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AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

COMMERCIALIZATION OF SPACE:
NATIONAL POLICY AND DEFENSE NEEDS

MAJOR JOSEPH J. TAYLOR 85-2675

"insights into tomorrow"

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This report evaluates potential impacts of commercialization of space on U.S. space policy and space defense needs for the future. Historical trends of U.S. space commercialization and U.S. space policy form a foundation for projecting space commercialization out to the year 2025. The report contains tables and figures of space vehicle launch statistics, satellite launches, satellite lifetimes, capital investment in satellites, revenues from space industry, and other quantitative data. The study concludes that future U.S. space defense must include security needs of U.S. space-based commercial assets.

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PREFACE

During a September 1984 meeting at Air University, discussions with Mr. Albert Engel of TRW Corporation sparked the idea that led to this study. Working under Air Force contract, Mr. Engel visited Air University to enlist student help for preliminary studies on topics related to Space Strategy. The result of his visit is this study and several others that provide small preludes to the year-long Space Strategy Option Study scheduled to begin in 1985. This study presents research data, analysis, conclusions, and recommendations intended to provide answers, ideas, and questions useful to the Space Strategy Option Study panel members.

It is important to emphasize the principal purpose of this study to help guide its use. Primarily, it provides research information on the commercialization of space. Therefore, the author incorporated research data explicitly into the text wherever possible. Beyond providing research information, this study projects space commercialization into the future, and presents the author's conclusions and recommendations on defense needs for space commercialization. Thus, the author gives the reader three options for using this study. First, the reader may use the entire document. Second, by stripping off the author's conclusions and recommendations, the reader can draw his (her) own conclusions based on the research data and analysis presented. Third, the reader can choose to use only the historical research data without the projections to the future, or use different projection rules to get an alternative view of the future. The author structured this study modularly to allow maximum flexibility for use of its contents.

ABOUT THE AUTHOR

Military Experience. Major Taylor developed his interest in space while assigned to the Advanced Radiation Technology Office of the Air Force Weapons Laboratory at Kirtland Air Force Base, New Mexico. He served as a LASER Weapon System Analyst from 1976 to 1981. While studying LASER operating characteristics in the earth's atmosphere and in space, Major Taylor developed an interest in the space environment's hostile uniqueness.

Formal Education. Major Taylor studied Physics at the Stevens Institute of Tecnnology, Hoboken, New Jersey He earned his Bachelor of Science degree in 1971 and moved on to the University of Michigan where he received a Master of Science degree, Physics, in 1972. During undergraduate and graduate studies, Major Taylor studied several space-related subjects: Astrophysics, Orbital Mechanics, Relativity Theory Impacts on Space Bodies, and Space Thermodynamics.

Professional Military Education. Major Taylor began Air Force active duty in 1972, after receiving his commission through the Reserve Officer Training Corps in 1971. Major Taylor is a graduate of the Air Force Squadron Officer School and the Air Command and Staff College correspondence courses. He is currently enrolled in the Air War College Associate Program.

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REPORT NUMBER 85-2675

AUTHOR(S) MAJOR JOSEPH J. TAYLOR, USAF

TITLE COMMERCIALIZATION OF SPACE: NATIONAL POLICY AND DEFENSE NEEDS

I. <u>Purpose/Background:</u> This study examines commercialization of space in view of its impact on U.S. national policy and defense needs. The idea for the study was sparked by Mr. Albert Engel of the TRW Corporation and Lt Col Ted Schroeder of the Air Staff. This study and several others from Air University address specific topics from a much broader area that will be investigated later this year during the Space Strategy Option Study.

II. <u>Problem:</u> Responding to President Reagan's Strategic Defense Initiative, U.S. defense planners are at a critical juncture where they must determine the goals and means for future space defense. Commercialization of space may add another dimension to the space defense problem. Is space commercialization an important factor to consider when planning U.S. space defense? This study reviews the history of space commercialization and extrapolates its trends to determine its defense needs, if any, for the next century.

CONTINUED

III. Findings: First, this study historically reviews space commercialization. It finds satellite communications to be the only mature commercial space industry. However, trends show continued strong growth in communications and much interest and activity in other commercial space areas. Space industry growth trends and corporate planning figures indicate that space commercialization is moving strongly forward and will be an important U.S. economic factor by the year 2025.

A review of U.S. Government space policy and international space law shows two distinct trends. First, the U.S. Government is aggressively working to stimulate space commercialization through legislative actions, through research and development funding, and through NASA. On the other hand, the international policy forums show no evidence of increasing interest in space commercialization issues.

IV. Conclusions: This study concludes that U.S. policy must include an approach and a plan to protect U.S. commercial assets and commercial interests in space.

V. Recommendations: This study recommends that defense needs of U.S. commercial space assets be integrated into Department of Defense planning for space defense.

It also recommends development of the Space Strategy Options Model as a tool to help the U.S. arrive at reasonable decision options for devising and implementing an integrated space defense strategy that suits both military and civilian needs.

Chapter One

INTRODUCTION

OVERVIEW

Chapter 1 performs four major functions. First, it introduces this study to the reader by bridging it with a much larger effort being prepared by a team of Department of Defense and defense contractor field experts. Second, this chapter provides background to acquaint the reader with previous work on the study subject. Third, it describes the study scope and limitations. Finally, Chapter 1 lists the primary study objectives.

MOTIVATION FOR THIS STUDY

This section describes the Space Strategy Option Study and the Staff Problem Solving Project. It discusses the requirements of each, and explains the link between them.

Space Strategy Option Study

Background. Colonel T. Schroeder conceived the idea of building a Space Strategy Option Model. The Space Strategy Option Study provides the method to develop it. The model, when completed, will be a tool used to consider issues relating to space policy, space strategy, and space weapon system selection. It will accept a wide range of objective and subjective inputs, project the myriad of potential outcomes from their combination, evaluate alternatives to affect the outcomes or to react to the outcomes, and finally recommend decisions on the course(s) of action that provides the highest probability for favorable returns to the United States. Recommendations will cover national policy objectives, national strategy, and weapons options, if weapons are seen as an appropriate response. A prime advantage of the model is its ability to handle complexity and fluidity of the "real" world while still presenting timely decision options. The second major contribution is the model's projected improvement of U.S. long term decision making. Space systems have long lead-times and long life-times; therefore, accurate decisions on space systems needs are essential for producing useful space systems and for avoiding waste of procurement funds. (57:--).

Working under an Air Force contract, Mr. A. E. Engel from TRW conducted preliminary research on the Space Strategy Option Model concept during 1982 and 1983. His study identified deficiencies in current strategic planning, identified a need for improved models and methodology, and pointed out the potential long-range value of the Space Strategy Option Model plan (57:6). Study methodology included development of a small-scale space option model and data base. A final recommendation of the study was formation of the Space Strategy Option Study group. The TRW study produced the guidance and instructions for that group.

The Space Strategy Option Model attempts to grapple mathematically with very subjective concepts--national policy and strategic planning. Although this approach is difficult for the objective mind to understand, the approach has been demonstrated successfully by physicist Alvin M. Saperstein from Wayne State University (34:13). Saperstein uses data describing arms races in nonlinear differential equations to predict the transition from order (peace) to chaos (war). Joseph Ford, a chaos theory guru and physicist from the Georgia Institute of Technology, agrees with the feasibility of the approach. Speaking of Saperstein's work, he states, "It's a legitimate, honest and quite useful effort" (34:13). Based on his results to date Saperstein says, "Given a lot of people working on it and a lot of time, it's conceivable that the models could begin to approximate national behavior" (34:13).

