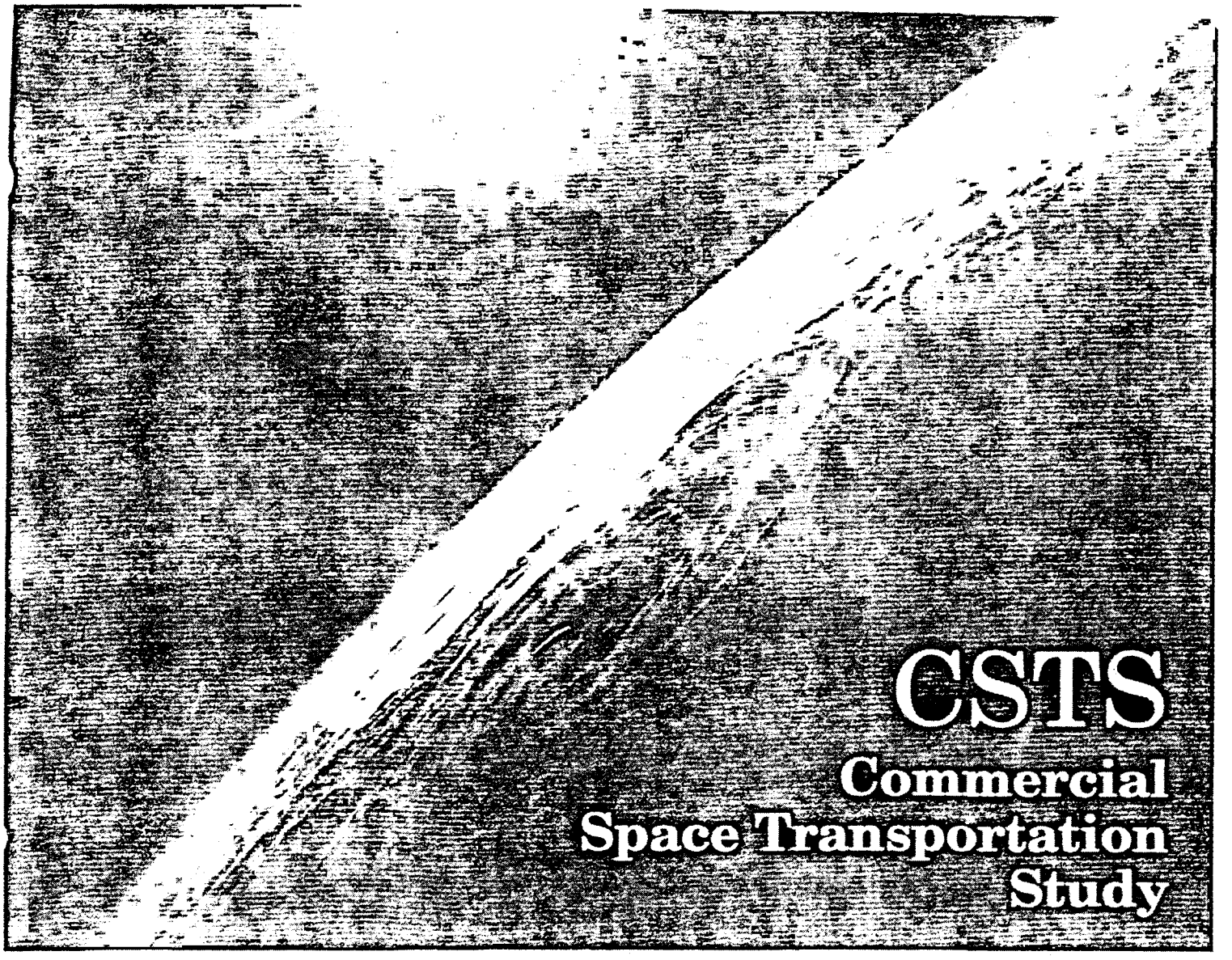


May 1994

# Final Report

Boeing
General Dynamics
Lockheed
Martin Marietta
McDonnell Douglas
Rockwell

# Commercial Space Transport Study Final Report

April 1994

BOEING GENERAL DYNAMICS Lockheed
MARTIN MARIETTA MCDONNELL DOUGLAS Rockwell

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# Commercial Space Transport Study Final Report

