The “Top Ten” Things We Learned During the ASCENT Study

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Introduction

Futron has recently completed a groundbreaking study of existing and emerging space markets. The study, commissioned by NASA's Marshall Space Flight Center (MSFC) as part of the Space Launch Initiative, was dubbed the ASCENT Study, which stands for Analysis of Space Concepts Enabled by New Transportation. The "new transportation" in question at the onset of the study was the Space Shuttle follow-on, then known as the 2nd Generation Reusable Launch Vehicle (2nd Gen RLV).

NASA envisioned that the 2nd Gen RLV would be commercially owned and operated. For this to be accomplished, a business case would need to be made regarding the viability of a 2nd Gen RLV. The key aspects of a business case for any RLV include the available launch market for the vehicle (government and commercial) and the flight rate it could achieve. The ASCENT Study was initiated specifically to address the business case for a 2nd Gen RLV.

In order to accurately assess the potential market and flight rate for an RLV, the underlying demand for launches must be quantified. As anyone who follows the launch industry knows, accurate forecasts of existing space markets (e.g., telecommunications, surveillance, and remote sensing) are hard to find. Furthermore, current data and forecasts on nascent and future space markets (e.g., space tourism, space manufacturing, and space solar power) are practically non-existent.

Determining the underlying demand for space-related applications and translating that demand into global launch forecasts were the challenges Futron met in the ASCENT Study. The study forecasted the size of government and commercial space markets for the next 20 years, determined sensitivities to the forecasts, and assessed the business opportunities for current and future launch systems. Futron's goal was to establish the "definitive word" on the various space markets, their viability, maturity, size, and elasticity.

Futron applied several principles in the execution of the ASCENT Study, including the following:

- **Objectivity** — Futron is not tied to any launch vehicle or concept;
- **Standard economic and market theory** — Futron used NAICS codes, S curves, and other industry-accepted procedures and practices;
- **Comprehensive data collection** — Futron accumulated over 350 publications, reports, and other media during the course of this study;
- **Analytically rigorous assessments** — Futron used detailed modeling techniques, never "guessed," and always had some basis for all assumptions used in our analyses; and
- **Business realism** — Futron applied the mindset of a bank or venture capitalist being asked to invest in a concept when evaluating the various space markets.

This pragmatic approach brought a cold blast of realism to past studies and forecasts. We now have a much better understanding of what is possible, what is not, and where we should focus our attention. Thus, even though NASA has redefined its space transportation strategy to focus on an Orbital Space Plane (OSP), the ASCENT Study uncovered the answers to some unanswered questions. This White Paper highlights the 10 most interesting findings.

1. Many "Favorite" Markets Not Realistic in Next 20 Years

Futron's extensive data collection took approximately 10 months and began with the identification of 42 distinct space markets. The next step was to determine which markets to include (and which not to include) in the forecast. Since Futron was developing a 20-year forecast, we applied a standard filter to all markets to determine their likelihood to exist within that timeframe.

The filter criteria included such commonsense checks as rejecting any market whose existence depended on a market or infrastructure that had not yet been established, or that faced significant regulatory or environmental policy barriers. Futron also assessed the technological readiness of the markets and whether they had strong terrestrial competition. The application of the filter criteria eliminated many of the space industry's "favorite" markets such as asteroid mining, space hotels, and terrestrial use of space solar power. This allowed Futron to focus on the markets that could realistically come to fruition within the targeted forecast period.

Of the 42 markets identified, 13 commercial markets were determined either to exist now or would likely exist within the next 20 years (Existing and Evolving Commercial Markets), 13 government markets were included (Government Markets), and the remaining 16 markets were relegated to the post-20-year timeframe (Emerging Commercial Markets) and were not included in subsequent forecasts or analyses. Table 1 lists all 42 ASCENT Study market sectors within their respective categories.

