophisticated, the portion of switched traffic addressed will grow from 0 percent in 1980 to 25 percent by 1990 and 50 percent by 2000.

The other consideration used in developing the forecasts is the number of establishments or organizations with traffic volumes large enough to justify the cost of CPS facilities, either dedicated or shared. Also, traffic not suitable for CPS, such as residential Message Toll Service (MTS) and video (except videoconferencing), were removed from the forecasts. The satellite addressable traffic was reduced by the ITT derived distribution/connectivity factors on a service by service basis to arrive at the CPS addressable forecasts.

The final forecast to be derived was the Ka-band CPS addressable traffic. ITT assumed the Ka-band CPS systems could, depending on the design, differ from lower frequency CPS systems in earth station size, cost, and availability. As part of the user survey conducted for the study, however, ITT found that earth station size could be neglected as a significant factor. With respect to cost and availability, if these factors are comparable to those of lower frequency band satellites, the Ka addressable CPS traffic will be the same as in the previous CPS addressable forecasts. On the other hand, Ka-band CPS systems may offer services of a lower availability level at a reduced cost. The aforementioned survey examined both the extent to which lower availability services could be addressed and the cost reduction that would be expected for such services. Based on costs and availability, ITT estimated, on a service by service basis, percentages of the CPS addressable traffic that would be addressable by Ka-band systems.

One final step performed by ITT was the conversion of annual traffic forecasts to peak hour demand forecasts. This step was performed through the utilization of a "peak factor" for each service and assumptions as to the number of active days per service year. The results were left in terms of Mbps because of the assumption of all-digital CPS satellites.

COMPARISON OF RESULTS

As presented in the contractors' reports, the peak hour forecasts of WU and ITT are difficult to compare because of the different units used by each. The ITT final report presents results in terms of Mbps for all three services: voice, data, and video. WU results, on the other hand, were presented in terms of 36 MHz equivalent transponders. WU postulated that future trunking transponders would consist of varying proportions of analog and digital transmission modes. These proportions, along with the capacities assumed for the various transponders considered, are presented in table III.

The following discussion summarizes the WU and ITT voice, data, and video results in terms of common units. Two formats are employed: fundamental transmission units for each service category, and WU equivalent 36 MHz transponders. In the former, voice quantities are expressed in terms of half voice circuits, data in terms of megabits per second, and video in terms of video channels. This format is used to allow the reader to utilize his own technological assumptions regarding future transponder characteristics when calculating satellite requirements. For the second format, the ITT results have been converted to WU equivalent transponder units in order to provide a ready estimate of future satellite needs.

Conversion of the ITT results to fundamental units essentially involved working back from their reported Mbps results. The ITT voice forecasts were transformed to half voice circuit units by utilizing a factor of 64 thousand bits per second (Kbps) per half voice circuit. ITT believes this equivalence will hold over the entire forecast timeframe (the rationale for this assumption is discussed in their report). With respect to the ITT data forecasts, no transformation was necessary as results were already in terms of Mbps units. Conversions of the video forecasts were handled differently, depending on whether results were for broadcast or videoconferencing services. The broadcast forecasts in Mbps were converted to numbers of one way video channels while the two way videoconferencing forecasts were converted to numbers of videoconferences. Various compression factors assumed by ITT for different video services at different times in the forecast period were backed-out of the video results. Once the ITT results had been put in terms of the fundamental transmission units, they were then transformed to WU equivalent 36 MHz transponders by utilizing the transponder capacities given in table III.

The WU results were already in one of the desired formats--equivalent 36 MHz transponders. To obtain results in terms of fundamental transmission units, the transponder counts for each of the services were transformed also using the contents of table III. Compression ratios assumed for various video services were also backed-out of the results, as had been done for the ITT forecasts.

The transformed voice, data, and video service results, in that order, are presented below. Individual voice and video subcategory forecasts are also presented. Transponder counts of the service categories are then combined to give an overall addressable transponder forecast to the year 2000.

Voice

Individual forecasts of Residential MTS and Private Line voice services were developed by both WU and ITT. However, whereas ITT developed individual forecasts for Business MTS and Wide Area Telephone Service (WATS) as well, these two subcategories were combined into one by WU. To facilitate comparisons, the ITT results have also been combined. WU also prepared forecasts for six relatively minor voice service subcategories: Mobile Radio, Public Radio, Commmercial and Religious, Occasional, CATV Music, and Recording. As there are no counterpart ITT forecasts for these services, and as they account for on the order of 1 percent or less of the WU total voice forecasts, they have been grouped together as "Other" in the summaries to follow.

Tables IV and V present the voice transmission unit and transponder results, respectively. As can be seen in table IV, the total long haul voice forecasts of the two contractors are comparable within a factor of 1.4. This cannot be said of the individual voice subcategories contributing to the total, where differences as large as an order of magnitude exist. WU sees a greater portion of long haul voice traffic as being satellite addressable than does ITT. On the other hand, ITT foresees more CPS addressable traffic than does WU.

Data

The individual data service subcategories utilized by the two contractors in forecasting total data demand were quite dissimilar. Seventeen subcategories were used by WU, six by ITT. Two of the ITT subcategories were identical with WU: TWX/Telex and Facsimile. Each of the remaining ITT subcategories encompassed all or part of one or more of the WU subcategories. For example, the ITT "Terminal/CPU" subcategory encompasses all or part of the WU "Data Entry," "Remote Job Entry," "Inquiry/Response" and other subcategories. Because of this overlapping of subcategories, and the relatively small contribution to the total of the subcategories that were the same, the forecasts presented below deal only with the overall total data category demand.

Results are given in tables VI and VII, both as developed by the contractors (i.e., including the efficiency factors described earlier in this report), and with the efficiency factors backed out. The impact of the inclusion of the efficiency factors is significant. Examination of the year 2000 Mbps results show that the factors used by ITT increase total forecast demand in the "Net Long Haul" case by a factor of over 100, while those used by WU increase demand by a factor of about 12.5. The "Net Long Haul" data results without efficiency factors, however, are within a factor of 1.4 as was the case for the overall voice forecasts. Also, as for the voice forecasts, this comparability diminishes when going to the satellite addressable or CPS addressable cases.

Video

The major subcategories considered by WU and ITT in their video forecasts were basically identical. Some minor subcategories were not. Table VIII lists the video subcategories utilized by the two contractors, with brief descriptions as to the content of each. For the following comparison purposes, the video subcategories have been split into two groups: broadcast (one-way video) and videoconferencing (VC). The VC has been further split into one-way and two-way VC.