## 1.0 INTRODUCTION

The U.S. commercial launch industry needs revitalization to recapture the market from subsidized foreign competition. The principal technology base for our launch industry is 30 years old. This study will change this situation by systematically identifying future launch opportunities and defining a next-generation launch system to optimally meet the users' requirements. The results of this study will benefit commercial, civil, and DOD users, as well as make the United States more competitive across the aerospace industry.

### 1.1 BACKGROUND

The basis for this study was the perception held worldwide by government and industry that (1) significant untapped markets exist or could be created if the costs for access to space could be reduced by an order of magnitude or more, (2) a new launch system can provide this order of magnitude reduction in launch costs, and (3) a reduction of that magnitude will cause the equivalent of a space industrial revolution with a tremendous increase in users and traffic. This conjecture is often stated but has never been proved. Phase I of the study identifies those new users and categorizes their prospective payloads. Once the business opportunity has been identified, the best prospective launch system can be determined and the required technologies put in place. This is the linkage between phase I and the proposed phases II and III.

### 1.2 GOALS AND OBJECTIVES

It is commonly recognized that the U.S. space launch industry needs revitalization to recapture commercial markets from foreign competition and to stimulate the development of new commercial ventures in space. To this end, representatives of six aerospace companies (Boeing, General Dynamics, Lockheed, Martin Marietta, McDonnell Douglas, and Rockwell) and NASA met in March 1993 at NASA's Langley Research Center (LaRC) to discuss means by which a new, commercial space transportation system might be developed.

A perception is held by government and industry that a new, state-of-the-art launch system can provide an order of magnitude reduction in launch costs and that a reduction of that magnitude will cause the equivalent of a space industrial revolution with a substantial increase in users and traffic. The group meeting at NASA LaRC concluded that to become economically viable, a new launch system must generate new commercial markets. This group, now known as the Commercial Space Transportation Study (CSTS) Alliance, established the need for a market exploration study to identify potential customers, determine price elasticity of demand, and assess the commercial business opportunities for such a future launch system. This plan was briefed to NASA Administrator Dan Goldin on April 30, 1994, and in May the partnership between NASA and the companies began.

The CSTS objectives, as illustrated in figure 1.2-1, were to assess market elasticity with the long-term goal of expanding the market for space products and services. Significant results of the phase 1 CSTS effort, performed between June 1993 and February 1994, are summarized in this document.