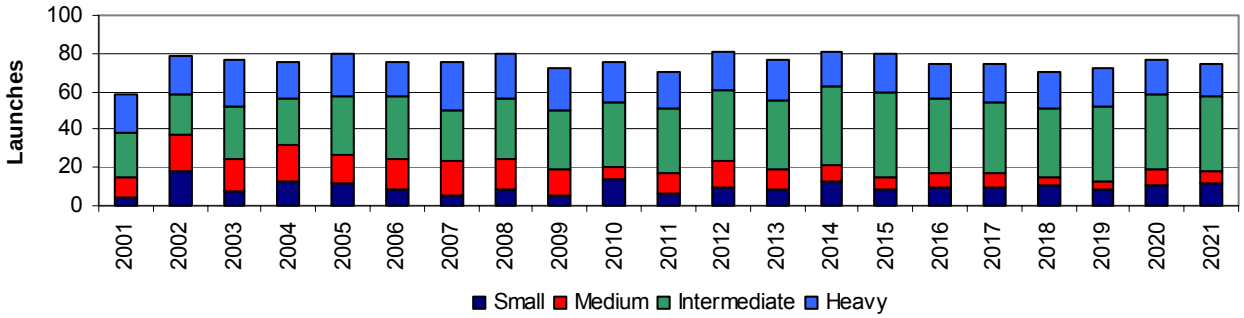
Table 1: ASCENT Market Sectors

Existing and Evolving Commercial Markets	Government Markets	Emerging Commercial Markets (not included in forecast)
Telephony	Asteroid Detection and Negation	Artificial Space Phenomena
Television/Radio	Civil Remote Sensing	Hazardous Waste Disposal
Data Communications	Human Space Exploration	Non-terrestrial Mining
Commercial Satellite Remote Sensing	Human Space Rescue	On-orbit Construction
On-orbit Sparing	ISS Missions	On-orbit Education
Commercial ISS Module	Law Enforcement	Orbiting Billboards
Orbital Asset Servicing & Salvage	Military & Civil Communications	Public Space Travel – Hotels
Propellant Depot	Military Remote Sensing	Space Agriculture
Public Space Travel	Other Government Missions	Space Athletic Events
Space Burials	Positioning	Space Crystal Growth
Space Hardware R&D	Space Science (non-ISS)	Space Debris Management
Space Product Promotion	Space Traffic Control	Space Hospitals
Space Solar Power – On-orbit Uses	Space Weapons	Space Settlements
**Evolving Markets are shaded*		Space Solar Power – Terrestrial
		Space Theme Park
		Vacuum Deposition Processing

2. Launch Demand Will Remain Fairly Stable for Next 20 years

Futron's market forecasts for 26 commercial and government markets were translated into global launch forecasts. Figure 1 shows the overall forecast from the ASCENT Study (all mass classes, government and commercial markets, worldwide). Aggregated launch demand remains fairly flat: between about 70 and 80 launches a year throughout the whole forecast period of the ASCENT Study. The actual flight rate for 2001 is included as a base year.

Figure 1: Aggregated Launch Forecast for All ASCENT Study Markets



For this forecast, launch prices were assumed to stay constant over the forecast duration (the effect of lowering launch prices is discussed later). Also, Futron assumed that no revolutionary changes would occur such as a deployment of a space-based strategic defense system, or a near-term human expedition to Mars, and no major breakthroughs in enabling technologies that would alter the fundamental principles of space launch would emerge.

As with all forecasts, some assumptions were made. To understand the uncertainty associated with these assumptions, Futron performed sensitivity analyses within each of the 26 individual markets. Futron identified the key assumptions used for each market forecast and then applied generally more optimistic assumptions than those used in the baseline forecast and also applied assumptions where the overall outcome is less positive. When aggregated, there was only a +/- 15 percent variation around the baseline forecast. This increased our confidence level associated with the accuracy of the forecast.

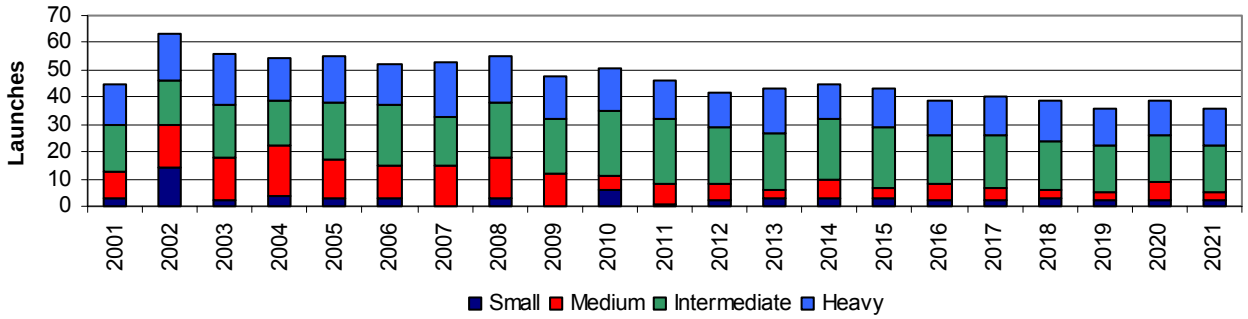
3. Under the Surface, Many Markets Change

