NASA CR-168270
Com 21-384-T6

(NASA-CR-168270) STUDY TO FORECAST AND DETERMINE CHARACTERISTICS OF WORLD SATELLITE COMMUNICATIONS MARKET (Communimetrics, Inc.) 112 p HC A06/MF A01 CSCL 17B G3/32

N84-16426

Unclas
18151

WORLD COMMUNICATIONS SATELLITE MARKET

CHARACTERISTICS AND FORECAST

by

R. Filep, A. Schnapf, and S. Fordyce

COMMUNICATIONS 21 CORPORATION

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA Lewis Research Center

Contract NAS 3-23782

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CR 168270		

4. Title and Subtitle	5. Report Date
Study to forecast and determine characteristics of World Satellite Communications market	November, 1983
	6. Performing Organization Code
7. Author(s) Dr. Robert T. Filep, Abraham Schnapf and Samuel W. Fordyce	8. Performing Organization Report No.
	10. Work Unit No.
9. Performing Organization Name and Address Communications 21 Corporation Suite 206 1611 South Pacific Coast Highway Redondo Beach, CA 90277	11. Contract or Grant No. NAS 3-23782
	13. Type of Report and Period Covered Contractor Report
12. Sponsoring Agency Name and Address NASA - Lewis Research Center 21000 Brookpark Road Cleveland, OH 44135	14. Sponsoring Agency Code

15. Supplementary Notes

Project Manager, David Namkoong, Communications Section, NASA Lewis Research Center, Cleveland, Ohio, Volumes, 1

16. Abstract

The project focused upon the world commercial communications satellite market during the spring and summer of 1983 and developed characteristics and forecasts of the market extending to the year 2000. Past, present and planned satellites were documented in relation to frequencies, procurement and launch dates, costs, transponders, and prime contractor. Characteristics of the market were outlined for the periods 1965 - 1985, 1986 - 1989, and 1990 - 2000. Market share forecasts, discussions of potential competitors in various world markets, and profiles of major communication satellite manufacturing and user countries are documented.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Communication Satellites, World Market Forecast, Frequency Bands, Satellite characteristics, Expenditure levels, National communication satellite activies.	Unclassified

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	112	

* For sale by the National Technical Information Service, Springfield, Virginia 22161

NASA-C-168 (Rev. 10-75)

WORLD COMMUNICATIONS SATELLITE MARKET
CHARACTERISTICS AND FORECAST

TABLE OF CONTENTS

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE OF CONTENTS (Continued)

FIGURES

TABLES

I. SUMMARY

PROJECT OBJECTIVES

The overall objective of the project is to describe and forecast characteristics of the world communications satellite market up to the year 2000. The specific project tasks are:

1. Document Events To Date

Task 1 identifies the communications satellites operating worldwide and tabulates the quantifiable data that exist in the historical files regarding each satellite. Data include procurement and launch dates, fixed service bands (C, Ku, and Ka), DBS bands, other advanced frequencies, satellite prime contractor, and satellite cost whenever available. If actual costs are not available, reliable estimates are provided.

2. Market Forecast

Task 2 develops a forecast of the worldwide commercial communications satellite market for the period up to 1990 and the period up to 2000. This forecast:

a) Includes expenditures for the total communications satellite systems by frequency band types (C, Ku, Ka, DBS bands, and advanced frequencies).

b) Estimates the portion of the above expenditures that are expected to be provided by the manufacturers within the country originating the system (domestic), and the portion expected to be supplied by foreign manufacturers.

c) Documents present and potential future suppliers of communications satellite systems by frequency band types and services, both U.S. and foreign.

3. Forecast Potential Competitors

Using the data from Task 2, Task 3 estimates the market share of each of the potential competitors in the world communications satellite market according to frequency band types and according to whether the supplier is domestic or foreign.

The past and planned expenditures for communication satellites commencing in 1965 and extending to the year 2000 are estimated to be 19 billion 266 million dollars. A potential 409 commercial communication satellite launches will have been recorded during the thirty-five year period. During the first third of time reported upon, two nations the United States and Canada, and the international organization INTELSAT, were the primary entities involved in the procurement and utilization of communication satellites. By the 1990's twenty countries and eight regional organizations will be participating as owners or operators of communications satellites.

Patterns of use of various frequency bands for transmission from communication satellites, in the period to 1985 show that the four billion expended for satellites was primarily for C-band or single frequency capacity. Forecasts for the duration after 1990 reflect planned expenditures for spacecraft of eight and one-half billion dollars with multiple frequency capacity such as C/Ku band accounting for almost sixty percent of the total. The advent of the 80's was direct-broadcast satellite use in the Ku-band. This commercial service continues to be seen as expanding. Approximately one-fifth of the planned expenditures after 1985 are for this type of satellite.

A detailed table is provided of all the past, present, and projected satellites from 1965 to 2000. Date of procurement and launch, cost per satellite, actual and equivalent transponders, design lifetime and prime contractor are provided.

Profiles are also provided of the major countries in the world market, other than the United States, involved in the production and/or use of commercial communication satellites. Information pertaining to the history, major firms engaged in spacecraft or component production and their proposed plans, as well as brief profiles of countries which are major operators of communication satellite systems are included.

II. INTRODUCTION

The world commercial communications satellite market officially started in 1965 with the launch of INTELSAT I-I and the subsequent voice service at C-band over that satellite. Seventy western commercial satellites have been successfully launched since that date, and many more are under contract or planned. Section IV includes a comprehensive list of the commercial satellites that have been launched since that year by country or organization, year of contract, cost per satellite, official designation of the satellite, frequency band or bands, transponder capacity, and prime contractor. By the year 2000 as many as 400 communications satellites or their equivalents will have been launched.

PROJECT OBJECTIVES

The overall objective of this project is to describe and forecast characteristics of the world communications satellite market up to the year 2000. The specific project tasks are listed below.

1 - Document Events to Date

Task 1 identifies the communications satellites operating worldwide and tabulates the quantifiable data that exist in the historical files regarding each satellite. Data include procurement and launch dates, fixed service bands (C, Ku, and Ka), DBS bands, other frequency bands, satellite prime contractor, and satellite cost whenever available. If actual costs are not available, reliable estimates are provided.

2 - Market Forecast

Task 2 develops a forecast of the worldwide commercial communications satellite market for the period up to 1990 and the period up to 2000. This forecast:

(a) Includes expenditures for the total communications satellite systems by frequency band types (C, Ku, Ka, DBS bands, and other frequency bands).

(b) Estimates the portion of the above expenditures that are expected to be provided by the manufacturers within the country originating the system (domestic), and the portion expected to be supplied by foreign manufacturers.

(c) Documents present and potential future suppliers of communications satellite systems by frequency band types and services, both U.S. and foreign.

3 - Forecast Potential Competitors

Using the data from Task 2, Task 3 estimates the market share of each of the potential competitors in the world communications satellite market according to frequency band types and according to whether the supplier is domestic or foreign.

DOCUMENTATION AND ANALYSIS PERIODS

In an attempt to reflect the activities to the present, the time period from 1965 to 1985 was selected as the initial category. Since procurement and construction of satellites must be started at least 30 to 36 months before launch, satellites scheduled for deployment and use in 1985 are already underway. The second period selected for examination was 1986 to 1989. Numerous filings with the International Telecommunications Union for satellite positions in the geostationary orbit have been made. Within the United States, potential procurement of direct broadcast and fixed-service satellites in the Ku frequency band have been announced, or formal applications have been vested with the U.S. Federal Communications Commission. Consequently, this time period may reflect a great deal of activity in the world market when planning is finalized. Yet, even at this writing, not all endeavors have been announced nor procurement of all satellite systems consummated. Thus the data used to characterize this time period and to develop the forecasts are not entirely complete.

The third period of study extends from 1990 to 2000. In this time frame, communications satellite use is not well defined nor are plans for communications satellite systems known, let alone publicly announced. However, projections and extrapolations can be made by estimating replacements for systems that will exhaust their design life in the 1990's and by examining the new systems that have been announced for deployment in the 1990's such as the INTELSAT VII series.

The sections that follow are organized according to the three time periods and reflect the activity to date and the market forecasts. Sections then follow that (1) provide profiles of the communications satellite activities in the major countries involved in the market, (2) describe the specific characteristics of communications satellites that have been launched since 1965 or are planned for launch through the year 2000, and (3) discuss the potential competitors in the world market.

INTERNATIONAL AND REGIONAL TELECOMMUNICATIONS ORGANIZATIONS

International and regional telecommunications organizations are not manufacturers of satellite systems or components. They do, however, play an important role in the world market since they determine specific frequency bands, service requirements, and spacecraft characteristics; fund research and development activities; and are key participants in the characteristics and performance specifications of terrestrial systems and earth stations. The member nations of these regional and international organizations that have aerospace or electronics industries play an especially important role in the world market since they are both members of these organizations and since they compete individually in the world market. The international and regional organizations are treated in this report as major participants, but they are factored out where appropriate in analyzing and forecasting solely national activities.

The International Telecommunications Satellite organization (INTELSAT) owns, maintains, and operates satellites in a global satellite system used by countries around the world for international public telecommunications services. Capacity in the INTELSAT satellite system is also available for domestic public telecommunications services. The INTELSAT V's, the fifth generation of INTELSAT, are currently being launched. These satellites and their successors, the INTELSAT VI's, are currently built by manufacturers in the United States; however, many of the subsystems are built abroad.

The International Maritime Satellite organization (INMARSAT) provides communications via satellite to shipping and off-shore marine platforms around the world. Its headquarters are in London, and it is financed by 38 nations with merchant fleets. The organization was created in 1979 and took over the Marisat service in 1982, which had been organized to service maritime requirements. Three Marisat satellites were built by Hughes Aerospace Corporation on orders from Comsat Corporation; these were launched in 1976. These satellites use C-band links between the satellites and the earth stations, and L-band links between the satellites and the ships. The Marisats were augmented by a Marecs satellite, built by British Aerospace on orders from the European Space Agency in 1981. A Maritime package is incorporated on four of the INTELSAT V's, the first of which was launched in 1982. In the near future, INMARSAT plans to replace the present satellites with second-generation satellites that will be operational in 1988.

The European Telecommunications Satellite organization (EUTELSAT) was created in 1977 under agreements signed by 17 members of the European Conference of Postal and Telecommunications Administrations (CEPT). Its purpose is to establish and operate a regional European telecommunications satellite system. At present, there are 20 members of EUTELSAT. The organization's headquarters are in Paris.

The European Communications Satellite (ECS), the prime space vehicle for EUTELSAT, was developed from the experimental Orbital Test Satellite (OTS). ECS-1 was launched in June 1983 on the Ariane L-6 launch vehicle. It is used for distribution of television throughout Europe plus the interchange of trunk traffic through three spot beams. ECS-2 and ECS-3 are scheduled for launch in 1984 and 1985.

MAJOR COMMUNICATIONS SATELLITE COUNTRIES

Subsequent to the initial work in Canada and the United States, other countries in Europe and Asia have become active in the development of communication satellites or their major components. A review of these developments is provided in Section VII. The work of certain European countries and Japan reflects high levels of activity and expenditures and are treated in considerable detail.

A discussion of market share capture by various spacecraft manufacturers is provided in Section VIII followed by a brief discussion of the scenarios that might affect the forecasts through the year 2000, in Section IX.

It is hoped that this report will deepen an understanding of the activities and characteristics of the commercial communications satellite field to the present and will be helpful in planning for the future.

III. WORLDWIDE COMMUNICATION SATELLITE ACTIVITIES THROUGH 1985

ESTIMATED WORLDWIDE INVESTMENT

A considerable allocation of funds to communication satellites was and will be made by the United States and Canada from 1965-1985, with INTELSAT also being an exceptionally active participant. Early entrants include Indonesia, with the initiation of its Palapa system, and Japan. Later entrants with comparable levels of expenditures include France and the European regional system EUTELSAT. Figure 1 shows the levels of expenditures and the launches conducted by each major participant country, region, or international organization. The data used to construct the charts and graphs were derived from Table I, Section IV. Estimated cost per satellite has been adjusted for inflation to 1983 dollars based upon the NASA R&D escalation index (Fy'83 Baseline). The years referred to are the launch year as contrasted to the procurement year.

EXPENDITURE BY FREQUENCY BAND

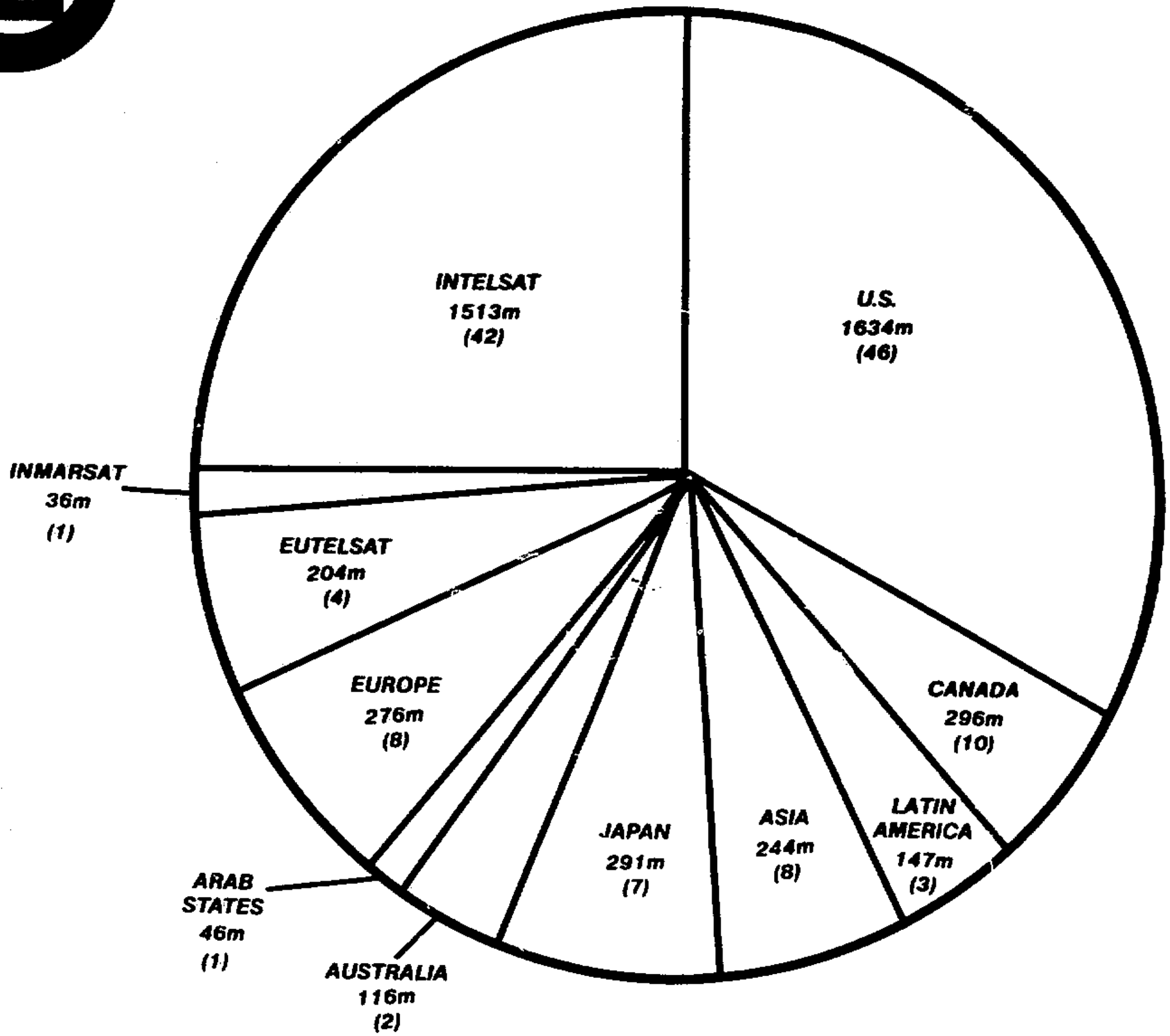
The total expenditures for purchase of the space segment exclusively amounted to over 4 billion dollars during the 20-year period. As indicated in Figure 2, almost 40 percent of the satellites and close to 50 percent of the investment was for C-band capacity, which was one of the initial frequency bands used for communications satellite transmission.

SATELLITES LAUNCHED BY FREQUENCY BAND

Figure 3 provides profiles of satellite activity in relation to frequency band in three separate time periods encompassing the 20 years from 1965. The first 10 years saw construction of satellites using the C-band frequency exclusively. The latter two periods reflect the use of C-band in combination with other frequency bands such as Ku, Ka, L and

fig.1

ESTIMATED WORLDWIDE INVESTMENT IN COMMERCIAL COMMUNICATION SATELLITES 1965 - 1985



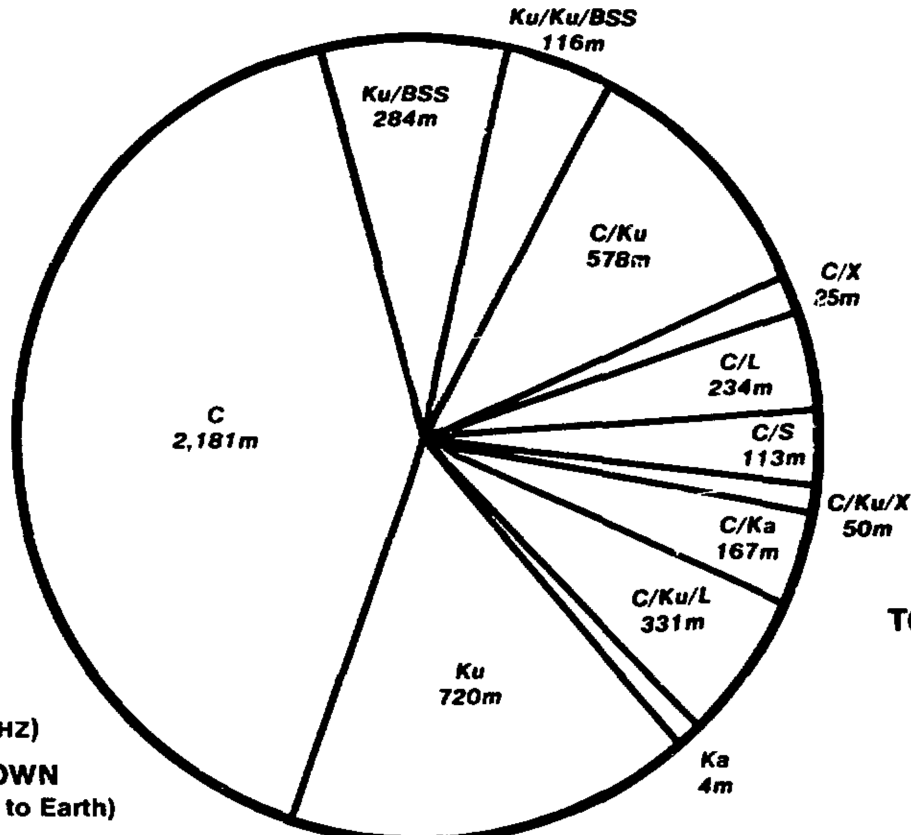
TOTAL EXPENDITURES
$4,803m

LAUNCHES (132)

* DOES NOT INCLUDE THE SOVIET UNION

fig.2

EXPENDITURES FOR COMMUNICATION SATELLITES BY *FREQUENCY BAND* 1965 - 1985



ORIGINAL PAGE IS OF POOR QUALITY

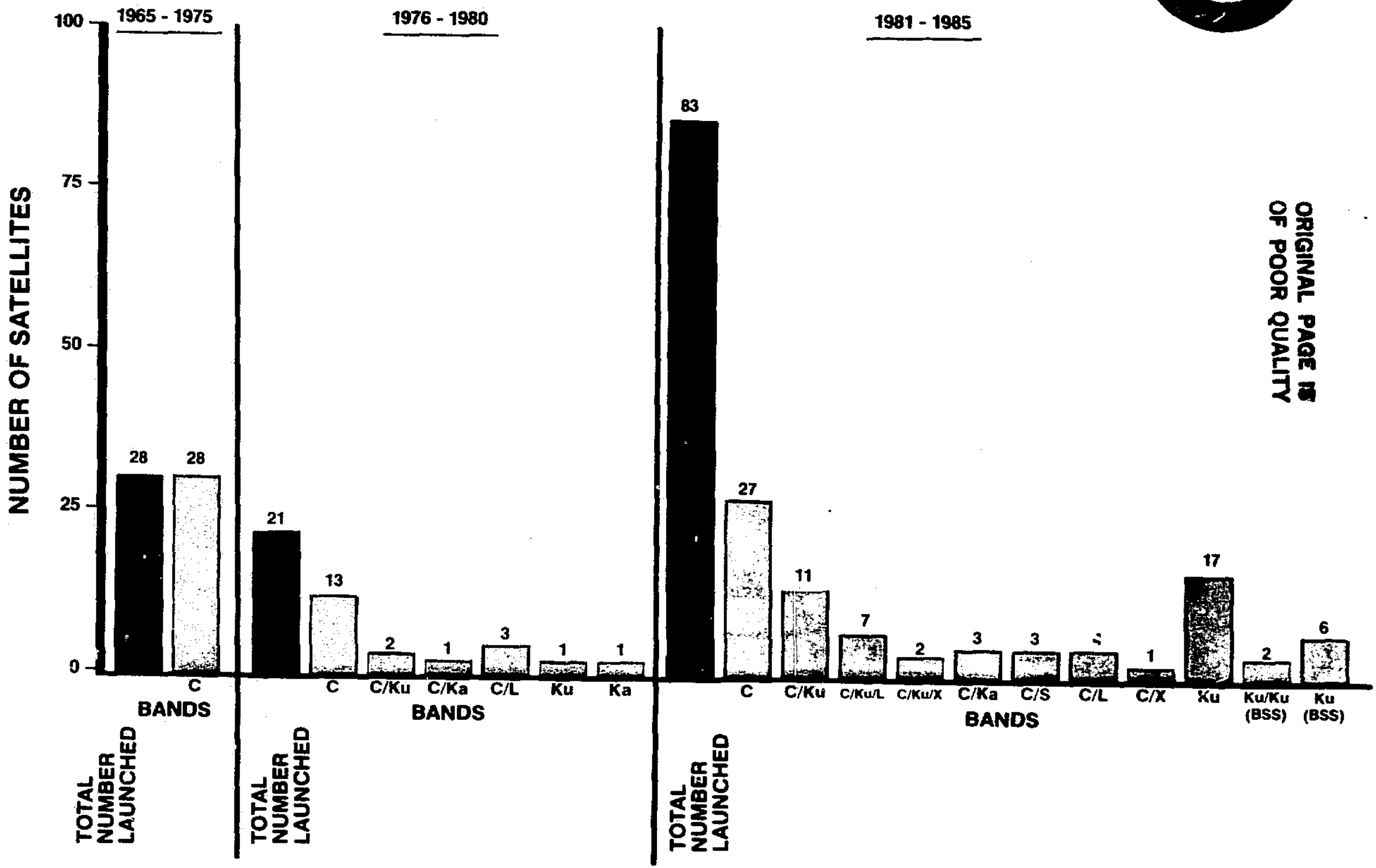
TOTAL EXPENDITURES $4,803m

FREQUENCY BANDS (GHz)

BAND	UP (Earth to Space)	DOWN (Space to Earth)
L	1.6365 - 1.645	1.535 - 1.5435
S		2.5 - 2.69
C	5.925 - 6.4.25	3.7 - 4.2
Ku	14.0 - 14.5	11.7 - 12.2
Ku (BSS)	17.3 - 17.8	12.2 - 12.7
Ka	27.5 - 31.0	17.7 - 21.2

fig.3

SATELLITES LAUNCHED OR PLANNED IN VARIOUS FREQUENCY BANDS 1965 - 1985



ORIGINAL PAGE IS OF POOR QUALITY

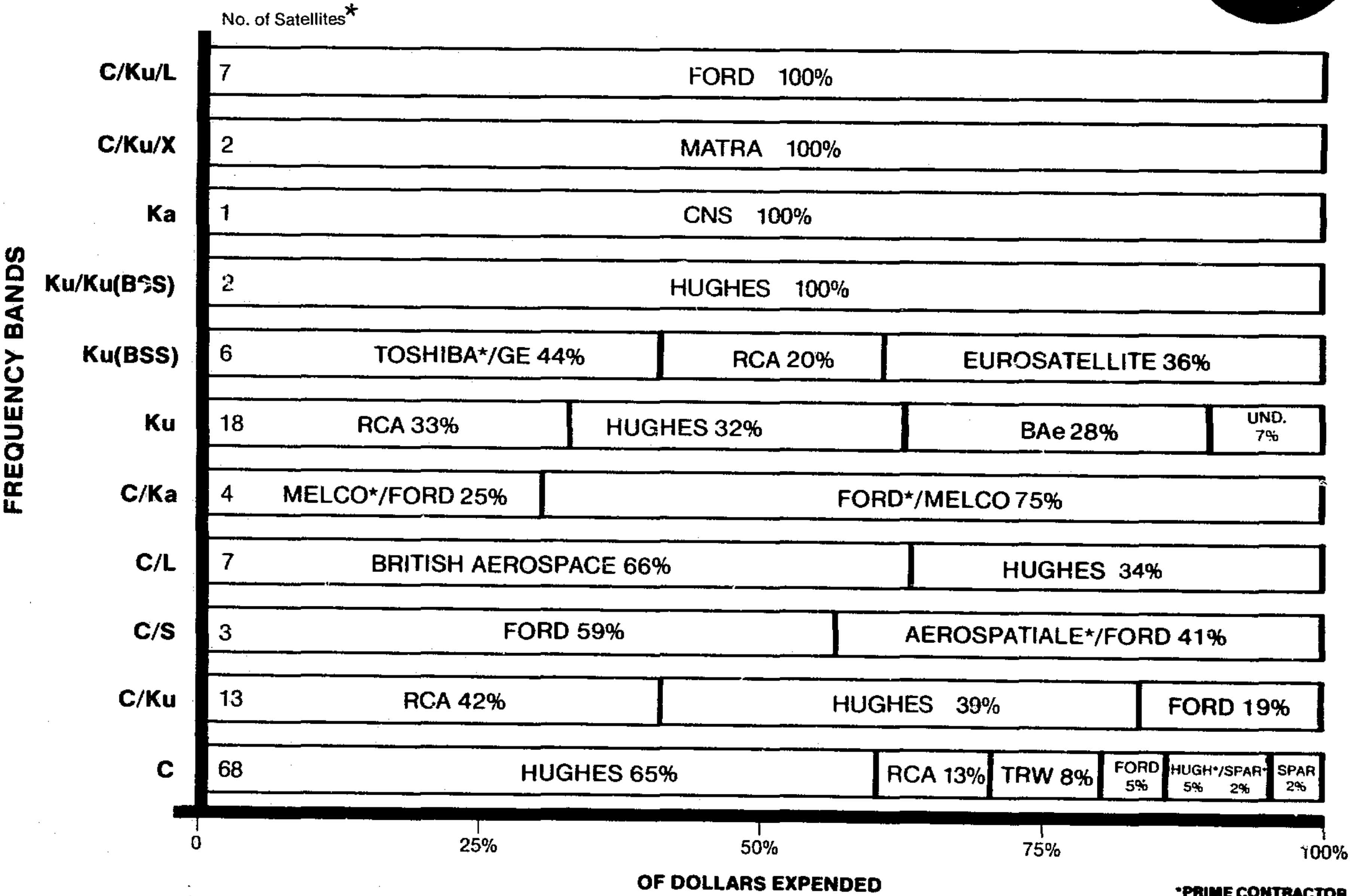
satellites with frequency bands devoted solely to Ku and Ka band. The period from 1981 forward witnessed the advent of direct broadcast satellites in the Ku (BSS) designation.