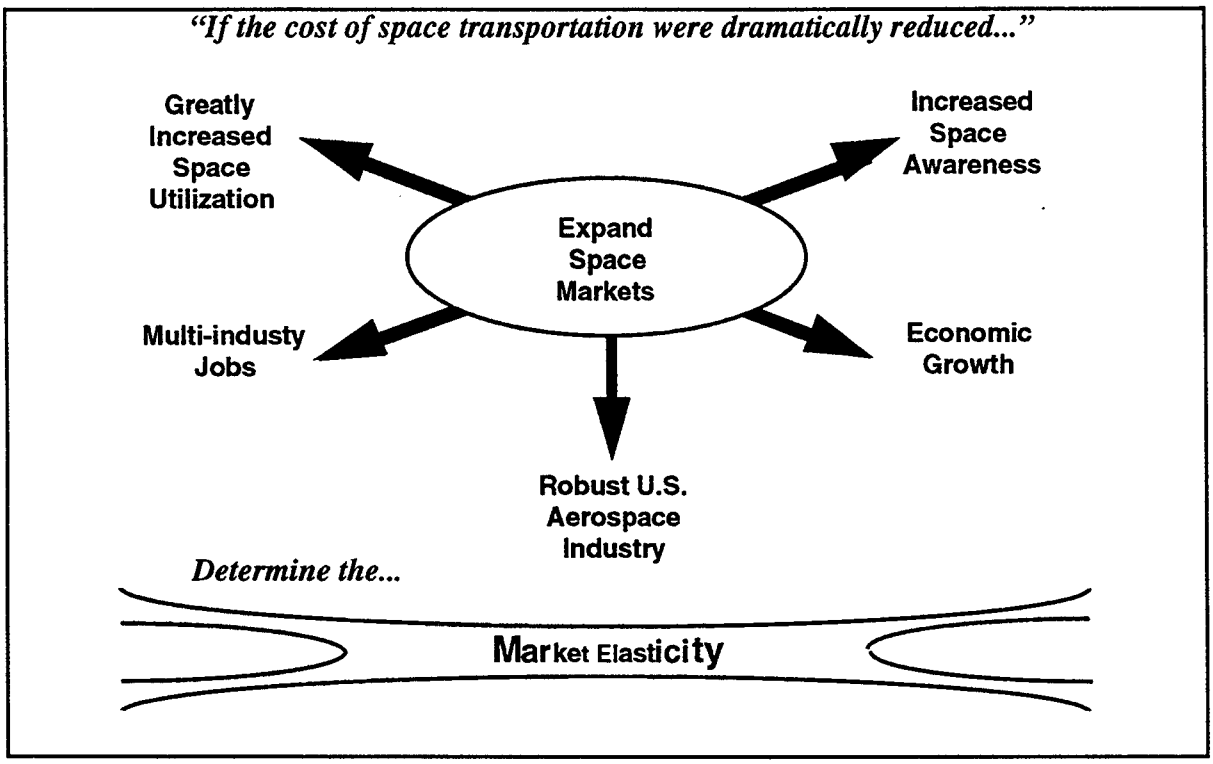


*Figure 1.2-1. CSTS Objectives Were ...*

# 2.0 Study Methodology and Approach

## 2.0 STUDY METHODOLOGY AND APPROACH

The CSTS approach differed from traditional studies and is summarized in figure 2.0-1. First, six normally competitive aerospace companies worked together to accomplish the objectives of the study. Second, this study researched potential customer needs rather than starting with a preconceived solution of a transportation system and then trying to identify customers for it.

The CSTS market assessment followed two paths. Key decision makers within a broad range of industries who might have future business activities in space were contacted. These contacts spanned the spectrum of industry, including advertising, electronics, energy, entertainment, health care, manufacturing, telecommunications, tourism, and academia.

In parallel, a business analysis effort assessed the various opportunities using analytical business models to validate the data from the market surveys and to test assumptions about the new markets. Interview findings identified additional characteristics of the markets, new commercial space markets, key decision factors from an "insider's" perspective, and space transportation system attributes necessary to meet commercial user needs. Market area revenues and capture opportunities were then quantified. CSTS tasks, identified in figure 2.0-2, were augmented by additional efforts performed by the Alliance under discretionary resources (shaded boxes).

For each market area a range of demand was identified for high, medium, and low probability projections. High probability projections represented the lowest market risk and produced the lowest estimate of future transportation demand. Its business ventures included those that fall within current business operating conditions and meet market area financial projections. In contrast, the low probability demand projection allowed optimistic extrapolations and expansions of current business activities into space, with business activities still within current market area financial projections and acceptable market area rates of return. The medium probability demand model was a nominal extrapolation between the low and high probability markets.

| CSTS Approach | Classical Approach |
|---|---|
| • Focus on market thresholds and market elasticity | • Focus on vehicle concepts |
| • Create the market addressing both traditional and nontraditional customers | • Survey the market |
| • Create opportunities | • Identify needs |
| • Contractors working together | • Contractors compete |
| • Government supported technology; commercially supported development and operation | • Government funded and operated |
| • Economic growth from government and commercial investment, and financial returns | • Economic growth from government investment |
| • Focus on economic return | • Vehicle performance driven |