<u>Goals.</u> The Space Strategy Option Study group will perform two major functions. First, it will construct a comprehensive data base using inputs from panels of experts covering a broad spectrum of topics. Second, it will "...develop coherent, integrated goals, policy, strategy options and recommended approach [for space]" (57:6)

<u>Organization.</u> The study organization consists of an executive advisory board and eight analysis panels of experts. The advisory board itself consists of four development panels. The development panels cover goals/policy, options/strategies, recommendations/approaches, and public/media interaction. Analysis panels address threat/classification, doctrine, economics, politics, military interests, social impacts, missions, and system architectures. Panel membership will range from technical specialists to nationally recognized senior

senior executives. (57:3).

Schedule. Study length spans one year. It begins with analysis panel chairmen and member selection. Four months later the advisory board panels begin to enter the study. The First Space Strategy Option Conference will convene at the end of six months. Following the first conference, the advisory panels continue working full-time while the analysis panels reduce their effort to cover residual issues. Eleven months into the schedule the Second Space Strategy Option Conference meets. The study concludes with a meeting of the executive advisory board during the twelfth month. (57:4).

Study Linkage

The preceding subsection was a summary of the Space Strategy Option Study. The following subsection summarizes the background, goals, organization, and schedule of the Staff Problem Solving Project. However, before continuing, it is important to understand the linkage between the two efforts.

This Staff Problem Solving Project provides an input to the Space Strategy Option Study. A letter from Headquarters Space Division to Air University asked for help with a topic entitled, "The Space Strategy Option Model" (45:1). The model will be one output from the Space Strategy Option Study. Guidance and instructions for the Space Strategy Option Study were provided in an unpublished paper of the same name (57:--). Mr. A. Engel from TRW briefed a group of Air Command and Staff College students on details of the unpublished paper. Those discussions produced the title and general study direction for this Staff Problem Solving Project.

Staff Problem Solving Project

Background. Staff problem solving represents a key skill taught at the Air Command and Staff College of Air University. Each year the Air Command and Staff College class members choose a topic to investigate as part of the college's curriculum requirements. To make this exercise as realistic and as useful as possible, the students are encouraged to choose topics that help solve current, relevant Air Force problems. (44:1).

Goals. Staff problem solving has two primary goals. First, it aims at sharpening the student's decision making skills by exercising his abilities of "...defining the problem, collecting quality information about the problem, formulating a logical approach to its solution, performing the critical analysis required to support a recommended course of action, and communicating the process..." (44:1). Second, it provides a means to conduct useful investigation of a current issue. Staff problem solving outputs must "...create products of practicality and immediate benefit" (44:1).

Organization. The staff problem solving organization consists of one or more students, an advisor, and a sponsor. The student(s) chooses the topic, conducts the research, and prepares the study report. The advisor aids the student(s) by providing technical expertise on the study topic. Advisors also provide guidance and critiques on the study report. The sponsor defines the initial problem and receives a copy of the final study report. (44:4-6).

Schedule. Staff problem solving (44:2), "...begins the last week of August and ends the last week in February." Major milestones are a completed first draft in the third week of January and final turn-in for evaluation on the first Monday in March (44:2).

SCOPE AND LIMITATIONS

Space Strategy Option Study

Scope. The Space Strategy Option Study scope is broad. It covers the range indicated by the names of its twelve panels: (1) goals/policy, (2) options/strategies, (3) recommendations/approaches, (4) public/media interaction, (5) threat/classification, (6) doctrine, (7) economics, (8) political, (9) military, (10) social, (11) mission requirements, and (12) systems architecture (57:3). Members of panels 5-12 will investigate their topics in sufficient depth to identify which factors exert primary influences within their subject area and among the other panel areas. Further, they must establish the relationships among the entire suite of panel topics.

Limitations. The chief limitation on study depth is time allotted--twelve months. Other limitations will be defined during two months of panel guidance development. (57:4).

Staff Problem Solving Project

Scope. In contrast to the Space Strategy Option Study, this study on commercialization of space has much narrower scope. It focuses on space commercialization by U.S. private enterprise and on the need for space defense measures to protect commercial space assets. This study will relate to the Space Strategy Option Study through the economics, policy, and mission requirements panels. It begins with an historical survey of space commercialization and related policy. It ends by projecting commercialization trends through the year 2025 and by assessing defense needs of commercial assets in space. This study will offer findings, conclusions, and recommendations.

Limitations. The principal limitation to this study is the time available to conduct it. Air Command and Staff College guidance recommends each student target 150 hours for staff problem solving (44:1). That time is spread over developing a project plan, gathering data, analyzing data, and producing a final report (44:2). Other limits reflect the student's experience in research techniques, staff problem solving, and the subject area chosen. The author, a student of science, has had experience in experimental research and experience in scientific (objective) problem solving. However, the author provides an unbiased (no experience) opinion with respect to the commercialization of space.

STUDY OBJECTIVES

Primary objectives of this study are listed below:

1. Determine numbers, types, lifetimes, values, and return-on-investment (ROI) of current U.S. satellites.
2. List current international space laws and U.S. space laws and policies that affect space commercialization.
3. Compute the value of business ventures planned by U.S. industry.
4. Predict the lifetimes of future satellites.
5. Predict the total value of commercial equipment in space versus time over the next forty years.
6. Compare the value of commercial equipment investments in space against a standard U.S. economic measure over the next forty years.
7. Evaluate the need for U.S. space policies and space defense to match space commercialization

prediction results.

Chapter Two

SPACE COMMERCIALIZATION HISTORY

OVERVIEW

Chapter 2 presents a collection of historical data on the commercialization of space. The chapter begins by selecting which data to consider for conducting an historical survey. Selected data cover the following range of topics: launch rates, launch costs, satellite lifetimes, capital investment in satellites, satellite-produced income, and return-on-investment (ROI) from commercial satellites. These data cover the period from the first U.S. satellite launch through 1984. Data of Chapter 2 provide the foundation used in Chapter 4 to project space commercialization trends into the next century.

SELECTION OF TREND DATA

Marketing Theory

Background. A meaningful trend analysis demands identification and use of the key factors that influence the commercial space market. One identifies the space market key factors by looking at the factors affecting all commercial markets. Investigation produces the following generalized list: consumer behavior, pricing, purchasing, sales management, product management, marketing communications, packaging, channels of distribution, marketing research, social issues in marketing, retailing, wholesaling, international marketing, and physical distribution (2:10). Although general marketing theory includes the entire preceding list, all market decision making can be organized and condensed into four strategy elements: product planning, marketing channel organization, promotion, and pricing (2:23). This paper concentrates on historical trends of the product planning and pricing elements as predictors of future space commercialization. These two elements were chosen because they contain quantitative factors suited to historical and predictive analysis.

In contrast, the other two market strategy elements (marketing channel organization and promotion) have more qualitative influences on market development. Two other facts also reduce the importance of market channels and promotion to space commercialization. First, the country's sophisticated product distribution network has proven its ability to rapidly disperse a wide range of products from the technical simplicity of the hula hoop to the electronic complexity of video cassette recorders and cable television service. Therefore, established distribution channels should easily absorb products of the commercial space market. Second, promotion is most critical when introducing new products. However, past space commercial ventures and products-in-planning concentrate exclusively on improving existing products and services. For example, past space efforts have concentrated on worldwide communications, weather prediction, and aerial imagery. Future products concentrate on further expansion of past efforts plus materials processing such as pharmaceuticals and metals. Vast markets already exist for these products; space industry aims mainly to improve product quality and to reduce product price. Therefore, product planning and pricing were chosen as the two market strategy elements that apply to this study of space commercialization.