The contractors' results for the broadcast video group are presented in tables IX and X. Note that forecasts are given only for the "Net Long Haul" and the Satellite Addressable situations. These forecasts were considered identical by the contractors for broadcast video services. No CPS forecasts are given, as both contractors consider the broadcast video services to be non-addressable by CPS. Tables IX and X also show the WU one-way VC forecasts. No ITT one-way VC results are shown. Considered as broadcast in nature by ITT, one-way VC requirements are included as part of other broadcast requirements and are not separable from those results. Examination of the uncompressed channel forecasts in table IX indicates relatively close agreement in the overall totals for the years 1980 and 1990. The much larger disparity in the year 2000 forecasts is primarily due to the ITT Educational TV subcategory. Similar comments apply to the transponder forecasts in table X.

Tables XI and XII present the forecasts for two-way VC for both contractors in terms of peak hour numbers of conferences and numbers of transponders, respectively. Also shown in table XII are the WU one-way VC transponder forecasts for CPS, as CPS categories were not included in tables IX and X. ITT has no CPS-addressable one-way videoconferencing, considering this video service to be broadcast in nature as stated earlier, and hence not addressable by CPS.

Examining the two-way VC results, it is apparent that a much larger CPS addressable demand (on the order of 5 times as much) is forecast by WU than by ITT. As fractions of the satellite addressable demand for the year 2000, the ITT CPS addressable is only about 10 percent, compared with about 41 percent for WU.

Total Addressable Demand

The preceding voice, data, and video demands in terms of WU 36 MHz equivalent transponders are summarized and totaled in table XIII. Examination of table XIII shows that reasonable agreement exists between contractors as to the potential total demand for transponders in the overall satellite and CPS satellite addressable cases. For satellite addressable, on the order of 1200 to 1400 transponders are forecast by 1990, and on the order of 3000 by the year 2000. In the case of CPS satellite demand, 190 to 270 transponders are forecast for 1990, and on the order of 700 by the year 2000. The Ka-band CPS data displayed in table XIII show some disagreement existing between the contractors, particularly with respect to the lower availability (0.995) service where a difference of about a factor of two exists. To aid in the reader's comparison of these and other results displayed in table XIII, they have also been assembled in graphical form in figures 4 to 9. The transponder totals discussed above are plotted in figures 4 and 5, with the satellite addressable and CPS addressable demand cases in figure 4, and the Ka-band CPS addressable together with the CPS addressable in figure 5.

While agreement exists between contractors as to the potential total numbers of transponders, forecasts as to the voice, data, and video shares of these totals have been shown to be quite different. These differences are easily seen in figures 6 to 9. Figure 6 shows, for the satellite addressable demand, that while the video forecasts as a percent of the total are comparable between contractors, the voice and data forecasts are not. The ITT data contribution to the total is about twice the voice contribution, while the WU voice contribution is over three times that due to data. The much larger share held by data services in the case of ITT is to a large extent due to the smaller efficiency factors used. If the WU efficiency factors for data services were similar to those of ITT, the data contribution share of the WU overall forecast would increase considerably. It can also be noted in figure 6 that the magnitude of the WU voice forecast for the year 2000 is approximately twice that of ITT. A review of table IX indicates that this is primarily due to differences between the contractors in the Private Line category forecasts. Higher WU forecasts for both Residential and Business MTS also contribute, but to a lesser extent.

Figure 7, a display of CPS satellite addressable demand, indicates a larger contribution of voice to the ITT year 2000 total than to that of WU (44 percent versus 14 percent). On the other hand, the major contributor to the total as seen by WU is data services (72 percent).

Considering Ka band CPS, figures 8 and 9 indicate the contractors do not see much difference between 0.999 and 0.995 availability insofar as the percentage contributions of voice, data, and video to the total are concerned. Considerable difference between contractors does exist, however, as to the magnitude of traffic in going from the higher to the lower availability. The WU total demand at the 0.995 level for the year 2000 is about 90 percent of that at the 0.999 level, a small drop-off. On the other hand, the decrease in demand seen by ITT for the reduction in availability is much greater; the demand at 0.995 being about 40 percent of that at 0.999.

CONCLUDING REMARKS

The preceding has presented domestic fixed service demand forecasts by WU and ITT on a common basis to facilitate their comparison. These forecasts represent the most comprehensive and thorough assessment of the demand for fixed services within the U.S. developed to date and available in the public domain.

It has been shown that while considerable differences exist at the service category level, the overall transponder forecasts of the contractors are quite similar. A more detailed analysis of the differences at the service category level is in progress and will be reported on at a later date.

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TABLE I. - WU FORECAST SERVICE CATEGORIES

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

TABLE II. - ITT FORECAST SERVICE CATEGORIES

	Grouping	Service
Voice	Switched	Residential MTS Business MTS WATS
	Dedicated	Private Line
Video	Broadcast	Network Commercial Non-commercial CATV Educational Intrastate Interstate Specialized Public Service Telemedicine Public Affairs
	Videoconferencing	Two-way Videoconferencing
Data	Message	TWX/Telex Facsimile Electronic Mail
	Computer	Terminal/CPU CPU/CPU (Distributed Processing) CPU/CPU (EFT)

TABLE III. - WU 36 MHz TRANSPONDER CAPACITY ASSUMPTIONS

	1980	1990	2000
Voice			
Trunking Transponder			
Analog (Half Voice Circuits)	1200	3000	6000
Digital (Half Voice Circuits)	937.5	2812.5	3750
Percent Voice on Analog/Digital	100/0	75/25	50/50
CPS Transponder			
Digital (Half Voice Circuits)	562.5	1640.6	2187.5
Data			
Trunking Transponder (Mbps)	60	90	90
CPS Transponder (Mbps)	36	52.5	52.5
Video (includes compression)			
Network Quality (one way channels)	1	1	1.5
Video Conferencing, Full Motion (one way channels)	1	4	6
Video Conferencing, Limited Motion (one way channels)	12	36	48
Video Conferencing, Slow Motion (one way channels)	300	600	900

TABLE IV. - VOICE FORECASTS (10^3 HALF VOICE CIRCUITS)