While the trend in the overall launch forecast is fairly flat, several individual markets experience more pronounced trends. For the Existing Commercial Markets (Telephony, Television/Radio, Data Communications, On-orbit Sparing, and Commercial Remote Sensing), the outlook hovers around 20 launches a year globally until around 2012, when there is an increase due to the replenishment of a number of satellites. After a few years of higher-than-average launches, the demand for Existing Commercial Markets returns to the previous average of around 20 launches a year.

There is a gradual decline in launch demand from Government Markets, from a high of over 60 to less than 40 launches per year (see Figure 2). While there are many factors contributing to this overall decline (the Government Sector forecast includes launch requirements from all space-faring and near-space-faring nations and 13 individual markets), sizable decreases are seen in non-ISS space science missions and Russian military launches. Also, the overall government share of

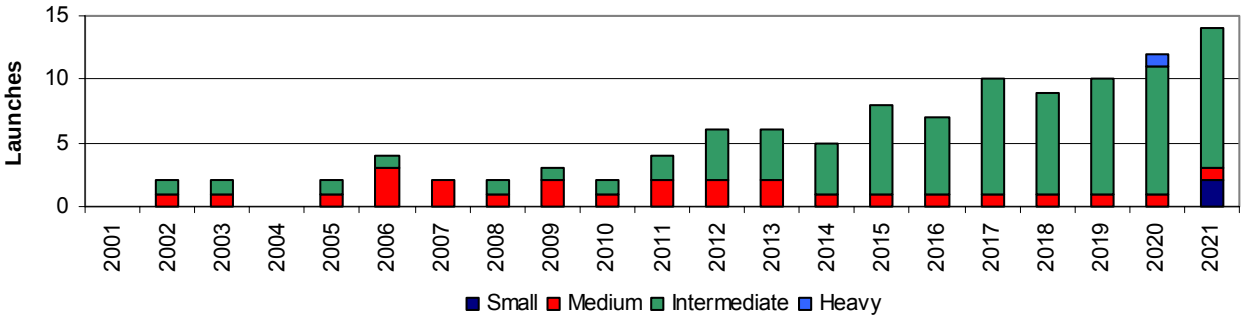
launches decreases from 75 percent to 50 percent, finally making commercial markets an equal partner by 2021.

Figure 2: Launch Forecast for Government Sectors



In contrast to the flat and declining launch rates from the Government and Existing Commercial Markets, there is growth in the Evolving Commercial Markets (see Figure 3). This sector makes up almost 20 percent of the total launch demand (14 of the 75 launches) in 2021. By far, the major contributor to this growth is public space travel, accounting for 10 of the 14 launches.

Figure 3: Forecast of Evolving Commercial Markets



4. Demand for Public Space Travel is Real and Robust

Public space travel, while always capturing the attention of the media and the public, has at times been dismissed by aerospace professionals. Some do not believe that the demand is real, and some feel it is not a “real” space market. However, Futron confirmed the reality of this market.

Futron determined the demand for public space travel via a careful, comprehensive, and sound survey of affluent Americans. This survey was *not* part of Futron’s contract with NASA MSFC; in fact, Futron was discouraged from performing the survey on NASA’s behalf due to U.S. Office of Management and Budget survey-related regulations. Thus, Futron performed the survey at its own expense in conjunction with Zogby International.

