Abstract

This IQP will investigate commercial aspects of space. The definition of space commercialization is dynamic and somewhat imprecise due to several years of conflicting national policy debate. One of the major goals of this project is to develop a contemporary and static definition.

In order to develop a more comprehensive definition, the categories of space commercialization are identified. Since new technologies have progressed over time, many new opportunities have arisen which, when placed into categories, may be more easily subject to evaluative analysis. By examining these opportunities within this framework, it may be possible to determine which can be economically successful, which are implausible, and which can be grouped within discrete sectors. With this information, a concrete group of categories can be established to enhance the precision of the definition.

The next objective is to develop general standards to determine the market potential for future products drawn from this group of categories in space commercialization. These standards are then compared to the standards of earthbound business investment to determine if the general decision making rules and issues of commercialization apply to space commercialization.

With this knowledge, an analytical model can be assembled to measure the commercial market potential of a space product. This model is then tested against a potential space investment, the AVStar satellite system, a new AstroVision International project.

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Chapter 1: Introduction

This is a study to better define space commercialization and apply this new definition to create an analytical model to measure the potential success of current and future space products. Commerce is defined as, "The exchange or buying and selling of goods, commodities, property, or services esp. on a large scale and involving transportation from place to place" ("Commerce", 2005).

Since the beginning of space exploration, commercialization has been an ongoing topic of debate. Even though this concept has been debated for some time, technology and other factors such as cost, risk, demand, profitability, investor base, need, complexity, and other elements have limited progress and made the definition of space commercialization imprecise. The usage of categories breaks the broad definition of space commercialization into more manageable units that can be individually examined.

Nathan Goldman refers to space commerce as, "The market for space goods and services including space transportation, communications, and remote sensing satellites; manufacturing in space; and eventually the transmission of solar energy back to Earth by satellite and the mining of celestial bodies" (Goldman, 1985). The spin-offs created from the ideas of space commercialization will not be examined or applied to the definition because these types of products do not have any actual application to space. Since new technologies have progressed after Nathan Goldman defined space commercialization, new categories have arisen. One such category is the biomedical industry which will be added to the comprehensive analysis and definition.

To acquire a better understanding of space commercialization, Goldman's space categories and the biomedical category are described in terms of its history and its current status.

Transportation

One of the primary categories of space commerce is the idea of space transportation. In order for other aspects of space commerce such as mining of celestial bodies and manufacturing in space to succeed, it is essential that the ability to traverse through space is first made possible. Space transportation is the movement of humans or goods through space by means of a space vehicle. Satellites do not seem to fit into the idea of space transportation as they are simply objects in orbit as opposed to objects being transported.

Though many spacecrafts have been developed with the ability to carry living organisms and various goods, none have established a profit. The first spacecraft to transport a living organism or goods was Sputnik 2, which was the second spacecraft to be launched into Earth orbit. It was launched by the Soviet Union in 1957 with a female dog named Laika on board and it could be considered the first step in the concept of space transportation ("Sputnik 2"). In 1969, man was sent to the Moon through the revolutionary Apollo 11 mission operated by NASA. This was the first manned space mission where the destination was outside Earth orbit. Since this inspirational mission to the Moon, the main focus of NASA has been on the space shuttle. There have also been missions to Mars to deploy rovers that explored the surface in search for indications of life. In July of 2004, the first privately created space craft entered Earth orbit manned by

Mike Melvill, a cofounder of Microsoft (Coren, 2004). The concept of space tourism is derived from the idea of space transportation.

"Space Tourism is the term that's come to be used to mean ordinary members of the public buying tickets to travel to space and back" ("Introduction - What is Space Tourism"). Currently, only those like Mike Melvill with an outstanding income can afford to tour space. In the future, it is anticipated that citizens with average income will be able to travel in space through private businesses.

It is likely that there will be a short term period where citizens with average income are given the opportunity to travel through space for the sheer excitement of it. But in the long term view, people will be traveling through space to reach a destination instead of traveling as a form of entertainment. There will likely be businesses in the future to transport people through space in a similar fashion to how airlines transport passengers around Earth today.

Communications

The communications aspect of the space commercialization involves the exchange of information through the use of communications satellites. The data relayed may be voice, video, or other information. As in other commercialization areas of space, there is a demand for government use and for public use (Whalen).

The usage of satellites for communication is in direct competition with more current methods of transmitting data on Earth. These methods include wires, fiber optics, and wireless communication systems that do not involve space (Dinerman, 2004). The land based methods are firmly established and many have been proven to provide high speed, reliability, and relatively low cost methods for moving information.

Communication satellites can also be used for internet connections. Shin Satellite, a private company based in Thailand that launches and operates satellites, launched the largest geosynchronous satellite with the help of the ESA. This satellite, known as iPSTAR, is able to provide internet access approximately from Japan to Australia (Clark, 2005). COMSAT, although created by an act of Congress, is still a major player in the launching of satellites, specifically communication. COMSAT in the past has worked with other companies that are either privately or publicly owned to develop and launch satellites (Whalen).

Remote Sensing Satellites

The remote sensing of Earth by satellite is defined as taking specialized images of the Earth's surface as well as other moons and planets. The remote sensing does not necessarily only serve as an application to Earth. The information gained from remote sensing may be spectral, spatial, or temporal. Remote sensing can be accomplished by either passive or active means. In passive remote sensing, the satellite only collects information that is naturally coming from Earth. In active remote sensing, radar may be used to collect the information ("Remote Sensing").

Remote sensing on Earth is dominated by the United States Government through NASA. The remote sensing accomplished by NASA is performed through their Jet Propulsion Lab and Landsat program ("Earth and Planetary Remote Sensing", 2005). There are few remote sensing companies that have not been established and funded by the United States Government. There are, however, organizations that use the data collected by various government operated satellites ("About the CRESS Project", 2002). One such organization, Digital Globe, claims to be creating a collection of high resolution satellites to take black and white pictures and color pictures of Earth. Their images are of the highest resolution commercially available today (“About Us”). Another remote sensing organization, MDA, provides many services concerning remote sensing of Earth to other companies and countries around the world. Although MDA does not possess their own satellites, they have, “Exclusive distribution rights to Canada’s RADARSAT-1 and RADARSAT-2 synthetic aperture radar (SAR) satellites” (“Geospatial Services”).

Space Manufacturing

Space manufacturing is the production of goods outside the Earth’s atmosphere. There are several advantages to space manufacturing over manufacturing on Earth. Because of the flexibility of orbital space, there are many industrial processes to run that cannot be managed on Earth. Raw materials in space can be collected to make products as opposed to launching materials from Earth into space. New processes can be performed through the use of space properties such as the vacuum in space, zero gravity, and electrical power from the sun. In addition, space manufacturing provides a safe means of manufacturing since it can be performed out of range of Earth and other planets (Prado, 2002).

There are also negative aspects to space manufacturing. The biggest negative feature is cost. The usage of governmental launch services costs about $20,000 per pound for each material sent into space. In most cases, the cost to launch materials is more expensive than the value of the products manufactured. There is also an issue of launching materials into space consistently enough to continuously perform space manufacturing (Phillips).

There are currently five forms of manufacturing on Earth. Making manufacturing a space operation could double the number of manufacturing processes through zero gravity and different centrifugal gravities, the vacuum of space, and solar ovens. On the other hand, some common Earth manufacturing processes will not be possible to manage in space because of these characteristics (Prado, 2002).

There has not been significant progress made in space manufacturing. In the 1980s, an industry team developed an electrophoresis process (Kingdon). Electrophoresis is a method that separates molecules under the influence of an electric field ("Electrophoresis", 2005). The process of electrophoresis was originally planned to be a manufacturing process performed in space. Because of a lack of space manufacturing development, however, researchers on Earth developed this process without the necessity of space properties (Kingdon).

Transmission of Solar Energy

Scientists have been discussing the use of solar satellites to consume energy and transmit it back to Earth for use in industry, transportation, and personal homes. The biggest advantage of transmitting solar energy is that it provides virtually an infinite supply of power. This would be a solution to the current energy problem on Earth with oil resources dwindling over time (Price, 2001).

Solar energy is currently used in limited amounts on Earth because most positions on Earth are exposed to the sun's rays for only half of a day. Often the weather prevents the sun's rays from reaching solar panels. But if a method to transfer the energy from solar panels on a satellite to Earth were to be developed, there would be a continuous absorption of solar energy ("Solar-Power Satellites", 1999).

The first person to develop this theory was Peter Glaser in the 1960s. The idea of transmitting power through microwaves was a fairly new idea that had not yet been put into practice. Glaser's idea was to station a satellite over a single location on Earth. However, this would mean that the satellite would have to be about 36,000 kilometers above Earth. The antennas would also have to be large to have a successful transmission ("Solar-Power Satellites", 1999).

Recently, the communications industry has increased discussion on this concept. Communication satellites use the same microwave technology as Glaser's theory to transmit audio, video, and other data throughout the world. These satellites are mostly located in low orbits. The idea is to use the same beam for the solar energy as is used by communication satellites. Because communication satellites have a lower orbit, the antennas can be smaller and inexpensive compared to those proposed by Glaser (Hoffert, 1997).

The only setback to this plan is the difficulties of low Earth orbit. Because the satellites are so low, they move quickly around the planet. In order for the plan to work effectively, complex computer-control systems must be installed so that the microwave beam will consistently target the receiving station (Hoffert, 1997).

Mining of Celestial Bodies

Another category of space commerce is the idea of mining celestial bodies. Space mining is the gathering of resources from a celestial body in space beyond Earth orbit. The ultimate goal of mining a celestial body would be to gather minerals or products that could be sold for a profit or be used in trade.

The history of mining celestial bodies is limited. Approximately 842 pounds of samples have returned to the Earth by American missions to the Moon and 3/4 of a pound has been returned through Russian missions. All of these lunar samples were collected during the American Apollo missions and the Russian Luna missions (“Lunar Mineralogy”). These samples were primarily examined in order to determine their age to gather a better understanding for the origin of life and the planets. One product found on the Moon in 1969 during the Apollo missions was helium-3, a high quality fuel source scarcely found on Earth that causes no pollution. Not until 1986 was it realized that the resource discovered was helium-3. It is estimated that the Moon contains 1 million tons of helium-3 and that, "One space shuttle load...could supply the entire United States' energy needs for a year" (Wakefield, 2000).

In January of 2004, Mars rovers Spirit and Opportunity landed on the surface of Mars as a result of a complex mission developed by NASA. Like the journeys to the Moon, the goals of the mission were not to delve into the soil to find potential valuable materials. Rather, the goal was to attempt to discover water, an indication of previous life on Mars. "Months of scientific sleuthing by Spirit is dedicated to study Martian rock and soil to ascertain whether the past environment in Gusev Crater was ever watery, enough so to have been an abode for life" (David, “Six Wheels on Mars! Spirit Free to Roam”, 2004). It is understandable that such an early Mars mission would not involve researching the soil of Mars for valuable resources. To make any advanced determination on the soil, it would need to be returned to Earth to be studied by scientists. Currently, a return mission from Mars would be too technologically advanced and too expensive, but the future appears promising for the study of Martian soil.

History indicates that the mining of resources on celestial bodies has great potential as a future commercial business. As mentioned in the definition, the mining of celestial bodies includes the mining of not only the Moon and planets, but also asteroids. "Even a relatively small asteroid with a diameter of one kilometer can contain billions of metric tons of raw materials...A comparatively small M-type asteroid with a mean diameter of 1 km could contain more than 3 billion metric tons of iron-nickel ore, or 3,000 times the annual production for 1989" (“Asteroid Mining”). All three methods of mining the Moon, the planets, and asteroids are possible. As of right now, it is likely that the first celestial body to establish a solid mining industry would be the Moon. With oil becoming scarcer on Earth, the Moon seems to be the logical choice as the first celestial body to heavily mine. This is because the Moon contains the valuable fuel supply, helium-3. Asteroids would be the next most logical choice, but the major difference between extracting substances from an asteroid as opposed to the Moon is the fact that the Moon is a more stable platform and is in orbit of Earth. This would provide for a substantially longer mining station as opposed to a temporary mining station on an asteroid.

The principle actors in a future celestial body mining industry would likely be similar to contemporary miners on Earth. Because of this, it is likely that a mining station on the Moon, assuming it is the first celestial body to be heavily mined, would not be established for several years. This is because space would first have to develop a system for more workers to travel into space and a steady space transportation system for the helium-3 and other resources to return to Earth.

Biomedical Industry

An alternative category to those specified by Goldman is the biomedical industry. Biomedical space businesses would take advantage of the weightless environment of space. With a weightless atmosphere, nearly identical complex substances can be separated. Expensive and rare medicines could be made purer and cheaper because of the increased efficiency through biomedical engineering in space (Goodrich, 1989).

Biomedical engineers on Earth currently use electrophoresis to separate substances. In electrophoresis, molecules are separated by electrical charges. This process does not work reliably in the Earth's atmosphere since fragments of dense material have a tendency to collapse. McDonnell Douglas performed one experiment in space similar to this process. The experiment produced over seven hundred times more separated product than what it would have had it been done on Earth. The product was also generated with four to five times as much of an improvement in the purity of the product (Goodrich, 1989).

ESA has studied the role of zero gravity in bone and tissue loss of astronauts. This may potentially lead to the development of "countermeasures" against diseases such as osteoporosis. The resources available on space stations would provide scientists with a unique research opportunity to test these and other theories (Massow, 2005).

Category Analysis

These six space categories presented by Goldman present a solid representation of the space market. The developed definition of space commercialization was formed by taking these six categories and narrowing them down due to some similarities between them. Because communications and remote sensing techniques both require the use of satellites, these space categories were grouped into one category entitled “Satellites.” The five categories of space commercialization in the developed definition are therefore biomedical, mining, manufacturing, satellites, and transportation.

Chapter 2: Literature Review

This chapter provides background information to gain a better understanding of the space market and concepts referred to throughout this IQP. It will include a brief description of general commercialization, space commercialization, impediments related to space commercialization, business policy, forms of analysis, and the progress space commercialization has made in the last few decades.

General Commercialization

In order to properly look at the commercialization of space, general commercialization needs to be defined. Commercialization is defined as doing something for financial gain ("Commercialization", 2005). The definition of commercialization process varies in specifics from source to source. The definition of the process varies slightly due to combining and renaming steps and also because the definition is slightly more specific to commercializing new technologies or inventions. In all of the steps in the different definitions of commercialization, there are goals that need to be accomplished.