	1980		1990		2000	
	WU	ITT	WU	ITT	WU	ITT
"Net Long Haul"	2523.6	2316.9	7634.8	6042.5	18685.5	13361.6
MTS Residential	539.6	92.0	1200.5	221.6	2636.0	423.6
MTS Business & WATS	1424.6	1354.7	3972.4	3565.0	9209.2	7597.8
Private Line	556.2	870.0	2421.2	2255.9	6718.3	5340.0
Other	3.1	NA	40.8	NA	121.9	NA
Satellite Addressable	227.5	253.3	1781.0	1319.5	8842.0	4481.6
MTS Residential	4.2	8.6	149.4	38.3	944.3	104.7
MTS Business & WATS	11.0	175.2	475.4	818.8	3171.7	2379.7
Private Line	209.9	69.5	1133.6	462.5	4637.6	1997.2
Other	2.5	NA	22.6	NA	88.4	NA
CPS Satellite Addressable	0.5	14.7	27.6	140.2	219.6	669.2
MTS Business & WATS	0.3	0.0	11.0	43.0	77.7	249.8
Private Line	0.2	14.7	16.6	97.2	140.9	419.4
Other	0.0	NA	0.0	NA	1.1	NA
Ka CPS Satellite (0.999 Avail., Shared & Unshared)	0.0	14.7	23.1	140.2	185.9	669.2
MTS Business & WATS	0.0	0.0	6.7	43.0	47.5	249.8
Private Line	0.0	14.7	16.4	97.2	137.8	419.4
Other	0.0	NA	0.0	NA	0.7	NA
Ka CPS Satellite (0.999 Avail., Unshared Only)	0.0	5.9	4.3	56.7	60.6	270.9
MTS Business & WATS	0.0	0.0	1.3	17.3	15.5	101.1
Private Line	0.0	5.9	3.0	39.4	44.8	169.7
Other	0.0	NA	0.0	NA	0.2	NA
Ka CPS Satellite (0.995 Avail., Shared & Unshared)	0.0	6.6	21.0	63.1	168.7	301.2
MTS Business & WATS	0.0	0.0	6.1	19.4	43.1	112.5
Private Line	0.0	6.6	14.9	43.8	124.9	188.8
Other	0.0	NA	0.0	NA	0.7	NA
Ka CPS Satellite (0.995 Avail., Unshared only)	0.0	2.7	3.9	25.5	54.7	121.9
MTS Business & WATS	0.0	0.0	1.2	7.8	14.0	45.5
Private Line	0.0	2.7	2.8	17.7	40.5	76.4
Other	0.0	NA	0.0	NA	0.2	NA

TABLE V. - VOICE FORECASTS (36 MHz EQUIVALENT TRANSPONDERS)

	1980		1990		2000	
	WU	ITT	WU	ITT	WU	ITT
Satellite Addressable	189.4	212.0	604.5	448.4	1824.0	976.3
MTS Residential	3.5	7.2	50.6	13.0	193.7	22.7
MTS Business & WATS	9.1	146.9	161.5	278.4	654.2	518.2
Private Line	174.9	57.9	384.7	157.0	957.8	435.4
Other	1.9	NA	7.6	NA	18.2	NA
CPS Satellite Addressable	0.9	26.1	16.8	85.4	100.4	305.9
MTS Business & WATS	0.5	0.0	6.7	26.2	35.5	114.2
Private Line	0.4	26.1	10.1	59.2	64.4	191.7
Other	0.0	NA	0.0	NA	0.5	NA
Ka CPS Satellite (0.999 Avail., Shared & Unshared)	0.0	26.1	14.2	85.4	85.1	305.9
MTS Business & WATS	0.0	0.0	4.1	26.2	21.7	114.2
Private Line	0.0	26.1	10.0	59.2	63.0	191.7
Other	0.0	NA	0.0	NA	0.3	NA
Ka CPS Satellite (0.999 Avail., Unshared Only)	0.0	10.6	2.6	34.6	27.7	123.8
MTS Buiness & WATS	0.0	0.0	0.8	10.6	7.1	46.2
Private Line	0.0	10.6	1.8	24.0	20.5	77.6
Other	0.0	NA	0.0	NA	0.1	NA
Ka CPS Satellite (0.995 Avail., Shared & Unshared)	0.0	11.7	12.9	38.5	77.2	137.7
MTS Business & WATS	0.0	0.0	3.7	11.8	19.7	51.4
Private Line	0.0	11.7	9.1	26.7	57.1	86.3
Other	0.0	NA	0.0	NA	0.3	NA
Ka CPS Satellite (0.995 Avail., Unshared Only)	0.0	4.7	2.4	15.5	25.1	55.7
MTS Business & WATS	0.0	0.0	0.7	4.8	6.4	20.8
Private Line	0.0	4.7	1.7	10.8	18.5	34.9
Other	0.0	NA	0.0	NA	0.1	NA

TABLE VI. - DATA FORECASTS (PEAK HOUR MBPS)

		1980		1990		2000	
		WU	ITT	WU	ITT	WU	ITT
Net Long Haul	With Eff. Factors W/O Eff. Factors	15,165 206.8	48,530 83.3	31,279 1084.6	142,850 910.2	40,344 3243.4	333,150 2352.3
Satellite Addressable	With Eff. Factors W/O Eff. Factors	787 8.4	3170 6.0	10,840 332.3	27,070 199.6	28,914 2050.2	103,640 742.6
CPS Satellite Address	W. Eff. Factors W/O Eff. Factors	774 6.8	530 1.0	10,516 280.7	4,830 35.6	27,762 1698.2	19,590 140.3
Ka CPS Sat. (0.999 Avail., Shared & Unshared)	W. Eff. Factors W/O Eff. Factors	0 0.0	530 1.0	9,224 256.7	4,830 35.6	23,636 1573.7	19,590 140.3
Ka CPS Sat. (0.999 Avail., Unshared Only)	W. Eff. Factors W/O Eff. Factors	0 0.0	220 0.4	9,224 256.7	1,960 14.4	23,636 1573.7	7,930 56.8
Ka CPS Sat. (0.995 Avail., Shared & Unshared)	W. Eff. Factors W/O Eff. Factors	0 0.0	180 0.4	8,306 230.6	1,660 23.6	21,273 1414.2	6,680 71.6
Ka CPS Sat. (0.995 Avail., Unshared Only)	W. Eff. Factors W/O Eff. Factors	0 0.0	70 0.2	8,306 230.6	670 8.7	21,273 1414.2	2,710 29.0

TABLE VII. - DATA FORECASTS (36 MHz EQUIVALENT TRANSPONDERS)