SATELLITE MARKET SHARE BY FREQUENCY BAND

The participation of various companies in the manufacture of communications satellites and their respective market share makes for interesting patterns. A market share activity in different bands is reflected in Figure 4. The Hughes organization commands an important portion of most of the C-band related activities and also vital aspects of the C/Ku and Ku/Ku (BSS) market. Other U.S. firms such as RCA and GE, as well as European firms such as British Aerospace, were also active. The percentage share in each frequency band must be viewed in light of the total number of satellites procured in the frequency band and the level of expenditure during that time period.

fig.4

SATELLITE MARKET SHARE BY FREQUENCY BANDS 1965 - 1985



*PRIME CONTRACTOR

* C/X-1, 100% BY NON-COMMERCIAL GOVERNMENT ENTITY

ORIGINAL PAGE IS OF POOR QUALITY

IV. PAST, PRESENT AND FUTURE COMMUNICATION SATELLITES

The listing provided in Table I in this section commences with the first communication satellite launched for commercial purposes, INTELSAT I-I in the year 1965. Data are provided for satellites launched thereafter, the year of contract, launch (if successful), and estimated cost per satellit^ in 1983 dollars. Pre-1983 costs have been adjusted for inflation via the NASA R&D escalation index.

Each satellite has a designation for actual transponders and equivalent transponders. Actual transponders reflect the number of transponders which can be powered simultaneously. Actual transponder and equivalent transponder definitions are both provided on the first page of Table I. Frequency bands are provided for all satellites listed as well as design lifetime and prime contractor of the spacecraft, when known. The cost, numbers of transponders, and design life for all satellites for whom formal filings have not been made, proposal requests issued, or are not yet under contract, are estimates.

The table was constructed from many resource documents which are listed in the reference section, via personal and telephone interviews with individuals directly involved with the operation or construction of a specific communications satellite or series in the U.S. and other countries, representatives of the Federal Communication Commission (F.C.C.), International Telecommunications Union (I.T.U.), and other government or international agencies which deal with communications satellites, as well as members of the international or regional organization such as INTELSAT, European Space Agency (ESA), EUTELSAT, ARABSAT, and others.

Commencing with the listing for 1985, a probability of occurrence rating is indicated for any satellite which may not be under contract and for whom questions are still unanswered or data unknown relating to its launch. A low probability of occurrence is indicated by a .5, a modest level of occurrence via a .7 and if no probability is indicated it has been assumed that the satellite will be launched. Unless otherwise indicated, a satellite is assumed to have a high probability of occurrence.

The rapidly changing nature of this field and the tenuous nature of forecasting, let alone prophesying future events relating to communications satellite activity, would suggest that all satellites scheduled for 1990 and forward should be rated as low probability events. However, in order to provide some structure and definition to the possible events in the 90's timeframe, all satellites were presumed to be possible and the above described ratings applied to the earlier periods. The authors careful calculations and clinical judgments of statistical and factual data obtained during the course of this project, and their combined sixty years of experience working in the field of communications satellites provide the basis of the estimates in the accompanying graphs.

TABLE I

As of September 1, 1983

PAST, PRESENT AND FUTURE COMMERCIAL SATELLITES

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER SATELLITE	(M$)'83 Cost	SATELLITE	ACTUAL** TRANS-PONDERS	E.T.***	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR
INTELSAT	1965	1964	10	16	I-I	2	1	C	1.5	Hughes
INTELSAT		1965	4	13	I-II F1*	1	2	C	--	Hughes
INTELSAT	1967	1965	4	13	I-II F2	1	2	C	3	Hughes
	1967	1965	4	13	I-II F3	2	2	C	3	Hughes
	1967	1965	4	13	I-II F4	1	2	C	3	Hughes
INTELSAT		1966	8	22	I-III F1*	2	4	C	--	TRW
	1968	1966	8	22	I-III F2	2	4	C	5	TRW
INTELSAT	1969	1966	8	22	I-III F3	2	4	C	5	TRW
	1969	1966	8	22	I-III F4	2	4	C	5	TRW
		1966	8	22	I-III F5*	2	4	C	--	TRW
INTELSAT	1970	1966	8	22	I-III F6	2	4	C	5	TRW
	1970	1966	8	22	I-III F7	2	4	C	5	TRW
		1966	8	22	I-III F8*	2	4	C	--	TRW
INTELSAT	1971	1968	15	39	I-IV F2	12	12	C	7	Hughes
	1971	1968	15	39	I-IV F3	12	12	C	7	Hughes
CANADA	1972	1970	12	23	ANIK A-1	12	12	C	7	Hughes
INTELSAT	1972	1968	15	39	I-IV F4	12	12	C	7	Hughes
	1972	1968	15	39	I-IV F5	12	12	C	7	Hughes
CANADA	1973	1970	12	23	ANIK A-2	12	12	C	7	Hughes
INTELSAT	1973	1968	15	39	I-IV F7	12	12	C	7	Hughes
		1968	15	39	I-IV F6*	--	--	C	--	Hughes
U. S.	1974	1972	11	23	WESTAR-1	12	12	C	7	Hughes
	1974	1972	11	23	WESTAR-2	12	12	C	7	Hughes
INTELSAT	1974	1968	15	39	I-IV F8	12	12	C	7	Hughes
U. S.	1975	1973	11	45	SATCOM-F1	24	24	C	7	RCA

* Failure, at launch or shortly thereafter.

** Actual Transponders are the number of transponders which can be powered simultaneously. Many of the newer satellites carry additional spare transponders which can be switched to replace failed transponders.

*** "Equivalent" Transponders have r-f band widths of approximately 36MHz, and have EIRP's of about +35 dBw in the antennae "footprint". They can relay one TV signal or approximately 1000 voice circuits between earth stations with G/T = 29 dB/K.

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER(M$) SATELLITE	'83 COST	SATELLITE	ACTUAL TRANS-PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR
CANADA	1975	1970	12	23	ANIK A-3	12	12	C	7	Hughes
INTELSAT		1968	15	39	I-IV F6*	12	12	C	--	Hughes
	1975	1968	23	39	I-IVA F1	20	20	C	7	Hughes
U. S.	1976	1973	13	26	MARISAT-1	1/1	n/a	C/L	8	Hughes
	1976	1973	11	45	SATCOM-F2	24	24	C	7	RCA
	1976	1973	16	34	COMSTAR-D1	24	24	C	7	Hughes
	1976	1973	13	26	MARISAT-2	1/1	n/a	C/L	8	Hughes
	1976	1973	15	54	COMSTAR-D2	24	24	C	7	Hughes
	1976	1973	13	26	MARISAT-3	1/1	n/a	C/L	8	Hughes
INDONESIA	1976	1975	12	16	PALAPA-1	12	12	C	7	Hughes
INTELSAT	1976	1973	23	39	I-IVA F2	20	20	C	7	Hughes
INDONESIA	1977	1975	12	16	PALAPA-2	12	12	C	7	Hughes
JAPAN	1977	1975	35	54	SAKURA-1	2/6	16	C/Ka	3	Ford/Melco
ITALY	1977	1973	3	4	SIRIO-1	1	1	Ka	2	C.N.S.
INTELSAT	1977	1973	20	37	I-IVA F4	20	20	C	7	Hughes
		1973	20	39	I-IVA F5*	20	20	C	--	Hughes
U. S.	1978	1973	16	34	COMSTAR-D3	24	24	C	7	Hughes
CANADA	1978	1976	20	30	ANIK-B	12/6	24	C/Ku	7	RCA
INTELSAT	1978	1973	20	39	I-IVA F3	20	20	C	7	Hughes
	1978	1973	20	37	I-IVA F6	20	20	C	7	Hughes
U. S.	1979	1972	8	23	WESTAR-3	12	12	C	7	Hughes
		1973	11	45	SATCOM-3*	24	24	C	--	RCA

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER(M$) SATELLITE	'83 COST	SATELLITE	ACTUAL TRANS-PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR
INTELSAT	1980	1976	36	54	I-V F2	21/6	27	C/Ku	7	Ford
U. S.	1980	1978	23	29	SBS-1	10	12	Ku	7	Hughes
U.S.	1981	1973	16	34	COMSTAR-D4	24	24	C	7	Hughes
	1981	1978	23	29	SBS-2	10	12	Ku	7	Hughes
	1981	1979	17	23	SATCOM-3R	24	24	C	10	RCA
FRANCE	1981	1973	40	46	MARECS-A	1/1	n/a	C/L	7	BAe
INTELSAT	1981	1976	36	54	I-V F1	21/6	27	C	7	Ford
	1981	1976	36	54	I-V F3	21/6	27	C	7	Ford
U. S.	1982	1979	17	23	SATCOM-4	24	24	C	10	RCA
	1982	1980	25	26	WESTAR-4	24	24	C	10	Hughes
	1982	1980	25	26	WESTAR-5	24	24	C	10	Hughes
	1982	1979	24	24	SATCOM-5	24	24	C	10	RCA
	1982	1978	23	29	SBS-3	10	12	Ku	7	Hughes
CANADA	1982	1977	23	31	ANIK-C3	16	24	Ku	8	Hughes
	1982	1979	39	23	ANIK-D1	24	24	C	9	Hughes/Spar
INDIA		1978	30	36	INSAT-1A*	12/2	14	C/S	--	Ford
INTELSAT	1982	1976	35	54	I-V F4	21/6/1	27	C/Ku	7	Ford
	1982	1976	42	54	I-V F5	21/6/1	27	C/Ku/L	7	Ford
FRANCE		1979	35	38	MARECS-B*	1/1	n/a	C/L	--	BAe
INTELSAT	1983	1976	42	54	I-V F6	21/6/1	27	C/Ku/L	7	Ford
	1983	1976	42	54	I-V F7	21/6/1	27	C/Ku/L	7	Ford
	1983	1980	42	31	I-V F8	21/6/1	27	C/Ku/L	7	Ford

ORIGINAL PAGE IS OF POOR QUALITY

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER(M$) SATELLITE	'83 COST	SATELLITE	ACTUAL TRANS-PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR
U. S.	1983	1979	24	24	SATCOM-IR	24	24	C	10	RCA
	1983	1980	44	45	TELSTAR-301	24	24	C	10	Hughes
	1983	1979	17	23	SATCOM-2R	24	24	C	10	RCA
	1983	1981	37	37	GALAXY-I	24	24	C	9	Hughes
	1983	1981	37	38	GALAXY-B	24	24	C	9	Hughes
INDONESIA	1983	1980	40	41	PALAPA-B1	24	24	C	8	Hughes
CANADA	1983	1980	23	31	ANIK-C-2	16	24	Ku	8	Hughes
JAPAN	1983	1980	35	36	SAKURA-2A (CS-2a)	2/6	36	C/Ka	3	Ford/Melco
	1983	1980	35	36	SAKURA-2B (CS-2b)	2/6	36	C/Ka	3	Ford/Melco
FRANCE	1983	1979	35	36	MARECS-C	1/1	n/a	C/L	7	BAe
EUTELSAT	1983	1980	50	51	ECS-1	12	24	Ku	7	BAe
INDIA	1983	1978	30	31	INSAT-IB	12/2	14	C/S	7	Ford
FRANCE	1984	1980	24	25	TELECOM-1A	4/6/2	16	C/Ku/X	7	Matra
	1984	1980	24	25	TELECOM-1B	4/6/2	16	C/Ku/X	7	Matra
JAPAN	1984	1982	41	42	BS-2A (YURI-B)	2	n/a	Ku(BSS)	3	Toshiba/GE
INTELSAT	1984	1980	45	46	I-V F9	21/6/1	27	C/Ku/L	7	Ford
	1984	1980	45	46	I-VA F10	32/6	38	C/Ku/L	7	Ford
	1984	1980	45	46	I-VA F11	32/6	38	C/Ku/L	7	Ford
U. S.	1984	1981	40	41	SPACENET-A	18/6	36	C/Ku	8.5	RCA
	1984	1983	23	23	SBS-4	10	12	Ku	10	Hughes
	1984	1981	28	29	WESTAR 6	24	24	C	10	Hughes

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER(M$) SATELLITE	'83 COST	SATELLITE	ACTUAL TRANS-PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR
U. S.	1984	1981	44	45	GSTAR-A	16	24	Ku	10	RCA
	1984	1981	44	45	TELSTAR-302	24	24	C	10	Hughes
	1984	1981	40	41	SPACENET-B	12/6	36	C/Ku	8.5	RCA
	1984	1981	25	26	WESTAR-3R	24	24	C	7	Hughes
	1984	1981	44	45	GSTAR-B	16	24	Ku	10	RCA
	1984	1981	37	38	GALAXY-C	24	24	C	9	Hughes
EUTELSAT	1984	1980	50	51	ECS-2	12	24	Ku		BAe
CANADA	1984	1980	24	24	ANIK-C1	16	24	Ku	7	Hughes
INDONESIA	1984	1980	40	41	PALAPA-B2	24	24	C	8	Hughes
ARAB STATES	1984	1981	45	46	ARABSAT-A	25/1	25	C/S	7	Aerospat/Ford
CHINA (P.R.C.)	1984	1982	25	25	STW-02	2	2	C/X	7	C.A.S.T.****
ESA/INMARSAT	1984	1981	35	36	MARECS-B 2	1/1	n/a	C/L	7	BAe
EUTELSAT	1985	1980	50	51	ECS-3	12	24	Ku	7	BAe
CANADA	1985	1979	39	41	ANIK-D2	24	24	C	9	Hughes/Spar
U. S.	1985	1982	24	24	SATCOM-6	24	24	C	10	RCA
	1985	1982	44	44	TELSTAR-303	30	24	C	10	Hughes
	1985	1981	40	41	SPACENET-C	12/6	36	C/Ku	8.5	RCA
	1985	1981	44	45	GSTAR-C	16	24	Ku	10	RCA

**** Chinese Academy of Space Technology

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER(M$)'83 SATELLITE	COST	SATELLITE	ACTUAL TRANS- PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR	P
U. S.	1985	1982	34	35	SBS-5	10	12	Ku	10	Hughes	
	1985	1982	57	58	STC-DBSA	3	n/a	Ku/(BSS)	7	RCA	
	1985	1983	50	50	SATCOM K-1	24	24	Ku	7	RCA	
	1985	1983	50	50	SATCOM K-2	24	24	Ku	7	RCA	
	1985	1983	50	50	AMERSAT-A	12/6	36	C/Ku	8.5	RCA	
	1985	1983	40	40	SPACENET-D	12/6	36	C/Ku	7	RCA	
	1985	1983	50	50	USAT-A	10	12	Ku	8		.7
INTELSAT	1985	1982	45	45	I-VA F12	32/6	36	C/Ku	7	Ford	
	1985	1982	45	45	I-VA F13	32/6	36	C/Ku	7	Ford	
	1985	1982	45	45	I-VA F14	32/6	36	C/Ku	7	Ford	
	1985	1982	45	45	I-VA F15	32/6	36	C/Ku	7	Ford	
FRANCE	1985	1981	50	51	TDF-1 F3	3	n/a	Ku(BSS)	7	Eurosatellite	.7
GERMANY	1985	1982	50	51	TV-SAT-1 D3	3	n/a	Ku(BSS)	7	Eurosatellite	
JAPAN	1985	1982	41	41	SAKURA-3	2/6	36	C/Ka	5	Melco/Ford	
	1985	1982	41	41	BS-2B	2	n/a	Ku(BSS)	3	Toshiba/GE	
	1985	1982	41	41	BS-2C	2	n/a	Ku(BSS)		Toshiba/GE	
MEXICO	1985	1982	46	47	MORELOS-A	18/4	36	C/Ku	9	Hughes	
AUSTRALIA	1985	1982	57	58	AUSSAT-A	11/4	16	Ku/Ku(BSS)	7	Hughes	
	1985	1982	57	58	AUSSAT-B	11/4	16	Ku/Ku(BSS)	7	Hughes	
EUTELSAT	1985	1981	50	51	ECS-4	12	24	Ku	7	BAe	
CANADA	1985	1983	39	44	TELESAT-H	24	24	C	8	Spar	

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER(M$) SATELLITE	'83 COST	SATELLITE	ACTUAL TRANS-PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR	P
BRAZIL	1985	1982	49	50	SBTS-1	24	24	C	10	Spar/Hughes	
	1985	1982	49	50	SBTS-2	24	24	C	10	Spar/Hughes	
INDONESIA	1985	1981	40	41	PALAPA B-3	24	24	C	8	Hughes	
UNITED KINGDOM	1986	1983*****	35		UNISAT-A	3	n/a	Ku(BSS)	10	BAe	
	1986	1983	35		UNISAT-B	[illegible]	n/a	Ku(BSS)	10	BAe	
AUSTRALIA	1986	1982	57		AUSSAT-C	11/4	16	Ku/Ku(BSS)	7	Hughes	
	1986	1982	57		AUSSAT-D	11/4	16	Ku/Ku(BSS)	7	Hughes	
ARAB STATES	1986	1981	45		ARABSAT-B	24/1	25	C/S	7	Aerospat/Ford	
INDIA	1986	1983	58		INSAT 1-C	12/2	14	C/S	7	Ford	
MEXICO	1986	1982	46		MORELOS-B	18/4	36	C/Ku	9	Hughes	
CANADA	1986	1983	39		ANIK E-1	24	24	C/Ku	10	Spar	
	1986	1983	39		ANIK E-2	24	24	C/Ku	10	Spar	
E.S.A.	1986	1981	59		L-SAT (OLYMPUS-1)	3	n/a	Ku/Ka(BSS)	5	BAe	
SWEDEN	1986	1982	42		TELE-X	3	n/a	Ku(BSS)	5	Eurosatellite	
INTELSAT	1986	1982	133		I-VI F1	36/10	46	C/Ku	10	Hughes	
	1986	1982	133		I-VI F2	36/10	46	C/Ku	10	Hughes	
	1986	1982	133		I-VI F3	36/10	46	C/Ku	10	Hughes	
U. S.	1986	1982	57		STC-DBS-B	3	n/a	Ku(BSS)	7	RCA	
	1986	1982	57		STC-DBS-C	3	n/a	Ku(BSS)	7	RCA	
	1986	1984	34		SBS-6	24	24	Ku	10	HUGHES	.7
	1986	1984	48		RSI-A	16	16	Ku	8		.7
	1986	1984	48		RSI-B	16	16	Ku	8		.7
	1986	1984	40		USSI-1	20	20	Ku	8		.7
	1986	1984	40		USSI-2	20	20	Ku	8		.7

***** Cost, numbers of transponders, and design life for all satellites for whom Formal Filings have not been made, proposal requests issued, or are not yet under contract, are estimates.

