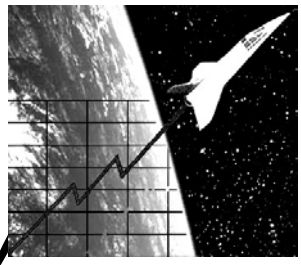


Executive Summary

Introduction

Space technology, which emerged in the 1950s, opened up a new era of human exploration and exploitation of outer space. Since then, the number of space-faring nations has increased substantially. As more nations develop space-related capabilities, opportunities for both international collaboration and commercial development are enhanced.

Many governments include space commercialization as part of their national policy. For example, NASA envisions three broad categories of opportunities; utilization, operations, and new capability development; ESA and NASDA foresee opportunities for research, while Russia is focused on tourism and transportation for the commercialization of the International Space Station.

We believe the establishment of a single, consolidated, global space commercialization plan should be considered. To date there are many dedicated, isolated studies and predictions on the future of space commercialization. However, integrated, unified ideas for commercializing space are noticeably absent. The goal of our project, therefore, is to fill this gap for the next two decades, until 2021.

More specifically, the mission of our project *CASH 2021: Commercial Access and Space Habitation* is to document a plan that identifies commercial opportunities for space utilization that will extend human presence in space, and that charts the way forward for the next 20 years.

In the context of our report, commercialization refers to the steps taken along a path, utilizing both public and private resources in the near-term, in order to create sustainable commercial industries in the future. These industries will

encompass profit-generating, private entities with a customer base composed of primarily private individuals or industry. Finally, we define 'human presence' to include both physical and virtual presence. Commercialization is thus viewed as a means to develop further these forms of human presence.

We created a single plan to chart the way forward from 2002 to 2021 by identifying our vision of the future by 2021, and then designing the roadmap to get there. Our plan was developed based on a 'preferred future scenario' methodology; one that is appropriately optimistic based on the current positive momentum in the space world. It is built on analyses of selected, potentially viable business sectors including tourism, entertainment, space systems servicing, and research, development and production, for which potential stakeholders were identified.

In order to chart the future of space commercialization for the next two decades, it was necessary to outline and unify the activities of the four business areas previously identified. The selected approach was to divide the time period into three overlapping phases and propose how commercialization might evolve in each.

We also addressed the universal areas of legal and policy issues, advertising, enabling technologies and transportation. We see these subjects as having common threads that link all business areas. Suggestions for new policy changes and predictions for future technologies are addressed as common needs for commercialization in any form.

The assessment of legal and regulatory issues in the CASH 2021 project has highlighted the need for a common legislation, as well as institutional revolution of Space Law. This should begin with existing treaties, via an implementation of customary law by national legislation, until an International Space Authority that shall further harmonize and/or unify the applicable legal system is set up.

Uniformity and harmonization is important particularly for import/export regulations, liability, intellectual and industrial property rights, licensing procedures and technical standards, transportation regulations, space debris, jurisdictional issues and tax harmonization. Furthermore, it is advisable that a

uniform legal setting be put in place, in order to support private investments in space, public-private partnerships and the space insurance business.

Our Future Scenario

To contend with the inherent ambiguity of the future, a preferred future scenario was constructed which formed the basis for our 20-year roadmap. This scenario essentially defines the perimeter of the project, by specifying the assumptions made about the future in the areas of space systems and other technologies, economics and government expenditures on space, geopolitics, and social conditions. The scenario was conceived to be appropriately optimistic based on the current positive momentum in space endeavors.

The preferred future for 2021 is one in which space activities are familiar, routine, and easily accessible. In addition, space is presumed to remain a reserve for peaceful purposes. In terms of space systems and technologies, an elaborate space infrastructure is predicted. Included are a lunar base, a gateway station at the first Lagrangian point (L1), several free-flying platforms, and large, modular COMSATs requiring human and robotic assembly and maintenance. Furthermore, advances in computational systems and artificial intelligence create the necessary technology for the development of reliable, autonomous, robotic systems.

In terms of economic outlook, overall global growth is predicted to average 4-5% annually over the next 20 years. Government expenditure on space in the developed world would increase from approximately USD 40B/year to USD 50B/year by 2011. Global government expenditure on manned space activities and transportation is calculated to total approximately USD130B over this 20-year period. Economic recovery is expected in Russia, and productivity in the developing world is also expected to improve continually improve. Emerging markets assume many of the higher-skilled industrial activities from the developed markets, and greater global access to investment markets allows a much broader share of the world's population to generate disposable income. Finally, there has been no energy crisis over this time period, and fossil fuel production continues to dominate the energy industry.

Geopolitically, the world is viewed as essentially multi-polar with Russian stability, a unified Europe providing competition to US dominance, Chinese involvement in cooperative space programs following the International Space Station (ISS), and tensions in the Middle East remaining geographically contained.

Social conditions in the future scenario reflect the movement of the millennial generation into a dominant position in the workforce. Most importantly, a greater number of stakeholders find profit in space. The result is that space activities are strongly supported by a collection of powerful special interests.

Thus, by the year 2021, space has become a regular component of economic, social, and political aspects of life for a large proportion of the world's population. Although the risks associated with space ventures remain high, investors make reasonable returns on their investments.

The roadmap is divided into three time periods, each with unique challenges, and each contributing technologically, politically, and economically to the next era.

Roadmap Phase 1: 2002-2011

The first phase of our plan to commercialize space covers the present and the immediate future, 2002-2011. In this time period, the ISS is under development as the primary space-based research, development, and technology verification platform. Access to the ISS for commercial entities is in the process being transferred from governments to commercial user centers. In the initial stages, the ISS will also serve as a destination for tourists and a setting for entertainment activities.

Tourism is restricted to the ISS for the very wealthy, via the limited-capacity Soyuz spacecraft. Although this activity is restricted, it still generates revenue and lays the groundwork for future endeavors. Since the completed ISS will not support a growing tourist or entertainment industry, the key to improving these markets is a tourist purpose-built space station in low Earth orbit (LEO). Such a station is built with revenue gained from tourists, film, broadcasting,

advertising, and limited additional equity financing. This private station using Russian hardware will be launched by 2005.

Coupled with the tourism growth is the entertainment industry. Broadcasting and marketing have already primed this market. Television shows set in space, remote control of space objects, and telepresence also show great commercial promise in the short term. The first space-based television contract has already been signed in 2001 between MirCorp and producer Mark Burnett, and projects using remote controlled space objects are foreseen. Remote controlled telescopes may be in operation as early as 2003.

In 2006, the money generated from tourism drives the development of a large, dual-use, inflatable module to support the burgeoning entertainment industry. With the addition of this 20-meter spherical module in 2007, the space station will be able to accommodate up to 50 visitors.

In order to reach the broader markets anticipated, higher-capacity transportation vehicles are required. The use of a privatized Shuttle, or use of Shuttle for the transportation of tourists in a human payload module will increase transportation capacity. The commercial shuttle operation will allow many tourists to fly into space and will begin to make space tourism routine.

Due to increased human presence in space, there is a need to establish space travel suitability criteria for health, as well as in-orbit emergency medical and operational procedures, and infrastructures.

Commercial research and development currently manifests itself via sales of ISS capacity. Privately-owned but government-subsidized commercial user centers for research and development service this market. Small free-flying platforms are launched for research and development purposes in addition to mini-space stations that are either human-tended (but not permanently occupied) or completely autonomous free-flying capsules.

To support the predicted growth in space travel and space infrastructure the creation of common infrastructure including an in-space assembly platform at LEO by 2011 is critical. To facilitate that goal, the following objectives must be met over the short term:

establish common integration, assembly, and servicing standards;
verify the technologies necessary to support orbital debris, servicing, and assembly businesses;
perform initial proof-of-concept services for clients using the ISS as a platform.

Roadmap Phase 2: 2007-2016

The second phase of space commercialization covers the time period from 2007- 2016. The following section describes our roadmap for the exploitation of the rapidly-maturing markets that have been developed in the short-term within the space sector. We foresee a decrease in the cost of access to space, the establishment of a common infrastructure, and the broadening of the base markets as fundamental to commercializing space in this phase.

This period sees the emergence of a commercial tourism and entertainment space station. The advent of a reusable launch vehicle (RLV) around 2015 enables the delivery of an increased number of tourists to a larger, dedicated tourism and entertainment space station. This station is then expanded to include large, inflatable-structure modules including windows to facilitate a tourism experience in a true ‘space hotel’.

Media projects are still important commercial businesses aimed at entertaining, educating, and initiating new business opportunities. The continual development of the lunar rover market for both scientific exploration and entertainment; as defined in the short-term provides a revenue stream, in addition to a virtual space presence for the general population. Capitalizing on the demand for actual presence in space by way of lotteries for participation in space activities become both a commercial and public success.

