Futron

NASA ASCENT Study Final Report

Volume II – Appendices

31 Jan. 2003

ASCENT Study Final Report – Volume II: Appendices

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1. Definitions and Acronyms

Acronyms

ASCENT – Analysis of Space Concepts Enabled by New Transportation

CSTS – Commercial Space Transportation Study

ELV – Expendable Launch Vehicle

EOL – End of Life

FUD – Fundamental Unit of Demand

GEO – Geosynchronous Earth Orbit

GTO – Geosynchronous Transfer Orbit

IR&D – Independent Research and Development

ISDN – Integrated Services Digital Network

ISP – Internet Service Provider

ISS – International Space Station

LEO – Low Earth Orbit

NAICS – North American Industrial Classification System

NGSO – Non-Geosynchronous Orbit

OOM – On-Orbit Matrix

PST – Public Space Travel

RLV – Reusable Launch Vehicle

SLI – Space Launch Initiative

SME – Small to Medium Enterprise

SOHO – Small Office/ Home Office

SSP – Space Solar Power

VSAT – Very Small Aperture Terminal

Definitions

Business Models - The relationship between costs and revenues for a business operating within a market sector.

Conceptual Model - An initial approach to the design of a demand-forecasting model for a commercial market sector, which reflects an understanding of the underlying business approach for the sector.

Contacts Database - The repository of contact information collected during the ASCENT Study related to data collection sources.

Demand-Based - Refers to a forecasting method or model; estimates of future launches are derived from an analysis of the need for basic end-user services, e.g., for minute of telephone usage.

Emerging Market - Potential commercial space markets whose initial start date is not expected before 2021.

End-User – Refers to the entity or entities that demand a service being offered that relies to some degree on a space infrastructure, e.g., a viewer of TV program.

Evolving Market - A potential commercial space market that has just begun, or one that has a possibility of coming into existence before 2021.

Existing Market - A commercial space market that has been producing revenues for a decade or more prior to 2001.

First Order Impacts (of Price Change) - Changes in the quantity of demand resulting from incremental changes in the price (e.g., of a launch), as prescribed by classical economic theory.

Fisher-Pry - A formulation of the logistic or S- curve that is particularly useful for forecasting the developments of future markets.

Fundamental Unit of Demand (FUD) - The element that is the most appropriate basis, in any given end-user market, for measuring use of the service.

Ground Segment - The elements of terrestrial infrastructure that are needed to support any given space application. Examples are control stations, earth stations and user terminals.

Initial Pricing - The set of prices that represent the cost of getting into orbit in 2001, and which vary from market segment to market segment.

Interviews Database - The repository of information collected during the ASCENT Study that records the interviews conducted to aid in demand modeling.

Launch Price Gearing Factor - A concept developed during the ASCENT Study to explain the relationship between launch price changes and any impact at the end-user level. A low-geared market, such as telephony markets, receives little benefit from launch price changes. Highly geared markets receive demand stimulation from launch price reductions.

Market -

Available - Represents the ceiling on the demand that would be achievable assuming a product or service could be offered at zero price.

Market - Potential – Represents the maximum level of the available market if there were no regulatory, political or access constraints for the product or service. Above the potential market ceiling there is no interest in the product or service.

Market - Saturation – Represents a theoretical limit to demand at any given price level for a product or service. In practice, the market demand approaches the saturation level yet never actually reaches it (due to the time needed to obtain the last marginal customers).

Market - Target – At any given price, a target market may be defined by the take-up or S-curve that leads ultimately to the saturation level. The Fisher-Pry equation allows the curve to be derived, knowing the target market and the time to reach market saturation at a given price.

Mass Classes - A classification scheme formulated by the FAA that assists in the planning and marketing of launch vehicles (see below).

Mission Model - A source of planning assumptions for launches in the civil and military government sectors. A set of planning documents that record a country's plans for space hardware, services and launch requirements. Usually augmented by data from conferences and press reports.

Multi-manifesting - Describes the situation when more than one payload is placed in orbit from a single launch vehicle.

Operator Types - In the ASCENT Study Market Share Model, there are groupings of satellite service operators who share the same weighting factors in the launch vehicle selection algorithm, e.g., entrepreneurial commercial operators put less emphasis on reliability, and more on price factors.

Operational Models - Somewhat akin to the conceptual model from the commercial sectors, this term is applied to government sectors and helps in defining the respective sectors to avoid double counting of demand.

Payload - For the ASCENT Study, this term is used exclusively in reference to the spacecraft that is launched to provide a service for a given market sector. In the ASCENT Study, demand is first calculated at the FUD level, and then these demand elements are aggregated into payloads, based on known and projected satellite technologies. (Not to be confused with the terminology in the satellite manufacturing business, which refers to the payload as part of the spacecraft).

Price Elasticity of Demand - The amount of change of demand for any product or service that results from a unit change in the price of the service. In the ASCENT Study there has been a careful separation of two different price elasticities of demand. One of them in the degree to which end-user demand varies when end-user prices change; the other is the degree to which launch vehicle demand changes when launch vehicle price are reduced. For any given sector, these two different elasticities are linked together by the gearing factor for that sector.

Primary Research - This refers to market research that is conducted for an express purpose, usually by interviewing or surveying individuals to obtain their knowledge and opinions.

S-Curve - This is a standard formulation of the way in which new markets develop. Initial growth is slow because of supply constraints and the need to find the early adopters of a product or service at a given price. Then the rate of uptake increases as the product or service moves into the mainstream, and early supply constraints are removed. Finally the rate of growth tails off as it becomes increasingly difficult to find marginal customers still willing to pay the price for the product or service.

Secondary Research - This refers to market research that can usually be carried out using existing sources of data such as documents, internet sites, and can be carried out as a consequence by desk research.

Second Gen RLV - This refers to a planned follow-on to the Space Shuttle that was undergoing preliminary architecture evaluation as part of the Space Launch Initiative (SLI) during the course of the ASCENT Study. It was intended to be human-rated and fully reusable and have a ten-fold improvement in reliability over the space shuttle, and be capable of delivering payloads to low earth orbit (LEO) at a price of around $1000/lb.

Second Order Impacts (of Price Change) - Considered to be potential major impacts of dramatic price changes that could result from introducing an RLV into the marketplace. Such changes would be in addition to first-order impacts and could include e.g., a total redesign of payloads and a re-structuring of the competitive marketplace. Such changes are not quantified in the ASCENT Study forecasts.

Source Summary Database - The repository of information collected during the ASCENT Study that summarizes the various data source documentation.

Space Segment - The elements of the space infrastructure that are needed to support any given space application (e.g., spacecraft, tugs, depots). For the purposes of the ASCENT Study, the term is used to refer to all of the payload elements that are placed in orbit by the launch vehicle (and therefore not the launch vehicles themselves).

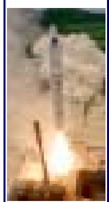
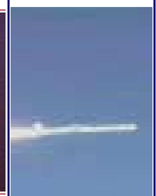
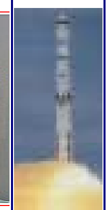
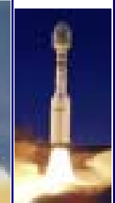
Start Year - For Evolving Markets this refers to the year in which launches are expected to commence. For Emerging Markets it is assumed in the ASCENT Study that start dates will be later than 2021. For Existing markets the start year is a matter of historical fact, which nevertheless helps define the parameters of the associated market sector S-curve.

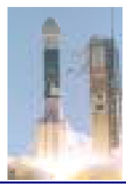
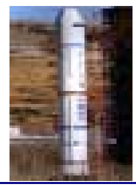
Supply-based – Refers to a forecasting method or model; estimates of future launches are derived by aggregating the demand predictions from a number of constituent governments' mission models. Used in the ASCENT Study for all government sector forecasts.

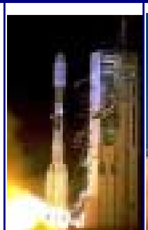
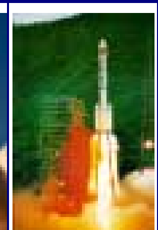
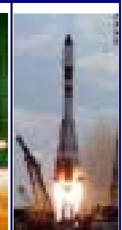
Survey Database - The repository of information collected during the ASCENT Study related to surveys that were conducted to determine demand indications.

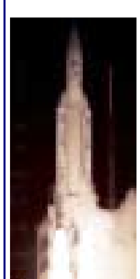
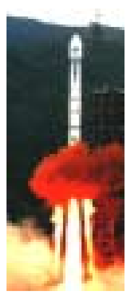
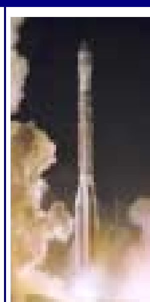
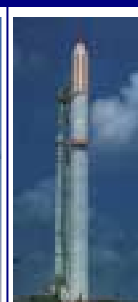
Take-up Curve - See S-curve.

Mass Class Charts (with sample launchers)

Launch Vehicle Mass Class: Small							
Capacity to LEO: 0-5000 lbs							
Vehicle name	Athena 2	Cosmos	Pegasus XL	Rockot	Shtil	START	Taurus
Country/Region of origin	USA	Russia	USA	Russia	Russia	Russia	USA

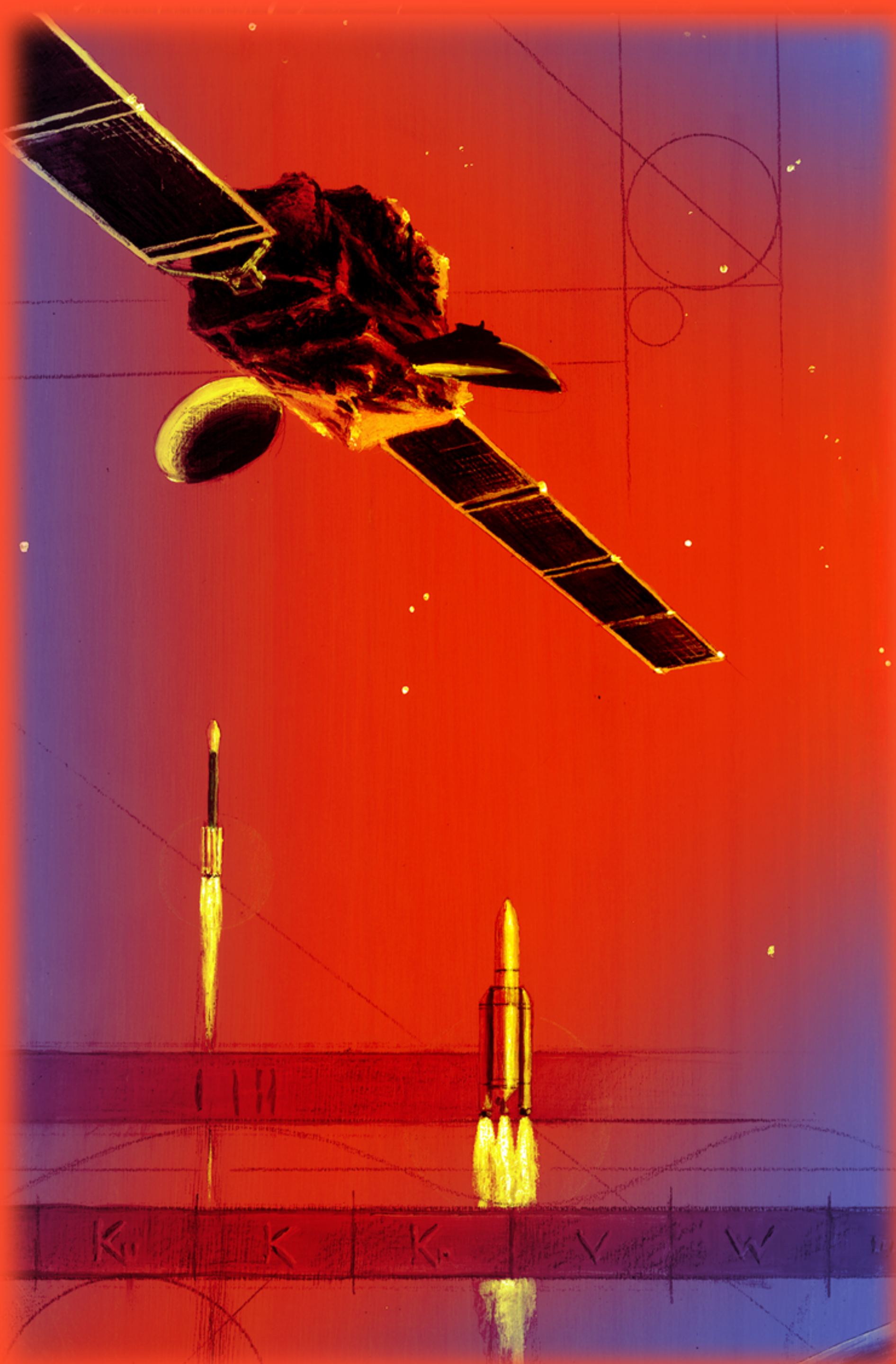
Launch Vehicle Mass Class: Medium			
Capacity to LEO: 5001 - 12000 lbs			
Vehicle name	Delta 2 (7920)	Dnepr	Long March 2C
Country/Region of origin	USA	Russia	China

Launch Vehicle Mass Class: Intermediate				
Capacity to LEO: 12001-25000 lbs				
Vehicle name	Ariane 44L	Atlas 2AS	Long March 2E	Soyuz
Country/Region of origin	Europe	USA	China	Russia

Launch Vehicle Mass Class: Heavy						
Capacity to LEO: 25001+ lbs						
Vehicle name	Ariane 5G	Long March 3B	Proton	Space Shuttle	Zenit 2	Zenit 3SL
Country/Region of origin	Europe	China	Russia	USA	Ukraine	Multinational

2. Sector Synopses

2.1 Existing Commercial Market Sectors



Commercial Market Sectors (Existing)

Sector 2.1.1: Telephony

Market Sector Description and Overview

The transition of telephony traffic (including fax and modem over ordinary telephone lines) via satellite to either augment terrestrial telephony infrastructures or provide telephone service to fixed and mobile end-users. Note: includes GEO and NGSO. Government use of commercial services is also included in this market.

Economics (U.S. Only)

NAICS Code: 51 **Industry Sector:** Information

Size of terrestrial sector: $5.10 B[1]

Sample Business Model

This is a well-established business sector with international company involvement, financing and end users.

Historical and Base Year (2001) Data

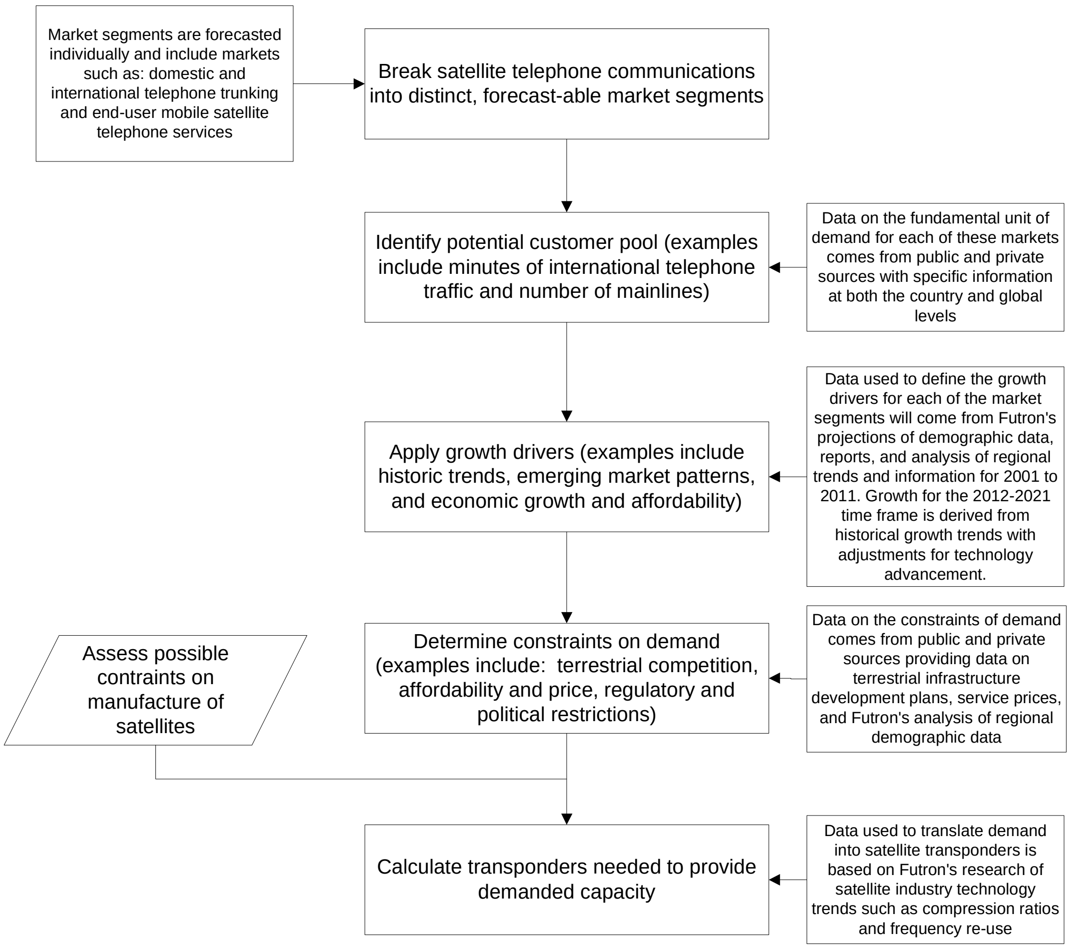
Satellite telephony began in 1965 and still represents a significant percentage of commercial space markets. In the base year (2001), the percentage was 16%.

Terrestrial Competitive Sector Information

The most important factor in determining demand for satellite telephony is the availability of terrestrial connections: fiber-optic undersea/terrestrial cables and national infrastructure for trunking services; and pay phones, mainlines, and mobile telephone infrastructure for end-user services. For the long history of satellite telephony, satellites have been used predominantly when terrestrial options were not available. The ASCENT Study forecast remains consistent with this underlying assumption.

1 U.S. Census Bureau, 1997 Economic Census: Information, Table 1: Summary Statistics for the United States: Satellite Telecommunications. http://www.census.gov/prod/ec97/97s51-sm.pdf. Issued April 2001.

Demand Model Description and Flowchart



Baseline Assumptions

Converting from FUD to Payloads (by Mass Classes): Proprietary methodology.

Converting from Payloads to Launches (Including Manifesting): Futron uses a proprietary methodology that leverages our knowledge of the trends in satellite masses with our understanding of the availability and history of multi-manifesting of telecommunications satellites.

Market Maturity (S-Curve) Assumptions:

This is an existing, mature market. The start year for the market was 1965.

Baseline Forecasts

Baseline Trend

The telephony markets are well-established markets that are experiencing moderate growth in the demand for transponders in developing areas of the world that are less wired terrestrially, and moderate decreases in transponder demand in the developed economies.

Sensitivity Ranging

Robust Case

Assumptions:

- Trunking markets: the percentage of traffic carried over satellite is increased according to the country's level of telecommunications infrastructure development
- End-user markets: the estimation of long term growth of some countries' telecommunications infrastructure is adjusted so that demand is met earlier

Constrained Case

Assumptions:

- Trunking markets: the percentage of traffic carried over satellite is decreased according to the country's level of telecommunications infrastructure development
- End-user markets: the estimation of long term growth of some countries' telecommunications infrastructure is adjusted so that demand is met later

Launch Price Gearing Factor

Launch Price Gearing Factor (Trunking)	
98.3%	Other (Access charges, ground equipment, etc.)
1.5%	Space Segment
0.2%	**Launch Price**

Launch Price Gearing Factor (Mainlines)	
84.0%	Other (Access charges, ground equipment, etc.)
14.0%	Space Segment
2.0%	**Launch Price**

The telephony market is split into two major categories, trunking and mainlines. The trunking section of the market consists of long-haul telephony infrastructure supplied by satellites. The mainline side of the market includes satellite infrastructure to end-user telephony customers, connecting them to the public telephone network. The gearing factor was calculated separately for these two sections of the telephony market.

For both sectors, Futron began by calculating the proportion of launch price to the wholesale price of satellite bandwidth. Futron calculated the yearly launch costs (amortized) as a proportion of total yearly operating costs of a major international satellite operator. This was found to be 24%. (Source: PanAmSat Corporation 2001 Annual Report). As a percentage of a single transponder's wholesale price this percentage (of launch costs) drops to 13% (based on Futron internal transponder pricing database).

For trunking, the gearing analysis began with the fundamental unit of demand – telephone calls. The cost breakout for the elements of a call is outlined in *TeleGeography 2001*, which indicates that the cost of bandwidth comprises between 1% and 2% of the retail cost of a telephone call. As 13% of the bandwidth cost is attributable to launch, the gearing factor of launch price to the service price for telephony trunking is approximately 0.2%.

For mainlines, Futron estimated that bandwidth costs consist of approximately 16% of the total service price per telephony VSAT terminal. As 13% of bandwidth cost is attributable to launch, the gearing factor of launch price to the service price for telephone mainlines is approximately 2%. The weighted average of the gearing factors is 0.2%, as trunking comprises 98% of total telephony demand.

PRICE ELASTICITY INFORMATION AND PRICE CHANGE FORECASTS

Not evaluated, because of extremely low gearing factor.

INTERNATIONAL ASPECTS

In every country of the world there is demand for telephony services. This forecast specifically considers the build-out of terrestrial infrastructures, growth in discretionary spending for telecommunications services, and the availability of telephony equipment, and the connection between these factors and the political and economic conditions on a country-by-country basis.

Commercial Market Sectors (Existing)

Sector 2.1.2: Data Markets

Market Sector Description and Overview

This market sector focuses on the transmission of data via satellite to fixed and mobile users using GEO and NGSO systems. Includes all applications that are based on data transmission using Internet Protocol (IP) or other packet-based protocols. Market includes: telemedicine, distance-education, and video-conferencing over private networks; asset tracking, and government uses of commercial data services. New markets such as digital movie distribution are also included.

Economics (U.S. Only)

NAICS Code: 51 **Industry Sector**: Information

Size of terrestrial sector: $5.07B[2]

Sample Business Model

The data markets that are addressed are either based on existing, well-established business sectors with international scope, or are derivative markets that will evolve from these existing businesses.

Historical and Base Year (2001) Data

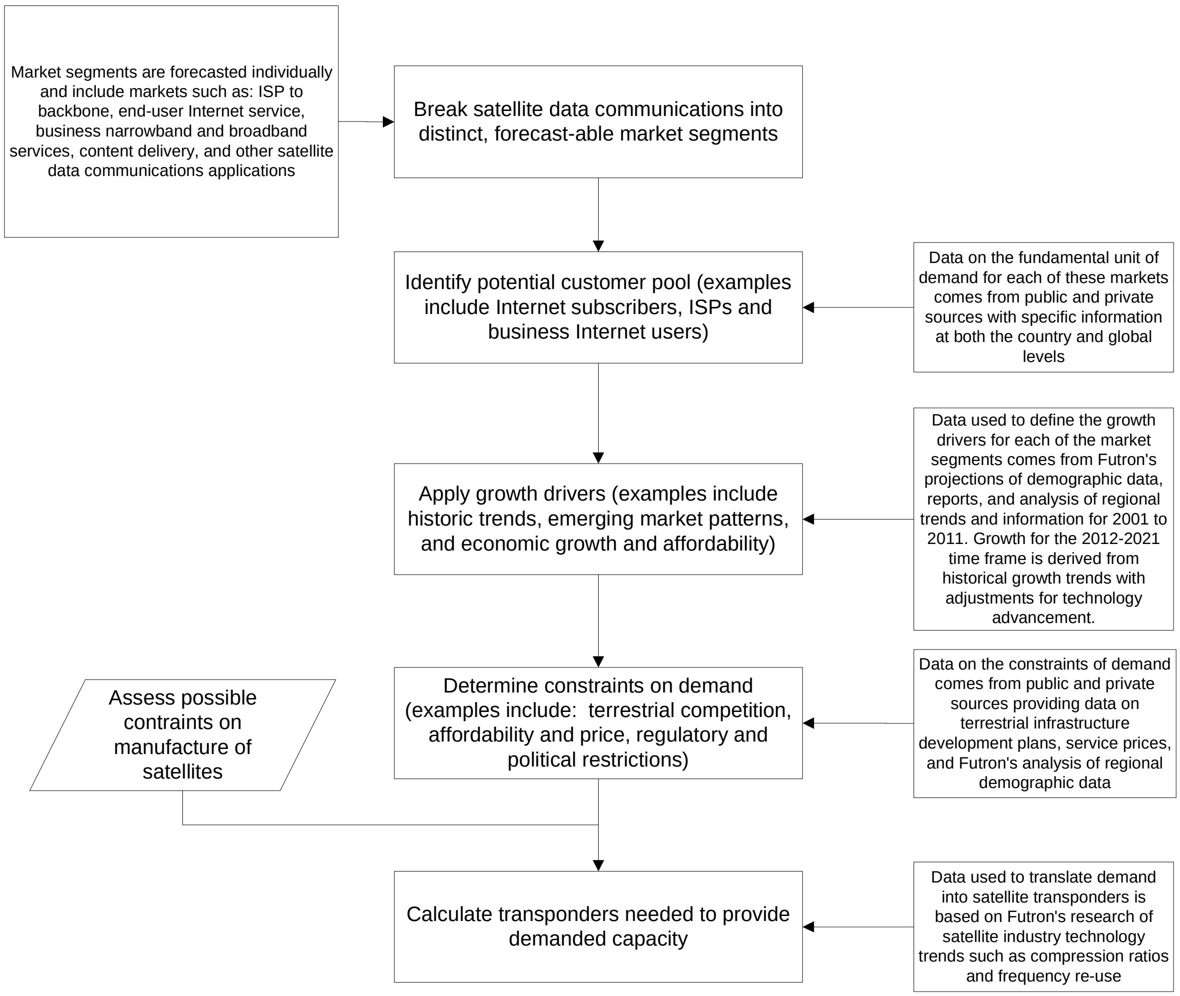
This traditional satellite service market began with low data rate transmission in 1965, and data rates have steadily increased until today. Data applications accounted for 24% of the base year commercial satellite traffic in 2001.

Terrestrial Competitive Sector Information

For all the data over satellite markets, the most important factor driving or limiting demand is the availability of terrestrial alternatives: fiber-optic undersea/terrestrial cables, Digital Subscriber Line (DSL), cable-model or other (hybrid fiber coaxial/ISDN/fixed wireless) solutions. For point-to-point applications, these are assumed to always be the first choice due to cost. The build out and penetration of such alternatives becomes the key element in determining what demand is likely to be satisfied via satellite

[2] U.S. Census Bureau, 1997 Economic Census: *Information*, Table 1: Summary Statistics for the United States: Satellite Telecommunications. http://www.census.gov/prod/ec97/97s51-sm.pdf. Issued April 2001.

Demand Model Description and Flowchart



Baseline Assumptions

Converting from FUD to Payloads (by Mass Classes): Proprietary methodology.

Converting from Payloads to Launches (Including Manifesting): Futron uses a proprietary methodology that leverages our knowledge of the trends in satellite masses with our understanding of the availability and history of multi-manifesting of telecommunications satellites.

Market Maturity (S-Curve) Assumptions:

This is an existing, mature market. The market for this sector began in 1965.

Baseline Forecasts

Baseline Trend

The baseline case is predicated on the following assumptions: (1) Moderate growth in average bandwidth per user, (2) Moderate terrestrial broadband penetration rates in the key economies of the OECD, Russia, Brazil, Mexico, China, India, Indonesia, Moderate increase in transponder efficiency (Mbps and MHz ratio), and (4) Region-specific growth rates in international Internet bandwidth consumption.

Sensitivity Ranging

Robust Case

Assumptions:

Last-Mile Broadband Access markets (Residential, SOHO, SME and Large Enterprises)*:*

- Removal of the 180 kbps 'ceiling' on average bandwidth per user
- The delayed (2-year lag) achievement of 2:1 (Mbps: MHz) transponder efficiency by 2007
- Dropping all terrestrial broadband penetration rates in baseline trend by 10% for OECD nations and in Mexico, Brazil and Russia. Penetration rates for India, Indonesia and China are dropped by only 5%.

ISP-to-Internet Backbone markets:

- The robust case assumes 25% increase in baseline growth rates in international Internet bandwidth

Constrained Case

Assumptions:

Last-Mile Broadband Access markets:

- Retention (as in baseline trend) of the 180 kbps 'ceiling' on average bandwidth per user
- Accelerated (1-year early) achievement of 2:1 (Mbps: MHz) transponder efficiency by 2004
- Increasing all terrestrial broadband penetration rates in baseline trend by 10% for OECD nations and in Mexico, Brazil and Russia. The penetration rates for India, Indonesia and China are increased by only 5%.