		1980		1990		2000	
		WU	ITT	WU	ITT	WU	ITT
Satellite Addressable	With Eff. Factors	21.7	87.8	204.4	510.4	541.6	1941.3
	W/O Eff. Factors	0.2	0.2	5.8	3.5	35.7	13.0
CPS Sat. Addressable	With Eff. Factors	21.5	14.8	200.2	92.0	528.8	373.1
	W/O Eff. Factors	0.2	0.1	5.3	0.7	32.3	2.7
Ka CPS Sat. (0.999 Avail., Shared & Unshared)	W. Eff. Factors	0.0	14.8	175.7	92.0	450.2	373.1
	W/O Eff. Factors	0.0	0.1	4.9	0.7	30.0	2.7
Ka CPS Sat. (0.999 Avail., Unshared Only)	W. Eff. Factors	0.0	6.0	175.7	37.2	450.2	151.0
	W/O Eff. Factors	0.0	0.1	4.9	0.3	30.0	1.1
Ka CPS Sat. (0.995 Avail, Shared & Unshared)	W. Eff. Factors	0.0	5.0	158.2	31.6	405.2	127.3
	W/O Eff. Factors	0.0	0.1	4.4	0.4	26.9	1.4
Ka CPS Sat. (0.995 Avail., Unshared Only)	W. Eff. Factors	0.0	2.0	158.2	12.8	405.2	51.5
	W/O Eff. Factors	0.0	0.1	4.4	0.2	26.9	0.6

TABLE VIII. - VIDEO SERVICE CATEGORIES

Category	WU	ITT
Network	Commercial (NBC, et.al.), Noncommercial (PBS), and Educational TV	Commercial (NBC, et.al.), Non-commercial (PBS)
CATV	CATV - Non-Network National and Regional	CATV Non-Network National and Regional
Occasional	Special Event Broadcasting	Not a separate category. Utilizes spare time on other category transponders.
Educational	Included in "Network"	Includes some forms of one-way videoconferencing, as well as college and university instructional broadcasts.
Public Services	Not an explicit category.	Telemedicine, public affairs, emergency & similar broadcast applications. Includes some forms of one-way videoconferencing.
Recording Channel	Special broadcast channels for recording by home enthusiasts.	Not a separate category.
Videoconferencing	Both one- and two-way videoconferencing	Two-way videoconferencing only. One-way videoconferencing demand implicit in educational and public services demand above.

TABLE IX. - VIDEO FORECASTS - ONE-WAY (VIDEO CHANNELS - UNCOMPRESSED)

Net Long Haul or Sat. Address (Identical)	1980		1990		2000	
	WU	ITT	WU	ITT	WU	ITT
Network	10.0	10.0	42.9	12.0	63.0	16.0
CATV	34.0	29.0	82.4	98.0	102.3	160.0
Occasional	14.3	a	41.6	a	54.0	a
Educational	b	15.0	b	165.0	b	500.0
Public Service	c	0.0	c	25.0	c	50.0
Recording	0.0	c	0.0	c	2.0	c
Subtotal	58.3	54.0	166.9	300.0	221.3	726.0
One-Way Videoconferencing	1.4	d	87.4	d	118.6	d
Total Video	59.7	54.0	254.3	300.0	339.9	726.0

Notes:

a. Not forecast separately. ITT assumes requirements met by open time on other category transponders.
b. Part of "Network" forecast.
c. Not forecast separately.
d. Included as part of other category forecasts (educational, public service).

TABLE X. - VIDEO FORECASTS - ONE-WAY (36 MHz EQUIVALENT TRANSPONDERS)

Net Long Haul or Sat. Address (Identical)	1980		1990		2000	
	WU	ITT	WU	ITT	WU	ITT
Network	10.0	10.0	42.9	12.0	42.0	10.7
CATV	34.0	29.0	82.4	98.0	68.2	106.7
Occasional	14.3	a	41.6	a	36.0	a
Educational	b	15.0	b	165.0	b	333.3
Public Service	c	0.0	c	25.0	c	33.3
Recording	0.0	c	0.0	c	1.3	c
Subtotal	58.3	54.0	166.9	300.0	147.5	484.0
One-Way Videoconferencing	1.4	d	43.7	d	39.5	d
Total Video	59.7	54.0	210.6	300.0	187.0	484.0

Notes:

a. Not forecast separately. ITT assumed requirements met by open time on other category transponders.
b. Part of "Network" forecast.
c. Not forecast separately.
d. Included as part of other category forecasts (educational, public service).

TABLE XI. - VIDEO FORECASTS - TWO-WAY VIDEOCONFERENCING

(NUMBER OF PEAK HOUR TWO-WAY VIDEOCONFERENCES)

	1980		1990		2000	
	WU	ITT	WU	ITT	WU	ITT
Net Long Haul/Satellite Addressable	1.6	4.4	1158.5	807.4	4339.6	3139.0
CPS Satellite Addressable	0.2	0.2	365.4	86.4	1784.6	328.2
Ka CPS (0.999 Avail., Shared & Unshared)	0.0	0.2	244.3	86.4	1190.8	328.2
Ka CPS (0.999 Avail., Unshared Only)	0.0	0.1	244.3	34.1	1190.8	133.8
Ka CPS (0.995 Avail., Shared & Unshared)	0.0	0.1	219.8	38.9	1071.4	146.8
Ka CPS (0.995 Avail., Unshared Only)	0.0	0.1	219.8	15.5	1071.4	60.4

TABLE XII. - VIDEO FORECASTS - TWO-WAY VIDEOCONFERENCING*

(36 MHz EQUIVALENT TRANSPONDERS)

	1980		1990		2000	
	WU	ITT	WU	ITT	WU	ITT
Net Long Haul/ Satellite Addressable	1.7 (1.4)	8.7	121.6 (43.7)	111.5	226.0 (39.5)	191.9
CPS Satellite Addressable	0.2 (0.1)	0.4	38.4 (13.8)	11.9	93.0 (16.3)	20.1
Ka CPS (0.999 Avail., Shared & Unshared)	0.0	0.4	25.6 (9.2)	11.9	62.0 (10.8)	20.1
Ka CPS (0.999 Avail., Unshared Only)	0.0	0.2	25.6 (9.2)	4.7	62.0 (10.8)	8.2
Ka CPS (0.995 Avail., Shared & Unshared)	0.0	0.2	23.1 (8.4)	5.4	55.8 (9.8)	9.0
Ka CPS (0.995 Avail., Unshared Only)	0.0	0.1	23.1 (8.4)	2.1	55.8 (9.8)	3.7

*Also included are WU one-way videoconferencing forecasts shown in parentheses.