According to Vijay K. Jolly, the steps of commercialization include imagining, incubating, demonstrating, promoting, and sustaining. The imagining phase is where the concept or technology defined and the potential for success in the market is looked at. If the potential success appears bleak, the concept or technology may be abandoned at this point. In the incubating phase, the technology or concept needs to be proved that it can perform as said and can accomplish what is claimed. This step hopefully proves the potential of the technology or concept in the market place (Jolly, 1997). The demonstration of the concept or technology forms the demonstration phase. The demonstration is done by showing the concept or technology in marketable products or processes. Once the market potential of the concept or technology has been successfully demonstrated, the promotion of the concept or technology to the entire market can begin. This forms the promotion phase. If the concept or technology is truly successful all around, it will enter the sustaining phase. This is basically were the concept or technology has been fully commercialized (Jolly, 1997). Jolly compares his steps to others in Table 2.1.

The Segmented, Value Build-up View of Commercialization	Schumpeterian and Traditional 3-way Classifications	Bright (1970) Stages	Cooper (1986) Seven-Stage New Product Game Plan	National Society of Professional Engineers (1990) Engineering Stages	Dupont (1995)
1. Imagining		1. Scientific suggestions, discovery, recognition of need or opportunity 2. Proposal of theory or design concept	1. Idea generation	1. Concept	1. Idea
2. Incubating	1. Concept Development	3. Laboratory concept	2. Preliminary assessment 3. Concept Generation	2. Technical feasibility 3. Development	2. Scouting
3. Demonstrating	2. Product Development	4. Laboratory demonstration of application 5. Full-scale or field trial	4. Development 5. Testing 6. Trial production	4. Commercial validation and production preparation 5. Full-scale production	3. Project 4. Prototype
4. Promoting	3. Market Development	6. Commercial Introduction or first operational use	7. Full production and market launch		5. Introduction and commercial
5. Sustaining		7.Widespread adoption as indicated by substantial profits, common usage, significant impact 8. Proliferation		6. Product support	6. Product Support

Table 2.1 (Jolly, 1997)

Jolly takes the stages developed from other people and organizations and arranges them so that their stages line up with his. As seen in Table 2.1, all methods of commercialization are similar to each other. This is most likely because the steps in each method are defined in slightly different ways and cover slightly different tasks to be accomplished. The end result in all of these methods is the same, which is a commercialized product or technology.

The steps in a commercialization process defined by Rensselaer Polytechnic Institute are discovery, disclosure, evaluation, intellectual property protection, and marketing and licensing. The discovery step is equivalent to Jolly's imagining step, the step where the idea is created. The disclosure step is when the owner creates an invention disclosure form to formally record the idea. In the evaluation step, the commercial potential of the idea is defined. Intellectual property protection is needed to protect the owners from others that may use their idea. A sizable profit can be made from just licensing the idea to others for use. The intellectual property protection is very important in a competitive market. This provides legal documentation that can be used if another organization uses the idea or a similar idea. The last step in Rensselaer's commercialization process is marketing and licensing. This is where the idea is marketed or licensed to others for use ("Commercialization Process", 2005).

Joshua S. Gans and Scott Stern state that the commercialization environment is important for startup companies. Depending on the commercialization environment, the entrepreneur will choose either a cooperative or competitive strategy as an appropriate commercialization method. Cooperative commercialization is performed when intellectual property is highly important. If intellectual property is not of high importance, a competitive commercialization strategy should be performed. Gans and Stern believe that the commercialization process is more important and more difficult to accomplish than the invention or idea (Gans and Stern, 2002). Gans and Stern also put emphasis on, "The nature of the appropriability environment and the distribution of ownership and control over specialized complementary assets" (Gans and Stern, 2002). The ability for an entrepreneur to have ownership or access to complementary assets can be a deciding factor as to whether or not the idea or product can be successfully commercialized. If these complementary assets are not common, the technology that the product is based on may be hindered. The startup company may want to keep product publicity to a minimum in order to avoid detection from larger competitors in the market. Depending on what the technology is, it could potentially fill a neglected spot in the market. This helps to avoid detection from other potential competitors and increases potential success for the company (Gans and Stern, 2002).

The commercialization process was outlined by Jolly to be imagining, incubating, demonstrating, promoting, and sustaining. The commercialization process as defined by others is similar to Jolly's process. There are many issues that need to be considered in this process such as intellectual property, commercialization environment, and licensing to define how the commercialization process is accomplished in finer detail.

Space Commercialization

Space commercialization is a dynamic concept that does not have a solid definition. Several analysts have developed definitions of space commercialization, many of which break the definition down into different categories. Austin Stanton established a definition of space commercialization in 1966, before man had landed on the Moon. Instead of focusing on services, Stanton focused on the properties of space that could be utilized for products. Stanton focused on the positive environment for space and how it allows for easy maintenance and better durability for various architectural structures. He also explained how the temperature extremes between hot and cold could provide commercial applications and how materials from other planets could be mined and converted to solar cells (Foust, “Space Commercialization: the view from 1966”, 2004).

Nathan Goldman breaks down space commercialization into six different entities. These are space transportation, communications, remote sensing satellites, space manufacturing, transmission of solar energy to Earth by satellite, and the mining of celestial bodies. He expresses how space transportation involves space shuttles, expendable launch vehicles, and launched payloads. He associates the sector of communications with satellites and he views satellite communication as the first major space business used throughout the world. Goldman also explains that remote sensing satellites is not a business like communications, but has commercial potential. He explains the commercial advantages of remote sensing satellites for meteorologists since remote sensing satellites take readings of various locations by photographing and measuring aspects of the Earth from a remote distance. He describes how transmission of solar energy would work through mile long satellites armed with PV cells that could convert solar energy into microwave energy and send the energy to the Earth. He also describes how manufacturing could reduce costs of commercial activities in space by making the shuttle hold more cargo. He also elaborates on how mining of celestial bodies for various resources could become profitable and mining on the Moon has potential to occur (Goldman, 1985). Goldman focuses on services in addition to goods through his categories of communications and satellites as opposed to Stanton's sole focus on goods.

Jonathan Goodrich breaks down the categories of space commercialization differently than Goldman in "The Commercialization of Outer Space." Goodrich breaks commercialization down into the three branches of infrastructure needs, application markets, and technology spin-offs. He then further separates these categories into many subcategories with similarities to Goldman's six categories. Goodrich explains how infrastructure markets encapsulate transportation, preparation of flight payloads, and the manufacturing of shuttle parts and space suits. He describes how applications markets incorporate defense, communications satellites, remote sensing satellites, as well as manufacturing in space. Goodrich further elaborates how the medical industry could benefit from the manufacturing of space because of the weightlessness of space. He explains how spin-offs incorporate earthbound businesses and technology. Technology intended to be used in space has been incorporated into earthbound services. One example of a spin-off is the X-ray system at airports, which was originally designed for use in space. Goodrich incorporates similar categories as Goldman and Stanton, but also provides other sectors like the biomedical industry and the spin-offs of space technology (Goodrich, 1989).

William Piland believes that space commercialization consisted of activities depending on or relating to the Earth's orbit and satellites. Piland shares similar views with Goodrich and Goldman with his categories of space commercialization. He states that space commercialization includes the manufacturing and launching of satellites and transportation systems, the operation of satellites or transportation systems outside of Earth's atmosphere, the operation of facilities designed for space commerce on Earth, and the application of space technology to other industries (Piland, 1997). Essentially, Piland shares with Goodrich the view that spin-offs are a category of space commercialization.

He also shares with Goldman and Goodrich the view that transportation, satellites, and manufacturing for space are essential for space commercialization.

Another aspect considered to be a separate category of space commercialization is the concept of space tourism. John Olds believes that space tourism can become a long-term business, but prices to go into space must be reasonable for many citizens, not just multi-millionaires. He states that a possible start for space tourism to become a potential business would be to have the government pay for a reusable space vehicle to send citizens into space (David, “Creating Commercial Spacecraft for Space Tourism", 2002).

Impediments

Space commercialization has several impediments to be successful including moral obstacles, governmental obstacles, and legal obstacles. Phillip K. Chapman feels that the largest impediment and the main reason for a currently downplayed commercialization of space is the lack of progress made by NASA. Chapman views NASA as a failure, taking into consideration that $450 billion has been spent by NASA since the 1969 Apollo 11 mission landing on the Moon. Chapman comments on how this money has resulted in little advancement by stating how man was able to land on the Moon in 1969, but has not even left Earth's orbit since then. Chapman also explains how the unfinished International Space Station has been under construction for over twenty years and is being created for political reasons as opposed to commercial or scientific reasons (Chapman, 2003).

Dwayne Day has a different opinion on NASA than Chapman. Day views the landing of the twin rovers of Spirit and Opportunity on the Mars surface as an impressive comeback for the NASA program. Day expresses how NASA seems to be able to learn from its mistakes by putting more money into pre-flight testing to land the rovers on Mars successfully (Day, “The thin line between success and catastrophe”, 2004).

David M. Livingston analyzes the ethical and moral obstacles of space commercialization. Livingston debates how some negative business models on Earth could be applied to space businesses in the future. An ethical concern he has is that a business that markets a product that leads to the deaths of many citizens such as the tobacco industry could be established in space. A harmful space product developed by such a business could potentially lead to the deaths of many people. Livingston also states that he is uncertain if the government, private organizations, or international organizations would be able to successfully regulate space commerce or space business practices. He believes that several businesses in space will begin to operate and that many legal issues will arise. From these legal issues, he believes that space business guidelines would be established in the future through the courts (Livingston, “The Ethical Commercialization of Outer Space”, 1999).

Sam Dinkin holds an opposing view to this in "Property rights and space commercialization." Dinkin believes that the only way for there to be commercialization in space is through the establishment of property rights. Dinkin explains how a property right excludes a person from doing something (Dinkin, "Property rights and space commercialization", 2004). This is different than Livingston's view. Livingston believes in rules being established through legal action after businesses begin operating. Dinkin, on the other hand, believes that there must be property rights created before there can even be any space commercialization, and therefore, any businesses in space.

Sam Dinkin also discusses the impediment of establishing a legal system for space and the Moon in "Dividing up the spoils." Dinkin believes that if there is a legal issue on the Moon, cases will have to occur on Earth unless courts are established on the Moon. Dinkin also focuses heavily on the question of who can claim the spoils of a ship that has broken down. He goes on to state that having no seizure law would have a negative impact on commerce since various sectors including banks, courts, and law enforcement officials would lobby for the majority of the spoils of a seized ship (Dinkin, "Dividing up the spoils", 2005).

Policy

Dinkin explains the importance of an American private property system to intensify space commercialization. He notes that many inventions have always evolved into new and better innovations in a fifty year span. One example was the evolution of the Wright brothers' first plane to the current commercial airplanes that fly people around the world. However, he thinks that the colonization and exploration of space should only be performed by governments. Dinkin sees two methods of successful attempts for commercializing development. The first method regards the manner in which colonists bought property rights in "The New World." Dinkin believes that this was the starting point of the development of the airplane as well as the integrated circuit. The second method involves assuring companies of exclusive rights to various industrial branches to create a new business. This arrangement would become the United States current patent system. He stands behind the idea that owners take better care of a house than a renter. Owners invest time and money into their property to benefit their livelihood whereas a renter depends on a landlord to take care of the property. Without property rights in space, there will not be sufficient investments and space will not be used to its full potential (Dinkin, "Property rights and space commercialization", 2004).

W. D. Kay talks about how space policy was defined when the Reagan administration called for the private investment and involvement in space commercialization. Congressional testimonies since then have always included some sort of allusion to the idea that Russia might be ahead or behind in this area. A group was established to purely find business leaders to establish private space commercialization businesses. One of the major problems that private industry first encountered was receiving launch authorization. There had been many laws and treaties that needed to be reworked in order for a private company to have launching capabilities. This required the company to secure many licenses and waivers which was an expensive process in itself. This would add to the difficulty of gaining a profit (Kay, 1998).

A. J. Mackenzie investigates how Congress will promote private commercialization. Congress has created bills to provide tax credits for space companies. Unfortunately, these bills were terminated when referred to the "Ways and Means Committee." The idea behind the bills was to give entrepreneurs immediate rewards for investing in some sort of space product, regardless of its success. Mackenzie believes that these credits will not help as much as originally planned. He does not think that space companies are attractive enough for typical investors. Most investors are searching for companies that will quickly succeed to supply them with an exit strategy, which many space businesses generally cannot provide. Most space companies have long term plans for its products. There are too many earthly businesses that hold a much shorter period of time to be successful. Space is also considered a small business market compared to most earthbound markets (Mackenzie, 2005). Ultimately, an expanded space market is more important than tax credits to make space commercialization more productive.

Alan Pell Crawford discusses the reality of an industrial policy for space. He first concludes that the general public is interested in the commercialization of outer space. This statement is based on the rising of technology, especially in the area of satellite communications, and Reagan's re-election in 1984. Reagan showed confidence in America to make the nation the leader in the new space race. Crawford admits that many analysts have generally been pessimistic about a profitable space policy, but is optimistic that potential space commercialization could show an enormous economic expansion for the world. Crawford also concludes that because the government is so involved in the majority of companies established in space, it is difficult for space commercialization to reach its full potential because the government's decisions are based on political notions instead of market circumstances (Crawford, 1986).

Dwayne Day believes that there has been a feminization of America's space policy. Unlike Reagan at his re-election, President George W. Bush did not make reference to the notion of America being the leader in space during his address of a new civilian space policy. Throughout the 1980s, Reagan and other United States Government officials made it clear that America was to be the leader in space. After Bush's address, Reagan believed that Bush did not tackle the issue of America's position in the space race to avoid the fact that America has made little progress in commercializing space (Day, "The Feminization of American Space Policy", 2004).

Day states that the language people have used toward private space policy has had a feminine attitude. He believes the goals have been brought back to a more masculine attitude. Day comes to the conclusion that since women have become more equal and political correctness has become more important, the private space policy has lightened up. He believes that this is the reason why America has lost its leadership in space (Day, “The Feminization of American Space Policy”, 2004).

Sam Dinkin discusses the importance of money in space commercialization. He first explains how many businesses defray costs for citizens to access parks or highways that have entry fees. Many of the programs developed by these businesses are financed. If these programs functioned without gaining a profit, they would no longer be funded. Dinkin explains how NASA should look into ways to defray costs of a space station by involving other countries in developing it. The Falcon 9, a RLV (reusable launch vehicle), is an advancement made to defray costs. The Falcon 9 is projected to cost less than $6,600 per pound. Elon Musk, a spokesperson for the Falcon project, predicted at the International Space Development Conference that producing a shuttle with a cost of $2,200 per pound would be obtainable by the year 2010 (Dinkin, “The Most Important in Situ Resource is Money”, 2005).