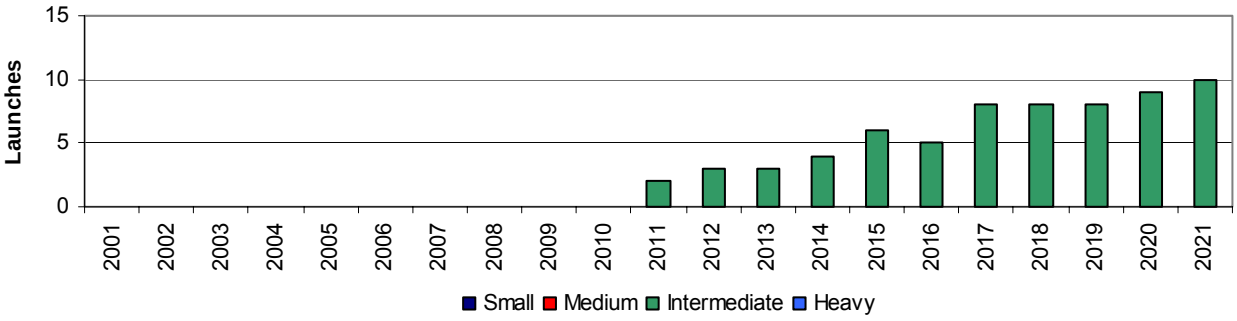
The survey featured the following:

- Only affluent Americans were surveyed, i.e., the population most likely to be able to afford a trip into space;
- Survey respondents were provided with a realistic description of what the space travel experience would be like — a former Space Shuttle commander vetted our description;
- We cross-referenced survey respondents' answers with other responses on the perceived risk, respondent's health, past buying habits, etc. — we validated their desire to travel into space with other questions; and
- The Futron/Zogby survey interviewed over 450 millionaires (interviews lasted approximately 30 minutes each) — the margin of error was calculated at +/- 4.7 percent.

Again, Futron applied the "business realism" test to objectively evaluate the results of the survey. The public space travel market met this challenge conclusively. The full results of the Futron-sponsored survey are available in a publication for sale on Futron's Web site, http://www.futron.com.

Futron did develop a public space travel forecast for the ASCENT Study assuming a US$20 million price tag for launch on a Russian Soyuz, the only vehicle currently capable and available to provide public space travel services. Even with all the constraining factors (i.e., limited supply, relatively high price, long training times in Russia), public space travel launches are a significant contributor to launch demand as seen in figure 4.

Figure 4: ASCENT Study Baseline Launch Forecast for Public Space Travel



The challenge for the aerospace industry is to develop a vehicle that can cost-effectively meet this demand. The company that ultimately meets this challenge may come from the X-Prize competition; it may be a traditional aerospace company (perhaps leveraging some OSP-developed technology); or it may come from a company not based in the United States (this last option is becoming more and more likely). However, regardless of where the company comes from or how it meets the challenge, the demand for the public space travel is real, robust, will eventually make someone very wealthy, and is one of the few areas where growth can be predicted for the launch industry.

5. Existing Commercial and Government Markets are Inelastic to Lowering Launch Prices

In the economics of a marketplace, the demand for a product changes as the price changes. This is an inverse relationship — demand goes up when prices come down (and vice versa). This phenomenon is known as the "price elasticity of demand."

Many people in the launch industry believe that lower launch costs will significantly stimulate demand for launches. In fact, lowering launch costs has been the explicit goal of almost every major launch vehicle development program since the Space Shuttle.

Futron's analysis proved conclusively that Existing Commercial and Government Markets are inelastic — meaning demand does not increase significantly when launch costs are reduced, even when the reduction is substantial.

Table 2 below shows the results of Futron's analysis. For Existing Commercial Markets, a massive 75 percent reduction in launch prices results in a negligible increase in the number of launches. The primary reason is that launch costs are a relatively insignificant part of the cost to the end-user for the service. For example, launch costs represent only 0.2 percent of the price a person pays for a telephone call. Thus, even if launch costs were zero, there would be no discernable difference in the price to the end-user for the service.

Government Markets exhibit a greater degree of elasticity, but not much. A 75 percent reduction in launch prices results in only a 33 percent increase in demand. The primary reason is that government space missions are generally driven by political or military needs, as opposed to market needs.

