Industry Structural Analysis of the Commercial Suborbital Research Market

Ken Davidian and Cindy Conrad

1Office of Commercial Space Transportation, Federal Aviation Administration, Washington, District of Columbia. 2Southwest Research Institute.

ABSTRACT

In support of the Federal Aviation Administration Office of Commercial Space Transportation’s goal to “encourage private sector launches, reentries, and associated services,” the analysis described in this article is a continuation of a series of reports that are based on management theory of industry structure and innovation dynamics as applied to different segments of the emerging commercial space transportation industry. These studies are being performed to inform the output of policy and acquisition decision makers. This report specifically analyzes the commercial suborbital research industry segment using the industry structural analysis framework based in management theory and developed by Michael Porter of Harvard Business School. This analysis intentionally avoids detailed proprietary data within the commercial suborbital research market in order to avoid potential financial or political sensitivities held by members of the industry. Of the five forces, the Bargaining Power of Buyers (Force 4) is estimated to be High in strength solely due to the power of the U.S. government as a buyer in this emerging market segment. The remaining four forces are estimated to be Moderate or Low in strength. Based on the varying strengths of these five forces, which are estimated overall to be Moderate, the profitability of the suborbital reusable launch vehicle (sRLV) research market could be expected to be moderate as well. Even this level of profitability could entice new entrants into the market segment in pursuit of profits, increasing the market forces and ultimately driving industry profitability down.

INTRODUCTION

It has been noted that “U.S. policymakers, particularly at the state and local levels, have been groping toward an explicit entrepreneurship policy for at least a couple of decades. Their experiments have typically been pragmatic, inspired by immediate needs and pressured and by one another’s examples, rather than by a grand theoretical design.”1 Space policy and acquisition strategies of the U.S. government (USG), aimed at commercial development and stimulation of innovations, have been inspired and executed in a similar fashion. This approach, however, is not unusual. “We train managers and do research about management [with] the belief that decisions should be grounded in solid analysis of data.”2 But analyses that are based on data alone “rely on an implicit theory: The past is a good predictor of the future.”2

In fact, the basis of the emerging commercial space transportation industry is an assumption that the future will not be a repeat of the past, so an alternative to analyses based primarily on data is highly desirable. However, the role of data-based analyses should not be discounted. Although “[g]ood theory provides a robust way to understand important developments, even when data is limited…Theory is even more helpful when there is an abundance of data” and “[t]heory helps to block out the noise and to amplify the signal.”2

In support of the Federal Aviation Administration (FAA) Office of Commercial Space Transportation (AST) goal to “encourage private sector launches, reentries, and associated services,” the analysis described in this article was conducted as one of a series of reports that attempt to address the lack of a “grand theoretical design” by using well-established, academically based economic theory of industry dynamics, applied to the different segments of the emerging commercial space transportation industry,3–10 to complement data-rich analyses of similar market segments.11 Taken together, analyses based in data and theory can be a powerful tool with which policy and acquisition decision-makers should be working.

An analysis of this nature is intended to be a starting point for more in-depth discussions among interested members of the industry with well-defined, baseline structure and vocabulary to facilitate a better understanding and comprehension of the observations.

Market Segment Description

This analysis focuses on the suborbital transportation research market segment with a focus on suborbital reusable launch vehicles (sRLVs). The existing sRLV research market segment consists of service providers giving their customers access to (a) time in a microgravity environment, or (b) access to various launch and/or space environments (e.g., time at altitude, radiation levels, launch conditions, etc.). The types of facilities and vehicles that have traditionally characterized the suborbital market for scientific payloads included in this report consist of drop towers, parabolic-trajectory aircraft, and sounding rockets. The sRLVs are new entrants to this market segment.