Analysis

B. Abitzsch and F. Eilingsfeld write about the probability of transportation in space as a commercial service. They describe that the cost per person to orbit the Earth is too high to allow any credible development of space tourism. It costs at least $30 million per flight depending on the annual rate and number of people on the flight. There has been a proposed 74 passenger module, but the estimated cost per ticket would be about $4 million. As long as these prices are this expensive, the demand for this type of service will remain low. Abitzsch and Eilingsfeld develop a circle of human space activity. The high launch costs and rare launches lead to a low transportation rate. This rate leaves little or no interest for a business to develop a new cost-saving launch program. However, Abitzsch and Eilingsfeld come up with different scenarios to increase this market. Each of these scenarios has space transportation increasing greatly by the year 2050. According to their analysis, prices will not get below $30,000 and will only lower once 100 million people are transported through space per year (Abitzsch and Eilingsfeld, 1992).

At Michigan State University, Ramani Narayan came up with a commercialization model of technology. Its largest acknowledgment is that the only accurate measurement of successful technology is its profitability. A product must first be considered feasible and a patent for it must be established. If the product is not protected by patents, many companies will not pursue the development. Also, companies will not choose to develop a product if it does not meet their market volumes and hurdle rates. For these reasons, a company must develop a system to determine the potential of a technology. The most important aspect of the system is cost. If the feedback from the system is positive, a business plan is developed (Narayan, 1997).

Henry Hertzfeld of George Washington University believes that the reason for the lack of space commercialization is due to Congressional committees. The federal government spreads out their space budget over many departments and agencies with oversight by multiple committees. Because of this, there is no incorporated view of what the United States aerospace efforts are supposed to be. He believes that the multiple committees analyze the problem with insufficient data. Federal budget figures could be broken down in a more effective way and data from research and development for space could also be improved with a more consistent system. Hertzfeld also does not consider it possible to separate private commercialization companies from defense and security programs in the United States or in any other country (Hertzfeld, 2003).

Gans and Stern came up with a strategy for starting up a company. The most important decision that a company needs to make regards whether they are going to be cooperating with other companies or if there is going to be a competition of products between companies. Cooperative strategies are practiced more often with higher technological products and competitive strategies are practiced with less complex products. This cooperative strategy allows smaller companies to join the fewer large companies in their effort to make profit. Gans and Stern also suggest that competitive marketing for smaller businesses is unwise in higher technological productions based on historical situations. In "weaker property protection" situations, smaller businesses have shown more success in overcoming larger, established companies. Gans and Stern state that in the case of space commercialization, this cooperative strategy would be a more conventional way to improve the space market (Gans and Stern, 2002).

Jeff Foust analyzes whether or not RLVs have the potential to reduce launch costs. If RLVs were to be successful, costs for launches could become as low as $100 per pound. However, Foust sees too many hurdles that would have to be overcome in order for RLVs to be incorporated into the market. The first of these hurdles is that it will cost a great deal of money to produce an RLV. The technology needed to develop an RLV is highly advanced and some reports have suggested that it would cost up to $35 billion to produce a single RLV. Foust, backed by some recent research, does not believe that RLVs will have a high flight rate (Foust, "Is There a Business Case for RLVs", 2003).

His conclusion seems to be based on the commercialization that is already in progress without considering other forms of products that would become more feasible with lower launch costs.

Progress

The progress made in space commercialization spans several decades and should be examined to help define where commercialization has been and where it is going. The progress made in commercializing space has not developed as quickly as in other industries. NASA, although part of the United States Government, may play a role in the commercialization of space because it is currently the most developed space program in America.

Douglas O. Jobes examines how the United States Government may spark interest in having the private sector venture into space. The government can offer sizable awards to teams of scientists that accomplish some task to improve the potential of future space ventures. A modern prize is $100 million to the first group that can safely send three people to an altitude of 400 kilometers and orbit the Earth three times. Although many of the results of these teams are more specific to space tourism, they could lead to the development of other companies dealing with space commercialization. Jobes also makes the point that there may not be enough interest in having the private sector venture into space at the political level. He points out that there have been several bills that have not even reached the President (Jobes, 2004).

Alan Pell Crawford states that there is a lot of interest and promise in the commercialization of space, yet the progress is slow. He states how there is a great deal of discussion on the political level, but little activity is being made. He points out that the federal government has had monopolistic powers in space. Although Crawford discusses this in 1986, it can be observed that NASA still has the majority of control over space related technologies. Crawford states that this government control creates a large obstacle for space commercialization, making progress slow. As a possible solution to this problem, Crawford would like to see an entire market driving itself with no governmental motives or driving forces. He states how the large defense contractors are the organizations that are most involved in space commercialization with NASA. Because the risk involved in the commercialization of space is high, the return on investment is often questionable. Crawford gives an example of how many years may go by before any profit is seen by a company in space commercialization. There are many that believe the government should actively assist companies in commercializing space and allow investors the opportunity to take the risk in such a company. When analyzing the history of commercialization, it is apparent that the government attempts to assist companies in space commercialization, but in the end creates more problems. The role of the government may be a limiting or encouraging factor for the commercialization of space (Crawford, 1986).

Joan Lisa Bromberg points out that after the Cold War, there were few large companies that made bids for government contracts from NASA. This was mainly caused by the reorganization of companies by selling and buying of parts from competitors. The reorganization of companies caused there to be less competition concerning the space market. Bromberg explains how some large companies may have joined their remote sensing venture together. The problem of simply launching the payloads into space is large enough to have entrepreneurs find a cheaper launching method. This led to the creation of companies that could launch small payloads. Bromberg states that the Cold War affected the commercialization of space by establishing the government as the leader in space. When the Cold War ended, the private sector should have taken more of a role in space, but the government still today controls much of space (Bromberg, 1999).

Charles Vane sees the awarding of prizes for different accomplishments as a way to increase interest and action in space commercialization. He reviews the early aviation industry and makes some predictions of what space prizes may become. In the early years of aviation, prizes were awarded for accomplishing different feats. The prizes gave a direct incentive for groups of people interested in the private aviation. These prizes also drew interest from large organizations to see what the groups were accomplishing. Vane believes offering prizes for different accomplishments will help commercialize space. Although most prizes are currently offered for launching people into space, the technologies created and tested could easily be applied to other ventures in space commercialization. This prize system is similar to that of early aviation and could potentially lead to breakthroughs in space technology (Vane, 2005).

The progress in commercialization of space has been limited and unprogressive. The governments of the world have had complete control over any space related endeavors. This hold has loosened slightly with the rise of commercial companies. The role of government in the commercialization of space has been important in the past and remains so today.

Chapter 3: Commercialization

Attracting capital is the process of developing a new business product and conveying the product application to potential investors and venture capitalists. A company must be able to show investors that the product is centered on a desirable growing market. One aspect of the commercialization process is based on the attractiveness a product seems to have to venture capitalists.

Venture capital money comes from a well organized group of investors. These types of firms look for products with large growth potential to invest in. Because of the large group of investors within the firm, it does not share the risk of bankruptcy due to fallout of a large investment ("Career Profiles").

There are many features that a company must possess in order to establish the appeal of their product to investors. They need to have an established management team since many venture capitalists look for expertise, enthusiasm, and trustworthiness in a company. The next feature is that the product needs to be in a growing market. If the market has been well established, it makes it difficult for a smaller company to achieve a strong market position. If the product is unique in the market, the investment is much more attractive, particularly if the product has been patented or is protected legally by some other means ("What Do Capitalists Look For?", 2005).

Venture capitalists are interested in how they are going to benefit from an investment. It puts investors in a more comfortable position to invest in a product knowing it will generate a large profit. With a large gross profit margin, there is a larger acceptable tolerance for error. The business strategy must also be reliable to gather interest from venture capitalists. The more developed the product is, the more trust investors have in the investment. The final feature that a company must possess to attract venture capitalists is the presentation of the product. The presentation not only has to be precise on the product itself, but it must also include a full analysis of possible obstacles and problems the company could encounter ("What Do Capitalists Look For?", 2005).

The venture capitalist takes into account many criteria in deciding which startups receive money and how much is given. The investment criteria provide a methodology for the venture capitalist to make a decision as to which startup receives money. These criteria combine to provide a methodology for venture capitalists to use when deciding if a startup company is worthy of an investment. The venture capitalists distribute money in locations that have low risk and a high rate of return. The specific criteria differ between venture capitalist firms, but generally fall into equivalent categories. The specific criteria fall into several fundamental categories of management, market, products, and financial opportunity ("Internet Money Sources", 2000). There are other categories that may be considered such as technical and social. The importance of the categories may also vary from individual venture capitalist firms, but tend to be similar ("Investment Selection Criteria"). Since the venture capitalist relationship with the entrepreneur or founding team may have been established at an early point of production, the startup may be continually evaluated for risks and potential returns (Henos, 1991).

The current commercial method in space is underdeveloped and yet to be fully utilized to its full potential. Some reasons for the commercial market in space being underdeveloped are high launch costs as well as limited technology. Because of limited technology, there has been no RLVs developed, keeping launch costs high for private companies. "No fully reusable launch vehicle has ever emerged from the drawing boards, and no launcher has thus far been developed without some form of federal funding or backing" (Sietzen, 1999).

These issues cause great concerns for venture capitalists about the commercialization of space. These concerns include: "High cost of getting into space, high insurance expenses, long development times, restrictive government policies, high risks of funding with the requirement of equally high returns, market uncertainties, inexperienced space company management, and complex legal issues" (Livingston, "$pace: The Final Financial Frontier", 2000). It costs about $10,000 per pound to send anything into space. With the space market being underdeveloped because of these problems, there are currently no standard protocols for evaluating a product in the space market. In the absence of such standards, one logical approach would be to use a time-tested venture capitalist analysis model to measure the success of a product in space.

The transferability, however, of the standard protocols in the venture capitalist context to the space context is not fully suitable for an accurate analysis of a future space product. In one venture capitalist model, the analytical element "Size of investment" is ranked as the twenty-third most important element out of twenty-seven behind other elements related to competition and promoting cost in the market ("Investment Selection Criteria"). This ranking is logical in a venture capitalist market, but its rank seems highly out of place when put into the context of a space-based market. One of the biggest concerns of venture capitalists relating to space commercialization is the large cost to establish a product in space due to launch costs. Consequently, the importance of "Size of investment" in a space-based market should be higher than twenty-third out of twenty-seven as it is ranked in the venture capitalist ranking.

In addition, this venture capitalist model lacks analytical elements that relate to the context of space commercialization. Because the technology to take advantage of outer space commercially is underdeveloped, a model for the space market needs to include technical elements such as technical feasibility to ensure that the technology to develop a product is available. The venture capitalist model lacks any technical elements since it is assumed in the model that the technology is available to develop the product being evaluated. Therefore, the venture capitalist model needs to be altered and weighted differently to fit the space market.

Chapter 4: Methodology

This chapter will discuss the need for a space-based model to measure the potential success of a space product and the methodology that was followed to formulate such a model. An analytical model for space commercialization is needed since the traditional earthbound venture capitalist model does not take into account several important space characteristics. Also, many of the analytical elements in a venture capitalist model have different rankings if put into the context of space.

Despite the context of earthbound businesses being largely different than space-based businesses, the venture capitalist model was used as a basis of comparison for the developed space model. The space-based model was developed through an intricate weighting system that was formulated by comparing the importance among each analytical element. The space-based model included elements both similar and unique to the venture capitalist model. A product can be tested against both the venture capitalist model and the space-based model to compare the final score of the product given from each model. If the score in the space-based model is significantly higher than the score of the venture capitalist model, it means that the product would be better suited in the space context as opposed to the earthbound context. This would indicate that the market for space is different than the market for earthbound businesses, confirming that a space-based product needs to be analyzed through a space model as opposed to the venture capitalist model.

In developing the space-based model, information was taken from various business articles. Elements were taken from these articles and merged into the space-based model if they applied to the context of space. Some elements from these business models were considered inadequate for space's unique characteristics and were not included in the model such as "Enthusiasm of Entrepreneur."

Many elements were taken from "Key Success Factors for R&D Project Commercialization," an article that examined thirty-six characteristics which the author believed to determine the probability of a successful R&D project once it reached the market. These data were based on over five hundred projects developed outside of established organizations. The accuracy of the analysis was 80.9%, which was a higher percentage than R&D managers predicted for their own products (Astrebo, 2003).

Most of the remaining elements were taken from "The Product and the Market of Ideas." This article discussed a framework for the start-up of commercialization strategy. It discussed why some technology entrepreneurs undermine successful firms while others do not. The article's analysis concluded that competition between innovators depends on the presence of a "market for ideas." The modeled structure holds several "implications for the management of high-technology entrepreneurial firms," however this model does not include space-based production (Gans and Stern, 2002).

It was necessary to rank these elements with respect to their importance in the space environment to better develop the space-based model. Not only would this make the space model more accurate, but it would also allow for a better comparison with the traditional venture capitalist model that contains many of the same elements. The space-based model has more emphasis on the analytical categories of technical and financial whereas the venture capitalist model emphasizes characteristics of the entrepreneur and does not even take into account technical aspects of a product. Below is a list of the rankings of the compiled elements along with the reasoning behind each ranking:

1. **Technology of Production:** "Technology of Production" is ranked as the most essential element because without sufficient technology, a space-based product would not have any chance to be successful.

2. **Knowledge and Technical Ability: "**Knowledge and Technical Ability" is a top essential element since without knowledge to build a complex space-based product, it would not be successful as an earthbound product. Another reason for the high ranking is that knowledge on space product design is not as common as knowledge of building earthly goods. Also, technical ability for a space-based product is much more important than that of an earthbound product because the consequences of a faulty design are more severe.

3. **Size of Investment:** Considering how much more money must be invested in a space-based product than an earthly product, "Size of Investment" is the third most important element.

4. **Legality:** It is important that the methods in building the product and the function of the product do not break any applicable laws. The application of legality in space does not differ greatly from national and international law on Earth since human life is essentially managed by law. This would logically be extended to the context of space.

5. **Safety:** The product should not be hazardous or dangerous to people or other objects around it. If a space product malfunctions, there is not much that can be done to correct the problem. More importantly, if the space product involves humans, their lives are at risk if there is a malfunction.

6. **Cost of Production:** Production cost must be reasonable. If the cost of production is too high, it would cause the product price to increase, resulting in fewer customers willing to pay the product price.

7. **Development Risk:** It is important to have a low degree of uncertainty between early development and finished product. The effects of having a high degree of uncertainty would jeopardize the success of the company in the space-based model more than earthbound businesses because of the higher investment incorporated with a space product.