Product Planning Factors. When considering product planning, a question often asked is, "Why should a company bother to pursue a high risk venture in space when many established marketing opportunities are available in earthbound product lines?" Dr. Rom Markim (2:226), Dean of the College of Business and Economics at Washington State University, explains as follows:

> Creating, testing, and developing new-product ideas are enormously risky and absorb a great deal of management time and company resources. Yet a successful new product can bring the firm tremendous profits as well as other benefits. It is the possibility of such large gains that entices business people into high-risk ventures. An examination of the successful firm shows that their achievement can be largely attributed to the size and intensity of their research and development efforts. For example, Dr. Edwin Land, founder of the Polaroid Corporation. spent $500 million developing the SX-70 camera.

In the product development process, the screening and business analysis phases consider raw materials supply, effect on other products, sales forecasts, profit analysis, and patent position when evaluating market potential (2:236). Markim also emphasizes the role of new technology in the product development process by referencing the U.S. space program. He says, "[Technology]...has given rise not only to new products, but to vast new industries as well. [The space program]...has spawned among others, Teflon, weather and communication satellites, hand-held computers, and electronic wristwatches" (2:236,237).

Having identified important product planning factors, the study moves on to consider product pricing factors.

Product Pricing Factors. Pricing also strongly influences market growth. It is the second, and last, of the four elements of market strategy used in this study to measure the growth trends of space commercialization. Product pricing depends upon product demand and product cost (2:456). Thus, this study considers demand and cost as the key product pricing factors.

Historical and Analysis Data-Type Selection

As a summary of the above market theory discussions, Table 1 lists the general market factors that influence the space arena. Data-types chosen for space commercialization trend analysis appear opposite each factor. Data-types were selected based on their relevance to the Table 1 market factors and to their availability in the research literature.

MARKET FACTORS	TREND DATA-TYPE
Product Planning Factors	
raw materials supply	
effect on other products	
sales forecasts	satellite income
profit analysis	return on investment
patent position	
technology	satellite lifetimes
Product Pricing Factors	
product cost	launch cost
	capital investment
product demand	satellite launch rates

Table 1. Trend Data-Type Selection

Thus, having established which data-types were chosen for analysis, and why, the next section looks at historical data to establish trends for each of them.

TREND DATA

This section contains tables that present research results of the data-types from Table 1. General trends are noted where they appear to be developing.

Definitions

Before continuing, several system categories must be defined for this study. The following terms appear throughout the remainder of this report.

Military. A space system owned by the U.S. Air Force, Army, or Navy is a military system.

Civilian. A space system carrying a primary payload for other than military or international customers is a civilian system.

Commercial. A civilian space system that carries a payload intended for profit-making is a commercial system.

Total. The sum of all military and civilian systems, including international customers, is the number of total systems.

Launch Rates

Table 2 shows launch data. Data aggregates listed include launch rates of total payloads (includes payloads jointly funded by the U.S. and other countries, and launched on U.S. vehicles), civilian payloads, commercial payloads, total launches, and civilian launches. The table shows several trends. First, and most obvious, is the frenzied pace of U.S. space activity in response to the perceived Soviet lead in space due to their launch of Sputnik in 1957. A U.S. Congressional report describes the phenomenon (54:44), "The no-priority [U.S. space] project which had been Vanguard shifted quite suddenly into the national spotlight. It became the great hope of the entire Nation." In the early years the U.S. space program was paced by the rate that money could be spent, not by the amount of money available (54:68). However, U.S. activity peaked in 1966 followed by a sharp decline during the remainder of the 1960s. From

1970 to 1980 a general trend of declining launch rate continued.

Second, U.S. launch rate appears to have turned around since 1980. Although four years of data aren't strong support for a trend reversal, when underlying factors are examined the trend reversal gathers firmer support (see Chapters 3 and 4).

Year	Total Launches	Civilian Launches	Total Payloads	Civilian Payloads	Commercial Payloads
1958	5	0	5	0	0
1959	13	8	13	8	0
1960	21	10	21	9	0
1961	35	16	40	15	0
1962	57	21	58	18	1
1963	42	14	62	13	1
1964	62	25	74	24	0
1965	66	25	92	24	1
1966	77	34	93	23	0
1967	58	24	84	23	3
1968	45	16	60	17	1
1969	39	16	54	14	2
1970	30	11	30	8	2
1971	33	10	41	10	2
1972	31	13	30	13	2
1973	23	12	23	11	1
1974	23	7	15	7	3
1975	28	16	27	16	3
1976	27	12	30	12	7
1977	23	6	20	6	1
1978	33	13	27	13	3
1979	16	8	16	7	1
1980	12	6	15	6	2
1981	18	13	19	14	5
1982	18	10	17	11	7
1983	22	13	25	14	6
1984	23	17	31	24	10

Sources: (43:B-4,B-5; 28:201; 16:13)

Table 2. U.S. Satellite Launch Rates

As the third trend of Table 2, civilian satellite launches have shown an increase in their percentage of total U.S. satellite launches. Table 3 shows this more clearly by listing civilian satellite launches as a percent of total satellite launches. Although the total number of U.S. payload launches has declined, of those that remain, emphasis has gradually shifted from military use toward civilian use.

Also listed in Table 3 are the commercial satellite launches shown as a percent of the total U.S. satellite launches. The table clearly shows that commercial payloads are increasing as a percent of total payloads. It also shows commercial launch percentages recently increased sharply, while the percentage of all civilian launches showed less growth. This indicates that commercial launches are becoming an increasing share of all civilian launches, as well as becoming a sharply increasing share of total launches. It must also be pointed out that all commercial launches through 1983 were for placing communications satellites in orbit. So far, all commercial space ventures have been communication satellites or the space launch vehicles themselves.

Year	Civilian Satellites (% tot.)	Commercial Satellites (% tot.)	Year	Civilian Satellites (% tot.)	Commercial Satellites (% tot.)
1958	0	0	1972	43	7
1959	62	0	1973	48	4
1960	43	0	1974	47	20
1961	38	0	1975	59	11
1962	31	2	1976	40	23
1963	21	2	1977	30	5
1964	32	0	1978	48	11
1965	26	1	1979	44	6
1966	25	0	1980	40	13
1967	27	4	1981	74	26
1968	28	2	1982	65	41
1969	26	4	1983	56	24
1970	27	7	1984	77	32
1971	24	5			

Source: Table 2

Table 3. Civilian and Commercial Satellite Percentages

Launch Costs

Launch costs are a key factor in determining the commercial viability of all space ventures. The true cost of a satellite system equals the cost to build it, plus the cost to boost it to an altitude where it can be useful, plus the cost to operate it. The sum of a satellite's production cost and its launch cost equals the value of the system as a capital asset. Operating cost must be included to calculate a total system cost for determining profitability.

The first half of Table 4 shows an historical sampling of launch costs per pound of payload launched into low earth orbit (100-600 nautical miles altitude) (54:457). However, many satellites depend on orbits higher than low earth orbit. In their case an additional thrust (cost) is necessary to boost them into geosynchronous earth orbit (22,300 nautical miles altitude) (54:144). The second half of Table 4 shows per pound costs for boosting payloads from low earth orbit to geosynchronous orbit.