ISP-to-Internet Backbone markets:

- The constrained case assumes 5% decrease in baseline growth rates in international Internet bandwidth

Launch Price Gearing Factor

Launch Price Gearing Factor (Retail Data Communications Bandwidth)	
76.5%	Other (Access charges, ground equipment, etc.)
20.5%	Space Segment/Transponder
3.0%	**Launch Price**

The data market comprises several categories, but they all involve the provision of point-to-point bandwidth either to a re-seller, or to an end-user. Futron calculated the proportion of the wholesale price of one satellite transponder that is comprised of launch costs. This was done by looking at a major international satellite operator, and calculating yearly launch costs (amortized) as a proportion of its total yearly operating costs. This was found to be 24%. (Source: PanAmSat Corporation 2001 Annual Report). As a percentage of a single transponder's wholesale price this percentage (of launch costs) drops to 13% (based on Futron internal transponder pricing database).

Futron then looked at the retail side and examined a satellite bandwidth re-seller that provisions ISP-to-Backbone, VSAT and Last-Mile Broadband (to SOHOs) services. Futron looked at this re-seller's total operating costs, and what percentage of these costs is comprised specifically of transponder (space segment) costs. This was calculated to be approximately 23% for a company that leases a single 36 MHz. standard Ku-band transponder. (Source: Based on Futron research on a typical VSAT service provider).

Even assuming no profit margin, the percentage of launch costs in the retail price of a single 36 MHz. transponder is 13% X 23% = 3%. Factoring in a standard profit margin would decrease this percentage even further.

Thus the direct impact of launch price on the retail price of a single transponder is at most 3%, which Futron has therefore determined is the gearing factor for this market.

Price Elasticity Information and Price Change Forecasts

Not evaluated, because of extremely low gearing factor.

International Aspects

Because the use of data services have not grown evenly throughout the world, it is especially important to consider country-level differences when forecasting these markets. The ASCENT Study forecast specifically considers the build-out of fiber optic cables across regions, the existence of fiber-optic cable 'hubs' within each nation, political and regulatory restrictions on the use of data services, as well as geographical factors, such as the size of a country's landmass.

Commercial Market Sectors (Existing)

Sector 2.1.3: Television/Radio

Market Sector Description and Overview

The television and radio markets include the use of satellites to deliver audio and video program content either to intermediary distributors or directly to the consumer. In the case of infrastructure services, intermediary distributors such as local television network affiliates and regional cable television service providers retransmit the audio and video program content to the end user via terrestrial alternatives such as cable and tower broadcast. This market excludes video conferencing and video transmission via IP or other data transmission protocols (covered in Data Markets).

Broadcast TV: The transmission of video programming to network affiliates and the provision of news feeds and live events from the field to network programming centers

Cable TV: The transmission of video programming to cable head-ends

Direct-to-Home (DTH) TV: The provision of video services directly to consumer end-user receiver equipment.

Digital Audio Radio Service (DARS): Delivery of radio programming directly to consumer end-user receiver equipment via satellite

Economics(U.S. Only)

NAICS Code: 51 **Industry Sector**: Information

Size of terrestrial sector: $5.07B[3]

Sample Business Model

These are Existing businesses, with DARS in the early startup phase.

Historical and Base Year (2001) Data

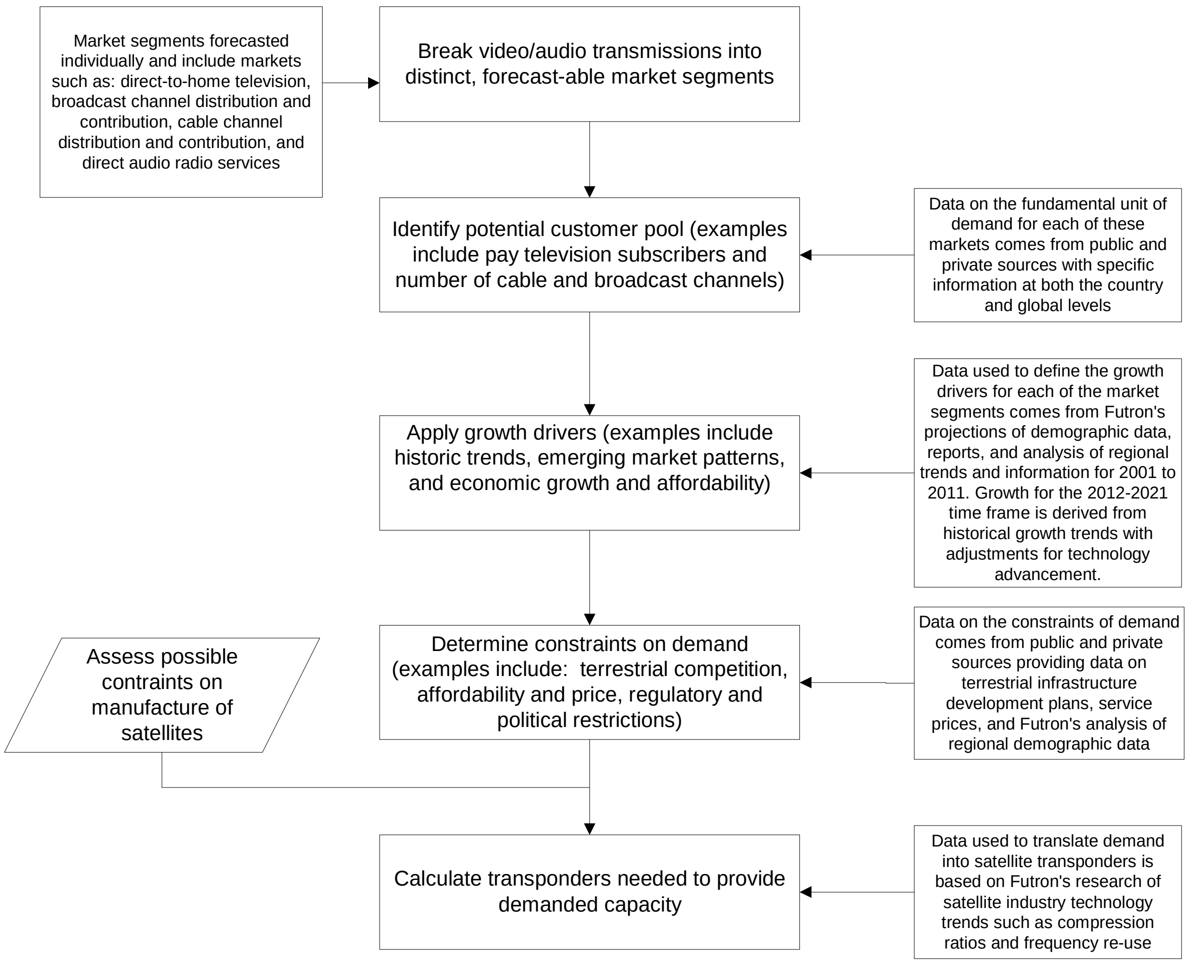
This is a traditional satellite broadcasting application, and the first such use dates back to 1965. In the base year of 2001, 60% of commercial satellite use was allocated to these markets.

Terrestrial Competitive Sector Information

Because satellites are uniquely suited to the broadcast nature of video signal distribution, it is unlikely that they will be superseded by fiber optic cable for distribution services any time soon (which comprises the majority of demand for broadcast and cable satellite capacity). DTH has found a balance with cable television, often serving underserved or sparsely populated regions within a country, or entering service ahead of cable television in newly liberalizing economies.

[3] U.S. Census Bureau, 1997 Economic Census: *Information*, Table 1: Summary Statistics for the United States: Satellite Telecommunications. http://www.census.gov/prod/ec97/97s51-sm.pdf. Issued April 2001.

DEMAND MODEL DESCRIPTION AND FLOWCHART



BASELINE ASSUMPTIONS

Converting from FUD to Payloads (by Mass Classes): Proprietary methodology.

Converting from Payloads to Launches (Including Manifesting): Many satellites that handle video services are extremely large and typically launch one satellite at a time. This is especially true for DTH satellites, which typically carry many transponders requiring high power levels. DARS satellites also require a high level of power and typically launch one satellite at a time.

Market Maturity (S-Curve) Assumptions:

This is an existing, mature market. The market for this sector began in 1965.

Baseline Forecasts

Baseline Trend

Satellite video transmission is an established business that will continue to grow commensurate with the economic growth of the industrialized world, the increasing liberalization of non-western economies, and the advancement of video technologies.

Sensitivity Ranging

Robust Case

Assumptions:

DTH:

- Increasing revenues per subscriber (over baseline); decreasing transponder costs (over baseline)

Broadcast and Cable:

- Moderate introduction of HDTV in western economies and Japan

Constrained Case

Assumptions:

DTH:

- Increasing transponder costs (over baseline) in out-years

Broadcast and Cable:

- Increasing compression of digital video without High Definition Television (HDTV) introduction

Launch Price Gearing Factor

Launch Price Gearing Factor	
95.6%	Content, ground equipment, marketing, etc.
3.7%	Satellite
0.7%	**Launch Price**

The video market involves satellite transmission and distribution of video programming. Because the DTH space segment costs exhibit the greatest proportion of total cost of all the video sub-markets, Futron used the DTH gearing factor as the most conservative assumption, i.e., the one likely to generate the biggest impact.

During the early years of a DTH service operation, providers can spend several times the annual revenues on the space segment through debt or investment financing. However, as subscribership grows and space segment costs remain constant, this proportion falls. On average, mature and profitable DTH service providers spend approximately 4.4% of their revenues on the overall space segment (Source:

Futron proprietary forecast model). Other expenses include the cost of content, ground equipment, marketing, and customer-oriented operations.

Futron calculated the yearly launch costs (amortized) as a proportion of total yearly operating costs of a major international satellite operator. This was found to be 24%. (Source: PanAmSat Corporation 2001 Annual Report). As a percentage of a single transponder's wholesale price this percentage (of launch costs) drops to 13% (based on Futron internal transponder pricing database). Applying this 13% to the 4.4% of revenues spent on the space segment by satellite operators produces a gearing factor of launch price to DTH service price of 0.7%.

Price Elasticity Information and Price Change Forecasts

Not evaluated, because of extremely low gearing factor.

International Aspects

The transmission of video and audio signal via satellite is an international market. All regions make significant use of space assets to meet television broadcasting needs, while direct-audio-radio systems (DARS) are becoming increasingly popular in the United States, Africa, and Asia. Video services are typically offered by multinational organizations in addition to national broadcasters.

Commercial Market Sectors (Existing)

Sector 2.1.4: Commercial Satellite Remote Sensing

Market Sector Description and Overview

Commercial satellite remote sensing includes the obtaining of images using space-based platforms, transmitting the raw data to ground stations, and distributing the images to value-added service providers. Includes partially commercial systems such as SPOT. Future systems may include real t8ime delivery to distributed end users. This analysis concentrates on space assets and is not a full evaluation of aerial imagery, Geographic Information Systems (GIS), or other value-added services. Exclusively government remote sensing satellites for meteorology and intelligence are covered in two separate sections in the government market.

Economics (U.S. Only)

NAICS Code: 54 **Industry Sector**: Professional, Scientific and Technical Services

Size of terrestrial sector: $4.1 B[4]

Sample Business Model

The Baseline model assumes government-subsidized systems, with centralized organizations selling a range of imagery with different technical and price characteristics. Systems deployed entirely with private funding, are also considered. Business models include governments purchasing commercial data for purposes of resource management, agriculture, aquaculture, urban planning, military intelligence, commercial competitive intelligence (CI), and other related applications.

Future applications may include the distribution of raw remote sensing products to individual users via the Internet, whereby the user manipulates the data at will using purchased software packages. Although the Internet does not currently have sufficient bandwidth to handle a large number of such customers, there is a possible commercial paradigm shift to decentralized users getting real-time or near real-time data to handsets via Internet/mobile communications, using secure protocols (requires new satellite constellation) within the timeframe of this study.

Historical and Base Year (2001) Data

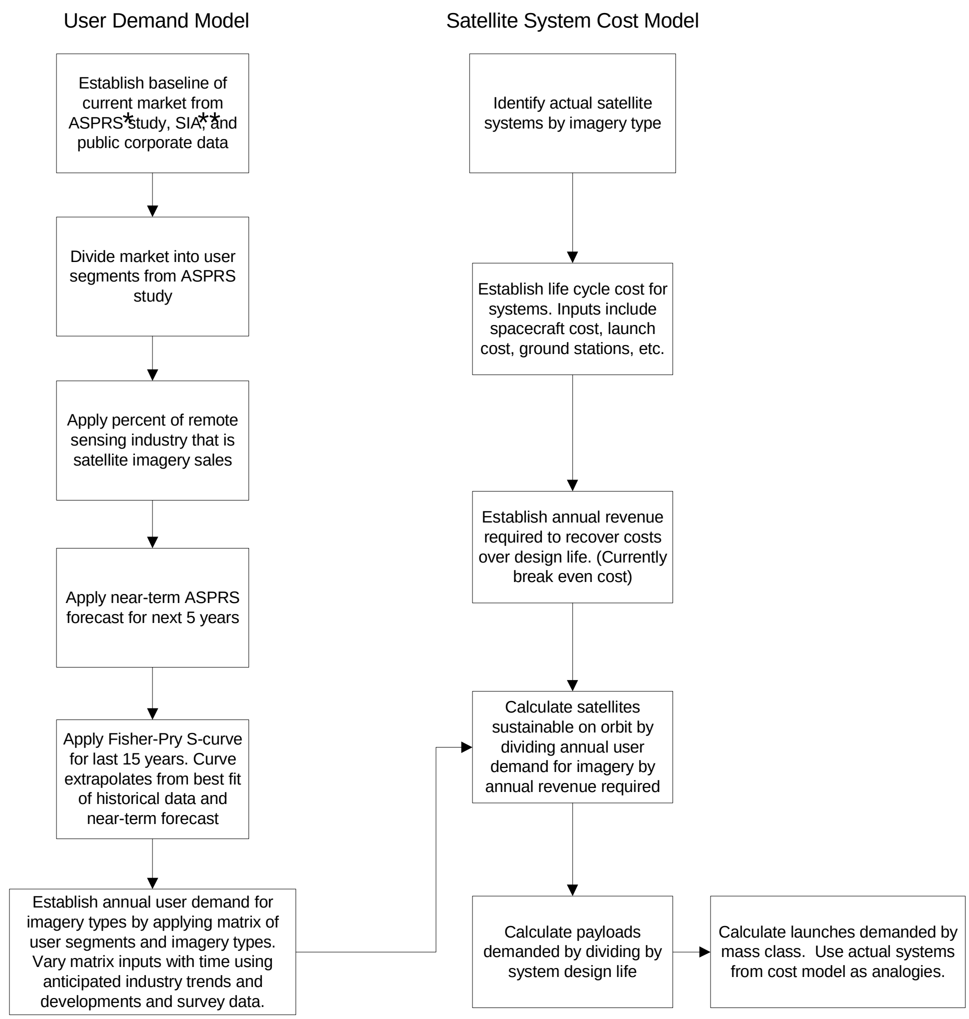
This existing application dates back to the first launches of Landsat 1 in 1972. While remote sensing was expected to develop into an application that rivaled the satellite telecom business in its impact, the growth to date has been relatively slow and in the base year of 2001, only 10% of commercial satellites launched served this sector.

Terrestrial Competitive Sector Information

Aerial imagery is the closest alternative but there are fewer opportunities to cut into aerial's market share than believed a few years ago; they are often complementary and service different niches.

[4] U.S. Census Bureau, 1997 Economic Census: *Professional, Scientific and Technical Services*, Table 1a: Summary Statistics for Firms Subject to Federal Income Tax for the United States:, Geophysical Surveying and Mapping Services and Surveying and Mapping Services, except Geophysical. http://www.census.gov/prod/ec97/97s54-sm.pdf. Issued April 2001.

Demand Model Description and Flowchart



* American Society for Photogrammetry and Remote Sensing (ASPRS)

** Satellite Industry Association

Baseline Assumptions

Converting from FUD to Payloads (by Mass Classes): The payloads forecast is the number of payloads that can be sustained by the value of imagery demanded using the cost model. Demand and costs are broken out by imagery type.

Converting from Payloads to Launches (Including Manifesting): The launch forecast assumes one payload per launch. The mass classes of past satellites for each imagery type determine the mass classes in the forecast.

Market Maturity (S-Curve) Assumptions:

Start Year: 1991

Time to market saturation: 20 years

Baseline Forecasts

Baseline Trend

Growth in the industry translates into only modest growth in the deployment rate of new satellites. The forecast illustrates both an increase in the demand for satellites on orbit and for replacements. While the growth is nearly linear, the model creates a launch only when enough demand has accumulated to stimulate a whole new launch.

Sensitivity Ranging

Robust Case

Assumptions:

- The robust case assumes that Landsat-like imagery can be obtained using smaller satellites, thereby reducing cost.
- It also assumes a proportional increase in the use of satellite-based imagery over aerial imagery such that satellite imagery sales account for 15% of the total remote sensing market (including value-added services) compared to 10% in the baseline.
- In the Robust Case, no extra demand was included for hand-held real-time imagery applications due to the low level of interest in these applications found via Futron's top-level survey on niche market opportunities.

Constrained Case

Assumptions:

- The constrained case applies the same cost model for Landsat-like imagery as the baseline
- It also assumes a slight proportional decrease in the use of satellite-based imagery in favor of aerial platforms, such as Uncrewed Aerial Vehicles (UAV)'s. Satellite imagery sales as a percent of the total remote sensing industry is reduced from 10% to 9%.

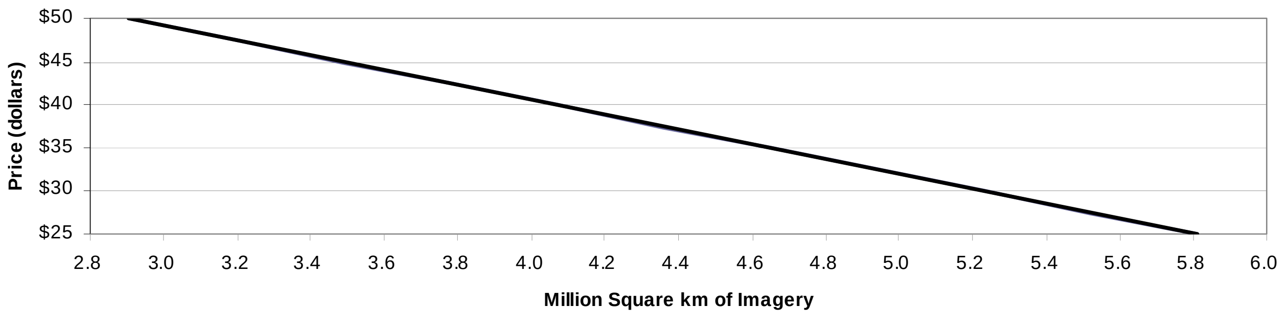
Launch Price Gearing Factor

Launch Price Gearing Factor	
60%	Satellite
15%	Operations
25%	**Launch Price**

The 25% figure representing the gearing factor is the value of the launch cost as a proportion of the total life cycle cost of a satellite system. Spacecraft cost, operations and ground segment costs, and launch costs are combined over the expected service life of the satellite to determine life cycle cost. Several recent and proposed satellite systems for each imagery type (high and low resolution panchromatic and multispectral imagery, radar imagery, lidar, etc.) were analyzed to calculate the components of life cycle cost. Data to develop the life cycle cost estimates came from official press releases for Landsat, SPOT, Radarsat, DigtalGlobe, Space Imaging, Orbimage, and Astrovision. Additional data was gleaned from various trade press articles and reference guides such as Jane's Space Directory. These satellite systems span a wide range of spacecraft masses and launch vehicles, so these figures represent a combination of the various life cycle cost models.

Generally, the gearing factor for commercial remote sensing satellites is higher than in other existing commercial markets. This sector tends to utilize smaller satellite platforms and smaller launch vehicles than telecommunications markets. Since small vehicles tend to be more costly on a dollar per pound basis, this helps to explain why the proportion of life cycle cost represented by launch cost tends to be higher for this sector. Since many of these satellites are placed into polar orbits, a launch vehicle of a given price will typically carry a lower payload mass, also increasing the effective cost per pound.

Price Elasticity Information and Price Change Forecasts



Formula for PE Curve: $y = -8.6022x + 75$

Service Demand	5.81	5.52	5.23	4.94	4.65	4.36	4.07	3.78	3.49	3.20	2.91	**M sq Km**
Service Price	$25.00	$27.50	$30.00	$32.50	$35.00	$37.50	$40.00	$42.50	$45.00	$47.50	$50.00	**$**

It is difficult to determine a price elasticity curve for satellite imagery since the value of most imagery is in the information that can be linked to the picture, such as other data sets from GIS systems, rather than the raw imagery. Advances in information technology have expanded the possible uses for such data, so the nature of the product has changed over time.

Nevertheless, various price points for imagery are available and have in fact begun to fall in 2002. Drawing from statements made by executives of the major commercial satellite imaging companies, an elasticity curve was generated by estimating the expected increased demand for imagery with the price drops announced in early 2002.

International Aspects

Forecast is based upon global figures.

2.2 Evolving Commercial Market Sectors

Commercial Market Sectors (Evolving)

Sector 2.2.1: Public Space Travel

Market Sector Description and Overview

Public space travel is the transportation service to Earth orbit that supports leisure travel, business travel, and the human crewed components of other evolving commercial markets. It does not include government human space travel, such as crewed flights to the International Space Station or potential military crewed space transportation. The market includes only the transportation portion (i.e. not on-orbit habitation) of leisure and business travel. It does not include suborbital flights for the purposes of the ASCENT Study.

Economics (U.S. Only)

NAICS Code: 48-49 **Industry Sector**: Transportation and Warehousing

Size of terrestrial sector: $20.2 B[5]

Sample Business Model

Public space travel will serve as both a new form of transportation and as a new destination for the existing travel industry. Possible package offerings provided by tour operators will vary in content, price, duration, as well as in the various types of space flight experience.

Historical and Base Year (2001) Data

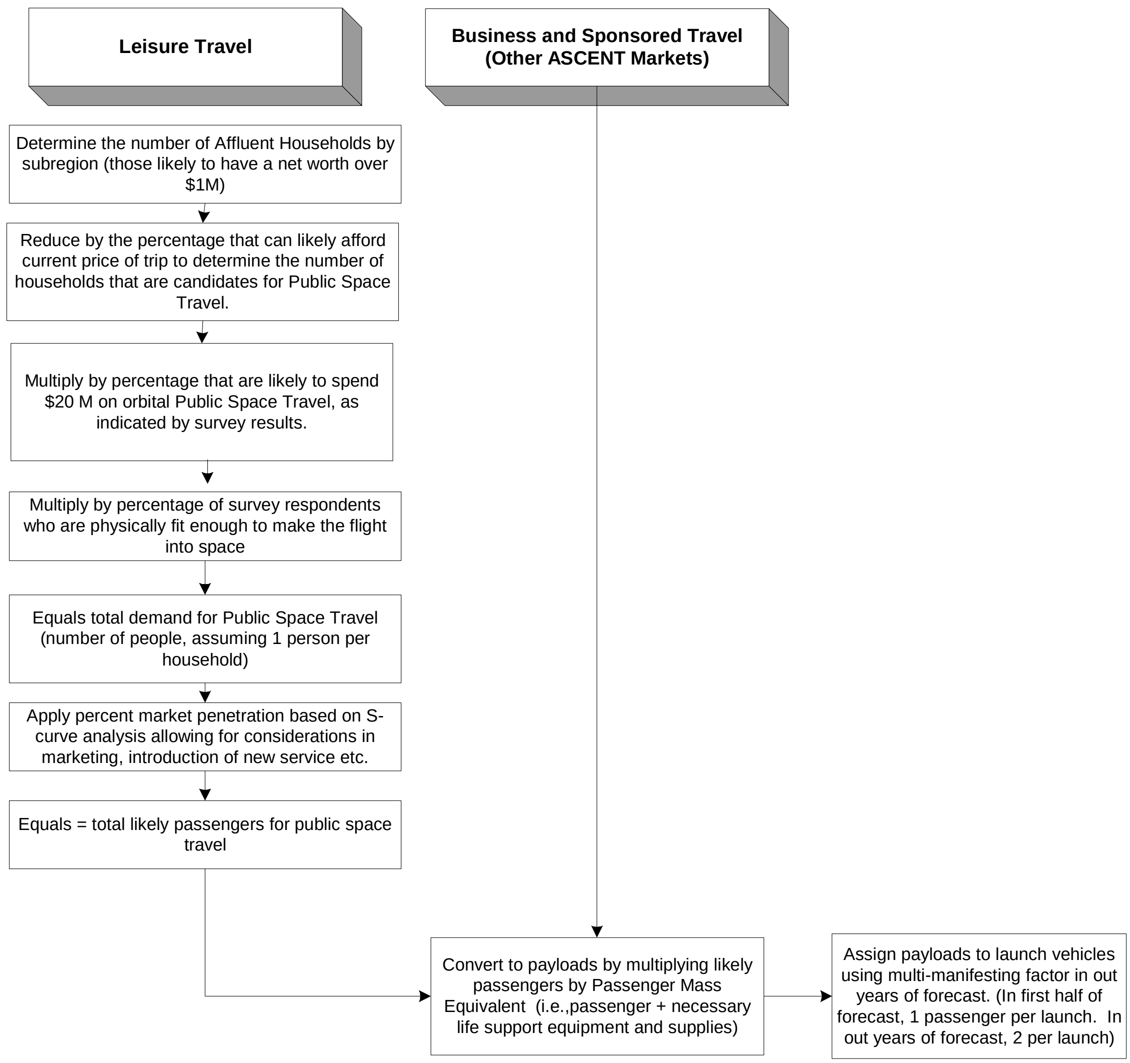
Despite earlier flights by a Japanese journalist and a British scientist on board Soyuz vehicles, the public space travel market was considered a bona fide commercial business with the 2001 flight of Dennis Tito and the 2002 flight of Mark Shuttleworth. Both Tito and Shuttleworth flew on Russian Soyuz vehicles and reportedly paid U.S. $20 million for their respective rides.

Terrestrial Competitive Sector Information

Traditional terrestrial tourism, in particular, “adventure” or “extreme” tourism, presents competition for Public Space Travel.

[5] U.S. Census Bureau, 1997 Economic Census: *Transportation and Warehousing*, Table 1: Summary Statistics for the United States: Air Transportation. http://www.census.gov/prod/ec97/97t48-sm.pdf. Issued March 2001.

Demand Model Description and Flowchart



Baseline Assumptions

For the Public Space Travel sector, key market data was obtained from the Futron/Zogby Survey on Public Space Travel. Details and results from the survey can be found in Section 4 of this document.

Converting from FUD to Payloads (by Mass Classes): FUD is people demanding public space travel. Number of passengers is then converted into payloads via a Soyuz capsule mass equivalent.

Converting from Payloads to Launches (Including Manifesting): Assume Public Space Travel passengers will travel on a Russian Soyuz for the baseline forecast. One passenger per launch in the beginning of the forecast, then, multi-manifesting two passengers per launch in the out years.

Market Maturity (S-Curve) Assumptions:

Start Year: 2001

Time to market saturation: 40 years

Baseline Forecasts

Baseline Trend

Public Space Travel is a new sector and in the first few years demand is constrained by the supply of Soyuz vehicles, which are currently the only way for a public space traveler to achieve orbit. In the last 10 years of the forecast, a small decrease in interest in Public Space Travel is assumed due to the "pioneering" effect – i.e., those people who wanted to take the trip because of its novelty value decide on another alternative once public space travel becomes "routine." The S-curve allows for greater market penetration in the out years of the forecast achieving approximately 53 passengers/year. The price of the trip is assumed to be U.S.$20 million and the estimated time to market maturity is 40 years. Initial passengers will fly in available seats on Soyuz missions to ISS. Dedicated Soyuz flights are assumed to commence in 2013 with one crewmember and two paying passengers.

Sensitivity Ranging

Robust Case

Assumptions:

- Market maturity is achieved in 25 years.
- A lower pioneering discount rate is applied

Constrained Case

Assumptions:

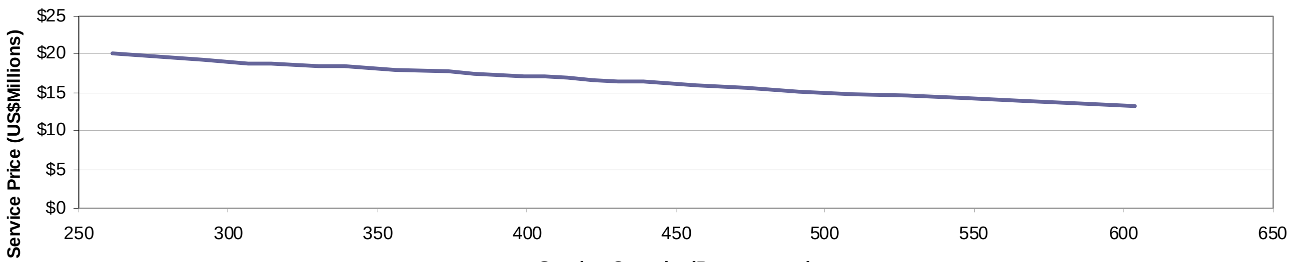
- Market maturity is achieved in 50 years.
- A greater pioneering discount rate is applied

Launch Price Gearing Factor

Launch Price Gearing Factor	
6.0%	Training fees
8.0%	Service fees
52.0%	Capsule
34.0%	**Launch Price**

The public space travel market, as addressed in the ASCENT Study, focuses on a two-week orbital flight scenario, including accommodations at an on-orbit destination, as was the case with the first two public space travelers, Dennis Tito and Mark Shuttleworth. The current price for this trip scenario hovers around US$20 million. Futron derived the gearing factor for public space travel by calculating the proportion of estimated launch costs to other costs associated with the current ticket price. Estimated costs were calculated based on publicly available data, including historical prices of Soyuz launch vehicles, Soyuz capsules and spaceflight medical qualification and training scenarios. Futron estimated that launch costs (assuming a Soyuz launch vehicle) account for 34% of the ticket price for public space travel. The remaining 66% of the ticket price can be attributed to costs associated with the Soyuz capsule, training costs and related service and/or contract fees. The largest component of the ticket price, in this case, 52%, is assumed to be for the expendable Soyuz capsule. The extensive training required to take the trip is assumed to account for roughly 6% of the ticket, with the remaining 8% assigned to contract and/or service fees associated with arranging the trip.