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER SATELLITE (M$)	SATELLITE	ACTUAL TRANS-PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR	[illegible]
U. S.	1986	1983	50	AMERISAT-B	18/6	36	C/Ku	10	RCA	
	1986	1984	50	STC-DBS-D	20	n/a	Ku(BSS)	8.5	RCA	
	1986	1983	40	ABCI-A	20	20	Ku	10	RCA	
	1986	1984	42	SPOTNET-1	24	20	Ku	10	RCA	
	1986	1984	42	SPOTNET-2	24	20	Ku	10	RCA	
FRANCE	1986	1983	35	TDF-2 F5	5	n/a	Ku(BSS)	7	Eurosatellite	.5
LUXEMBOURG	1986	1984	35	LUXCOM	16	16	Ku	7		.5
	1985	1984	35	LUXCOM	16	16	Ku	7		.5
U. S.	1987	1984	45	AMERISAT-C	18/6	36	Ku	8.5	RCA	
	1987	1984	55	RCA-DBS-A	3	n/a	Ku(BSS)	7	RCA	.7
	1987	1984	55	RCA-DBS-B	3	n/a	Ku(BSS)	7	RCA	.7
	1987	1984	60	USSB-DBS-A	6	n/a	Ku(BSS)	10	RCA	.7
	1987	1984	55	RCA-DBS-C	3	n/a	Ku(BSS)	10	RCA	.7
	1987	1984	24	SATCOM-8	24	24	C	10	RCA	
	1987	1984	50	SATCOM-K3	24	24	Ku	10	RCA	
	1987	1984	50	US DBS	3	n/a	Ku(BSS)	10	RCA	
	1987	1984	40	USAT-B	10	12	Ku	8		
	1987	1984	40	ABCI-B	20	20	Ku	10		
	1987	1984	35	WESTAR-R	24	24	C	10		
	1987	1984	40	US DOMSAT	24	24	C	10		
	1987	1984	80	FORDSAT	54	54	C/Ku	10	FORD	
	1987	1984	80	FORDSAT	54	54	C/Ku	10	FORD	
	1987	1984	40	US DOMSAT	24	24	C/Ku	10		
	1987	1984	44	ORION	10	12	Ku			.7
	1987	1984	50	SPOTNET-3	24	24	Ku	10		.5
	1987	1984	50	SPOTNET-4	24	24	Ku	10		.5
	1987	1983	75	DBSC-COMBO	14	n/a	Ku(BSS)	7		
	1987	1983	44	ORION	20	20	C	10		.7
UNITED KINGDOM	1987	1983	35	UNISAT-C	8	n/a	Ku(BSS)	10	BAe	.5
INTELSAT	1987	1982	133	I-VI F4	36/10	46	C/Ku	10	Hughes	
	1987	1982	133	I-VI F5	36/10	46	C/Ku	10	Hughes	
	1987	1982	67	I-VI F6	36/10	46	C/Ku	10	Hughes	
	1987	1982	67	I-VI F7	36/10	46	C/Ku	10	Hughes	

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER SATELLITE (M$)	SATELLITE	ACTUAL TRANS-PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR	P
GERMANY	1987	1984	36	DFS-A(PSTST)	12	12	Ku/Ka	7	S/M/E/A*****	
	1987	1984	36	DFS-B(PSTST)	12	12	Ku/Ka	7	S/M/E/A	
CHINA (P.R.C.)	1987	1984	35	DBS-1	2	n/a	Ku(BSS)	7		
KOREA	1987	1984	35	KOR-1	3	n/a	Ku(BSS)	7		
ITALY	1987	1984	45	ITALSAT-A	6	6	Ka	10	CNS	
ARGENTINA	1987	1984	35	ARGENSAT-A	24	24	C/Ku	10		
EUTELSAT	1987	1984	50	ECS-4	12	24	C/Ku	7	BAe	
ARGENTINA	1988	1984	35	ARGENSAT-B	24	24	C/Ku	10		.7
JAPAN	1988	1983	41	BS-3A	3	n/a	Ku(BSS)	7	Melco	
U.S.	1988	1984	40	US DOMSAT	24	24	C	10		
	1988	1984	40	US DOMSAT	24	24	C	10		
	1988	1984	44	ORION	20	20	C	10		.7
	1988	1985	44	TELSTAR304	24	24	C	10	Hughes	
	1988	1984	45	SBS-7	24	24	Ku	10	Hughes	
	1988	1984	45	US DOMSAT	24	24	Ku	10		
	1988	1984	45	US DOMSAT	24	24	Ku	10		
	1988	1984	75	US DOMSAT	18/6	36	C/Ku	10		
	1988	1984	95	US DOMSAT	36/10	46	C/Ku	10		
	1988	1984	75	US DOMSAT	18/6	24	C/Ku	10		
	1988	1984	75	DBSC COMBO	14	n/a	Ku(BSS)	7		
	1988	1984	60	USSB DBS-B	6	n/a	Ku(BSS)	7		
	1988	1984	75	CBS DBS-A	3	n/a	Ku(BSS)	7		.7
	1988	1984	75	CBS DBS-B	3	n/a	Ku(BSS)	7		.7
	1988	1984	45	ISI-1	24	24	Ku	10		.7
INMARSAT	1988	1985	55	INMARSAT-A	2	n/a	C/L	7		
	1988	1984	55	INMARSAT-B	2	n/a	C/L	7		
INTELSAT	1988	1984	67	I-VI F8	36/10	46	C/Ku	10	Hughes	
	1988	1984	67	I-VI F9	36/10	46	C/Ku	10	Hughes	
	1988	1984	67	I-VI F10	36/10	46	C/Ku	10	Hughes	
	1988	1984	67	I-VI F11	36/10	46	C/Ku	10	Hughes	
	1988	1984	67	I-VI F12	36/10	46	C/Ku	10	Hughes	

***** Siemens/MBB/ERNO/AEG/ANT

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER SATELLITE (M$)	SATELLITE	ACTUAL TRANS-PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR	P
GERMANY	1988	1984	55	TV-SAT D5	5	n/a	Ku(BSS)	7	Eurosatellite	
CUBA	1988	1985	50	CUB-A	24	24	C	10		.5
KOREA	1988	1985	35	KOR-2	3	n/a	Ku(BSS)	7		
JAPAN	1988	1984	65	CS-3A	8	54	Ka/C		Melco	
	1988	1984	65	CS-3B	8	54	Ka/C		Melco	
U.S.	1989	1985	80	CBS-D	3	n/a	Ku(BSS)	10		.7
	1989	1985	80	CBS-E	3	n/a	Ku(BSS)	10		.7
	1989	1985	75	US DBS	6	n/a	Ku(BSS)	7		.5
	1989	1985	75	US DBS	3	n/a	Ku(BSS)	7		.5
	1989	1984	45	ISI-1	24	24	Ku	10		.7
	1989	1985	36	SBS-8	24	24	Ku	10	Hughes	
	1989	1985	45	US DOMSAT	24	24	C/Ku	10		
	1989	1985	45	US DOMSAT	24	24	C/Ku	10		
	1989	1985	45	US DOMSAT	24	24	C/Ku	10		
	1989	1985	50	US DOMSAT	24	24	C/Ku	10		
	1989	1984	58	US DBS	6	n/a	Ku(BSS)	7		
	1989	1984	60	DBSC-DBS-C	6	n/a	Ku(BSS)	7		.7
	1989	1984	58	US DBS	6	n/a	Ku(BSS)	7		
JAPAN	1989	1985	41	BS-3B	3	n/a	Ku		Melco	.7
SWITZERLAND	1989	1985	40	HELVESAT	4/4/4	36	C/Ku/Ka	10		.7
	1989	1985	40	HELVESAT	4/4/4	36	C/Ku/Ka	10		
INTELSAT	1989	1984	67	I-VI F13	36/10	46	C/Ku		Hughes	
	1990	1984	67	I-VI F14	36/10	46	C/Ku		Hughes	
	1990	1984	67	I-VI F15	36/10	46	C/Ku		Hughes	
	1990	1984	67	I-VI F16	36/10	46	C/Ku		Hughes	
U. S.	1990	1984	44	ORION	20	20	C	10		.7
	1990	1987	45	TELSTAR-R	24	24	C/Ku	10		
	1990	1987	50	RCA-DBS-D	3	n/a	Ku(BSS)	10	RCA	.7
IRELAND	1990	1985	60	ERINSAT-A	12/4	36	Ku/Ku/BSS			.7
E. S. A.	1990	1987	59	L-SAT (OLYMPUS-2)	3	n/a	Ku(BSS)	10		
PAKISTAN	1990	1986	35	PAKSAT	12	36	C/Ku	10		

ORIGINAL PAGE IS OF POOR QUALITY

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER SATELLITE (M$)	SATELLITE	ACTUAL TRANS-PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR	P
INMARSAT	1990	1987	44	INMARSAT-C	2	n/a	C/L	7		
CHINA	1990	1987	25	STW-03	2	2	C/X	7	C.A.S.T.	
	1990	1987	35	DBS-2	2	n/a	Ku(BSS)	7		
IRELAND	1991	1985	60	ERINSAT-B	12/4	36	Ku/Ku(BSS)	10		.7
AFROSAT	1991	1986	55	AFSAT-A	12/12	36	C/Ku	10		.5
	1991	1986	55	AFSAT-B	12/12	36	C/Ku	10		.5
INTELSAT	1991	1985	98	I-VI 17	36/10	46	C/Ku	10	Hughes	
	1991	1985	98	I-VI 18	36/10	46	C/Ku	10	Hughes	
	1991	1985	98	I-VI 19	36/10	46	C/Ku	10	Hughes	
U. S.	1991	1988	45	TELSTAR-R	24	24	C	8		
	1991	1987	50	RCA-DBS-R	6	n/a	Ku(BSS)	7	RCA	
	1991	1988	24	SATCOM-7	24	24	C	10		
NORDCOM	1991	1988	50	NORDCOM-1	6	n/a	Ku(BSS)	7		.7
INDONESIA	1991	1988	45	PALAPA-C-1	36	36	C	10		
	1991	1988	45	PALAPA-C-2	36	36	C	10		
FRANCE	1991	1987	26	TELECOM-1-C	4/6/2	16	C/Ku/X	7		
	1991	1987	26	TELECOM1-D	4/6/2	16	C/Ku/X	7		
CANADA	1991	1988	40	ANIK-C2-R	24	24	Ku	10		
ARAB STATES	1991	1987	45	ARABSAT-C	24/1	25	C/S	7		
	1991	1987	45	ARABSAT-D	24/1	25	C/S	7		
U. S.	1992	1988	30	WESTAR-R	24	36	C	10		
	1992	1988	24	SATCOM-8	24	36	C/Ku	10		
	1992	1988	24	SATCOM-9	24	36	C/Ku	10		
	1992	1988	40	SPACENET-D	12/6	36	Ku	7		
	1992	1988	37	GALAXY-R	24	36	C	10		
	1992	1988	37	GALAXY-R	24	36	C	10		
	1992	1988	50	US DOMSAT	24	36	C	10		
	1992	1989	50	SATCOM-K-4	24	36	Ku	10		
	1992	1989	50	SATCOM-K-5	24	36	Ku	10		
ANDEANSAT	1992	1989	54	ANDEAN-A	3	n/a	Ku(BSS)	7		.7

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER SATELLITE (M$)	SATELLITE	ACTUAL TRANS-PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR	P
INTELSAT	1992	1989	50	I-VI-A-1	24	36	C/Ku	10		
	1992	1989	50	I-VI-A-2	24	36	C/Ku	10		
	1992	1989	50	I-VI-A-3	24	36	C/Ku	10		
CANADA	1992	1989	45	TELESAT-R	24	24	C	10		
E. S. A.	1992	1989	60	L-SAT (OLYMPUS-3)	3	n/a	Ku(BSS)	10	BAe	
JAPAN	1992	1989	35	NTT-1	24	24	Ka	10		
	1992	1989	35	NTT-2	24	24	Ka	10		
INDONESIA	1992	1989	45	PALAPA-C-3	36	36	C	10		
AUSTRALIA	1992	1989	57	AUSSAT-E	11/4	16	Ku(BSS)	10		
	1992	1989	57	AUSSAT-F	11/4	16	Ku(BSS)	10		
FRANCE	1992	1989	35	TDF3F5	5	n/a	Ku(BSS)	7		.7
U. S.	1993	1989	40	USAT-C	24	36	Ku	10	RCA	
	1993	1989	45	TELSTAR-305	24	36	C	8		
	1993	1989	45	SATCOM-5	24	36	Ku	10		
	1993	1989	40	SPACENET-E	18/6	36	C/Ku	10		
	1993	1990	46	SPACENET-F	18/6	36	C/Ku	10		
	1993	1989	37	GALAXY-R	24	36	C	10		
	1993	1990	36	SBS-9	24	36	Ku	10	Hughes	
	1993	1990	48	RSI-C	16	16	Ku	10		.5
	1993	1990	48	RSI-D	16	16	Ku	10		.5
ANDEANSAT	1993	1989	54	ANDEAN-B	3	n/a	C/Ku			
INTELSAT	1993	1989	50	I-VI-A-4	24	24	C/Ku	10		
	1993	1989	90	I-VII-F-1	36	36+	C/Ku/Ka	10		
	1993	1989	90	I-VII-F-2	36	36+	C/Ku/Ka	10		
CANADA	1993	1989	42	ANIK-E-3	24	24	C/Ku	10		
	1993	1988	60	MSAT-1	10	n/a	UHF	7		
EUTELSAT	1993	1988	50	ECS-4	12	36	Ku	10		
	1993	1989	50	ECS-5	12	36	Ku	10		

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER SATELLITE (M$)	SATELLITE	ACTUAL TRANS-PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR	P
GERMANY	1993	1989	55	TV-SAT-3D5	6	n/a	Ku(BSS)	7	Eurosatellite	
FRANCE	1993	1989	40	TDF-3F6	6	n/a	Ku(BSS)	7	Eurosatellite	
U. K.	1993	1988	35	UNISAT-D	8	n/a	Ku(BSS)	10		
	1993	1988	35	UNISAT-E	8	n/a	Ku(BSS)	10		
CHINA	1993	1987	30	STW-04	2	2	C/X	7		
U. S.	1994	1988	35	WESTAR-R	24	36	C			
	1994	1990	45	TELSTAR-306	24	36	C	10		
	1994	1990	50	STC-DBS-R	6	n/a	Ku(BSS)	7		
	1994	1990	50	STC-DBS-R	6	n/a	Ku(BSS)			
	1994	1990	44	GSTAR-D	16	36	Ku	10		
	1994	1990	44	GSTAR-E	16	36	Ku	10		
	1994	1990	40	SPACENET-F	12/6	36	C/Ku	10		
	1994	1994	50	US DOMSAT-R	24	36	C	10		
	1994	1988	30	WESTAR-R	24	36	C	10		
INTELSAT	1994	1989	90	I-VII-F-3	36	36+	C/Ku/Ka	10		
	1994	1989	90	I-VII-F-4	36	36+	C/Ku/Ka	10		
	1994	1989	90	I-VII-F-5	36	36+	C/Ku/Ka	10		
ITALY	1994	1988	45	ITALSAT-B	12	12	Ka	10		.7
ESA	1994	1988	59	OLYMPUS-3	3	n/a	Ku(BSS)	10	BAe	
JAPAN	1994	1988	38	CS 4A	8	54	Ka/C	7		
	1994	1988	38	CS 4B	8	54	Ka/C	7		
CHINA	1994	1988	35	CHINDBS	3	n/a	Ku(BSS)	7		
MEXICO	1994	1988	46	MORELOS-C	18/4	36	C/Ku	9		
EUTELSAT	1994	1988	50	ECS-R	12	24	Ku	7		
CARIBSAT	1994	1990	56	CARIB-A	3	n/a	Ku(BSS)	7		.7

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER SATELLITE (M$)	SATELLITE	ACTUAL TRANS-PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR	P
U. S.	1995	1991	32	WESTAR-R	24	36	C	10		
	1995	1991	45	TELSTAR-307	24	36	C	10		
	1995	1990	34	SBS-10	24	36	Ku	10		
	1995	1991	40	AMERSAT-R	12/6	36	C/Ku	10		
	1995	1991	50	USAT-D	24	36	Ku	10		
	1995	1991	40	ABCI-C	24	36	Ku	10		
	1995	1991	44	GSTAR-F	16	36	Ku	10		
	1995	1991	57	RCA DBS-E	3	n/a	Ku(BSS)	10		.5
	1995	1991	57	CBS DBS	3	n/a	Ku(BSS)	10		.5
	1995	1991	60	CBS DBS	3	n/a	Ku(BSS)	10		.5
	1995	1993	24	SATCOM-R	12	36	C	10		
	1995	1992	24	SATCOM-R	24	36	C	10		
INTELSAT	1995	1991	90	I-VII-F7	36+	36	C/Ku/Ka	10		
	1995	1991	90	I-VII-F8	36+	36	C/Ku/Ka	10		
	1995	1991	90	I-VII-F9	36+	36	C/Ku/Ka	10		
GERMANY	1995	1990	40	TVSAT-F4-D5	5	n/a	Ku(BSS)	7		
CANADA	1995	1991	50	M-SAT-2	10	n/a	UHF	7		
U. K.	1995	1990	60	OLYMPUS-4	3	n/a	Ku(BSS)	10	BAe	
INMARSAT	1995	1990	44	INMARSAT-D	2	n/a	C/L	7		
JAPAN	1995	1990	35	NTT-3	24	24	Ka	10		
CHINA	1995	1990	42	DBS-3	2	n/a	Ku(BSS)	7		
BRAZIL	1995	1990	49	SBTS	24	24	C	10		
	1995	1990	49	SBTS	24	24	C	10		
EUTELSAT	1995	1991	50	ECS	12	24	Ku	10		

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER SATELLITE (M$)	SATELLITE	ACTUAL TRANS-PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR	P
U. S.	1996	1992	32	WESTAR-R	24	36	C	10		
	1996	1993	32	WESTAR-R	24	36	Ku	10		
	1996	1992	50	AMERSAT-R	12/6	36	C/Ku	10		
	1996	1992	24	SATCOM-R	24	36	Ku	10		
	1996	1992	40	ABCI-D	24	36	Ku	10		
	1996	1993	40	USSI-3	20	20	Ku	8		
GERMANY	1996	1992	40	DFS-C (POSTSAT)	12	12	Ku/Ka	10	S/M/E/A	
INTELSAT	1996	1992	90	I-VI-A-5	24	36	C/Ku	10		
	1996	1992	90	I-VI-A-6	24	36	C/Ku	10		
	1996	1992	90	I-VI-A-7	24	36	C/Ku	10		
ARAB STATES	1996	1992	45	ARABSAT	25/1	25	C/S	10		
U. K.	1996	1992	60	OLYMPUS-5	3	n/a	Ku(BSS)	10	BAe	
INMARSAT	1996	1992	44	INMARSAT-E	2	n/a	C/L	7		
JAPAN	1996	1992	35	NTT	3	n/a	Ku(BSS)	7		
	1996	1992	43	BS-4	3	n/a	Ku	7		
CHINA	1996	1992	42	STW	3	n/a	Ku(BSS)	7		
NORDCOM	1996	1992	44	NORDSAT	3	n/a	Ku(BSS)	7		
U. S.	1997	1993	34	WESTAR	24	36	Ku	10		
	1997	1993	80	FORDSAT	54	54	C/Ku	10		
	1997	1993	80	FORDSAT	54	54	C/Ku	10		
	1997	1993	50	RCA-R	24	36	Ku	10		
	1997	1993	36	SBS-11	12	36	Ku	10		
	1997	1994	37	GALAXY-R	24	36	C	10		
	1997	1994	57	RCA-DBS-R	3	n/a	Ku(BSS)	7		
	1997	1994	57	RCA-DBS-R	3	n/a	Ku(BSS)	7		
INTELSAT	1997	1993	90	I-VII-F-13	36	36+	C/Ku/Ka	10		
	1997	1993	90	I-VII-F-14	36	36+	C/Ku/Ka	10		
	1997	1993	90	I-VII-F-15	36	36+	C/Ku/Ka	10		

TABLE I (continued)

"COUNTRY"	LAUNCH YEAR	CONTRACT YEAR	COST PER SATELLITE (M$)	SATELLITE	ACTUAL TRANS-PONDERS	E.T.	FREQUENCY BAND	DESIGN LIFETIME (YEARS)	PRIME CONTRACTOR	P
CANADA	1997	1993	40	TELSAT-R	24	24	C	10		
INMARSAT	1997	1993	44	INMARSAT-E	2	n/a	C/L	7		
JAPAN	1997	1993	42	BS-4A	6	n/a	Ku	7		
	1997	1993	42	BS-4B	6	n/a	Ku	7		
	1997	1993	38	CS-4C	8	54	Ka/C	7		
CHINA	1997	1993	42	CHINDBS	3	n/a	Ku(BSS)	7		
U. S.	1998	1993	30	WESTAR-R	24	36	C	10		
	1998	1993	45	TELSTAR-308	24	36	C	10		
	1998	1993	60	STC-R	6	n/a	Ku(BSS)	10		
	1998	1993	40	SPACENET-R	12/6	36	C/Ku	10		
	1998	1993	36	SBS-12	10	36	Ku	10		
	1998	1995	50	SATCOM-K-6	24	36	Ku	10		
INTELSAT	1998	1995	50	I-VI-A-8	24	36	C/Ku	10		
	1998	1995	50	I-VI-B-9	24	36	C/Ku	10		
JAPAN	1998	1995	38	CS-4D	12/6	54	Ka/C	8		
	1998	1995	38	CS-4E	12/6	54	Ka/C	8		
	1998	1995	45	AMS	36	36	Ka	10		
ITALY	1998	1995	45	ITALSAT	24	36	Ka	10		
CHINA	1998	1995	25	STW-R	12	12	C/X	10		
MEXICO	1998	1995	46	MORELOS	18/4	36	C/Ku	10		
	1998	1995	46	MORELOS	18/4	36	C/Ku	10		
EUTELSAT	1998	1995	50	ECS-R	12	24	Ku	10		
INTELSAT	1999	1996	90	I-VII-F15	36	36+	C/Ku/Ka	10		
	1999	1996	90	I-VII-F-16	36	36+	C/Ku/Ka	10		
U. S.	1999	1995	80	CBS-DBS	6	n/a	Ku(BSS)	10		
	1999	1995	80	CBS-DBS	6	n/a	Ku(BSS)	10		
	1999	1996	36	SBS-13	24	36	Ku	10		

V. FORECAST OF ACTIVITIES FROM 1986 TO 1989

ESTIMATED INVESTMENT

Considerable growth is forecast for the period 1986 to 1989 in most of the major frequency bands, as shown in Figure 5. The four-year period has a level of announced expenditure of approximately six billion dollars, which exceeds by almost 23 percent the amount spent in the prior 20 years.

The planned U.S. domestic endeavors are considerable during this period with increased use of Ku frequency for both fixed service and direct-broadcast activities. A number of countries such as Germany and China have planned launchings, representing the entry of additional countries in the procurement and use of communication satellite systems.

EXPENDITURE BY FREQUENCY BAND

The extensive use of Ku band and the combined C/Ku band activities comprise the major portion of planned expenditures for this period. Together they account for over 60 percent of the anticipated activity as shown in Figure 6.

SATELLITES LAUNCHED OR PLANNED

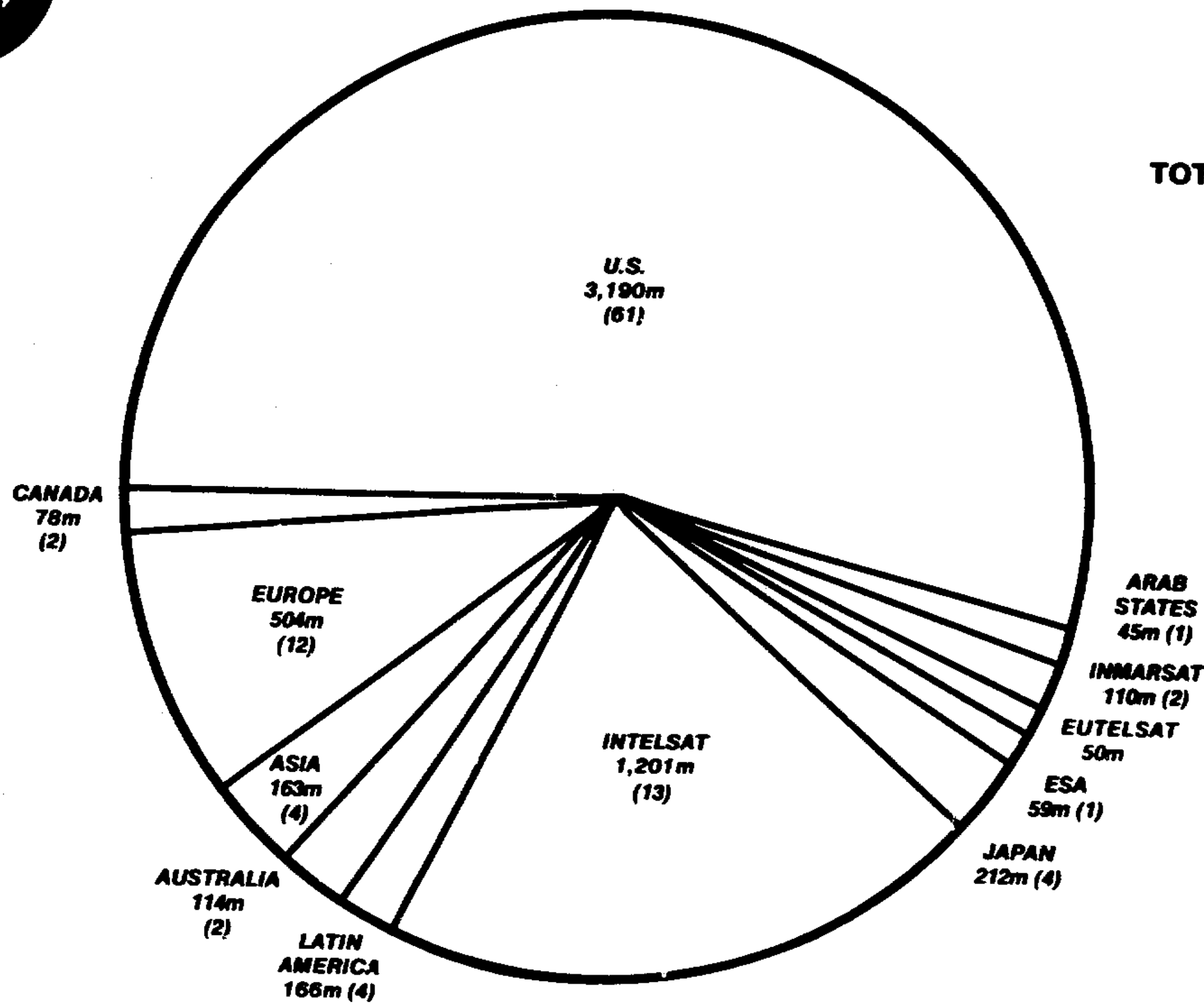
Of the 107 satellites forecast for the period, the announced direct broadcast satellites lead the group with the Ku, and C/Ku categories following closely behind as reflected in Figure 7. Increased activity can be observed during this period in the various combinations of frequency bands. This type of multiple frequency band use on a single spacecraft was not as prevalent in the earlier period.