8. **Durability:** The product must endure the strains of short-term and long-term damages associated with launching the product into space or the product will have a shortened life span.

9. **Function:** If the product does not work at a comparable level with other products of similar purpose, then the product will not stand much of a chance considering the low number of space-based products currently available.

10. **Profitability:** Profitability is important in any product venture since there is no logical reasoning in investing money to develop a product that has no foreseeable returns.

11. **Technical Feasibility:** The product must be sound and complete or it will not be durable or safe, both elements that rank high on the list. If it is not sound and complete, the product will not perform its function.

12. **Need:** As is the case with any product, if the customer does not desire it, it will not sell. Since space has been characterized as the final frontier, many people have a strong desire to go into space simply for the thrill of it. Therefore, space products that incorporate humans will create a greater longing to be used because they involve space.

13. **Existing Competition:** If there is existing competition in any market, it is more difficult for the product to be successful. With the space market being fairly small compared to the earthbound market, it makes existing competition less important in the space market. Also, there is likely to be few products of the same purpose in the space context since the success or failure of a company would likely hinge on the outcome of its space product.

14. **Research and Development:** If there is a great amount of research and development needed to create a product, the implementation costs for the product will increase.

15. **Tooling Cost:** Having a high tooling cost will be passed onto the customer through a higher product price. This will deter potential customers from the company's product or services.

16. **Potential Sales:** Potential sales show the probability of how much the product will sell. If the product does not sell sufficiently, the company will lose money and likely go bankrupt due to the large size of investment and breakthrough technological research needed for a space-based product.

17. **Impact of Failure/Potential Liquidity:** Any failure in the processing and distribution of a product can be an end to a company. A company has to be aware and be able to compensate for any failure to the production. The lower the chance of failure is for a company, the greater the chance of success and profit will be for the company.

18. **Protection:** Many companies could lose considerable money and possibly go bankrupt if it were to be overrun by other companies with virtually the same product. If they can protect their product from these companies through patents or other means of

protection, they have a greater chance of success. Lack of protection can allow other competition to take some of the market away from the company.

19. **Functional Performance:** If the product works better than the alternatives, it has a more likely chance of being successful. If the product does not work better than already existing alternatives, it will be difficult for the product to be successful.

20. **Potential Market:** The larger the market is for a product, the larger the potential profitability becomes.

21. **Duration of Demand:** The duration of the demand is crucial in many space products. Many space products are made for long term production, making this a more important aspect of analysis.

22. **Existing Facilities/Resources:** It is currently expensive to bring materials into space. If there are already existing resources in space, the cost of production is lowered and company profit is increased. If a company can find ways to use already existing resources in space, the time spent figuring out how to use them will most likely be more profitable than launching material into space.

23. **Unintended Consequences:** Unintended consequences can be disastrous to a product. Presently, most customers are far away from the products. As technologies are developed, this distance between customer and product could be reduced substantially. Unintended problems must be a factor to consider in order to prevent disasters.

24. **Uses Environment to Advantage:** Because of the space environment's characteristics, there are many new innovations that can be developed. Through research, companies can create new ways to take advantage of the unique features of space.

25. **Technology Significance:** The product or service should have high technology significance to space-based products and services. Contributing little to space-based products and services will make the idea common and potentially hurt its chance at being successful.

26. **Price:** The price of the product or service to the customers must be at competitive levels when compared to the competition. Having a price that is higher than most of the competition will result in a smaller customer base since potential customers will go elsewhere for the same product or service.

27. **Trend of Demand:** The trend of demand should ideally not be negative. Since the costs to accomplish any space-based product or service is much greater than earthbound products, it is ideal to have the profit be obtainable and sustainable.

28. **Economic Environment:** The economic environment is important to space-based products and services because it helps to better define marketing, product, and technology strategies and methods.

29. **Product Strategy:** The product strategy that the company chooses can define how successful the product becomes. The manufacturing and introduction into the market strategies has the potential to help or hurt the price and profitability of the product or service.

30. **Production Cost:** If the promotion cost to get the space-based product known is too great compared to the returns of the product, it can potentially hurt the company's success.

31. **Societal Benefits:** The space-based product or service should benefit humanity or contribute to technological advancement in society. If the product contributes to society

in a negative way, the product may not be accepted by society and could be detrimental to the company's overall success.

32. **Compatibility:** If the space-based idea conflicts with current attitudes and ways of doing things, the acceptance will not come easy. If the product is compatible with current attitudes, it will have a better chance of being successful.

33. **Compliment Other Products:** If a product enhances or contributes to the aspects of other products, it will result in more sales and profit. This does not have a high importance because the likeliness of space products complimenting other space products is fairly low due to the small market.

34. **Learning: "**Learning" is important for a space product, but not excessively important because everybody going into space will not need to learn how to operate the product. With the example of a space transportation product, consumers are not going to be able to purchase this type of product. A space tourism company would likely purchase a space transportation product and charge citizens a fee to venture into space. Because of this, only designated pilots would need to understand how to operate the product. As a result, the amount of learning could be said to be on a similar level of an airplane, which requires training and a license to operate. A citizen does not need to know how to operate a plane to use it.

35. **Complementary Assets:** If the company has complementary assets, it will make the start up less costly and easier to accomplishment. If the company does not have any complementary assets, this will add to initial start up costs which may not make the venture as profitable.

36. **New Competition:** Facing new competition in the space market is not as big of a threat as facing competition in an earthbound market. This is because of how new the space market is and also how much more money a product will cost the consumer in the space market. When an original innovation comes to the space market, it will be the most used item. When new competition with a product that has similar qualities comes along, it will not be flocked to like the original product since people already paid a large amount of money for the original product and would not be willing to buy an item of the same function for a large amount of money.

37. **Marketing Research:** Marketing research is the effort to define the product price range. This is not as important as potential sales, potential market, and many of the other marketing elements for a space product.

38. **Payback Period:** Payback period, though important, is not of high importance for a space-based product. Space products will incorporate a much larger investment than an earthbound product. As a result, the payback period will usually be later in the life of the innovation as opposed to early in the life of the innovation.

39. **Distribution:** Accessing distribution channels is not of high importance because most space products are not the type of products that the average income citizen would be able to purchase.

40. **Environmental Impact:** "Environmental Impact," though important on Earth, is not as important in space. On Earth, automobiles that release carbon dioxide impact the intensity of heat on Earth. In space, however, not nearly as much harm can be done. If a product breaks down and heads for Earth, it will likely burn up in the atmosphere and

cause no harm. In addition, releasing substances into space should have little or no impact on Earth's environment.

41. **Product Line Potential: "**Product Line Potential" is of fairly low importance. When developing a space-based product, it is likely that the aim is to create a breakthrough product, not a product that will lead to other breakthroughs.

42. **Appearance:** Appearance is the least important aspect of a space product. Since most of the products will have people inside them or be unseen by the human eye when it is performing its function, the overall appearance of a product seems unimportant. Also, considering how the product is new, the appearance should not be expected to be the most appealing aspect of the product.

Once ranks were assigned to each of the analytical elements, they were associated with a specific analytical category. These analytical categories consisted of "Competition," "Technical," "Social," "Financial," "Marketing," "Product Characteristics," and "Other Venture Capitalist Criteria." Weights for the analytical categories and elements were then calculated. The weighting reflected the importance of each individual criterion. The method used to assign weightings incorporated several steps and calculations. The first calculation was to assign a new number to each of the analytical elements. These new numbers were created by subtracting their rank from forty-three, the number of elements plus one. This was done so that the more important elements had the higher weights for the final score. In order to assign a weighting for each of the analytical elements, the recently obtained numbers were divided by 903 so that the sum of the numbers would be one. These numbers are the weightings associated with each of the analytical elements. Additionally, a weight was assigned for each of the analytical categories to better compare the space model to the venture capitalist model. This was done by adding all of the weights in a particular analytical category and multiplying by one hundred to give a percentage score.

The following tables show the results of the calculations made to the rankings decided upon. Table 4.1 shows the weighting for the analytical categories. Table 4.2 shows the weighting assigned to each of the analytical elements.

Category	**Weights**	
	Venture capitalist	Space-based Model
Competition	5.80474934	11.18493909
Technical	0	26.1351052
Social	9.234828496	16.38981174
Financial	24.01055409	21.70542636
Marketing	13.98416887	15.06090808
Product Characteristics	10.29023747	9.523809524
Other Venture Capitalist Criteria	30.34300792	0

Table 4.1

Criteria	**Weights**	
Competition	Venture capitalist	Space-based Model
Existing Competition	0.026385224	0.033222591
New Competition	0.026385224	0.007751938
Complementary assets	0.005277045	0.008859358
Functional Performance	0	0.026578073
Economic Environment	0	0.016611296
Price	0	0.018826135
Technical		
Technical Feasibility	0	0.035437431
Technology Significance	0	0.019933555
Research and Development	0	0.032115172
Knowledge and Technical Ability	0	0.045404208
Technology of Production	0	0.046511628
Function	0	0.03765227
Existing Facilities/Resources	0	0.023255814
Uses Environment to Advantage	0	0.021040975
Social		
Safety	0	0.042081949
Environmental Impact	0	0.003322259
Societal Benefits	0.005277045	0.013289037
Compatibility	0	0.012181617

Legality	0	0.043189369
Protection (Overall, informal, formal)	0.087071	0.027685493
Unintended Consequences	0	0.022148394
Financial		
Tooling Cost	0.013192612	0.031007752
Cost of Production	0.018469657	0.040974529
Size of Investment	0.007915567	0.044296788
Potential Sales	0.055408971	0.029900332
Payback Period	0.050131926	0.005537099
Profitability	0.058047493	0.03654485
Impact of Failure/Potential Liquidity	0.036939314	0.028792913
Marketing		
Promotion Cost	0.018469657	0.014396456
Marketing Research	0.01055409	0.006644518
Distribution	0	0.004429679
Trend of Demand	0.029023747	0.017718715
Duration of Demand	0.029023747	0.024363234
Potential Market	0.052770449	0.025470653
Development Risk	0	0.03986711
Product Line Potential	0	0.002214839
Product Strategy	0	0.015503876
Product Characteristics		
Need	0.034300792	0.034330011
Learning	0.023746702	0.009966777
Appearance	0	0.00110742
Durability	0.042216359	0.03875969
Compliment Other Products	0.002638522	0.011074197
Other Venture capitalist Criteria		
Enthusiasm of Entrepreneur	0.060686016	0
Trustworthiness of Entrepreneur	0.065963061	0
Expertise of Entrepreneur	0.063324538	0
Investor Liked Entrepreneur upon Meeting	0.044854881	0
Track Record of Entrepreneur	0.047493404	0
Possibility of Investor's Involvement in Business Development	0.021108179	0

Table 4.2

A zero in a weight signifies that there was no rank associated with the analytical criteria, therefore the analytical element does not receive a weighting for the particular model.

In Table 4.1, the weightings associated with each of the analytical categories have different weightings dependent on whether it was applied to the venture capitalist model or the space-based model. There were similar weightings associated with the analytical categories of "Financial," "Marketing," and "Product Characteristics."

There are differences in "Competition" and particularly the "Technical" and "Other Venture Capitalist" analytical categories. The space-based model does not contain any of the analytical elements in the "Other Venture Capitalist" analytical category. The venture capitalist model does not factor in the "Technical" analytical category. When the space-based model was being developed, a technical analytical category was needed since technical aspects in space-based ventures are important. In a space-based venture, the technical aspects are much more important since the technology and knowledge are new and more advanced.

The "Other Venture Capitalist" analytical category mainly covers analytical criteria that pertain to elements concerning the entrepreneur. The space-based model does not take any of these analytical elements into account. None of the analytical elements are related to the actual product or service that the entrepreneur is trying to develop.

When looking at the individual analytical elements, there are some similarities and many more differences. The similarities and differences between the weightings for the analytical elements for each of the models are dependent on the similarities between the analytical category's weight.

The process of analyzing and evaluating a product through the space-based model was a two-step process. The first step was to evaluate the categories of space commercialization. After developing the analytical model for space commercialization, the five space categories of biomedical, mining, manufacturing, satellites, and transportation were evaluated through the model. For each analytical element in an evaluated space category, a score of 0, 0.5, or 1 was given depending on how well the space category performed for that element. A score of 0 represents a poor performance, a score of 0.5 represents an average performance, and a score of 1 represents a high quality performance in that analytical element. Based on the weighting system, a final score was given for each of the five space categories. The results are in Table 4.3.

Criteria	***Biomedical***	***Mining***	***Manufacturing***	***Satellites***	***Transportation***
Competition					
Existing Competition	0.5	1	0.5	0	1
New Competition	1	0	1	1	1
Complementary assets	0	1	1	1	0
Functional Performance	1	0.5	1	0	1
Economic Environment	0	0	0	0	0
Price	0	0.5	0	1	0
Technical					
Technical Feasibility	0	0	1	0	0
Technology Significance	1	1	1	0	1
Research and Development	0.5	0.5	1	1	0.5
Knowledge and Technical Ability	0	1	1	1	1
Technology of Production	0	0.5	1	1	1
Function	0.5	1	1	1	1
Existing Facilities/Resources	0	0	0	1	0.5
Uses Environment to Advantage	1	1	1	0.5	0
Social					
Safety	0.5	0	0.5	1	0.5
Environmental Impact	1	1	0.5	1	0.5
Societal Benefits	1	1	0.5	1	1
Compatibility	0.5	1	0.5	1	1
Legality	0.5	0.5	1	1	1
Protection (Overall, informal, formal)	1	0	0	1	0.5
Unintended Consequences	0.5	0.5	0.5	1	0.5
Financial					
Tooling Cost	0.5	0	0.5	0.5	0
Cost of Production	0	0	0	0.5	0
Size of Investment	0	0	0	1	0
Potential Sales	0.5	1	0.5	1	1
Payback Period	0.5	0	1	1	0.5
Profitability	0	0	0	1	0.5
Impact of Failure/Potential Liquidity	0.5	0.5	0.5	1	0.5
Marketing					

Promotion Cost	0.5	1	0.5	0	0.5
Marketing Research	1	1	0.5	1	1
Distribution	1	1	0.5	0.5	0.5
Trend of Demand	1	1	0.5	0.5	1
Duration of Demand	1	1	1	1	1
Potential Market	0.5	1	0	1	1
Development Risk	0.5	0	0	0.5	0.5
Product Line Potential	0	0.5	1	0	0.5
Product Strategy	1	0.5	0.5	1	1
Product Characteristics					
Need	0.5	1	0.5	0.5	1
Learning	1	0	0	1	0.5
Appearance	1	1	0	0	0
Durability	1	0	0	1	0
Compliment Other Products	0	0	1	0.5	1
Final Score	0.45404208	0.471207	0.522148394	0.750277	0.596899225

Table 4.3

The ratings of 0, 0.5, or 1 for each of the analytical elements are explained in the following sections with respect to the five space categories evaluated. In addition, the performance of each space category and final score for each space category is evaluated and discussed. If a space category received a final score greater than or equal to 60%, then the space category could be deemed potentially successful. If the space category did not obtain a 60% or better, then it could be deemed likely a failure.