The space sports market is also a developing business objective in this time frame. A space sports facility, situated in an inflatable module, serves as part of the 2008 Olympic games in China. In addition, the technology and requirements for space racing, as discussed in the scenario, are being developed for this new sport to emerge in subsequent years.

The space infrastructure that was concept tested in the short-term phase in now maturing. Once each of the core technologies is verified on the ISS, the LEO assembly and servicing business becomes a normal part of space operations. Building on this infrastructure, debris removal and reuse initiatives begin and a decision to proceed with a moon base governs the next expansion in space infrastructure development.

To enable the continuation of commercial space applications and the related infrastructure, a continued program of research and development is implemented with the rewards of initial endeavors. Though the ISS dominates the first part of this period, the later section relies on free-floating platforms and the aforementioned lunar robotics to provide the knowledge base and system verification necessary for the development of a continued human presence in space.

Roadmap Phase 3: 2012-2021

The long-term is characterized by the establishment of mature and enduring industries. By 2021, the Moon is populated by several revenue-generating businesses, such as the entertainment industry, which uses a lunar facility to generate a variety of entertainment products. The space systems servicing industry and the debris business become profitable businesses.

Space-based assembly and servicing have established stations in LEO, L1, and possibly GEO which serve as operations centers for a variety of space services. Production operations mine the polar craters for lunar water, which is converted to fuel and sent to the L1 gateway.

The creation of advanced robotic technologies for entertainment and lunar development, have directly translated into common infrastructure components, providing more efficient in-orbit servicing and enabling new business, including the extension of telepresence to Mars and space racing.

Racing events begin in 2021 and involve multiple spacecraft in LEO that can be viewed from the Earth, either directly in the sky or from one of four special multimedia stadiums around the world. Furthermore, with advances in orbital assembly, new large-scale sports facilities will enable new crowd-pleasing

events by 2021. The evolution of telepresence robotics allows remote control of human-like robots on the Moon or Mars.

While the collective focus of infrastructure development moves towards the moon by the end of this period, larger and possibly cheaper transportation will lead to even larger LEO space hotels. Although tourism was never the primary driver in returning to the Moon, lunar tourism will inevitably follow.

Other events in this time frame could affect the outcome of the business ventures on the long-term roadmap. For example, if in 2012 a space accident were to occur, then the small debris business would become commercially viable, even an international space debris law. It is also possible that a micro debris project will begin in this time frame, most likely driven by government interests.

With the development of more common infrastructure, advanced robotics, increased human presence in space, and the refurbishment and possible privatization of the ISS, space-based R&D becomes a primary business. Furthermore, the decision to build an international Moon base provides a boost to the further development of testing and verification services. The emergence of fuel and other resource production on the Moon is a watershed moment for space business.

Recommendations

On the basis of this report, a number of recommendations can be made. Several of the key recommendations are listed below, with a more complete list in the report.

The progressive coordination and harmonization of state legislation shall provide a basis for the setting up of a more stringent International Space Law and in particular a new regime for property in space, allocation of licenses for the exploitation of scarce resources and efficient managing of space debris. This can possibly be done through creation of the International Space Authority, responsible for: the introduction of a unique setting of regulations for the space business, minimizing conflicting laws, setting up common jurisdiction, defining common access rules to space business, harmonizing existing licensing regimes, providing unique certification provisions, managing

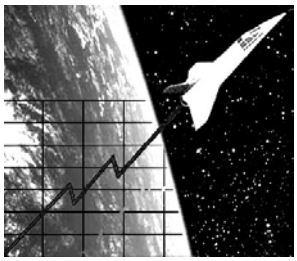
intellectual property rights, and encouraging security via the introduction of standards which limit risk.

Several of the business sectors are proposing commercial activities that have no precedents here on Earth and hence lack crucial market information that would enable speculation on the economic viability of such enterprises. In view of this, we recommend that a more detailed market survey be carried out, dedicated to the various commercial space activities proposed in this report.

It is technologically feasible today to reduce the cost of access to space by a factor of 100, but in order to accomplish this a demand for such transportation must exist. Currently the size of the launcher market does not justify the cost of constructing such transportation infrastructure; a hurdle that may be overcome by mitigating the risk of such investment and therefore opening up new markets to sustain this development.

Conclusion

It is not easy to predict the future. Our plan is an optimistic one, based on a future scenario and an end-goal of establishing four viable space industries. By the year 2021, space is a regular component of economic, social and political life. Although the risk remains high, investors make reasonable returns on investments in space ventures. Though the training remains rigorous, a segment of the global population actively considers the possibility of a once-in-a-lifetime vacation in space. Although the technologies involved remain complex, private companies undertake the construction of in-space infrastructure. Space laboratories and production facilities are an essential component of the research and production portfolio of a number of firms. In short, space has become an integral part of daily life.



1. Introduction

'To document a plan that identifies commercial opportunities for space utilization that will extend human presence in space, and charts the way forward for the next 20 years.'

CASH 2021 Project Mission Statement

The scope of mankind's activities has expanded from land to ocean, from ocean to atmosphere, and from atmosphere to outer space. Space technology, which emerged in the 1950s, opened up a new era of human exploration and exploitation of outer space. Now, the year 2001 is marked with significant events in the realm of space commercialization. In March, Mr. Dennis Tito became the first-ever commercial space tourist. In September, MirCorp announced its intent to build a commercial space station and subsequently reached an agreement with Hollywood producers for a new 'reality TV' adventure series to be performed in space. We will undoubtedly witness vigorous development of commercial space activities across the world in the 21st century.

It is timely, then, to produce a report about commercialization as it relates to space. The *CASH 2021: Commercial Access and Space Habitation* report begins with the present time and outlines a process for extending the human presence in space through commercialization over the next 20 years.

How shall we define commercialization? While ensuring profit for private industry is the goal in the long run, commercialization refers to the steps taken along a path, utilizing both public and private resources in the near-term in order to create a sustainable commercial industry in the future. 'Sustainable commercial industries', in this context, refers to private entities able to generate profit having a customer base composed of primarily private individuals or industry. On the other hand, privatization is the process of transferring public to private ownership, and is not the focus of this report.

What is meant by human presence in space? Human presence consists of both a physical and virtual presence. In the context of this project, commercialization is seen as being a means to increase and spread human presence in space.

We created a single plan to chart the way forward from 2002 to 2021 by identifying our vision of the future by 2021, and then designing the roadmap to get there. Our plan was developed based on a 'preferred future scenario' methodology; one that is appropriately optimistic based on the current positive momentum in the space world. It is built on analyses of selected potentially viable business sectors including tourism, entertainment, space systems servicing, and research, development and production, for which potential stakeholders were identified.

The ability to stimulate business investment and to develop new markets and industries in space is contingent on several factors: technological developments, social conditions, a regulatory framework, government expenditure, economics, and geopolitics. The four business sectors were developed based on speculation of the future status of these factors.

1.1. Significance and Motivation for Project

The number of space-faring nations is increasing every year, with space policy no longer being driven by the two space powers of the 1960's, the USA and the Soviet Union. In August 2001, Japan successfully launched the H-IIA rocket, which will improve Japan's position in the commercial space industry. In two years, China may become the third nation capable of sending humans into space using its Long March 2F launch vehicle. Europe's Ariane program is already a successful launch business. The International Space Station (ISS) is an example of an international, cooperative government venture that would not have been realized without high-level collaboration. This endeavor highlights the need to create a single consolidated plan that incorporates international cooperation and the large number of interdependencies between industries, governments, and society.

There are many dedicated, isolated studies and predictions on the future of space commercialization addressing topics such as a Mars mission, space life science research, Human Transfer Vehicle (HuTV), Crew Transfer Vehicle

(CTV), and space tourism. In fact, many governments include space commercialization as part of their national policy, yet there is no single, integrated plan for commercializing space. Our goal is to fill this gap for the timeframe from today until 2021.

1.2. Stakeholders

The entities that we believe have the greatest probability of reaping the initial benefits from the recommendations defined in this report are space agencies and space companies, through increased support from governments and the general public. Financial institutions, venture capitalists, and private investors can also benefit from commercialization recommendations.

An increase in public interest in space will bring additional support from governments, which will in turn be passed down to the respective international space agencies and space companies. An example of this was seen during the 1960s during the 'Space Race', when John F. Kennedy's call for "landing a man on the Moon and returning him safely to the Earth by the end of the decade" both enhanced public interest and persuaded government decision-makers to financially support space projects. This particular historical example was initiated by the desire of one country to 'beat' other countries to the Moon. A similar response could occur again for a different purpose with the right motivation behind it, for example international cooperation in a joint Mars mission.