TABLE XIII. - FORECAST ADDRESSABLE DEMAND TOTALS (36 MHz EQUIVALENT TRANSPONDERS)

	1980				1990				2000			
	WU		ITT		WU		ITT		WU		ITT	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Satellite Addressable												
Voice	189.4	69	212.0	59	604.5	53	448.4	33	1824.0	66	976.3	27
Data (Incl. Eff. Factors)	21.7	8	87.8	24	204.4	18	510.4	37	541.6	19	1941.3	54
Video	61.4	23	62.7	17	332.2	29	411.5	30	413.0	15	675.9	19
Total	272.5	100	362.5	100	1141.1	100	1370.3	100	2778.6	100	3593.5	100
CPS Satellite Addressable												
Voice	.9	4	26.1	63	16.8	6	85.4	45	100.4	14	305.9	44
Data (Incl. Eff. Factors)	21.5	95	14.8	36	200.2	74	92.0	49	528.8	72	373.1	53
Video	.3	1	.4	1	52.2	19	11.9	6	109.3	15	20.1	3
Total	22.7	100	41.3	100	269.2	99	189.3	100	738.5	101	699.1	100
Ka CPS (0.999 Shared & Unshared)												
Voice	-----	---	26.1	63	14.2	6	85.4	45	85.1	14	305.9	44
Data (Incl. Eff. Factors)	-----	---	14.8	36	175.7	78	92.0	49	450.2	74	373.1	53
Video	-----	---	.4	1	34.8	16	11.9	6	72.8	12	20.1	3
Total	-----	---	41.3	100	224.7	100	189.3	100	608.1	100	699.1	100
Ka CPS (0.995 Shared & Unshared)												
Voice	-----	---	11.7	69	12.9	6	38.5	51	77.2	14	137.7	50
Data (Incl. Eff. Factors)	-----	---	5.0	30	158.2	78	31.6	42	405.2	74	127.3	46
Video	-----	---	.2	1	31.5	16	5.4	7	65.6	12	9.0	3
Total	-----	---	16.9	100	202.6	100	75.5	100	548.0	100	274.0	99

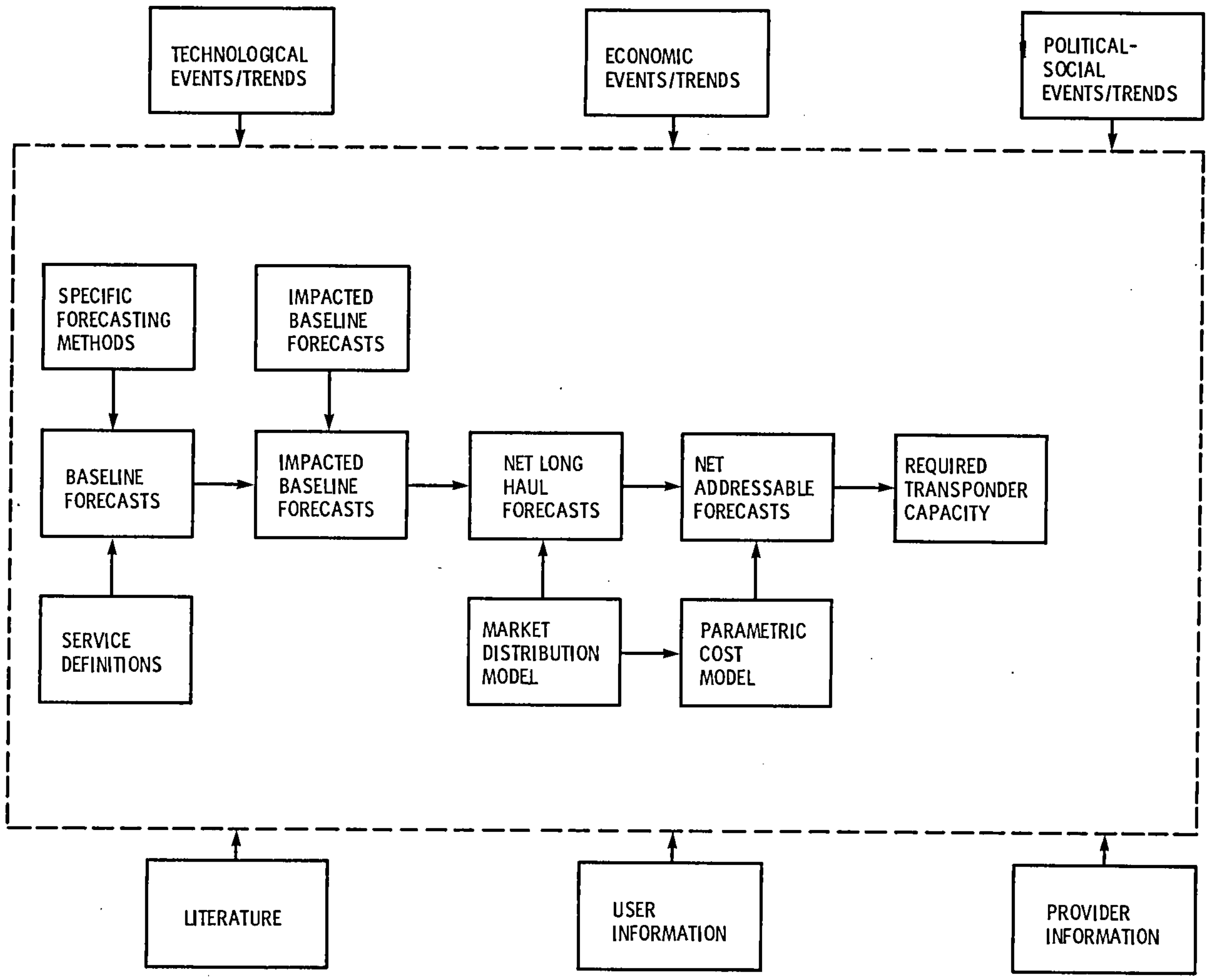

Figure 1. - Overall forecasting methodology: Western Union trunking services study.