*Figure 2.0-1. Why the CSTS Approach Is Different*

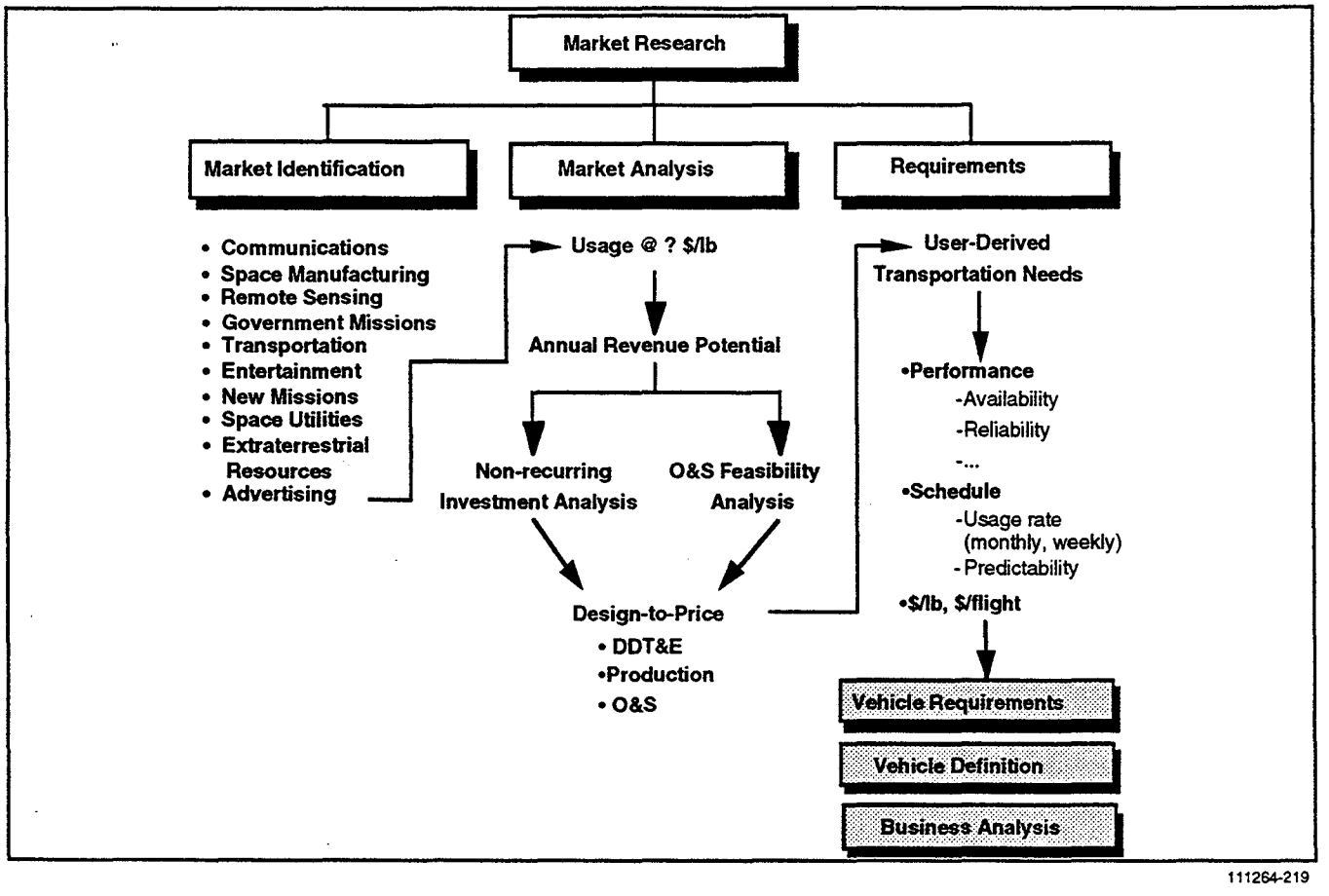


*Figure 2.0-2. CSTS Approach and Methodology*

# 3.0 Market Assessment/ Market Analysis

# 3.0 MARKET ASSESSMENT/MARKET ANALYSIS

## 3.1 COMMUNICATIONS MARKET

### 3.1.1 Introduction

#### 3.1.1.1 History of Satellite Communications

In 1962 the world's first active relay telecommunication satellite was launched. Since that time the developed world has come to depend upon the services provided by these satellites. The advent of communications satellites has change the world. Because it is now possible for telephone and television companies to offer worldwide service, people over the entire globe are able to simultaneously share in historical and sporting events. This has been used to truly increase social understanding and provide a stronger bond between all the people of the world. Figure 3.1.1.1-1 highlights the history of satellite communications.

| Year | Satellite | Technology Event |
|---|---|---|
| 1958 | SCORE | First satellite with broadcast capability |
| 1958 | Courier 1B | First teletype relay by satellite |
| 1960 | ECHO | First passive relay communications satellite |
| 1962 | Telstar | First fully functional active communications satellite |
| 1962 | Relay | First worldwide TV transmission satellite |
| 1963 | Syncom II | First geostationary communications satellite |
| 1965 | IDSCS | First operational military communications satellite |
| 1965 | Early Bird | First operational commercial communications satellite |
| 1967 | INTELSAT II | First communications satellite capable of multiple access transmissions |
| 1968 | TACSAT | First satellite to provide UHF mobile communications |
| 1968 | INTELSAT III | First satellite with a despun antenna |
| 1971 | INTELSAT IV | First satellite with high-power spot-beam antennas |