SATELLITE MARKET SHARE

There has been some indication of the companies that have been awarded contracts to construct certain satellites. However, as is shown

fig.5

ESTIMATED WORLDWIDE INVESTMENT IN COMMERCIAL* COMMUNICATION SATELLITES 1986 - 1989



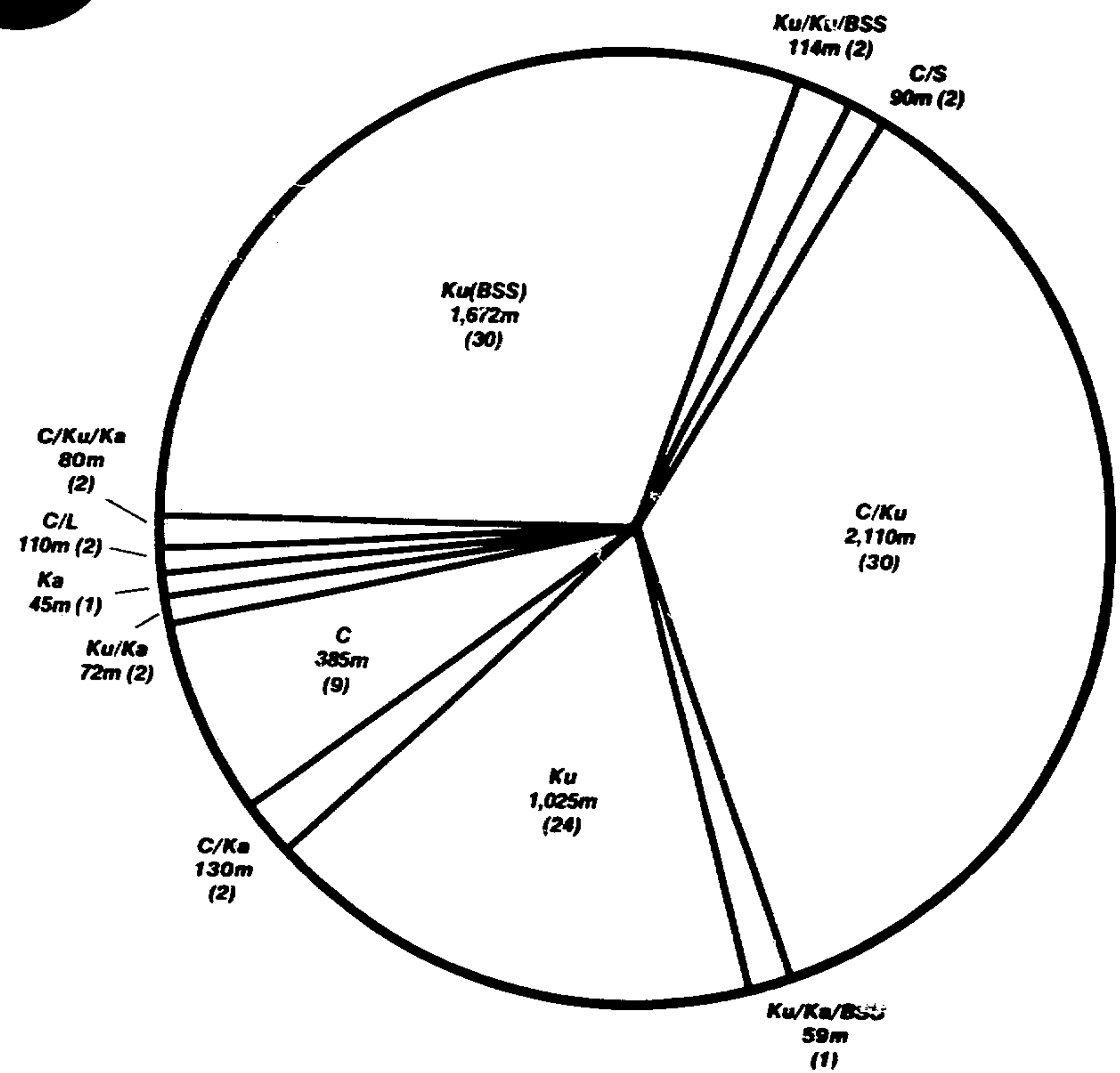
TOTAL $5,892m

TOTAL LAUNCHES (107)

* DOES NOT INCLUDE THE SOVIET UNION

fig.6

PLANNED EXPENDITURES FOR COMMUNICATION SATELLITES BY *FREQUENCY BAND* 1986 - 1989

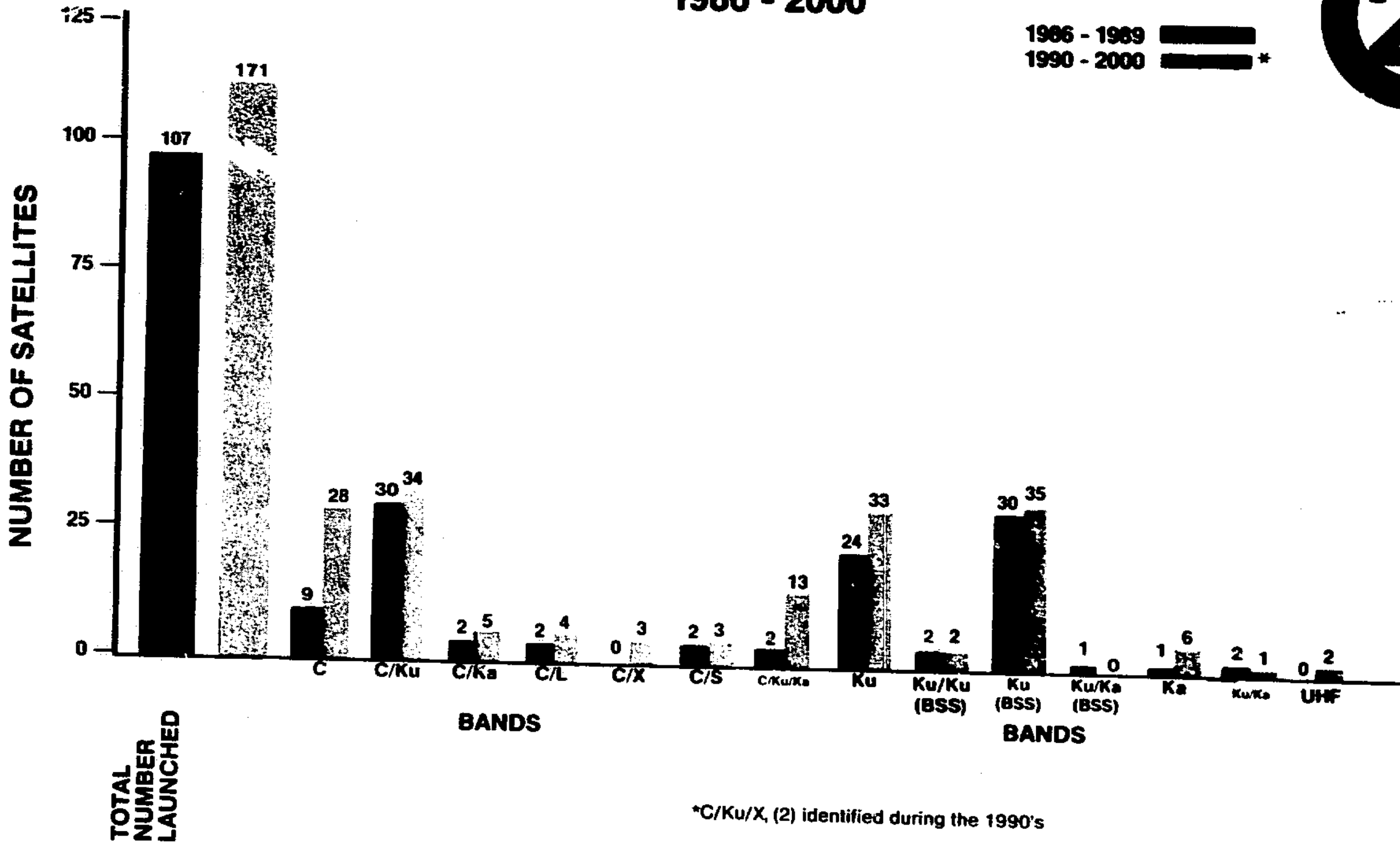


TOTAL EXPENDITURES
$5,892m

TOTAL LAUNCHES
107

fig. 7

SATELLITES PLANNED IN VARIOUS FREQUENCY BANDS
1986 - 2000

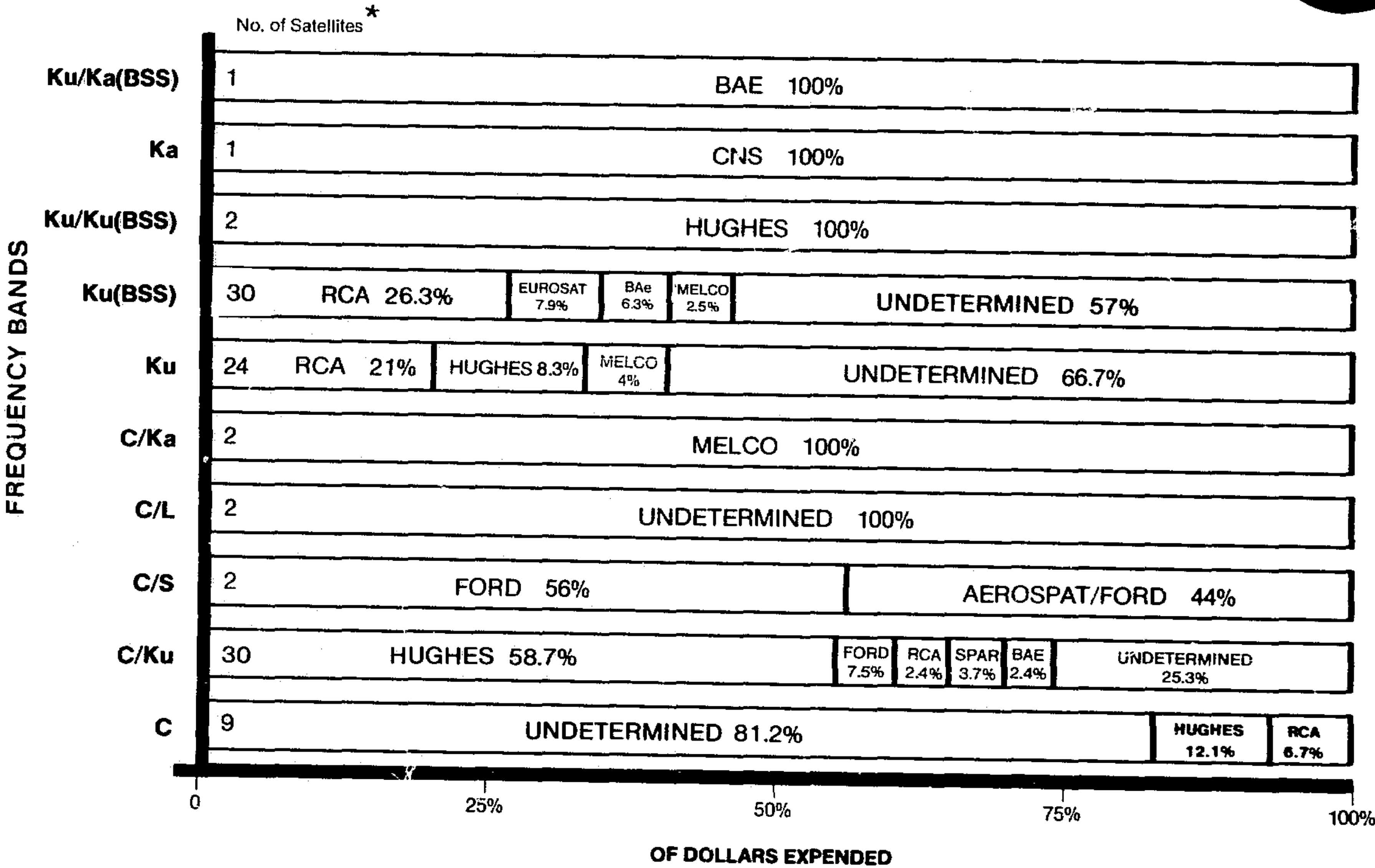


*C/Ku/X, (2) identified during the 1990's in Figure 8, many of the procurements in various frequency bands are unknown at this time and the portion of the market share is listed as undetermined.

Hughes and RCA continue to play major roles and have captured important segments of five major frequency band markets. A discussion of the potential market share captured by various companies is provided in Section VIII.

fig.8

SATELLITE MARKET SHARE BY FREQUENCY BANDS 1986 - 1989



* C/Ku/Ka(2), Undetermined: 100% and Ku/Ka(2), S/M/E/A: 100%

ORIGINAL PAGE IS OF POOR QUALITY

VI. FORECAST OF ACTIVITIES FROM 1990 - 2000

ESTIMATED WORLDWIDE INVESTMENT

Users of communication satellite services in the United States and INTELSAT are each scheduled to provide the largest levels of expenditures during the last decade of this century. In the previous four year period (1986-1989), the U.S. investment will be almost three times that of INTELSAT. However, with replacement satellites required, as well as new systems being planned, INTELSAT's investment in spacecraft during this period will be sizeable.

Also noteworthy during this period, as shown in Figure 9, are continuing levels of investment in new or continuation series of satellites by many areas of the world such as Europe, Japan, Asia, and Latin America. The regional satellite systems such as EUTELSAT, INMARSAT, and the African states are seen as investors of note in communication satellites.

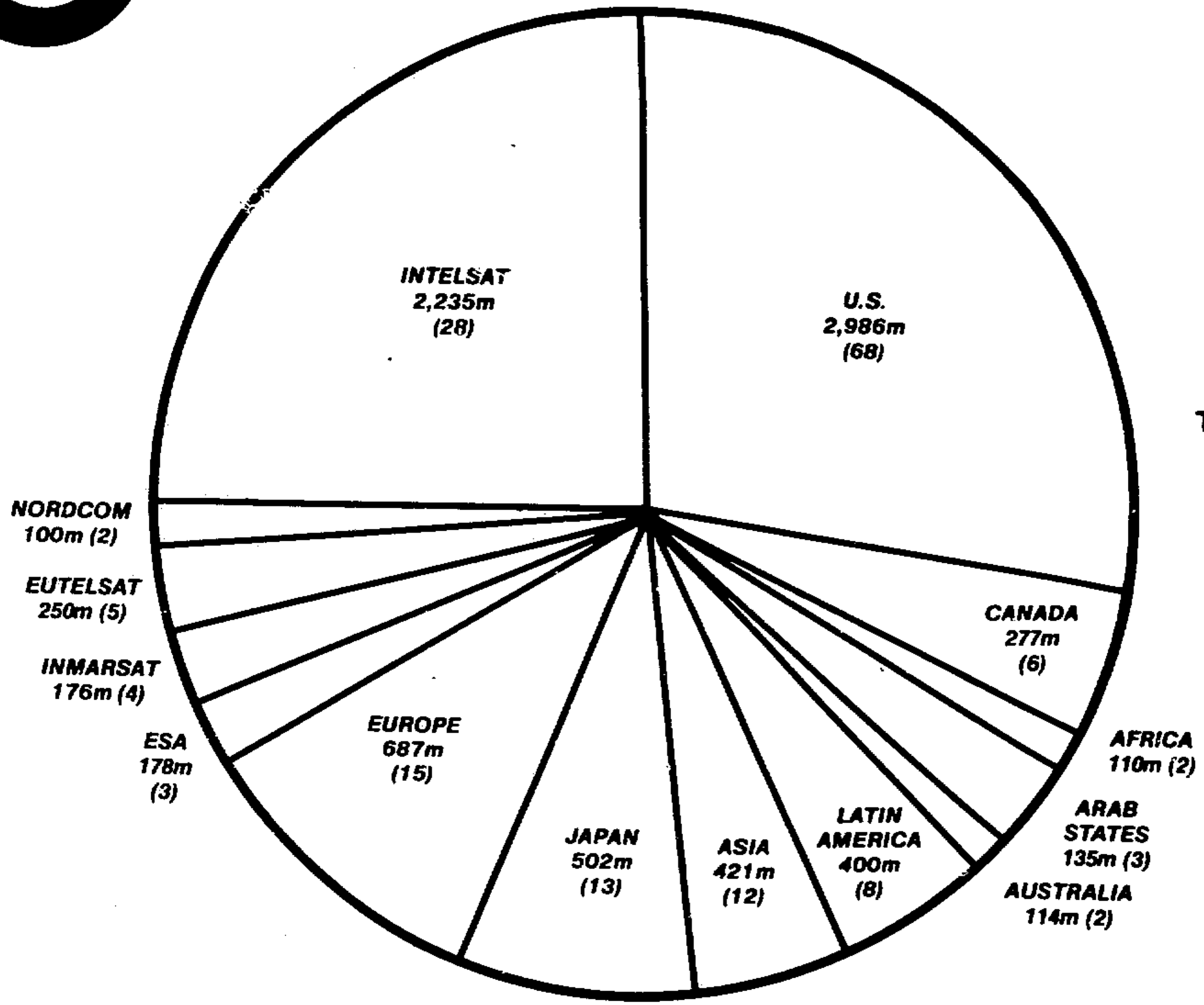
EXPENDITURE BY FREQUENCY BAND

Spacecraft with combined frequencies of C/Ku reflect continuing high levels of investment during this period as does investment in Ku direct broadcast satellites. New satellites in these frequencies will be launched as well as a steady stream of replacement satellites to spell those put into service in the mid-80's and whose design life had expired. Increased levels of expenditure are forecast as illustrated in Figure 10. Use of three major frequency bands, C/Ku/Ka, on a single spacecraft is expanded and increased via a sizeable investment of over one billion dollars for this type of capacity, which is approximately one-eighth of the funds currently planned.

Use of the Ka frequency spectrum is also increased via Ka, Ka/C and the foregoing spacecraft .

fig. 9

PLANNED WORLDWIDE INVESTMENT IN COMMERCIAL* COMMUNICATION SATELLITES 1990 - 2000

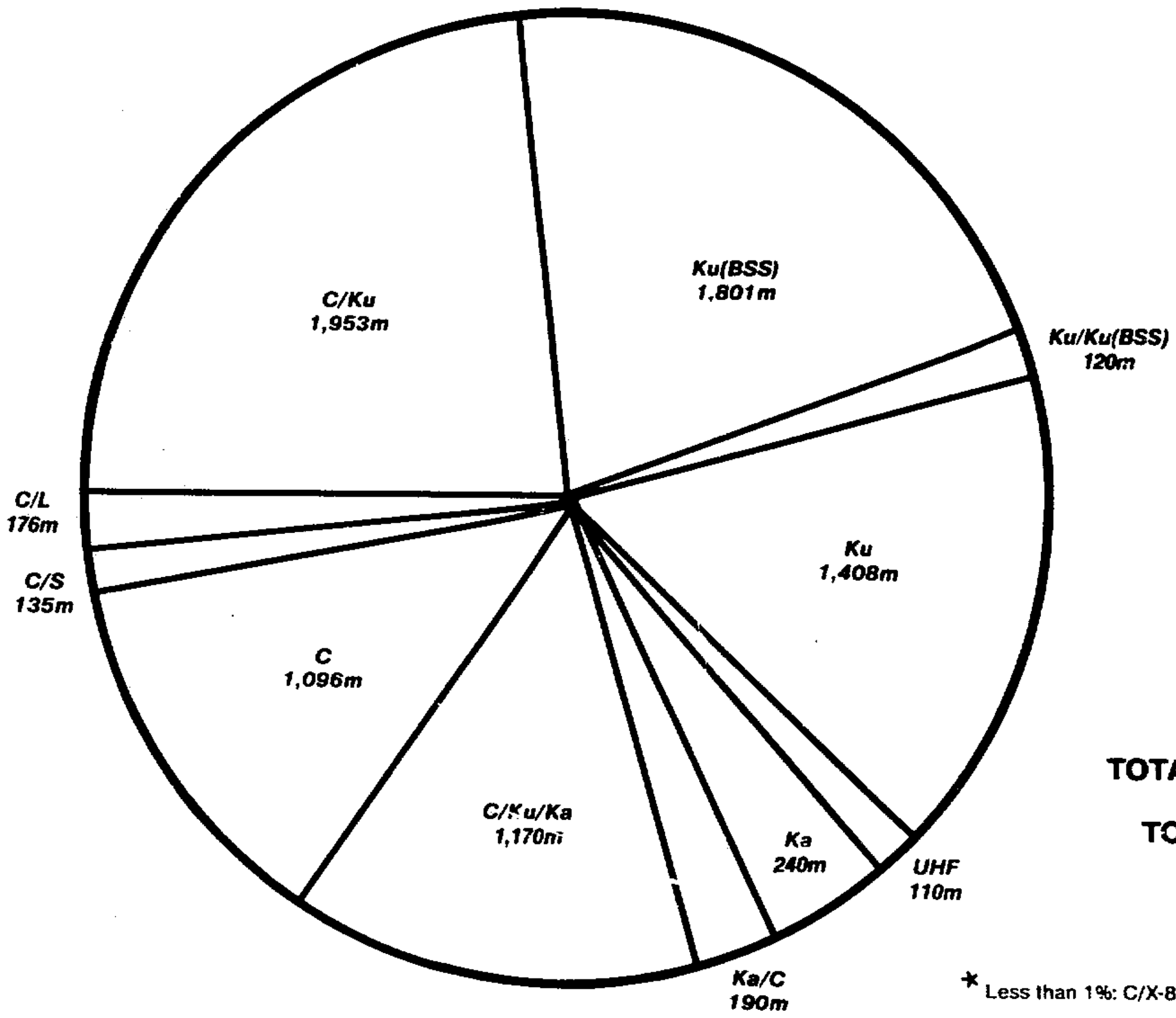


TOTAL EXPENDITURES
$8,571m
TOTAL LAUNCHES
171

* DOES NOT INCLUDE THE SOVIET UNION

fig.10

PLANNED EXPENDITURES FOR COMMUNICATION SATELLITES BY *FREQUENCY BAND* 1990 - 2000



ORIGINAL PAGE IS
OF POOR QUALITY

**TOTAL EXPENDITURES*
$8,571m
TOTAL LAUNCHES
171**

* Less than 1%: C/X-80m, C/Ku/X-52m, Ku/Ka-40m.