LOW EARTH ORBIT

Use Dates	Type Vehicle	Payload Capacity (Lbs)	Launch Cost ($/Lb)	Source
1956-58	Jupiter C	18	7 mill	(3:3-7; 15:186; 1:27)
1960-61	Atlas Agena A	5,000	2,900	(54:202,250; 1:27)
1960-63	Atlas Mercury	3,000	19,400	(54:200; 3:3-4,3-6; 1:27)
1967-73	Saturn V	200,000	2,400	(54:214-217, 260; 1:27)
1965-84	Titan III C	29,000	2,700	(54:207,260)
1975-85	Delta	3,900	6,400	(54:195,620)
1981-85	Space Shuttle	65,000	2,600	(15:14,16)

LOW EARTH TO GEOSYNCHRONOUS ORBIT

Use Dates	Type Vehicle	Payload Capacity (Lbs)	Boost Cost ($/Lb)	Source
1978-85	PAM-D	1,000	8,000	(23:169,170; 4:158)

Note: All costs are in 1984 dollars.

Table 4. Satellite Launch Costs

Table 4 shows that launch costs to low earth orbit have dropped over three orders of magnitude since launch of the first U.S. satellite, Explorer I (the first table entry). Although launch costs have shown a remarkable decline since 1958, the trend is only expected to continue possibly another one or two orders of magnitude (54:268). Low earth to geosynchronous orbit cost is shown using PAM-D; however, PAM-D's normal role is to boost payloads from low earth to geosynchronous transfer orbit.

Satellite Lifetime

Table 5 shows satellite lifetime versus launch year for several series of communication satellites and for the earth-imaging satellite, Landsat. The data show lifetime is a slowly increasing function of launch year. Two factors that dictate satellite lifetime are fuel supply (used for station-keeping/pointing accuracy) and component design lifetime (55:34). Tradeoffs between these two factors produce ultimate satellite design lifetime. Beyond a point extended lifetimes lose importance, because satellites eventually become obsolete due to changing technology and changing user demands. INTELSAT Series VI, due to be launched in 1986, still has a design lifetime of seven years, which is unchanged from INTELSAT IV-A (55:177).

Launch Year	Satellite Names	Lifetime (years)	Source
1958	SCORE	0.03	(55:121)
1960	Courier	0.05	(55:122)
1962	Telstar I	0.3	(55:122)
1965	INTELSAT I	1.2	(55:133)
1967	INTELSAT II	2.4	(55:133)
1971	INTELSAT IV	6.2	(55:133)
1972	Landsat 1	5.5	(55:219)
1974	ATS-6	5.0	(55:95)
1975	Landsat 2	5.0	(55:223)
1976	CTS	3.5	(55:102)
1976	Marisat I,II,III	5.0	(55:84)
1976	INTELSAT IV-A	7.0	(55:133)
1977	GOES	5.0	(30:264)
1981	INTELSAT V	7.0	(55:133)
1983	SARSAT	6.5	(55:109)
1984	GSTAR	10.0	(55:138)
1984	Galaxy	9.0	(17:123)

Table 5. Commercial-Class Satellite Lifetimes

Capital Investment in Satellites

This subsection presents statistics on the capital investment in several satellite programs. It considers only the cost of on-orbit systems, not their ground stations. Launch costs are not considered here either. They have been broken out separately and were shown in Table 4 above. Note that satellite weights are also presented. Hopefully a relationship between satellite weight and cost will become apparent, i.e. dollars per pound of satellite. Table 6 lists launch date, satellite name, weight, cost, and data source.

Launch Date	Satellite Name	Weight (Pounds)	Cost (Dollars)	Source
1965	INTELSAT I	86	41.0 mill	(55:33; 43:B-56)
1968	INTELSAT III	640	38.4 mill	(55:33; 43:B-65)
1974	ATS-6	2,590	432.0 mill	(55:99; 43:B-77)
1976	Marisat	720	26.6 mill	(55:76,77)
1976	CTS	780	121.0 mill	(55:102; 43:B-82)
1976	INTELSAT IV-A	3,330	92.4 mill	(55:33; 43:B-82)
1978	Landsat 3	2,100	73.7 mill	(55:222,223,227)
1979	SATCOM III	1,010	45.3 mill	(55:133; 43:B-92)
1981	INTELSAT V	4,240	85.7 mill	(55:33; 43:B9.)
1984	Westar 6	1,000	37.5 mill	(13:66)

Notes: Costs are in 1984 dollars
Dollar-year conversions source (1:27)

Table 6. Satellite Capital Investment

Table 6 shows that the cost per pound of INTELSAT I, the first commercial communication satellite, was very high. Since then the cost has decreased and become fairly stable at approximately $40,000 per pound. The exceptions are ATS-6 and CTS. These two communication satellites were experimental direct broadcast models. They operated at much higher power than conventional communication satellites, thus their signals could be received by small (2-foot diameter) antennas installed by homeowners. In contrast, the standard communication satellite signals must be received by a ground station with large (20-foot diameter) antennas. Direct broadcast communication satellites may become an important future market.

Satellite-Produced Income

As mentioned previously, communication satellites are the only true commercial space systems. The Communication Satellite Corporation (Comsat), being in business the longest, serves as a good example of a commercial space company. Their INTELSAT series satellite revenue for 1982 was $300 million (55:39).

The U.S. Government also produces some income from Landsat earth-imaging satellites and from its global weather satellites. However, those income figures were not used, because they are influenced by government subsidy. Also, there is not yet any private U.S. industry competition in either of those two potential business areas. However, Landsat is currently being transitioned from U.S. Government ownership and operation to U.S. private business.

Also, numerous companies derive income from reprocessing and reselling remote sensing data from the Government-operated Landsats. However, this study treats only income produced directly from on-orbit systems.

Return on Investment

Comsat also provides a sample of space commercialization ROI. Comsat ROI has been steady at 16.1% per year since 1973. Comsat uses 14% per year as its target (55:39).

RESEARCH SUMMARY

The preceding data show the general historical relationships of factors selected to measure trends of space commercialization. The following is a list of significant findings:

- Commercial satellite launch rates are increasing.
- Satellite launch costs show a slowly decreasing trend.
- Satellite lifetimes show a slowly increasing trend.
- Capital investment in satellites (excluding launch costs) is stable at approximately $40,000 per pound.
- INTELSAT ROI is stable at approximately 16%.

Having completed a review of hardware progress, this paper now shifts toward U.S. and international policy developments relating to space commercialization.

Chapter Three

SPACE POLICY AND LAWS

OVERVIEW

The purpose of this chapter is to review space policy and laws, and to assess their impact on the commercialization of space. Chapter 3 fulfills this purpose by first tracing the history of space policy and space laws that relate to the commercialization of space by U.S. private enterprise. Second, it looks at issues resulting from recent studies and Congressional hearings. Third, it presents pending legislation of significance to space commercialization. This chapter promotes understanding and appreciation of the origins of space policies and laws governing commercialization of space. Although emphasis is on U.S. space policy, the discussion includes international laws to illustrate the interdependence of U.S. thinking with that of its global partners. The following chapter uses this chapter and Chapter 2 as foundations for projecting future developments.

HISTORICAL DEVELOPMENT

U.S. Space Policy and Laws

The following is a collection of the major U.S. policies and laws that affected space commercialization over the history of the space program. The launch of Sputnik by the Soviets in October 1957 awakened the U.S. to the fact that it was number two in the race for space. That event produced a determined response from the U.S. that resulted in passing of the National Aeronautics and Space Act. This Act became the first U.S. space policy. (54:44-50).

The National Aeronautics and Space Act. Congress passed the National Aeronautics and Space (NAS) Act in 1958. Thus, it legislated a highly centralized approach to space following the Manhattan Project philosophy that had served the country so well during World War II. The Act established NASA as the lead agency "...to provide for research into problems of flight within and outside the earth's atmosphere, and for other purposes" (49:372).