Where will this motivation come from? "… until recently, governmental organizations have been the major driving force behind new developments in space. But now, industry and private ventures are becoming more important players in the space applications sector" [Jasentuliyana, 1999].

Financial institutions, such as banks, typically invest in ventures with extremely low risk. They are considered to be very conservative when deciding whether or not to invest, and typically make their analyses on the basis of past financial performances. On the other hand, venture capitalists and private investors are more willing to invest in higher-risk ventures. They are concerned with the future of the investment, or the potential growth of the company, and typically invest in synergistic businesses. Another primary concern is the exit strategy from the investment, including how and when to sell the investment for a profit. Venture capitalists and private investors will

consider investing in riskier ventures because they have an overall risk portfolio, with some investments being less risky than others to offset the chance of having to accept a loss.

Many investors today, however, shy away from the innovative space market. This caution is based on a history of past failed ventures such as Iridium. Our hope is that in the coming years, the space business will become more of a viable market, and that future space business proposals will at least be considered by this group of individuals. However, there must first be validity in the space market segment, with defined investment opportunities.

There are many other potential stakeholders for various commercial space businesses. Some of these are listed below, along with samples of investment opportunities:

- Tourism companies looking for a new 'product' to offer.
- Insurance agencies that would gain additional business from insurance purchased for travelers or new payloads launched into space.
- Pharmaceutical and biotechnology companies that could perform experiments in the microgravity environment of space.
- Educational institutions that could provide more 'hands-on' teaching opportunities to students both on the ground and in space.
- Advertising companies that could sell not only physical space on spacecraft to companies that want a worldwide advertising opportunity, but that could also capitalize on the virtual reality industry.
- Broadcasting and media companies that could develop new television shows and movies based on, or set in space stations.
- Environmental agencies that could enhance their existing monitoring capabilities through new or revitalized satellites.
- 'Dot com' Internet companies that are looking for new, high-tech Internet alternatives.

1.3. Sector Definition and Rationale for Choices

Our initial list of approximately 200 commercial opportunities in space was produced through a series of brainstorming sessions. We subsequently analyzed, refined, and consolidated these ideas to create unified areas of interest. Our report focuses on the four sectors that we believe will play a defining role in space commercialization over the next twenty years: tourism, entertainment, space systems servicing, construction and debris removal; and research, development, and production.

Tourism

On Earth, travel and tourism is a multi-billion dollar industry. Coupled with the human need for exploration and adventure, and foreseeable technological advances, space travel could eventually grow to be the same size as the terrestrial tourism industry. For example, according to estimates of the completion date of the MirCorp commercial space station, the first space hotel is expected to be available to the public in 2004. An international poll indicates that if ticket prices were in the order of USD 1000, about 20 million people per year would be interested in travelling into space [Peeters, 2000]. In order to exploit the possibility of commercial gain through this large new market, the objective of the tourism segment is to chart the course for a commercially viable tourist industry in space for the next 20 years.

Entertainment

The objective of the entertainment segment is to develop a plan for a profitable, accessible and exciting commercial space entertainment industry over the next 20 years, focusing on:

- Space Robotics
- Space Sports
- Space Racing

The entertainment industry is one of the largest on Earth, and covers many diverse areas. The rationale for focusing on these three areas is based on the extent of the current popularity of similar Earth-based events and applications. For example, the Internet continues to grow in popularity since its inception in 1993, and the use of Web sites to engage the public has been highly successful. In 1997, the Sojourner rover Web site was the most

popular Internet site, necessitating the installation by NASA of 25 servers in order to cope with 35 million 'hits' daily [Harmon, 1997]. In sports, more than 1 billion people watched the last Soccer World Championship [FIFA, 2001], while more than 3.7 billion watched the last Olympic games [IOCSydney]. The Formula 1 car racing industry is extremely popular and lucrative, with profits in excess of USD 200 M per year [F1, 2001]. Compared to the cost of setting up and marketing a space racing event to be viewed on Earth, Formula 1 vehicle costs are actually extremely high.

Space Systems Servicing, Construction, and Debris Removal There are many potential markets for generic technologies that could be used for servicing on-orbit systems and assembling large platforms such as space stations. Furthermore, as more satellites and objects are launched into space, there is a greater need for mitigation and cleanup of orbital debris. The objective of the Space Systems Servicing, Construction and Debris (S3CD) segment is to plan commercial opportunities, based on future infrastructure and technology platforms, to provide in-orbit services to space systems and the space environment.

Research, Development, and Production (RDP)

The commercial opportunities offered by research and development carried out in microgravity facilities in space would permit industry to research without the confines and restrictions of using government platforms. Commercial research facilities would offer routine reliable access, predictable pricing, and an intellectual property-cognizant environment. Successful research and development would lead to commercially-viable spin offs for use on Earth. For example, reducing material requirements for integrated circuit (IC) production through space research has a commercial potential of saving USD 100 M annually in the production of IC's on the ground [Peeters, 2000]. The objective of the RDP segment is therefore to provide the framework that will successfully put commercial research, development and production on space stations and celestial bodies, in order to create a profitable pasture for industry beyond the realm of Earth.

In order to enable the commercialization of these four business segments, the report addresses several common areas including legal and policy issues, advertising, finance and transportation. These are common threads linking all segments, and supporting the development of fruitful private ventures.

Suggestions for new policy changes and projections on future technologies are addressed as needs for space commercialization.

1.4. Report Overview and Scope

We have divided the report into three main time frames, with a chapter dedicated to each: first, 2002-2011 in which a foundation for growth is prepared; second, 2007-2016 in which the emergence of new infrastructure is described; and lastly, 2012-2021 in which we discuss maturing enduring industries and the return to the Moon. We developed a 20-year roadmap including each time frame, and within each, the report discusses the significant commercial developments in each of the four selected business areas of tourism, entertainment, S3CD and RDP, with each analysis focusing on marketing and advertising, financial considerations, systems and technology, social issues, political and legal matters.

In Chapter 1, we introduce the project and its mission statement. Then we elaborate the significance of the report, and our motivation for pursuing this project. We identify potential stakeholders, and describe four commercial sectors with the rationale for our choices.

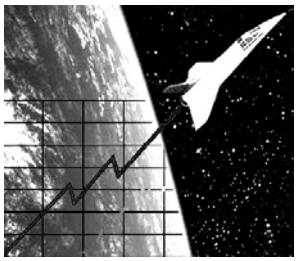
Chapter 2 provides the historical perspective, and outlines the predicted future scenario on which the commercial sector analyses are based.

Chapters 3, 4, and 5 identify and examine marketing and financial considerations, technology, and social issues for the commercial sectors, in each of the three time frames, 2002-2011, 2007-2016, and 2012-2021 respectively.

Chapter 6 develops a legal framework for each of the business sectors.

Chapter 7 presents a sensitivity and feasibility analysis. Our plan was developed with a set of assumptions about world events, the successful execution of programs, and legal and policy regimes, to mention but a few. In this chapter, an analysis of the impact of changing these assumptions is achieved, as well as a discussion on the feasibility of the overall commercial plan.

Chapter 8 encompasses our recommendations and general conclusions.



2. Historical Perspective

2.1. Introduction

This chapter commences with an overview of commercial space activities that have emerged from the beginning of the space era. The chapter further encompasses discussion of future-scenario planning approaches and the specific methodology that has been used in the CASH 2021 project, for the purpose of identifying a preferred future scenario. Additionally, outlined below is an architectured route that elaborates how commercial space activities will further develop, given the considered scenario.

2.2. Historical Background of Commercial Space Activities

In retrospect, space activities have significantly evolved from simple industrialization to commercialization and present day privatization of certain

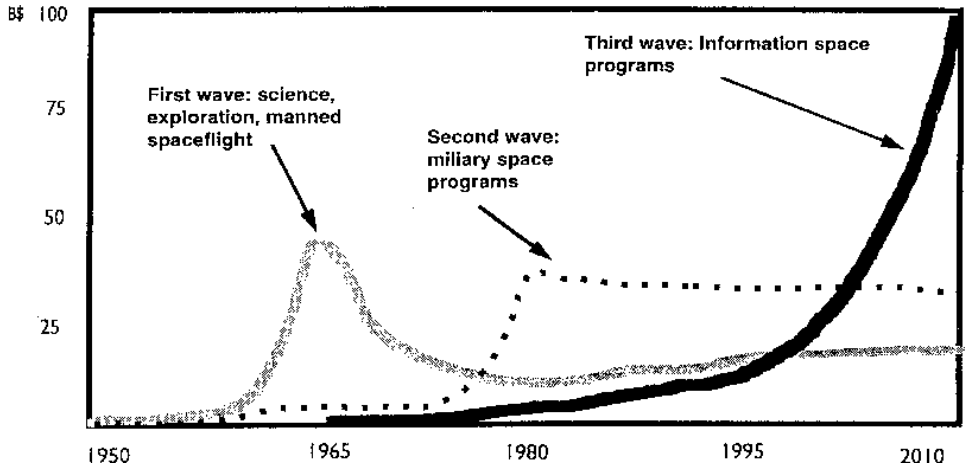


Figure 2.1: Waves of Space Development [Dupas, 1995]

space sectors. It is crucial to outline new paths for commercialization via evolutionary analysis of the roles played by the public and the private sector in space, and to highlight the associated rationales supporting them.