Table 2: Effects of Lower Launch Prices on Existing Commercial and Government Sectors

Market Sector Type	Launches at Baseline Price	Launches at 25% Price Reduction	Launches at 50% Price Reduction	Launches at 75% Price Reduction
Existing Commercial	478	480 (+0%)	482 (+1%)	484 (+1%)
Government	935	1035 (+11%)	1145 (+22%)	1245 (+33%)

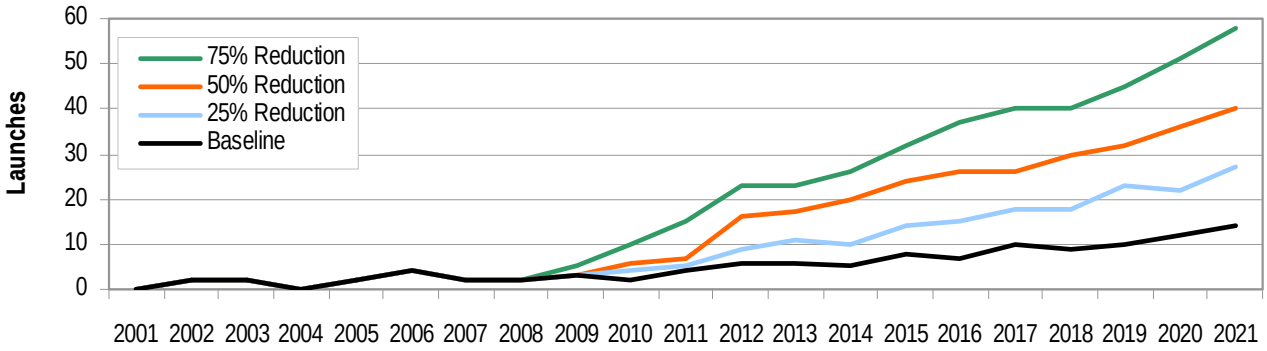
6. Evolving Commercial Markets Would Benefit from Lower Launch Prices

By contrast to the Existing Commercial and Government Markets, Evolving Commercial Markets exhibit a high degree of price elasticity. These markets, which are either in nascent stages of development or could be initiated in the near future, have been constrained by the prohibitive costs of access to space. Futron's analysis showed that a 75 percent reduction in launch prices results in a 281 percent increase in the number of launches for Evolving Commercial Markets (see Figure 5).

Half of the demand in this sector comes from public space travel. The other market that is significantly affected by price changes is the Commercial ISS Module market, an on-orbit multi-purpose facility. This market had zero launches in the baseline forecast; however, a reduction in launch prices enables this market to "close its business case" and launches for this market occur within the forecast period. The Propellant Depot market, an orbital fuel storage and transfer system used to refuel platforms in space, also begins to generate demand for launches once launch prices

are reduced. Other markets showing a greater degree of elasticity include Orbital Asset Servicing and Salvage and Space Solar Power — On-orbit Uses.

Figure 5: Impact of Decreasing Launch Prices on Evolving Commercial Market Forecast



7. There is No "Magic Number" of Dollars-per-Pound to Orbit

Another unanswered question in the launch industry is, "At what price does demand for launches increase?" In other words, where is the "knee in the curve" at which point demand for launches dramatically increases?

The unequivocal answer is that there is no such number. There is already a huge variation in the price various market sectors pay to launch a payload to orbit. Thus, no single number is valid for all markets. Additionally, an analysis of individual vehicles produces values for price-per-pound to low Earth orbit (LEO) throughout the 1990s varying from around $14,000-per-pound for a Pegasus XL down to as low as $1,400-per-pound for a Zenit 2.

One of the main tenets of the 2nd Gen RLV program was to produce a vehicle with a capability of offering flights to LEO at $1,000 per pound. This was assumed to be an order of magnitude reduction from the current price level of $10,000 per pound. Unfortunately, as seen in Table 3, there is plenty of evidence to indicate that current prices for many kinds of missions are already well below the $10,000 per pound (although none as low as $1,000 per pound).

Table 3: Current Launch Price per Pound by Market Sector (in 2001 dollars)