Biomedical Evaluation

The space category of biomedical was evaluated using the developed model. In the analytical category of “Competition”, the space category of biomedical was evaluated for each of the analytical elements. It received half points for “Existing Competition.” Despite there currently being no other space-based biomedical businesses, the end product of a biomedical business has to compete directly with earthbound medical businesses.

The analytical element “New Competition” received full points. Once a specific biomedical product is established, it is unlikely that a new space-based biomedical business would spend the money and resources to develop a similar product with the same effects. For space biomedicine, it would not be a wise business decision for a new corporation to slightly alter the medicinal properties to create a new product since the development costs are much higher in space than they are on Earth.

Biomedical received no points for “Complementary Assets” since it is unknown if the technology and the skills to develop a biomedical establishment in space exist. The analytical element “Functional Performance” received full points since it is assumed that the medicinal product being built in space would have superior medicinal effects than current medicinal products. Biomedical received no points for “Economic Environment” since the market is well-developed and it is difficult for a startup corporation to establish a new product. “Price” also received no points since it would cost significantly more to develop the technology and machines for space medicine than to develop medicine on Earth. Overall, biomedical did slightly below average in the analytical category of “Competition.”

In the analytical category “Technical,” biomedical was evaluated for each of the analytical elements. It received no points for “Technical Feasibility” since there is no technically complete process yet to establish a biomedical business in space. The analytical element “Technology Significance” received full points since the advanced medicines developed using the properties of space could yield potentially life saving medicines. “Research and Development” received half points. Machines need to be developed that use the space environment to separate substances to create new medicines.

Analytical elements “Knowledge and Technical Ability” and “Technology of Production" both received no points because it is unknown if the technology or skills are available to build machines capable of space biomedical engineering. Biomedical received half points for “Function” since new medicines and products developed will fulfill a purpose not currently available from medicines manufactured on Earth. The analytical element “Existing Facilities/Resources” received no points because there are no facilities that can simulate the vacuum of space sufficiently enough to test the separation of substances. Biomedical received full points for “Uses Environment to Advantage” since the entire point of biomedical engineering in space is to use the weightlessness to break apart substances efficiently and develop new and improved products. Overall, biomedical did slightly below average in the analytical category of “Technical.”

In the analytical category of “Social,” the biomedical category was evaluated for each of the analytical elements. It received half points for “Safety” since something could go wrong in the separation of materials, though this is unlikely if the machinery is as well developed as earthbound medical technology. For “Environmental Impact,” the biomedical category received full points since there does not seem to be any detrimental impacts to the Earth's environment from a biomedical business in space. It also received full points for “Societal Benefits” since new potentially life saving medicines could result from a biomedical business in space. The analytical element “Compatibility” received half points since it seems to coincide with the views of most, but some people may feel that the development of medicine in space is not safe for the consumers.

“Legality” also received half points. With any medical product, there could be heavy legal ramifications if it proved to be faulty or produced highly dangerous side effects. “Protection” received full points since the intellectual protection of medicines by businesses produced in space would likely follow the current medicinal protection policy in place on Earth. The category of biomedical received half points for “Unintended Consequences” since there could always be defective medicine that leads to fatalities due to an error in development in space. Overall, the category of biomedical did above average in the analytical category of “Social.”

In the analytical category of “Financial,” the biomedical category was evaluated for each of the analytical elements. The analytical element “Tooling Cost” received half points since the cost to set up machinery to perform the biomedical engineering in space would be expensive, but not nearly as expensive as some of the other space categories such as mining. Analytical elements “Cost of Production” and “Size of Investment” both received no points for similar reasons. Not only must it be taken into account the cost to produce machinery to actually perform the biomedical engineering, but also the cost of researching products that can be assembled from biomedical engineering in space. The analytical element “Potential Sales” received half points. Unless there is a breakthrough product, most sales of biomedical products from space would not perform much better than current earthbound products.

“Payback Period” received half points as well since the cost of production is high, but there is potential for sales even if the product is only as good as earthbound products. Even with average sales, the money invested would not be recovered early in the establishment of a biomedical space business. The category of biomedical received no points for “Profitability” since it is likely a product will only generate a profit if the medicine is groundbreaking and solves a major problem. “Impact of Failure/Potential

Liquidity" received half points. Even if the attempt at developing a space medicine fails, the machinery is still intact and more research can be done to try and develop a different medicine. Overall, the category of biomedical did below average in the analytical category of "Financial."

In the analytical category of "Marketing," the biomedical category was evaluated for each of the analytical elements. "Promotion Cost" received half points. Currently, any advanced biomedical medicine from space produced would get enough attention that it would not need much promotion to get consumers interested. But the medicine should perform a function not already available or perform it more efficiently or else it would need just as much promotion as a medicine produced on Earth. The analytical element "Marketing Research" received full points since it is unlikely to be difficult to determine how much to charge the end medicine produced by the biomedical machinery since the amount of materials needed to produce the new medicine is known.

"Distribution" received full points since the process of approving and selling medicine through pharmacies to consumers is already established on Earth. Analytical elements "Trend of Demand" and "Duration of Demand" both received full points since the demand of an efficient medicine or a medicine with a new function would hold long-term interest and would at least stay steady on the market. "Potential Market" received half points. A medicine produced by the biomedical machinery would be sold to pharmacies, a large market. "Development Risk" received half points. If the attempt at developing a researched medicine in space failed, the machinery would still be intact and available for a newly researched medicine to be developed. "Product Line Potential" received no points since it is unlikely a different medicine is discovered while a medicinal product is being developed. Since there will need to be a heavy amount of research before it is attempted to develop a new medicine, the analytical element "Product Strategy" received full points. Overall, the category of biomedical did above average in the analytical category of "Marketing."

In the analytical category of "Product Characteristics," the biomedical category was evaluated for each of the analytical elements. The analytical element "Need" received half points. There is currently no need for a medicine that can only be developed in space, though the medicines developed in space could yield more efficient results and improve health of many individuals.

"Learning" received full points since the likely form of the medicine developed by the biomedical machinery would be a pill. All the consumer would have to do is read the directions and use the product. "Appearance" also received full points. Appearance is trivial to the consumer since the medicine developed by the biomedical machinery would likely be a simple pill. "Durability" received full points since the machinery performing the biomedical engineering in space would not be under hazardous conditions since its primary purpose is to separate and assemble materials. The category of biomedical received no points for the analytical element "Compliment Other Products" since it is unlikely that the machinery used to build the medicine would support anything other than constructing medicine. Overall, the category of biomedical did above average in the analytical category of "Product Characteristics."

A final score for the space category of biomedical was calculated using weighted values of each analytical element from the score given to it. The category of biomedical received a score of .454 out of 1, which is approximately 45%. Based on the standard of a 60% implying a successful space venture, it could be inferred that the biomedical industry would likely be a failure in space at this time.

Mining Evaluation

The space category of mining was evaluated using the developed model. In the analytical category of "Competition", the space category of mining was evaluated for each of the analytical elements. It received full points for "Existing Competition" since there are currently no space mining operations taking place. It received no points for "New Competition" because a new corporation entering the market would be mining the same resources as the current companies. Also, these corporations mining the same materials could be offering the same product and could possibly sell it at a lower price if the company had a business strategy that would get higher revenues than the existing competition. The analytical element "Complementary Assets" received full points since the skills and technology to perform a space mining operation on the moon exist.

The analytical element "Functional Performance" received half points. This is because if a new mining business or company starts up, it is unlikely that it will be significantly better than the competition. This is because the business will likely be marketing a similar mined resource as the competition with the only possible advantage being a lower price. So the product does not work better than the alternatives, but the price is a large influence. Mining received no points for "Economic Environment" because the market is developed and it is therefore difficult for a new company to establish a product. "Price" received half points for mining. This is because a resource will not have a higher value for one company over another company. The price advantage comes in business strategy and developing a coherent mining system. Overall, mining did average in the analytical category of "Competition."

In the analytical category entitled "Technical", mining was evaluated for each of the analytical elements. It received no points for "Technical Feasibility" since the current idea behind space mining is incomplete. There is no technically complete process as of yet to mine any celestial body. The analytical element "Technology Significance" received full points since the ability to mine a celestial body would contribute greatly to society in terms of potentially valuable resources. Mining received half points for "Research and Development" since the strategy behind providing a high-scale mining operation would require excavation tools as well as vehicles capable of transporting the resources to be developed. "Knowledge and Technical Ability" received full points since the knowledge to perform space mining is available. "Technology of Production" received half points since the technology in developing space excavation tools is not a highly researched area of space commercialization.

Mining received full points for "Function" since this category of space commercialization involves gathering resources from celestial bodies, a purpose not currently existing. The analytical element "Existing Facilities/Resources" received no points since there are countless objects needed to be built in order for a space mining operation to occur. These include the mining tools and vehicles that need to be designed and developed. Mining received full points for the analytical element "Uses Environment to Advantage" since obviously mining a celestial body makes use of resources available outside of Earth. Overall, mining did slightly above average in the analytical category of "Technical."

In the analytical category “Social,” mining was evaluated for each of the analytical elements. Since early mining operations will likely involve human lives and not be automated, the space category of mining received no points for “Safety.” Many things could go wrong during a space mining operation, especially if it occurs within a volatile environment such as an asteroid. The analytical element “Environmental Impact” received full points since mining operations would have no harmful effects on the environment.

Many celestial bodies contain valuable resources. The moon contains helium-3, a potential energy resource. Because many resources in space are valuable to man, the analytical element “Societal Benefits” received full points. “Compatibility” received full points since space mining does not go against any current attitudes. “Legality” received half points since space mining can lead to problems of deciding which celestial bodies can be mined by whom. These problems are the same reason why the analytical element of “Protection” received no points. Since there is a threat to life but not much of a threat to the environment, the analytical element “Unintended Consequences” received half points. Overall, mining did slightly above average in the analytical category of “Social.”

In the analytical category “Financial,” mining was evaluated for each of the analytical elements. The analytical element “Tooling Cost” received no points since the cost to set up a mining operation is large. The mining tools and vehicles all have to be taken into account, in addition to setting up the excavation sites and transferring of resources from its site back to Earth with transportation vehicles. Likewise, the analytical elements “Cost of Production” and “Size of Investment” received no points since the cost level seems unreasonable and unlikely obtainable when taking into account the many expensive components needed to establish a mining operation. "Potential Sales," on the other hand, received full points because of the value of many resources outside of Earth. Helium-3 is one of many resources that could prove highly useful if other energy resources on Earth were to become heavily depleted. Because of the substantial investment to establish a working mining operation, it is unlikely that the investment would be recovered early in the establishment of the mining business. Even if a highly valuable resource was found, a profit would only likely be gained in the long-term and if there was a sustained amount of the resource. Therefore, analytical elements "Payback Period" and "Profitability" received no points. Overall, mining did poorly in the analytical category of "Financial."

In the analytical category of "Marketing," mining was evaluated for each of the analytical elements. It received full points for "Promotion Cost" since the need to promote a valuable resource such as helium-3 is not needed. The analytical element "Marketing Research" received full points as well since it is unlikely to be a problem to determine the cost of a mined resource. By determining the amount of the resource remaining on the celestial body, it could be determined how much to charge with respect to the abundance of the resource and value of the resource. Mining received full points for "Distribution" since distributing the mined resource does not appear to be any different than distributing an earthly mined resource once it is returned to Earth. Analytical elements "Trend of Demand" and "Duration of Demand" both received full points since the demand of a valuable mined resource is likely to be long-term and either stay steady or rise. "Potential Market" also received full points because the market for a valuable mined resource could be large. Governments would likely pay millions of dollars to get a valuable power supplying resource. "Development Risk" received no points though because of the high number of things that can go wrong with a mining business. After the excavation site is set up, it could be determined that the resource is low in value or availability. Also, human error is likely in a mining operation that could lead to deaths or machine damages. Mining received half points for "Product Line Potential" since it is possible that while mining a particular resource, a different expensive resource is discovered in the same site. "Product Strategy" also received half points since it is known what resource is being sought after. Overall, mining did well in the analytical category of "Marketing."

In the analytical category of "Product Characteristics," mining was evaluated for each of the analytical elements. It received full points for "Need" since the call for new power sources may be in higher demand in the future once Earth resources are highly depleted. It received no points for "Learning" since the process of mining is a complex endeavor involving human lives and training astronauts to undergo a mining operation would take time. The analytical element "Appearance" received full points since it does not matter what the resource or the tools to mine the resource look like, as long as the process works. "Durability" received no points because it is unknown whether a mining business would support long usage. Many machine components would likely only support one time usage, meaning that machinery may not be easily transferable from celestial body to celestial body. For the analytical element "Compliment Other Products," mining received no points since it is unlikely that the mining tools or mining business could support other space technologies. Overall, mining did slightly below average in the analytical category of "Product Characteristics."

A final score for the space category of mining was calculated using weighted values of each analytical element from the score given to it. Mining received a score of .471 out of 1, which is approximately 47%. Based on the standard of a 60% implying a successful space venture, it could be inferred that the biomedical industry would likely be a failure in space at this time.

Manufacturing Evaluation

The manufacturing space category was evaluated using the analytical model. "Competition" was the first analytical category. Manufacturing received half credit for "Existing Competition" because there are already several manufacturing processes on Earth. However, there is currently no manufacturing market established in space. It is for this reason that the "New Competition" element was given its full value. "Complementary Assets" was given full value because manufacturing is an important part of the economy. There are also machining tools that can be brought into this field from the earthbound productions. Because manufacturing in space would be more efficient than the types of manufacturing on Earth, "Functional Performance" also received its full value. "Economic Environment" received no credit because the current manufacturing industry has always been in practice and is well established with the technology the world has been developing. The "Price" element also did not receive any value. Because launch prices are expensive, manufacturing on Earth is still cheaper than trying to manufacture in space.