Space development has historically been driven by political interests over a number of cyclical phases (see Figure 1.1). The first 'wave' was due to the 'Space Race' between the United States (US) and the former Soviet Union. Human spaceflight and solar system exploration were the two main growth areas during that period. The space programs were almost exclusively publicly funded as a result of the high investments required to meet the political challenge of winning the space race, and because of the large level of associated risks. In fact, NASA budgets reached up to 0.8% of the US Gross National Product (GNP) in 1965, whereas it now stands at less than 0.14% [Peeters, 2000].

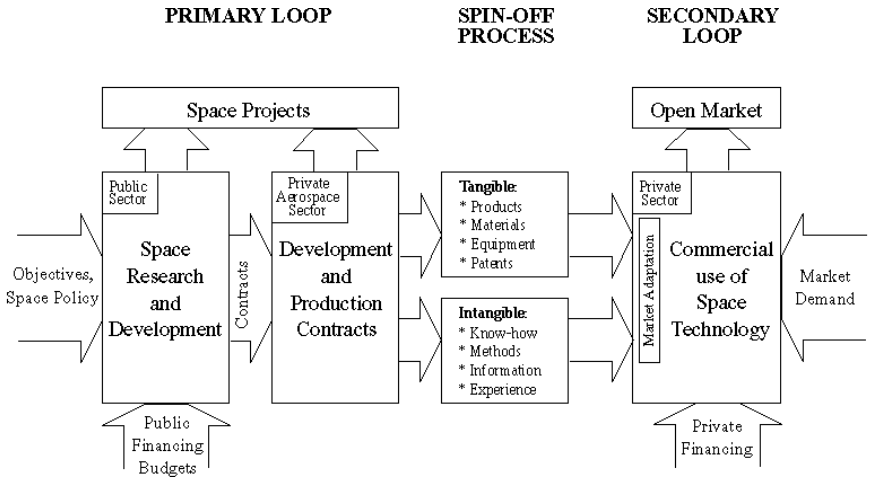


Figure1.2: Schematic Spin-Off Process [Peeters, 2000]

During the 1960's, companies did not pay significant attention to spin-offs due to the quasi-unlimited nature of funding from governments. Even though Senator Lyndon B. Johnson considered spin-offs as the main rationale for NASA creation in 1958, the space sector was controlled entirely by the governments who were providing contracts to the private sector as shown by the primary loop in Figure 1.2. The mentioned system of functioning began to change when the amount of public funds available for civil space activities decreased in the late 1960s.

The second wave was characterized by the use of space for national security purposes. With the funding still coming mainly from the government, the private sector developed significant expertise in the space sector especially in satellite communications and launch vehicles, reducing the risk level previously associated with space activities. Thus the spin-off process started to play a significant role for space industries.

The analysis shown in Figure 1.2 also argues that the next wave will be characterized by an exponential growth in the use of space for "information-based" activities. However, the role of traditional government space agencies compared to the role of the private sector remains unclear [Logsdon, 1999]. The tendency in Europe, illustrated in Figure 1.3, shows that the space sector will eventually be controlled by market demand instead of space policy. Governments are attempting to accelerate this transition by promoting commercial activities on board the International Space Station and by creating organizations like the Canadian ISS Access Company (CIAC).

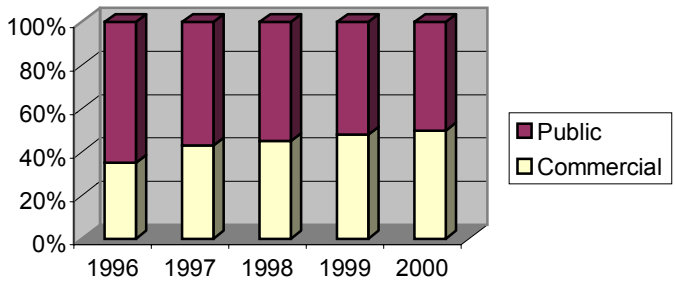


Figure 2.3: Public vs. Commercial Space Budgets in Europe [Euroconsult, 1999]

However, as shown in Table 1.1, the forecast of future commercial activities was often inaccurate, at least in the short term. Space tourism and solar power are the only two activities that have remained in the commercial forecasts over the last ten years. *CASH 2021* is not intended to forecast future commercial activities, but rather it is to chart roadmaps that will lead to these commercial activities assuming a desired scenario.

1979	*1991*	*1999 (ESA)*	*1999 (ISBC)*
•Space Comm. •Nuclear Waste Disposal •Manufactur. in Space •Space Solar Power.	•Sub-orbital transport •Space tourism •Solar Power •Manufactur. in space •Mining •Colonization.	•Mars exploration •Moon exploration •Solar Power •Space Tourism.	•Tourism •Solar power •Tele-operated Satellite Repair •Industrial platforms •Asteroid mining •Lunar & mars stations

Table 2.1: Evolution of Commercial Forecasts [Peeters, 2000]

2.3. Overview of Past and Present Status of Commercialization Efforts

In defining new paths for commercialization of outer space activities it is most relevant to consider the historical significance of those endeavors that have already been proven economically beneficial and/or viable. While much of the data on commercial space activities to date has been discouraging to private corporations and investors, several industries have emerged as the forerunners in capitalizing on various commercial space businesses such as; satellite communications, launch vehicles, navigation services, research and development, satellite servicing, entertainment, tourism, advertising and various other private entities.

The satellite communication sector provides a striking example of continuous revenues and industry growth. Satellite Internet is just one portion of communications that is undergoing great expansion, as shown in Figure 1.4. It involves a number of space markets in the short term like direct-to-home television, multimedia, mobile communications and Internet access services [Space News, 2000]. EchoStar Communications Corp. is rated the 5th biggest space company in the world by Space News [Space News, 2001], after being rated 8th last year during the same period. However, even if the

satellite communication sector is growing quickly, the ability to correctly assess the market is essential, since industry: failure to do so can result in bankruptcy, as seen in the Iridium case.

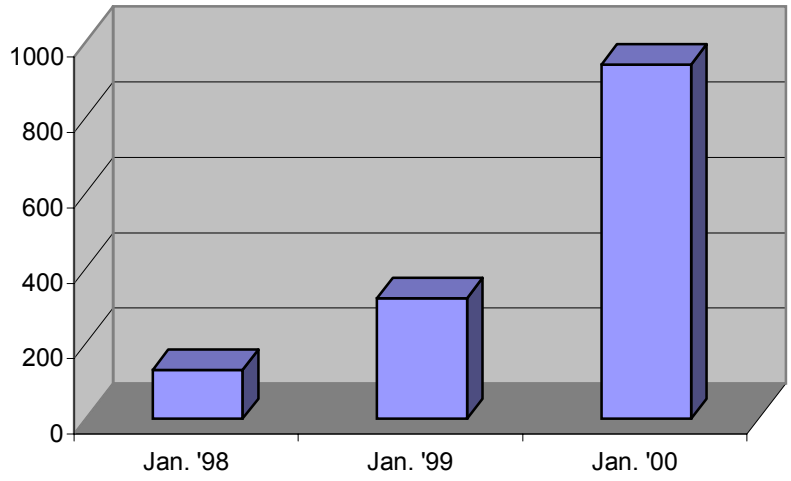


Figure 2.4: Satellite Internet Market Expansion (in USD millions)
[Bates, 2000]

The launch vehicle sector is also an important sector being almost completely privatized by now. Boeing Corporation, Lockheed Martin and EADS are among the most important private rocket manufacturing companies receiving contracts not only from governments but also from other space companies.

Navigation services are now becoming a very promising market with an increase of 25 % per year in the number of units sold worldwide [ITA, 1998]. The advent of Galileo (a European venture to instate a standard civilian navigation system similar to GPS) is expected to support this market increase in the near term.