Price Elasticity Information and Price Change Forecasts



Passengers Over Forecast Period	604	567	528	491	457	422	391	356	322	292	261
Ticket price ($M)	$13.2	$13.9	$14.6	$15.2	$15.9	$16.6	$17.3	$18.0	$18.6	$19.3	$20.0

To evaluate the effect of price changes on the demand for public space travel, Futron utilized data on interest levels and willingness to pay for orbital travel gathered via the Futron/Zogby survey (see Section 4). Evaluation of the survey data revealed that willingness to pay for orbital travel increases as the price decreases. Interest levels were matched to corresponding price points and incorporated into the Futron public space travel model to generate results that take into account existing public space travel market limitations such as fitness, affordabilty, market penetration and supply constraints.

Although survey data exists for price points as low as US$1 million, the public space travel gearing factor of 34%, implies that even with zero launch cost, 66% of the ticket price (for Soyuz capsule, training, etc.) would still remain resulting in the lowest possible price within the forecast period being just over US$13 million. At this price, cumulative demand for flights over the forecast period rises from the Baseline level of 261 passengers to 604 passengers, a 131% increase. With a 50% decrease in launch costs (US$16.6 million) a cumulative increase of 161 passengers, or 62%, occurs throughout the forecast period.

International Aspects

The model works on a sub-regional basis to calculate demand, then aggregates demand into a global number for manifesting into payloads.

Commercial Market Sectors (Evolving)

Sector 2.2.2: Commercial ISS Module

Market Sector Description and Overview

An on-orbit multi-purpose facility, envisioned as Spacehab-type extension to ISS or possibly an independent crewed platform. Uses would include research and development, e.g. pharmaceutical. Does not include Space Hardware R&D, which is addressed as a separate market. New markets may include multimedia users (orbiting movie studio) or use as a destination for public space travel. Use as a dedicated, staffed space hotel is not included; this is addressed as a separate market.

Economics (U.S. Only)

NAICS Code: 53 **Industry Sector**: Real Estate Rental and Leasing

Size of terrestrial sector: $29 B[6]

Sample Business Model

The model assumes the use of a SpaceHab type module attached to the ISS. It is assumed to be self-funding.

Addressable markets evaluated included microgravity research, an orbiting movie studio concept, and volume leased for on-orbit habitation and storage.

Historical and Base Year (2001) Data

As an Evolving market sector, there is currently no historical data.

Terrestrial Competitive Sector Information

For entertainment-related uses of an on-orbit module, computer-generated imagery and parabolic flights are alternative options for those wishing to simulate microgravity.

The time horizon from experiment design to launch is too long for most commercial research. Ground based techniques for high throughput protein structure identification are gradually improving. Protein crystallography (the part where microgravity research is relevant) is only a small niche in the overall industry.

[6] U.S. Census Bureau, 1997 Economic Census: *Real Estate Rental and Leasing*, Table 1: Summary Statistics for the United States: Commercial & Industrial Machinery & Equipment Rental & Leasing. http://www.census.gov/prod/ec97/97f53-sm.pdf. Issued February 2001.

Demand Model Description and Flowchart

Baseline Assumptions

The orbiting movie studio application was found to be economically unrealistic, and so the other applications were quantified for this sector.

Converting from FUD to Payloads (by Mass Classes): The payload model plots money available for microgravity research against the supply cost curve for a Mid-deck Locker Equivalent (MLE) from the cost model. For the orbiting movie studio scenario, money for zero-g effects is plotted against the supply cost curve for filming zero-g scenes with a standard estimate of a cast and crew with their equipment.

Converting from Payloads to Launches (Including Manifesting): The launch forecast for research counts the number of MLEs as a fraction of a Progress-type supply flight, times the number of flights per year to service the locker (nominally 6 flights).

Market Maturity (S-Curve) Assumptions:

Start Year: 2000

Time to market saturation: 20 years

Baseline Forecasts

Baseline Trend

The baseline shows that projected industry-supported funding for microgravity research alone will not support the deployment of a commercial ISS module and servicing launches. An orbiting movie studio is not likely within the forecast period, as it would require significant reductions in launch costs because of the high cost of launching people and equipment to the facility.

Sensitivity Ranging

Robust Case

Assumptions:

- The cost of the module is decreased by 15%. No launches are stimulated. While not included in a realistic robust scenario, sensitivities tests indicate only a 44-fold increase in industry-supported experiments begins to support a module and a servicing launch in 2021. A 100-fold increase in spending would support a module with a total of 20 servicing flights from 2016 to 2021.

Constrained Case

Assumptions:

- Since the baseline is zero, the constrained case is the same as the baseline.

Launch Price Gearing Factor

Launch Price Gearing Factor	
2%	Module
25%	Operations (excluding servicing launches)
73%	**Launch Price**

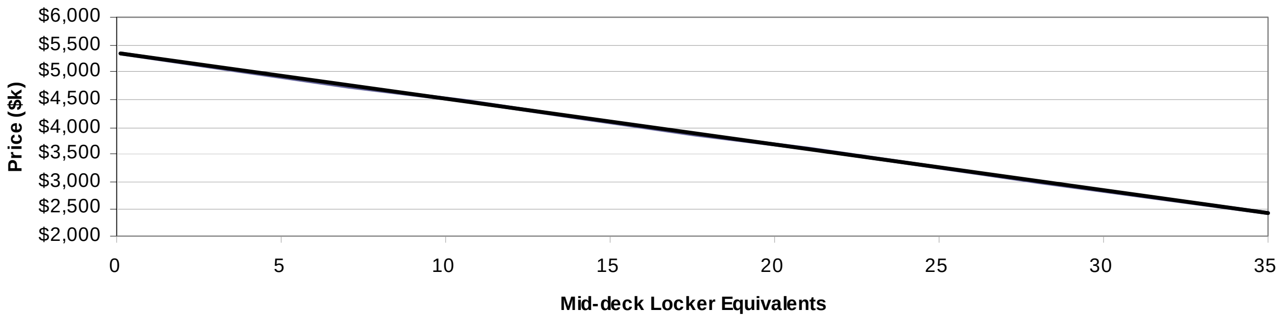
Based on an analysis of funds available for microgravity effects in movies, there was found to be a significant gap between the cost of launching people and equipment to a module and the funds available for such a purpose. The analysis accounted for the number of new movies per year and their average cost, the average percentage of the special effects budget per movie, and the percentage of movies that might need microgravity effects. Given the significant gap in cost and available funds, the movie studio scenario was not considered further in the analysis.

When considering the module alone, such as Spacehab's proposed module, the launch price gearing factor is only about 16 percent. The model assumes $100 million to build, $100 million a year to operate for 15 years (Spacehab) and $300 million to launch on Shuttle. When launches to service the module are included, i.e., launches to carry experiments back and forth on a regular basis, then the figure rises to an upper limit of about 73 percent. When the total accessible volume is packed with experiment lockers or equivalents, and each locker is serviced on a regular basis, the launch cost of performing these servicing operations at $10,000 per pound raises the overall gearing factor to 73 percent.

There are, however, many alternative configurations for a commercial module. A module fully packed with experiments, as in the Baseline scenario, would require some of them to consume no external power or other consumable resources due to limitations on the facility as a whole. One commercially proposed scenario envisioned a 30/70 split in accessible volume between experiment lockers and space for habitation and storage. If under this scenario the experiment lockers were expected to generate 50 percent of overall revenue, the launch gearing factor is reduced to about 63 percent, operations 35 percent, and the cost of the module itself (amortized on an annual basis over 15 years) remains at 2 percent.

In any case, the high launch gearing factor implies that once a revenue threshold is crossed to begin supporting a commercial module, the number of launches becomes highly sensitive to reductions in launch price. Current spending on commercial microgravity research would still have to increase to many times its current level to reach this threshold. If alternative module designs and configurations are considered as part of a second order effects analysis, reducing this threshold cost could bring the market closer to fruition.

Price Elasticity Information and Price Change Forecasts



Formula for PE Curve: y = -83.441x + 5336.4

Service Demand	0	4	7	11	14	18	21	25	28	31	35	**MLE's**
Service Price	$5,330	$5,039	$4,748	$4,456	$4,165	$3,874	$3,583	$3,291	$3,000	$2,709	$2,418	**$K/MLE/year**

Research indicated that at around $3 million dollars per locker, the market for commercial microgravity experiments begins to emerge. This model assumes the price includes a lease to use a locker for one year and up to six servicing flights (transporting experiments to and from the module). The line was determined by establishing two points. The first is based on correlating the $3 million figure with the number of lockers that matches the one in a proposal for a commercial module from Spacehab. The proposed configuration would have 28 commercial experiment lockers with half the total cost of the module being supported by the experiments (the second half of costs would be recovered through leasing for habitation and storage). The second point of the curve correlates current spending by commercial microgravity researchers to the fraction of a locker that could be supported using the life cycle cost model for the module. The same 50 percent figure for cost recovery through experiments was applied.

International Aspects

Forecast is based upon global figures and a world multiplier for some US figures.

Commercial Market Sectors (Evolving)

Sector 2.2.3: Space Product Promotion

MARKET SECTOR DESCRIPTION AND OVERVIEW

Space product promotion is the demonstration and/or advertising of products in the space environment and is segmented into 3 areas: product placement advertising, logo advertising, and sale of products that have been in orbit. This market excludes orbiting billboards, which are addressed in the Emerging Markets section.

ECONOMICS (U.S. ONLY)

NAICS Code: 54 **Industry Sector**: Professional, Scientific, and Technical Services

Size of terrestrial sector: $49 B[7]

SAMPLE BUSINESS MODEL

Space product promotion is an existing, though small, commercial space business. The range of demonstration and/or advertisement will vary in product and content, price and duration. This business model is similar to NASCAR selling sponsorship real estate on a team's vehicle, but may include the use of a human crew trained for the purpose of promotion.

HISTORICAL AND BASE YEAR (2001) DATA

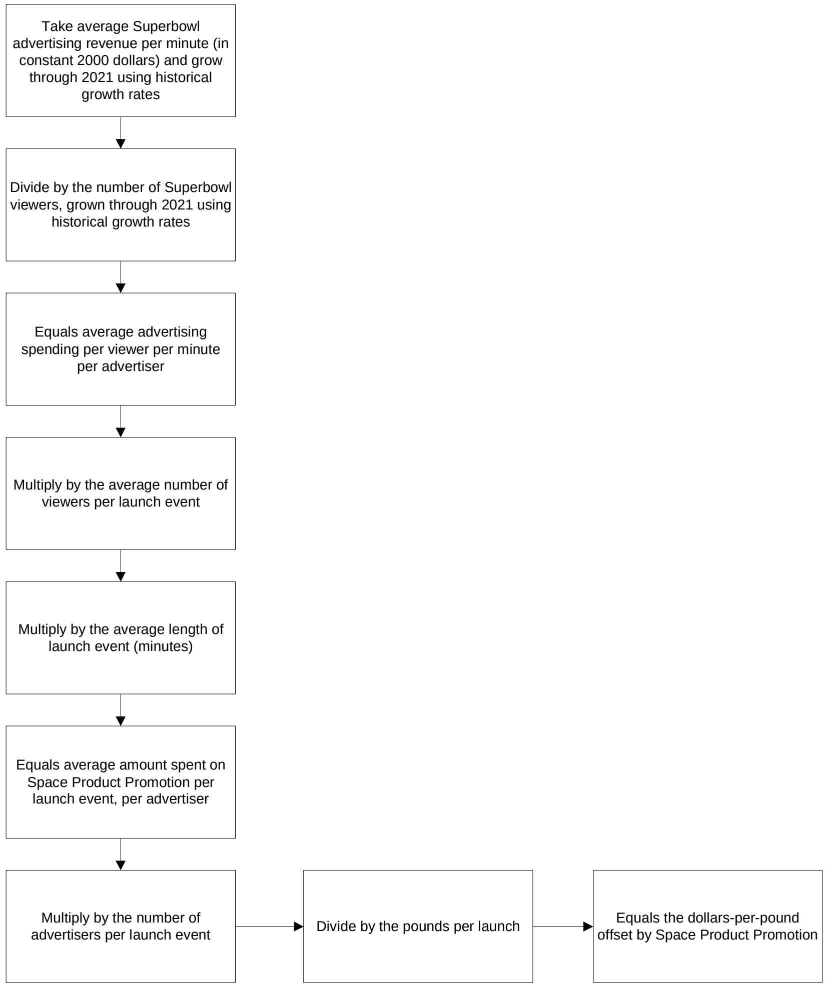
Although classified as an Evolving market, there is some historical data related to advertising related to MIR missions, although there were no examples in the base year of 2001. Pizza Hut, Pepsi, Fisher Space Pens, and RadioShack have all made advertising investments in the commercial space arena.

TERRESTRIAL COMPETITIVE SECTOR INFORMATION

Traditional advertising, specifically "single large event" advertising, like the Superbowl

[7] U.S. Census Bureau, 1997 Economic Census: *Professional, Scientific and Technical Services*, Table 1a: Summary Statistics for Firms Subject to Federal Income Tax for the United States:, Advertising and Related Services. http://www.census.gov/prod/ec97/97s54-sm.pdf. Issued April 2001.

Demand Model Description and Flowchart



Baseline Assumptions

Converting from FUD to Payloads (by Mass Classes): Model results in revenue available for cost offset of future launches.

Converting from Payloads to Launches (Including Manifesting): If cost offset is great enough to significantly reduce the per-pound launch cost, more launches could be generated. Currently there is only a slight effect on launch costs.

Market Maturity (S-Curve) Assumptions:

Due to the method used in forecasting this market, there is no S-curve associated with it.

Baseline Forecasts

Baseline Trend

Space product promotion is a small market that will grow over the forecast period, but will have a minimal impact on offsetting launch prices.

Sensitivity Ranging

Robust Case

Assumptions: This scenario assumes that all other factors remain constant, and viewership increases for launches at the rate that Superbowl audiences have grown over the past 30 years. The result is an increased rate of growth in dollars per pound offsets, but still not significant enough to lower launch prices noticeably.

Constrained Case

Assumptions: This scenario assumes that the audience for launches is limited to only those who view a live launch in person. This number, according to Florida Space Authority, is about 9,000 people, down from half a million worldwide in the other two cases. The result is a drastically reduced offset of less than $10 per pound.

Launch Price Gearing Factor

Launch Price Gearing Factor	
98.5%	Amount paid by launch customer
1.5%	Amount paid by advertiser (launch cost offset)

Unlike other market sectors in which launch cost can be calculated as a total cost to an organization wishing to launch a payload into space, Space Product Promotion enables the cost of a launch to be reduced by splitting the launch provider's revenue between the launch customer and the advertiser. This figure is expressed as a launch *revenue* gearing factor, as opposed to a *cost* gearing factor.

The above example uses data for the launch of the Proton carrying the Zarya module to the ISS. For this launch, our analysis estimates Pizza Hut paid approximately $1.25 million to place the company's logo on the outside of the launch vehicle. The above calculation shows what percent of the launch price for that event was offset by the revenue generated by Pizza Hut's advertisement. This is used as an example of the rough order of magnitude of space product promotion compared to the cost of a launch.

Price Elasticity Information and Price Change Forecasts

As launch prices reduce, the percent contribution due to space product promotion increases as a consequence. If launch prices are reduced by 75%, on average, the offset percentage will increase from less than 1% to nearly 3%, but this will vary based on the cost of the vehicle.

International Aspects

Global numbers used throughout the calculations.

Commercial Market Sectors (Evolving)

Sector 2.2.4: Space Hardware R&D

Market Sector Description and Overview

Use of the space environment for testing of new equipment, components and modules destined for use in future flight hardware or space missions. This could take the form of a reusable or permanent on-orbit test bed facility, or satellite launch for technology demonstration. Includes vehicle test flights with dummy payloads.

Economics (U.S. Only)

NAICS Code: 54 **Industry Sector**: Professional, Scientific, and Technical Services

Size of terrestrial sector: $13.9 B[8]

Sample Business Model

Space segment manufacturers and/or subcontractors will perform cost/benefit trade-offs for performing the R&D on new components in space rather than in ground facilities such as thermal vacuum chambers. This could be important for large and/or complex folding mechanisms designed only to work in microgravity or vacuum environments.

Historical and Base Year (2001) Data

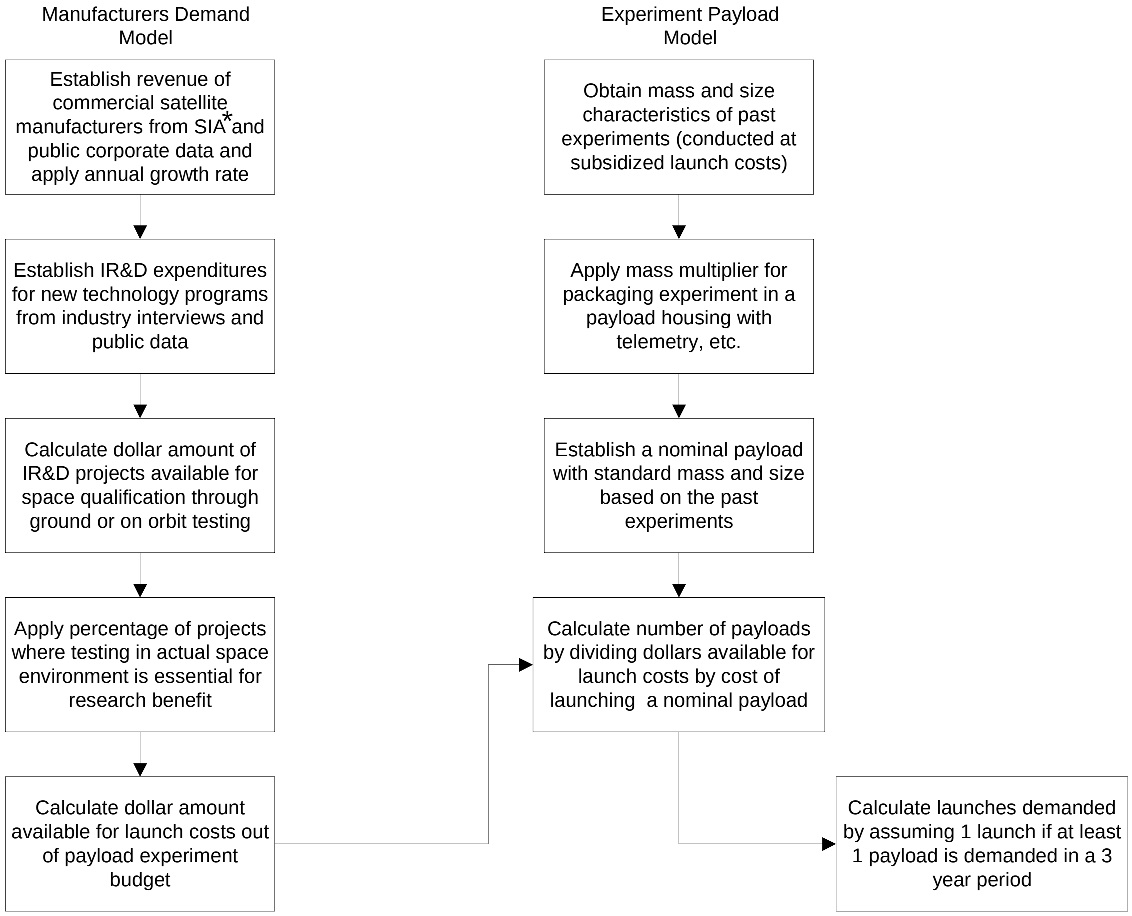
As an Evolving market sector, there is yet very little real data, and no examples from the base year of 2001. Probably the best historical example is the loop heat pipe experiment by Hughes from the year 1997.

Terrestrial Competitive Sector Information

Ground based testing satisfies most space qualification needs. The fraction of technology projects requiring the actual space environment is small.

[8] U.S. Census Bureau, 1997 Economic Census: *Professional, Scientific and Technical Services*, Table 1a: Summary Statistics for Firms Subject to Federal Income Tax for the United States, Physical and Engineering Sciences Research and Development. http://www.census.gov/prod/ec97/97s54-sm.pdf. Issued April 2001.

Demand Model Description and Flowchart



*Satellite Industry Association (SIA)

Baseline Assumptions

Converting from FUD to Payloads (by Mass Classes): The payload forecast uses the cost model for a standard experiment package to determine how many experiments (payloads) could be supported by the money available for launch costs in space qualifying R&D technology projects. The standard payload package is in the small mass class category.

Converting from Payloads to Launches (Including Manifesting): One launch is assumed if the accumulated demand for at least one payload exists over a three-year period, since this is the maximum preferred time horizon for these projects. If this threshold is not reached, assume zero launches.

Market Maturity (S-Curve) Assumptions:

Due to the method used in forecasting this market, there is no S-curve associated with it. The growth of the Space Hardware R&D market is related to the expected growth of commercial satellite manufacturing revenue.

Baseline Forecasts

Baseline Trend

At current launch prices, no new launches are stimulated to space-qualify new satellite technologies funded by commercial manufacturers.

Sensitivity Ranging

Robust Case

Assumptions:

- The fraction of IR&D research projects of commercial satellite manufacturers that cannot be space-qualified using ground-based testing is increased by a factor of three from 5% to 15%. The demand for test-payloads begins to emerge, and a model assigning a fraction to piggy-back launches and the remainder to small launches shows a demand for a few dedicated launches in the out years. Since piggybacks do not stimulate new launches, only the dedicated flights are shown.

Constrained Case

Assumptions:

- Since the baseline is zero, the constrained case is the same as the baseline.

Launch Price Gearing Factor

Launch Price Gearing Factor	
95%	Ground-based space qualification testing
3%	Space-based space qualification testing
2%	**Launch Price**

The Space Hardware R&D demand module of the forecast assumes an IR&D line item in the budget of commercial satellite manufacturers.

Most space qualification of hardware is done on the ground in vacuum chambers, with sun simulators, or other equipment. Research shows that commercial spacecraft engineers attribute little value to having components tested in space when the performance of ground-based facilities is well understood. Data from in-space testing is a "nice-to-have" bit of information but is not strictly necessary. Only hardware projects that require aspects of the actual space environment that cannot be simulated on the ground, such as sustained microgravity, are likely to actually be tested in space as part of a dedicated experiment. Examples of these types of hardware are loop heat pipes and inflatable structures. Therefore it was determined that about 95 percent of space qualification for IR&D projects can be done on the ground. Of the remaining 5 percent, 40 percent of the space qualification budget is estimated to be available for launch costs and 60 percent for planning, building, and analyzing the experiment. Therefore, launch costs represent about 2 percent of the total IR&D space qualification budget of the typical commercial manufacturer.

Price Elasticity Information and Price Change Forecasts

Not evaluated, because of extremely low gearing factor.

International Aspects

Forecast is based upon global figures.

Commercial Market Sectors (Evolving)

Sector 2.2.5: Space Burial

Market Sector Description and Overview

The launch of cremated remains into Earth orbit or beyond. Future applications may make possible funerals in space.

Economics (U.S. Only)

NAICS Code: 81 **Industry Sector**: Other Services

Size of terrestrial sector: $12.6 B[9]

Sample Business Model

This is an existing, though small, space business – only a few grams of payload are involved. It is a natural extension of terrestrial funeral businesses, with burials at sea being the closest analog.

Historical and Base Year (2001) Data

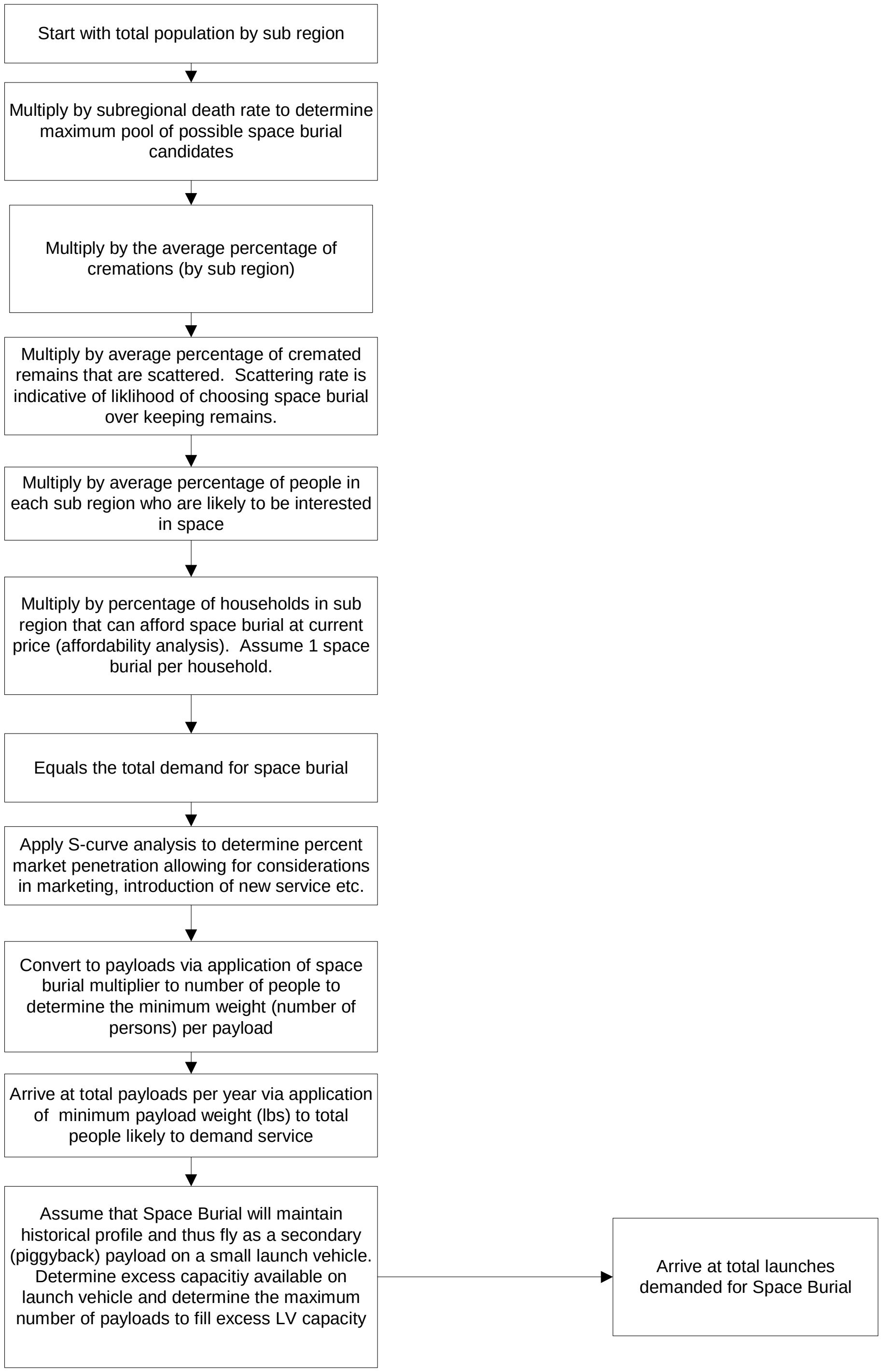
Although classified as an Evolving market, there are some historical data points for this relatively new space market application. Missions were flown in 1997, 1998, 1999, and 2001.

Terrestrial Competitive Sector Information

Traditional cremation scattering services such as scattering at sea and over land.

[9] U.S. Census Bureau, 1997 Economic Census: *Other Services*, Table 1a: Summary Statistics for Firms Subject to Federal Income Tax for the United States: Death Care Services. http://www.census.gov/prod/ec97/97s81-sm.pdf. Issued April 2001.

Demand Model Description and Flowchart



Baseline Assumptions

Converting from FUD to Payloads (by Mass Classes): FUD is people demanding space burial service. People are then converted into a Space Burial weight equivalent to build a minimum payload.

Converting from Payloads to Launches (Including Manifesting): Space Burial launches have traditionally been secondary payloads. As a result, minimum payloads are aggregated to fill excess capacity on small launch vehicles until one launch is achieved.

Market Maturity (S-Curve) Assumptions:

Start Year: 1997

Time to market saturation: 34

Baseline Forecasts

Baseline Trend

Although Space Burial is an existing service, it is still in the infant stages of development. The business model for this market favors piggyback payloads. As such, all dedicated launches seen in the original Baseline have been re-allocated and dedicated Space Burial launches do not occur until an aggregated payload meets certain weight requirements. The payload is then launched on a dedicated launch. Sensitivities to this sector include the scattering rate of ashes, interest of population in space, and the time to market maturity. For the Baseline, market maturity is achieved in 34 years.