Market	$-Per-Pound to LEO	$-Per-Pound to GSO	Notes
Telephony	$8,816	$13,830	Average effective price per pound (launch price divided by payload masses) from telecom launches 1996-2001. LEO based on Iridium and Globalstar.
Data	$8,816	$13,830	
TV/Radio	N/A	$13,830	
Commercial Satellite Remote Sensing	$17,198	$28,758	Wide variety of payload sizes and vehicles - vehicle capacity often in excess of payload mass.
Public Space Travel	$2,993	N/A	Based on Soyuz capsule.
Commercial ISS Module	$10,000	N/A	Pressurized cargo.
Space Product Promotion	($29)	N/A	Revenue represents an offset of $29/lb.
Space Hardware R&D	$10,000	N/A	Based on Shuttle.
Space Burial	$13,832	N/A	Based on Pegasus vehicle.
On-orbit Sparing	$4,200	$11,500	Based on commercial telecom markets: vehicle price divided by capacity.
Orbital Asset Servicing and Salvage	$4,200	$11,500	
Space Solar Power - On orbit Uses	$4,000	N/A	Assumes heavy lift launch vehicle to LEO.
Propellant Depot	$4,000	N/A	Assumes heavy lift launch vehicle to LEO.
Government	$22,577	$30,088	For U.S. and European government payloads on ELV's 1996-2001. Titan IV, with the largest effective $/lb, is responsible for the high average.

8. Any RLV, Whether U.S. or Non-U.S., Would Dominate the Market

One of the final deliverables Futron produced for the ASCENT Study was a Market Share Model, which applied forecasted payloads to launch vehicles using a complex series of choice algorithms that incorporated the buying behavior of launch vehicle customers. The Market Share Model calculates the percentage market share each vehicle will receive using a variety of user inputs allowing for different scenarios to be explored.

The Market Share Model demonstrated that the introduction of a U.S. RLV with characteristics consistent with the goals of the 2nd Gen RLV would have a profound impact on the launch industry. Figures 6 and 7 depict the "before" and "after" scenarios associated with the introduction of an RLV with a U.S. RLV being introduced in 2015.

Figure 6: ASCENT Baseline Forecast Without an RLV

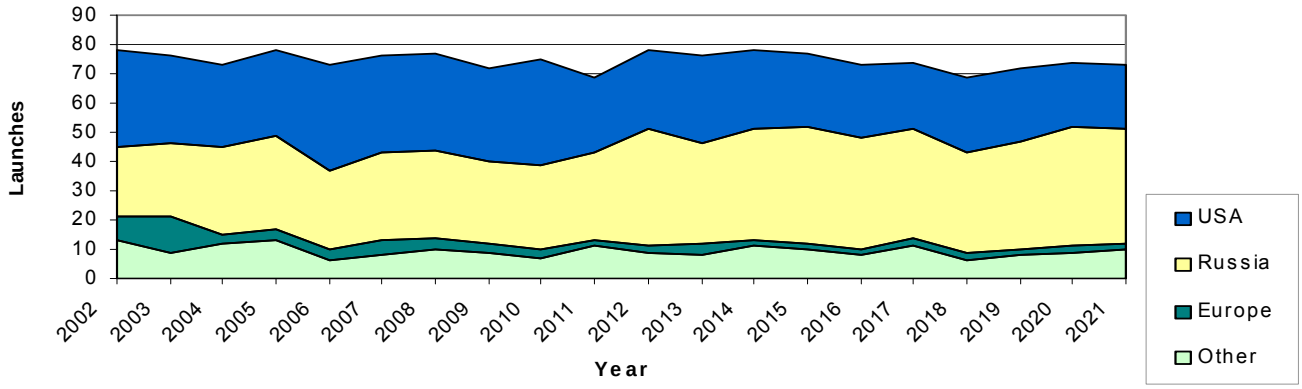
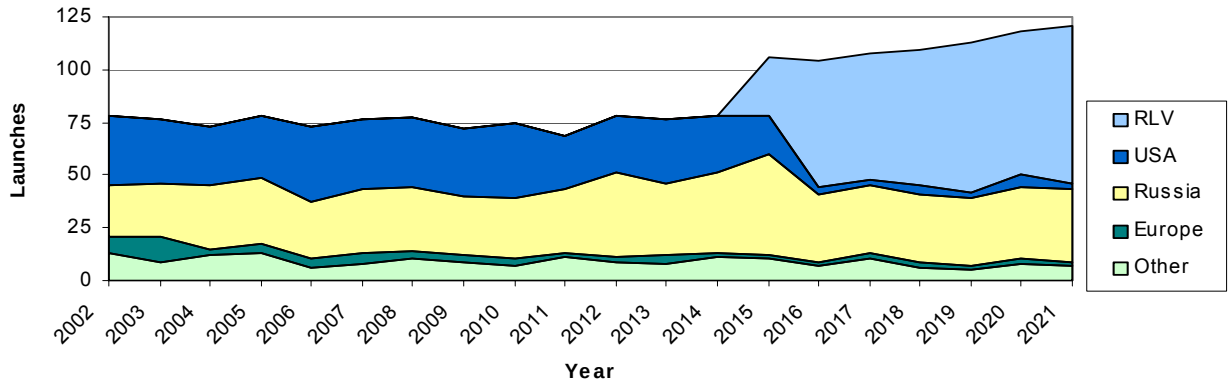