SATELLITES LAUNCHED OR PLANNED

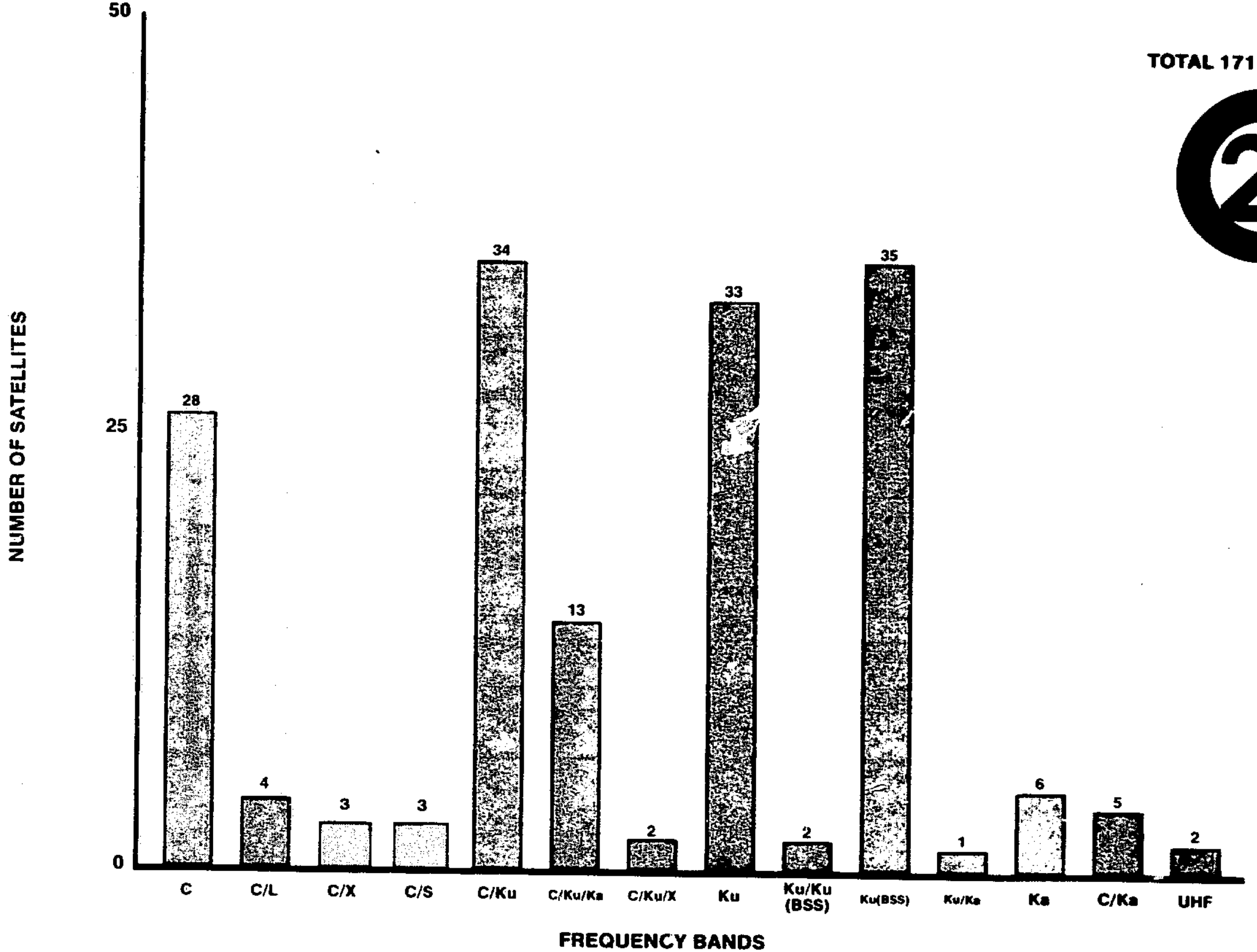
Figure 11 illustrates the high levels of activity in C/Ku, Ku and direct broadcast Ku(BSS) satellites. Replacement satellites for C-level service account for almost fifteen percent of the spacecraft scheduled for the period.

SATELLITE MARKET SHARE BY FREQUENCY BAND

Since the majority of spacecraft forecast for the period have not been designed, nor formal request for proposals issued, the major participants and the share of the future market must at this time remain undetermined. Figure 12 does identify known companies with a series of satellites currently under construction that will extend into the 90's, or those with contracts such as INTELSAT that provides for a future procurement of 5-15 satellites. Minimal assumptions were made regarding replacement contracts of "capture" by the same manufacturer that is providing current versions, for instance of C or Ku satellites. Satellite operators may change their spacecraft requirements and request the entire industry to bid anew thus enabling different companies to develop new or different satellites to provide replacement capacity.

fig. II

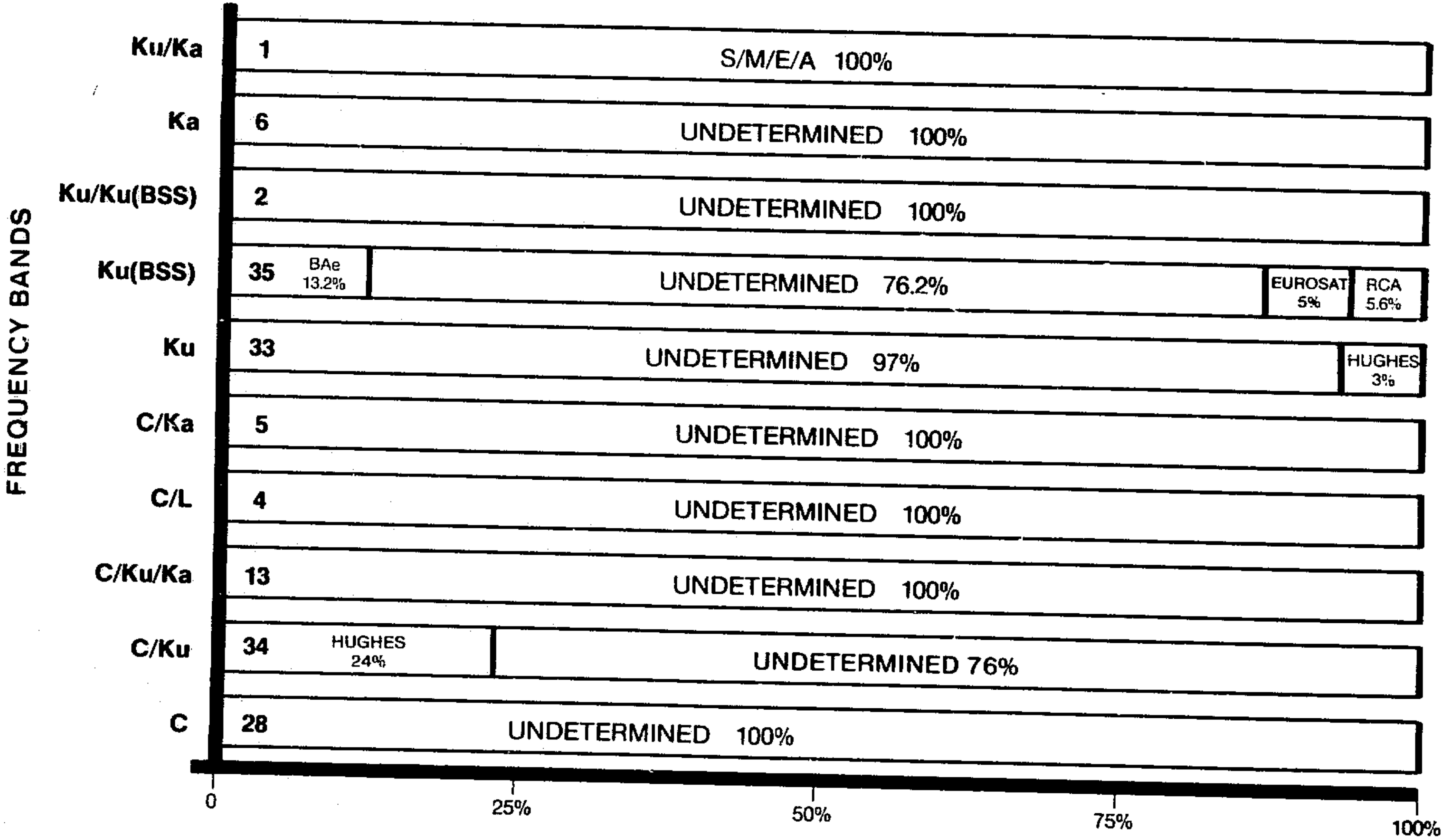
SATELLITES PLANNED IN VARIOUS FREQUENCY BANDS 1990 - 2000



ORIGINAL PAGE IS OF POOR QUALITY

fig. 12

SATELLITE MARKET SHARE BY FREQUENCY BANDS* 1990 - 2000

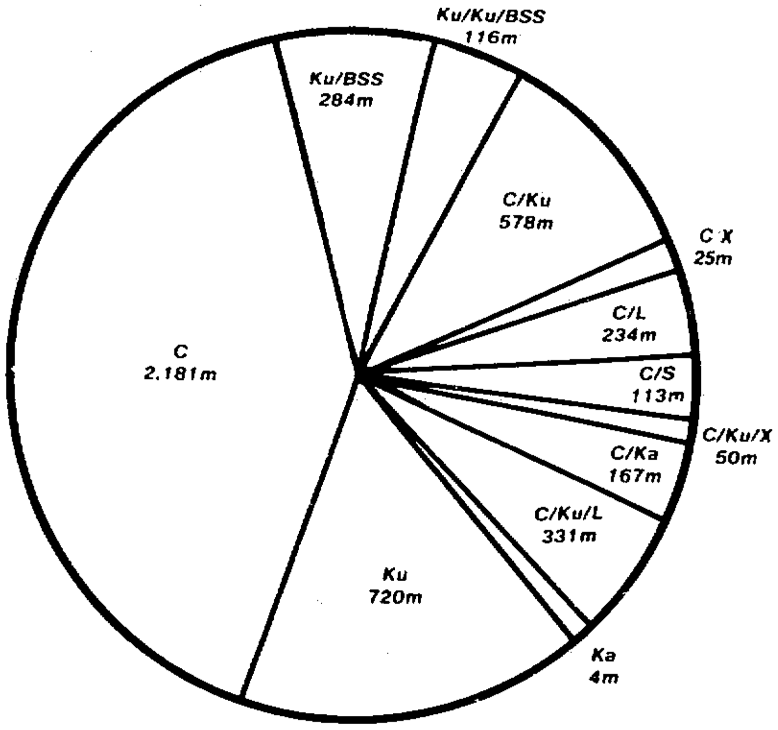


*(C/X, 100% C.A.S.T. (3); C/S (3), C/Ku/X (2), UHF (2), All Undetermined)

OF DOLLARS EXPENDED

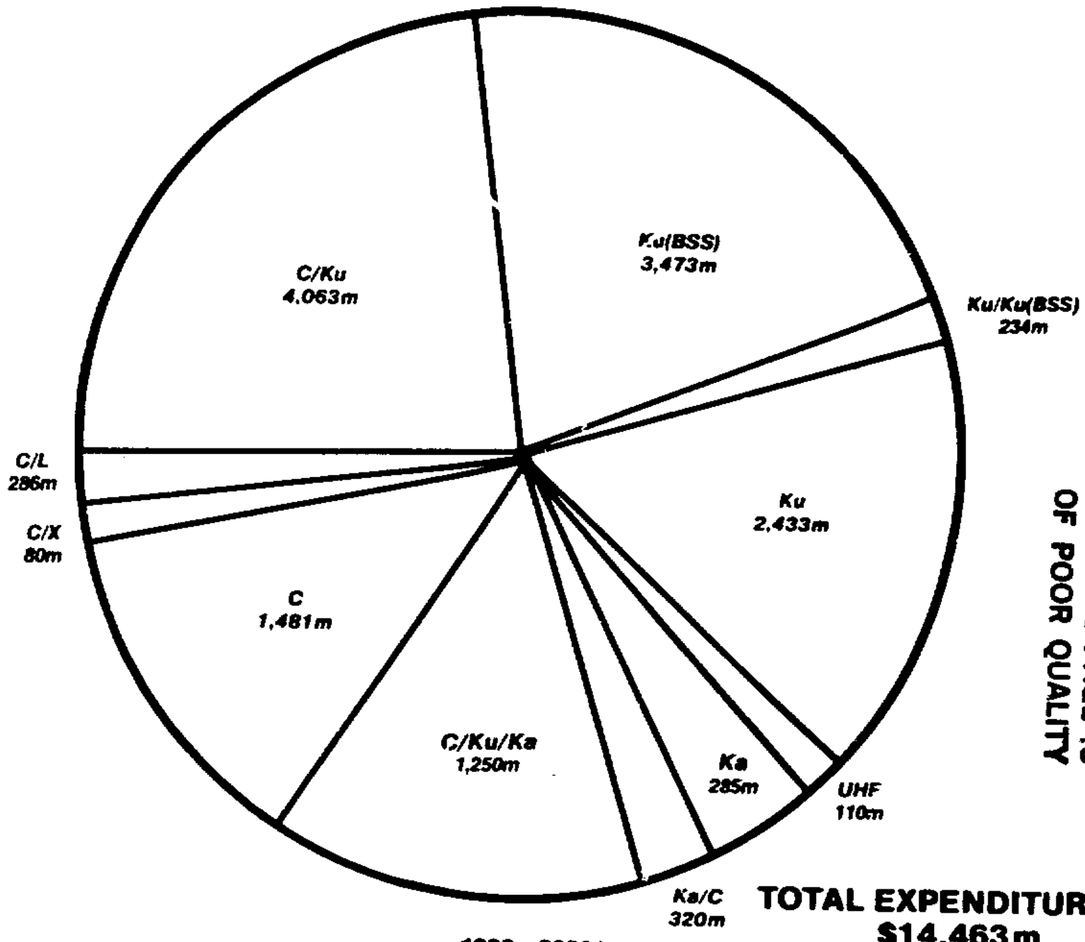
fig. 13

ACTUAL AND PLANNED EXPENDITURES FOR COMMUNICATION SATELLITES BY *FREQUENCY BAND* * 1965 - 2000



1965 - 1985

TOTAL EXPENDITURES
$4,803m



1986 - 2000*

ORIGINAL PAGE IS OF POOR QUALITY

TOTAL EXPENDITURES
$14,463m

1986 - 1989 $5,892m

1990 - 2000 $8,571m

Ku/Ka, C/Ku/X, C/S, Ku/Ka(BSS) Less than .05% each

GRAND TOTAL: $19,266m

VII. PROFILES OF MAJOR COUNTRIES INVOLVED IN SATELLITE ENDEAVORS

1. INTRODUCTION

About ten years ago, the first procurements were made whereby countries other than the United States and Canada could operate their own communications satellite systems. Now, since numerous countries in this field have made plans into the 1990's, the area requires considerable attention from any U.S. firm interested in launching communications satellites or active in spacecraft or component engineering or manufacturing.

This section provides information that will enable the reader to determine the countries and satellite systems that warrant either direct contact with individuals or the gathering of additional information pertaining to plans and programs. It provides information on each country other than the United States which is active in the production of communication satellites or components, or which has or is currently procuring a major satellite system.

Communications satellites, arranged according to region:

Europe
Middle East
Asia/South
Asia/East
Asia/Japan
North America/Canada

A profile is provided for each country which includes the type of activity, proposed schedules, and major firms engaged in spacecraft, launch, or component endeavors. Military satellites are not included. The Union of Soviet Socialist Republics (USSR) is not treated since they have not participated in the international commercial market and do not appear to have plans for such action. Countries with minor or non-existent industries or plans for such are not profiled at this time.

2. EUROPE AS A MAJOR CENTER OF ACTIVITY

European Space Agency (ESA) is a matrix organization that encompasses national programs in countries such as France, Germany and the United Kingdom; multilateral cooperative programs such as those among the 11 countries participating in the European Space Agency (ESA); as well as the bilateral programs for television satellites such as those conducted by France and Germany. In addition, it is involved with the participation of the 23 European countries in the INTELSAT system, and the 16 countries sharing the Marisat programs.

ESA replaced two other organizations in 1975. The European Space Research Organization (ESRO) had been founded in 1964 and was chartered to carry out scientific research and to organize the activities of the various countries into a harmonious effort. As initially conceived, ESRO was to carry out the European space effort, integrate the technical research, coordinate international space programs, and establish centralized facilities. The European Space Vehicle Launcher Development Organization (ELDO) was also established in 1964. By the 1970's, both had outgrown their charters.

Since its inception, the ESA program emphasis has shifted from scientific to applications missions. In addition to its mandatory programs, ESA allowed its members to support other programs that interested them. France pursued Ariane, Germany took on Spacelab, and the United Kingdom supported the development of the maritime satellite. ESA subsequently decentralized, setting up the European Space Technology Center (ESTEC) for projects and technical research management and the European Space Operational Center (ESOC) for operations management.

From 1975 to 1980, ESA supported ongoing programs such as the Dutch astronomical satellite ANS and the COS-band and HEOS programs. In 1977, key decisions were made to pursue major communications satellite programs, including the extension of MAROTS (Marine Aeronautical Radio Operation Tracking Satellite) to two satellites in orbit, the ECS European regional communications system, the H-SAT heavy platform for satellite television broadcast, and advance system and technology programs; a tentative hold was placed on the production of Ariane. The Earthnet program was initiated, Spacelab for STS was inaugurated, and approval was granted for participation in the Space Telescope and the International Solar Polar Mission (ISPM).

In the fall of 1977, there were two successful launches of the ISEE-B and Meteosat-1; there were two launch vehicle failures with the OTS-1 and GEOS-1. In 1978, IUE, OTS-2, and GEOS-2 were all successful. During the same year, the EUTELSAT program was initiated by which ESA would provide the ECS satellite. The MAROTS program was reoriented and changed to MARECS, and a decision was made to utilize the ECS platform. The Ariane production for five launchers was approved, and project SIRIO 2, proposed by Italy, was approved.

In 1979, agreement was reached with NASA to supply a second spacelab, an H-SAT study could not find common ground among the member states, and France and Germany made a bilateral agreement to build an operational television broadcast satellite, TV-SAT/TDF. In the same year, the United Kingdom, Italy, and the Netherlands initiated the L-Sat program, and the first Ariane was successfully launched from Kourou, French Ghiana.

In 1980, Arianespace was created for the commercialization of Ariane launches. An agreement between ESA and INMARSAT was reached to supply two MARECS spacecraft as part of the international maritime satellite system. The Science Policy Committee of ESA agreed to undertake the science projects GIOTTO (Halley's Comet intercept) and HIPPARCOS (a star mapping satellite). The second Ariane launch was a failure.

By the end of the 1970's, the tendency to Europeanize the national activities had decreased, and a rebirth of national space activities had taken place. This change resulted from increased international competition in the commercial exploitation of space and the periodic difficulties experienced in European cooperation and politics.

In 1981, ESA streamlined the organization, and increased the responsibilities of the Program Director. ESA issued a ten-year plan for the period 1980 to 1990 that included the following items:

(a) The agency is essentially a research and development organization.

(b) There must be a heavy involvement of the user community.

(c) Conditions must be created that will enable European industry to compete successfully with the United States and Japan.

(d) The agency will provide a forum for the coordination of space activities.

The European countries have placed financial constraints of 450 MAU* annually. The distribution of these funds will be approximately as follows:

Area	Percent
Space science	29
Microgravity	2.5
Earth observation	20
Telecommunications	17
Space transportation	19.5
Technology	12

* MAU = million accounting units. In 1982, one accounting unit equalled $1.066; consequently 450 MAU would be equivalent to approximately $480 million.

ESA 1982 Budget

In 1982 the budget allocations for specific programs was as follows:

Program	Percent
Ariane	20.2
Spacelab	10.0
L-Sat	11.7
ASTP	7.9
MARECS	3.7
Telecom	9.9
Sirio-2	1.4
Remote sensing	2.1
Meteosat	1.5
Sciences	12.7
General budget	18.9
	100%

The International Aeronautics Federation (IAF) thirty-third Space Congress was held in Paris, France, from September 27 to October 2, 1982. This was the first time that the Western Europeans dominated the presentations at this annual space congress. A total of 418 technical papers were presented in 49 different sessions. The distribution of papers during these sessions was as follows: Japan, 23; Canada, 10; the USSR and Eastern Bloc countries, 61; the United States, 144; the Western European countries, 165; and all other countries, 15. The technical display in the exhibition hall was predominantly European. The quality of the papers and the breadth of the subjects that were covered is indicative of the progress that has been made by the Western European countries in the field of space technology. Their space activities have reached a technical level equal to that of U. S., Japanese, and Soviet unmanned space activities.

The achievements of the Ariane launch vehicle and the status of the medium- and high-power TWT for communications satellites are significant and place the Europeans in the forefront of these technologies. Other areas have shown growth and sophistication, such as the design and manufacture of lightweight deployable solar arrays, magnetically suspended momentum wheels, carbon fiber structures for spacecraft, and the support of precision optical devices like the Spot Radiometer and the

Faint Object Camera. The Europeans have made great strides in the design and development of three-axis stabilized spacecraft for earth observation and for communications satellites. Their new generation of scientific satellites is designed to complete complex missions such as GIOTTO (the Halley Comet intercept satellite) and the EXOSAT, which will measure x-ray cosmic sources. The new high-resolution SPOT imaging camera can provide 10-m resolution and, with a pair of cameras, can provide stereoscopic images for earth resources observation.

Over the past three years, various European space communications and high technology industrial consortiums have been competing in the world commercial markets. Although they have not won a recent competition, they are increasing their technical quality and are becoming competitive in price.

Following is a summary of the national programs.

FRANCE

By 1976, France had successfully completed the Symphonie 1 and 2 experimental communications satellites (in conjunction with Germany). In 1977 and 1978, the Centre National d'Etude Spatiale (CNES) undertook the development of remote sensing, and the government decided to build the SPOT remote sensing satellite. France initiated telecommunication programs Telecom 1 and TV-SAT; the latter was a joint program with West Germany. France has been the leading European force in space development. Its main goals are:

a. Commercial exploitation of space.
b. Commercial organizations to implement these programs, such as Arianspace and Spot Image.
c. Cooperative programs with ESA.
d. Long-range alternative manned space missions, such as Solaris space robotics.
e. The continued growth of the European space transportation system.

The diversity of industrial and government involvement in the European programs is evident in first-hand visits to the sites of the French, and other European facilities. The Centre National d'Etudes Spatiale (CNES) space center in Toulouse, France was selected as examples along with Thomson-CSF, a large electronic equipment manufacturer, and Matra Space, a supplier of spacecraft systems and system integration.The technology, hardware, and facilities are impressive and compare favorably to many in the United States.

CNES TOULOUSE, FRANCE

CNES Toulouse is one of three divisions reporting into CNES headquarters in Paris. The main objectives of CNES are:

(a) To assist the French government in establishing French space policy.

(b) To implement this policy and manage the associated programs.

(c) To create appropriate facilities and develop the necessary know-how.

(d) To promote the scientific and commercial utilization of space technology.

The CNES center at Toulouse employs approximately 1,100 persons, of which 50 percent are engineers, 25 percent are technicians, and 25 percent are administrative personnel. The facility covers almost 600,000 sq.ft. The principal vacuum chamber measures 18 ft. in diameter and is 21 ft. high; it is configured with solar simulators.

System studies are performed to support various disciplines such as controls, optical systems, mechanical structures and mechanisms, energy sources, and thermal control. Mission studies are performed to support the French national programs such as Argos, SPOT, Telecom 1, and TDF; support studies are performed for other countries like Colombia, Saudi Arabia, and Brazil. CNES also is responsible for France's effort in the European programs, such as OTS 1 and 2, Marecs, and Meteosat, and the center is the principal facility for testing ESA satellites. CNES also provides the focus in France for international space cooperative programs such as Eole with NASA, magnetosphere studies with the USSR, cooperative programs with Germany on Symphonie, and the ESA programs OTS and Meteosat.

In addition to the above tasks, the CNES space center at Toulouse is the primary satellite command and control center for the French national satellite programs. The facility has been undergoing modification in preparation for the SPOT earth resources program. The search and rescue data processing center is already in place and is receiving and processing data from the Russian Cospas satellite, as well as from the U.S.A. NOAA-8 SARSAT satellite. The Argos data collection processing center is also located at this facility.

The Satel Conseil is located at the Toulouse center. This organization is a joint space engineering group created by three government sponsored organizations: CNES, Direction Generale des Telecommunications (DGT), and TeleDiffusion de France (TDF). This group provides international consulting services.

The CNES budget for 1981 and 1982 in millions of French francs was as follows:

	1981	1982	1983
Research and development	55.27	95.05	1286.20
Multilateral cooperation	1003.00	951.55	436.59
Program support	659.71	802.55	866.03
National programs	334.82	628.65	846.93
Bilateral cooperation	485.11	475.85	125.00
Total:	2538.11 ($444M)	3013.30 ($443M)	3560.75 ($448M)

The major programs that CNES has underway are briefly summarized below. Appendix B provides a more detailed listing of the entire French space budget for this period.

TELECOM 1

The TELECOM program, derived directly from the European operational telecommunications satellites OTS, ECS, and MAREC, is designed and developed by the mesh consortium for the European Space Agency. TELECOM 1 is a three-satellite system; the first in the series will be launched in 1984. The three principal missions are:

(a) Intercompany links and video transmission in Ku-band, high-speed data transmission, rapid facsimile, video conferencing, and telephone interconnection.

(b) Links with the French overseas territories in C-band, telephone, and television.

(c) Military communications in the X-band.