| 1975 | INTELSAT IVA | First communications satellite to achieve frequency reuse |
| 1976 | MARISAT | First communications satellite to provide commercial mobile satellite services |
| 1980 | INTELSAT V | First complex hybrid communications satellite capable of operating in multiple frequency bands with multiple frequency reuse |

*Figure 3.1.1.1-1. Communication Satellite Development Highlights*

The earliest systems were sponsored to provide services for individual national governments and militaries. These earlier communications satellite systems were fitted into existing terrestrial networks utilizing existing end user hardware. As the consumer base has grown, the technology base has grown and expanded the product utility which has further expanded the consumer base. It is this expansion cycle that continues to fuel the development of telecommunications satellite systems. They have been sponsored by governments and corporations in member groups and individually. Most of the development and governments commercialization of each type of system was led by those in the United States.

Today there are approximately 150 geostationary satellites in orbit around the globe. Of that number around 125 are used for commercial communications. These satellites are shown in figure 3.1.1-2. Satellite communications are continuing to expand to new applications and technologies. The first quarter century of development in communications satellites has provided global coverage for telecommunications systems of

numerous types. As the development continues other countries have taken increasing involvement and leads into various markets. The demand for additional features and expanded service areas has attracted new investors. Various user consortium-owned systems have been formed to spread the high initial cost for service. The continuing market expansion has given rise to entrepreneurial provider systems.