In the **Research & Development** sector, NASA recorded a series of recent success stories in the fields of agribusiness, biotechnology and material R&D [SPD, 2001]. Similar success stories can be found in ESA's "Spin-Off Successes" [ESA-BR, 1999]. Earth Observation is an emerging commercial sector in the R&D business, with successful companies like Radarsat International for example. Although substantial amounts of public and private money have been spent on extensive research for materials sciences, life sciences and other applications for which microgravity product processing

would be beneficial, none of this work has been able to produce any breakthroughs for returns on investment.

We believe that **spacecraft servicing** also warrants our attention. During the last two decades we have witnessed numerous servicing related events in-orbit, including those associated with the retrieval and disposition of a number of different spacecraft by the STS, the successful servicing and return to mission of the Solar Max satellite and Hubble Space Telescope, and the Russians performing numerous EVAs in support of Mir. The ISS is in the process of being assembled through the use of more advanced robotics and a large number of EVAs. While the conduct of the foregoing is prohibitively expensive, and is currently funded by the respective governments, we believe that a commercial market will materialize where tasks such as assembly, repair, re-orbit, and refueling, can be performed more cost effectively.

Entertainment is a new promising sector that could have a huge public impact. Among the significant commercial attempts is Dreamtime [Dreamtime, 2001], which has the mandate to open the archived assets that NASA has collected over the years and to make them available to the public [Wilhide and Welch 2000]. Recently, Dreamtime signed a contract to upgrade all NASA Centers, the four Space Shuttles and the International Space Station with high definition television cameras and equipment (HDTV) [Root, 2000]. Dreamtime's HDTV equipment was recently shipped to the ISS on STS-105. Also, film producer James Cameron offered to film sequences of a movie on board the Mir space station. The main actor for this movie was in training at the Russian facilities in Star City until the de-orbiting of Mir. In September 2001, MirCorp announced its intent to build a commercial space station and its agreement with "Survivor" producer Mark Burnett for a new reality adventure series to be performed in space [MirCorp, 2001].

In the realm of **space tourism**, the fall of 2000 saw an enormous precedent established in Russia with the signing of an agreement between the Russian MirCorp and American Dennis Tito. The agreement aimed for Tito's passage to Mir as the first legitimate space tourist. The deal was worth a reported USD 20 M. After the space station Mir was de-orbited early in 2001, the deal was modified to allow Mr. Tito to fly to the ISS despite considerable resistance from NASA and the other ISS partner states. Mr. Tito's flight prompted a hearing on Space Tourism by the Committee on Science in June of 2001

[Committee on Science, 2001]. Tito's flight led to the proposal of the Space Tourism Promotion Act before the US congress [Act, 2001]. On July 23rd, 2001, South African information technologist billionaire Mark Shuttleworth announced that he has completed the initial stage of astronaut training in Star City outside of Moscow, and that he intends to become the second space tourist [BBC, 2001]. In light of the foregoing, NASA is re-evaluating its official position as it applies to tourism and the ISS.

However, Mr. Tito was not the first non-professional astronaut into space. In December 1985, Bill Nelson, a Florida Congressman, flew aboard STS-61C. [NASA, 1985] Then in 1986, Christa McAuliffe, a young teacher, was launched on board Challenger. Unfortunately, the destruction of Challenger brought back the stark reality of the extreme risk that is inherent with space travel and policies were adopted to prohibit civilians from traveling with Space Shuttle missions. However, in December, 1990, a Japanese news director, Toyohiro Akiyama was sent on an 8 day Mir mission [CNN, 1997]. In May 1991, a British chemist, Helen Sharman, also boarded Mir, both were flown on Soyuz capsules [Poix, 2001].

The Advertising sector is also seen as a major future sector of space activities and an important source of revenues. Since the 'Space Race' in the late 1950's and 1960's, a significant amount of prestige has been attached to some space faring activities. Consequently, there has been an active interest amongst large corporate providers of consumer goods to exploit space activities for marketing purposes. Appendix A, lists some companies that have pursued pure advertising ventures in the space sector.

Private enterprises are not the only businesses using space activities for promotional purposes. For many years space agencies have utilized promotional outlets to increase general public awareness. Most significant is the use of NASA facilities, footage and activities for the production of major Hollywood films. These include many recent blockbuster releases such as Apollo 13 (1995, Universal Pictures), Armageddon (1998, Touchstone Pictures and Disney) and Space Cowboys (2001, Warner Brothers). Furthermore, due to a trend in recent years of public apathy towards space activities space agencies such as NASA have begun to invest more significant portions of their budgets to public educational programs. ESA has begun to recognize the importance of promoting public interest in space activities and

has recently initiated educational programs for this purpose. [ESA-SP, 1999] In Canada similar programs are being promoted to increase public awareness of the activities of the CSA. In particular, the CAISU (Canadian Alumni of the ISU) has been given the exclusive right to promote the CSA through merchandising with the CSA logo. Although the intent of these promotions is not to develop a return on investment, they are important for continued public support of government spending on space programs.

It is evident that some areas of commercial activities have already been conducted with much success while others are yet emerging. The expectation is that they will proliferate in the near future, emerging at the forefront of the space industry.

2.4. Planning for the Future of Human Space Habitation

The future is impossible to predict, but easy to talk about. Somewhere in between lies planning for the future, which is merely difficult. This is, of course, the task we have chosen to undertake in this project. We are assisted in this task by the work of a great many theorists and scholars who have developed analytical tools for developing sound, rigorous plans for highly uncertain futures.

Beginning in the 1980s, and fueled by the notable success of Royal Dutch Shell, a tool for future planning known as scenario based planning came into use among a select few strategic planners [Schwartz, 1996], [Van der Heijden, 1999]. Over the ensuing 20 years a growing discipline developed around futures research in general and scenario planning in particular.

Scenario planning is particularly well suited to the problems presented by the CASH 2021 project. According to Shoemaker [Shoemaker, 1997] scenarios go beyond objective analyses, entailing subjective interpretations. Scenario planning attempts to capture the richness and range of possibilities, stimulating decision makers to consider changes they would otherwise ignore. At the same time, it organizes those possibilities into narratives that are easier to grasp and use than are great volumes of data or formal models. Above all, however, scenarios are aimed at challenging the prevailing mind set.

Organizations facing the following conditions would especially benefit from scenario planning [Shoemaker, 1997]:

- Uncertainty is high relative to managers' ability to predict or adjust.
- Too many costly surprises have occurred in the past.
- Insufficient new opportunities are perceived and generated.
- The quality of strategic thinking is low (i.e., too routinized or bureaucratic).
- The industry has experienced or is about to experience significant change.
- A common language and framework are desired, without stifling diversity.
- Strong differences of opinion exist, with multiple opinions having merit.

Arguably, the CASH 2021 project satisfies all of the above criteria. Unquestionably it meets four of the six.

Scenario planning enables strategists to plan for the future without the necessity of predicting the future. This seeming intellectual slight of hand is accomplished by developing well reasoned hypothetical futures, then formulating plans based on an assumption that this future will exist. From here, there is some divergence of paths regarding methodologies. There exist two options when planning future scenarios. Firstly, to consider multiple scenarios in parallel, and/or to secondly evaluate a preferred single scenario.

As a primary option, one must consider that since the future will almost certainly not evolve in the fashion described in any single scenario, many scenario planners suggest developing several equally possible futures, then developing and testing possible strategic plans against those future scenarios. The suggested number of future scenarios may be as high as five [Baldock, 1999], [Schwartz, 1996[, [Van der Heijden, 1999].

A second option suggest that the most productive means of developing future strategies is to focus on a single preferred scenario. Assumption-Based Planning, a tool developed by the RAND Corporation, focuses on a single preferred vision for the future, then examines and tests the explicit and implicit

assumptions underlying that future. More flexible strategies are then developed by creation of shaping and hedging strategies based on the potential failure of critical assumptions[Dewar, 1993]. Consequently, we have adopted the mentioned preferred single scenario methodology for CASH 2021.

2.4.1. CASH 2021 Methodology

Beginning early in the design project, we assembled a team of experts, each representing a particular area of commercial space interest, into a scenario working group. This team worked together to develop a picture of our collective preferred future. Some future visions projected by the group seemed wildly optimistic, others depressingly pessimistic. But in all cases the visions were innovative, and cognizant of the limited resources available for human space development.

As the broader membership of the design project conducted further research, and the scenario working groups developed a better understanding of common assumptions, our vision of the future converged on a particular vision. Some of these assumptions proved, in the judgment of the group, to be overly optimistic. These were adjusted, and the scenario was altered accordingly. For example, if we assumed that government civil space budgets would grow in real terms, it might be possible to launch a manned Mars mission. However, historical data indicates that government budgetary growth is unlikely, so the groups concluded that a manned Mars mission was unlikely. By the same token, some of the assumptions appeared to be too conservative and were adjusted accordingly.