The Act, although broad, did not address commercialization of space explicitly. However, two of its eight objectives bear indirectly on space commercialization:

> (1) "The expansion of human knowledge of phenomena in the atmosphere and space;"
> (2) "The establishment of long-range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes;" (49:372,373).

These two objectives relate to commercialization when considered with NASA's responsibility to "Provide for the widest practical and appropriate dissemination of information concerning its activities and the results thereof" (49:374). Basically, NASA was charged with responsibility to investigate outer space and to report its results, thus providing information needed for commercialization feasibility studies.

Although the Act has been amended numerous times (1959, 1963, 1964, 1968, 1973, 1974, etc.), its important guidelines remain unchanged. The NAS Act still forms the basis of this country's space policy. In recent review hearings of the Act, Harold Volkmer (52:iii), chairman of the House of Representatives Subcommittee on Space Science and Applications, said:

> The consensus view at these hearings was that the National Aeronautics and Space Act of 1958 is a remarkably sound piece of legislation that has reliably served the Nation as a basis for U.S. policy-making for space matters for twenty-five years. At the same time, the Act continues to retain a vision for future U.S. activity in space.

Early Presidential Policy Statements. President Eisenhower made the first explicit push for space commercialization in a space policy statement issued in December, 1960:

> To achieve the early establishment of a communication satellite system which can be used on a commercial basis is a national

> objective which will require the concerted capabilities and funds of both Government and private enterprise.... With regard to communication satellites, I have directed the National Aeronautics and Space Administration to take the lead within the Executive Branch both to advance the needed research and development, and to encourage private enterprise to apply its resources toward the earliest practical utilization of space technology for commercial civil communications requirements (49:349).

Next, President Kennedy expanded commercialization of space by policy statements he made during his 1961 State of the Union message. He encouraged, "...accelerating the use of satellites for worldwide communications...[and]...a satellite system for worldwide weather observation" (51:4). Today communications and weather observation have become two of the most commercialized aspects of space. Communications satellites are directly owned by private and public companies. Weather satellites, while government owned, produce forecasting data used by private and public television and radio networks. President Kennedy recognized the commercial use concept and potential in his statement, "...[space] will be of inestimable commercial and scientific value" (51:4).

Also during the Kennedy Administration, Congress approved the Communications Satellite Act of 1962. This Act formed the Communications Satellite Corporation (Comsat), the first space commercialization project (49:268).

The Nixon Administration accounts for the next significant impact on commercialization of space. Nixon did not directly support commercialization, but his decision to start the Space Shuttle Program (51:6) led to our current capability to launch, repair in orbit, and return spaceborne experiments and satellites to earth.

Carter Administration Space Policy. President Carter issued two space directives. Both made progress beyond the NAS Act by recognizing and promoting the commercial potential of space. The first directive, issued 19 June 1978, resulted from a presidentially directed National Security Council review of existing space policy (ie., the NAS Act of 1958). Results contain the following five principles that apply to space commercialization. Principles one, four, and five explicitly support space commercialization. Principles two and three promote the unhindered exploitation of space and protection of national assets in space:

> 1. The United States will pursue space activities to increase scientific knowledge, develop useful commercial and governmental applications of space.
> 2. The United states rejects any claims to sovereignty over outer space or over celestial bodies, or any portion thereof, and rejects any limitations on the fundamental right to acquire data from space.
> 3. The United States holds that the space systems of any nation are national property and have the right of passage through and operations in space without interference. Purposeful interference with space systems shall be viewed as an infringement upon sovereign rights.
> 4. The United states will encourage domestic commercial exploitation of space capabilities and systems for economic benefit and to promote the technological position of the United States.
> 5. The United States will develop, manage, and operate a fully operational Space Transportation System (STS), through NASA, in cooperation with the Department of Defense. The STS will service all authorized users--domestic and foreign, commercial and governmental--and will provide launch priority and necessary security to national security missions while recognizing the essentially open character of the civil space program. (54:1117-1119).

The second Carter directive, issued 11 October 1978, contains four additional points pertaining to space commercialization. This directive, titled, U.S. Civil Space Policy, recognizes the need for government involvement to encourage private investment in space applications with particular emphasis on remote sensing. The second point again shows government concern of making space a safe place for operating and investing:

> 1. Emphasize space applications that will bring important benefits to our understanding of earth resources, climate, weather, pollution and provide for the private sector to take an increasing responsibility in remote sensing and other applications.
> 2. Confirm our support of the continued

development of a legal regime for space that will assure its safe and peaceful use for the benefit of mankind.
3. Specific details and configurations of the LANDSAT system and its management and organizational factors will evolve over the next several years to arrive at the appropriate mix, test organizational arrangements and develop the potential to involve the private sector.
4. Along with other appropriate agencies, NASA and Commerce will prepare a plan of action on how to encourage private investment and direct participation in civil remote sensing systems. (54:1120-1121).

Reagan Administration Space Policy. President Reagan's initial national space policy resulted from a ten month interagency review of the previous administration's space policy guidance. It was released on 4 July 1982. The policy retains the commercialization encouragement of President Carter's policy statements. However, it addresses the space shuttle as an operational space transportation system (STS). STS specific guidance for commercial exploitation follows:

1. STS capabilities and capacities shall be developed to meet appropriate national needs and shall be available to authorized users--domestic and foreign, commercial and governmental.
2. NASA will assure the shuttle's utility to the civil users.
3. The United States Government will provide a climate conducive to expanded private sector investment and involvement in space activities, with due regard to public safety and national security. These space activities will be authorized and supervised or regulated by the government to the extent required by treaty and national security. (53:312,313).

The next important Presidential policy decision, announced on 8 March 1983, proposed to offer the Landsat system for sale to the private commercial sector (53:320).

President Reagan announced support for commercial operation of expendable launch vehicles (ELV's) in a policy statement issued on 16 May 1983. As one basic goal of U.S. space launch policy the directive stated, "...encourage the U.S. private sector development of commercial launch operations" (42:103).

On 24 February 1984 President Reagan issued an Executive Order to: "...encourage, facilitate and coordinate the development of commercial expendable launch vehicle (ELV) operations by private United States enterprises..." (50:22). The order designated the Department of Transportation as the lead government agency for carrying out the policy.

The Reagan Administration produced a subsequent space policy statement on 23 March 1984. The commercialization support remained unchanged from the previous statement, but he offered the prospect of sharing room on the proposed manned space station as a commercialization inducement for private industry.

President Reagan issued new space policy on 20 July 1984, the 15th anniversary of the lunar landing of Apollo 11. Much stronger than previous statements, this policy statement dealt exclusively with space commercialization incentives. It contained the following provisions (37:16,17):

1. Eliminate provisions in the tax codes and regulations that discriminate against commercial space ventures.
2. Update laws and regulations predating space operations to accommodate the commercial use of space, including streamlining regulatory decisions affecting future space projects.
3. Expand industry's role in setting the nation's research agenda, to expand research and development in areas that have commercial application and will result in development of marketable commercial space products and services.
4. Take steps to assure companies and potential investors of policy consistency to encourage the long-term commitment required for most space projects.

In August 1984, President Reagan approved an updated National Space Strategy. The President's directive addressed long-range national goals beginning in the 1995 period. It showed interest in a U.S. manned lunar base and U.S manned missions to Mars. In the nearer term, it affirmed commitment to a U.S manned space station, to routine access to space by a fully operational (not later than 1988) space shuttle, and to the July initiatives to stimulate space commercialization. The directive also established the Cabinet Council on Commerce and Trade Working Group on the Commercial Use of Space as a means for focusing high level national attention on commercial space issues. New policy elements pertaining to commercialization of space are the following (15:.4-16; 40:34,35):

1. ...make the Space Transportation System [STS] fully operational and cost effective in providing routine access to space.
2. On October 1, 1988, prices for STS services and capabilities provided to commercial and foreign users will reflect the full cost of such services and capabilities.
3. A high level focus for commercial space issues will be created through the establishment of the Cabinet Council on Commerce and Trade Working Group on the Commercial Use of Space.