Sensitivity Ranging

Robust Case

Assumptions:

- Scattering rate increased in robust scenario
- Percentage of population likely to have interest in space increased in robust scenario
- Market maturity is achieved in 30 years

Constrained Case

Assumptions:

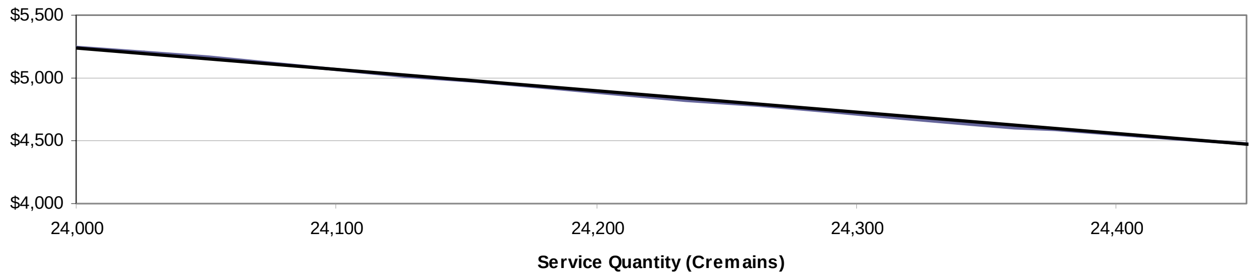
- Scattering rate decreased in constrained scenario
- Percentage of population likely to have interest in space decreased in constrained scenario
- Market maturity is achieved in 40 years

Launch Price Gearing Factor

Launch Price Gearing Factor	
82%	Operations and Service Fees
18%	**Launch Price**

The space burial market focuses on the launching of secondary "piggyback" space burial payloads attached to the upper stage of a Pegasus launch vehicle. A space burial payload consists of a number of capsules bundled together, each containing a "symbolic" portion (i.e., 7-gram or 1-gram sample) of cremated remains. The current service price is $5300 for the 7-gram service and $995 for the 1-gram service (source: Celestis). Futron derived the gearing factor for space burials by calculating the proportion of estimated launch costs to the current service price. Futron estimated that launch costs (assuming a Pegasus launch vehicle) account for 18% of the service price for space burials. The remaining 82% of the service price can be attributed to operations, administration and related service fees.

Price Elasticity Information and Price Change Forecasts



Formula for PE Curve: y = -1.6983x + 45997

Service Quantity	24,540	24,475	24,408	24,346	24,290	24,234	24,181	24,127	24,076	24,026	23,975	**Cremains launched/year**
Service Price	$4,346	$4,441	$4,537	$4,632	$4,728	$4,823	$4,918	$5,014	$5,109	$5,205	$5,300	**Space Burial Service Price**

To evaluate the effect of price changes on the demand for space burials, Futron analyzed the total cumulative demand over the 20-year forecast period at various price points. Space burial service prices were varied, taking into account the gearing factor of 18%, and incorporated into the Futron space burials model. Futron then generated alternative forecasts, taking into account existing space burial market limitations such as death rates, cremation rates, interest in space, affordabilty and market penetration dynamics.

The current price for space burial is US$5300 for launching 7 grams of cremains into LEO.[10] The space burials gearing factor of 18%, results in the lowest possible service price (assuming 100% launch cost reduction) within the forecast period being just over US$4300. At this price, cumulative demand for space burial service over the forecast period increases by 565 additional people. However, given the nature of the small payloads, cumulative demand for launches over the forecast period does not change from the Baseline level of 1 dedicated launch.

International Aspects

The model works on a sub-regional basis to calculate demand, then aggregates demand into a global number for manifesting into payloads.

[10] Celestis price information. http://www.celestis.com

Commercial Market Sectors (Evolving)

Sector 2.2.6: On-orbit Sparing

Market Sector Description and Overview

On-orbit sparing provides replacement connectivity for satellite operators through the use of on-orbit satellites with excess capacity to be available in the event of a satellite failure. This is one of the OOM markets, for further explanation of the OOM see section 2.3.

Economics (U.S. Only)

NAICS Code: 52 **Industry Sector**: Finance and Insurance

Size of terrestrial sector: $18 B[11]

Sample Business Model

The original business case, categorized as an Evolving market sector, was an enterprise providing on-orbit sparing services launching one or more satellites with the intent to lease capacity to operators who have experienced a failure. The business might be financed via savings to the insurance community and reduced revenue losses from satellite operators. However, subsequent analysis showed this business case was difficult to close. Currently, excess transponder capacity is leased to operators who have experienced a failure; this is a profitable, and thus more feasible, business and forms the basis of the subsequent forecast analysis. Although this later perspective is that of an Existing market, the designation has remained unchanged so that all OOM markets operate within the Evolving sector market category.

Historical and Base Year (2001) Data

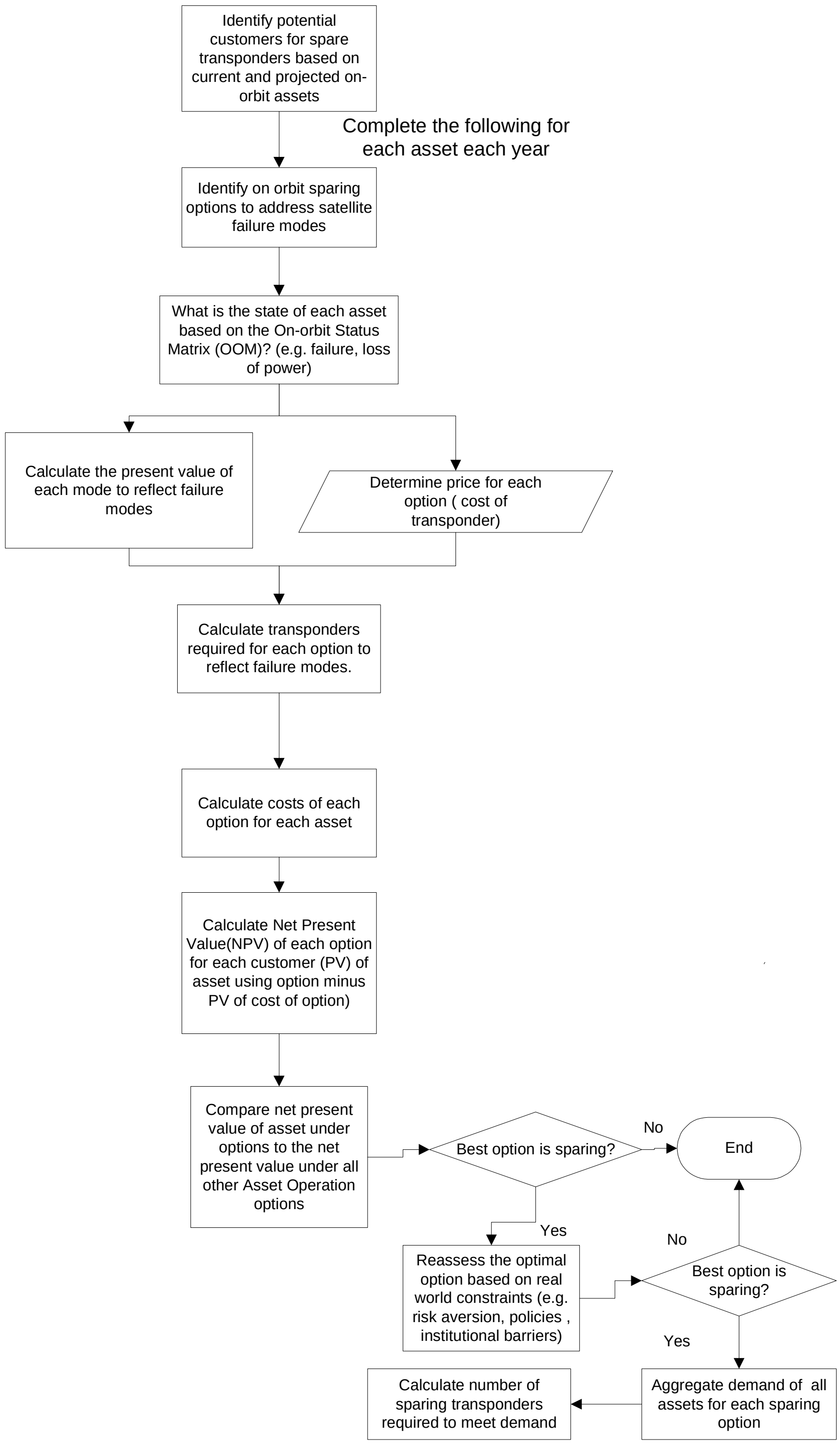
Two launches are included in the 2001 base year.

Terrestrial Competitive Sector Information

Competition for this market includes the launch of satellite spares that have been stored on the ground as a backup, or on-orbit maintenance of satellite with anomalies.

[11] U.S. Census Bureau, 1997 Economic Census: *Finance and Insurance*, Table 1: Summary Statistics for the United States – 1997. Other Insurance Related Activities. http://www.census.gov/prod/ec97/97s81-sm.pdf. Issued March 2001.

DEMAND MODEL DESCRIPTION AND FLOWCHART



Baseline Assumptions

Converting from FUD to Payloads (by Mass Classes): FUD is converted into numbers of equivalent 36 MHz transponders.

Converting from Payloads to Launches (Including Manifesting): Transponder equivalents are converted into equivalent launches across various mass classes.

Market Maturity (S-Curve) Assumptions:

Due to the method used in forecasting this market, there is no S-curve associated with it.

Baseline Forecasts

Baseline Trend

The baseline forecast for on-orbit sparing is dependent upon other ASCENT market forecasts (and their related assumptions) as the need for sparing capacity is directly related to the number of assets on orbit for other applications, such as the traditional telecom markets (i.e., Telephony, Data, and TV/Radio).

Sensitivity Ranging

Robust Case

Assumptions:

- The robust forecast for on-orbit sparing is dependent upon other ASCENT market robust forecasts (and their related assumptions) as the need for sparing capacity is directly related to the number of assets on orbit for other applications, such as the traditional telecom markets (i.e., Telephony, Data, and TV/Radio).

Constrained Case

Assumptions:

- The constrained forecast for on-orbit sparing is dependent upon other ASCENT market constrained forecasts (and their related assumptions) as the need for sparing capacity is directly related to the number of assets on orbit for other applications, such as the traditional telecom markets (i.e., Telephony, Data, and TV/Radio).

Launch Price Gearing Factor

Launch Price Gearing Factor	
69%	Other Costs
18%	Space Segment
13%	**Launch Price**

To find the gearing factor for the on-orbit sparing market, Futron calculated the proportion of the wholesale price of one satellite transponder that is comprised of launch costs. Futron calculated the yearly launch costs (amortized) as a proportion of total yearly operating costs of a major international satellite operator. This was found to be 24%. (Source: PanAmSat Corporation 2001 Annual Report). As a percentage of a single transponder's wholesale price this percentage (of launch costs) drops to 13% (based on Futron internal transponder pricing database).

PRICE ELASTICITY INFORMATION AND PRICE CHANGE FORECASTS

Not evaluated, due to low gearing factor.

INTERNATIONAL ASPECTS

The model considers global transponder capacity and the unused proportion that is available as an alternative resource for sparing.

Commercial Market Sectors (Evolving)

Sector 2.2.7: Orbital Asset Servicing and Salvage

Market Sector Description and Overview

The on-orbit servicing of space assets, and the recovery of space assets. On-orbit servicing and salvage applications may be performed by a crew or robotically. This is one of the OOM markets, for further explanation of the OOM see section 2.3.

Economics (U.S. Only)

NAICS Code: 44-45 **Industry Sector**: Retail Trade

Size of terrestrial sector: $14.5 B[12]

Sample Business Model

Spacecraft would be serviced on-orbit to mitigate the losses of failed space assets, improve or expand the capabilities of space assets, or to extend their service lives. A human crewmember or a remote-controlled robot could accomplish this. Space assets could also be recovered and returned to Earth for refurbishment and re-launch, allowing operators and insurance companies to partially recover losses due to failed spacecraft. Recovered space assets could also be sold at auction to collectors for their historical value.

Historical and Base Year (2001) Data

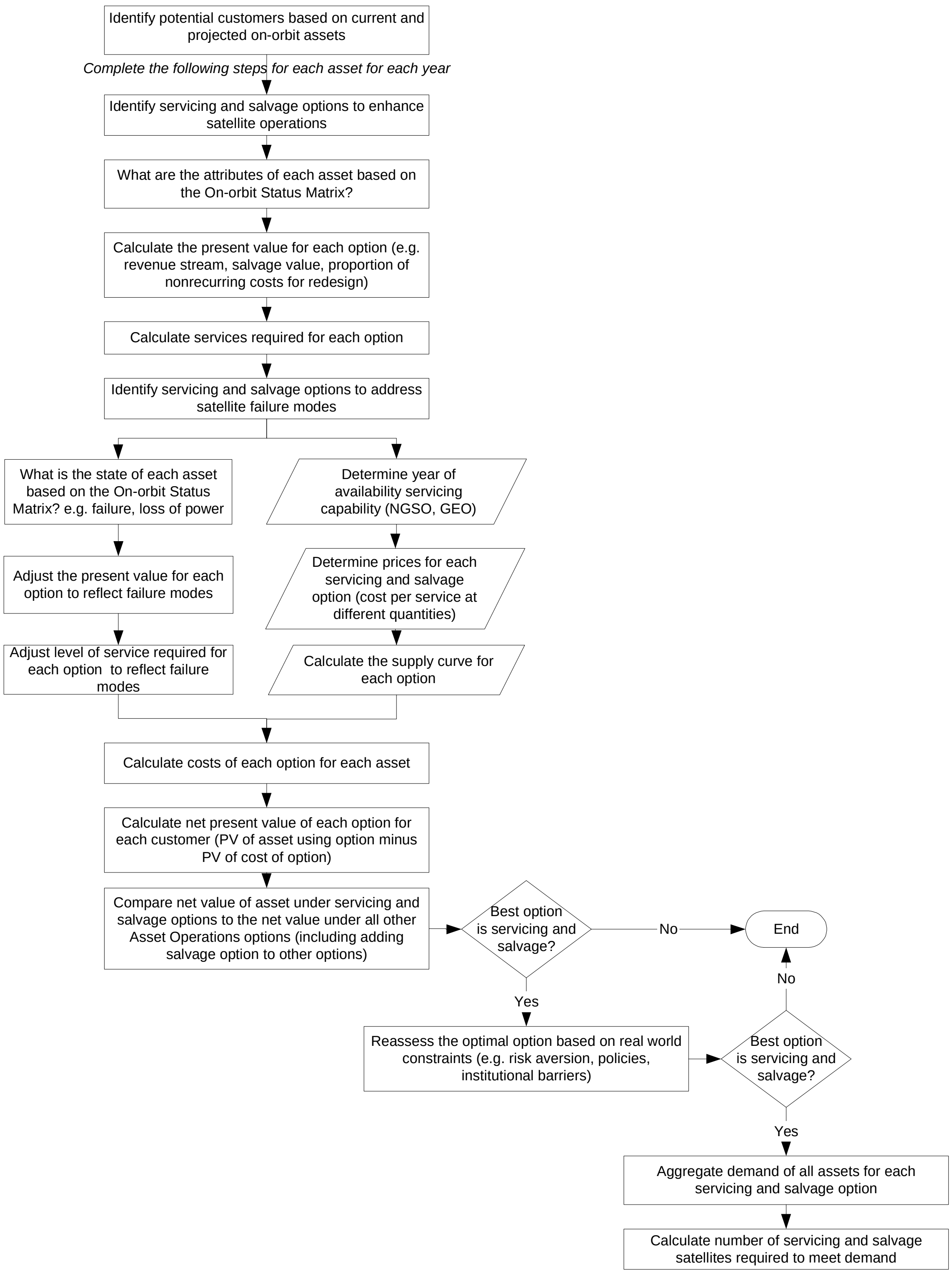
An Evolving sector that as yet has generated no historical data.

Terrestrial Competitive Sector Information

The competition to servicing and salvage is the replacement of the failing spacecraft with a ground spare or new satellite. Currently, on-orbit asset servicing and salvaging is not much more price competitive than this "terrestrial" alternative.

[12] U.S. Census Bureau, 1997 Economic Census: *Retail Trade*, Table 1: Summary Statistics for the United States 1997 Gift, Novelty, & Souvenir Stores. http://www.census.gov/prod/ec97/97r44-sm.pdf. Issued January 2001.

Demand Model Description and Flowchart



Baseline Assumptions

Converting from FUD to Payloads (by Mass Classes): There are no asset servicing and salvage payloads in the baseline forecast.

Converting from Payloads to Launches (Including Manifesting): There are no asset servicing and salvage launches for the baseline forecast.

Market Maturity (S-Curve) Assumptions:

Due to the method used in forecasting this market, there is no S-curve associated with it.

Baseline Forecasts

Baseline Trend

The on-orbit asset servicing and salvage market presumes a single servicing vehicle, on-orbit, which responds as required to assets in need. The servicing vehicle is expected to require refueling at an orbiting propellant depot in between servicing missions. The servicing vehicle is presumed to be a single, large-class payload with a 15-year lifetime. Start year for the service is set at 2012; for the parameters of demand forecast here, only one servicing vehicle, and therefore one launch, is required to service multiple assets in need.

Sensitivity Ranging

Robust Case

Assumptions:

- High levels of government subsidization of research and development
- Advanced, high-efficiency propellant technology eliminates need for refueling at propellant depot between servicing missions
- Four assets require servicing in robust case – produces demand for one servicing-related launch in 2012

Constrained Case

Assumptions:

- Higher than expected development and manufacturing costs
- Little application of government-subsidized research and development to servicing unit

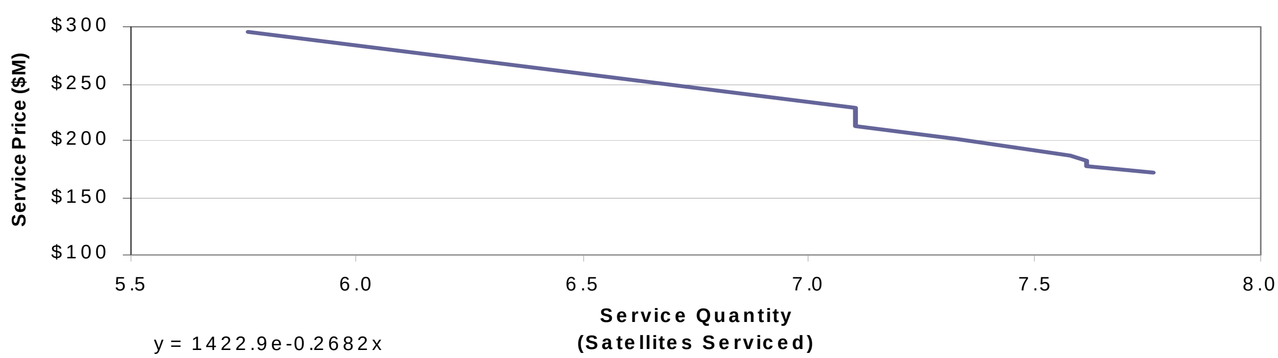
Launch Price Gearing Factor

Launch Price Gearing Factor

7%	Space Segment Development
12%	Space Segment Manufacturing
22%	Financing
1%	Operations
58%	**Launch Price**

The orbital service and salvage architecture includes one servicing vehicle, which docks and refuels at the propellant depot. Total cost of the system includes space segment development and manufacturing, operations based on a 15-year design life, finance costs, and launch costs. Launch costs are comprised of delivering required fuel to the propellant depot and a single heavy launch for the servicing vehicle. Baseline launch costs represent 58% of the total cost of an orbital service and salvage service. Space segment development costs are a conservative estimate based on an award given to Defense Advanced Research Projects Agency to develop the Orbital Express. Finance costs are based on financing 70% of the launch of the servicing vehicle and space segment costs at a 6% interest rate.

Price Elasticity Information and Price Change Forecasts



Service Price	$172	$179	$183	$187	$202	$213	$228	$296	**Service Price ($M)**
Service Quantity	7.8	7.6	7.6	7.6	7.3	7.1	7.1	5.8	**Satellites**

Futron utilized the on-orbit matrix model to determine the price elasticity of demand for on-orbit servicing. The on-orbit matrix and servicing submodel were used to calculate demand at different price points. A market appeared once launch prices were reduced by at least 40%, resulting in the service price and quantity demanded shown in the graph above. Groups of satellites can afford service at different price levels. As the price of the service increases, groups of satellites will drop out of the affordable range. At these threshold points, slight increases in price will not change the number of serviceable satellites, thus causing the kinks in the curve.

INTERNATIONAL ASPECTS

This market is an international market. Satellite operators around the world routinely purchase space assets from international vendors. In addition, in order for the service to eventually compete, it will have to address the entire orbital population, not just that of one or two nations.

Commercial Market Sectors (Evolving)

Sector 2.2.8: Space Solar Power: On-orbit Uses

Market Sector Description and Overview

The use of space solar power satellites in GEO capable of beaming power to other orbiting spacecraft. This is one of the OOM markets, for further explanation of the OOM see section 2.3.

Economics (U.S. only)

NAICS Code: 22 **Industry Sector**: Utilities

Size of terrestrial sector: $269 B[13]

Sample Business Model

Satellite manufacturers develop new generation of spacecraft designed to operate using solar power from solar concentrator satellites. Benefits result from two alternative design approaches:

Maintain the power and decrease the size of the solar panels. Savings would come from decreased manufacturing costs and lower launch costs due to lower weight.

Maintain the solar panel size and load more transponders onto a satellite due to the increase in power. Satellite operators would not need to launch as many satellites to fulfill the demand for satellite services, thus lowering both manufacturing and launch costs.

"Savings" would be split between the in-orbit power company, satellite manufacturers, and operators.

Historical and Base Year (2001) Data

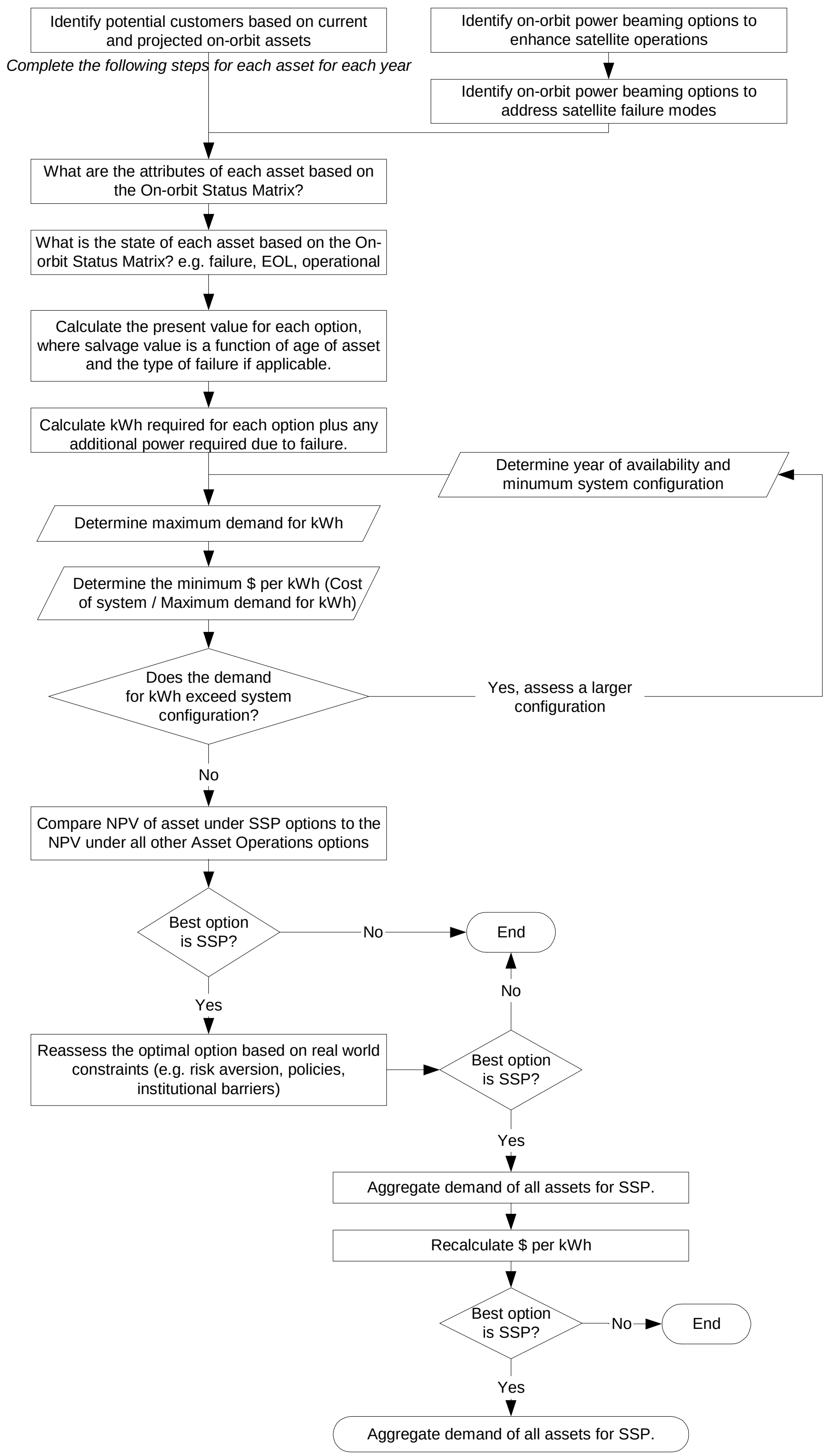
This is a potential Evolving market sector that as yet has generated no historic data.

Terrestrial Competitive Sector Information

There is no terrestrial competition for beaming solar power to on-orbit assets. The only other option for the assets is to do nothing therefore decrementing service.

[13] U.S. Census Bureau, 1997 Economic Census: *Utilities*, Table 1: Summary Statistics for the United States 1997 Electric Power Generation, Transmission and Distribution. http://www.census.gov/prod/ec97/97t22s-sm.pdf. Issued December 2000.

Demand Model Description and Flowchart



Baseline Assumptions

Converting from FUD to Payloads (by Mass Classes): The FUD for this market is kWh. The demand for kWh drives the SSP satellite configuration, i.e. the higher the demand for kWh the larger the SSP satellite system must be to meet that demand. The SSP satellites must be launched modularly and assembled on orbit, therefore the number of payloads is dependent on the configuration.

Converting from Payloads to Launches (Including Manifesting): In the case of SSP the number of payloads will be equal to the number of launches.

Market Maturity (S-Curve) Assumptions:

Due to the method used in forecasting this market, there is no S-curve associated with it.

Baseline Forecasts

Baseline Trend

There has been extensive research on space solar power satellites designed for terrestrial power. For on orbit uses a much smaller system is required. For this analysis a terrestrial SSP system has been scaled down to provide estimates of the cost of an on-orbit beaming SSP system. The terrestrial system is a 1,200 MW GEO Suntower with 3 satellites each producing 400 MW of power. The on orbit beaming system needs only 2 satellites in GEO. Each satellite's power has been scaled down to 1% of the terrestrial system for a total system power of 8,000 kW. Not all systems receive the same benefits of scaling as power. The mass, space segment costs, and operations/maintenance costs were scaled down to 10% of the terrestrial system. The expected lifetime of the satellites is 20 years. At current costs a SSP system is not probable due to a very high cost of service.

Sensitivity Ranging

Robust Case

Assumptions:

- The system configuration is the same as the baseline scenario. The scaling benefits were decreased to 5% of the terrestrial system.

Constrained Case

Assumptions:

- The system configuration is the same as the baseline scenario. The scaling benefits were increased to 20% of the terrestrial system.

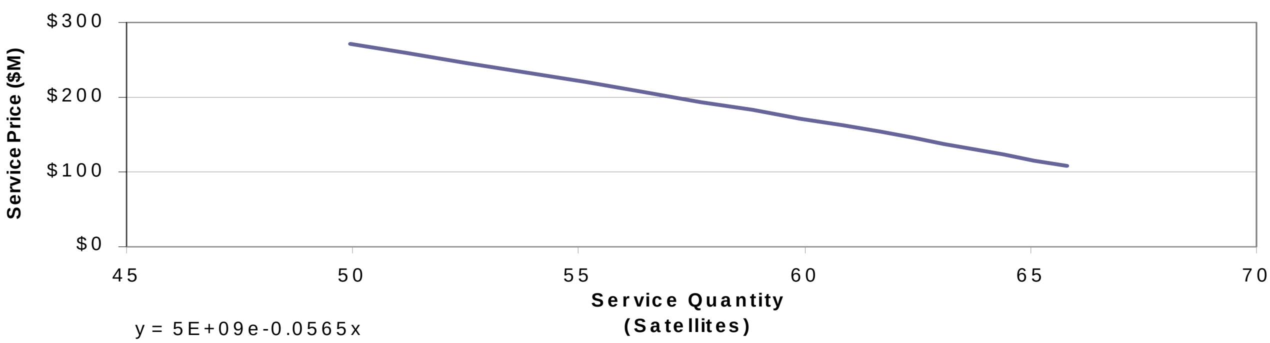
Launch Price Gearing Factor

Launch Price Gearing Factor

3%	Space Segment
4%	Operations & Maintenance
58%	Financing
35%	**Launch Price**

The on-orbit space solar power system consists of two satellites, each a scaled down version of the 400 MW GEO Suntower satellites designed for terrestrial use. The scaling factor used for the baseline cases is 90%, i.e., the satellite providing power to on-orbit assets is one-tenth the size of the concept design to provide terrestrial services. Detailed terrestrial power concepts and cost research can be found in "An Executive Summary of Recent Space Solar Power Studies and Finding" presented by Joe Howell, Marshall Space Flight Center and John Mankins, NASA headquarters in April 1999. Futron has scaled down estimated costs from this study to calculate the total cost of an on-orbit space solar power system. The total cost can be broken down as follows: The space segment costs include all costs associated with building the satellites. Operations and Maintenance costs are based on a 20-year design life. Finance costs represent the bulk of the SSP system cost and are based on financing 70% of the launch and space segment costs at a 6% interest rate. The launch costs ($21B in the Baseline) are composed entirely of the costs associated with launching the mass of these two satellites, which would take 140, Delta IV launches.