In the end, we arrived at a vision: a scenario for the future. This vision is expressed in the following subsection. It is an optimistic vision, to be sure, but it is rigorously defensible. It is a future grounded in clear assumptions about the plausible occurrences. In analytic terms, therefore, it should be treated as a hypothesis. If certain conditions are met, and particular events occur, then it is possible that such a future will exist.

Following the development of a common future, the scenario working group examined the implicit and explicit assumptions underlying the scenario and

documented these assumptions. The group considered the consequences of assumption failure. Alternative futures were developed based on the failure of certain assumptions judged by the group to be key drivers. In this fashion we developed a sensitivity analyses. This analysis is presented in Chapter 7. In some cases, the failure of an assumption created powerful repercussions for our future vision. For these we analyzed hedging and shaping strategies as coping mechanisms. Our plan, therefore, includes the flexibility to cope with a vast array of alternative futures. In this fashion we accomplish much more diversity with a single scenario than possible with a wide variety of competing scenarios.

2.4.2. The Preferred Future Scenario: Commercial Access and Space Habitation for the World in 2021

By the year 2021 space is a regular component of economic, social and political life for the vast majority of the world. Though the risk remains high, investors make reasonable returns on investments in space ventures. Though the training remains rigorous, a segment of the global population actively considers the possibility of a once in a lifetime vacation in space. Though the technologies involved remain complex, private companies are undertaking the construction of in-space infrastructure. In space, laboratories and production facilities are an essential component of the research and production portfolio of a number of firms. In short, space has become normal.

Economics

Although the global economy has experienced cyclic activity, overall global growth averages 4-5% annually over the next 20 years. The initial period of declining growth in developed economies is more than offset by increased growth due to productivity gains in emerging markets. Well conceived and executed policies on government pensions, welfare, fiscal restraint, and military spending, enable elimination of government deficits in the developed world and significant reductions in debt financing requirements in the emerging economies [IMF, 2001].

In the developing world, improvements in communications and computational technology enable continued improvements in productivity. The resulting growth enables many of the presently developed economies to move into a

post-industrial society. Younger and middle aged workers, mistrustful of the viability of the government pensions, set aside greater shares of their incomes for investment in developed economies, and in Japan in particular. The combination of greater investment and lower government deficits leads to reduced interest rates which supports greater economic growth in the developed economies beginning in the 2012-2021 period. However, the available money for investment in space activities remains a constant share of GNP for the currently developed space-faring nations.

Emerging markets assume many of the higher skilled industrial activities from the developed markets. This leads to higher growth rates in these economies, and the creation of a large and prosperous middle and upper middle class. The improved fiscal conditions of the governments combined with a much higher technology base causes several emerging economies to embark on international cooperative space projects, in part for reasons of national prestige, and in part as an attempt at increasing industrial development. This greatly increases the amount of money available for global government investment in space. True to their historical industrial polices, most of the emerging markets offer heavy subsidies to companies investing in space.

Greater global access to investment markets allows a much broader share of the world's population to generate disposable income. Global access to investment markets creates a much larger group of wealthy investors. A large number of aging wealthy adventure tourists are created as a result of global economic improvements.

Although there is a growing realization of the finite nature of energy supplies, there has been no energy crisis over this time period. Fossil fuel production continues to dominate the energy industry.

Government expenditures on space

In the developed world, government expenditures on space remain relatively constant at ~USD 40 B/year in real terms. [Euroconsult, 1999] However, a proliferation of emerging economies entering the club of space-faring nations in the 2007-2016 time frame increases the total space spending to USD 50 B/year by 2011. Primarily seeking the prestige of international cooperation on manned programs, these nations devote 25% of these funds to international

cooperative manned programs. Economic recovery in Russia has led to stable funding for the Russian manned space program in the range of USD 500 M/year.

Assumed discretionary funding devoted to manned programs and launch vehicle development (assuming figures remain constant) is shown in Figure 1.5.

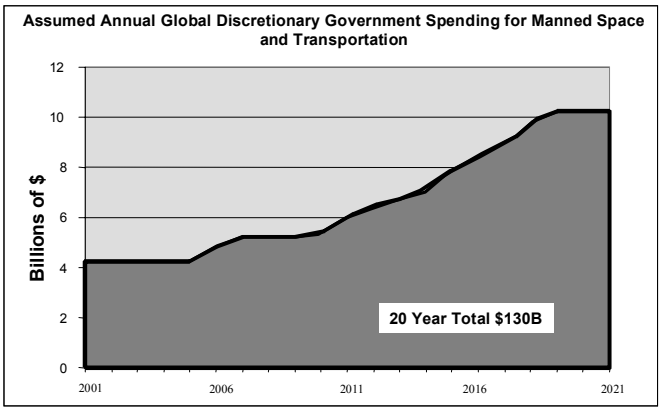


Figure 2.5: Discretionary Governmental Spending

This did not occur by accident, nor without the supporting development of broad segments of the global economic and social system. Broad-based economic growth, generational shifts, geopolitical evolution, and developments in key technologies were instrumental to the progression of humans into space. Nevertheless, what may seem most remarkable about this progression is that it did not occur due to any miraculous events or technological developments, but rather due to the steady progression of the human race across a wide range of fronts. It is an optimistic future to be sure, yet a reasonable one. Assumptions regarding private and commercial investment have not been included thus far, instead they are developed in the succeeding categories.

Social conditions

The movement of the millennial generation into the dominant force in the workplace leads to a search for greater stability and intellectual satisfaction. The aging of the population in the developed world creates a social and economic burden on the younger generation, but the retirement of the

workforce also leads to increasing opportunities for employment advancement.

Large aerospace companies provide an attractive job opportunity alleviating some of the labor problems of the early 2000s. Millenials also bring a more pragmatic view to management of national space programs. The emphasis is on building an infrastructure for larger scale human activities in space.

Extensive robotic activities, popularization of space through entertainment and advertising, and increasing space passenger travel lead to increased public interest in space. Most importantly, a greater number of stakeholders find profit in space. Space is strongly supported by a collection of powerful special interests, rather than weakly supported by general public interests.

Geopolitics

Europe begins acting as a unified state around 2010. This introduces a much more effective competitor to US dominance. The EU model of active governmental support of industry provides incentive for the US to adopt similar policies. The result is a broader consensus on the need for subsidization of ISS commercial operations by 2005. The world is essentially multi-polar. The US is no longer the unquestioned dominant power. Increasingly, its position is balanced by a unified Europe which acts in its own interests. Russia is stable and increasingly prosperous, but remains somewhat independent from the West. China remains outside the Western alliance system but insists on its place in international space cooperative programs following ISS. The Middle East has seen periods of great tension, but this has not erupted into a war involving more than the nations of the Middle East.

Technology Development

Computational technologies continue to follow Moore's law. Continued increases in computational speed allow greater increases in design and production capabilities across a broad front. In particular, computational advances and associated advances in artificial intelligence create the necessary technology for the development of autonomous robotic systems capable of performing many space assembly and repair activities. Other specialized activities remain beyond the capabilities of even the best robots by 2021.

Significant progress has been made along a variety of fronts in the development of fusion energy. Research reactors are coming on line, but the commercial utilization of fusion remains some time off in the future.

Space systems by 2021

Often by design, and occasionally by fortuitous convergence of interest, by 2021 a vast human infrastructure has been created in space. Unlike the history of space which preceded the 21st century, featuring dramatic leaps in

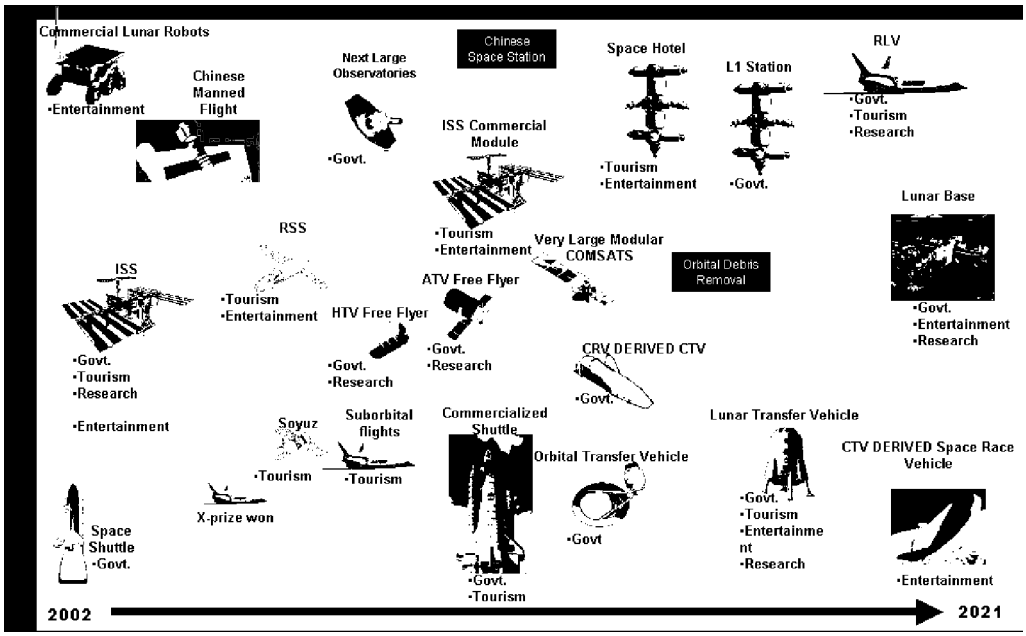


Figure 2.6: Overall Scenario

technologies and heroic adventures launched by entire countries, the history of space in the first decades of the 21st century is relatively unmarked by the spectacular. What is perhaps most remarkable, is rather the lack of the spectacular. Humankind has simply extended its presence in space in a very permanent way. It is the presence itself which is spectacular to observe.