On 9 October 1984, Congress enacted the Commercial Space Launch Act (9:212). This Act sets the rules for licensing commercial launches of expendable launch vehicles (ELV) by private enterprise (50:1). The Act supports President Reagan's Executive Order of 24 February 1984 (see above). Primary purposes of the legislation are the following:

1. Promote economic growth by encouraging the private sector to provide launch services and utilize space for peaceful purposes.
2. Encourage a U.S. ELV industry by simplifying and expediting the issuance of commercial launch licenses and by facilitating the commercial utilization of government-developed ELV technology.
3. Designate a single agency (DOT) [Department of Transportation] to oversee commercial launch operations and issue licenses authorizing such activities. (17:7; 50:7).

This Act immensely simplifies the approval process for commercial space launches by private industry. It reduces the number of Government approval agencies from 17 to one (50:21,22).

INTERNATIONAL SPACE LAW AND TREATIES

This section presents a listing of international space guidelines and highlights the provisions that have potential impact on space commercialization. The United States has signed the following space-related international agreements: (1) Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water(October 10, 1963), (2) Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (October 10, 1967), (3) Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (December 3, 1968), (4) Convention on International Liability for Damage Caused by Space Objects (October 9,1971), (5) Convention on Regulation of Objects Launched Into Outer Space (September 15, 1976), and (6) Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (January 17, 1980).

The first treaty does not impact the commercialization of space. The second treaty contains the following points of relevance (54:1100-1103):

> 1. Exploration and use of outer space,...and...celestial bodies, shall be...for the benefit and in the interests of all countries....
> 2. Outer space...and...celestial bodies [are] not subject to...claim(s) of sovereignty, by means of use or occupation, or by any other means.
> 3. ...carry on...exploration and use of outer space,...and other celestial bodies, in accordance with international law....
> 4. ...non-governmental entities in outer space,...and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the treaty.
> 5. State...from whose territory...an object is launched, is internationally liable for damage to another State Party to the treaty.
> 6. ...pursue studies...and conduct exploration...so as to avoid...harmful contamination and also adverse changes in the environment of the Earth...

Treaty three has no direct bearing on space commercialization. Treaty four states, "...absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft in flight" (54:1107). This treaty will become very important as crowding occurs in certain preferred orbits. Treaty five requires each launching state, "...register the space object by means of an entry in an appropriate registry which it shall maintain" (54:1115). Treaty six does not apply to space commercialization.

Summary

Figure 1 summarizes domestic and international space policy and treaty activity. The figure presents output frequency of guidance by the U.S. and international organizations.

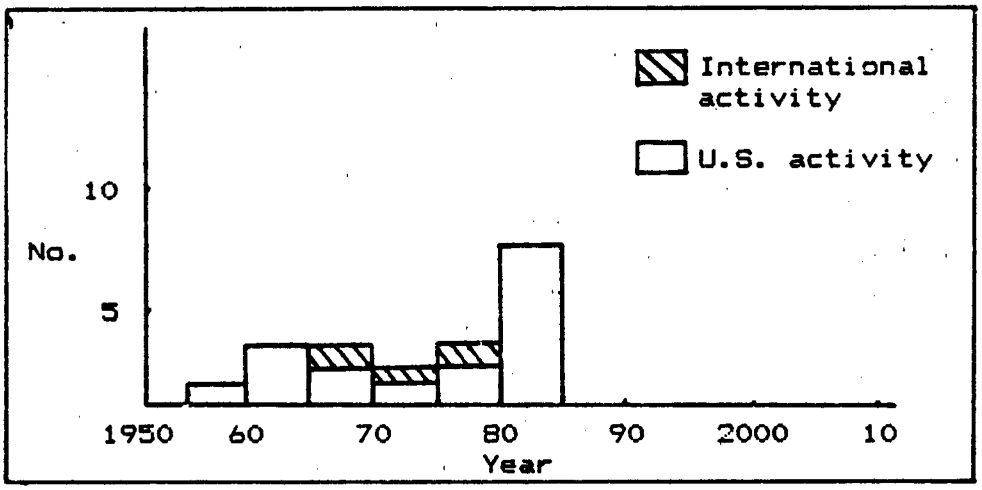

Figure 1. Space Commercialization Policy and Treaties

PENDING POLICY AND LEGISLATION

This section looks at government regulation currently in the review process. These measures have a good probability of becoming future guidance. Policy and legislation beyond this section are left to the mind of the reader.

Governmental Policy

Competition with INTELSAT. President Reagan has decided that private competition with the International Telecommunications Satellite Organization (INTELSAT) (Comsat is part owner of INTELSAT) is in the national interest (21:24). From its origin in 1962, INTELSAT has been protected as a monopoly under the Communications Satellite Act of 1962. Although INTELSAT has been a highly successful commercial venture, it is widely believed that its monopoly status has impeded private investment in space. This is supported by the fact that five companies have private satellite applications on file with the Federal Communication Commission awaiting the outcome of this pending policy (21:24).

Long-Range National Space Goals. President Reagan directed the Office of Science and Technology for Policy to send long-range space policy recommendations to the White House Senior Interagency Group for Space. He directed that action occur within 60 days of receiving results of a congressionally mandated National Space Commission study that began in September, 1984 (15:14).

Legislation

No significant space commercialization legislation was pending as of December 1984, except for the 1986 NASA budget.

OPEN POLICY ISSUES

This section presents a sampling of space commercialization issues. Sources of the issues are government studies and congressional testimony of private industry and NASA spokesmen. Below is a listing of issue topics. They are addressed separately throughout other sections of this report:

1. Taxes
2. Patents
3. Competition
4. Government subsidy
5. Government regulations and red tape
6. Security
7. Proprietary rights

SUMMARY

In summary, this chapter accomplished three tasks. First, it presented segments of U.S. policy and international treaties that affect commercial activities in space. Second, it identified policies and laws currently under consideration. Finally, it listed some contemporary space commercialization issues.

Five key findings result from this chapter. The first finding is that rapidly increasing national attention is being directed toward the commercialization of space.

Figure 1 above supports this finding. The second finding is that the government is strongly encouraging private commercialization of space through space policy updates. In recent policy changes space commercialization receives more explicit attention, while in earlier policy statements commercialization guidance was more often implicit. The third finding is that an increasing number of issues develops as the commercialization of space proceeds. Fourth, international space law is vague (probably purposely) on the commercial use of space. Finally, international space law shows no sign of near-term reaction to the rapidly increasing U.S. interest in space commercialization. This finding, also, is illustrated by Figure 1.

Chapter Four

SPACE COMMERCIALIZATION FUTURE

OVERVIEW

Chapter 4 investigates the future of space commercialization. The extent of future space commercialization will determine its impact on national space policy and defense needs. This chapter begins with a qualitative discussion of the future, and ends by attempting to quantify future space commercialization. Chapter 4 results are intended to give the "big picture" view that is needed to assess the interrelationship between future space commercialization and future national space policy and space defense needs.

This chapter continues the discussion of commercialization of space beyond the historical perspective of Chapter 2. It projects the trends of commercialization 40 years into the future through the year 2025. This trend analysis begins by discussing commercialization incentives, the most subjective influencing factors. It then moves on to less subjective corporate planning, and concludes by extrapolating a mixture of corporate projections and historical data from Chapter 2.