Price Elasticity Information and Price Change Forecasts



Service Price	$ 108	$ 173	$ 271	Service Price ($M)
Service Quantity	66	60	50	Satellites

Futron utilized the On Orbit Matrix model to determine the price elasticity of demand for on-orbit space solar power services. The On Orbit Matrix and space solar power submodel were used to calculate demand at different price points. A market appeared once launch prices were reduced by at least 90%, resulting in the service price and quantity demanded shown in the graph above.

INTERNATIONAL ASPECTS

Since failure rates are applied to all assets within a market independent of country of origin, the global analysis is obtained by distributing the assets according to the input markets.

Commercial Market Sectors (Evolving)

Sector 2.2.9: Propellant Depot

Market Sector Description and Overview

A Propellant Depot is an orbital fuel storage and transfer system used to refuel platforms in space. It is assumed that such facilities would initially be managed by government entities, with commercial management options occurring only later in the forecast time frame. This is one of the OOM markets, for further explanation of the OOM see section 2.3.

Economics (U.S. only)

NAICS Code: 22 **Industry Sector**: Utilities

Size of terrestrial sector: $8 billion[14]

Sample Business Model

For this study, it is assumed that propellant depots would initially be government managed and funded facilities. The satellite and platform operators could have a contract for these services. Satellite manufacturers would need to invest in redesigning future generations of satellites to take advantage of the fuel depots.

Historical and Base Year (2001) Data

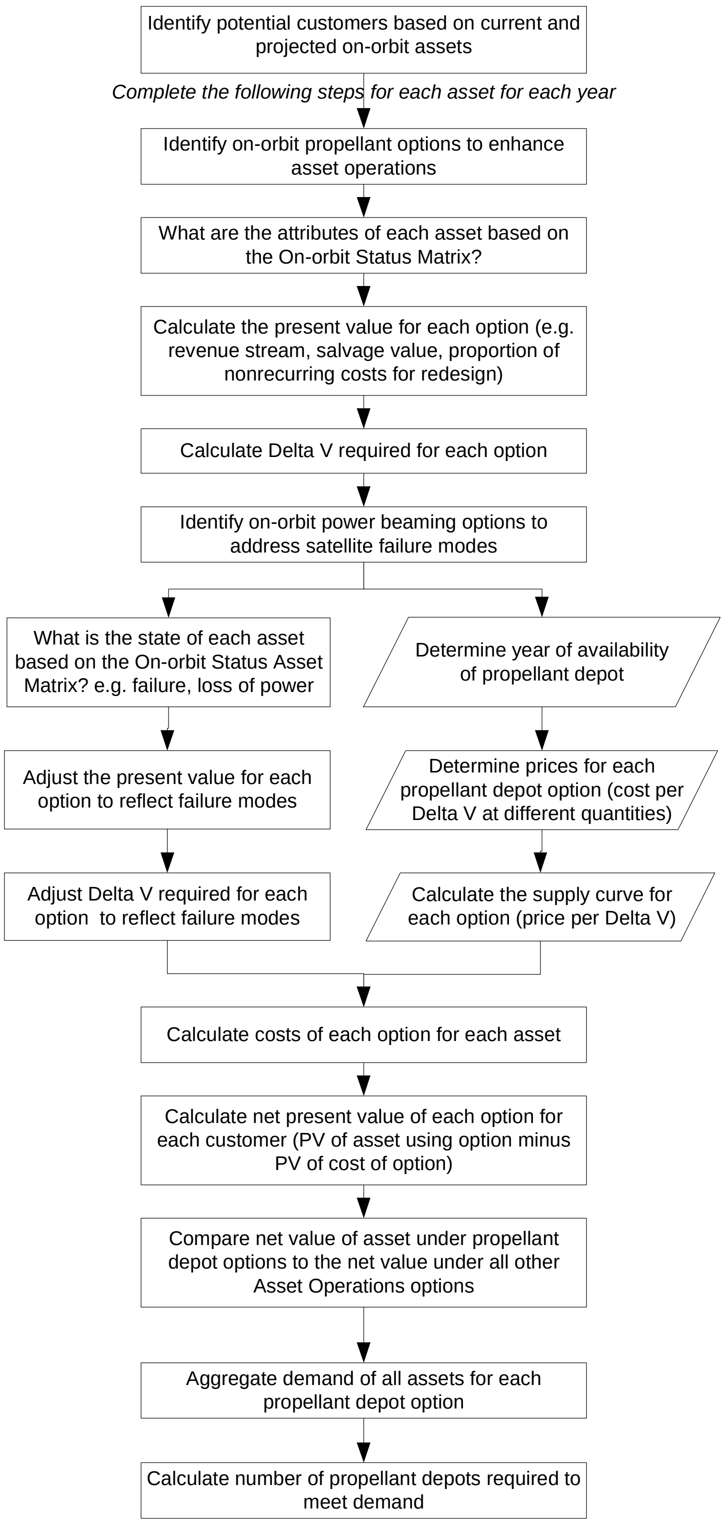
This potential Evolving market has as yet not generated any historical mission data.

Terrestrial Competitive Sector Information

There is no terrestrial competition for a propellant depot. The only other option for the assets is to do nothing therefore decrementing service, and bring forth the relaunch of a next generation spacecraft.

[14] U.S. Census Bureau, 1997 Economic Census: *Utilities*, Table 1: Summary Statistics for the United States 1997 Other Electric Power Generation. http://www.census.gov/prod/ec97/97t22s-sm.pdf. Issued December 2000.

DEMAND MODEL DESCRIPTION AND FLOWCHART



Baseline Assumptions

Converting from FUD to Payloads (by Mass Classes): The FUD for this market is fuel, the mass of cryogenic fuel required to correct the asset's orbit. The demand for fuel drives the propellant depot configuration, i.e. the higher the demand for fuel the more propellant depots and/or fuel launches will be needed to meet that demand. A cryogenic propellant depot can be launched in a single launch and then at least one fuel launch must follow.

Converting from Payloads to Launches (Including Manifesting): In the case of propellant depot the number of payloads will be equal to the number of launches

Market Maturity (S-Curve) Assumptions:

Due to the method used in forecasting this market, there is no S-curve associated with it.

Baseline Forecasts

Baseline Trend

At current costs a propellant depot is not cost effective. The methodology includes development and manufacturing costs, financing costs, and the launch cost of the minimum propellant depot system (one propellant depot, one orbital transfer/maneuver vehicle (OMV/OTV), and the fuel required to service failed assets). The launch costs for fuel have been discounted to allow for economy of scale and lower insurance costs.

Sensitivity Ranging

Robust Case

Assumptions:

- Assume government pays all of the development costs and some of the manufacturing costs due to existing government requirements

Constrained Case

Assumptions:

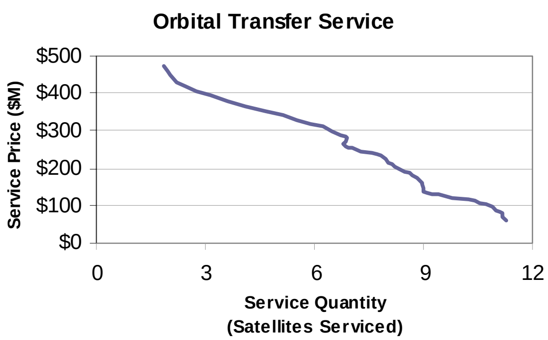
- Assumes higher than anticipated development and manufacturing costs

Launch Price Gearing Factor

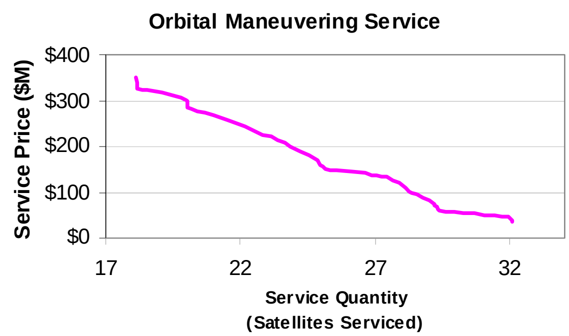
Launch Price Gearing Factor	
20%	Space Segment Development
25%	Space Segment Manufacturing
0%	Operations (minimal)
36%	Financing
19%	**Launch Price**

The propellant depot architecture is based on a previous study Futron completed in August 2001 for NASA Marshall Space Flight Center, “An Analysis of Potential Markets and Their Fuel Requirements for an In-Space Propellant Depot”. The architecture includes one propellant depot station, one orbital transfer/maneuver vehicle, and propellant required to service demand. Total cost of the system includes space segment development and manufacturing, operations based on a 10-year design life, finance costs, and launch costs. Space segment development costs are a conservative estimate based on an award given to DARPA to develop the Orbital Express. Finance costs represent a third of the Propellant Depot system cost and are based on financing 70% of the launch and space segment costs at a 6% interest rate. The launch costs represent 19% of the total cost of a propellant depot system at Baseline costs and includes launches for the propellant depot station, orbital transfer/maneuver vehicle, and propellant.

Price Elasticity Information and Price Change Forecasts



Formula for PE curve: y = 841.44e-0.1933x



Formula for PE curve: y = 5521.5e-0.1456x

Orbital Transfer Service

Service Price	$62	$84	$108	$134	$158	$180	$204	$233	$261	$283	$319	$417	$474	**Service Price ($M)**
Service Quantity	11	11	11	9	9	9	8	8	7	7	6	2	2	**Satellites serviced**

Orbital Maneuvering Service

Service Price	$35	$47	$60	$73	$86	$98	$110	$125	$138	$151	$167	$191	$215	$267	$285	$301	$326	$335	$351	**Service Price ($M)**
Service Quantity	32	32	29	29	29	28	28	28	27	25	25	24	23	21	20	20	18	18	18	**Satellites serviced**

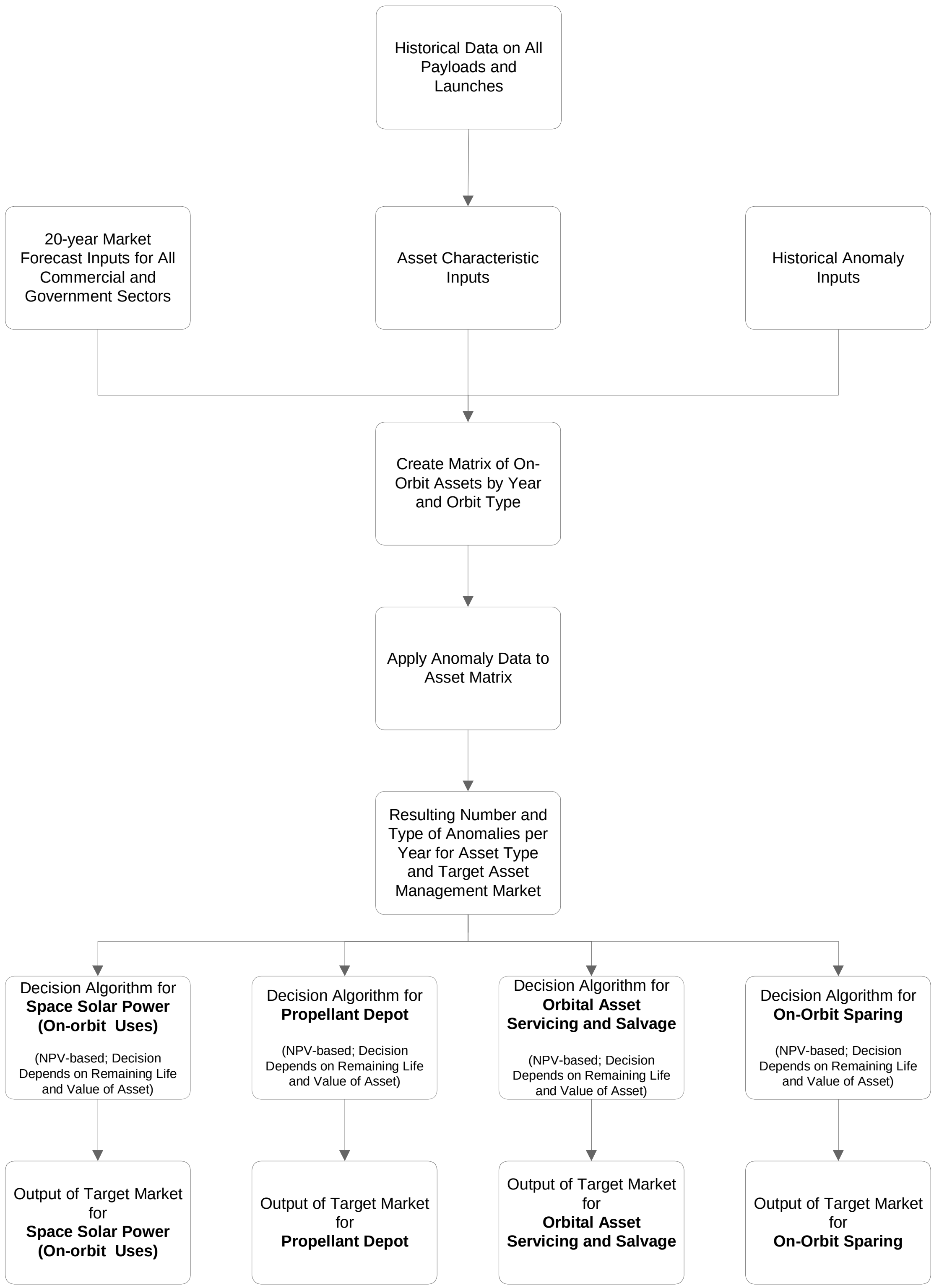
Futron utilized the On-orbit matrix (OOM) model to determine the price elasticity of demand for a propellant depot. The market has two interdependent services: orbital maneuver and orbital transfer. The OOM and depot submodel were used to calculate demand at different price points for both services. These graphs show the number of satellites on orbit being serviced at various price points. For the number of new launches generated to carry out these services, see Volume I of the ASCENT Study Final Report.

A market appeared for orbital maneuver service once launch prices were reduced by 5% and for orbital transfer (a much more expensive service) once launch prices were reduced by 35%, resulting in the service price and quantity demanded shown in the graphs above. Satellites can afford service at different price levels. As the price of the service increases, some satellites will drop out of the affordable range. At these threshold points, slight increases in price will not change the number of serviceable satellites, thus causing the kinks in the curve.

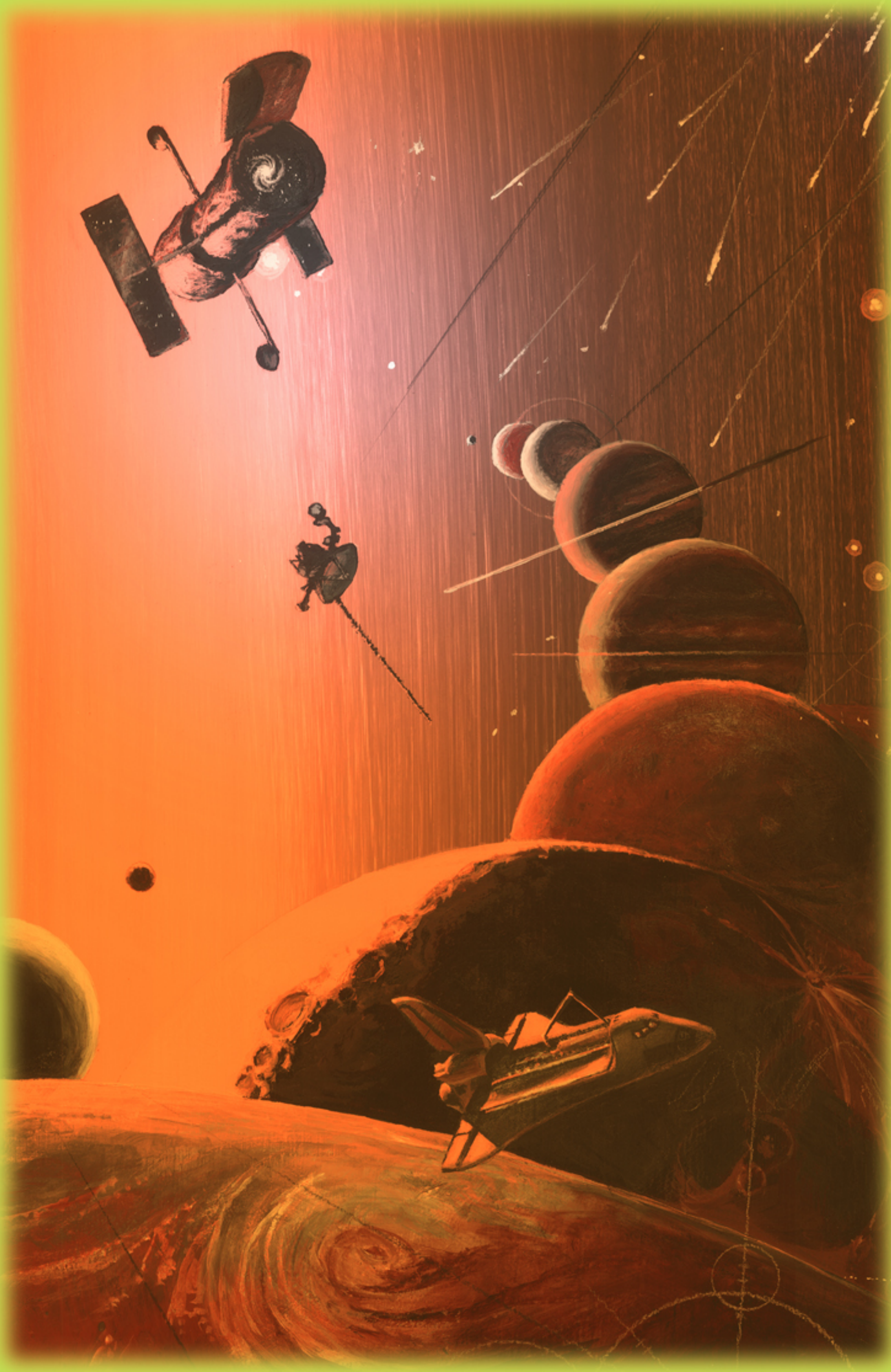
International Aspects

The global analysis was obtained by distributing the assets according to the input markets.

2.3 O.O.M. Commercial Market Sector Relationships



2.4 Government Sectors



Government Sectors

Sector 2.4.1: ISS Missions

GOVERNMENT SECTOR DESCRIPTION AND OVERVIEW

Dedicated logistical, scientific and crew exchange missions to ISS, excluding human space rescue.

SAMPLE OPERATIONAL MODEL

Supply-based support to ISS. Commercial operation of the ISS or its research programs may be profitable. An add-on commercial module for the ISS is treated separately in the Evolving Commercial Sector section.

Source & Amendments to Mission Plans:

The NASA Design Analysis Cycle (DAC) -8 publication was used to determine resupply mission frequency, and some NASA offices were contacted to verify certain information.

It is assumed that ISS will operate through 2020.

It is assumed the Japanese H2 Transfer Vehicle (HTV) will be cancelled due to funding problems, but that the Kibo module will be launched.

It is assumed the number of Shuttle flights will drop per year to between 5-6 flights. Three of those will hold Expedition Crews, while others (1-2) will launch cargo. One to two Shuttle flights will be non-ISS related, and as such, are counted in Other Government Missions (Sector 2.4.13).

HISTORICAL AND BASE YEAR (2001) DATA

In 2001, thirteen aggregated payloads were launched to the ISS.

BASELINE FORECASTS

Baseline Trend

Shuttle flights will likely fluctuate between 2002 and 2005 as the ISS is being assembled. From 2005 to 2021, the number of Shuttle flights to the ISS is expected to be five per year. The number of Soyuz replacement flights is expected to remain at two per year until 2005, when the number increases to four per year due to Crew Return Vehicle (CRV) cancellation (assumption is ISS crew will be six at construction complete). Number of Progress flights will remain steady at four per year (two for provisions, two for fuel). Europe is expected to provide one Automated Transfer Vehicle (ATV) flight per year, and no HTV flights are expected due to budget cut backs.

Converting from Payloads to Launches (Including Manifesting): Three Shuttle flights containing an Expedition Crew of three members are expected per year. These flights may also include ISS assembly components, a factor considered in the forecast to avoid double counting. All other ISS-related flights, such as Soyuz, Progress, and ATV, are single manifested.

SENSITIVITY RANGING

Robust Case

Assumptions:

- Dedicated ISS Shuttle flights increase to six per year, with the number of Soyuz replacement flights remaining the same as projected for baseline forecast. Japanese HTV flights are projected; with one flight every other year beginning in 2004. The number of Progress flights per year remains the same as in baseline forecast.

Constrained Case

Assumptions:

- Dedicated ISS Shuttle flights decrease to only four per year, with the number of Soyuz replacement flights holding at two per year throughout the forecast period. European ATV flights, of which nine have been contracted, are included in constrained forecast, but no further flights are expected to follow after 2013. The number of Progress flights per year remains the same as in baseline forecast. No HTV flights are projected.

PRICE CHANGE FORECASTS

Assumed no impact.

INTERNATIONAL ASPECTS

Because the CRV was cancelled, many ISS partners are concerned that the ISS will hold only three personnel from now on. Pressure to address this issue is expected to increase demand for Soyuz flights from two per year to four.

Government Sectors

Sector 2.4.2: Military and Civil Communications

Government Sector Description and Overview

Orbital communications and telemetry platforms dedicated to military and/or civil applications.

Sample Operational Model

Demand-based on military needs. Typically, a strategic plan is drafted which, depending on budget availability, may include requirements for dedicated communication satellites.

Some governments may transfer some routine communications from military systems to commercial systems, with the responsible defense agency acting as a paying customer. This move may alleviate budget strains and free up monies for dedicated battle-ready communication satellites.

Source & Amendments to Mission Plans:

Military and civil communication satellite information gathered from relevant program offices (when possible), the 2001 National Launch Forecast (for U.S.), recent articles, and reports.

Government communication satellite programs of Europe, India, and Japan were easily available.

Information regarding all other government communication satellites, such as those operated by Russia and China, are based on recent news articles and assumptions based on historical data. Russia's continuing economic woes, however, were factored into the forecast.

Futron's databases were also used to develop historical trends in an effort to determine validity of forecasts.

Historical and Base Year (2001) Data

In the base year of 2001, fifteen separate payloads were launched for military and civil communications purposes.

Baseline Forecasts

Baseline Trend

Worldwide civil and military communications satellites are included in baseline if sufficient public information exists regarding their status. If system is still in planning phases, and little to no funding is projected in near-term budget forecasts, system is not included in baseline forecast. A peak is evident between 2002 and 2006 due to greater information regarding specific proposed programs. The trend flattens out as replacements are projected.

Converting from Payloads to Launches (Including Manifesting): Government telecommunication satellites are typically launched one at a time. Exceptions to this are those launched aboard Ariane 5G vehicles, and in those instances it may be paired with a commercial GEO payload. When two European government telecommunication satellites are to be launched in one year, they were doubled up on one vehicle.

Sensitivity Ranging

Robust Case

Assumptions:

- Systems with an ambiguous schedule but with a reasonable chance of being funded are included in robust forecast. Examples include a follow-on system for Russia's existing Gorizont program, and Iran's Zohreh satellites.

Constrained Case

Assumptions:

- Some U.S. systems, such as AEHF and MUOS, are delayed by a few years in the constrained forecast. Number of replacement satellites for systems like Gals and Gonets dropped to almost nothing due to lack of funding, though most systems remain unchanged from baseline.

Price Change Forecasts

Assumed no impact.

International Aspects

Some countries launch government telecommunication satellites commercially because they do not have an indigenous launch capability. Most countries requiring government telecommunication service often lease transponders on commercial satellites.

Government Sectors

Sector 2.4.3: Remote Sensing: Civil

Government Sector Description and Overview

Orbital science platforms dedicated to civil missions to passively or actively image the surface and/or atmosphere of the Earth. Excludes law enforcement missions by federal, state, or local government agencies.

Sample Operational Model

Supply-based programs supporting government and university programs related to Earth resource management, meteorology and scientific research related to the Earth's atmosphere and surface. The timing of government markets is supply-based and depends on policy decisions and not commercial market demand.

Source & Amendments to Mission Plans: Civil remote sensing satellite information gathered from relevant program offices (when possible), the 2001 National Launch Forecast, recent articles, and reports. Civil remote sensing programs of Europe, India, and Japan were easily available. Information regarding all other civil remote sensing satellites, such as those operated by Russia and China, are based on recent news articles and assumptions based on historical data. Russia's continuing economic woes, however, were factored into the forecast. Futron's databases were also used to develop historical trends in an effort to determine validity of forecasts.

Historical and Base Year (2001) Data

In the base year of 2001, nine identified payloads were launched in support of the civil remote sensing government sector.

Baseline Forecasts

Baseline Trend

Worldwide civil remote sensing satellites are included in the Baseline if sufficient public information exists regarding their status. If system is still in planning phases, and little to no funding is projected in near-term budget forecasts, system is not included in baseline forecast.

Converting from Payloads to Launches (Including Manifesting):

Typically, civil remote sensing satellites are launched one at a time. Rocsat 3, consisting of six satellites, will be launched as a unit in 2005. The Disaster Monitoring Constellation, and a Chinese variant of the program, will be launched two-three at a time, though some may be paired with other satellites. TERRA-SAR satellites will be launched two at a time.

Sensitivity Ranging

Robust Case

Assumptions:

- No change from baseline.

Constrained Case

Assumptions:

- This does not affect launches. Some systems, particularly if little information exists about them, are not counted. Since these are likely to be secondary payloads, the number of launches is unaffected. Examples include Russia's EORSAT, China's disaster monitoring constellation and the Australian Aries.

Price Change Forecasts

Assumed no impact.

International Aspects

Joint programs were considered under the country with primary responsibility. It is probable that countries interested in remote sensing data but not currently having a space program will purchase such services from commercial suppliers. This is an expected trend based on recent precedent. As a result, few new space powers with their own satellites are listed.

Government Sectors

Sector 2.4.4: Remote Sensing: Military

Government Sector Description and Overview

Orbital military platforms dedicated to intelligence gathering and treaty verification missions using passive or active sensors focused on the surface and atmosphere of Earth.

Sample Operational Model

Supply of assets is based on military needs. Typically, a strategic plan is drafted which, depending on budget availability, may include requirements for space-based terrestrial observation.

Source & Amendments to Mission Plans: Military remote sensing satellites, otherwise known as intelligence gathering satellites, belong to programs and organizations of a classified or highly sensitive nature. As a result, significant assumptions are made based on historical data and some articles published in unclassified sources. The U.S. will continue to launch heavy and intermediate-class NRO satellites, based on news that Boeing has been awarded a substantial contract to build them. It is assumed that SBIRS High and Low will be launched, despite current funding problems. NPOESS will replace DMSP and NOAA satellite functions over time. This program will be chiefly operated by USAF, which is why it is classified as military. NPP, which is an interim system due to come on line prior to NPOESS 1, will not be operated by USAF, and was counted in Civil Remote Sensing. Futron's databases were also used to develop historical trends in an effort to determine validity of forecasts.

Historical and Base Year (2001) Data

In the base year of 2001, seven separate payloads were launched in support of the Military Remote Sensing sector.

Baseline Forecasts

Baseline Trend

Worldwide military satellite systems dedicated to intelligence gathering and early warning are included in baseline. Replacements or spares for certain constellations are projected based on published data.

Converting from Payloads to Launches (Including Manifesting): These types of satellites are normally launched one at a time.

Sensitivity Ranging

Robust Case

Assumptions:

- Forecast remains essentially unchanged. The potential demand for military remote sensing satellites is expected to be limited even in the robust forecast due to the expected proliferation of available commercial remote sensing products and services, as well as the increasing use of UAVs.

Constrained Case

Assumptions:

- Two key systems, the U.S. SBIRS Low and SBIRS High, are delayed by a few years due to high potential for budget shortfalls. Other systems remain unchanged from baseline forecast.

Price Change Forecasts

Assumed no impact.

International Aspects

These satellites are never launched aboard another country's launch vehicles.