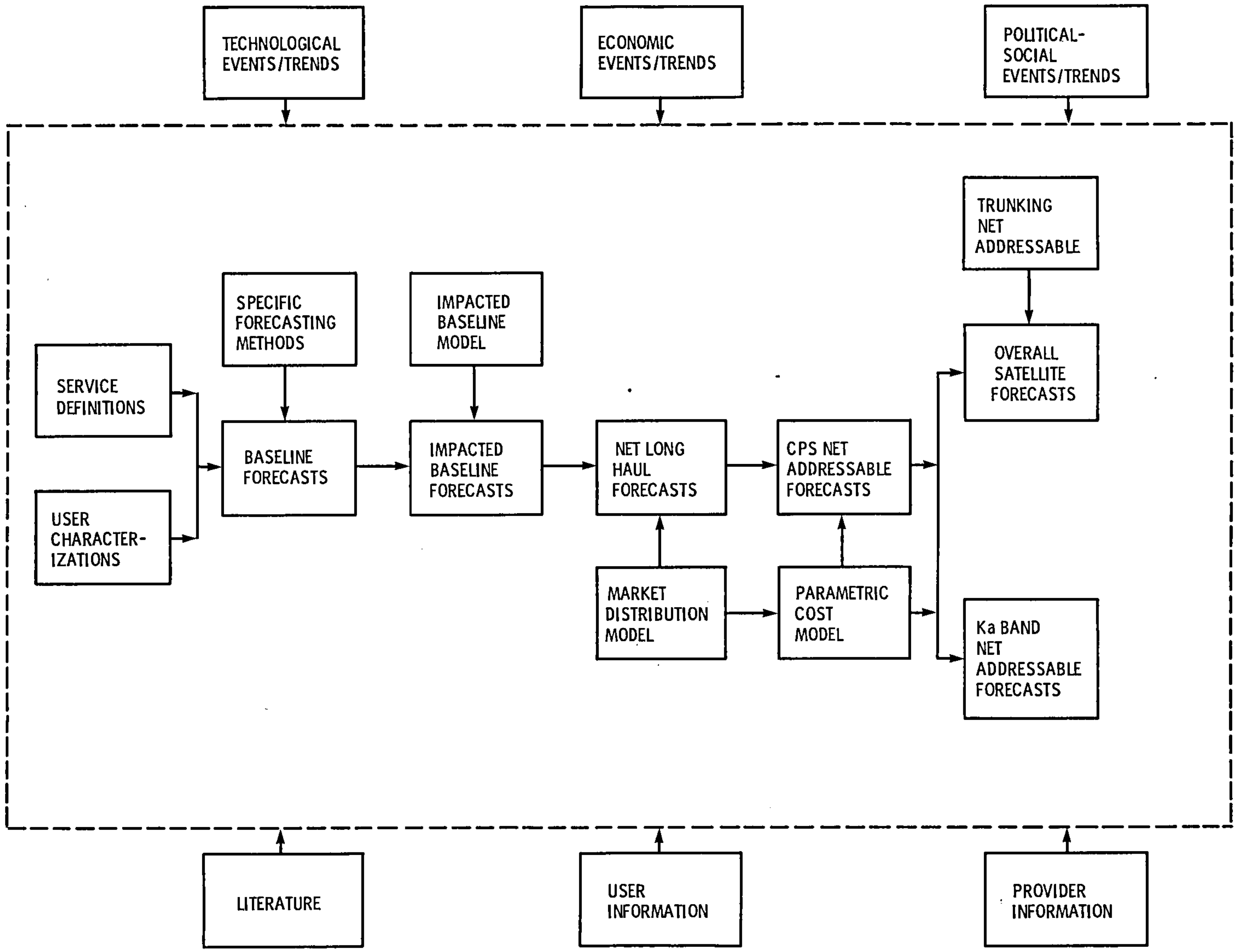

Figure 2. - Overall forecasting methodology: Western Union customer premises services study.

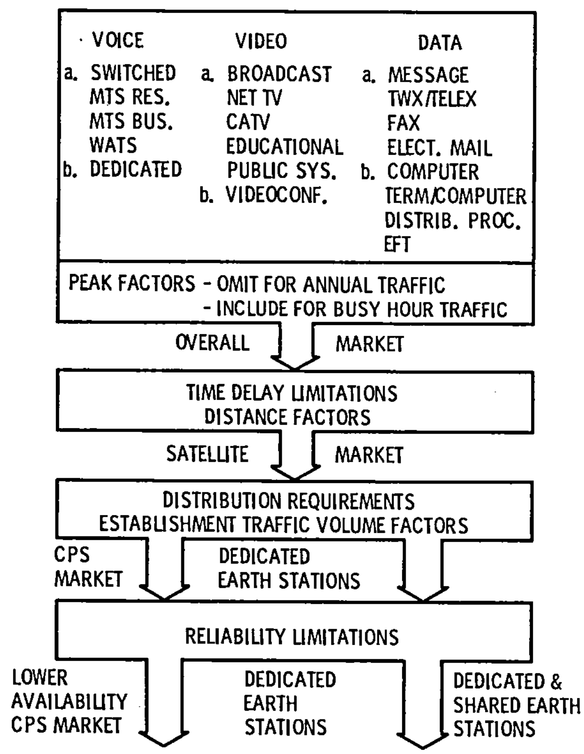

Figure 3. - Overall forecasting methodology: ITT customer premises services study.