By 2021, the Moon is populated by several revenue generating businesses sharing much of the same infrastructure located at the South Pole. The entertainment industry uses a lunar facility to generate a variety of content. Production operations mine the polar craters for lunar water which is converted to fuel and sent to an L1 Gateway station which serves as the operations center for a variety of space services.

Satellites and other space systems are routinely assembled, serviced, and reconfigured in space. The boom in demand for satellite communications from the developing world has led to the construction of very large modular COMSATs requiring human and robotic maintenance and assembly. High value space assets are no longer considered disposable. System architects now consider the possibility that their systems may be designed for servicing and reconfiguration.

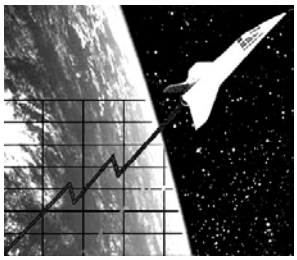
Low Earth Orbit (LEO) is populated by a growing variety of systems performing useful tasks for people on Earth. Fusion of remote sensing, global positioning and communications systems allow people to pay a virtual visit to have a virtual presence on any place on the globe.

Space tourism has developed as a reasonable recreational alternative, for those who are merely rich. A simple orbital mission is available at costs comparable to those spent on more terrestrial vacations for the wealthy (around USD 100 K per seat). Tourists desiring a longer stay in space may recreate at an inflatable space hotel providing a variety of in space activities for the wealthy. Travel to space is far more civilized than with the American Space Shuttles and Russian Soyuzes of the past.

Tourists, and cargo now travel to space on a horizontal take off horizontal landing two stage vehicle using the atmosphere for much of its oxidizer. In space, orbital transfer vehicles (OTV) ferry cargo and passengers between orbits and to the Moon.
Those on the ground have not been left out. Periodic space races provide the spectacle of piloted vehicles streaking across the sky, executing aerodynamic plane changes over major metropolitan areas. Paying spectators are afforded a more personal experience with these new space racers. Television programs, special events and movies are regularly produced in space for the viewing public.

The ISS remains in-orbit, serving as a research base for combustion, materials science, biological and pharmaceutical experiments. However, most of the more sensitive research has moved off the station to a series of free flying platforms orbiting in the immediate vicinity of the station.

Space remains primarily peaceful, but the military leaders of the world are increasingly attracted to the advantages afforded by space systems. As of 2021 the technologies required for a space-based defense missile system remain elusive, and political opposition form Russia, China, and most of Europe led the US to postpone any consideration of space-based missile defense systems to further in the future. Although suspicions grow regarding the possible existence of US, and Chinese anti-satellite systems in space, there is no public acknowledgement of the weaponization of space. Nevertheless, space is highly militarized. The US, Europe, Russia and China are all orbiting a wide variety of military reconnaissance and communications systems. In almost all nations, military space spending has increased considerably. In the US military space spending now exceeds the NASA budget by 50%. European military space spending has increased by several factors.



3. Laying the Groundwork

2002-2011

3.1. Introduction

From the input of past space exploration and based upon our scenario, it is time to embark on the commercialization of space. Past scientists, astronauts, companies and space agencies, have done some of the preliminary groundwork. This chapter lays the groundwork for the near term period (2002-2011) addressing commercialization of space-based on current information. This project first analyzes the markets for the different commercial opportunities that were identified in our scenario. From this market analysis a roadmap was established to identify important short-term milestones. To attain these milestones, a section is devoted to systems and technologies involved in this project's process. Also, important issues relating to society and health that will have an impact on implementing this project will be covered. Finally, financial considerations seek to present the feasibility of the identified commercial opportunities within the period 2002 to 2011. A summary and a brief outlook for the future will be presented at the end of the chapter.

3.2. Market Analysis

An analysis of the near term primary market for each of the identified commercial sectors is discussed below. The focus for each of these analyses are on the potential for growth and the short-term profit-making viability of each sector.

Tourism

In order to develop viable business plans, it is important that potential markets are identified. In this section, we discuss all the possible market areas that can be exploited. By identifying these opportunities, business plans can be developed for the commercialization of space. As has been stated in chapter 2 of this report, the exciting new area of space tourism has become a reality in the past year. What must be determined is whether tourism can be sustained if current costs are retained. It is clear that there is an interest from the general public in space flights. Collins, Stockmans and Maita [Collins, 1995] found that 62% of the population of the US and Canada was interested in space tourism. Similar studies presented in [Collins, 1994] state figures that are equally as astounding: 80% of Japanese under the age of 60 would like to go to space. Pragmatically, if only 50% of people in the developed world are interested in space tourism, this would lead to a customer base of over half a billion people [PRB, 2001].

Although it is clear that space travel adventure is an industry with the capability of drawing a massive market, two primary limiting factors remain: launch costs and risk. Currently ticket prices are out of the affordable range of many of those interested in space travel. Figure 3.1 shows the cost/market relationship for space tourism compiled between the price of a ticket and the number of passengers.

Space is a risky business and the failure rates for launchers are high compared to other transportation vehicles. For instance, it has been estimated that the chance of NASA's Space Shuttle suffering from a catastrophic failure is roughly 1 in 450 [Space, 2001] compared to death risks of 1 in 2 million for domestic air flights in the decade 1967-1976 [FAA, 2001]. While thrill seekers may be willing to accept this high level of risk, the investors required to jumpstart such a private industry are unable to mitigate against the risks. Investors are likely to wait and evaluate the success of early space tourism efforts in Russia before contributing significant funds to the development of the industry.

In the short term, orbital tourism will continue to be based on current technology and will be available only to a select group of very wealthy individuals or companies able to afford the high costs involved.

Space enthusiasts are interested in-more than just orbital flights. Even though costs of these flights are high, a market exists for sub-orbital tourism. Space Adventures [Spad, 2001], arranges flights aboard Migs or Sukhois for approximately 20 000 USD for high altitude adventure tourism and parabolic flight opportunities for microgravity thrill seekers. It is also feasible that, in the short term, the X-Prize [X-Prize, 2001] venture will lead to true sub-orbital space flights. Sub-orbital flights will foster a market for space enthusiasts by accommodating affluent adventure seekers in the middle to upper class.

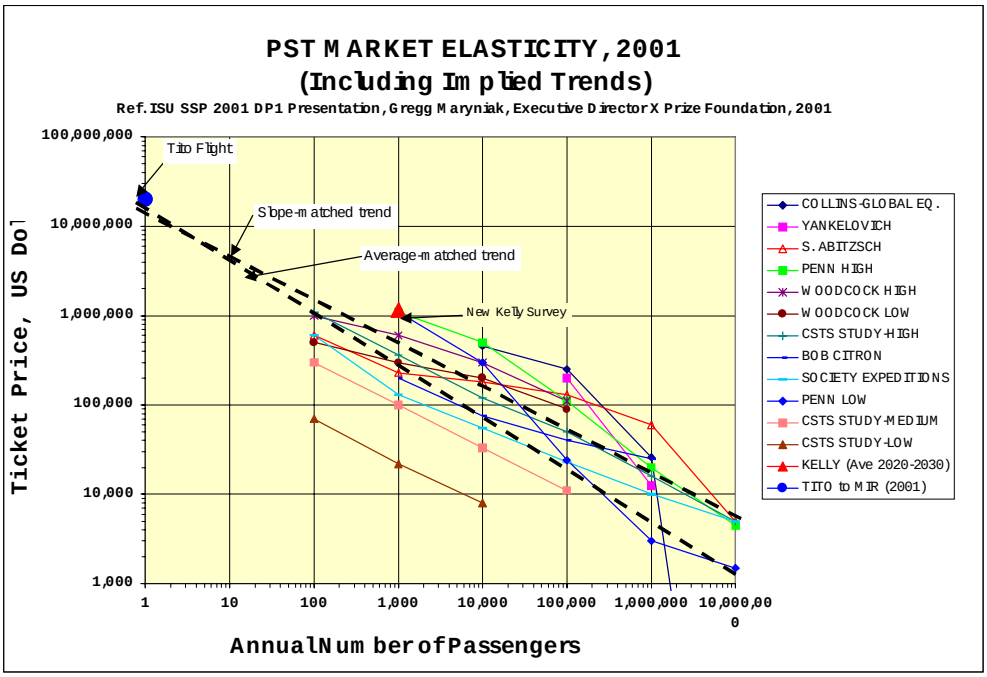


Figure 3.1 Cost/Market Relationship Survey Results for Space Tourism [O'Neil, 1998]