Government Sectors

Sector 2.4.5: Positioning

GOVERNMENT SECTOR DESCRIPTION AND OVERVIEW

Orbital platforms dedicated to providing timing and positioning data for purposes of navigation. Value added products are discussed in the commercial Data Market.

SAMPLE OPERATIONAL MODEL

Baseline is government agencies, both in U.S. and elsewhere, providing free position and timing information. This facility enables various terrestrial commercial businesses to operate for mobile users on land, sea, and air.

Source & Amendments to Mission Plans: For the United States Navstar constellation, information was gathered from the 2001 National Launch Forecast, the Global Positioning System (GPS) Program Office, and key articles and reports. Glonass, Nadezhda, and Parus navigation satellite information obtained from key articles and selected annual reports. While the European Galileo system is still in the formative stage, enough information regarding the number of satellites, launch years, and type of vehicle was available. Information regarding the Chinese Beidou and Indian SBAS is scarce, and assumptions were made regarding mass class and service life based on launch vehicle performance. Futron's databases were also used to develop historical trends in an effort to determine validity of forecasts.

HISTORICAL AND BASE YEAR (2001) DATA

In the base year of 2001, five separate payloads were launched worldwide in support of the positioning sector.

BASELINE FORECASTS

Baseline Trend

Major U.S. and Russian programs are included in this forecast, with projected spare and replacement satellites spaced evenly after constellations are complete. For baseline forecast, Europe's Galileo program is forecasted, with launch of the first satellite in 2004. China's Beidou constellation, located in GEO, is also included, as is the proposed Indian SBAS system.

Converting from Payloads to Launches (Including Manifesting): With the exception of Galileo, Glonass M, and Glonass K satellites, all navigation satellites listed are launched one at a time. Galileo satellites are expected to be launched five at a time aboard Ariane 5G vehicles, based on a constellation size of 30 in six orbital planes. Glonass M satellites are typically launched three at a time aboard Proton vehicles, a trend expected to continue for Glonass K. However, the first 18 Glonass K satellites are expected to be launched in groups of six.

Sensitivity Ranging

Robust Case

Assumptions:

- For robust forecast, a greater number of spare and replacement satellites are projected.

Constrained Case

Assumptions:

- Navstar GPS 2F and GPS 3 are delayed by a few years, and the Indian SBAS program is cancelled. The projected number of Glonass K satellites is also reduced.

Price Change Forecasts

Assumed no impact.

International Aspects

Nadezhda satellites contribute to the COSPAS/SARSAT constellation used for rescue and other emergency locating purposes. The other contributing system is NOAA, and these satellites are counted in Civil Remote Sensing.

Government Sectors

Sector 2.4.6: Space Science (Non-ISS)

Government Sector Description and Overview

Orbital and planetary spacecraft dedicated to a mission of exploration and discovery of phenomena in the Universe, excluding the surface and atmosphere of Earth.

Sample Operational Model

Supply-based government sector for scientific research.

Source & Amendments to Mission Plans: Civil remote sensing satellite information gathered from relevant program offices (when possible), the 2001 National Launch Forecast, recent articles, and reports. Space science programs of Europe, India, and Japan were easily available. Information regarding all other space science satellites, such as those operated by Russia and China, are based on recent news articles and assumptions based on historical data. Russia's continuing economic woes, however, were factored into the forecast. Futron's databases were also used to develop historical trends in an effort to determine validity of forecast.

Historical and Base Year (2001) Data

In the base year of 2001, five Space Science (non-ISS) aggregated payloads were launched.

Baseline Forecasts

Baseline Trend

All funded programs are included in forecast. Satellites belonging to a long-term program, such as the U.S. Discovery, UNEX, MIDEX, and others, are projected through 2021 based on historical trends. Similar programs for other countries, like China's Shijian satellites, are also projected.

Converting from Payloads to Launches (Including Manifesting): For purposes of this forecast, most payloads will not be multi-manifested. Historically, small science payloads will be launched aboard medium- and small-class launch vehicles, a trend likely to continue through 2020.

Sensitivity Ranging

Robust Case

Assumptions:

- Several obscure programs with unknown funding status are included, such as uncrewed small lunar missions proposed by China and India before 2010.

Constrained Case

Assumptions:

- Obscure programs or those with unclear funding status are effectively deleted. Since these are likely to be secondary payloads, forecasted launches are unaffected.

Price Change Forecasts

Assumed no impact.

International Aspects

Joint programs were considered under the country with primary responsibility.

Government Sectors

Sector 2.4.7: Human Space Rescue

Government Sector Description and Overview

Dedicated rapid response space missions designed to facilitate the rescue and aid of space-borne personnel in distress.

Sample Operational Model

The safety of humans in space is currently the responsibility of governments. Un-crewed space rescue will operate via crew return vehicle (lifeboat) services including replenishment, upgrades, refurbishment and re-launch. Crewed rescue vehicles would include trained rescue professionals capable of being launched on-demand to rescue humans in orbit. Eventually, a business/operational model similar to that of a private ambulance service could emerge.

Source & Amendments to Mission Plans: No dedicated human space rescue missions has been assumed during the forecast period.

Historical and Base Year (2001) Data

No historical data. No activity in the 2001 base year.

Baseline Forecasts

Baseline Trend

No dedicated human space rescue payloads or launches are included in the forecast.

Converting from Payloads to Launches (Including Manifesting): Not applicable.

Sensitivity Ranging

Robust Case

Assumptions:

- No dedicated human space rescue payloads or launches are forecast.

Constrained Case

Assumptions:

- No dedicated human space rescue payloads or launches are forecast.

Price Change Forecasts

Assumed no impact.

International Aspects

Several countries have contributed to the development of treaties and protocols for the safe recovery of astronauts on the ground. No such regimes exist for the rescue of personnel in space. Soyuz lifeboat missions to ISS are not classified as rescue in this study, since they are not dispatched during a time of emergency.

Government Sectors

Sector 2.4.8: Asteroid Detection and Negation

Government Sector Description and Overview

Space-based platforms used to identify, track, divert, or destroy naturally occurring objects threatening the biosphere of Earth.

Sample Operational Model

Any asteroid detection/negation systems would likely be a government or inter-governmental endeavor. The realization of these systems would be based on policy and budget priorities.

Source & Amendments to Mission Plans: Only Canada appears to have a plan for sending a satellite, called NESS, for purposes of detecting asteroids. Canada foresees needing three such satellites located in GEO, but it is not clear when they will be launched. For purposes of his forecast, it is assumed the launch will occur about midway through the forecast period.

Historical and Base Year (2001) Data

No historical data referring to dedicated satellites, although some asteroid detection work has been performed using data from other spacecraft not specifically designed for the task. No activities have yet been conducted related to the problem of asteroid negation.

Baseline Forecasts

Baseline Trend

Only one asteroid detection system has been proposed, and this is included in the baseline forecast. Possible dual use of early warning satellites for detection of asteroids near Earth are also considered since these may mitigate the need for dedicated systems in the future.

Converting from Payloads to Launches (Including Manifesting): Because the only program discussed consists of GEO satellites, it is probable they will not be multi-manifested.

SENSITIVITY RANGING

Robust Case

Assumptions:

- No change from baseline.

Constrained Case

Assumptions:

- No dedicated asteroid detection/negation payloads or launches are forecast.

PRICE CHANGE FORECASTS

Assumed no impact.

INTERNATIONAL ASPECTS

None.

Government Sectors

Sector 2.4.9: Human Space Exploration (Non-ISS)

Government Sector Description and Overview

Government-sponsored human missions into orbit, the interplanetary medium, and celestial objects. Excludes human missions to ISS.

Sample Operational Model

There may be opportunities for some commercial involvement, but the missions in this study are assumed to be entirely government funded.

Source & Amendments to Mission Plans: No human missions to the Moon or Mars are included during the forecast period. Other than crewed ISS missions, covered in ISS Missions, only the Chinese Shenzhou program will be active. Between two and three missions with crews of two or three are projected for each year. It is assumed that China will build a Salyut-like space station late in the forecast period, but that this will not significantly impact launch numbers.

Historical and Base Year (2001) Data

In the base year of 2001, one Human Space Exploration (Non-ISS) mission was launched.

Baseline Forecasts

Baseline Trend

Human space exploration by the United States, Russia, Europe, and Japan will largely be limited to the ISS. The Chinese Shenzhou program is expected to be successful during the baseline forecast period, with two to three missions per year. China is also expected to launch Salyut-type space stations beginning in 2010. No lunar or Mars mission is included in the forecast.

Converting from Payloads to Launches (Including Manifesting): Shenzhou spacecraft are launched one at a time aboard Long March 2F vehicles.

Sensitivity Ranging

Robust Case

Assumptions:

- No change from baseline forecast.

Constrained Case

Assumptions:

- Human space exploration by the United States, Russia, Europe, and Japan will largely be limited to the ISS. One to two Chinese Shenzhou spacecraft are expected to be launched per year. China is also expected to launch Salyut-type space stations beginning in 2015. No lunar or Mars mission is expected.

Price Change Forecasts

Assumed no impact.

International Aspects

None

Government Sectors

Sector 2.4.10: Law Enforcement

GOVERNMENT SECTOR DESCRIPTION AND OVERVIEW

The use of dedicated space-based surveillance and monitoring assets to enable federal, state, or local response against criminal activity on Earth or in space. Also includes law enforcement personnel stationed in space for similar purposes.

SAMPLE OPERATIONAL MODEL

Local, national and international law enforcement agencies would be the operators and beneficiaries of such a system. In terms of non-terrestrial operations, the responsible operating agency or agencies of communities in space and celestial bodies would maintain or host a security staff. It is not foreseen that any commercial element would be involved, although it is conceivable that insurance companies could provide some of the funding.

Source & Amendments to Mission Plans: Dedicated law enforcement satellites are not expected during the forecast period. Currently law enforcement agencies use the services of existing telecommunication and remote sensing satellites dedicated to other missions.

HISTORICAL AND BASE YEAR (2001) DATA

No historical mission data. No activity in 2001 base year.

BASELINE FORECASTS

Baseline Trend

No dedicated law enforcement payloads or launches are forecast. Law enforcement missions during the next twenty years are expected to be satisfied using existing satellite or aerial imaging platforms.

Converting from Payloads to Launches (Including Manifesting): Not applicable.

Sensitivity Ranging

Robust Case

Assumptions:

- No dedicated law enforcement payloads or launches are forecast. Law enforcement missions during the next twenty years are expected to be satisfied using existing satellite or aerial imaging platforms.

Constrained Case

Assumptions:

- No dedicated law enforcement payloads or launches are forecast. Law enforcement missions during the next twenty years are expected to be satisfied using existing satellite or aerial imaging platforms.

Price Change Forecasts

Assumed no impact.

International Aspects

None.

Government Sectors

Sector 2.4.11: Space Traffic Control

Government Sector Description and Overview

The use of space-based platforms to identify, track and otherwise manage space traffic immediately near the Earth and throughout the interplanetary medium.

Sample Operational Model

This will be a government activity analogous to Air Traffic Control for the airline industry.

Source & Amendments to Mission Plans: Not enough information exists in the public domain on dedicated space traffic control platforms, so none are included in the forecast.

Historical and Base Year (2001) Data

No historical data or activity in 2001 base year.

Baseline Forecasts

Baseline Trend

No dedicated space traffic control payloads or launches are forecast.

Converting from Payloads to Launches (Including Manifesting): Not applicable

SENSITIVITY RANGING

Robust Case

Assumptions:

No dedicated space traffic control payloads or launches are forecast.

Constrained Case

Assumptions:

No dedicated space traffic control payloads or launches are forecast.

PRICE CHANGE FORECASTS

Assumed no impact.

INTERNATIONAL ASPECTS

An international regime will likely be required in an effort to standardize operations between air traffic control and space traffic control in the future.

Government Sectors

Sector 2.4.12: Weapons Systems

Government Sector Description and Overview

Space-based platforms used to negate hostile activities on the surface and atmosphere of Earth, as well as in space. Also includes military personnel stationed in space for military offensive and defensive missions.

Sample Operational Model

This sector would be operated by militaries and its realization would be dependent upon national security and budgetary priorities. Terrorist groups may also conceivably utilize such weapons in the future if advanced weapon technology proliferates.

Source & Amendments to Mission Plans: Not enough information exists in the public domain on dedicated space weapons programs, so none are included in the forecast.

Historical and Base Year (2001) Data

No identified missions in base year 2001.

Baseline Forecasts

Baseline Trend

One U.S. Air Force microsatellite laser system is expected to be deployed during the forecast period. Further information regarding space-based weapons is classified.

Converting from Payloads to Launches (Including Manifesting): Not applicable.

Sensitivity Ranging

Robust Case

Assumptions:

- Despite recent efforts by the government of China to restrict the use of weapons in space, space-based weapons of a generic nature are projected for China every other year beginning in 2010.

Constrained Case

Assumptions:

- No change from baseline forecast.

Price Change Forecasts

Assumed no impact.

International Aspects

By treaty, signatories are prohibited from deploying weapons of mass destruction in space. However, weapons of a defensive nature, such as lasers and kinetic guns, appear outside this prohibition.

Government Sectors

Sector 2.4.13: Other Government Missions

Government Sector Description and Overview

Government missions not captured by the other 12 categories. Capability of a government to launch their own objects into space, or those of another country.

Sample Operational Model

Often supply-based, with governments allotting a small percentage of the nation's budget to space science, public services, and resource management.

Source & Amendments to Mission Plans: This sector includes government missions that did not easily fit the definitions of the other 12 government sectors. Examples include NASA's Space Technology Program missions and the occasional Shuttle mission to service the Hubble Space Telescope.

Historical and Base Year (2001) Data

In the year 2001, this category accounted for ten identified payloads in total.

Baseline Forecasts

Baseline Trend

Included in this forecast are non-ISS dedicated Space Shuttle flights, test payloads for new launch vehicles, space hardware demonstrators, and other difficult to classify payloads like Starshine. Trend for these infrequent missions is about one to two payloads per year, with some as secondary or piggyback payloads. This sector also includes the final Progress mission to the space station Mir in 2001.

Converting from Payloads to Launches (Including Manifesting): None of the payloads in this sector are multimanifested. All the equipment necessary for a Hubble Space Telescope mission or similar has been grouped together as a single large payload.

Sensitivity Ranging

Robust Case

Assumptions:

- Essentially the same as baseline forecast, but with more Starshine missions projected (which are only secondary payloads, and therefore not reflected as dedicated launches).

Constrained Case

Assumptions:

- No change from baseline forecast.

Price Change Forecasts

This category includes hybrid missions and non-specific university payloads (procured with the use of grants or other funding sources), and technology demonstrators funded by organizations like the Defense Advanced Research Projects Office (DARPA). These payload providers procure or produce very small satellites for low per-unit prices, but must contend with very high launch prices. To offset the price burden, several microsats are launched at the same time. Research indicates that even a modest drop in launch prices will significantly increase the number of multimanifested microsats launched per year.

International Aspects

None.

2.5 Emerging Commercial Markets

Emerging Commercial Markets

Sector 2.5.1: Space Agriculture

Market Sector Description and Overview

On-orbit production of plants for purposes of sustaining human space habitation or for production of special hybrid plants to be mass-produced on Earth.

Economics (U.S. only)

NAICS Code: 11 **Industry Sector**: Agriculture, Forestry, Fishing & Hunting

Size of terrestrial sector: $125.4 B[15]

Constraining Factors

Some experimentation has taken place. A full capability will not be developed until a requirement is identified for multi-year space missions.

Associated Data Collection Market

Public Space Travel (Transport) (See sector 2.1.1)

Market Size Reference Sources

DuPont Corporation partnered with the Wisconsin Center for Space Automation and Robotics (WCSAR) to explore soybean development (from seeds to harvested crop) in space on board the Space Shuttle (05/30/02). In 2000, 54 per cent of the world's soybean trade originated from the United States with soybean and product exports totaling more than $6.6 billion.[16] "Breeding seeds in space is expected to become a strong driving force behind Chinese agriculture in the 21st century since it can bring about high-yield and high-quality crops that are hard for ordinary breeding methods to obtain." An estimated 405,000 hectares of rice fields were planted with space seeds and 8,100 hectares of space vegetables were growing. Also, an estimated 243,000 hectares of space rice fields were to be added. China planned to invest the equivalent of $3.6 million (U.S.) in a space seed nursery.[17]

Launch Vehicle Factors

Space Shuttle/RLV needed.

[15] U.S. Census Bureau, Statistical Abstract of the United States: 2001, for 1999 in current dollars; Table No.846. Gross Domestic Product of Natural Resource-Related Industries in Current and Real (1996) Dollars by Industry: 1990 to 1999.

16"DuPont to Launch Soybeans Into Space", Press Release, Pioneer Hi-Bred International, Inc., http://www.pioneer.com/pioneer_news/press_releases/soybeans_space.htm

17 "China Expands Space Breeding Program Using Recoverable Satellites," http://www.spacedaily.com/news/china-00zb.html.

Emerging Commercial Markets

Sector 2.5.2: Non-terrestrial Mining (Lunar and Asteroid)

Market Sector Description and Overview

The prospecting, extraction, processing and distribution of metals, gases, ices and other materials from the Moon and Asteroids.

Economics (U.S. only)

NAICS Code: 21 Industry Sector: Mining

Size of terrestrial sector: $111.8B[18]

Constraining Factors

There are currently no funded government missions to go to the Moon or Asteroid Belt for mining purposes. The costs would be prohibitive and new technologies would need to be developed.

Associated Data Collection Market

Public Space Travel (Transport) (See sector 2.1.1)

Market Size Reference Sources

One class of asteroid is known to be mostly nickel.

Launch Vehicle Factors

Must be able to travel beyond Earth orbit.

[18] U.S. Census Bureau, Statistical Abstract of the United States: 2001, for 1999 in current dollars; Table No.846. Gross Domestic Product of Natural Resource-Related Industries in Current and Real (1996) Dollars by Industry: 1990 to 1999,

Emerging Commercial Markets

Sector 2.5.3: Space Solar Power (Terrestrial)

MARKET SECTOR DESCRIPTION AND OVERVIEW

Collection of solar power by GEO Space Power satellites for terrestrial uses such as base load power in high demand areas and peak load power during daily peak load demand cycle.

ECONOMICS (U.S. ONLY)

NAICS Code: 22 Industry Sector: Utilities

Size of terrestrial sector: $411.7B[19]

CONSTRAINING FACTORS

The sheer size of a Space Solar Power plant would require national and international commitments over several decades to achieve. Alternative energy sources are currently too inexpensive to provide the motivation to pursue this opportunity.

ASSOCIATED DATA COLLECTION MARKET

Space Solar Power (in-orbit) (See sector 2.2.8)

MARKET SIZE REFERENCE SOURCES

A 24-hour satellite, 1.2 GW SSP system would provide only about 1% of the projected worldwide consumption of electricity in 2020. The GEO SunTower architecture would deliver about 1.2 GW of power to a terrestrial electrical grid. Space-based solar power may have to compete for customers on Earth at competitive rates of <$0.05/Kw-hr.[20]

LAUNCH VEHICLE FACTORS

The massive Space Solar Power plant would be assembled in orbit and require multiple heavy launches. The reference architecture above requires 1400 Delta IV equivalents to finish the three satellite constellation.

[19] U.S. Census Bureau, 1997 Economic Census, Table 1. Sources of Revenue by Kind of Business for the United States: 1997, Aug. 9, 2000, http://www.census.gov/epcd/www/ec97stat.htm.
20 Charania, A.C. and Olds, John R. Dr., "A Unified Economic View of Space Solar Power(SSP), Imternational Astronautical Congress, October 2-6, 2000, Rio de Janerio, Brazil,
http://www.ssdl.gatech.edu/main/ssdl_paper_archive/IAF-00-R.1.06_charts.pdf

Emerging Commercial Markets

Sector 2.5.4: On-orbit Construction

Market Sector Description and Overview

Engineering support including the development of techniques for spacecraft servicing and on-orbit construction of structures. Excludes building the ISS.

Economics (U.S. only)

NAICS Code: 23 Industry Sector: Construction

Size of terrestrial sector: $845.5B[21]

Constraining Factors

This will not begin until some markets mature and provide the demand for further construction of on-orbit infrastructure (e.g., fully operational public space tourism industry)

Associated Data Collection Market

Public Space Travel (Transport) (See sector 2.1.1)

Market Size Reference Sources

No specific references.

Launch Vehicle Factors

No specific data, but heavy lift vehicles would be required.

[21] U.S. Census Bureau, 1997 Economic Census, Table 1. Industry Summary, 1997 Data Showing the Derivation of the NAICS Classification Based on the SIC Classification.

Emerging Commercial Markets

Sector 2.5.5: Crystal Growth Manufacturing Facility

Market Sector Description and Overview

Microgravity mass-production of crystal structures for use in research of molecular bonding and production of ultra-thin films (i.e., epitaxy, pharmaceutical production, biotechnology).

Economics (U.S. only)

NAICS Code: 31-33 Industry Sector: Manufacturing

Size of terrestrial sector: $92.9B[22]

Constraining Factors

Experiments have been carried out in various space stations, but a full manufacturing capability would require a regular RLV operation.

Associated Data Collection Market

Commercial ISS Module (See sector 2.2.2)

Market Size Reference Sources

Total spending in 1998 on items that could benefit from micro-gravity manufacturing was nearly one billion U.S. dollars. Companies included in the estimate are from the aerospace, biomedical and semiconductor markets.[23]

Launch Vehicle Factors

RLV capability required.

[22] U. S. Census Bureau, 1997 Economic Census, Table 1-1d. Industry Statistics for Industry Groups and Industries: Manufacturing Pharmaceutical & Medicine manufacturing. April 2002.

[23] ASI's Strategic Plan, page 5, http://www.adl.gatech.edu/nmb/2000prop/plan.hml.

Emerging Commercial Markets

Sector 2.5.6: Vacuum Deposition Processing

Market Sector Description and Overview

Use of the microgravity and vacuum environment for evenly depositing thin films or coating on surfaces. Refers to mass production and excludes R&D.

Economics (U.S. only)

NAICS Code: 31-33 Industry Sector: Manufacturing

Size of terrestrial sector: $14.5B[24]

Constraining Factors

Some experiments have been conducted on various space stations, but a full manufacturing facility would require regular flights of an RLV.

Associated Data Collection Market

Commercial ISS Module (See sector 2.2.2)

Market Size Reference Sources

Total spending in 1998 on items that could benefit from micro-gravity manufacturing was nearly one billion U.S. dollars. Companies included in the estimate are from the aerospace, biomedical and semiconductor markets.[25] Photocopier receptors are manufactured on Earth using massive, costly and time-consuming processes in vacuum chambers.

Launch Vehicle Factors

RLV capability required.

[24] U.S. Census Bureau, 1997 Economic Census, *Manufacturing.* Table 1-1d. Industry Statistics for Industry Groups and Industries: 1997. Metal coating /engraving (except jewelry/silverware)/allied services – Electroplating, plating, polishing, anodizing, & coloring, Coating, engraving, heat treating, &allied activities, http://www.census.gov/prod/ec97/97m31s-gs.pdf

[25] ASI's Strategic Plan, page 5, http://www.adl.gatech.edu/nmb/2000prop/plan.hml.

Emerging Commercial Markets

Sector 2.5.7: Space Settlements

Market Sector Description and Overview

A space settlement is a facility in orbit, or on another Solar System body intended for long-duration stays. Inhabitants would live inside gigantic cylinders, tori spheres and other, more complex structures. Settlements would probably be self-supporting (i.e., grow their own food etc.) and would likely incorporate some sort of artificial gravity.

Economics (U.S. only)

NAICS Code: 53 Industry Sector: Real Estate and Rental and Leasing

Size of terrestrial sector: $241B[26]

Constraining Factors

This would not happen within the 20-year ASCENT Study forecast timeframe, because it would be massively expensive and require a national and international commitment over several decades to achieve.

Associated Data Collection Market

Public Space Travel (Transport) (See sector 2.2.1)

Market Size Reference Sources

The literature suggests that the market size of the space settlement would vary with its population's dependency on Earth for resources. Research states that cities need populations of 100,000 to 200,000 in order to provide adequate services. Also, populations of 200,000 to 500,000 are required to support broadly based manufacturing activity. A small space settlement, having a population of less than 100,000, would need continuing support from Earth.[27]

Launch Vehicle Factors

Multiple launches of heavy class launch vehicles over many years.

[26] U.S. Census Bureau, 1997 Economic Census. *Real Estate & Rental & Leasing*. Table 1. Source of Revenue by Kind of Business for the United States: 1997, http://www.census.gov/prod/ec97/97f53-ls.pdf.
[27] "Human Needs in Space," Chapter 3, Space Settlements: A Design Study, R.D. Johnson and C. Holbrow, editors, NASA , SP-413, http://lifesci/arc.nasa.gov/Space Settlement/75SummerStudy/Chapt3.html

Emerging Commercial Markets

Sector 2.5.8: Orbiting Billboards

Market Sector Description and Overview

The use of orbiting billboards placed in Low Earth Orbit; large enough to be seen from Earth or advertising to an on-orbit population. Logos on launch vehicles, etc. are included in the Space Product Promotion sector.

Economics (U.S. only)

NAICS Code: 54 Industry Sector: Professional, Scientific, and Technical Services

Size of terrestrial sector: $6.0B[28]

Constraining Factors

There are environmental and political objections to some of these schemes. Other aspects require the prior establishment of a thriving public space travel sector.

Associated Data Collection Market

Space Product Promotion (See sector 2.2.3)

Market Size Reference Sources

No sources identified.

Launch Vehicle Factors

Not specified.

[28] U. S. Census Bureau, 1997 Economic Census: *Professional Scientific, and Technical Services.* Table 1a, Major Sources of Receipts From Customers for Firms to Federal Income Tax for the United States, Display Advertising Services, and Industrial Design Services, August 2000.

Emerging Commercial Markets

Sector 2.5.9: Hazardous Waste Disposal

Market Sector Description and Overview

The disposal of any substance that poses a substantial threat, present or potential, to human health or the environment when improperly treated, stored or disposed of, or otherwise mismanaged (e.g., Placement of Nuclear waste on the moon or sending it on a collision trajectory with the Sun)

Economics (U.S. only)

NAICS Code: 56 Industry Sector: Administrative and Support; Waste Management and Remediation

Size of terrestrial sector: $4.0B[29]

Constraining Factors

Major regulatory concerns will relegate this out of the next twenty years

Associated Data Collection Market

Space Traffic Control (See sector 2.4.11)

Market Size Reference Sources

No specific sources identified.

Launch Vehicle Factors

A highly reliable launch system is a prerequisite, especially for nuclear waste.

[29] U.S. Census Bureau. 1997 Economic Census, Hazardous waste collection and Hazardous waste treatment & disposal, http://www.census.gov/epcd/www/ec97stst.htm.

Emerging Commercial Markets

Sector 2.5.10: Space Debris Management

Market Sector Description and Overview

The tracking, management and/or destruction of material that is on orbit as the result of past space activities, but is no longer serving any function.

Economics (U.S. only)

NAICS Code: 56

Industry Sector: Administrative and Support; Waste Management and Remediation

Size of terrestrial sector: $4.0B[30]

Constraining Factors

The low level lack of current funded research on technologies that could be used for space debris management indicates that this area will not emerge as a viable market within the next 20 years.

Associated Data Collection Market

Space Traffic Control (See sector 2.4.11)

Market Size Reference Sources

Using the "Laser Broom," NASA's Project Orion, an operation to clean up debris between one and 10 centimeters would cost 200 million dollars and take two years. [31] Objects with diameters of 1 mm to 10 cm are estimated to be in the tens of millions.[32] Also, about 70,000 objects that have been estimated to be 2 cm in size have been observed in the 850-1000 km altitude band.[33]

Launch Vehicle Factors

Not specified.

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[30] U.S. Census Bureau. 1997 Economic Census, Hazardous waste collection and Hazardous waste treatment & disposal, http://www.census.gov/epcd/www/ec97stst.htm.
[31] "NASA Hopes Laser Broom Will Help Clean Up Space Debris," Space Daily, August 16, 2000, http://www.spacedaily.com/news/debris-00a.html.
[32] Belk, C. A., Robinson, J. H., Alexander, M.B., Cooke, W. J., Pavelitz, S.D., Meteoroids and Orbital Debris: Effects on Spacecraft, NASA Reference Publication 1408, Marshall Space Flight Center, Alabama, August 1997.
[33] "What is Orbital Debris?," Center for Orbital and Reentry Debris Studies(CORDS), The Aerospace Corporation, Research & Technology Solutions, http://www.aero.org/cords/orbdebris.html.

Emerging Commercial Markets

Sector 2.5.11: On-orbit Education

Market Sector Description and Overview

Human flights into space for the purpose of educational instruction or instruction from space. Includes "orbital colleges." Does not include distance learning applications in which both the students and the instructor are on the ground – these applications are covered under Data Markets.

Economics (U.S. only)

NAICS Code: 61 Industry Sector: Educational Services

Size of terrestrial sector: $0.964B[34]

Constraining Factors

Requires the prior introduction and development of enabling technologies and infrastructures, such as those associated with the Public Space Travel sector.

Associated Data Collection Market

Commercial ISS Module; Data Markets (See sectors 2.2.2 and 2.1.2)

Market Size Reference Sources

The International Space University (ISU) includes an orbiting campus in its longer term planning perspectives.