The intercompany links and video transmission service use six 20-W repeaters with a 36-MHz bandwidth; 25 Mbits/second per repeater are used for intracompany links, and 34 Mbits/second per repeater are used for video transmission. The system is accessed through time division multiple access (TDMA). For links with the overseas territories there are three 8.5-W repeaters with a 120-MHz bandwidth for telephone and one repeater with a 40-Mhz bandwidth for television. In addition to the two commercial missions, TELECOM 1 will be configured with two 7/8-GHz repeaters for a French government mission. The earth station antenna for the Ku-band is 3.5 m in diameter, and the C-band will be a B standard INTELSAT 11.8 m in diameter.

The European organizations associated with TELECOM 1 are:

MATRA	Prime contractor, also responsible for attitude control
	Telemetry and command and control
	Satellite communications integration and tests
Thomson	Payload
	Telemetry equipment
	Ground systems
ERNO	Propulsion
British Aero	On-board power supply
Aerospatiale	Components supply
Aeritalia	Structure
Saab	Remote control and telemetry equipment
INTA	Antennae S-band
SNIAS	Solar array
	Thermal control
SEP	Apogee motor

MATRA is also the prime contractor responsible for the SPOT platform, the HRV instrument, and the integration and test of the spacecraft. SPOT will be launched by ARIANE in mid-1984.

Thomson CSF

Thomson CSF, located in Meudon-la-Foret, France, is a world leader in industrial and government electronics. The company ranks seventh in the world and third in Europe in size; it employs 82,500 people. The 1981 consolidated sales amounted to 25 billion francs with approximately 48.2 percent sales outside France. The sales distribution was 55.8 percent for electronics and detection equipment, 8.5 percent for public telephone switching, 12.5 percent for medical products, 11.7 percent for components and electron tubes, 7.7 percent for electronic data processing and office systems, and 3.7 percent for other activities. A total of 15,000 people are involved with research and development, or about 20 percent of the work force.

The company is mostly decentralized and much of the research is performed by the operating units. The Central Research Laboratory at Corbeville, France, works with the operating units on electronics of the future.

TDF 1/V SAT

The TDF 1/TV is a cooperative telecommunications agreement between France and West Germany. The agreement was signed in 1980 for a joint effort to produce a direct broadcast satellite for each country, leading to an Ariane launch in 1985. The program is jointly directed by CNES and TDF in France and by DFVLR and BPM in Germany. The French and German consortium consists of Aerospatiale (24 percent), AEF-TFK (24 percent), Thomson (24 percent), MBB (24 percent), and ETCA (4 percent).

The bilateral program will include the development, manufacture, and launch of two pre-operational satellites plus one spare satellite stored on the ground as a backup. These satellites will have common technical modules and will be identical except for the payloads, which will be specific to each mission.

France's preoperational system, TDF, includes one satellite, a ground transmitter, a control center, and users' earth stations. The 1977 World Administrative Radio Conference (WARC) assigned to France an orbital position of 19°W. The French have decided to use the 17.3 to 18.1 GHz band among the three uplink frequency bands. The satellite will have five channels, of which only three will be active. Of the French satellite's three active channels, two channels are planned to be used for the two existing national television services: TF-1 and Antenna-2. Each service will then be broadcast both by satellite and by ground stations. If an operational system is established, the ground stations will gradually close down. The third television station is regional in character.

The integration of the TDF 1 in France is the responsibility of Aerospatiale; in Germany it is MBB. The subsystems that are common to both satellites are subcontracted to the following companies:

Structure	Aerospatiale, Saab
Solar array	Aerospatiale, AEG TFK, Dornier
Propulsion	MBB, ERNO, SEP, Aerospatiale
TTC	Thomson, Saab, LM Ericsson
Thermal control	Aerospatiale, ERNO
Electrical system	AEG TFK, Dornier, ETCA

Thomson is the coordinator of payloads. The French payloads are subcontracted as follows:

Antennas	Thomson, LM Ericsson, MBB, Saab, Aerospatiale
Repeaters	Thomson, AEG TFK, ETCA

The contractors for the German payload are as follows:

Antenna	MBB, LM Ericsson, Saab, AEG TFK, Aerospatiale
Repeaters	AEG TFK, Thomson, ETCA

The TDF1-F3 will be launched in September 1985 by Ariane. Its design life will be seven years and it will carry three transponders. France is also planning the development of the second direct broadcasting satellite, TDF2-F5, with launch in mid-1986 and carrying five transponders. With TDF-1 and 2 in orbit, operational DBS service in France is expected to begin in 1986. France, with three channels on each of the two satellites, is considering allocation of the third channel capability for a Euro-cultural channel project now being negotiated with neighboring countries.

GERMANY

The Federal Republic of Germany's space activities are managed by the Ministry of Research and Technology and are implemented by the German Aerospace Research Institute (DFVLR) and the Institute for Test Facilities Operations (IABG). In 1974 and 1975, there were three main trends in the German national space program: (1) national (bilateral) satellite programs (HELIOS and SYMPHONIE), (2) support for the Spacelab (65% contribution) and Ariane (20% contribution), and (3) coordination of technological research for ESA. From 1976 through 1978, West German space activities were concentrated in continued ESA support. spacelab support, and initiating studies for TV-SAT/TDF. In 1979 and 1980, the German activities focused on coordination of Spacelab experiments, definition of television broadcast satellite and bilateral agreement with France on TV-SAT/TDF, and support for remote sensing in Spacelab and on ESA programs.

The German space expenditures are as follows:

	National	$ M	ESA	$ M
1981	595 MDM*	238	393 MDM	157
1982	672 MDM	268	382 MDM	152
1983	708 MDM	293	392 MDM	157
1984	704 MDM	281	403 MDM	161
1985	706 MDM	282	430 MDM	161
1986	724 MDM	289	430 MDM	172

* MDM = One Million Deutschemarks $ 1 = 2.5 DM

Like France, West Germany is moving rapidly toward setting up its own national satellite systems for communications. The plans for a national DBS system are stated in the Franco-German agreement of 1980, by which the countries agreed to jointly build and launch a 12/14-GHz satellite that would then provide a preoperational service.

The West German satellite, TV-Sat, is being built by Messerschmidt-Bolkow-Blohm (MBB) and will be launched in 1985 with three transponders and will be designed to provide a two-year series of experiments. During this time, two national television services (ARD-1 and ZDF) and possibly seven or eight stereo radio channels will be distributed by TV-Sat. The prime contractor for the development of TV-Sat is the Eurosatellite Consortium. In addition to three operational DBS channels, TV-Sat will have two spare channels. Television programming with stereo audio from TV-Sat will be received by home antennas with 3-foot diameters. The $1.5 billion contract will cover construction of TV-Sat in addition to France's TDF-1. The contract will also include hardware needed to build a third direct broadcasting satellite. Both of the satellites will be launched via Ariane.

West Germany's domestic communications satellite project, called DFS (Deutsche Fernsehrundfunk Satellite) and also known as the Bundenspost Satellite, will provide conventional communications services such as telephone, telegraph, and facsimile as well as telematics. It will be launched in 1986.

The Bundespost and the West German Aerospace Agency (DFLVR) are conducting studies to select satellite specifications, payload, and performance characteristics, including the number of channels and the frequency bands that will be used. Three frequency bands are under consideration: 6/4, 14/12, and 30/20 GHz. Dornier Company has already conducted a feasibility study of 30/20 GHz for the DFS project.

Siemens was negotiating with West Germany's Bundespost to be the prime contractor to build West Germany's domestic communications satellite, POSTSAT. However, the Bundespost chose to award separate contracts for portions of the spacecraft following its traditional procurement procedures, including space and ground segments. Siemens, MMB, ERNO and AEG-Telefunken, now ANT, will all be subcontractors to build the communications payloads components.

Rosat is a new astronomy satellite that will be developed in West Germany with help from the United Kingdom and the United States. NASA will provide a high-resolution X-ray telescope similar to the one aboard its HEAO-2 satellite. The 2-ton Germany astronomy satellite will be able to search faint objects in space and is to be launched in early 1987 by the Space Shuttle. The satellite will be built by Dornier.

In July 1982, the West German government approved a new national space plan with $1.6 billion to be spent through 1986, which will include the development of a domestic communications satellite (DFS) and the first West German direct broadcasting satellite (TV-Sat).

UNITED KINGDOM

There is no single space agency in the United Kingdom. The Interdepartmental Official Committee on Space Policy is responsible for the coordination of the space programs of individual departments. Space activities are carried out by British institutions and industry through cooperative efforts with ESA, NASA, and commercial agreements between companies. The merging of the Rutherford and Appleton Laboratories (RAL) in September 1979 consolidated space sciences and communications systems.

The Science Research Council (SRC) funds the United Kingdom's contribution to ESA's science programs. The SRC has taken on cooperative programs with the Netherlands and the United States. The United Kingdom has participated in NASA IRAS; Copernicus NIMBUS 5, 6, and 7; Voyager 1 and 2; the Solar Max Mission; and Spacelab 2. SRC participated in 10 ESA missions including EXOSAT, Spacelab 1, ISPM, GIOTTO, and HIPPARCOS.

The Department of Industry coordinates the United Kingdom's participation in ESA's programs; it has supported MARECS, ECS, and L-SAT programs. The Royal Aircraft Establishment has pursued technical research for space applications and developed hardware for future remote sensing missions, and the Ministry of Defense has sponsored military telecommunications in the form of the Skynet program. The United Kingdom's overall expenditures are difficult to estimate because of the variety of financing sources.

In the United Kingdom space policies are the responsibility of the Department of Industry, but the Home Office becomes involved if a satellite is to be used for broadcasting. The first move was made in 1980 when the Home Office initiated a study of DBS implications. The BBC publicly declared its need for two satellite channels, one showing a mix of BBC-1 and BBC-2, and the other a pay-TV service. The IBA and ITV companies are not united on whether to support the British satellite. There is also growing interest in satellites among some U.K. commercial radio stations to challenge the BBC's monopoly with a private, satellite-broadcast, advertising-funded network of high-quality radio.

Several private companies have been set up to exploit satellites' potential. A private consortium, Satellite Television Ltd. is investigating the use of satellites for multinational services. Another company, Satellite Broadcasting Ltd., has been set up by British Aerospace and Rothschilds to construct, launch, and operate direct broadcast satellites as a common carrier.

The United Kingdom's earlier experience with non-commercial satellites dates back to November 1969 when Skynet was launched on a Delta launch vehicle to provide such services as telephone, digital data, and teletype for the U.K. military. In October 1971, the United Kingdom launched the Technology Satellite (GTS) to demonstrate high-quality telecommunication links as well as the overall performance of British spacecraft.

The British are currently in the planning stage for the launch of a direct broadcast satellite. The area coverage of the United Kingdom is suitable for reception by a 60-cm dish; a greater area coverage is possible by the use of larger dishes. The British satellite will be positioned at 31°W. The UNISAT is expected to be launched in 1986 and will operate at the 14/12 GHz frequency band.

British Aerospace, GEC-Marconi, and British Telecom announced in March 1982 that they are planning for a three-way venture, called United Satellite Ltd., to build a direct broadcast and business service satellite. The DBS capacity of the first of these, scheduled to be launched in 1986, will be used by the British Broadcasting Corporation for two channels of domestic television programming.

ITALY

The Italian space activities are controlled by the Ministry for Scientific and Technological Research. The management of national space activities is delegated to the National Research Council (NRC) while the management of the international activities (ESA, NASA, and Kenya Range) is delegated to the Space Office of the Ministry for Scientific Research. Italy's ESA programs are funded through the Foreign Office, the national effort is funded through NRC.

Until 1979, the national space effort was concentrated on the San Marco project and the SIRIO 1 program. In 1979, the national space program was reorganized and named the National Space Programs Division. The program for the period 1979 to 1983 was to be executed within the existing structure of NRC. The five-year plan includes basic and technological research, the Kenya Range, Spacelab (three payloads), the Italian Telecom Satellite (ITALSAT), remote sensing activities, IRIS (propulsion and auxiliary systems), and advanced structures.

The Italian National Space Programs budgets are as follows:

1981	35 billion lira	($29M)
1982	35 billion lira	($25M)
1983	45 billion lira	($28M)

Italy is a small country with limited prospects for managing its own national space programs on any reasonable scale since its industrial development is not sufficient to carry a national space program during the early stages of development. However, Italy has always been an active member in the European Space Agency. Italy has been contributing 10.9 percent of the ESA's total budget. Italy's participation has been especially intense in the European Space Agency's L-Sat program. Italy is contributing 24 percent of the cost.

L-Sat, renamed OLYMPUS, will be launched in 1986. Of the two transponders of the L-Sat, one will be allocated to Italy, partly because the satellite will be positioned at 19°W., which is the orbital slot that was allocated to Italy at the 1977 WARC. The plan suggests that the L-Sat channel should be used to provide preoperational service to promote Italian industry, especially in the manufacture of ground receivers. The main contractor for the L-Sat project is the British Aerospace consortium; however, many Italian companies such as Selenia, Contraves, Aeritalia, and Sia Viscosa actively participate in the project. The Italian contracts are worth about 40 billion lira.

Sirio, which was launched in August 1977, is an experimental communications satellite. The idea of Sirio was formulated at the end of the 1960's to enable Italian scientists and engineers to study communications at frequencies between 12 to 18 GHz. Sirio aimed to provide television, telephone, and data services at frequency band 17.4/11.6 GHz. The launch vehicle was a Delta.

ITALSAT is Italy's new preoperational domestic communications satellite; its development is scheduled to begin in mid-1983. ITALSAT is expected to operate in 30/20 GHz, with high-frequency propogation experiments in 50/40 GHz that transcend experiments, already conducted with Italy's Sirio satellite. The ITALSAT launch has been scheduled for the end of 1987 by the launch vehicle Ariane or the Space Shuttle. ITALSAT will be a large, three-axis stabilized satellite weighing 1,131 to 1,247 kg, depending on the launch vehicle. It has a 180-to 200-kg payload, six transponders, and a five-year life span. ITALSAT is planned to conduct the following missions:

(a) 30/20 GHz telephone communication through six transponders, covering Italy and point-to-point digital transmission in time division multiple access at 120 Mbs nominal speed.

(b) 30/20 GHz specialized services, such as data transmission, videoconferencing, and electronic mail.

(c) A 50/40 GHz propagation experiment covering all of Europe.

(d) An experiment involving wideband point-to-point data transmission.

The French and West German satellites will also provide partial coverage to Italy. The German satellite, TV-Sat, will be positioned at 19°W. and will have the same polarization as an Italian satellite. The French satellite TDF-1 will cover practically all northern and central Italy and northern Sardinia, with a signal reaching as far south as Naples.

NETHERLANDS

Space policy in the Netherlands is shared by the Ministers of Education and Science; foreign affairs, economic affairs, transport and finance are coordinated by the Minister for Science Policy.

The space activities are coordinated and managed by two organizations: the Netherlands Agency for Aerospace (NIVR), which is responsible for industrial aspects, and the Netherlands Commission for Geophysics and Space Research, which coordinates the scientific space activities. The key space programs have been national scientific missions: the Astronomical Satellite (ANS) launched in 1974, and the Infrared Astronomical Satellite (IRAS), a cooperative program with NASA and the United Kingdom. The Netherlands supports cooperative programs with ESA through NIVR and has supported the Indian Space Research Organization (ISRO) on the ATS-6 project. Their program for the 1980's is as follows:

(a) Participation in ESA programs such as L-SAT and ERS-1.

(b) Development of the technology of earth resource exploration in cooperation with Indonesia.

The Netherlands space budget in millions of Dutch guilders was as follows:

	1978	1979	1980
Scientific research	26	16	17
Space technology	2.7	3.3	5
National programs	35	31	18
ESA programs	43	45	41
Total	97 ($49M)	95 ($47M)	71 ($37M)

SPAIN

Space activities in Spain are managed by National Commission for Space (CONIE). CONIE in turn uses the services of the National Institute for Aerospace Techniques (INTA). Spain's activities are to support ESA; funds are provided by the Finance Ministry. The principal activities are associated with operating ground stations for NASA and ESA. INTA has a rocket sounding program. Spain integrated with the INTASAT scientific satellite in a joint effort with Hawker Siddeley Dynamics and NASA.

The space budget for Spain was as follows:

1978	1.39 billion pesetas ($19M)
1979	1.38 billion pesetas ($20M)

SWEDEN

The Swedish Board for Space Activities under the Ministry of Industry is the government agency responsible for Swedish national and international space and remote sensing programs. The executive functions of managing the space program are contracted by the board on a yearly basis to the state-owned Swedish Space Corporation. The important elements of the Swedish space program are:

	1981-1982	1982-1983	1983-1984
National programs	127M	116M	134M
ESA & Int'l. programs	256M	275M	552M
(in Krona)	383M ($77M)	391M ($80M)	686M* ($94M)

*Includes TELE-X

For many years Sweden was the leader of the Nordsat project, which was established in 1975 by the Nordic countries and which was the first DBS project in Europe. In the spring of 1979, Sweden adopted a new plan for space activities: a national project called Tele-X. Tele-X is a multi-purpose satellite that has a DBS potential. Furthermore, Tele-X is purely Swedish and aims to promote the national aerospace and the electronics industries.

The Board of Space Activities has prepared a proposal for Tele-X, a hybrid satellite that will serve the following purposes:

(a) Experiments with various telecommunication services (map/picture transmission, computer-to-computer links, direct television broadcasting, and land-mobile telex).

(b) The development of technical know-how, with the aim of creating a profitable space sector.

(c) The opening of new markets for the Swedish and Nordic electronic industries.

The first satellite will be ready to be launched by Ariane in 1986. An earth station to command and control the satellite will be placed near the existing aerospace installations at Kiruna in northern Sweden. Satellite and ground equipment will be developed and built by Scandinavian companies in cooperation with West German and French industries. Swedish companies that will participate in the development of the project include Saab-Scandia and Ericsson. It is expected that about half of the total space segment will be manufactured in Sweden. Responsibility for the system's specifications are shared between the Swedish Space Corporation and Televerket, the Swedish telecommunication administration. Two television channels and some data channels have now been proposed. There will also be a Nordic channel with news, sports, and special events.

The total cost of the project is estimated at $220 million. Sweden has agreed to pay 64 percent of the costs, and Norway 26 percent. Finland has not yet agreed to pay its 10 percent share, and Denmark withdrew in February 1982. Consequently, the final ownership profile remains open.

NORWAY

Norway's space activities are coordinated and managed by the Royal Norwegian Council for Scientific and Industrial Research (NTNF) which is advised by the Norwegian Space Activity Committee. The key programs are the Andoya rocket sounding range; the Tromso Station for reception of Nimbus NOAA, ISIS, and Landsat data; and support of the MARECS program.

The most important elements of the Norwegian national space program in recent years has been the support of the Maritime Satellite Telecommunications by participating in the ESA MARECS Project, of Scientific Space Research with sounding rocket payloads, and remote sensing activities with an earth resources receiving and analyses facility. Norway has also provided Earth Stations for Inmarsat and ECS.

Four key industries involved in space technology are Elektrisk Bureau, ELAB, Norsk Data, and NDRE.

3. MIDDLE EAST

Three satellites (ARABSATS) are being built by Aerospatiale of France at a cost of $134 million for a consortium of 22 Arab states that comprise the Arab Satellite Communications Organization. The Arab organizations extend through Africa and the Middle East and are headquartered in Riyadh, Saudi Arabia. Ford Aerospace and Communications Corporation is providing some of the hardware. Twenty-six percent of the total systems cost is being funded by Saudi Arabia.

The first ARABSAT will be launched in February 1984 on an Ariane rocket, to be located between 15° and 30°E. The second will be on board the Shuttle in October 1984, and the third will be used as a spare. Each satellite has 25 transponders: seven for television, one for community use, and the remainder for telephone and data service of approximately 8,000 circuits.

A contract for $11.6 million has been signed by NASA for the Shuttle launch of the second ARABSAT. A contract for the ground station is now being negotiated with ITT. The C-band earth terminals will also be separately procured. The S-band TVRO terminals might be manufactured in one of the Arab countries.

4. AUSTRALIA

The land area of Australia is about the same as that of the United States, and of the 16.5 million people who live there, 58 percent live in the cities of Melbourne, Sidney, Brisbane, and Adelaide. The remainder live, for the most part, in isolated rural communities. The farmers have emphasized the need for a reliable telephone system. Both telephone trunking and direct broadcast television services are planned to cover all six states of Australia, the Northern territory, surrounding coastal waters, and Papua New Guinea. These will be provided using three Aussat spacecraft--two in orbit (one of which is a spare) and one spare on the ground--for a total cost, including two earth stations, of $225 million (current Australian dollars). A contract was signed with Hughes for $173 million (U.S.). As soon as practical, 49 percent of the capital $225 million will be offered for investment to the Australian public. It is expected that the service will generate enough revenue to pay reasonable dividends and all debts.

Each spacecraft will carry 15 transponders, four with 30 W each, and 11 with 12 W each. The first two Aussats are scheduled for launch in 1985. Launch reservations have been made on the Space Shuttle for July and October of 1985. The spacecraft are to be built by Aussat PTY Ltd. and a subsidiary of Hughes Aircraft Company known as Hughes Communications International.

5. ASIA SOUTH AND EAST

INDONESIA

Indonesia covers about 250,000 square miles of territory, including 3,000 islands. Satellites are the most practical and economical method to link the islands together by telephone. Two Palapa A satellites are already in place; three more (Palapa B), are to follow. Each satellite will have 24 transponders, one of which will be used for regional television among the Association of Southeastern Nations.

The complete service will be generated by the Perushaan Oman Telekomanihasi (PERUMTEL), an Indonesian organization. The B series of spacecraft will cost $74.5 million, part of which is to be underwritten by the Eximbank and U.S. banks. The control center for the Palapa spacecraft will be in Jakarta, and at least 100 earth stations will be in use throughout the region in the near future.

INDIA

The advantages of satellite communications for applications to the domestic network in India have been amply demonstrated by India's use of a leased quarter transponder of INTELSAT IV.

The INSAT-1A, which failed five months after launch in the fall of 1982, was replaced by the INSAT-1B, which put the Indian system on an operational status. This launch was completed in 1983 via the Space Shuttle. This first-generation Indian national satellite system is a multipurpose project coming out of joint ventures within federal government departments. The INSAT satellite operates not only for telecommunications but also for meteorology; it has additional capacity for nationwide direct broadcasting to community television receivers in rural areas.

The INSAT-1A and its partner the INSAT-1B are located at 94°E. The 1B had been scheduled as a standby, but it is now the backbone of the system. There is no decision regarding further satellite programs at the present time, other than a commitment for an INSAT-1C.

India's experience in satellite communications began with the inauguration of the year-long satellite instructional television experiment (SITE) program on August 1, 1975. This experiment is significant because direct-reception television, as a concept, was tested for the first time on a large scale. Using the NASA geostationary satellite ATS-6, educational television programs were beamed every day to 2,400 specially selected villages in six states.

Another important landmark was the further conduct of the STEP communications experiment for one year during 1977 and 1979 using the Franco-German satellite Symphonie. In the field of earth observations, the launch of the Bhaskara-1 in June 1979 by the Soviets represented the culmination of a number of remote sensing experiments directed toward building a Landsat capability.

The successful launching and management of the complex three-axis stabilized experimental geostationary communications satellite, APPLE, on June 19, 1981, was a major milestone in the Indian space research program. Although not listed in the operational satellites in Table 1, it was important as an interim step. Unlike the earlier satellites (Aryabhata, Rohini, and Bhaskra), which were all spin-stabilized, APPLE had its own apogee boost motor for taking the spacecraft to a near-synchronous orbit of 36,000 km and its own small rocket thrusters for maneuvering control.

The main thrust of the Indian space program in the 1980's will be to put many of the earlier services into operation. A remote sensing satellite, the IRS, is the first semioperational remote sensing satellite that can provide images in the visual and near-infrared band. It is scheduled for launching in 1986 or 1987.

Although the loss of INSAT-A was a great disappointment, the Indian communications activities for the 1990's is now underway with the launching of INSAT-B which established geostationary orbit September 1, 1983, and with the procurement of INSAT-C. With the collective experience from all of these satellites, ISRO should be in a good position to develop future INSATs; it is also planning to launch them.