Manufacturing in space was run through the "Technical" analytical category. "Technical Feasibility" received the full portion of its value because many of the new forms of manufacturing that would be implemented in space have been completely developed at this time. “Technology Significance” would be a major enhancement for the world’s economy. The new forms of manufacturing that could be processed would lead to more products. This is why this element obtained the full value. There is not a great deal of remaining research and development remaining to bring manufacturing in space to a marketable platform. The “Research and Development” element received the full value because of this lack of need. “Knowledge and Technical Ability” was also given the full value because there are already professionals who know how to apply this type of manufacturing in space. “Technology of Production” received the full value because the technology to produce manufacturing in space exists. “Function” also received the full value for manufacturing in space because of the various types of manufacturing that could be practiced. “Existing Facilities/Resources” did not receive any value because at this time there are not any sources of manufacturing equipment in space. The new types of manufacturing that will be used in space uses the environment to its advantage via space characteristics such as its vacuum. Therefore “Uses Environment to Advantage” received the full value.

Manufacturing in space was evaluated in the analytical category of “Social,” the third analytical category. “Safety” was awarded half credit because although most of the manufacturing would be done with mechanics, something could break from the manufacturing process that would have the potential to cause harm to surrounding mechanical tools and other space products nearby. “Environmental Impact” also received half its value because of the possibility of debris. “Societal Benefits” received half the value because this innovation would primarily benefit manufacturing companies, and generally would not have an effect on the average person. “Compatibility” also received half the value. Although there are certain parts of the manufacturing process that will be constant, whether performed in space or on Earth, there will be new steps within the space procedures. "Legality" received the full value because all manufactured products have to go through a permissible process to approve what is being manufactured. "Protection" was not given any credit because there was minimal information about the protection of future space manufactured products. "Unintended Consequences" received half the value because of possible malfunctions that must be considered in any manufacturing process.

Manufacturing in space was evaluated in the "Financial" category. "Tooling Cost" was given half of the points because there will be expensive tools to manipulate the types of processes planned for space. "Cost of Production" is currently too high to give any value because of the expensive prices to bring materials into space. "Size of Investment" also received no value for the same reason. With launch prices, the investment would likely not reach its obtainable goal. "Potential Sales" was awarded half its possible value. Depending on how expensive the manufactured product is would determine whether or not the sales volume would be great enough. "Payback Period" was given its full value because the manufactured products would be sold soon after their construction, creating a short payback period. "Profitability" did not receive any value because current earthbound manufacturing would generate more revenue than space manufacturing. "Impact of Failure/Potential Liquidity" was given half its value. If the manufacturing was to fail, the investor would lose a substantial amount of money. However, the investor would not have many issues trying to liquidate the company.

In the “Marketing” category, manufacturing in space was evaluated by each analytical element. “Promotion Cost” received half its value because there is not expected to be a large quantity of money expected to promote these new manufacturing procedures. “Marketing Research” also received half its weight due to the fact that there would be a certain amount of research needed to evaluate who would be interested in the new space manufacturing. This field of options is somewhat limited, compared to other markets. The “Distribution” element obtained half its value because the current distribution from Earth factories to consumers is well established. However, the process of taking the manufactured product out of space has not fully evolved. The demand is likely to remain at a constant rate without other new forms of manufacturing. Therefore, “Trend of Demand” received half its value. However, “Duration of Demand” obtained its full value because manufacturing has a constant need to continue. “Potential Market” received no value because this element can rely solely on the type of product being produced. “Development Risk” received no portion of its value because there is currently no certainty that this will become market ready. “Product Line Potential” received its full value because manufacturing is the process of making something that can be sold elsewhere for a profit. “Product Strategy” was given half its value because the plan to bring manufacturing in space into the market has not been completed.

The final analytical elements of the “Product Characteristics” analytical category were evaluated. Although manufacturing is well developed on Earth, the new types of manufacturing awards “Need” half its value. The customer does not need to understand how to manufacture in space to enjoy its products. The “Appearance” of the mechanisms to manufacture in space is irrelevant to the success of manufacturing in space.

“Durability” also received no portion of its value because replacements of worn tools will be necessary periodically. The “Compliment Other Products” element received its full value because manufacturing is the creation of other products.

A final score for the space category of manufacturing in space was calculated using weighted values of each analytical element from the score given to it. The category of manufacturing in space received a score of .522 out of 1, which is approximately 52%. Based on the standard of a 60% implying a successful space venture, it could be inferred that the manufacturing industry would likely be a failure in space at this time.

Satellites Evaluation

The space category of satellites was run through the model to determine how well it ranked against the other space categories. The first analytical category that satellites was tested against was “Competition.” Satellites received no points for “Existing Competition” because several satellites have already been developed. This would make it harder for a company to establish a new satellite unless it had a technological edge over the current satellites. It received all possible points in “New Competition” because the satellite market is already well developed. Satellites received all points in “Complementary Assets” since the knowledge and skills are known and other key technologies are at hand. It received no points in “Functional Performance” since it is dependent on how well the satellite operates. Satellites received no points in “Economic Environment” since the market is well defined and it would be difficult for a startup to establish itself. The full amount of points was given to satellites for “Price” since it will likely have a price advantage over its competitors. The space category did average in the analytical category of “Competition.”

This space category was then ranked according to the analytical category of "Technical." Satellites received all of the points in "Technical Feasibility" since it is expected that the technical solution will be based on known technology that is easily obtainable. The space category received no points in "Technology Significance" because there is only a small chance that the satellite will present new technology. Since there will not be much research and development left, satellites received all of the points in "Research and Development." Since the technical ability is already established, satellites again received all of the points for "Knowledge and Technical Ability." Satellites received all of the points for "Technology of Production" since the technology and skills to develop a satellite are easily available. It received all of the points in "Function" since satellites have the potential to work better than the alternatives as technology advances. Satellites received all of the points for "Existing Facilities/Resources" since few specialty parts are required to be built in order to create a satellite. Satellites only received half of the points for "Uses Environment to Advantage" because the satellite still needs to endure launch and other stresses before its final destination is reached. Once in its destination though, a satellite uses the Earth's orbit to its advantage. The space category of satellites scored well in this analytical category compared to the others.

This space category was also ranked in the analytical category of "Social." Satellites received all of the points in "Safety" because the actual satellite has a low likelihood of damaging or harming other objects or people. Since a satellite does not effect the environment once in space, it received all of the points for "Environmental Impact." Any satellite has the potential to benefit society, thus satellites received all of the points for "Societal Benefits." A satellite is expected to fit in with the current methods of doing things and thinking since there are already several satellites in orbit of Earth. Satellites received all of the points for “Compatibility.” Assuming that the data broadcast by the satellite is monitored, there should be no legal issues. Because of this, satellites received full points for “Legality.” Satellites received all of the points for “Protection” since all unique technology and methods will be protected from the competition through some means. Since there are few, if any, unintended consequences a satellite could produce, satellites received all of the points for “Unintended Consequences”. Satellites scored well in this analytical criteria category

This space category was then ranked in the analytical category of “Financial.” Because satellites and the infrastructure needed to build satellites are expensive, satellites only received half of the points for “Tooling Cost” and “Cost of Production.” Since a reasonable amount of money will be needed to invest in satellites compared with other space categories, satellites received all of the points for “Size of Investment.” A satellite can easily be positioned in the marketplace to target a wide range of customers, which means there will be a large potential for sales. Satellites received all of the points for “Potential Sales.” Compared to the other space categories, the payback period for satellites is much shorter. Because of this, satellites received all of the points for “Payback Period.” Satellites received all of the points for “Profitability” since the space category of satellites will have better profitability compared to other space categories. Satellites received all of the points for “Impact of Failure/Potential Liquidity” because it is expected the company can survive if a satellite malfunction does occur. Satellites did well in this analytical criteria category also.

This space category was then ranked in the analytical criteria category of "Marketing." Satellites received no points for "Promotion Cost" since a large amount of money is needed to promote a new satellite into the market considering how many similar satellite services there may already be. The marketing research needed to define the price in the market is expected to be small compared to the others due to many satellites already established. Satellites therefore received all of the points in "Marketing Research." Satellites received half of the points for "Distribution" since the distribution method needs to take into account the fragility of the satellite. Satellites received only half of points for "Trend of Demand" because there is already many companies producing satellites and steady high demand is not foreseeable. Since the demand is expected to continue for satellites for many years, satellites received all of the points for "Trend of Demand." Because many sectors can benefit from what satellites can provide, satellites received all of the points for "Potential Market." Satellites have a relatively high risk during development, thus the space category satellites only received half of the points for "Development Risk." Satellites received no points in "Product Line Potential" because it has little potential in creating a wide product line. Since satellites can easily be positioned and marketed to consumers, it received all of the points for "Product Strategy." Overall, satellites scored about average in the "Marketing" analytical category.

This space category was then ranked in the analytical category of "Product Characteristics." Satellites received only half of the points in "Need" since there is potential for other products or services to offer the same service for less money. Since it would be easy to learn how to incorporate a satellite in another service, satellites received all of the points for "Learning." It received none of the points for "Appearance" since the appearance of the satellite is not important in any part of its life. Satellites received all of the points for “Durability” because satellites are not expected to wear out or fail, but are more likely to become outdated. Since satellites can easily compliment other products such as cell phones, radio, and computers, it received all of the points for “Compliments Other Products.” Overall, satellites did average in this analytical category.

From the analysis done on the space category of satellites, it scored a .75. This means that a startup company in satellites would currently have the potential to be successful.

Transportation Evaluation

The space category of transportation was run through the model to determine how well it ranked against the other space categories. The first analytical category transportation was tested against was “Competition.” Transportation received all of the points for “Existing Competition” since there are currently few companies in the business of space transportation. It also received all of the points for “New Competition” because once the company establishes itself successfully, it is expected that few other startups will be successful. Transportation received no points for “Complementary Assets” since the startup would have to build the entire needed infrastructure. Transportation received all of the points for “Functional Performance” because the transportation system must work effectively and safely in order for the company to survive. It did not receive points in “Economic Environment” because the economy does not currently favor transportation due to high launch costs. Transportation also received no points in “Price” because launching costs will remain expensive for the foreseeable future unless a technological breakthrough occurs. Transportation did about average in this analytical category.

Transportation was then evaluated in the analytical criteria category of "Technical." Transportation received all of the points for "Technical Feasibility" because launching has been done for several decades. It also received all of the points for "Technology Significance" because a company would be offering a service that is limited to most people. Since there is some remaining research and development that needs to be done before a launch vehicle can be successfully built, transportation received only half of the points for "Research and Development." Transportation received all of the points for "Knowledge and Technical Ability" because there are engineers that already know how to accomplish the launching task. It received all of the points for "Technology of Production" since the knowledge and technology is available to accomplish the task of transportation. Transportation received all of the points for "Function" since it would have to be more efficient than any current transportation alternatives. It received only half of the points for "Existing Facilities/Resources" because some of the infrastructure needs to be built. Transportation received no points to "Uses Environment to Advantage" because it does not use the environment of space to its advantage. In this space category, transportation scored above average.

Transportation was then evaluated in the analytical criteria category of "Social." Transportation received only half of the points for "Safety" since major problems still occur with highly experienced groups that perform launches. It is expected that the company will not be able to match more experienced groups in terms of successful launching. Since a rocket pollutes the air during the launch and toxic chemicals may be used, transportation only received half of the points for "Environmental Impact." The benefit to society that an economical launching service would provide is great, thus transportation received all of the points for "Societal Benefits." Transportation received all of the points for "Compatibility" since it is expected that a launching service would fit in with the current method of doing things and thinking. It received all of the points in "Legality" because transportation and launching is currently done and does not break any applicable laws. Transportation received all of the points in "Protection" since the technology and methods developed can easily be protected from the competition. Since something can still go wrong unexpectedly that could result in human death or lost goods, transportation received only half of the points in "Unintended Consequences." Transportation scored above average in the analytical criteria category of "Social."

Transportation was then evaluated in the analytical category of "Financial." Transportation received no points for "Tooling Cost" since it is expected that there will be a great financial burden in building the infrastructure to build the launch vehicles. The cost of building a single launch vehicle is high at this moment, thus transportation received no points for "Cost of Production." Since a great deal of money will be required to be initially invested, it may be difficult obtain the money needed. Transportation received no points in "Size of Investment." Once a company establishes itself as a successful launch service provider, many other companies would likely want to utilize the launch services. Therefore, transportation received all of the points for "Potential Sales." Transportation received only half of the points for "Payback Period" because of the immense startup costs associated with launching and the costs to build the vehicle itself. It only received half of the points in "Profitability" because of the costs to maintain the service. Transportation received only half of the points for "Impact of Failure/Potential Liquidity" since a company's future would likely be jeopardized if a large enough failure were to occur. Transportation scored poorly in this analytical category. This may be the limiting category for the success of a startup company offering launch services.

Transportation was then evaluated in the analytical category of "Marketing." Transportation received half of the points for "Promotion Cost" since media coverage would initially help in making the company known. Since there is a large market that requires launching services, transportation received all of the points in "Marketing Research." Since the consumers would need to bring their items to the launch site, transportation received half of the points for "Distribution." Transportation received all of the points for "Trend of Demand" since the demand is expected to remain relatively steady for years to come. Transportation received all of the points for "Duration of Demand" since space travel is a large stepping stone in establishing other space categories like space mining. So a space transportation company would likely have demand for a long period of time. Since any space product other than launching requires some means of getting into space, there is a large market for transportation. Transportation therefore received all of the points for "Potential Market." It received half of the points for "Development Risk" because it is expected that development costs on a space vehicle would be high. Since there is some potential to lead to other markets and products, transportation received half of the points for "Product Line Potential." Since it will be relatively easy to position the service, transportation received all of the points for "Product Strategy." Transportation scored above average in this analytical category.

Transportation was then ranked in the analytical category of "Product Characteristics." Transportation is the next logical step in space technology because it is a foundation for several other space categories. Because of this, transportation received all of the points for "Need." Since there will be some required learning for potential customers, transportation received only half of the points for "Learning." Transportation received no points for "Appearance" since appearance does not matter if the launch vehicle puts an item into orbit or beyond. It is not known if the launch vehicle will be durable enough to be reused or not, thus transportation received no points for "Durability." Transportation received all of the points for "Compliments Other Products" since all other space categories require launch services.

Transportation scored a fair score of .59. This means that a startup company may have questionable success. This falls in line with the current status of space transportation. There are many startups that are into launch services, but few are having a high success rate.

Now that the space categories have been analyzed and given a score, a product from one of the space categories can be selected to be run through the space-based model. This is the second step in the two-step process of evaluating a space product. The AVStar satellite system, a system of satellites designed to give consumers an up to the moment video feed of Earth to gauge weather patterns, will be the product evaluated in the case study.