COMMERCIALIZATION INCENTIVES

The government cannot dictate the rate of private innovation; however, it can indirectly influence the innovative performance of the private sector through its policies and its legislation (47:xiii). This section looks at space commercialization incentives offered by the government through NASA, through tax legislation, patent legislation, and government spending.

Incentives Offered by NASA

NASA, as the foundation of the U.S. space program, possesses key knowledge and influence that can aid members of the commercial space market. Fortunately, NASA has demonstrated a positive attitude toward encouraging private industry involvement in space. As a recent example, NASA established a new Administrative Office for Commercial Programs to focus NASA efforts for expanding private investment in space activities (27:18; 3:62). Following are several other NASA mechanisms aimed at promoting private investment in space.

NASA/Industry Agreements.

Joint Endeavor Agreements. The Joint Endeavor Agreement (JEA) enables formalized cooperation between NASA and private industry for materials processing in space. NASA and the private company tailor their JEA to provide a mutually beneficial mix of objectives, responsibilities, and financial risk. Generally, NASA provides free shuttle flights and the private company provides flight hardware for test. In return, NASA receives experimental data on the project's commercial potential, and the private company retains patent rights and the right to a fair return on investment from products sold during experimental project phases. (41:229).

JEAs supply an important incentive that encourages companies to enter space businesses. Their popularity demonstrates their success. As of 31 January 1982 only two JEAs were in force (49:232). By June of 1984 the number of JEAs doubled and applications for four more were pending approval (20:99; 7:62,63).

Other Agreements. Two other levels of NASA and industry agreements are possible. First, Technical Exchange Agreements (TEA) allow collaboration on projects where commercialization potential is not as mature as with materials processing in space. Microgravity technology serves as an example. TEAs involve much less expensive projects than JEAs and allow unrestricted information flow throughout industry (41:A4-5). At the end of June 1984 five TEAs were in force (20:99; 7:62,63).

Second, Industrial Guest Investigators (IGI) enable industry scientists to team with NASA-supported principal investigators. The IGI agreement documents proposed industry and NASA investigator contributions to furthering space commercialization knowledge through study and experimentation (41:A4-5).

Space Shuttle Getaway Special Program. The getaway special program was begun in 1976 (18:139). It gives shuttle users reduced rates for flying small, self-contained payloads. Cargo can weigh up to 200 pounds with a maximum volume of five cubic feet. A one-day to six-day flight costs $100 per pound of payload, while a seven-day and over flight costs $125 per pound (1984 dollars) (54:626; 18:139; 1:27). Even before the first shuttle mission flew, over 300 users had reserved getaway special cargo space (54:626). As of June 1984 the number had increased to 525 customers (18:141).

Hitchhiker. Hitchhiker is a new program approved by NASA in April 1984. Hitchhiker can carry up to 1,000 pounds per experiment, thus it supports more ambitious projects than can be accommodated by getaway specials. Hitchhiker flights will begin in 1985. (25:102-104).

NASAs Recent Commercial Space Policy. In November 1984, NASA issued a 150-page policy document containing results of its Commercialization Task Force's 18-month study. It offers the following commercialization incentives (11:18,19):

> 1. The stimulation of private sector research with agency [NASA] seed funding.
> 2. NASA agreements to purchase selected space venture products and services, if the agency has a need for such products, and the private venture places significant capital at risk above that covered by the NASA purchase.
> 3. Reduced shuttle flight charges to commercial ventures during the research and development phase.
> 4. NASA assurances that it will not undertake development of the same technology that is being developed by U.S. industry for commercial markets under a Joint Endeavor Agreement.
> 5. The agency will make cargo bay space available for commercial ventures every six months and a partial or entire Spacelab pressurized module flight available for commercial use once a year beginning in 1986.

Tax Incentives

Some benefits of tax incentives intended primarily for the research and development community have also aided space commercialization. Several tax incentives were introduced as part of the Economic Recovery Tax Act (ERTA) of 1981. ERTA enhances investment by encouraging capital-goods innovation through the accelerated capital recovery system (ACRS) (46:xvi). Another tax incentive is the incremental tax credit for increases in research and development spending. When combined with a 1954 tax law that allows labor and materials for research and development to be treated as expenses, the pair provide strong incentives for spending money on research and development (46:xvii). Orbital Sciences Corporation (OSC) used these tools to raise $60 million to fund their transfer-orbit-stage program. They were able to write off 86 cents of every dollar invested, because the money was targeted for research and development. OSC investors received personal tax shelter advantages of nearly 50% (36:80).

Patents

Up to this point, terrestrial U.S. and international patent laws are used to govern space commercialization projects. NASA agreements with private industry include references to U.S. patent procedures. NASA gives companies rights, title, and interest to inventions conceived in space (20:97). Allowing private industry to retain patent rights on their discoveries represents a critical incentive to space commercialization. However, the validity of U.S. patent laws extending into space may someday be challenged internationally (20:97). The eventual outcome of that challenge, if it happens, will be very important to the future of space commercialization. Meanwhile, private industry currently enjoys favorable patent laws through their agreements with NASA.

Government Spending

Another indicator of the national view toward space is reflected in the national budget. Proposed spending increases for space research and development indicate an uptrend versus declining real spending for other civilian research and development. In 1984 dollars, space gets $2.7 billion in 1985 then increases to $5.5 billion by 1989 (48:12). Viewed against the historical 7% (real) annual increase in total NASA funding from 1977 to 1985, a four-year 104% increase shows sincere federal commitment to space research and development. The 104% increase includes support for the proposed manned U.S. space station.

CORPORATE PLANNING DATA

This section presents areas of corporate interest and growth in space commercialization. As above, both qualitative and quantitative data are used to describe trends.

Space Station Interest

In September 1984, responding to President Reagan's call for a permanently manned U.S. space station, NASA released requests for industry proposals describing the station's preliminary definition and design (28:76). Industry response was incredibly enthusiastic. Over 100 companies and research organizations responded to the first 13 of the initial 412 contracts NASA will issue to build a space technology base for the space station program (12:16; 26:25).

Manned U.S. Lunar Station and Mars

President Reagan initially announced interest for a manned U.S. lunar station, followed by a manned U.S. mission to Mars, in his national space strategy statement of August 1984 (see Chapter 3). In October 1984, NASA sponsored a symposium hosted by the National Academy of Sciences to consider planning factors for such a goal. Three hundred scientists, engineers, and astronauts attended the meeting. NASA Administrator James M. Beggs (10:73) said, "I believe certainly sometime within the next 25 years we will return to the Moon." Several key points won consensus at the meeting. First, members agreed that lack of long-range planning led to the U.S. space program decline after Apollo. Second, they agreed that a manned U.S. orbiting space station, a manned U.S. lunar station, and a manned U.S. flight to Mars supply a complementary long-range suite of U.S. space objectives. Finally, they believe a lunar base will spur the commercial use of space. (10:--).

Two study groups independently estimated the lunar base cost in the 50 to 90 billion dollar (1984 dollars) range (6:314,315; 10:73-83; 33:323,324).

Corporate Case Studies

This subsection looks at two companies who have published plans and projections for their entries into the commercial space business. Where possible, the numbers presented here will also be used in the next section to help establish the magnitude of future space commercialization.

McDonnell Douglas/Johnson and Johnson. Table 7 shows space business financial planning for the McDonnell Douglas and Johnson and Johnson team. This team plans to market pharmaceutical products they will refine in space using a space materials processing technique called electrophoresis. The team hastens to mention that the following numbers include planning only for their initial drug candidate.