Launch Vehicle Factors

RLV capability required.

[34] U.S. Census Bureau. 1997 Economic Census. *Educational Services* Table 1b. Major Sources of Revenue From Customers for Firms Exempt From Federal Income Tax for the United States: Technical & Trade Schools. August 2000.

Emerging Commercial Markets

Sector 2.5.12: Space Hospitals

Market Sector Description and Overview

Hospital facilities on orbit that would serve space habitats' need for medical treatments and could possibly serve as an alternative treatment arena for patients whose healing might be accelerated by microgravity.

Economics (U.S. only)

NAICS Code: 62 Industry Sector: Health Care and Social Assistance

Size of terrestrial sector: $40.1B[35]

Constraining Factors

Requires the establishment of the public space travel sector.

Associated Data Collection Market

Public Space Travel (Transport) (See sector 2.2.1)

Market Size Reference Sources

No specific data references.

Launch Vehicle Factors

RLV capability required.

[35] U.S. Census Bureau, 1997 Economic Census. *Health Care & Social Assistance.* Table 1a. Summary Statistics for Firms Subject to Federal Income Tax for the United States: 1997, Hospitals. April 2001.

Emerging Commercial Markets

Sector 2.5.13: Space Athletic Events

MARKET SECTOR DESCRIPTION AND OVERVIEW

To coincide with space hotels, sports centers would provide guests with the opportunity to enjoy moving about freely in microgravity: the sports centers could later evolve into holding regular sporting events with a downlink for live international television broadcast.

ECONOMICS (U.S. ONLY)

NAICS Code: 71 Industry Sector: Arts, Entertainment, and Recreation

Size of terrestrial sector: $21.6B.[36]

CONSTRAINING FACTORS

Requires the establishment of a thriving public space travel sector.

ASSOCIATED DATA COLLECTION MARKET

Public Space Travel (Transport) (See sector 2.2.1)

MARKET SIZE REFERENCE SOURCES

The required annual revenue of an orbital space station would be $65 million.[37]

LAUNCH VEHICLE FACTORS

RLV capability required.

[36] U. S. Census Bureau, 1997 Economic Census. *Arts, Entertainment, & Recreation.* Table 1a, Major Sources of Receipts From Customers for Firms Subject to Federal Income Tax for United States, Spectator sports, Fitness & recreational sports centers, August 2000.
[37] http:www.spacefuture.com/archive/orbital_sports_stadium

Emerging Commercial Markets

Sector 2.5.14: Artificial Space Phenomena

Market Sector Description and Overview

Artificial Space Phenomena involves the placement of terrestrial objects in Earth's orbit for mass audience viewing on Earth (e.g., light shows and artificial auroras, arts objects).

Economics (U.S. only)

NAICS Code: 71 Industry Sector: Arts, Entertainment, and Recreation

Size of terrestrial sector: $0.259 B.[38]

Constraining Factors

Major environmental and political issues must be resolved.

Associated Data Collection Market

Space Product Promotion (See sector 2.2.3)

Market Size Reference Sources

Some early scientific experiments for sounding rockets studying Earth's Aurorae. A proposal by the OURS foundation of Switzerland to orbit a gigantic donut-shaped art object.

Launch Vehicle Factors

Not specified.

[38] U.S. Census Bureau. Economic Census 1997. *Arts, Entertainment, Recreation.* Table 1a. Major Sources of Receipts from Customers for Firms Subject to Federal Income Tax for the United States: 1997. Museums.

Emerging Commercial Markets

Sector 2.5.15: Space Theme Park

Market Sector Description and Overview

This market involves a theme park in space for entertainment and /or education for public space travelers.

Economics (U.S. only)

NAICS Code: 71 Industry Sector: Arts, Entertainment, and Recreation

Size of terrestrial sector: $7.2B.[39]

Constraining Factors

This market would not develop until the basic Public Space Travel sector is established.

Associated Data Collection Market

Public Space Travel (Transport) (See sector 2.2.1)

Market Size Reference Sources

In the first 25 years, the Air and Space Museum has had 219 million visitors, which is more than any other museum on the planet. [40]

Launch Vehicle Factors

Not specified.

[39] U.S. Census Bureau, 1997 Economic Census. *Arts, Entertainment, & Recreation* Table 1a. Major Sources of Receipts From Customers for Firms Subject to Federal Income Tax for United States: Amusement & Theme Parks. August 2000.
[40] Air & Space's 25th Birthday Has Visitors On Cloud Nine. http://www.washingtonpost.com/wp-dyn/articles/A6575-2001Jul1.html

Emerging Commercial Markets

Sector 2.5.16: Public Space Travel (Hotels)

MARKET SECTOR DESCRIPTION AND OVERVIEW

The construction and operation of hotel and resort facilities on orbit that will cater to space travelers. The customers of these facilities potentially include leisure travelers, business travelers, and government travelers. There is a marginal case that the first such application could be just within the 20-year horizon of Evolving Markets, by using, for example, a Spacehab-type module attached to the ISS, if entrepreneurs could be assured of the means of delivery of guests to the module.

ECONOMICS (U.S. ONLY)

NAICS Code: 72 Industry Sector: Accommodation and Food Services

Size of terrestrial sector: $73.5B.[41]

CONSTRAINING FACTORS

Requires the establishment of a successful, viable, long-term Public Space Travel Market.

ASSOCIATED DATA COLLECTION MARKET

Public Space Travel (Transport) (See sector 2.2.1)

MARKET SIZE REFERENCE SOURCES

One source speculates that there are over 7000 people worldwide, over a 10-year span, willing to spend $0.5M each to live in space for three weeks.[42]

LAUNCH VEHICLE FACTORS

Not specified, but heavy class launch vehicles would likely be required.

[41] U.S. Census Bureau, 1997 Economic Census. *Accommodation & Foodservices.* Table1. Merchandise Lines by Kind of Business for the United States: 1997. Merchandise Line Sales, July 2000.

[42] Sherwood, Brent and Fowler, C. Rob, "Feasibility of Commercial Resort Hotels in Low Earth Orbit," http://www.spacefuture/feasibility_of_commercial_resort_hotels_in_low_earth_orbit.shtm

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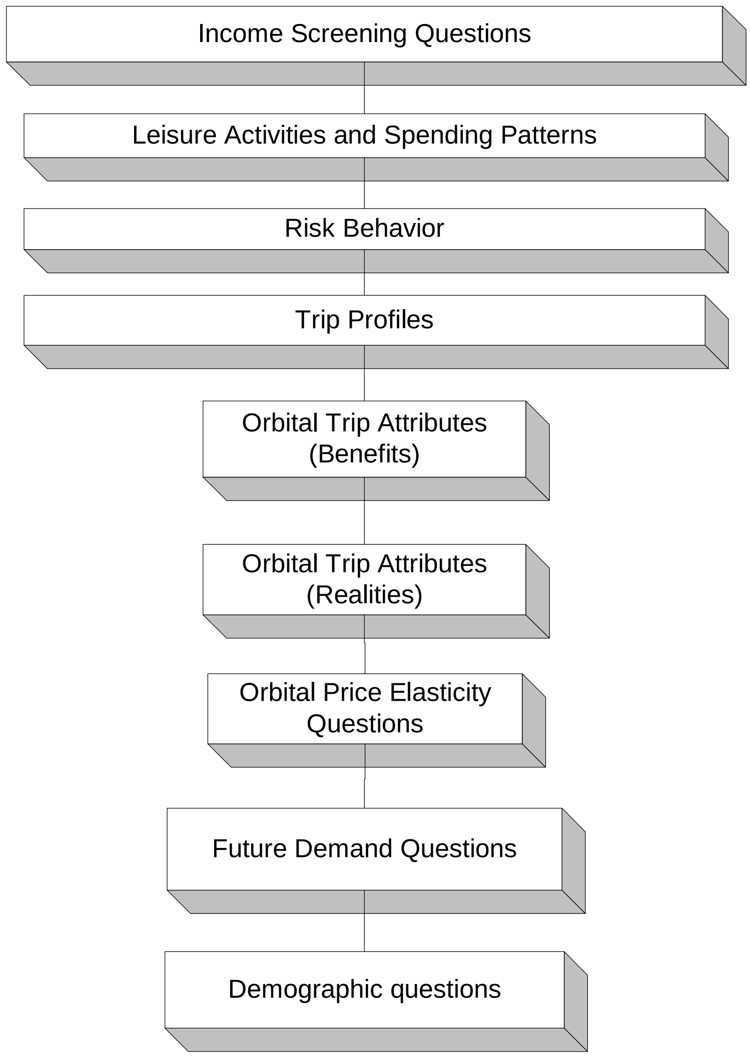
4. Orbital Data Summary from Futron Zogby Survey

Respondents to the Futron/Zogby survey were asked a full range of questions about both the respondents themselves and their preferences organized into subject themes. Figure 4-1: Futron/Zogby Public Space Travel Survey shows the subject themes for the questionnaire. This section summarizes those findings of the survey that were used in the ASCENT Study.

Figure 4-1: Futron/Zogby Public Space Travel Survey



The survey contained detailed demographic questions of each respondent, including questions about income, net worth, and employment. The results are shown in Table 4-1below.

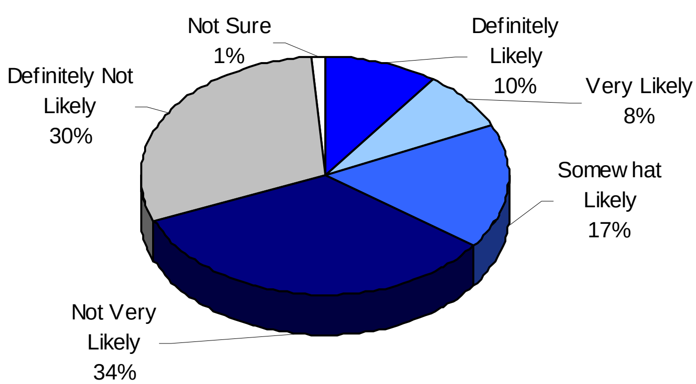
Table 4-1: Demographics of Public Space Travel Survey Respondents

Age	% of survey pool
18-29	0.7%
30-49	18.2%
50-64	57.8%
65+	22.4%
Gender	**% of survey pool**
Male	70.0%
Female	30.0%
Marital Status	**% of survey pool**
Married	86.2%
Single	2.4%
Divorced/Widowed/Separated	9.8%
Other	1.3%
Dependents	**% of survey pool**
Dependent Child	32.2%
Other Dependents	26.7%
Both	8.9%

Net Worth	% of survey pool
Less than $1 million	12.0%
Greater than $1 million	88.0%
Annual Income	**% of survey pool**
Less than $250,000	60.9%
$250,000 to $500,000	30.0%
$500,000 to $1,000,000	7.3%
$1,000,000 to $2,000,000	1.3%
$2,000,000 or more	0.4%
Employment Status	**% of survey pool**
Full-time	34.9%
Retired	29.3%
Self-employed	24.4%
Part-time	5.6%
Other	5.8%

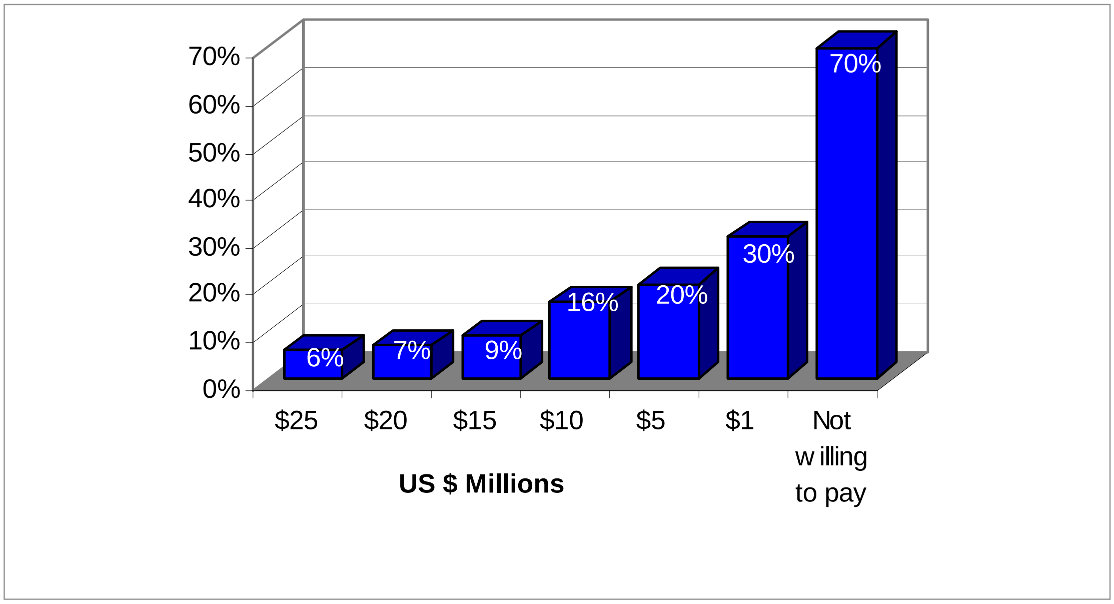
Respondents were asked to rate their likely interest in participating in Public Space Travel after hearing a realistic description of the experience. The responses are summarized in Figure 4-2 below.

Figure 4-2: Likely Participation in Public Space Travel



Regarding the price of a Public Space Travel trip, respondents were asked how much they would be willing to pay. Respondents were presented with a series of decreasing price points until they gave an affirmative response, or said no to all price points. Figure 4-3 shows the cumulative percent of respondents who responded positively to each price point or a higher amount.

Figure 4-3: Cumulative Percent of Respondents Willing to Pay for Public Space Travel



Note: In deriving the forecasts included in the ASCENT Study from the survey data, a great deal of other information was used, as described in Section 2.2.1 of Volume II.

Futron/Zogby Public Space Travel Survey Questions:

We would like to ask you about your vacation and travel preferences.

1. About how much money would you say you spend annually on vacation travel?
2. Which of the following best represents your household income last year before taxes?
3. Which of the following best describes your net worth?
4. What is the longest time you have ever spent on vacation?
5. On average, how much time each year do you typically spend on a vacation?
6. On what activity or item did you spend the most discretionary income last year?
7. Approximately how much did you spend on this activity or item?
8. On what activity or item did you spend the second most discretionary income last year?
9. Approximately how much did you spend on this activity or item?
10. Overall, on a scale of one to five with one being extremely fit and five being not at all fit, how physically fit would you rate yourself
11. Considering all the activities in which you participate, what is the most amount of time you have ever spent on training or physical preparation for any single activity?
12. If you had US$100,000 of discretionary income and could only spend it on one thing, which one of the following would you purchase?
    - A sports car
    - A dream vacation
    - A designer outfit
    - Jewelry
    - A sub-orbital space flight
    - Invest it

- Other

13. If you had US$5 million of discretionary income and could only spend it on one thing, which one of the following would you purchase?
    - A home in some exotic location
    - A piece of artwork
    - An orbital space flight
    - A yacht
    - A jet
    - Invest it
    - Other
14. Now I am going to read to you a list of activities. For each, please tell me if you participate in the activity regularly, sometimes, rarely, or never?
    - Mountain climbing?
    - Flying in a private aircraft?
    - Skydiving?
    - Skiing (on snow or water)/Snowboarding?
    - Sailing or boating?
15. Now, using a scale of 1 to 5 where 1 is not at all risky and 5 is extremely risky, please rate for me the risk of each of the following activities.
    - Mountain climbing?
    - Flying in a private aircraft?
    - Space travel?
    - Skydiving?
    - Skiing/Snowboarding?
    - Sailing or boating?
16. Have you ever participated in any of the following space tourism activities? (Respondents given a list of activities, e.g., visit to a planetarium, Space Camp, etc.)

Now I am going to ask you some questions about space flight.

In a sub-orbital space flight, you would experience what only astronauts and cosmonauts have experienced. During the 15-minute flight on a vehicle that meets government safety regulations, you will go 50 miles into space, and experience the acceleration of a rocket launch. You will also experience a few minutes of weightlessness and have the unique experience of viewing the Earth from space.

17. How likely would you be to participate in a sub-orbital space flight?

Now we want to tell you about other aspects of sub-orbital space flight.

Space flight is an inherently risky activity. The vehicle providing these flights will be privately developed with a limited flight history. In order to take the trip, you would have to undergo training for one week prior to the launch. Although you would experience weightlessness, you would be strapped into your seat throughout the trip.

18. Knowing what you know now, how likely would you be to participate in a sub-orbital space flight?

Please rate the following on their importance to you as an aspect of a sub-orbital space flight.

19. You would be able to view the Earth from space?
20. You would experience weightlessness?
21. You would experience the acceleration of a rocket launch?
22. You experience what only astronauts and cosmonauts have experienced.
23. Now I am going to ask you about certain aspects of the flight. Please rate each on your likelihood to participate in a sub-orbital space flight.
24. There is a required, one-week training period. Would this make you…?
25. Knowing that the vehicle would be privately developed with a limited flight history. Would this make you…?
26. You would be strapped into your seat throughout the trip. Would this make you…?
27. Now some questions about the prices of sub-orbital space travel.
28. Would you be willing to pay US$250,000 for a sub-orbital flight?
29. Would you be willing to pay US$200,000 for a sub-orbital flight?
30. Would you be willing to pay US$150,000 for a sub-orbital flight?
31. Would you be willing to pay US$100,000 for a sub-orbital flight?
32. Would you be willing to pay US$50,000 for a sub-orbital flight?
33. Would you be willing would you be to pay US$25,000 for a sub-orbital flight?

34. What is the most important reason why you are **not** interested in a sub-orbital flight?
35. The conditions I just outlined could change in the future and affect the demand for sub-orbital space travel. If certain conditions change, how likely would you be to participate in space travel? For instance if…
36. The training would take less than one week?
37. You would have the ability to leave your seat during a flight?

Now I have some questions about another type of space flight.

In an orbital flight, you would have the opportunity to experience what only astronauts and cosmonauts have experienced. The trip would begin with a launch aboard a thoroughly tested rocket. You would then dock with an orbiting space station and would have the freedom to move about the facility. During your two-week stay you would be weightless. You would have the opportunity to eat, sleep, exercise and view the Earth from space.

38. How likely would you be to participate in an orbital space flight?

Now we want to tell you about other aspects of orbital space flight.

Space flight is an inherently risky activity. Currently, the flight is only available on a Russian vehicle. In order to take the trip, you would have to undergo intensive cosmonaut training in Russia for six months prior to the launch. During the flight you may experience headaches and lower backache. While in space, you might experience some nausea. You would be able to view the Earth through porthole-sized windows. Upon your return to Earth and to normal gravity, you might experience some dizziness for a few days and have difficulty standing.

39. Knowing what you know now, how likely would you be to participate in an orbital space flight…?

Please rate the following on their importance to you as an aspect of an orbital space flight.

40. You would stay two weeks on a space station?
41. Orbiting the earth every 90 minutes?
42. Eating, sleeping and exercising in space, with the freedom to move about in a large space station?
43. Going into space in a thoroughly tested rocket?

Now I am going to ask you about certain aspects of the flight. Please rate each on your likelihood to participate in an orbital space flight.

44. You would undergo intensive physical and mental training over a six-month period. Would you be…?
45. Two weeks of weightlessness might cause you to experience dizziness/difficulty standing for a few days upon returning to Earth. Would you be…?
46. Going into space in a Russian-made vehicle. Would you be…?
47. Currently, the orbital trip is only available in Russia. Would six months of training in Russia, including learning to speak Russian make you…?

Now some questions about the prices of orbital space travel.

48. Would you be willing to pay US$25 million for an orbital space flight?
49. Would you be willing to pay US$20 million for an orbital space flight?
50. Would you be willing to pay US$10 million for an orbital space flight?
51. Would you be willing to pay US$5 million for an orbital space flight?
52. Would you be willing to pay US$2.5 million for an orbital space flight?
53. Would you be willing to pay for an orbital space flight if it cost US$1 million?
54. What is the most important reason why you are not interested in orbital flight?
55. What is the likelihood you would have six months available to prepare for space travel?
56. The conditions I outlined could change in the future and affect the demand for orbital space travel. If certain conditions change, how likely would you be to participate in orbital space travel? For instance…
57. If the orbital trip were available from a U.S. company, would you be…?
58. If you could train for a shorter period of time, perhaps three months, would you be…?
59. If you could train for only one month, would you be…?
60. If you could train in the United States, would you be…?
61. Currently, the only destination in orbit is the International Space Station. Would the possibility of visiting a commercial facility designed for tourists (with increased comforts) make you…?

62. How would the opportunity to take a spacewalk outside the vehicle -- even if it would cost more -- affect your likelihood of taking an orbital trip?
63. How about the opportunity to take a spacewalk, even if it meant a year's worth of training?
64. If you could take a companion with you on an orbital space flight, how would it affect your likelihood of participating?
65. If you could not travel to a space station, would you be much more likely, somewhat more likely, somewhat less likely, or much less likely to take a two-day orbital trip in which you would remain inside the vehicle, or would it make no difference?
66. If you could finance an orbital or sub-orbital flight, would you be interested in going?
67. What is the most important reason why you would have any interest in traveling into space?
68. What is the second most important reason why you would have any interest in traveling into space?
69. What is your age?
70. Which of the following best describes your highest level of education?
71. Which of the following best describes your employment status?
72. Are you a parent or guardian of a dependent child who is living at home?
73. Do you have any dependents other than children?
74. Which of the following best describes your marital status?

5. User Information for Market Share Model and Data Sources

All of the products of the ASCENT Study were commissioned by, and delivered to:

Barbara Stone-Towns
Cost and Economics Office
NASA Marshall Space Flight Center
Huntsville, AL 35812

The hard copy data files are retained at Futron Corporation's headquarters in Bethesda, MD, with the following contact details:

Luann McLaughlin, Librarian
Futron Corporation
7315 Wisconsin Avenue, Suite 900 W
Bethesda, MD 20814

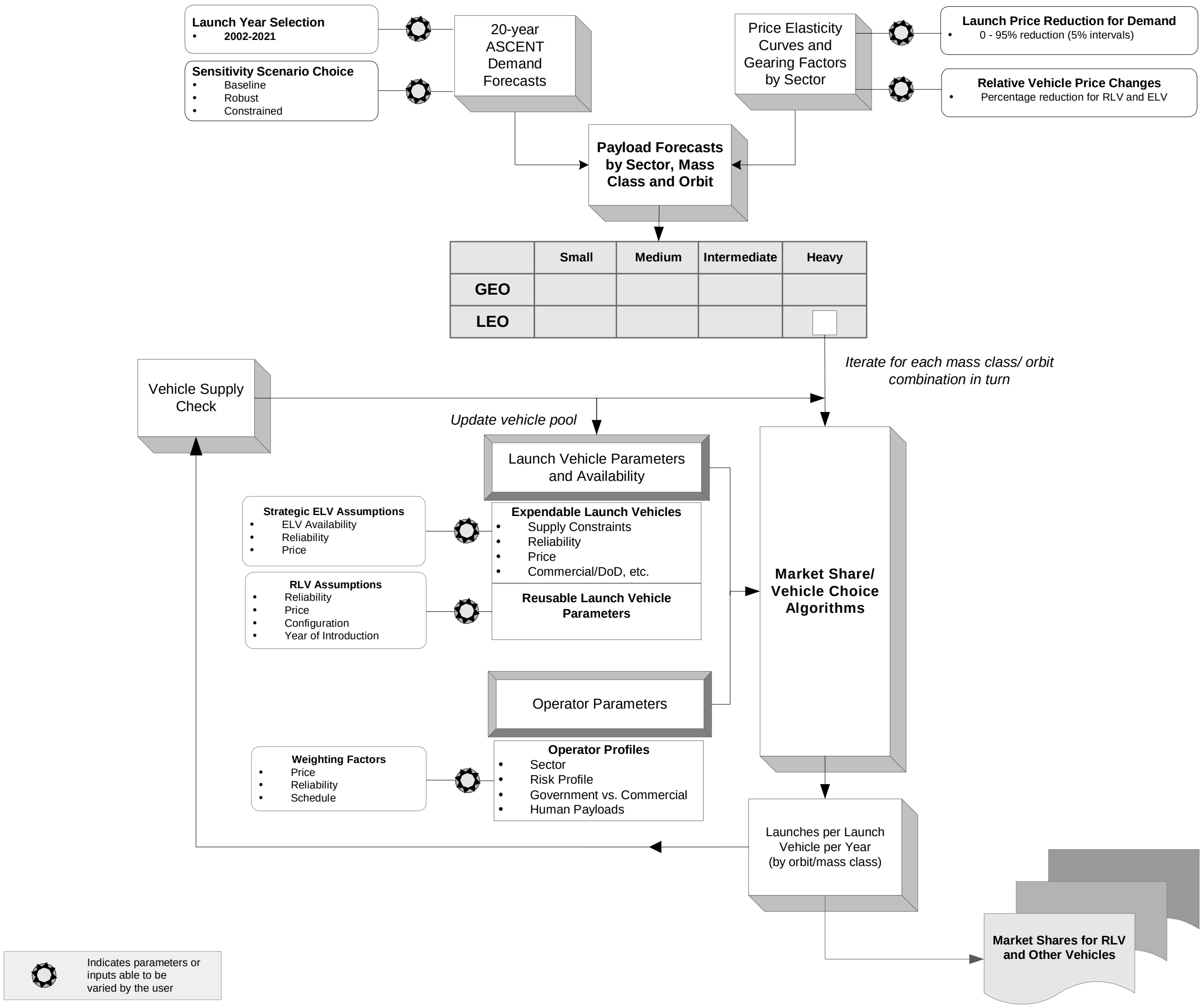
Introduction

The ASCENT Study Market Share Model was developed as part of the ASCENT Study under a contract to NASA Marshall Space Flight Center. For a full explanation of the demand forecasts that feed the model, the reader is referred to the interim deliverable documents of the study, available from MSFC. This guide is provided as an additional training product in support of the hands-on training sessions provided by Futron at Huntsville on January 9, 2003.

The ASCENT Market Share Model is a collection of two Microsoft Excel workbooks: Market Share Model.xls and Market Share Model Inputs.xls. Combined, these worksheets require just over 7 MB of storage space and Microsoft Excel 97 or higher. Both workbooks must be open for the model to work properly.

Figure 5-1 shows the logical flow of information in the Market Share Model. The dials indicate how the model incorporates user input.

Figure 5-1: ASCENT Study Market Share Model

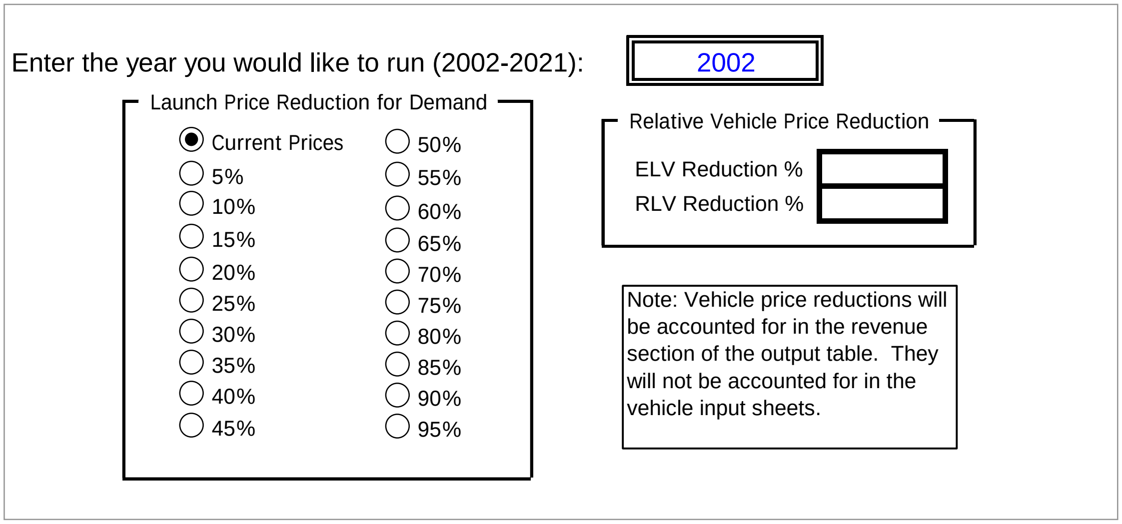


User Inputs

The ASCENT Market Share Model includes several steps to allow for user input and customization of the model results. All inputs are designated with either blue text in double outlined boxes, or in radio buttons (as seen in the graphic below under "Launch Price Reduction for Demand"). This portion of the user guide walks step-by-step through the input sections on the "Input Sheet" and "Vehicle Input" tabs of the Market Share Model.xls workbook.

Input Sheet

Step 1: Select the year, average launch price reduction for demand, and relative vehicle price reductions for which you would like to run the model.



Step 1 prompts the user to make three choices in running the Market Share Model. First, choose to run the model for any year within the ASCENT study forecast period, 2002-2021, and enter the year in the appropriate box.