Figure 7: ASCENT Forecast After the Introduction of a U.S. RLV



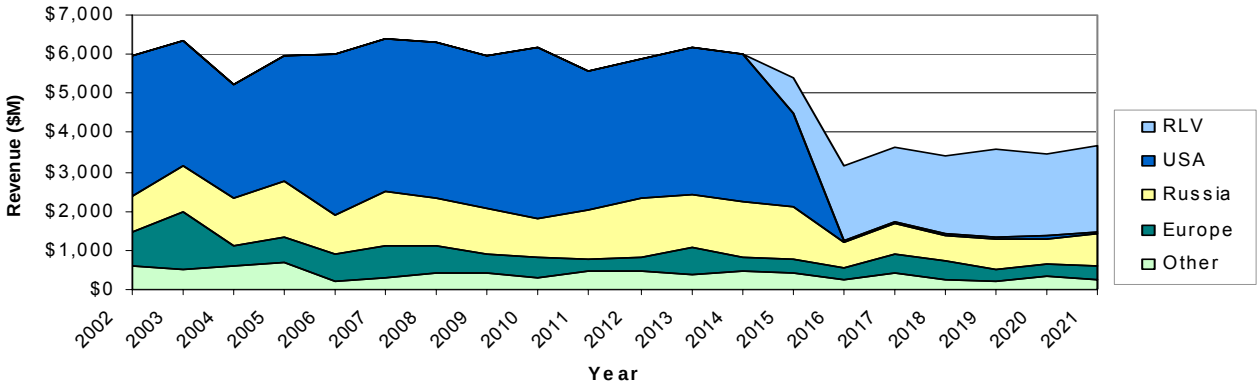
Several things stand out. First of all, the overall market grows due to the lower price offered by the RLV. The high price elasticity of the Evolving Markets comes into play here. Total launches increase from around 75 a year to nearer 120, of which the RLV captures 70 or more (this assumes that there would be no prohibition for using the RLV for Evolving Markets such as public space travel). Also, U.S. market share, which had declined from 40 percent today to around 25 percent by the end of the forecast period, recovers dramatically and reaches 60 percent.

Note, however, that the RLV does not pick up all the launches, even though it carries most of the trump cards in the customer choice algorithm (i.e., it is cheaper, more reliable, offers more schedule flexibility, and can carry passengers). This is because a U.S. RLV would not be able to pick up those launches destined for government payloads in other parts of the world. It does, however, pick up most of the U.S. launch demand (except for some small payloads). The implication is clear - the country or company that introduces an RLV with the right characteristics will capture the majority of launches, with a flight rate of up to 80 flights a year being possible.

9. Introducing an RLV Would Profoundly Impact the Launch Industry

Because of the lower price levels associated with the RLV, the introduction of an RLV results in a significant net reduction in overall launch industry revenues, even taking into account the increased number of launches generated by the RLV (see Figure 8).

Figure 8: Launch Industry Revenues Following the Introduction of a U.S. RLV



Currently, the business case for the RLV remains unproven because of the unknown development costs to produce the vehicle. However, such considerations do not detract from the fact that if an RLV could be produced, anywhere in the world, there would be a need for a major reassessment of the offerings and prices within the ELV industry.

10. The ASCENT Market Share Model is Capable of Providing a Realistic Snapshot of Future Launch Demand

In order to determine the market share that a 2nd Gen RLV could capture in the global launch marketplace, Futron developed the ASCENT Market Share Model, an Excel-based strategic planning tool, designed to utilize and translate the demand-based market forecasts generated during the ASCENT Study into launch vehicle market shares.