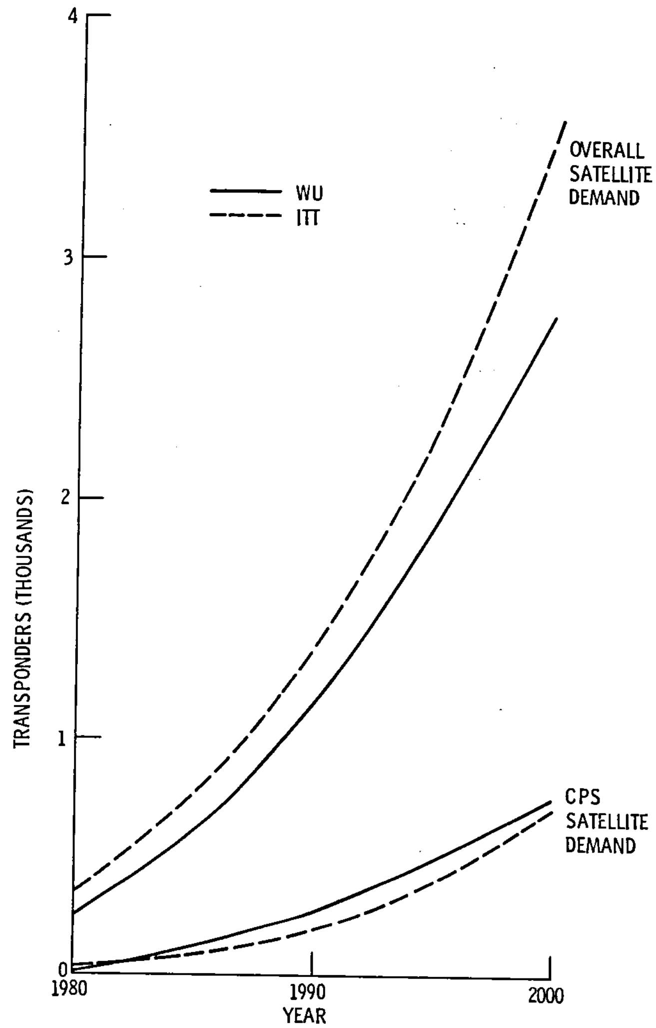

Figure 4 - Satellite and CPS satellite addressable demand (36 MHz equivalent transponders).

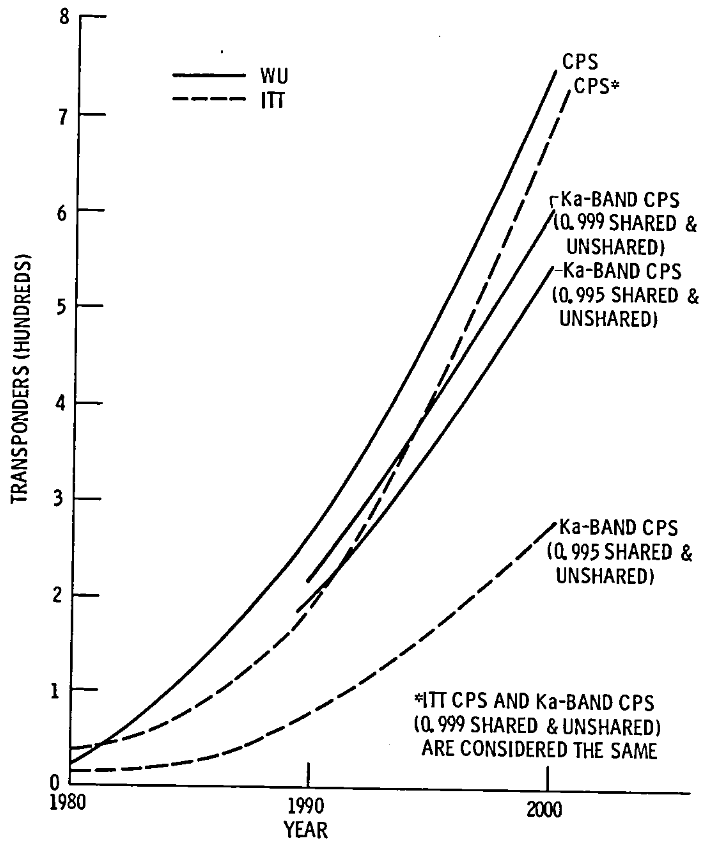

Figure 5. - CPS satellite addressable demand (36 MHz equivalent transponders).

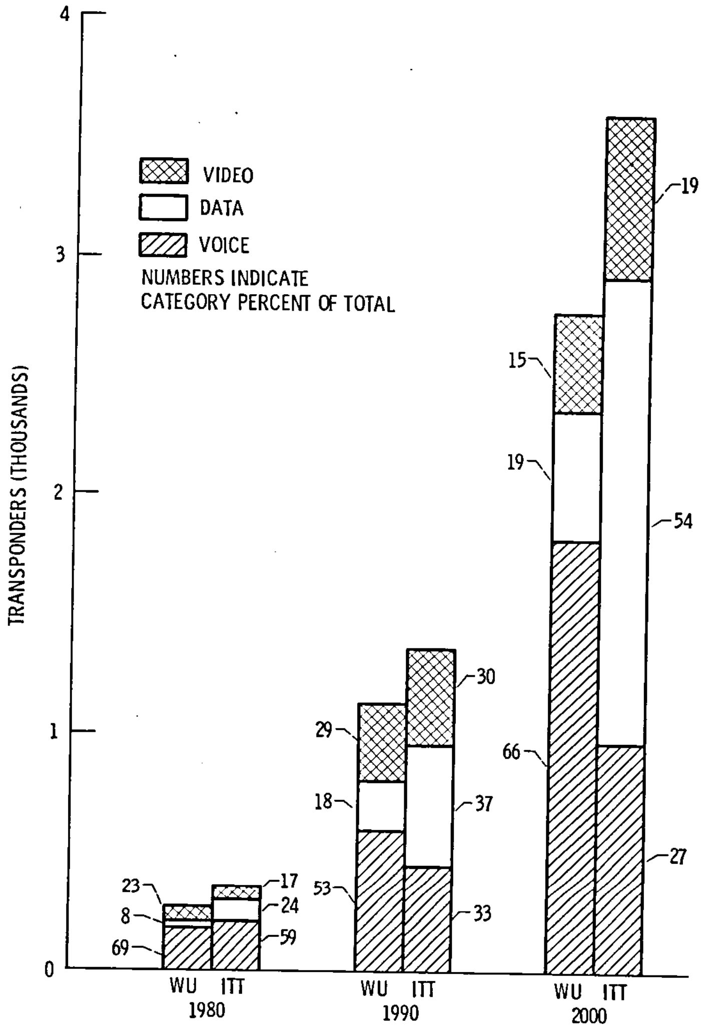

Figure 6. - Total satellite addressable demand (36 MHz equivalent transponders).