PEOPLE'S REPUBLIC OF CHINA

The latest plans of the People's Republic of China are to use its own Ariane-like (C23) launcher to launch its first domestic communications satellite (STW-2) into orbit in 1984. This is the first of two satellites, each weighing 420 kg, planned for geostationary orbit. They are to be located at 70° and 135°. Two earth stations will have control centers. The Chinese Space Agency has been established to oversee the development and launching of the STW2's,

These satellites are primarily for telephone communications and will be operated by the Postal and Telegraph Department, one of two bureaucracies in China interested in satellite systems. The other department, the Central Broadcasting Administration, is known to favor the use of China's very limited financial and technical resources to operate a television-based open university. This would educate students at one-third the cost of sending them to a conventional university.

Given the background of the two competing bureaucracies, it is possible that China will develop rapidly. The choice to allocate transponder space in the first satellite for the television open university underscores the commitment to education and indications are that this satellite will be procured outside of the People's Republic of China.

6. ASIA/JAPAN

INTRODUCTION

Space development in Japan is created in a comprehensive and systematic way under the leadership of the Space Activities Commission (SAC), the advisory organization to the Prime Minister. SAC was established in 1968, replacing the National Space Activities Council that was formed in 1960. SAC consists of the chairman (the Minister of State for Science and Technology) and four commissioners. SAC is authorized to submit its opinion to the Prime Minister on important matters related to space development.

SAC formulated an outline of Japan's space development policy in March 1978, which set forth guiding principles of Japan's space activities for the next 15 years. SAC also decided on a space development program to implement the 15-year plan. The Prime Minister, based on SAC recommendations, decides the government's basic space development program and the related administrative organizations to conduct research and development.

The Science and Technology Agency (STA) which reports to the Prime Minister's Office, was established in 1956. A number of important space organizations report to STA: The National Space Development Agency of Japan (NASDA), the Research Coordination Bureau (RCB), the National Aerospace Laboratory (NAL), and the Remote Sensing Technology Center of Japan.

NASDA is the central body for space development in Japan. In accordance with the space development program decided by SAC, NASDA promotes space development projects whose objectives include the peaceful use of space. The NASDA space budget is included in Table 1. The principal tasks are as follows:

(a) Development of satellites for application such as communications, meteorology (research or information), geodesy and remote sensing of the earth.

(b) Development of satellite launch vehicles.

(c) Development of ground support equipment and facilities for satellites and launch vehicles.

(d) Maintenance and consolidation of tracking and data acquisition networks.

(e) Operations of launching, tracking, and data acquisition.

The Research Coordination Bureau (RCB) was established in 1962. RCB is made up of three divisions: the Space Activities Planning Division, the International Space Affairs Division, and the Space Development Division. Its planning activities coordinate and consolidate plans and estimates from other organizations for submission to SAC.

The National Aerospace Laboratory conducts advanced research in the field of aeronautics and coordinates its programs with NASDA and other agencies. In satellite research, it has worked on ion engines, cryogenic engines, and three-axis satellite control systems.

The Institute of Space and Astronautical Science (ISAS) at the University of Tokyo reports to the Ministry of Education (MOE) and is responsible for the research and development of scientific satellites and their launch vehicles as well as their launch and data acquisition.

The ISAS space budget has been about 10 percent of the total Space expenditures in the annual budget.

The Ministry of Posts and Telecommunication (MPT) is responsible for the supervision of NASDA and the Telecommunication Satellite Corporation of Japan in the use of communications satellites. MPT has pushed ahead with satellite communications and satellite broadcasting. MPT has implemented the CS, BSE, and ECS satellite programs described in the sections that follow as national projects, with the cooperation of NTT, NHK, KDD, and NASDA. MPT supervises KDD, which is the signatory of INTELSAT and INMARSAT international communications systems. MPT represents Japan in the ITU.

The Radio Regulatory Bureau (RRB) reports to MPT and is responsible for planning and promoting policies in satellite communications and satellite broadcast systems as well as radio regulation with regard to space utilization development and research. RRL (Radio Research Laboratory) carries out research in radio wave propagation, space communications with the Japanese satellites, UME and ionosphere sounding satellite, with ETS II (KIKU-2); with experimental test satellite and ECS an experimental communications satellite, CS (Sakura) a medium capacity communications satellite, BSE (Yuri) an experimental medium scale broadcast satellite.

A number of other government agencies are involved with space: the National Police Agency, the Environment Agency, the Ministry of Foreign Affairs, the Ministry of Agriculture, Forestry and Fisheries, the Ministry of International Trade and Industry, the Ministry of Construction and the Ministry of Home Affairs, and the Ministry of Transportation, through its Japan Meteorological Agency (JMA). Table 1 summarizes the complete space budget.

To date, Japan has launched 24 satellites. Its comprehensive space program ranks third among international space programs (behind the USSR and the USA). Table 2 highlights NASDA space programs, and Table 3 Japan's Communication satellite evolution.

The Telecommunications Satellite Corporation of Japan (TSCJ) was formed by Japan's Parliament in July 1979. TSCJ is a corporation authorized under special law whereby the Ministry provides all necessary aid and supervision and its mission is to provide uniform control and operations of communications satellites. TSCJ is to ensure the growth and development of telecommunications and the effective use of the frequency spectrum in space. To achieve this objective, TSCJ controls the satellite position and attitude and has the authority to grant permission for the use of the communications subsystems on-board the satellite to the various users.

TSCJ is financed by both government and private corporations. The initial capitalization amounted to 840 million yen, with the government providing 420 million yen and the principal users (NTT, NHK, and KDD) each contributing 140 million yen. The capital will be increased yearly until the total is 7 billion yen. These funds will be used for construction of terrestrial operational and satellite control facilities. The costs of providing spacecraft and launching the satellites will receive separate funds and will be recovered from the organizations using the satellites.

NTT has long-range plans to acquire large communications satellites, some as heavy as four tons, to support a digital telecommunications system, supposedly the first of its kind in the world.

JAPAN'S INDUSTRIAL ROLE IN SPACE

There are 92 Japanese companies involved in space production and research. Sales totaled $507.5 million (U.S.) in 1981 for this group, and a total of 6,600 people were employed with these organizations. About 75 percent of the sales were expended in Japan, and $25.8 million was spent on research and development by these companies in 1981.

The three principal companies that design, fabricate, assemble and test spacecraft are Mitsubishi Corporation (Melco), Nippon Electric Corporation (NEC), and Toshiba. Each of these companies has teamed up with U.S. companies. Melco is teamed with Ford Aerospace. NEC has two team members: Hughes Aircraft Corporation for spin-stabilized spacecraft and RCA Astro-Electronics for three-axis stabilized systems. Toshiba has teamed with General Electric. Over the past ten years, the percentage of domestic space hardware has increased significantly. STA has put pressure on NASDA, which in turn puts pressure on the Japanese manufacturer to increase the Japanese domestic content of any new procurement, so that today some programs contain 85 to 90 percent Japanese effort. All of the scientific satellites sponsored by ISAS have always had very high Japanese domestic content. With respect to launch vehicles, NASDA has a large technology transfer program with McDonnell Douglas in the development of its N-I and N-II rocket which is a derivative of the U.S. Delta series. ISAS developed its own M series of launch vehicles through Mitsubishi Heavy Industries Ltd., which is the principal Japanese company that has produced the N-I, N-II, and the H-I launch vehicles.

TABLE 1
JAPANESE BUDGET FOR SPACE ACTIVITIES (IN 100 MILLION YEN*)

Fiscal Year	NASDA	ISAS	Other**	Unit: Total	$M
Up to 1970	248.8	200.2	43.3	492.3	210
1971	104.7	28.9	19.9	153.5	64
1972	182.7	32.7	24.2	239.6	102
1973	293.3	38.1	34.2	365.6	156
1974	475.6	50.8	48.3	574.7	233
1975	614.2	65.4	90.7	770.3	328
1976	726.5	71.4	82.3	880.2	374
1977	791.7	84.1	73.3	949.1	403
1978	794.1	92.2	73.3	959.6	408
1979	818.4	102.5	73.6	994.5	423
1980	837.3	103.7	79.1	1020.1	434
1981	853.6	112.4	84.0	1050.0	447
1982	884.2	129.3	71.2	1084.7	462
1983	905.6	151.8	76.5	1133.9	493
				10,688.1	$4,540M est.

* 235 yen = approximately $1.00 over the period reported.

** "Other" consists of the following organizations:

Ministry of International Trade and Industry
Ministry of Transport
Ministry of Posts and Telecommunications
Ministry of Construction
Ministry of Agriculture, Forestry and Fisheries
Environment Agency

TABLE 2
NASDA APPLICATION SATELLITES

Satellite		Launch Date	Weight (kg.)	Launch Vehicle
		Current Satellites		
KIKU	ETS-I	9-9-75	32	N-I-1
UME	ISS-1	2-28-76	139	N-I-2
KIKU-2	ETS-II	2-23-77	130	N-I-3
HIMWAWARI	GMS-1	7-14-77	315	Delta
SAKURA	CS	12-15-77	340	Delta
UME-2	ISS-2	2-16-78	141	N-I-4
YURI	BSE-1	4-7-78	355	Delta
AYAME-1	ECS-a	2-6-79	130	N-I-5
AYAME-2	ECS-b	2-22-80	130	N-I-6
KIKU-3	ETS-IV	2-11-81	638	N-II-1
HIMAWARI-2	GMS-2	8-10-81	290	N-II-2
KIKU-4	ETS-III	9-3-82	385	N-I-7
SAKURA-2A	CS-2a	2-83	350	N-II-3
SAKURA-2B	CS-2b	8-83	350	M-II-4
		Future Launches		
	BS-2a	2-84	350	N-II-5
	GMS-3	8-84	350	N-II-6
	BS-2b	2-85	350	N-II-7
	Test P/L	2-86	TBD	H-I-1
	MOS-1	8-86	750	N-II-8
	GS-1	2-87	550	H-I-2
	ETS-V	8-87	550	N-II-9
	ERS-1	8-87	750	H-I-2
	CS-3a	2-88	TBD	H-I-3
	CS-3b	8-88	TBD	H-I-4
	BS-3	2-89	TBD	H-I-5

TABLE 3
JAPAN'S COMMUNICATION SATELLITE EVOLUTION

ISSa - UME	Ionosphere studies.
ETS-II, KIKU-2	Japan's first geostationary communications satellite.
CS, SAKURA	Medium capacity experimental communication satellite.
ISSb, UME-2	Ionosphere studies.
BSE-1, YURI	Medium-scale broadcast experimental satellite.
ECSa, AYAME	Experimental communications satellite (failed to achieve orbit).
ECSb, AYAME	Experimental communications satellite (failed to achieve orbit).
ETS-IV, KIKU-3	Technology for large-scale communications satellite.
ETS-III, KIKU-4	Technology for three-axis and large solar array satellite.
CS-2a	Domestic communications satellite similar to Sakura.
CS-2b	Domestic communications satellite similar to Sakura.
BS-2a	Broadcast domestic communications satellite similar to YURI.
BS-2b	Broadcast domestic communications satellite similar to YURI.
ETS-V	Three-axis technology for geostationary orbit.
CS-3	Advanced domestic communications satellite.
BS-3	Advanced high-power broadcast satellite.
ECS-II	50/40-GHz experimental satellite

DESCRIPTION OF JAPAN'S COMMUNICATIONS SATELLITES

ETS-II, KIKU-2, ENGINEERING TEST SATELLITE 2

ETS-II, Japan's first geostationary satellite, was launched on February 16, 1977 by the N-I launch vehicle. This successful mission made Japan the third country in the world to place a satellite in geostationary orbit. The spacecraft weighs 130 kg. The mission objectives of ETS-II were to develop the launching and tracking/control technologies as well as the attitude control technology of a geostationary satellite. Tests were performed on a despun antenna, and the Radio Research Laboratory conducted propagation tests. ETS-II was configured with 1.7, 11.5 and 34.5 GHz transmitters.

ETS-IV, KIKU-3, ENGINEERING TEST SATELLITE 3

ETS-IV was the test payload for the development test flight of the N-II launch vehicle. The mission objectives of ETS-IV were to develop the technology for a large-scale, heavy, spin-stabilized satellite. The NASDA spacecraft was launched in February 1981 and placed into geostationary transfer orbit of 3600 km apogee and 225 km perigee with an inclination of 28.5°. The spacecraft weight was 640 kg.

CS, SAKURA, MEDIUM-CAPACITY COMMUNICATIONS SATELLITE FOR EXPERIMENTAL PURPOSE

CS was launched in December 1977 by the Delta launch vehicle and was placed into geostationary orbit at 135°E. The mission objectives of CS were to conduct experiments in satellite communications using quasi-millimeter waves. CS is a spin-stabilized spacecraft with a despun horn reflector. The spacecraft was equipped with six 30/20-GHz transponders and two 6/4-GHz band transponders. Both RRL and NTT have conducted experiments on SAKURA. These experiments were carried out with fixed and transportable earth stations.

ETS-III, KIKU-4, ENGINEERING TEST SATELLITE 4

ETS-III is intended to carry out tests on three-axis attitude control spacecraft, and to develop production and operation technology for satellites requiring high power, to deploy solar paddles, and to use active thermal control systems and on-board equipment. ETS-III was launched by the N-I launch vehicle on September 3, 1982. The spacecraft weighed 385 kg and was placed in a circular orbit at 1000 km at an inclination of 45°. An ion engine was installed on ETS-III for flight evaluation to study future space propulsion systems.

CS-2, COMMUNICATIONS SATELLITE 2

The CS-2 program is intended to establish the first Japanese domestic satellite communications system. The space segment is composed of two satellites in geosynchronous orbits located at 132° and 136°E. The mission objectives of CS-2 are to establish domestic public telecommunications services for natural disaster emergencies and to provide telecommunications networks for government agencies and corporations.

CS-2 was developed by NASDA and manufactured by Mitsubishi Electric Corporation; Ford Aerospace and Communication Corporation was the principal subcontractor. The communications antenna and transponder were based on a design developed by NTT and manufactured by Melco. Ford produced the spacecraft. CS-2a and 2b were launched by the N-II launch vehicle. NASDA directed the launch sequence, the orbit injection, and the initial station acquisition and spacecraft checkout. CS-2b was successfully launched on August 5, 1983.

The CS-2 communications subsystem consists of six channels at Ka-band and two channels at C-band. The Ka-band coverage is limited to the main Japanese islands, while the C-band coverage extends to the remote islands. The K-band antenna utilizes shaped beam technology. It has a three-year life with a design goal of five years.

The 130-MHz bandwidth channels are used for telephone, color television, and data transmission. The C-band channels will provide telephone, color television transmission, and data transmission between ground stations on the Japanese mainland and the remote islands. The spacecraft coverage (antenna) at K-band provides 33 db (min) gain to the main islands and 25 db (min) at C-band to the main and remote islands. The antenna has circularly polarized radiation at C- and K-band.

BSE AND BS-2a, 2b, MEDIUM SCALE BROADCASTING SATELLITE
FOR EXPERIMENTAL PURPOSE (BSE-YURI)

BSE was launched on April 7, 1978 as the first experimental direct broadcast satellite in Japan. It was launched by the U.S. Delta launch vehicle, and was placed in a geosynchronous orbit at 110°E. BS-2a and 2b broadcasting satellites are intended to establish the first operational direct broadcasting satellite system using Ka-band frequencies allocated to satellite broadcasting service at the 1977 WARC.

BS-2 will provide operational broadcasting services to solve television reception difficulties in mountainous areas and on the remote islands of Japan. BS-2 will establish the technology of the broadcast satellites. The DBS program is sponsored by MOPT, NASDA, and NHK through TSCJ. The contract was awarded to Toshiba with General Electric as a major subcontractor.

BS-2a is scheduled for launch in the first quarter of 1984, BS-2b in the summer of 1985. NASDA will perform the launch and initial in-orbit checkout of BS-2a and, after completion, it will hand it over to TSJC for operation control. The transponders will be utilized by NHK to provide color television to simple home receivers.

OVERVIEW OF EXPENDITURES FOR SPACE

Japan is moving with methodical determination to establish itself as one of the leaders in space technology. Japan's space programs are modest when compared to the U.S. space effort by NASA, DOD, and the private sector. However, Japan has a greater proportion of its space budget devoted to space application programs such as communications meteorological, and earth resources satellites. In addition, Japan has embarked on the scientific exploration of earth and deep space, technology programs to make Japan independent in spacecraft design, three-axis stabilization, large deployed power systems, active thermal control, ion engine thrusters, solid-state imaging systems, material processing in space, and launch vehicle technology, which includes cryogenic propellant upper stages. Japan's ground support systems are extensive and still growing. There are two principal launch sites, a satellite control center, dedicated centers for processing meteorological and earth resources satellite derived data, a comprehensive central satellite assembly and test facility, and a worldwide satellite communications network.

Japan has made large investments in acquiring U.S. space technology during the past decade. Some of the major procurements in the United States included the ECS, CS communications satellites, the GMS meteorological satellites, and the N-1 launch vehicle technology and hardware. Having done their homework well, the Japanese are now increasing the domestic content of all current and future space hardware procurements. (Table 4 depicts the steady growth in self-sufficiency.) Whereas in the past between 50 and 85 percent of the space programs were of non-Japanese content, many of these programs contain either predominantly Japanese-made hardware, or will do so with the follow-on procurements. In the past the Japanese space programs have not been cost-effective compared with similar programs in the United States, primarily because of the high cost of technology transfer from the United States to Japan. In addition, Japan invested funds to train its industrial teams in learning and adapting this new technology. On the other hand, the scientific satellites under the management of the ISAS have been designed and built in Japan.

Japan has become a principal developer and manufacturer of communications subsystems. Key components were developed for the INTELSAT IV, V, and VI programs. Table 5 summarizes the INTELSAT contracts in Japan. Japan has become a world leader in providing earth stations for domestic and international systems.

In the next five years, Japan will be making significant gains in space technology. In August 1983, the second CS-2b was launched as an in-orbit spare, ensuring operational service in the 30/20 GHz band. Earlier that year CS-2a was successfully launched providing NTT with eight transponders in the 30/20 GHz and 614 GHz band for business data, facsimile and video service. Japan's expenditures in the Ka-band greatly exceed the U.S. effort, providing Japan a significant lead in the technology and operational use. In February, 1984, the BS-2a medium broadcasting satellite will be the first operational DBS.

TABLE 4
JAPANESE SPACE PROGRAMS
DOMESTIC VERSUS FOREIGN FABRICATION

Program	Launch Date	Percent Japanese	Percent Foreign
Communications Satellites			
ETS-II Kiku	2-77	40	60
CS Sakura	12-77	24	76
BSE Yuri	4-78	15	85
ECS-1 Ayame	2-79	50	50
ECS-1 Ayame	2-80	50	50
CS 2a, 2b	2-83, 8-83	64	36
BS 2a, 2b	2-84, 8-85	29	71

TABLE 5
JAPANESE INTELSAT CONTRACTS

	Contract Value
INTELSAT IV (NEC)	
Repeater subsystem, including power supply converter output	$ 1,154,000
INTELSAT V (Melco)	
4/6 GHz earth coverage antenna, power conditioning and command unit, telemetry unit	$11,827,000
INTELSAT VI (NEC)	
K-band receivers, upconverter amplifiers, master oscillators, and solid state power amplifiers	$22,600,000

FUTURE JAPANESE SPACE PROGRAMS

The Japan Space Development Council, in preparing its 1984 fiscal budget request, has recommended a national space program aimed at developing a new launch vehicle with a 4,400-lb payload and the launching of 78 satellites from 1984 to 2000. Officials have stated that this program will cost more than $10 billion. The new launch vehicle, tentatively designated H-2, will cost $1 to $3 billion. Table 6 provides cost data for certain Japanese programs.

The plan calls for an annual increase in Japan's space budget of five to ten percent over the next 17 years. Current budget is $450 million. This program, if approved, will provide Japan the ability to compete with the United States and other countries in the satellite market. Additional proposals in the long-term plan include the following:

Large communication satellite, CS-4, capable of 100,000 to 200,000 telephone circuits.

Broadcast satellite, BS-4, to cover wider areas and operate in the 27/22 GHz frequency band. This latter satellite is scheduled for a 1996 launch.

A navigation, rescue, and intersatellite communication system, the first designated MCS-1, to be launched in 1992.

An experimental earth resources satellite, ERS-1, to be launched in 1990.

An ionosphere observation satellite, EMEOS (Electromagnetic Environment Observation Satellite), to be launched in 1993.

Three engineering test satellites for communications experiments, with moving vehicles in 1987, multibeam and digital three-axis controls in 1992, and another aimed at attitude control and research in lightweight structures.

TABLE 6
Cost of Japanese Space Programs

Program	Col. 1 $ M	Col. 2 $ M	Col. 3 $ M	Col. 4 $ M
ETS-II	18.26			
ECS-1	13.04			
ECS-2	33.04			
CS-1	15.65			35.00
CS-2a & b	86.96	56.27	CS-2b-48.9	70.00
BSE	19.13		63.00	50.00
BS 2a & b	89.57		76.4 (2)	
CS 3a & b		81.30	80.4 (2)	
ETS-I	2.17			
ISSa	5.65			
ISSb	6.52			
ETS-IV	10.00			
ETS-III	32.61			
ETS-V		33.32	32.9	
GMS-1	12.17			
GMS-2	23.04			
GMS-3a & b	20.87	23.67	23.2	
MOS-1	52.17	61.86	56.88	

* All conversions from yen to U.S. dollar is 230 Yen to 1 dollar and in FY '83 figures. The '83 fiscal year in Japan commenced in April, 1983.

** Above costs have not been adjusted for inflation or variations between U.S. # and the Yen.

Col. 1 data from a private Japanese source.
Col. 2 data from NASDA FY 83 prelim. budget.
Col. 3 data from Av Week 1/17/82 or 3/14/83.
Col. 4 - other sources, such as S. Fordyce

A comprehensive research and development program to support this far-reaching space program. The research includes the following:

Improvement of three-axis control and spin stabilizing technology.

Technology for large-size, large-capacity vehicles.

Standardization and commonality of subsystems for better reliability and cost reduction.

Development of star sensor/laser gyro inertial reference system and magnetic-bearing flywheel.

Development of transmission technology for telemetric data.

Development of new relay and antenna for new frequency bands, including 50/40 GHz band, 27/22 GHz band, 2.6/2.5 GHz band, and a multibeam communication technology.

Development of an active microwave sensor, synthetic aperture radar, microwave altimeter, and high-resolution optical sensor.

Development of guidance and control technology for launching orbiters into lunar and planetary orbits.

Development of reentry and soft landing technology for orbiters and surveyors, and development of lunar/planet and gravity-field utilized orbit transferring technology.

Development of rendezvous/docking technology and manipulator control technology for future robot satellites.

7. NORTH AMERICA/CANADA

Telesat Canada, a Crown Corporation commercial telecommunication carrier, was established in 1969 by an Act of Parliament. As early as 1976, Canada was the first country to demonstrate the ability to broadcast from a satellite to small receiving terminals, with the launch of Hermes, an experimental broadcasting satellite sponsored jointly by NASA and Canada's Communications Research Centers. Hermes contained a 200-W RF output transponder, which gave an effective isotropic radiated power of 60 dBW. Hermes is also known as the Communications Technology Satellite (CTS), and worked in the 12/14-GHz band. The CTS was the world's most powerful satellite. Its efficient solar powered transmitters enabled it to communicate effectively with relatively small ground stations. During its four-year life, CTS was able to deliver television of excellent viewing quality to earth stations with antennas as small as 60 cm. in diameter.

Anik A-1, launched in 1972, and Anik A-2, launched in 1973, are both turned off and boosted out of geostationary orbit. Anik-3, launched in 1975, is currently partially operational and has some spare capacity. Canada's Anik B, launched in 1978, is now offering commercial services in both the 4/6- and 12/14-GHz frequency bands. Anik B uses 3-axis stabilization rather than the spin-stabilization used for the Anik A series. Anik B has four 20 watt 12GHz transmitters which can deliver television signals to small earth stations. In addition, the signals do not interfere with conventional terrestrial communications, so these earth stations can be located in urban centers.

Anik B has two antennas. One antenna provides a single beam in the 6/4-GHz band. The 12 transponders in this band each carry one color television signal, with mono audio, or 960 one-way telephone circuits. The second antenna provides four spot beams in the 14/12-GHz band, with four transponders. The 6/4-GHz band will be used to provide common carrier services for television and voice. The entire 14/12-GHz capacity has been leased by The Department of Communications (DOC) for broadcasting experiments. DOC has purchased ground stations with antennas 1.2 or 1.8 m in diameter.