Second, the user can choose the average launch price reduction for demand (0%-95%) by selecting the corresponding radio button. The selected launch price reduction pulls the appropriate demand forecast, as presented in Deliverable 2-3. The launch price reduction represents a proportional drop in prices across all markets, where the absolute launch price differs. For example, a ten percent reduction in the average launch price represents a drop from $4,000/lb to $3,600/lb in some LEO markets, and a drop from $10,000/lb to $9,000/lb in some GEO markets. Current launch prices assumed for each market are shown in Table 3-1 of Deliverable 2-3.

The third input in Step 1 calls the user to reduce the prices of ELVs and RLVs separately by inputting a percent drop (i.e. 50%), allowing for the relative prices to change. This was introduced to allow for testing strategic pricing decisions by launch vehicle manufacturers in various RLV scenarios. This drop in price affects the relative demand between ELVs and RLVs and their resulting revenue shares. If these boxes are not filled in, the model reduces the baseline launch prices for ELVs and RLVs equally in the market share calculation. The scenarios, Case 3: Introduction of RLVs with Limited Strategic Response and Case 4: Introduction of RLVs with Maximum Strategic Response, presented in Deliverable 2-4 included changes in the relative launch prices of ELVs and RLVs.

***Step 2: Select the market scenario for which you would like to run the model*.**

Market Scenario
- (●) Baseline
- ( ) Robust
- ( ) Constrained

Step 2 allows the user to choose between the three market scenarios presented in Deliverable 2-2 of the ASCENT market study by selecting the corresponding radio button. The three cases, Baseline, Robust, and Constrained, portray different levels of demand based on non-price sensitivities. These three sets of assumptions can be applied to demand in addition to the change in launch prices to test up to 60 different demand scenarios with the Market Share Model.

***Step 3: Choose vehicle assumptions; Futron's guideline assumptions are provided to the right*.**

Step 3 allows the user to adjust three sets of assumptions dealing with vehicle reliability and throughput. In calculating the vehicle family's reliability, the mass class reliability is used if historical launch reliability for the vehicle family is unknown due to lack of recent data or if the vehicle has not yet launched. The reliability is then multiplied by the perceived reliability-weighting factor, which is based on the number of vehicle flights taken to date. The number of vehicle flights includes any actual flights as well as the throughput of the vehicle for each year into the future. If the expected number of launches per year is unknown, the model uses the RLV and ELV assumptions made in this step.

Figure 5-2: Reliability Assumptions for Vehicles with Unknown Reliability

Mass Class	Assumed Reliability	Futron Assumptions	
Small	94%	94%	Can lift less than 5,000 pounds to LEO.
Medium	98%	98%	Can lift between 5,001 and 12,000 pounds to LEO.
Large	97%	97%	Can lift between 12,001 and 25,000 pounds to LEO.
Heavy	90%	90%	Can lift greater than 25,000 pounds to LEO.

The reliability assumptions provided by Futron were calculated using historical launch data. These numbers are intended to serve as a guideline. To enter different assumptions, change the values in the outlined input boxes.

Figure 5-3: Perceived Reliability Weighting Factor

Flight History (up to)	Weighting Factor	Futron Assumptions
8	85%	85%
14	87%	87%
25	88%	88%
39	91%	91%
70	92%	92%
71+	94%	94%

The perceived reliability assumptions provided by Futron were calculated using historical launch data of major vehicle families. These numbers are intended to serve as a guideline and to reflect the initial relative riskiness of new launch vehicles. To enter different assumptions, change the values in the outlined input boxes.

Figure 5-4: Assumed Throughput Rate per Year when Actual is Unknown

		Futron Assumptions
For an ELV:	12	12
For an RLV:	100	100

The throughput of vehicle families is assumed to be similar among ELVs and among RLVs. Futron has provided assumptions based on the average historical throughput for ELVs, and expected future throughput for RLVs. To enter different assumptions, change the values in the outlined input boxes.

Step 4: Adjust operator preferences and market inclusion inputs; Futron's guideline assumptions are provided to the right.

Demand groups for launch vehicles have been categorized differently than demand groups for launch services in previous deliverables. Whereas demand was categorized by particular market segment, such as Commercial Remote Sensing or Public Space Travel, in previous deliverables, demand for launch vehicles is categorized by commercial category, country, and crew requirements. Demand preferences for these categories can be input and adjusted in this section. Futron has included the preferences believed to be the best fit for the model based on historical runs.

This section allows the user to include or exclude the different market segments, as well as adjust six other preference inputs used to calculate vehicle preferences in the model. The first three inputs, Reliability, Price, and Availability/Scheduling, are to be weighted in importance against one another. The sums of the three columns should equal 100%. These shares are used to determine a vehicle family's score in the vehicle preference ranking of the model.

Additionally, there are two options for choosing vehicles from a particular country. The first, "Government Capture," indicates that all launches in this market must launch on vehicles from a particular country. If blank, any country's vehicle can service the market. The second, "Government Preference," indicates that launches will launch on vehicles from a particular country unless there are no vehicles available from that country. If no vehicles are available, vehicles from any other country can fulfill the demand. The countries specified in this section of the model must exactly match the countries listed as operators of vehicle families. The model currently includes vehicle families from the following countries:

- Russia
- USA
- Europe
- China
- Japan
- India
- Brazil
- Israel

Finally, all markets can specify whether human delivery, and therefore a crew-rated vehicle, is required from the launch vehicle.

Figure 5-5: Operator Preference Input Sheet

Operator Preferences	Include Market Y/N	Reliability %	Price %	Availability/ Scheduling %	Government Capture Government Name	Government Preference Government Name	Human Delivery Required Y/N
Evolving Commercial	Y	50%	30%	20%			N
Evolving Commercial Crewed	Y	90%	5%	5%			Y
Existing Commercial Entrepreneur	Y	20%	70%	10%			N
Existing Commercial Risk Averse	Y	85%	5%	10%			N
US Government	Y	40%	40%	20%	USA		N
US Crewed ISS	Y	90%	5%	5%	USA		Y
US Crewed Non-ISS	Y	90%	5%	5%	USA		Y
US Uncrewed ISS	Y	60%	25%	15%	USA		N
Russia Government	Y	40%	40%	20%	Russia		N
Russia Crewed ISS	Y	90%	5%	5%	Russia		Y
Russia Crewed Non-ISS	Y	90%	5%	5%	Russia		Y
Russia Uncrewed ISS	Y	60%	25%	15%	Russia		N
Europe Government	Y	40%	40%	20%	Europe		N
Europe Uncrewed ISS	Y	60%	25%	15%	Europe		N
China Government	Y	40%	40%	20%	China		N
China Crewed Non-ISS	Y	90%	5%	5%	China		Y
Japan Government	Y	40%	40%	20%	Japan		N
India Government	Y	40%	40%	20%	India		N
Israel Government	Y	40%	40%	20%		Israel	N
Brazil Government	Y	40%	40%	20%		Brazil	N
Other Government	Y	20%	70%	10%			N

Vehicle Input

Step 5: Enter Vehicles and Vehicle Information

Figure 5-6: Vehicle Input Sheet

Include Vehicle	Vehicle Family	Country/ Region	Introduc-tion Year	Retirement Year	Launch Price (Millions $)	GTO Capacity Class	LEO Equatorial Capacity Class	Launch Attempts 01/01/97 to 11/7/02	Success & Partial 01/01/97 to 11/7/02	Return capability	ISS Serviceable	Commercially Available	Maximum # of Launches/Yr	Allocation %	Launch Thoughput Adjustment (%)	Scheduling Rating
Y	Angara	Russia	2005	N/A	$80.0	Heavy	Heavy	0	0	0		Y	18	75%	50%	1
Y	Ariane 4	Europe	1988	2003	$90.4	Intermediate	Intermediate	51	51	0		Y	12	75%	100%	1
Y	Ariane 5	Europe	1996	N/A	$165.0	Heavy	Heavy	12	11	0	Station	Y	8	50%	100%	1
Y	Athena	USA	1995	N/A	$20.3	N/A	Small	6	5	0		Y	12	25%	100%	1
Y	Atlas 1 & 2	USA	1990	2004	$88.8	Intermediate	Intermediate	32	32	0		Y	8	50%	100%	1
Y	Atlas 3	USA	2000	2005	$97.5	Intermediate	Intermediate	2	2	0		Y	4	25%	100%	1
Y	Atlas 5 551/2	USA	2002	N/A	$150.0	Heavy	Heavy	0	0	0		Y	12	25%	100%	1
Y	Atlas 5 4/531	USA	2002	N/A	$92.5	Intermediate	Intermediate	0	0	0		Y	12	25%	100%	1
Y	Atlas 5 4/501	USA	2001	N/A	$82.5	Medium	Medium	1	1	0		Y	12	25%	100%	1
Y	Cosmos	Russia	1961	N/A	$13.0	N/A	Small	13	12	0		Y	30	75%	30%	1
Y	Cyclone	Russia	1966	N/A	$22.5	N/A	Medium	8	7	0		N	18	75%	30%	1
Y	Delta 2	USA	1989	2010	$51.4	Medium	Medium	49	48	0		Y	15	75%	100%	1
Y	Delta 3	USA	1998	2010	$82.5	Intermediate	Intermediate	3	1	0		Y	5	25%	100%	1
Y	Delta 4 Heavy	USA	2003	N/A	$155.0	Heavy	Heavy	0	0	0		N	4	100%	100%	1
Y	Delta 4 Medium Plus	USA	2002	N/A	$92.5	Intermediate	Intermediate	0	0	0		Y	18	25%	100%	1
Y	Delta 4 Medium	USA	2002	N/A	$82.5	Medium	Medium	0	0	0		Y	18	25%	100%	1
Y	Dnepr	Russia	1999	N/A	$15.0	N/A	Medium	2	2	0		Y	20	75%	25%	1
Y	GSLV	India	2001	N/A	$35.0	Medium	Medium	1	1	0		Y	4	25%	100%	1
Y	H 2A	Japan	2001	N/A	$85.0	Heavy	Heavy	3	3	0		Y	6	25%	100%	1
Y	Long March Heavy	China	1996	N/A	$55.0	Heavy	Heavy	7	7	1		N	3	50%	100%	1
Y	Long March Intermediate	China	1990	N/A	$55.0	Intermediate	Intermediate	4	4	0		N	3	25%	100%	1
Y	Long March Medium	China	1975	N/A	$25.5	Medium	Medium	14	14	0		N	3	25%	100%	1
Y	Long March Small	China	2002	N/A	$12.5	N/A	Small	0	0	0		N	3	25%	100%	1
Y	M 5	Japan	1997	N/A	$40.0	N/A	Medium	3	2	0		N	2	25%	100%	1
Y	Minotaur	USA	2000	N/A	$12.5	N/A	Small	2	2	0		N	2	25%	100%	1
Y	Molniya	Russia	1960	N/A	$35.0	N/A	Small	11	11	0		N	9	75%	25%	1
Y	Pegasus	USA	1990	N/A	$13.5	N/A	Small	17	17	0		Y	12	25%	100%	1
Y	Proton	Russia	1965	2005	$80.0	Heavy	Heavy	50	47	0	Station	Y	18	25%	70%	1
Y	Proton M	Russia	2001	N/A	$92.5	Heavy	Heavy	1	1	0		Y	18	75%	70%	1
Y	PSLV	India	1993	N/A	$20.0	Medium	Medium	4	4	0		N	2	25%	100%	1
Y	Rockot	Russia	1994	N/A	$13.5	N/A	Small	3	3	0		Y	12	75%	50%	1
Y	Sea Launch	International	1999	N/A	$85.0	Heavy	Heavy	8	7	0		Y	7	25%	100%	1
Y	Shavit	Israel	1988	N/A	$12.5	N/A	Small	2	1	0		N	2	25%	100%	1
Y	Shtil	Russia	1998	N/A	$0.2	N/A	Small	1	1	0		Y	2	75%	100%	1
Y	Shuttle	USA	1981	N/A	$300.0	Heavy	Heavy	31	31	4	Station	N	10	50%	100%	1
Y	Soyuz	Russia	1964	N/A	$37.5	N/A	Intermediate	59	58	1	Station	Y	30	50%	80%	1
Y	START	Russia	1993	N/A	$7.5	N/A	Small	4	4	0		Y	4	75%	100%	1
Y	Taurus	USA	1994	N/A	$19.0	N/A	Small	5	4	0		Y	8	25%	100%	1
Y	Titan 2	USA	1964	2003	$35.0	N/A	Medium	6	6	0		N	3	25%	100%	1
Y	Titan 4	USA	1989	2004	$400.0	Heavy	Heavy	15	12	0		N	5	25%	100%	1
Y	Vega	Europe	2005	N/A	$20.0	N/A	Small	0	0	0		Y	6	25%	100%	1
Y	VLS	Brazil	1997	N/A	$6.5	N/A	Small	2	0	0		N	2	25%	100%	1
Y	Zenit	Russia	1985	N/A	$42.5	N/A	Heavy	8	6	0		Y	8	75%	25%	1
Y	RLV Intermediate/Heavy	USA	2015	N/A	$58.0	Heavy	Heavy	0	0	4	Station	Y	100	75%	30%	2
Y	RLV Medium/Intermediate	USA	2015	N/A	$25.0	Intermediate	Intermediate	0	0	4	Station	Y	100	30%	80%	2

The "Vehicle Input" sheet includes a large table with many details about vehicle families. As with the other inputs, Futron has provided a list of vehicle families compiled using collected information on current and future launch vehicles. There are empty rows at the end of the table to allow for the inclusion of additional vehicle families.

Please Note When editing this list, the following rules must be followed to maintain the integrity of the model. Add new vehicle families to the bottom of this list, completing all fields. Inputs below the outlined area will not be included in the model calculations. To remove a vehicle family from the spreadsheet, select the entire row, right click on the selection and select "Clear Contents." A vehicle family can also be removed from the active model by typing "N" in the "Include Vehicle?" column. Do not delete the row. To modify a vehicle family, type over the existing information in the appropriate cell. The following information must be completed for each vehicle family:

Figure 5-7: Detailed Explanation of Vehicle Input Sheet

Vehicle Input Sheet Values	
Include Vehicle?	This is a yes/no field, to be input as "Y" or "N."
Vehicle Family	Input the name of the vehicle family.
Country/ Region	Enter one of the following countries or International: Russia, USA, Europe, China, Japan, India, Brazil, or Israel
Introduction Year	Enter Year or "N/A" if unknown; unknown entries will be assumed to be 2005.
Retirement Year	Enter Year or "N/A" if unknown; unknown entries will be assumed to be 2021.
Baseline Launch Price (US$ million)	Enter Launch Price or "N/A"; "N/A" entries will be calculated based on market price and launch capacity.
GTO Capacity Class	Enter vehicle capacity (using FAA mass class categories to LEO as defined in Step 3) or enter N/A if not a GTO vehicle.
LEO Equatorial Capacity Class	Enter vehicle capacity (using FAA mass class categories to LEO as defined in Step 3) or enter N/A if not a LEO vehicle.
Launch Attempts 01/01/97 to 11/7/02	Enter number of launch attempts if available, else reliability will default to assumptions on input sheet.
Success & Partial 01/01/97 to 11/7/02	Enter number of successful and partial launches if available, else reliability will default to assumptions on input sheet.
Return capability	Enter 0 – 4 according to the vehicle family's return capability: 0=ELV no human capacity 1=ELV w/human capacity 2=RLV no human capacity 3=RLV w/ human capacity 4=RLV w/ cargo and human capacity
ISS Serviceable	Enter "Station" if vehicle can service ISS, otherwise leave empty.
Commercially Available	This is a yes/no field, to be input as "Y" or "N."
Maximum # of Launches/Yr	Enter maximum number of launches possible per year or "N/A" if unknown, the model will then default to assumptions on input sheet.
Allocation %	The allocation % limits the number of launches that can be allocated from a single market. The lower the %, the launches will be spread out among more markets.
Launch Throughput Adjustment (%)	Percent of maximum launches that vehicles will likely achieve. This allows further limitation on launch throughput if the maximum supply constraints are believed to be unrealistic.
Scheduling Rating	Enter a 1 or 2 according to the vehicle family's lead time: 1=standard lead time (ELV) 2=short lead time (RLV)

Model Function and Results

For each of the demand groups and their associated preferences listed in Step 4, vehicle families are scored according to inputs for reliability, price, scheduling, government capture, government preference, and human delivery requirements. For each demand group, separate scores are established for each destination (GEO, NGSO, ISS) and mass class. Each vehicle family is tested to see if it meets the requirements for each demand subgroup and if it is available for service in the specified year. These requirements include a minimum mass class capability, country association, human delivery requirement, ability to service the International Space Station, and whether the vehicle is commercially available.

Vehicle Preference

On the "Vehicle Preference" tab of Market Share Model.xls, vehicle families that meet the basic requirements of the demand group receive a score based on the weighting chosen in Step 4 between price, reliability, and scheduling. Below is a subset of the US Government scoring for the first few vehicle families established in Futron's delivered input set. As seen below, only some of the vehicle families meet the requirements of the demand subgroups and, therefore, receive a score.

Figure 5-8: Vehicle Preference Scoring

Destination:	Crewed ISS	Crewed Non-ISS	GEO	NGSO	Uncrewed ISS	Crewed ISS	Crewed Non-ISS	GEO	NGSO
Vehicle Mass Class:	Heavy	Heavy	Heavy	Heavy	Heavy	Intermediate	Intermediate	Intermediate	Intermediate
Vehicle Family	US Crewed ISS	US Crewed Non-ISS	US Government	US Government	US Uncrewed ISS	US Crewed ISS	US Crewed Non-ISS	US Government	US Government
Angara	-	-	-	-	-	-	-	-	-
Ariane 4	-	-	-	-	-	-	-	-	-
Ariane 5	-	-	-	-	-	-	-	-	-
ASLV	-	-	-	-	-	-	-	-	-
Athena	-	-	-	-	-	-	-	-	-
Atlas 1 & 2	-	-	-	-	-	-	-	8.38	8.38
Atlas 3	-	-	-	-	-	-	-	7.88	7.88
Atlas 5 551/2	-	-	6.86	6.87	-	-	-	6.86	6.86
Atlas 5 4/531	-	-	-	-	-	-	-	7.87	7.87

Vehicle Rank

These scores are ranked in ascending order in the "Vehicle Rank" tab of the workbook. To prevent tie scores between similar vehicles, a random number is added to each score in the thousandth digit. These rankings are called upon when making launch vehicle allocations in the model.

Figure 5-9: Vehicle Ranking

Destination:	Crewed ISS	Crewed Non-ISS	GEO	NGSO	Uncrewed ISS	Crewed ISS	Crewed Non-ISS	GEO	NGSO
Vehicle Mass Class:	Heavy	Heavy	Heavy	Heavy	Heavy	Intermediate	Intermediate	Intermediate	Intermediate
Vehicle Family	US Crewed ISS	US Crewed Non-ISS	US Government	US Government	US Uncrewed ISS	US Crewed ISS	US Crewed Non-ISS	US Government	US Government
Angara									
Ariane 4									
Ariane 5									
ASLV									
Athena									
Atlas 1 & 2								1	1
Atlas 3								3	3
Atlas 5 551/2			1	1				6	6
Atlas 5 4/531								5	4
Atlas 5 4/501									

Launch Allocation

Using the vehicle rankings shown above, the model assigns launch vehicles to individual demand subgroups, one at a time. The subgroups are organized so that those with fewer choices are given the first opportunity to select a vehicle. For each demand group, the subgroups are ordered as follows:

Figure 5-10: Launch Vehicle Demand Subgroups

Destination	Vehicle Mass Class
Crewed ISS	Heavy
Crewed Non-ISS	Heavy
GEO	Heavy
NGSO	Heavy
Uncrewed ISS	Heavy
Crewed ISS	Intermediate
Crewed Non-ISS	Intermediate
GEO	Intermediate
NGSO	Intermediate
Uncrewed ISS	Intermediate
Crewed ISS	Medium
Crewed Non-ISS	Medium
GEO	Medium
NGSO	Medium
Uncrewed ISS	Medium
Crewed ISS	Small
Crewed Non-ISS	Small
GEO	Small
NGSO	Small
Uncrewed ISS	Small

Additionally, the demand groups are ordered so that the government markets select vehicles first, followed by existing commercial markets and then evolving commercial markets. The groups are ordered as follows:

- US Government
- Russia Government
- Europe Government
- China Government
- Japan Government
- India Government
- Israel Government
- Brazil Government
- Other Government
- Existing Commercial Risk Averse
- Existing Commercial Entrepreneur
- Evolving Commercial

Below is a subset of the vehicle allocation for the Existing Commercial Entrepreneur demand group that shows the allocation of the first and second choice vehicles. For each demand subgroup in a specified year, the "# of launches" row shows the number of launches forecast. The next four rows assign the maximum amount of those launches to the first choice vehicle. The name of the vehicle family is shown, followed by the number of launches available to this market. This is calculated based on both the throughput and market allocation chosen for the vehicle family in Step 5 and the number of launches assigned to other demand subgroups. For example, in the table below, all of the Angara launches have been previously assigned, leaving 0 available to this subgroup. The model then assigns as many launches as possible to this vehicle family and displays how many launches are yet to be assigned.

The process is repeated up to 12 times to ensure that the maximum amount of demand is met by the supply of launch vehicles. However, some launches cannot be assigned due to excess demand for particular vehicle requirements.

Figure 5-11: Vehicle Allocation Subset

Destination:	GEO	NGSO	GEO	NGSO
Vehicle Mass Class:	Heavy	Heavy	Intermediate	Intermediate
On/Off:	1	1	1	1
	Existing Commercial Entrepreneur	Existing Commercial Entrepreneur	Existing Commercial Entrepreneur	Existing Commercial Entrepreneur
# of Launches	7	0	1	6
1st Choice Vehicle	Angara	Zenit	Angara	Soyuz
Launches Available to this Market	0	0	0	12
# of Launches Assigned to this Vehicle	0	0	0	6
Action Taken	Assigned 0 out of 0 Available Payloads to Angara		Assigned 0 out of 0 Available Payloads to Angara	Assigned 6 out of 12 Available Payloads to Soyuz
Remaining Launches	7	0	1	0
2nd Choice Vehicle	H 2A		H 2A	
Launches Available to this Market	2		2	
# of Launches Assigned to this Vehicle	2		1	
Action Taken	Assigned 2 out of 2 Available Payloads to H 2A		Assigned 1 out of 2 Available Payloads to H 2A	
Remaining Launches	5		0	

MARKET SHARE

The outcome of the launches allocated in the last section is summarized in the "Market Share" worksheet. This sheet lists the number of launches assigned and revenue generated by each vehicle family, as well as their relative market share and ranking among the other vehicle families. The revenue is calculated using the number of launches assigned, the baseline launch price input in Step 5, and the relative vehicle price reduction or launch price reduction chosen in Step 1. If a "Relative

Vehicle Price Reduction" is chosen, the baseline launch price is adjusted accordingly and then multiplied by the number of launches assigned to the vehicle family. If not, the baseline launch price is adjusted by the "Launch Price Reduction for Demand" percentage and then multiplied by the number of launches assigned to the vehicle family.

The "Market Share" tab of the ASCENT Market Share Model also annotates the forecast year, launch price reduction, and market scenario for which the model is being run, as well as any excess demand that was not captured by any of the vehicle families. Below is a sample of the output presented on this sheet. The vehicle families with the highest market share of launches and total revenue are highlighted in the "Rank" column.

Figure 5-12: Sample Market Share Model Output

Forecast Year: 2002
Launch Price Reduction: 0%
Market Scenario: Baseline 1
Total Excess Demand: 1

		Launches	Market Share	Rank	Revenue ($M)	Market Share	Rank
Totals		**75**			**$5,707**		
Angara	Russia						
Ariane 4	Europe	3	4.0%	8	$271	4.8%	7
Ariane 5	Europe	2	2.7%	12	$330	5.8%	6
ASLV	India						
Athena	USA	1	1.3%	15	$20	0.4%	20
Atlas 1 & 2	USA	3	4.0%	8	$266	4.7%	8
Atlas 3	USA						
Atlas 5 551/2	USA	4	5.3%	6	$600	10.5%	2
Atlas 5 4/531	USA						
Atlas 5 4/501	USA						
Cosmos	Russia						
Cyclone	Russia	4	5.3%	6	$90	1.6%	12
Delta 2	USA	7	9.3%	3	$360	6.3%	4
Delta 3	USA						
Delta 4 Heavy	USA						
Delta 4 Medium Plus	USA						
Delta 4 Medium	USA						
Dnepr	Russia	2	2.7%	12	$30	0.5%	18
GSLV	India	1	1.3%	15	$35	0.6%	16
H 1	Japan						
H 2	Japan						
H 2A	Japan	3	4.0%	8	$255	4.5%	9
Long March Heavy	China	3	4.0%	8	$165	2.9%	10
Long March Intermediate	China	1	1.3%	15	$55	1.0%	13
Long March Medium	China	1	1.3%	15	$26	0.4%	19
Long March Small	China						
M 5	Japan	1	1.3%	15	$40	0.7%	15
Minotaur	USA						
Molniya	Russia						
Pegasus	USA	9	12.0%	1	$122	2.1%	11
Proton	Russia	6	8.0%	5	$480	8.4%	3
Proton M	Russia						
PSLV	India	1	1.3%	15	$20	0.4%	21
Rockot	Russia						
Scout	USA						
Sea Launch	International						
Shavit	Israel	1	1.3%	15	$13	0.2%	22
Shtil	Russia	2	2.7%	12	$0	0.0%	25
Shuttle	USA	7	9.3%	3	$2,100	36.8%	1
Soyuz	Russia	9	12.0%	1	$338	5.9%	5
START	Russia	1	1.3%	15	$8	0.1%	23
Taurus	USA						
Titan 2	USA	1	1.3%	15	$35	0.6%	16
Titan 3	USA						
Titan 4	USA						
Vega	Europe						
VLS	Brazil	1	1.3%	15	$7	0.1%	24
Zenit	Russia	1	1.3%	15	$43	0.7%	14
RLV Intermediate/Heavy	USA						
RLV Medium/Intermediate	USA						

FORECAST INPUTS

The rest of the worksheets in the Market Share Model.xls file as well as the second Excel file control the inputs to the model from the demand forecasts generated throughout the ASCENT study. The second workbook, Market Share Model Inputs.xls, includes all of the outputs of the ASCENT market forecasts. This 700 KB file contains all of the information necessary to call up the appropriate demand numbers in Market Share Model.xls for each launch price reduction and market demand scenario. To ensure that the numbers are processing correctly when making changes to the inputs of the model, keep this file open in the background.

Please Note With the exception of the two input tabs in Market Share Model.xls, all of the worksheets in these two files are password protected to prevent accidental loss or change to the data and calculations in the model. The sheets can be accessed by employing the Tools/Protection/Unprotect Sheet command in Excel using the password "Futron."

6. Futron Space & Telecommunications Division Overview

Futron applies analytically rigorous decision-support methods to transform data into information. We collaborate closely with clients to relate decisions to future outcomes and measures of value. Our aerospace consulting services include market and industry analyses, safety and risk management, remote sensing, and communications and information management. Futron's vision and commitment to innovation, quality and excellence results in a higher performing future for our clients.

Summary of Capabilities

Futron's Space and Telecommunications Division is the industry leader in researching, analyzing, and forecasting space and telecommunications markets and programs. Futron offers our commercial and government clients a suite of proprietary, leading-edge analytical methodologies. Our world-class team of market and policy analysts, economists, and engineers bring unparalleled skills and expertise to each account.

- Futron has surveyed hundreds of aerospace firms to develop unique revenue, employment, and productivity profiles of the industry.
- Futron has developed country-by-country models of demand for telecommunication services that aggregate a global forecast up from the individual household PC or business network; these models have accurately predicted future launch levels and business changes in the satellite industry.
- Futron's database on satellite transponder pricing includes more than 4,000 price points from around the world, including actual deal pricing and terms.
- Futron's Electronic Library of Space Activity (ELSA) is a searchable, interactive database of every launch since 1957. The database also acts as a dynamic source of information on satellite activity, keeping track of the status and operational activity (including transponder coverage and carriage) of every satellite in orbit.
- Futron generates bottoms up, parametric, and analogous cost estimates for commercial satellite and launch vehicle programs.
- Futron provides a subscription-based service providing information on every FCC satellite application filed since 1990. Futron's FCCFilings.com is the only source for competitive intelligence and business data contained in FCC satellite licensing documents.

Credits

Futron Corporation offers thanks to all those in the industry who contributed to the work of the ASCENT Study by consenting to being interviewed as part of the data gathering process. Thanks are also extended to members of the planning teams from the architecture developers of the SLI/ Second Generation RLV Program, particularly those members from Boeing, Lockheed Martin, and Northrop Grumman who gave invaluable feedback throughout the duration of the Study.

Figure 6-1: ASCENT Study Team Members

The following members of Futron's Space & Telecommunications Division contributed to the work over the 20-month duration of the ASCENT Study.

Philip McAlister, *Director, S&T Division*
Derek Webber, *ASCENT Study Program Manager*

Contributing Analysts: Charles Murphy, S. Suzette Beard, Elaine Gresham, Stephanie Roy (not pictured), Bobby Jackson, Phil Smith, Eileen McGowan, Jennifer McLaughlin, Nihar Shah, Janice Starzyk (not pictured), Curtis Banks, Tim Brown, Pamela Luskin (not pictured), Anton Dolgopolov (not pictured), Jeff Foust (not pictured).

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