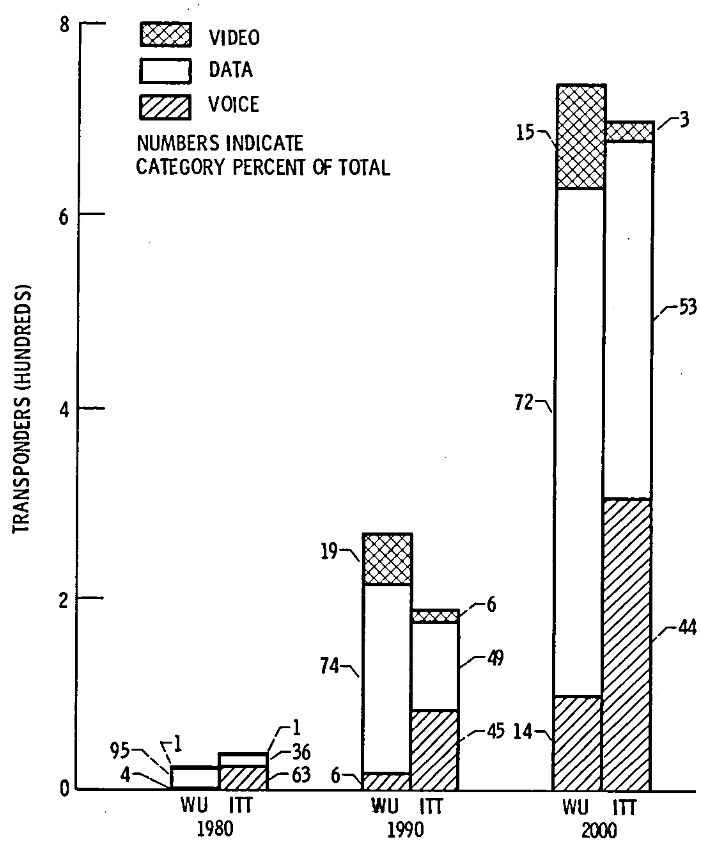

Figure 7. - CPS satellite addressable demand (36 MHz equivalent transponders).

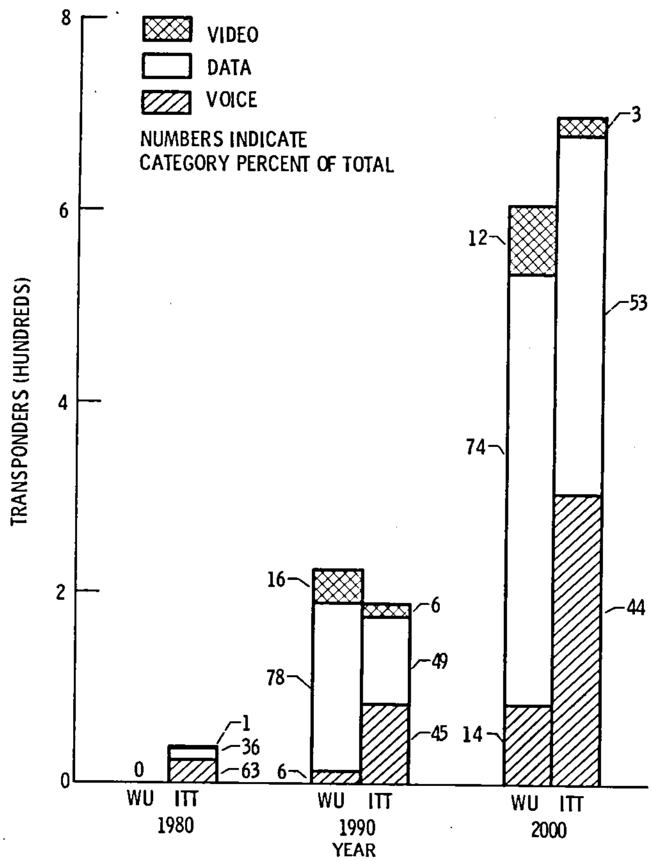

Figure 8. - Ka-band CPS addressable demand 0.999 availability; shared and unshared earth stations (36 MHz equivalent transponders).

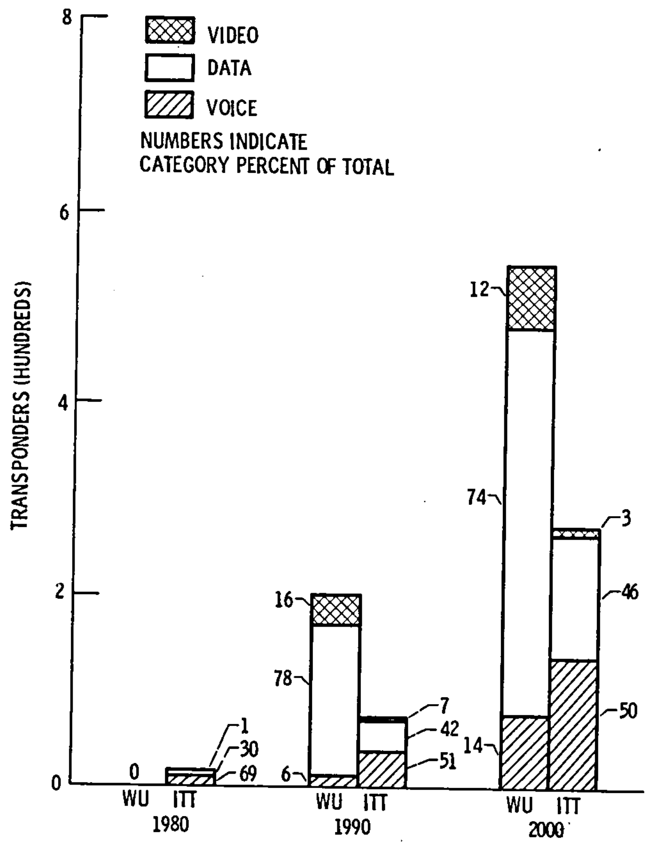

Figure 9. - Ka-band CPS addressable demand 0.995 availability; shared and unshared earth stations (36 MHz equivalent transponders).

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16. Abstract
The methodologies and results of three NASA-sponsored market demand assessment studies are presented and compared. The focus of these studies (performed by the Western Union Telegraph Company - WU and the International Telephone and Telegraph Corporation - ITT) was the demand for the U.S. domestic fixed telecommunications services. Forecasts of future satellite addressable traffic (both trunking and customer premises services) were developed for the three main service categories of voice, data and video and subcategories thereof for the benchmark years of 1980, 1990 and 2000. The contractor results are presented in this report on a service by service basis in two formats: equivalent 36 MHz transponders and basic transmission units (voice: half-voice circuits, data: megabits per second and video: video channels). It is shown that while considerable differences exist at the service category level, the overall forecasts by the two contractors are quite similar. ITT estimates the total potential satellite market to be 3594 transponders in the year 2000 with data services comprising 54 percent of this total. The WU outlook for the same time period is 2779 transponders with voice services accounting for 66 percent of the total. Both companies estimate the customer premises services market in the year 2000 to be approximately 700 transponders.

17. Key Words (Suggested by Author(s))
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