Chapter 5: Case Study

The second step of the two-step process is to evaluate a potential space product through the developed space-based model. The product selected to be evaluated through the model is the AVStar satellite system under development by AstroVision International Inc., a startup corporation with headquarters in Sydney, Australia.

Product Description

The AVStar satellite system consists of five satellites that will be placed in geostationary orbit, enabling the satellites to remain stationary over a certain position providing continuous coverage of the same location. The satellites are intended to update weather and other environmental images every second. These images will be broadcast in super high-definition, providing an image with eight times as many pixels as a high-definition image ("How it Works"). Each satellite has a total of seven cameras. Two narrow field cameras focus on locations with a range of 250 meters while a wide field camera identifies a specific area with a range of 2.75 kilometers. A multi-spectral camera will cover small bands across the near infrared, visible, and near ultraviolet. A low light level camera will be able to provide images of Earth at night. A lightning mapper camera detects lightning and turbulence. A thermal infrared camera will monitor temperature and clouds ("Cameras").

AstroVision is directing its service of the AVStar satellite system at a wide variety of industries, including energy, transportation, and insurance ("AstroVision: Executive Summary", 2002). These industries would likely be interested in the AVStar satellite system because, by comparison, the most technologically advanced satellite weather images provided by the government are low-quality, black and white, and can take up to fifteen minutes to broadcast for a location in the United States and up to three hours to broadcast for an image of Earth ("How it Works"). Every year, there is approximately $10 billion in damages from weather in the United States alone ("AstroVision: Executive Summary", 2002). An up to the moment awareness of weather patterns could give these industries the ability to make more accurate decisions and avoid costly damages. In a transportation company, for example, a plane could use this service to avoid potentially damaging or tragic weather conditions.

Other consumers that AstroVision is aiming the service at are media, websites, and wireless providers ("AstroVision: Executive Summary", 2002). AstroVision plans to provide its customers with images through cell phones, PDAs, television, and computers ("How it Works"). Media and websites would benefit from this service since they currently add computer graphics to enhance the low-quality images. By utilizing images provided by AVStar satellites, the media and websites could provide more accurate images without computer enhanced imagery since the quality of the images would be high enough so that the average person could distinguish geographical areas. Wireless providers could benefit from the service by bundling a cell phone with AVStar satellite video imagery of a given location.

Each of the five AVStar satellites will cost an estimated $50 million to develop, totaling $250 million ("AstroVision Raises Seed Capital To Begin AVStar System", 2000). The first satellite is planned to be launched in 2008 by means of an Ariane space rocket in French Guiana (Merrett, 2005). Along with providing images up to the second with a closest range of 250 meter resolution, the AVStar satellites can also collect temperature information within one degree Celsius and barometric pressure over water ("AstroVision: Executive Summary", 2002).

Competition

AVStar plans to compete with existing weather satellite services. AVStar has a large competitive edge over existing services by providing super high-definition quality images, up to the second image updates, and color images. This has an advantage over the images provided by government owned weather satellites since the quality of these images is lower, the delay between images is longer, and the images are in black and white. The AVStar satellite system also has an advantage over private remote sensing satellite companies. These companies provide images in color, but the delay between images is as long as a day or more ("How it Works"). After the AVStar satellite system has begun providing its service, new competitors would likely face difficulties establishing a service that could perform superiorly to the AVStar satellite system. Super high-definition quality is currently the best possible resolution and even if a weather satellite could perform faster image updates than one second, it would likely make an unnoticeable difference.

Technological Issues

There are some technological issues and issues of operating in space associated with the AVStar satellite system. Since the bandwidth for sending data is limited, the rate at which frames can be sent and their quality could become constrained in the future. A major issue of operating in space is maintenance. If one of the AVStar satellites malfunctions after being launched into space, there is little that can be done to solve the problem at a reasonable cost. If this happened to one of the AVStar satellites, the impact of failure would cost AstroVision $50 million and possibly royalties to contracted companies. However, it is unlikely that the malfunction of one satellite would cause AstroVision to go bankrupt since AstroVision plans to launch five satellites, not one. If all five satellites were operating, a possible solution would be to reposition the satellites to compensate for the malfunctioned satellite or to simply build a replacement satellite. This possible situation factors into the evaluation of the "Impact of Failure/Potential Liquidity" analytical element.

Methodology

The AVStar satellite system was evaluated by the developed space-based model to determine how potentially successful it would be as a space product. Similarly to how the space categories were evaluated in the previous chapter, each analytical element was give a score of 0, 0.5, or 1 depending on how well the AVStar satellite system performed for that element. A score of 0 represents a poor performance, a score of 0.5 represents an average performance, and a score of 1 represents a high quality performance in that analytical element. Based on the weighting system, a product score was given for the AVStar satellite system. The results are in Table 5.1.

Criteria	***Score***
Existing Competition	0.5
new Competition	1
Complimentary assets	0
Functional Performance	1
Economic Environment	1
Price	0
Technical	
Technical Feasibility	1
Technology Significance	0.5
Research and Development	1
Knowledge and Technical Ability	0.5
Technology of Production	1
Function	1
Existing Facilities/Resources	0

Uses Environment to Advantage	1
Social	
Safety	1
Environmental Impact	1
Societal Benefits	1
Compatibility	1
Legality	1
Protection (Overall, informal, formal)	0
Unintended Consequences	1
Financial	
Tooling Cost	0.5
Cost of Production	0.5
Size of Investment	0
Potential Sales	1
Payback Period	0.5
Profitability	0.5
Impact of Failure/Potential Liquidity	0.5
Marketing	
Promotion Cost	0
Marketing Research	0.5
Distribution	0.5
Trend of Demand	0.5
Duration of Demand	1
Potential Market	1
Development Risk	1
Product Line Potential	0
Product Strategy	1
Product Characteristics	
Need	0.5
Learning	1
Appearance	1
Durability	0.5
Compliment Other Products	0.5
Other Venture Capitalist Criteria	
Enthusiasm of Entrepreneur	1
Trustworthiness of Entrepreneur	1
Expertise of Entrepreneur	1
Investor Liked Entrepreneur upon Meeting	0.5
Track Record of Entrepreneur	0
Possibility of Investor's Involvement in Business Development	0

Product Scores	
Space-Based Model	0.683
Venture Capitalist	0.609

Table 5.1

Score Reasoning

Existing Competition: .5: The current competition is the commercial remote sensing satellite companies as well as the technologically advanced satellites owned by the government. AVStar satellite images have an advantage over both of the satellite images of the competition, but the government satellites are well-established.

New Competition: 1: By the time the AVStar satellite system is established, any new competition will have difficulty providing better service since the AVStar satellites provide the most advanced imaging contemporarily available.

Complementary Assets: 0: AstroVision will need outside contractors to get the AVStar satellite system operational, including manufacturers, launch companies, and wireless providers.

Functional Performance: 1: By providing super high-definition imaging up to the second, the AVStar satellite system produces quality results.

Economic Environment: 1: The economic environment currently favors AstroVision establishing the AVStar satellite system because of competitive edge and state of economy.

Price: 0: The prices that AVStar plans to charge its consumers is unknown.

Technical Feasibility: 1: The technology is currently available to build the AVStar satellites and to launch them into geostationary orbit.

Technology Significance: 0.5: The most notable technological advancement is in the quality of cameras and the frame rate of the images, which is more advanced than the government owned satellites and current commercial satellites.

Research and Development: 1: The key aspects and technologies have already been developed for the AVStar satellites. There is not a significant amount of research remaining to complete the satellites.

Knowledge and Technical Ability: 0.5: AstroVision has been working on the AVStar satellites for nine years and their management team has over 150 years of experience combined ("Team Members").

Technology of Production: 1: The technology and skills needed to develop and make the AVStar satellite system operational are available.

Function: 1: The AVStar satellite system provides higher quality image resolution and provides images with only a one second delay. The current competition does not have as high quality images as the AVStar satellites and the delay between images is at least ten minutes.

Existing Facilities / Resources: 0: There are no preexisting resources to build upon to develop the AVStar satellites.

Uses Environment to Advantage: 1: The AVStar satellites take advantage of geostationary orbit to remain in a fixed location while providing images of Earth.

Safety: 1: There is not any notable safety risk of the AVStar satellite system in geostationary orbit.

Environmental Impact: 1: The AVStar satellites do not pose any harm to the Earth environment or space environment.

Societal Benefits: 1: By being able to give real-time images of Earth, the AVStar satellites will allow companies to make more accurate decisions. This is because the AVStar satellites will allow people to see storms, tornados, and other environmental phenomenon approaching earlier than current satellites. This could not only help in decision making, but also in saving many lives.

Compatibility: 1: The AVStar appears to be acceptable by societal standards.

Legality: 1: AstroVision is complying with all applicable national and international laws.

Protection: 0: The technology of the camera systems is not patented by AstroVision, but AstroVision does hold patents for market research and pricing models ("AstroVision: Executive Summary", 2002).

Unintended Consequences: 1: There does not seem to be any consequences that could result from the establishment of the AVStar satellites.

Tooling Cost: .5: The AVStar satellites will cost a total of $250 million, but because of the large potential market, the profit could overcome the tooling cost.

Cost of Production: .5: To build the AVStar satellites, it will cost $50 million each.

Size of Investment: 0: The size of the investment is $250 million alone for producing the five AVStar satellites. Land stations, launch costs, salaries, licenses, and other factors make the total size of investment exceptionally high.

Potential Sales: 1: There are several industries that could make great use of a tool that would allow them to observe up to the moment incoming weather. There also appears to be a high interest in weather since there are 72 million subscribers to the Weather Channel alone (Motta, 2000). Many people would likely find great interest in a service on their PDAs or cell phones that would allow them to see incoming storm fronts and other up to the second weather.

Payback Period: .5: Because of investment size, it will take a considerable amount of time for AstroVision to payback its loans.

Profitability: .5: It is likely that the AVStar satellite system would produce more profit than its competition. Because of improvement in frame rate, more companies would be interested in having the technology accessible.

Impact of Failure/Potential Liquidity: .5: If the first satellite launched was to malfunction while in space before any of the other satellites launched, then AstroVision would likely encounter some problems. If there were contract obligations to begin service as soon as the first satellite was launched into space, then AstroVision would likely be faced with legal issues because of an unfulfilling service. If, on the other hand, a satellite other than the first was to malfunction, then the other satellites already in geostationary orbit could be repositioned to compensate for the malfunctioned satellite. Though it would be costly, AstroVision would at least be able to still broadcast images from space.

Promotion Cost: 0: The AVStar system is not the type of product that is revolutionary enough to require little or no promoting. Also considering how well-established the current system of obtaining weather images is, AstroVision will need to promote its AVStar satellites to convince companies that it is the superior product.

Marketing Research: .5: Considering the AVStar satellite images are of superior quality in every facet compared to the current competition, it is obvious that the price will be higher than that of the competition. Thus, the effort in establishing a price range to account for the investment size would not be difficult.

Distribution: .5: Distributing the satellite images to a PDA or a cell phone may be a technical feat, but will not be difficult once the infrastructure has been established.

Trend of Demand: 1: Considering the higher quality imagery, the trend of demand should be consistent.

Duration of Demand: 1: Super high-definition is the current forerunner of resolution quality. Also, a one second delay and a one-half second delay make little difference when tracking weather patterns. Therefore, it is likely that the AVStar satellite system will stay in demand for a long period of time.

Potential Market: 1: There are several companies interested in a high resolution and up to the second weather imaging service such as transportation companies and media.

Development Risk: 1: In the AVStar satellite system, the development risk is small because most of their technology is already completed and any further development is expected to be straightforward.

Product Line Potential: 0: The AVStar satellite system does not appear to open any new doors to innovation or new products.

Product Strategy: 1: The strategy of AstroVision has been well developed, including the satellite launching process.

Need: .5: The AVStar satellite system has the potential to save lives from storms and other destructive weather phenomena through its up to date weather image processing.

Learning: 1: Potentially, the consumer should only have to install a program on an electronic device and access it from there. In all likelihood, this will be a simplistic process.

Appearance: 1: The images are high resolution compared to existing competition.

Durability: .5: Satellites are usually damaged at launch or make it safely into orbit with no damage and remain operational for an extensive period of time.

Compliment Other Products: .5: With potential to be put on consumer owned electronic devices such as cell phones and PDAs, the AVStar satellite system could compliment other products.

Enthusiasm of Entrepreneur: 1: AstroVision is highly enthusiastic that the AVStar satellite will become the new standard for satellite imagery with high resolution images and up to the second coverage.

Trustworthiness of Entrepreneur: 1: Because of the management team's involvement in many operations such as SpaceVest, the entrepreneur is a reliable company ("Team Members").

Expertise of Entrepreneur: 1: The management team of AstroVision has over 150 years of experience.

Investor Liked Entrepreneur upon Meeting: .5: The government provided $5 million to AstroVision to help obtain patents, pay for licenses, and design systems. Through this is not a substantially large amount for a project with such a large investment size, it is still significant that the government supports AstroVision.

Track Record of Entrepreneur: 0: AstroVision does not hold a strong track record as the AVStar satellite system is one of their first major products.

Possibility of Investor's Involvement in Business Development: 0: The investor will only give money and will not contribute to the development of the AVStar satellite system.

The AVStar satellite system had a product score of .683. This product score was averaged with the satellite space category score to produce an overall score of .717. This score concludes that this product has potential to be successful.

Chapter 6: Conclusion

Discussion

In the evaluation of the AVStar satellite system, the overall score given was a 0.717 and was considered a potentially successful product.

In the space category evaluations and the product evaluations, a score higher than .60 was considered potentially successful.

The space category score was derived by simply evaluating it with the space-based model. The overall score of the AVStar satellite system, on the other hand, was derived by averaging the space category score with the score the product received when it was evaluated through the model.

The significance of the overall score that a product receives can be better explained by having score intervals with corresponding meanings. The intervals and their meanings were based on the results of the space categories being evaluated by the space-based model. An overall score of .599 or less would mean that the product is unlikely to be successful. A score between .600 and .649 would mean that the product has a borderline certainty of being successful. A score between .650 and .749 would mean that the product has an average likeliness of being successful. A score between .750 and .849 would mean that the product is likely to be successful. A score between .850 and .949 would mean that the product is highly likely to be successful. A score above .95 would mean that the product is exceptionally likely to be successful. These scores and their meanings can be seen in Table 6.1.

Score Range	Likeliness of Being Successful
.599 or less	Unlikely
.600 to .649	Borderline likeliness
.650 to .749	Average likeliness
.750 to .849	Likely
.850 to .949	Highly likely
.95 or more	Exceptionally likely

Table 6.1

Despite the venture capitalist model and space-based model having different rankings and some unique analytical elements, there are several similarities and differences between the two models.