They expect to be processing three different drugs in space by the mid-1990s, and up to 10 new drugs by the year 2000. (24:52).

Electrophoresis			
Projected market	1 Billion/yr	3 Billion/yr	10 Bil/yr
Time frame	1990-1995	1995-1998	2000
Project started	1977		
First sale of product	1987		
Projected profit	15%		
Break even point	1995		
		Source:	(24:--)

Table 7. Case Study - Pharmaceuticals

Orbital Sciences Corporation. Table 8 shows business planning figures for an Orbital Sciences Corporation (OSC) project. This is an example of an indirect capital investment in space. OSC proposes to build a family of upper stage space vehicles that will move satellites from low earth orbit to geosynchronous orbit. Although an OSC vehicle becomes worthless space junk after use, it still increases the cumulative capital investment in space by transferring its value to the satellite that it boosted to geosynchronous altitude. It will cease to be a space capital asset when its satellite companion expires as a useful asset.

Transfer Orbit Vehicles		
Projected market	38 missions	30 Mil/mission = 1.14 Bil
Time frame	1987-1992	
Projected market	30 missions	8 Mil/mission = 240 Mil
Time frame	1986-1992	
Project started	1982	
First sale of product	1986	
		Source: (32:--)

Table 8. Case Study - Upper Stage Vehicles

TREND ANALYSIS

Given the data presented in Chapter 2 and here, many approaches are possible to arrive at the financial impact of space business in the year 2025. The approach chosen by the author looks at space revenue produced and space capital asset value. The reader may prefer other measures to judge the economic impact of space commercialization. The variety of data in Chapter 2 should allow the reader flexibility to perform his (her) alternative analysis. Before beginning the analysis, results of one final data survey will be presented.

Addition Data

Table 9 lists results of a final data survey. It contains bits and pieces of information from various future business planning sources.

DESCRIPTION	SOURCE
Comm sat launches/yr = 16; growth 15-20%/yr	(5:15)
Comm sat launches(1986-1995) = 245	(38:161)
Leasecraft: cost = $200 mill; launch-1987	(42:19)
Space pharmaceuticals: profit = 15%	(24:53)
Space station: cost = $8 bill; launch-1992	(12:17)
Crystals: revenue = $200 bill/yr by 2005	(19:100)
Pharmaceuticals: revenue = $27 bill/yr by 2000	(14:40)
Crystals: revenue = $3.1 bill/yr by 2000	(14:41)
Glasses: revenue = $11.5 bill/yr by 2000	(14:41)
Other: revenue = $5 bill/yr by 2000	(14:41)
Pharm,crys,glass: revenue = $30 bill/yr by 1995	(14:41)

Table 9. Miscellaneous Data

Analysis

This analysis uses the space communication business as the projection foundation and then adds on the various estimates of contributions from other fields listed in Table 9. Figure 2 shows the result. The historical portion of the plot is purely communication satellite data. Communication satellite results come from using satellite launch rate, satellite lifetime and dollar-per-pound contributions from the satellites themselves, plus dollar-per-pound launch costs to position them in space.

Revenue is based on total number of operating satellites combined with the INTELSAT revenue figures. The far-term is computed the same way, but with Table 9 data superimposed.

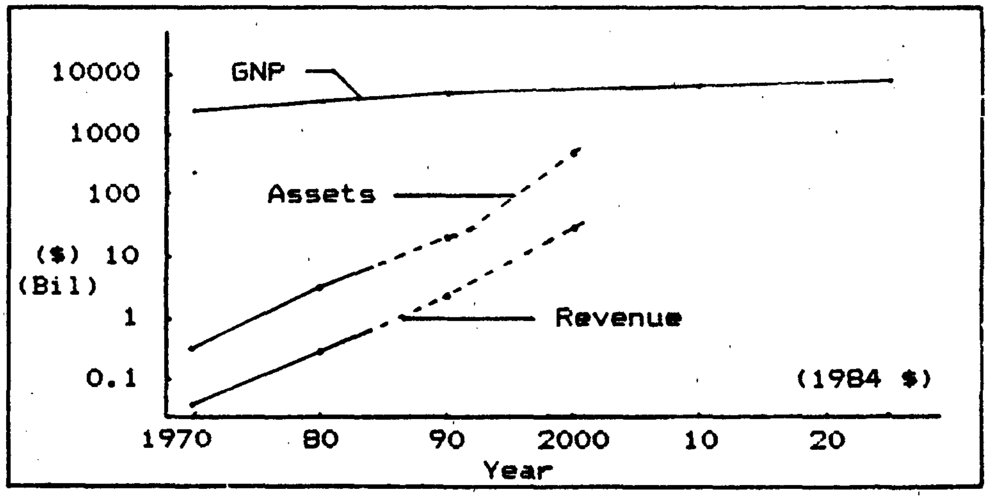

Figure 2. Space Commercial Assets and Revenues

SUMMARY

Chapter 4 has looked at several NASA and government incentives for space commercialization. It appears that private industry is eagerly accepting the space commercialization incentives being offered. Chapter 4 also presented some quantitative industry projections of the future business potential of several space industries.

An analysis of data trends found that commercialization of space appears to be an important economic force in this country's future. Figure 2 shows that capital investment in space is increasing rapidly. By the year 2025 commercial space assets may equal the U.S. gross national product ($8500 billion [1;19,20] in 1984 dollars). The projected revenue from space climbs to several hundred billion (1984 dollars) by the year 2025. These numbers appear quite significant; however, their true significance will depend on the views of the President and Congress.

Chapter Five

IMPLICATIONS TO U.S. POLICY AND DEFENSE NEEDS

OVERVIEW

Chapter 5 concludes this study by summarizing potential impacts of space commercialization on U.S. space policy and U.S. space defense needs. It does this in three steps. First it collects and summarizes the important findings of the previous chapters. Next it presents the author's conclusions derived from the findings. Finally it provides the author's recommendations.

FINDINGS

Beginning with Chapter 2, this study uncovered several trends. In the last five years, U.S. commercial satellite launches have sharply increased their share of the total U.S. satellite launches. Satellite launch costs have decreased dramatically since the late 1950s, and they are predicted to decrease by another factor of 100 over the next two decades. Satellite lifetimes have leveled off at around seven to ten years. To date, communication satellites account for most U.S. space commercialization. Chapter 3 pointed out that U.S. Presidential and Congressional interests in space commercialization have intensified with each successive administration. However, international organizations have made no response to the accelerating domestic interest in space. Chapter 4 displayed the keen corporate interest in space industry. It found that more than a hundred companies are actively seeking involvement in space ventures. Finally, Chapter 4 projected space commercialization into the future and found it has the potential to be a significant economic force.

CONCLUSIONS

The U.S. Government must fully recognize the commercial industry it is fostering in space, and plan for a means to defend it. Before the year 2025, the value of commercial capital assets in space will probably surpass the value of the U.S. gross national product. Revenue from commercial space operations will also comprise a significant share of the national economy. U.S. policy must include an approach and plan to protect U.S. commercial assets and commercial interests in space.

RECOMMENDATIONS

Recommend that control and protection of commercial space assets be included as an important element of our national policy objectives.

Recommend the U.S. devise a long-range strategy to develop a space defense system based partly on the need for protecting U.S. commercial assets in space.

Recommend that defense needs of U.S. commercial space assets be integrated into Department of Defense planning for space defense.

Recommend development of the Space Strategy Option Model as a tool to help the U.S. arrive at reasonable decision options for devising and implementing an integrated space defense strategy that suits both military and civilian needs.

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