A NASA/STA study showed that significantly more people, almost 10%, would be interested in space flight if accommodation and entertainment were provided [Crouch, 2001]. Entertainment, for those people taking part in space flights, and for those interested but who are unable to pay, will play an important role in ensuring that the market is ready for the time when launch costs are lowered. Moreover, the entertainment industry should be able to extract substantial revenues from the space sector due to relatively low initial start up costs, exclusive of launch costs.

Entertainment

The entertainment sector has been seen to exhibit rapid growth in recent history. For example, in the adventure sector, Bungee-jumping, which was non-existent 25 years ago is now accounting for around USD 100 M annual turnover in the US alone [Peeters, 2000]. It is reasonable to assume that in the coming decades similar motivation will be applicable to the early space enthusiast who is looking for an extraordinary experience. Imax has already capitalized on the unique appeal of space by producing several space films over a ten year period, including the well known Mission to Mir. A proposal was also made for a space survivor television series, to track contestants as they endure rigorous cosmonaut training in preparation for a trip to the Mir station. The plan was for a Russian training specialist to eliminate contestants who were not performing well, and for the last contestant left to win a launch to Mir [Wadhams, 2000]. This proposal was made prior to de-orbiting of the Mir Space Station and did not come to fruition. However, based on analogous Earth based events, such a proposal could be quite profitable.

Using the Earth-based Survivor program screened in the United Kingdom as a benchmark for a similar proposal for a Space Survivor program, it can be recognized that such a concept would be profitable. The Earth-based Survivor program had around 5-10 M viewers towards the end of the series, at a cost of around USD 15 M [Deans, 2001]. If every person who watched the show bought only a few dollars worth of products that were advertised during the commercial breaks, then the production was profitable. During the final episode of the British Big Brother series, Channel 4 charged USD 150,000 for a 30-second advertising slot [Arlidge, 2001]. Assuming the space 'Survivor'-style programs were broadcast in tendifferent countries and each country had approximately 10 M viewers then an estimated 100 Million viewers can be targeted for advertising. If only a few dollars per viewer was spent on advertised products within the viewing time of the Space survivor program, then the event would be definitely profitable.

Advertising

It is clear that advertising will play a major role in generating revenue from the promotion of space activities. The use of space in advertising is not a new concept. For several years, various companies such as Toyota and Coca Cola have used the novelty and the excitement of space as a way to sell their

products and services. What is fairly recent is space advertising, which can be defined as the advertising done using space assets. Russia, adding another first to their impressive space history records, has already started. So far, four major private organizations have paid for their product to be promoted by cosmonauts on the Mir space station: Radio Shack, Popular Mechanics, The LEGO Company and Pizza Hut [Space, 2001]. Pizza Hut also closed a USD 1.25 M deal with the Russian Space Agency to have its logo printed on the side of the Proton Rocket which launched the ISS Zvezda service module in July 2000 [AP, 1999]. But these advertising spurs are far from being routine. The purpose of this section is to identify and discuss the main types of advertising that are foreseen for the near future.

As the construction of the ISS reaches its completion and other human rated space facilities become available, there will be opportunities to film commercials in space. Initially, the Russian modules or the Enterprise Module from the private company Spacehab Inc. will most likely be used for this purpose initially. The other modules, being government funded will most likely be politically constrained. The total television expenditure on advertising in 1997 was over USD 38 B in the US only [McCabe, 1998].

On average in the US, the cost of a 30-second commercial is over USD 300 000 [Beatty, 1998]. Moreover, it has been shown that television advertising is one of the best media for product/service demonstration, entertainment, excitement, leadership and impact [Forbes, 1998].

Similar to television commercials, ads in magazines and newspapers could be used as a source of revenue for the space industry. Already, most companies involved in space related activities advertise in various technical and informational publications such as Popular Science, Space News, Astronomy Magazine and Space Daily. Newspaper and magazine expenditures in the US were estimated at over USD 31 B in 1997 [Shimp, 2000].

Sponsorship could lead to increased revenues for the space sector. For example, in the near future, it is proposed for private investors and companies to invest in a space station payload and a lunar orbiting satellite [Lunacorp 2001]. In North America, event sponsoring in 1998 totaled over USD 6 B [Promo, 1998].

Selling the right to use corporate names and logos could be another way of commercializing space. For example, clothing designers could have their name on clothing worn by astronauts, cosmonauts and space tourists to raise public awareness. Space agencies could sell their logo at media events, as NASA is planning to do [Space Daily, 1998]. Another example would be the selling of hotel naming rights: the athletic stadium naming rights in the USA is between USD 2-5 M [ecommercetimes, 2001].

The concept of interactive media is based on the interaction between the advertising itself and the consumer, where the latter is considered 'active'. Such media include the Internet, CD-ROM and virtual reality. With this type of advertising, the customer decides how much information he/she desires to acquire about a certain product or service. Accordingly, a commercial message ranging from one second to 20 minutes is provided.

Around the world, over 400 M [NUA, 2000] people have access to the Internet. The Internet currently is used to educate and inform the general public and specific businesses. Internet advertising revenue was USD 2 B in 1998, and USD 4 B in 2000 [NUA, 2000]. As more households gain access to the Internet every year, this number is bound to continue increasing. Increased use of the Internet offers the possibility of tapping into other markets that are entertainment based. The Internet allows for a greater amount of public interaction through teleoperation. Examples of these are automated robotic telescopes such as the "RAAP" telescope based at UC Santa Barbara, USA and the robotic telescope based in Bradford, UK. There is a demand for the services offered by these facilities, with the Bradford telescope peaking at roughly 160 simultaneous users.

Spurred on by the success of the Martian Sojourner explorer, a number of companies are also looking at the possibility of making money by placing rovers on the Moon. The Pathfinder web site for Sojourner had a one-day total of 30 M hits [Bloomberg, 1997]. Lunar Corp is hoping to take advantage and commercialize this interest by placing rovers on the Moon that can be then controlled via users on the web. Through proper promotions it is hoped that further revenue can be generated. Lunar Corp also plans to generate revenue by collecting and selling lunar scientific data [Lunacorp, 2001]. This idea of making money from space research is not a new one. Currently all the

international partners are looking at ways of commercializing the experimental facilities available on the ISS.

Research, Development and Production

From the start of the space age, governments have used research and development to justify public space activities. Since then, many advantages of research and development in the materials science, biotechnology, agriculture, applied physics, and space production industries have been identified. Until now there has not been a significant amount of commercial or private R&D expenditures in the space sector. Rather, most of the preliminary work that has been done has been conducted by non-profit public organizations in space faring nations. However, based on the results of years of microgravity research and with the advent of an orbiting facility with the capabilities of the ISS, governments are promoting private and commercial sector investment in space R&D.

Research Application (Sector)	Proposal	Potential
Osteoporosis (Medical Science)	Countermeasures	10% Countermeasure = 1B Euros
Combustion (Applied Physics)	Efficiency of Burners	2% Efficiency = USD 8B Savings in US
Proteins (Biotechnology - Pharmaceutical)	Production of Alpha Interferon	USD 750M per Year
Technology Demonstration (Production)	Test-bed for Commercial Satellite Construction	USD 30M - 120M per Year
Overflow sensor (Materials Science)	Air conditioners, Condensation Spilling	USD 100M per Year in Damage Savings
Telemedicine (Medical Science)	Diagnostic Kit	50% Fewer Emergency Landings = USD 500M Savings Worldwide

Table 3.1: Potential Research and Development Applications [Peeters 2000]

Marketing research on ISS commercialization has identified opportunities for commercial development in a few major sectors. For example, microgravity research is predicted to be capable of producing 10% improvement in osteoporosis countermeasures, implicating estimated medical industry savings in Europe of more than 900 M USD [Peeters, 2000]. Table 3.1 shows