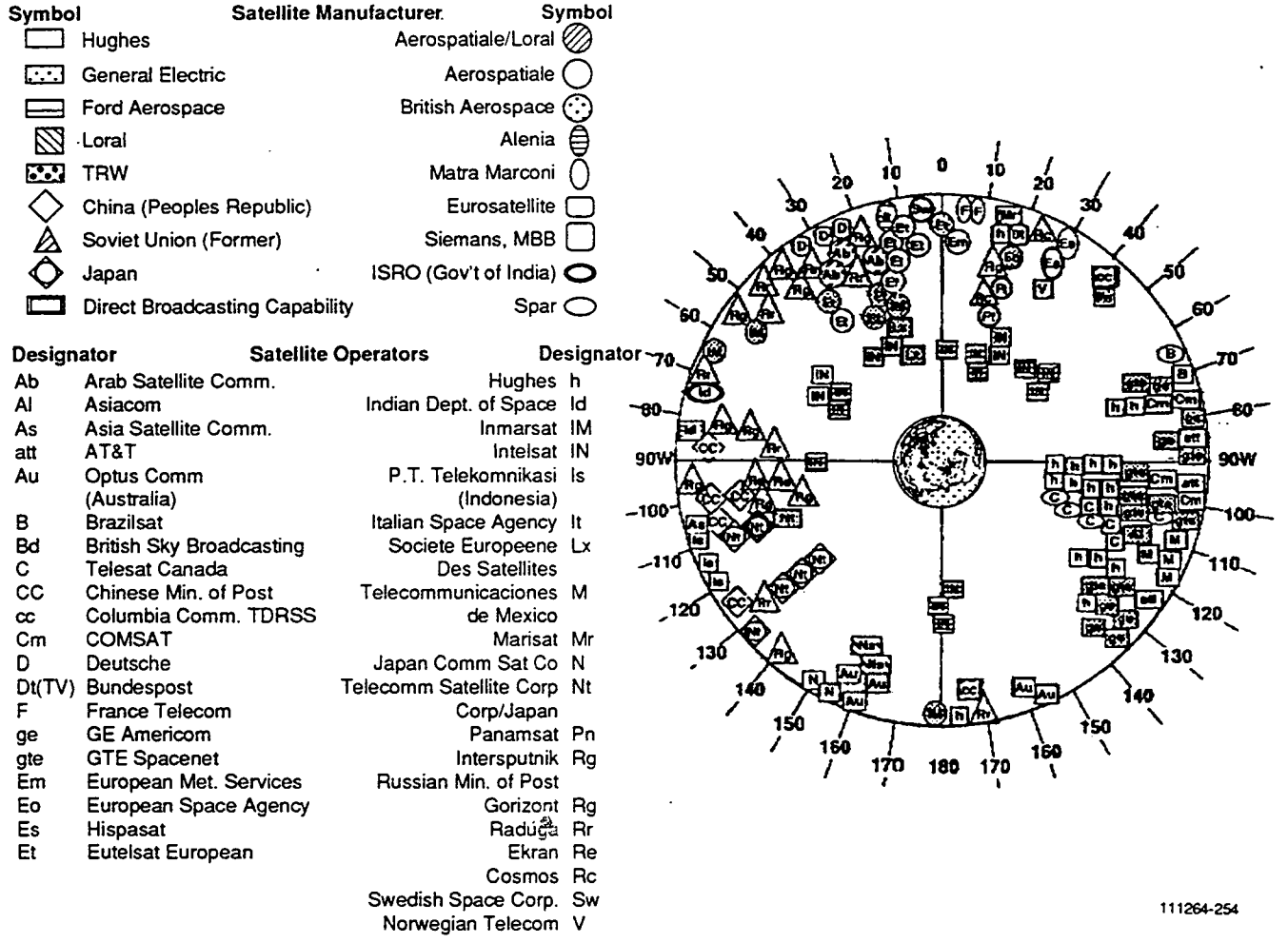


*Figure 3.1.1.1-2. Current Commercial and Communication Satellites and Their Positions*

### 3.1.1.2 Industry Overview

As satellite applications have grown the communications industry has grown at a fantastic rate. In the past 10 years all communications market areas increased in revenues. Domestic long distance calls, for example, grew exponentially from 4.7 billion calls in 1965, to 48.9 billions calls in 1989, to 66 billion in 1991, and a projected 260 billion in 2011( ref. NASA CR191145, "Potential Market for Advanced Satellite Communications"). Another example is cellular telephone usage, which has increased to 75 million subscribers. Like examples are possible for cable TV where TCI, a fledgling company 10 years ago is now earning $4 billion per year. Such performance results in high industrial growth, as shared by Pelton of the University of Colorado and cited by TCI in several references. The communications industry worldwide revenue in 1982 was $120 billion; today the industry is earning $460 billion. The same groups are predicting $3 trillion in revenue for the industry by the early 2000s. These growth projections are shown in figure 3.1.1.2-1.