Anik C-3, launched on November 11, 1982, operates in the 14/12 GHz Band. The $53.6 million contract was awarded to Hughes Aircraft Corporation, with Canadian industry receiving approximately $24 million in subcontracts, shared among the following companies: Spar Aerospace Products Ltd., of Saskatoon, Saskatchewan; Comdev Ltd., of Montreal, Quebec; and Fleet Industries of Fort Erie, Ontario.

Anik C-2, launched June 18, 1983, will supply some communications services to the U.S. The spacecraft was launched by The Space Shuttle. Each of the 16 transponders delivers 15 w of power. The antenna patterns consist of a wide-beam receive and four (47dBW e.i.r.p.) transmit spot beams with footprints the size of a U.S. time zone covering areas below the 60th parallel. Anik C was originally designed for telephone and data, but the successful television experience with Anik B and the regional coverage of Anik C led to the use of this new satellite for television broadcast distribution.

Anik D-1 was launched August 12, 1982 on a NASA Delta launch vehicle. Anik D-1 is a 24-channel communications satellite, and is the biggest Canadian satellite. Anik D's 24 communications channels, each 36 MHz in bandwidth, will be located in the 6/4 GHz Band. This satellite will have twice the communications capacity of earlier Anik A series. Both of the Anik D's will provide a full country coverage of Canada. The satellite will be used by Telesat in orbit replacement and backup for the Anik A and Anik B satellites. The contract of $78.6 million for the construction of Anik D-1 and Anik D-2 was awarded to Spar Aerospace Limited of Toronto. The spacecraft were built by Hughes Communications Satellite Group, under a subcontract from Spar.

VIII MARKET SHARE CAPTURE

The potential for market share capture by various companies external to their own domestic market is summarized in Table 7 and Table 8. It should be observed from the outset that, generally, a manufacturer within a country has first preference in the bidding for a satellite system to be launched by its country, or wherever a country is part of a regional consortium (such as Eutelsat, etc.) which is planning to place a satellite system into operation. During the last five to ten years, countries such as Japan, which have developed the ability to construct their own satellites, have tended to favor their national manufacturers when procuring communication satellite systems.

Portions of the market have been identified in earlier Figures 4, 8 and 12. Since many procurements have not been issued, the predictions of potential capture rest upon a number of factors, including follow-on sales of present systems which are currently under construction, and indications that countries or consortia such as Eurosatellite are obtaining experience with in-flight systems. For instance, the current components and experience on TDF and TV Sat which is being utilized in the development of Tele-X, provides continuity in Ku(BSS) spacecraft and a capability which will be highly marketable in the 90's. Indications are that countries such as Japan will begin to market satellite capability in their regions once they have gained sufficient experience domestically with their "locally produced" satellite systems.

Table 7 provides an estimation of the number of satellite sales that each company may be considered as "capturing" from 1986 through 2000. These represent the population of satellites listed in the undetermined categories on the earlier Figures 4, 8, and 12. Table 8 provides data relating to the possible capture of satellite sales by regions of the world.

Each spacecraft manufacturer will sell within his own country or region, hence the "D" or domestic designation. Potential sales outside the region are indicated by "F". The data are highly speculative and

ORIGINAL PAGE IS OF POOR QUALITY

Table 7

"ESTIMATED NO." OF SATELLITES OF UNDETERMINED MARKET, BY *FREQUENCY BAND* 1986 - 2000

		BAND												
COMPANY	REGION*	C	C/Ku	C/S	C/L	Ku	Ku/BSS	Ku/Ku/BSS	C/Ku/Ka	C/Ka	C/X	Ka	C/Ku/X	UHF
HUGHES	D	22	4			15	4							
	F		9				2							
RCA	D	5	2			17	8							
	F						8	1						
FORD	D		5			2	2							
	F		1	3			1		12		1			
GE	D													
	F						1				1			
TRW	D					3	2							
	F													
SPAR	D	2	1			1								
	F				4								1	
ES	D					4	2		3			1	1	
	F	1	2			3	4					2		2
BAe	D													
	F	2					2	1						
J.CO.	D					2	2			5		4		
	F	3					1							

*D = DOMESTIC (operating in same region as manufactured)
F = FOREIGN (operating in region other than where manufactured)

C-2

Table 8

"ESTIMATED NO." OF SATELLITE SALES BY EXPORT REGION*
1986 - 2000

	INMARSAT	INTELSAT	U. S.	EUROPE	NORTH AMERICA	ASIA (NOT JAPAN)	LATIN AMERICA	AFRICA	AUS.	ARAB STATES
HUGHES		22				1	8		2	
RCA				3		4	1			
FORD		11				1	3			3
GE				1		3				
SPAR	3						2			
ES		2			2	3	1	2		
BAE			2							
J. CO.						3				
AEROSPAT/FORD										1

*Table 3 reflects all high probability, known or potential sales. It does not include all 74 undetermined production sales listed in Table 2, but does assume that ninety percent of countries having major satellite production capabilities will sell to their own. Assuming this to be true, at the current time, approximately one hundred and ten satellites would fall into the "export category." Approximately twenty-five percent are too undefined at this time to estimate as "possible capture" by a particular satellite manufacturer.

based upon potential follow-on sales of a current spacecraft currently under contract, i.e., Palapa (Hughes); known or increased marketing activity by a manufacturer in a region; or an indication of buying preferences in certain regions, and purely clinical judgments.

Replacement of satellites currently in orbit and the establishment of new systems will affect the market share capture. A company which is currently manufacturing a spacecraft series for a client, should be in a good position to obtain repeat sales, should a country or regional consortium decide to extend a series and procure additional satellites. Table 9 provides an estimate of the new and replacement satellites required each year.

INTELSAT Procurements

The involvement in INTELSAT procurements is treated as an international or "foreign" activity as defined in Figure 14 in the foregoing. The rationale for this assumption is the multiple country representative forumlation of requirements and review of proposals submitted for satellite procurement.

As outlined in Tables 10, 11, and 12, many countries have participated in the sub-contracts for the INTELSAT 3, 4, and 5 spacecraft and the trend for greater participation in the total contract value is indicated with the V and Vi purchases. As European countries and Japan, as well as other Asian countries such as India, develop greater space production capability and experience, the numbers of countries participating and the level of involvement could increase to thirty-forty percent of the procurement cost. Also, it is not inconceivable that the prime contractor could be a non-U.S. firm in the mid-90's, thus boosting the share of "foreign participation" by a given country or countries.

Table 9

SATELLITES SCHEDULED
Estimated New and Replacement
1984 - 2000

	New	Replacement
1984	11	10
1985	21	9
1986	21	7
1987	26	6
1988	20	9
1989	15	2
1990	8	4
1991	10	17
1992	8	13
1993	16	6
1994	10	10
1995	15	9
1996	13	4
1997	6	11
1998	8	8
1999	3	2
TOTAL	211	117

TABLE 10 INTELSAT IV SUBCONTRACTORS[1]

COUNTRY/SUBCONTRACTOR	APPROXIMATE VALUE OF SUBCONTRACT $US
United Kingdom	
British Aircraft	$ 6,766,000
Ferranti	589,000
France	
CFTH-HB	3,329,000
S.A.T.	625,000
Germany	
AEG-Telefunken	2,716,000
Japan	
Nippon Electric	1,154,000
Italy	
Selenia	794,000
Switzerland	
Contraves	777,000
Belgium	
ETCA-ACEC	849,000
Canada	
Northern Electric	1,366,000
Sweden	
Svenska Radio	419,000
Spain	
Kolster-Iberica	34,000
Grand Total:	$ 19,418,000

[1] Based upon Visher, P.S. "Intelsat Competition and Cooperation" paper presented at the AIAA Annual Meeting, Long Beach, CA. May 10, 1983.

TABLE 11 INTELSAT V SUBCONTRACTS

COUNTRY/SUBCONTRACTOR	DELIVERY/INC. INCENTIVES $USM	% OF CONTRACT VALUE
France		5.4
Snias	7.6	
	10.1	
Thomson CSF	1.8	
	2.5	
Germany		10.3
MBB	18.2	
	24.3	
Italy		3.6
Selenia	6.3	
	8.4	
Japan		2.9
Mitsubishi	5.0	
Electric Corp.	6.7	
United Kingdom		1.0
Marconi	1.7	
	2.3	
	94.9	23.2

TABLE 12 INTELSAT VI SUBCONTRACTS

PARTICIPANT	US$M	% OF CONTRACT VALUE
United Kingdom		
British Aerospace	32.4	4.8
France		
Thomson CSF	24.8	3.7
Germany		
MBB	18.5	2.8
Selenia	24.4	3.6
Japan		
NEC	22.6	3.4
Canada		
Spar	18.0	2.7
	$140.7	21.0

IX. SOME SCENARIOS THAT MIGHT ALTER SATELLITE MARKET PROJECTIONS

There are a number of scenarios that could drastically alter the satellite projections contained in this report.

- A breakdown in the cooperation of the signatories to the International Telecommunications Union could compromise the orbit assignments and operation of geostationary satellites. If the ITU were unable to resolve disputes between Administrations contending for orbital slot assignments, their use could be compromised.

Alternatively, the ITU could make arbitrary slot assignments based on the premise of equal votes for all Administrations. This could contribute to large numbers of assigned orbital positions lying fallow, and unusable by the Administrations planning to place large numbers of satellites in orbit.

In addition, to a lack of international cooperation, there are a number of commercial considerations which could alter the satellite projections.

- A major unknown is the extent to which INTELSAT will be able to maintain its monopoly on the international satellite communications. Because of the lack of competition and the involvement of local PTT Organizations as "middlemen," the INTELSAT circuits cost the users far more than most regional or domestic satellites. Inroads have been made in the INTELSAT traffic when Hawaiian traffic was routed on U.S. domsats rather than INTELSAT. 60% of the Pacific INTELSAT traffic was lost when this occurred. Regional satellites such as PALAPA, ECS, and ARABSAT promise to capture much more INTELSAT traffic. Proposals for direct interchange of television traffic over new entries rather than INTELSAT could "skim the cream" off the intercontinental markets.

The widespread practice of routing this traffic over new satellites could become lucrative, and could result in large increases in the numbers of satellites devoted worldwide to this purpose.

- The contest between direct broadcasting satellites and the use of satellites operating in the fixed satellite service allocations to distribute television to small terminals is yet to be resolved. Currently in the U.S., there are in excess of 100,000 TV R/O (television receive-only) terminals using dishes with diameters ranging from 8 to 15 feet receiving multiple television channels from "cable birds" such as SATCOM's and GALAXIES. During the fall of '83, television distribution will begin at the Ku-band allocations for the fixed satellite service (11.7 to 12.2GHz). These transmissions, from the Canadian ANIK C and the SBS satellites, will be able to reach small terminals with dish antennas only 4 to 5 feet in diameter. If successful, this SMATV (satellite master antenna television) could usurp the market contemplated for direct broadcasting satellites (DBS). This would eliminate many of the DBS entries in the projections, but increase the number of domsats operating the fixed satellite service allocations.

- Many third world nations have begun ordering their own national satellites. Even nations in financial straits have been able to borrow the money from international banks to order communications satellites. If the concept that improved communications are necessary for development, and national pride argues for dedicated satellites, rather than relying on the satellites of a foreign power or international consortium, then the proliferation on domsats may increase beyond the estimates contained herein. An analogy can be seen in the development of national airlines, which proceed beyond the point justified by economic considerations. The technical limitations of the frequency allocations and geostationary orbit spacing can be extended many times above their current capacity by the use of the Ka-band pioneered by NASA's ACTS and Japan's CS series, and by the frequency re-use possible with multiple spot beam spacecraft antennas and other technological advances.

Nuclear bursts in the atmosphere, whether from a resumption of testing of nuclear weapons or the use of these weapons in anger, would release large amounts of ionizing radiation which could damage the electronics on commercial satellites. Anti-satellite weapons could also harm commercial satellites. Since these satellites are in known locations in the geostationary orbit, and are continuously transmitting, anti-satellite weapons with conventional warheads could be designed and launched to home on commercial satellites, and destroy them. Jamming these satellites would be simpler, for high powered transmitters on Earth could be used to saturate the receivers on commercial satellites, and prevent their use by their owners.

The projections in this report assume that hostile acts by unfriendly powers will not compromise the lifetime or usefulness of commercial communications satellites.

A final unknown which should be considered is the prognosis for economic well being of the world. If a severe economic recession is forthcoming, then the plans for the development of satellites and launch vehicles may be curtailed. If the world economy prospers, then these projections may be outstripped by many launches of future communications satellites.

APPENDIX A

THE COST OF COMMUNICATIONS SATELLITES

PROCUREMENT CONSIDERATIONS

The cost of most communications satellites can be determined exactly from the price paid by the customer to the manufacturer. This cost is included in the application from the Communications Common Carrier to the Federal Communications Commission for U.S. domestic communications satellites. The cost paid by INTELSAT is reported in the INTELSAT annual reports. The cost of satellites exported by U.S. manufacturers is reported to the Munitions Control Board in the Department of State.

The cost of satellites manufactured and sold outside the United States is more difficult to determine. However, these purchases are usually reported by the buyer. They are also contained in financing arrangements with international banks, as well as in insurance negotiations.

Even with accurate reporting of the satellite's price, it can be difficult to compare different satellites because of the varying contractual agreements. Contracts can call for flight spacecraft; delivery to the launch pad and integration with the launch vehicle; tracking, telemetry and command from launch to injection into the transfer orbit (or insertion into the geostationary orbit); or check-out, monitoring, and control during operations.

Contracts can also include varying incentive payments for satisfactory performance on orbit. Some include the manufacture of a ground spare or parts and subsystems that could be assembled into a spare. Others may include the manufacture and delivery of earth stations to be used with the satellites. These earth stations have included the master control station as well as network stations. Further, the training of the customer's personnel to operate these equipments can be extensive.

The financial arrangements can vary from cash in advance to long-term, low-interest loans from commercial or government banks. In some cases, satellites have been sold under barter arrangements in which the manufacturer's government agrees to take goods in exchange for the satellite.

A further problem in assessing costs is posed by sales by manufacturers to customers within the same organization. In some cases there is a tendency to load the costs onto the regulated carrier and allow the unregulated manufacturer a greater share of the profits.

While these factors make the assessment of comparable costs difficult, these problems are not unique to communications satellites. The purchase of any "big ticket" items, whether they be ships or aircraft, or even houses or automobiles, are subject to similar problems in comparing costs.

TECHNICAL CONSIDERATIONS

In making cost comparisons among communications satellite systems, one has to examine the detail elements of the program since there are sufficient differences among programs to affect the cost and the cost-effectiveness of the mission.

The following list summarizes some of the variations that must be taken into account before making cost comparisons, whether it be on a spacecraft-to-spacecraft basis, or per transponder.

(a) In counting transponders, one has to take into account the total complement per spacecraft and the number of transponders in use. Some space missions cannot utilize the full complement because of the limitations in the power systems capacity to support all the transponders. For example, Westar 1, 2, and 3 were configured with 12 transponders but could only support 10. Similarly, the INTELSAT IV series was equipped with 20 transponders but used only 12. In some configurations, excess transponders are for backup purposes.

(b) Satellites have differed in design life. Configurations to date have varied from 3 to 10 years of operational service. It is obvious the longer-life spacecraft will be more cost-effective, thus minimizing the total spacecraft required and the number of launch vehicles and associated launch services needed.

(c) The spacecraft configurations have differed in their abilities to sustain the maximum number of transponders in service from beginning to end of mission life, mainly because of power system degradation and fuel capacity.

(d) The overall missions vary insofar as some programs provide hot spare spacecraft in orbit while others provide stored spacecraft on the ground.

(e) A major cost driver that varies from program to program is the basic spacecraft configuration. Some spacecraft have been optimized to be compatible with the lowest-cost launch vehicle, while others with the same communication capacity have been configured for larger launch vehicles. A case in point is the INTELSAT IV and the Comstar series, both having up to 24 transponders requiring the Atlas-Centaur launch vehicle, considerably more costly than the Delta launch vehicle employed by RCA for the Satcom series also configured with 24 transponders.

(f) In comparing costs on a per-transponder basis, again there are differences in the performance capability of transponders from one system to another. For example, the RCA Satcom G & H series have solid-state systems that could yield 1.7 times more capacity per transponder than some of their competitive systems.

(g) Nonrecurring costs have been kept to a minimum by the RCA and Hughes organizations because of their cost-effective approach of utilizing existing space-proven designs, hardware, and software. Although each organization is involved with many communication satellite programs with different payload configurations, both manufacturers have successfully maintained common use of many existing subsystems (such as power, thermal, attitude control, propulsion, structure, and solar array), as well as common assembly and test of spacecraft, test and flight software, and launch vehicle interfaces. On the other hand, they both have customers who specify prototype spacecraft and subsystems that add to the overall cost of a program. INTELSAT and Comsat are more conservative in their approach and generally have a higher nonrecurring cost element in their respective programs.

Even though comparative costs are difficult to assess, nevertheless, the question "What did it cost?" is of considerable interest, particularly to other buyers and sellers. This section attempts to provide the rationale for how this answer may be formulated to answer this question. In this report, the program payment to the manufacturer is divided by the number of flight spacecraft. This tends to lower the cost of spacecraft with long production runs and to penalize those with high research and development expenses. It also penalizes customers who order spares that are not flown or who contract for extensive launch and operational support services as well as training form the manufacturer. These auxiliary services add to the cost, and it is reasonable that this cost is reflected in the spacecraft cost. If the satellite buyer contracted with organizations other than the spacecraft manufacturer for launch and operational support and training, then these cost comparisons would be skewed to that extent.

With these caveats, this report attempts to provide cost comparisons that are reasonably accurate and that have not been available before in such a form.

APPENDIX B

The French Space Budget [1] (1981-1983)

The CNES Budget (Subsidies and Centre's own resources) divides into five categories.

Program Category	1981 Million Francs		1982 Million Francs		1983 Million Francs	
European Programs	1,003.00	39.5%	951.55	31. %	1,286.20	36.1%
Bilateral Programs	485.11	19.1%	475.85	15.7%	436.59	12.3%
National Programs	334.82	13.2%	628.68	20.9%	866.03	24.3%
Program Support	659.71	26 %	862.20	28.6%	846.93	23.8%
R & D	55.27	2.2%	95.05	3.1%	125.00	3.5%
	2,538.11		3,013.30		3,560.75	

The 1983 Budget is 18.2% greater than the 1982 Budget.

Budget Breakdown by Type of System

	Amount 1983	% 83	% 82
Launchers	515.10 MF	14.84	9.83
Satellites	1316.357MF	37.92	42.16
Spacelab	50.60 MF	1.46	1.56
Balloons	17.10 MF	0.50	0.53
Scientific Experim.	101.00 MF	2.91	3.68
Application Systems	61.51 MF	1.77	1.53
R&D	125.00 MF	3.60	3.22
Program Support	1284.48 MF	37.00	37.49
Total (1)	3471.15 MF	100.00	100.00

(1) 89.60 MF remitted to ESA for thc Guiana Space Center is not included.

Budget Breakdown by Program Objectives

	Amount (MF) 1983	% 83	% 82
Sciences	325.70	9.38%	10.11%
Applications	1735.97	50.02	49.20
Telecommunications	439.40	12.66	16.78
Earth Observation	778.471	22.43	22.48
Launch Facilities	515.10	14.84	9.83
Misc. Applica.	3.00	0.09	0.11
R&D	125.00	3.60	3.22
Program Support	1284.48	37.00	37.47
Total	3471.15	100.00	100.00

The French Space Budget is mainly financed by the Ministry of Research and Industry. The Center's own resources are added to the Government funding.

Ministry of Research and Industry		75%
Other Ministries		13%
Defense	6.8	
MOPT	4.7	
6 others	1.5	
Centers own resources		12%

Source of data, French Embassy, Washington, D.C., September, 1983.

REFERENCES

TRW, TRW Space Log, Vol. 19, Redondo Beach, California, 1983.

Filep, R. The Communications Satellite Market, C21C, Redondo Beach, California, February 1982.

Committee on the Peaceful Uses of Outer Space, "Physical Nature and Technical Attributes of the Geostationary Orbit," United Nations Document A/AC, 105/103/Add., 3 May 22, 1979.

Cardiff Publications, Inc., Satellite Communications, Vols. 1, October 1977 through Vol. 7, No. 9, September 1983. Denver, Colorado.

Batelle Columbus Laboratories, Outside Users Payload Model, June, 1983, NASW-3381, June, 1983.

Satellite Systems Engineering, Inc.: Satellite Systems Digest, Washington, D.C., 1981.

Communications & Marketing Systems, Telcom Highlights, Vol. 382, No. 20, May 12, 1982 through Vol. 483, No. 35, August 31, 1983, Midland, Park, New Jersey.

Phillips Publishing, Inc. Satellite News, Vol. 1, No. 3, July, 1978 through Vol. 6, No. 36, September 5, 1983, Washington, D.C.

International Institute of Communications, Satellite Broadcasting in Western Europe. London, May, 1982.

Schnapf, A., et.al. Communication Satellites: Overview and Options for Broadcasters. Communications 21 Corporation client publication for the National Association of Broadcasters, COM/TECH Report Vol. 1., No. 4, Washington, D.C., December 1982.

International Astronautical Federation. Papers presented at 28th (Prague) 30th (Munich), and 33rd (Paris) IAF Congresses; IAF, Paris, France.

AIAA, Proceedings of the AIAA 9th Communications Satellite Systems Conference, San Diego, California, March, 1982.

P.T.C., Proceedings of the Pacific Telecommunications Conference, January, 1981 (PTC '81). Honolulu, Hawaii.

Filep, R., Plummer, D., and Blanton, J. Commercial-Related Communication Missions for A Space Station, TRW, Inc. - C21C NAS-3681, Redondo Beach, California, November 1982.

ESA, ESA Journal, Vol. 1, No. 1 through Vol. 7, No. 3, ESA, Paris, France.

ESA, ESA Bulletin, No. 23, August, 1980 through No. 34, May, 1983, ESA, Paris, France.

CNES, Prospace Catalog, CNES, Paris, France, 1983.

Filep, R. "Prospects for Twenty-First Century Telecommunications" in Telecommunications in the Year 2000: National and International Perspectives, Ablex Publishing, March 1983.

Datter, A., Reflections on Europe in Space--The First Two Decades and Beyond. Paris, European Space Agency, March 1982.

Bazzy, Wm., Publisher, Telecommunications Vol. 14, No. 9, 1980 to Vol. 17, No. 9, September 1983, Dedham, MA.

Fordyce, S. W. "The Costs of Communications Satellites" in Future Connections, NASA HQS., Vol. 1, No. 2, November 1981.

Astrain, S. Telecommunications and the Economic Impact of Communications Satellites, 31st International Astronautical Congress, Tokyo, Japan, September 21-28, 1980.

AIAA. Projection of Non-Federal Demand for Space Transportation Services Through 2000, prepared for the Office of Science and Technology Policy, The White House: New York, New York, January 19, 1981.

I.T.T. Market capture by 30/20 Ghz satellite systems, NASA Contract N3-21266,, CR 165231, April 1981.

Western Union. 30/20 Ghz net accessible market assessment, NASA Contract NAS 3-21359, CR-159837, 1979.

Filep, R. "The Economics of DBS," Paper presented at the 4th SCUC, Denver, August 1982.

West German Embassy. "German Space Expenditures" Washington, D.C. June 1983.

French Embassy. "CNES Budget" Washington, D.C., June 1983.

NASDA. Biannual Report NASDA 83-84 Tokyo, 1982 and Revision, 12/82.

Space Technology Agency. Annual Review of Japan's Space Development, Tokyo, 1983.

"Future Japanese Space Programs" in Aviation Week, 1/22/83.

Visher, P. "Intelsat Competition and Cooperation" Paper presented at the AIAA Annual Meeting, Long Beach, California, May 10, 1983.

INTERVIEWS

Conducted via telephone and in person during the period April, 1983 through November, 1983 with the following: U.S., Canadian, European, and Japanese Aerospace Manufacturers and Telecommunications personnel; INTELSAT, International Telecommunications Union, U.S. Federal Communications Commission and U.S. Department of State representatives as well as those from telecommunications agencies in user nations, and employees of current and prospective operators of communication satellite systems.