"Size of Investment" was one analytical element that varied greatly in terms of weight between the two models. This can be explained since the investment size for a space venture would be higher than a venture capitalist venture because of launch costs and higher development costs.

"Compliment Other Products" is another analytical element that had a significant difference in weight between the two models. This is appropriate since the space market is smaller than the earthbound market, making it unlikely for a product in space to compliment another product.

"Duration of Demand" is an analytical element that had similar weight between the two models. Regardless of market, the demand for a noteworthy product would be long term. "Need" is another analytical element with similar weighting between the space-based model and venture capitalist model. Similar to "Duration of Demand," the type of market does not matter if the product is significant enough to supply the needs or desires of consumers. The similarity in weights between the two models is likely due to analytical elements having similar importance in any market setting. This suggests that the weighting system for the two models is sound. In addition to the weight differences and similarities, the venture capitalist model does not take into account any of the technical attributes of the product and the space-based model does not take into account any of the entrepreneurial attributes.

Future Work

When reviewing the various sections of the methodology, there appears to be several concepts that could be built upon.

The most obvious extension is to evaluate additional past and present space products through the space-based model developed. By evaluating more services and products, future students could develop a more sound system of assigning score intervals and meanings.

In addition, future students could add more analytical elements to the space-based model to increase the accuracy of the model. Also, future students could rework the rankings of the analytical elements to apply to a more contemporary context or enhance the weighting system used.

Another idea for future students would be to consider space categories that were not included in this report. One such space category that could be considered is spin-offs, which are products used in earthbound businesses that were originally intended for use in space. Spin-offs were not incorporated as a space category in this project because they were not considered to be products or services physically in space. Perhaps future students could make a case against this statement and evaluate spin-offs as a space category through the model to determine if spin-offs should or should not be considered space products.

The role of governments in the space industry was not considered in this project. An extension of this project could be made to evaluate the impact that governments have on the commercialization of space. The impact of the governments on current space commercialization can also be evaluated in terms of whether they are helping or harming the commercialization of space.

Bibliography

Abitzsch S. and Eilingsfeld F. “The Prospects for Space Tourism.” *SPACE FUTURE*, 1992. http://www.spacefuture.com/archive/investigation_on_the_economic_and_technological_feasibiity_of_commercial_passenger_transportation_into_leo.shtml. 19 September, 2005.

“About the CRESS Project.” *CRESS Project*, February 2002. http://www.geog.umd.edu/cress/about.htm. 7 September, 2005.

“About Us.” *DIGITALGLOBE*. http://www.digitalglobe.com/about/index.shtml. 5 September 2005.

"Asteroid Mining." *Answers.com*. http://www.answers.com/topic/asteroid-mining. 5 September 2005.

Astrebo, Thomas. “Key Success Factors for R&D Project Commercialization.” *University of Waterloo*, Jan. 2003. http://www.rotman.utoronto.ca/bicpapers/pdf/03-07.pdf. 24 October, 2005.

“AstroVision: Executive Summary.” *AstroVision.com.* 6 January 2002. http://www.astrovision.com/business/ExecSummary.pdf. 18 January, 2006.

“AstroVision Raises Seed Captial To Begin AVStar System.” *SpaceandTech.com.* 19 June 2000. http://www.spaceand tech.com/digest/sd2000-15/sd2000-15-003.shtml. 19 January 2006.

Bromberg, Joan Lisa. NASA and the Space Industry. Baltimore: John Hopkins University Press, 1999.

“Cameras.” *AstroVision.com.* http://www.astrovision.com/business/cameras.html. 21 January, 2006.

“Career Profiles.” *The Princeton Review*. http://www.princetonreview.com/cte/profiles/dayInLife.asp?careerID=214. 29 November, 2005.

Chapman, Philip K. "The Failure of NASA: And a Way Out." *SpaceDaily*, 30 May 2003. http://www.spacedaily.com/news/oped-03zn1.html. 14 September, 2005.

Clark, Stephen. “Ariane 5 rocket gives weighty cargo ride into orbit.” *Spaceflight Now*, 11 August 2005. http://www.spaceflightnow.com/ariane/v166/. 7 September, 2005.

“Commerce.” *Dictionary.com*, 2005. http://dictionary.reference.com/search?q=commerce. 29 Aug. 2005.

“Commercialization.” *Dictionary.com*, 2005. http://dictionary.reference.com/search?q=commercialization. 22 September, 2005.

“Commercialization Process.” *RPITechnology.com*, 2005. http://www.rpitechnology.com/?action=static&page=CommercializationProcess. 24 September, 2005.

Coren, Michael. "Private craft soars into space, history.". *CNN.com*. 14 July 2004. http://www.cnn.com/2004/TECH/space/06/21/suborbital.test/. 7 September, 2005.

Crawford, Alan Pell. “Policy Analysis: An “Industrial Policy” for Space?” *cato.org*, 25 April, 1986. http://www.cato.org/pub_display.php?pub_id=935&full=1. 25 September, 2005.

Dailey, Brian. “Space Commercialization Act of 1996: Hearing.” *House.gov*, 13 July 1996. http://www.house.gov/science/brian_dailey.htm. 20 September, 2005.

David, Leonard. "Creating Commercial Spacecraft for Space Tourism." *SPACE.com*, 27 November 2002. http://www.space.com/businesstechnology/technology/tourism_spacecraft_021127.html. 26 September, 2005.

David, Leonard. "Six Wheels on Mars! Spirit Free to Roam." *SPACE*.com, 15 January 2004. http://www.space.com/missionlaunches/spirit_rolling_040115.html. 5 September, 2005.

Day, Dwayne. “The Feminization of American Space Policy.” *The Space Review*, 12 April 2004. http://www.thespacereview.com/article/130/1. 25 September, 2005.

Day, Dwayne A. "The thin line between success and catastrophe." *The Space Review*, 1 March 2004. http://www.thespacereview.com/article/108/1. 21 September, 2005.

Dinerman, Taylor. “Beaver pelts, communication satellites, and space exploration.” *The Space Review*, 15 March 2004, http://www.thespacereview.com/article/114/1. 7 September, 2005.

Dinkin, Sam. "Dividing up the spoils." *The Space Review*, 6 June 2005. http://www.thespacereview.com/article/386/1. 26 September, 2005.

Dinkin, Sam. "Property rights and space commercialization." *The Space Review*, 10 May 2004. http://www.thespacereview.com/article/141/1. 14 September, 2005.

Dinkin, Sam. “The Most Important in Situ Resource is Money.” *The Space Review*, 12 September 2005. http://www.thespacereview.com/article/451/1. 22 September, 2005.

"Earth and Planetary Remote Sensing." 1 August 2005. http://www.gi.alaska.edu/remsense/. 7 September, 2005.

"Electrophoresis." *Dictionary.com*, 2005. http://dictionary.reference.com/search?q=electrophoresis. 6 September, 2005.

Foust, Jeff. "Is There a Business Case for RLVs." *The Space Review*, 2 September 2003. http://www.thespacereview.com/article/44/1 25. Sept. 2005.

Foust, Jeff. "Space Commercialization: the view from 1966." *The Space Review*, 22 March 2004. http://www.thespacereview.com/article/117/1. 14 September, 2005.

Gans, Joshua S. and Stern, Scott. "The Product and the market of "ideas": commercialization strategies for technology entrepreneurs." *Melbourne Business* School, 2002. http://www.mbs.edu/downloads/emba/Gans%20&%20Stern.pdf. 25 September, 2005.

"Geospatial Services." *MDA*. http://www.rsi.ca/. 7 September, 2005.

Goldman, C. Nathan. *Space Commerce: Free Enterprise on the High Frontier*. Cambridge: Ballinger Publishing Company, 1985.

Goodrich, N. Jonathan. *The Commercialization of Outer Space: Opportunities and Obstacles for American Business*. New York: Quorum Books, 1989.

Henos, Michael. "The Road to Venture Financing." *Alliance Technology Ventures,* 1991. http://www.atv.com/static/road_to_venture.php3. 29 November, 2005

Hertzfeld, Henry. "Testimony of Henry R. Hertzfeld Jr.: The Commercial Space Act of 2003." *SpaceRef.com*, 5 November 2003. http://www.spaceref.com/news/viewsr.html?pid=10910. 11 December, 2005.

Hoffert M. and Potter D. "Beam it Down: How the New Satellites Can Power the World." *SPACE FUTURE*, October 1997. http://www.spacefuture.com/archive/beam_it_down_how_the_new_satellites_can_power_the_world.shtml. 5 September, 2005.

"How it Works." *AstroVision.* http://www.astrovision.com/business/howworks.html. 19 January, 2006

"Internet Money Sources." *Speedyadverts.com*, 2000. http://www.speedyadverts.com/SABusiness/BusinessGuides/internetmoneysources.pdf. 29 November, 2005.

"Introduction - What is Space Tourism?" *SPACE FUTURE*. http://www.spacefuture.com/tourism/introduction.shtml. 7 September, 2005.

"Investment Selection Criteria." *1000ventures.com*. http://1000ventures.com/venture_financing/investcriteria_bavc_hbs.html. 29 November, 2005

Jobes, Douglas O. "Will government-sponsored space prizes fly?" *The Space Review*, 15 November 2004. http://www.thespacereview.com/article/270/1. 25 September, 2005

Jolly, Vijay K. Commercializing New Technologies. Boston: Harvard Business School Press, 1997.

Kay, W. D. "Space Policy Redefined: The Reagan Administration and the Commercialization of Space." *H*-Net, 1998. http://www.h-net.org/~business/bhcweb/publications/BEHprint/v027n1/p0237-p0247.pdf. 18 Sept. 2005

Kingdon, Jim. "Space Manufacturing." http://www.panix.com/~kingdon/space/manuf.html. 6 September, 2005.

Livingston, David M. "$pace: The Final Financial Frontier." *SPACE FUTURE,* 2000. http://www.spacefuture.com/archive/space_the_final_financial_frontier.shtml. 29 November, 2005.

Livingston, David M. "The Ethical Commercialization of Outer Space." *SPACE FUTURE*, 14 August 1999. http://www.spacefuture.com/archive/the_ethical_commercialization_of_outer_space.shtml. 14 September, 2005.

Livingston, M. David. "The Obstacles to Financing New Space Industries." *SPACE FUTURE*, 13 August 1999. http://www.spacefuture.com/archive/the_obstacles_to_financing_new_space_industries.shtml. 29 August, 2005

"Lunar Mineralogy." *The EUORMIN Project*. http://euromin.w3sites.net/Nouveau_site/gisements/extra/GISEXTe.htm. 5 September, 2005.

MacKenzie, A.J. "Tax Policy and Space Commercialization." *The Space Review*, 10 January 2005. http://www.thespacereview.com/article/300/1. 1 September, 2005.

Massow, Dr. Micheael. "Space-Based Biomedical Opportunities at MEDICA." *European Space Agency*, 7 December 2005. http://www.esa.int/esaHS/SEMVFKTLWFE_index_0.html. 14 November, 2005.

Merrett, Nick. "AstroVision Sees Bright Future in Asia." *Terradaily.com.* 10 November 2005. http://www.terradaily.com/news/eo-05zzzzzzb.html. 21 January, 2006.

Motta, Mary. "Planet Video: AstroVision Plans Constant Eye on Earth." 13 June 2000. http://www.space.com/businesstechnology/business/astrovision_000613.html. 21 January, 2006.

Narayan, Ramani. “Commercializing Technology: From Laboratory to the Marketplace.” *Michigan State University*, May 1997. http://www.msu.edu/user/narayan/commercializingstarchplastics.htm. 19 September, 2005.

“Orbital Receives Contract For Horizons-2 Commercial Communications Satellite.” *SpaceRef.com*, 31 August 2005. http://www.spaceref.com/news/viewpr.html?pid=17692. September 7, 2005.

Phillips, Kim. “Manufacturing in Space.”*University of Alaska*. http://ffden-2.phys.uaf.edu/212_fall2003.web.dir/Kim_Phillips/index.html. 6 September, 2005.

Piland, William M. "Commercialization of the Space Frontier." *Langley's Digital Library Repository*, 6 October 1997. http://library-dspace.larc.nasa.gov/dspace/jsp/bitstream/2002/11301/1/NASA-97-48iac-wmp.pdf. 26 September, 2005.

Prado, Mark. “The Space Environment and Manufacturing -- Advantages and Disadvantages.” *Permanent,* 2002. http://www.permanent.com/i-sp-env.htm. 10 December, 2005.

Price, Steve. “Beam it Down, Scotty!” *Science@Nasa*, 23 March 2001. http://science.nasa.gov/headlines/y2001/ast23mar_1.htm. 5 September, 2005

“Remote Sensing.” *GIS Development*, http://www.gisdevelopment.net/tutorials/tuman008.htm. 7 September, 2005.

Sietzen, Frank Jr. “Space Launch Startups Worry About ‘Iridium’ Effect.” *SPACE.com*, 1 September 1999. http://www.space.com/missionlaunches/launches/iridium_effect.html. 29 November, 2005.

“Solar-Power Satellites.” *IEEE Virtual Museum*, 1 September 1999. http://www.ieee-virtual-museum.org/collection/tech.php?taid=&id=2345888&lid=1. 5 September, 2005.

“Sputnik 2.” *NSSDC Master Catalog Display*. http://nssdc.gsfc.nasa.gov/nmc/tmp/1957-002A.html. 4 February 2006

“Team Members.” *AstroVision.com.* http://astrovision.com/team.html. 21 January, 2006.

Vane, Charles. “Spaceport New Mexico and the X Prize Cup.” *The Space Review*, 2 May 2005. http://www.thespacereview.com/article/366/1. 25 September, 2005.

Vercheval J. and Steegmans A. “Space Balances (as of Dec. 31,2002).” *Belgian Institute for Space Aeronomy*. 31 December 2002. http://www.oma.be/BIRA-IASB/Public/PubServ/Astronautics/results/Results.en.html. 29 August, 2005.

Wakefield, Julie. "Researches and space enthusiasts see helium-3 as the perfect fuel source." *SPACE.com*, 30 June 2000. http://www.space.com/scienceastronomy/helium3_000630.html. 5 September, 2005.

Whalen, David J. “Communications Satellites: Making the Global Village Possible.” *NASA History Division*. http://www.hq.nasa.gov/office/pao/History/satcomhistory.html. 7 September, 2005.

“What Do Capitalists Look for?” *All Business*. 2005. http://www.allbusiness.com/articles/FinanceAccounting/454-32-1858.html. 29 November, 2005.