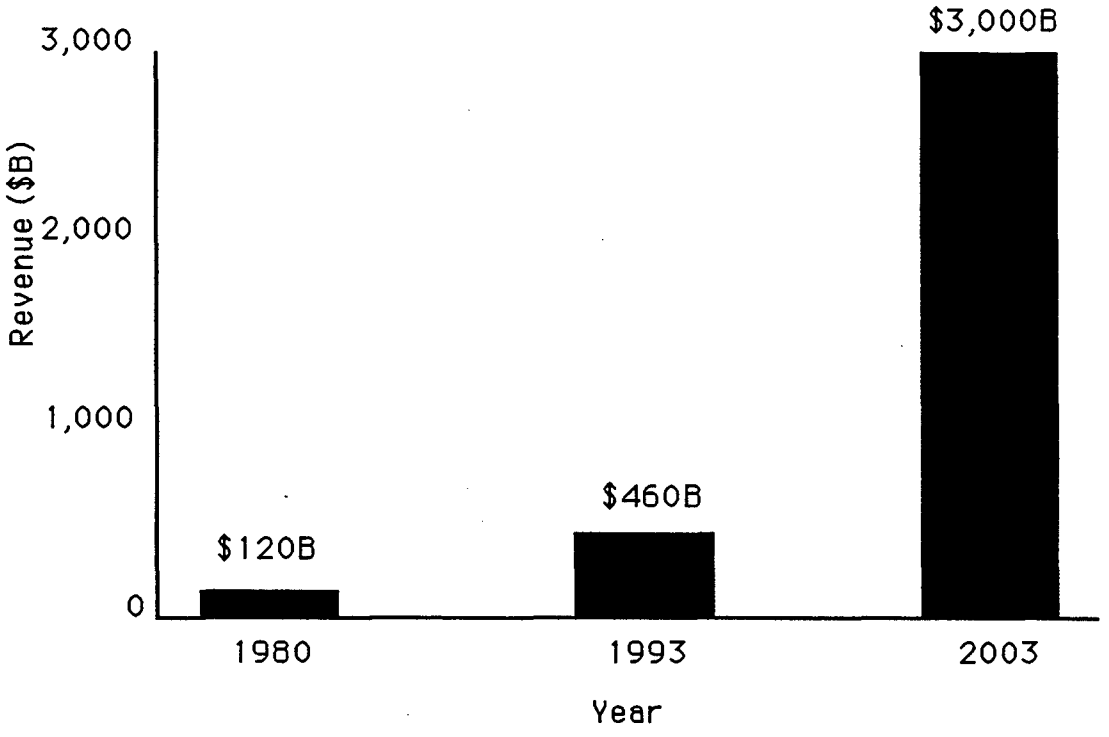


*Figure 3.1.1.2-1. Industry Revenue Projections*

One reason for this high growth is an industry strategy of high dollar amount reinvestment into high technology. This also has a high amount of capital available for such reinvestment. For example, AT&T, in its 1992 annual reports, cites $65 billion in revenue with $39 billion coming from telecommunications. The margin from the telecommunications portion by itself was $14 billion.

### 3.1.2 Current and Evolving Communications Satellite Applications

#### 3.1.2.1 Applications Roadmap

There are three spheres of technology included in each satellite communications system. They are the satellite, the distribution system/network interfacing to the end user, and the mechanism by which the end user accesses the communication system. Within each sphere, of course, are multiple designs and management solutions. It is common to each, however, that development within that sphere proceeds only to a point where it either drives or waits for development in another sphere. Figure 3.1.2.1-1 tracks the increases in each of these areas and illustrates the relationship between developments within one area and the resultant growth in another area. The development of smaller scale user apparatus, resulting in localized broadcast systems, from the ability for worldwide telecommunications satellite "feeds" by broadcast Networks can be viewed as a "top-down" evolution. Another evolution, if not revolution, is the development within the distribution system sphere of interactivity, combined with the development within the user sphere of individual-sized hardware driving the development of satellite networks.