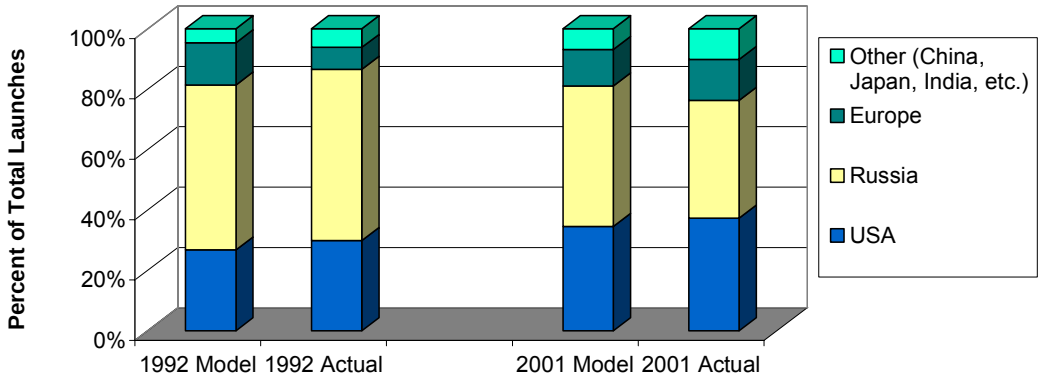
Vehicle market shares in the ASCENT Market Share Model are allocated using a vehicle choice algorithm. The model compares a pool of available launch vehicles (defined by key characteristics of reliability, price, schedule, flexibility, country of origin and whether human-rated) with the potential array of launch vehicle customers (risk-averse, entrepreneurial, government, etc.) and decides, for each combination of launch vehicle mass class and orbit in any given year, which launch vehicle will be chosen to satisfy the demand.

Recognizing the dynamic nature of the global launch marketplace, the Market Share Model was developed with a wide range of user inputs to maximize the utility and longevity of the model as a planning tool. The Model allows a number of strategic inputs to be varied, such as RLV parameters, which launch vehicles or customers are included and which forecasts are utilized. Examples of the user-defined inputs include the following:

- Forecast Size
- Launch Price
- Strategic Response by Expendable Launch Vehicle Providers
- Vehicle Reliability
- Vehicle Throughput
- Customer Preferences and Weighting
- Market Inclusion or Exclusion
- Government Preference
- Human Rated vs. Non-human Rated

In order to validate the ASCENT Market Share Model and its accuracy for 20-year forecasts, Futron conducted a fit test to determine how well it could predict backwards in time when compared to actual launches. Futron maintains in-house databases of all launches since Sputnik, thus a fit test was easily accomplished. Futron used two different years for the fit-test – 1992 and 2001.

Figure 9: ASCENT Market Share Model Fit Test Results with Historical Data



As can be seen from the results in Figure 9, the predicted market shares were very close to the actuals. For example, the U.S. launch vehicle market share prediction for 1992, derived by the model, was 27 percent and the actual historical value was 30 percent. In 2001, the model exactly predicted six Ariane 4 launches. Also for 2001, the model output differed by only one launch from historical fact for the vast majority of vehicles that had any difference at all, and in no case was the model off by more than 3 launches. The fit test demonstrated the model's ability to accurately assess global market shares based on its vehicle selection algorithms.

Given its flexibility and historical accuracy, the ASCENT Market Share Model remains a valuable tool for the launch industry in any analysis of existing or future launch vehicle programs.

To view the entire ASCENT Study Final Report, visit Futron's Web site at http://www.futron.com.

Corporate Overview

Futron Corporation is a technology management consulting firm providing innovative solutions that enable clients to address the challenges of managing information, people, and technology in a rapidly evolving environment. Since its founding in 1986, Futron Corporation has established an outstanding track-record as a high performance consultant. Futron is headquartered in Bethesda, Maryland with a branch office in Houston, Texas. Futron employs approximately 100 professionals and has annual revenues of over $10 million.

Futron's headquarters in Bethesda, Maryland

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 analytic methodologies. Our world-class team of market and policy analysts, economists, and engineers bring unparalleled skills and expertise to each account.

- We have surveyed hundreds of aerospace firms to develop a unique revenue, employment, and productivity profile of the industry.

- We have 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 helps clients win competitions, analyze competitors, estimate costs and prices, and track opportunities.

- Futron also performs cost estimates and economic analyses. 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.

For information about this or other Futron reports, or to inquire about Futron™s consulting services, please contact Suzette Beard at 301-347-3454 or sbeard@futron.com.