Incumbent drop-tower facilities serving the suborbital marketplace include:

• National Aeronautics and Space Administration (NASA) Glenn Research Center (GRC) 2.2 Second Drop Tower
• NASA GRC Zero Gravity Research Facility
• Microgravity Laboratory of Japan (MGLAB) Drop Experiment Facility

1Title 51 US Code Subtitle V, §50901(a)(7)
The suborbital payload market but were not considered in this study. Microgravity environments but was not considered in this analysis either.

Following:13 was too low to realistically be included in this report.

In the following reasons: (1) their vehicle operations were essentially identical to that of sounding rockets, and (2) the level of firm maturity was too low to realistically be included in this report.

The sRLV firms upon which this study focused includes the following:13

- Center of Applied Space Technology and Microgravity (ZARM) Bremen Drop Tower

Incumbent parabolic-trajectory aircraft serving the suborbital marketplace include:

- NASA Johnson Spaceflight Center C-9B Aircraft
- European Space Agency A300 Zero G
- Ilyushin II-76 MDK, Russia
- ZER0-G Corporation’s G-Force 1

Incumbent sounding rocket launch vehicles serving the international suborbital marketplace since 2005 are shown in list below.12

- Black Brant V, IX, X, XI, XII
- Castor 4B
- Coyote
- HATF II
- Loki Dart
- M-100B
- Maxus
- Nike-Orion, -Improved Orion
- Orion, Improved Orion
- RH-200, 200SV
- RH-300 MkII
- RX-250-LPN, 320
- S-310
- Skylark 7
- SM-2
- Super Loki
- Talos Castor
- Terrier-ASAS, -Orion, -Improved Orion, -Lynx, -Malemute, -Oriole
- Viper, 3A
- VS-30, -30/Orion
- VSB-30

Two types of traditional research vehicles that focus primarily on atmospheric science, the aircraft, and balloon-based research sectors are not included in this report because they do not provide microgravity services. The International Space Station (ISS) does provide access to microgravity environments but was not considered in this analysis either.

Below is a list of the sRLV companies that are potential entrants to the suborbital payload market but were not considered in this study.

- Booster Space Industries
- Copenhagen Suborbitals
- Rocketplane Global
- Up Aerospace
- Whittinghill Aerospace
- Garvey Spacecraft Corp
- Armadillo Aerospace
- Blue Origin
- Masten Space Systems
- Virgin Galactic
- XCOR Aerospace Inc.

Current and potential customers for this market include universities and private research organizations, as well as government organizations in the following areas of research: physical and biological processes in microgravity, Earth science, atmospheric and planetary science, heliophysics and human and flight training research, and technology testing and demonstration.

Methodology Used

The “grand theoretical design” upon which this analysis is conducted is based on the descriptive overview of industrial organization (IO) economics that takes into consideration the competitive forces and concentration of the industry. IO economics is a valid foundation from which to model the sRLV research market segment because of the high-tech and high-risk nature of the industry, which raises multiple barriers of entry (BOEs) such as proprietary technology (a cost disadvantage independent of scale) and capital requirements. These barriers limit the initial number of competing firms involved, so the market is not perfectly competitive. Furthermore, because of stringent certification and qualification of process and product, the market is not perfectly contestable either (i.e., market entry is hindered by High barriers of entry and/or exit). The validity and accuracy of more familiar economic “supply-and-demand” market forecasts or finance-based analyses are questionable for any emerging industry simply due the high level of uncertainty that surrounds the input and results.

Michael Porter provides a three-part analysis of competitive posturing using a model of five market forces.14 The first of the three part analysis is the Industry Structural Analysis (ISA). (Details about the other two analyses, the Competitor Analysis and the Competitive Strategy, can be found in Ref. 14.) The ISA is employed here to understand the strength of these five forces as they exist in the current sRLV research market. Porter’s ISA does not attempt to forecast market demand in any way but comprehensively evaluates the strength of forces acting on an industry as a whole from the perspective of IO economics and management theory.

The five forces included in the ISA (with brief descriptions quoted from the text) are:

- Force 1: Threat of Entry is comprised of two different components: BOEs to new firms and competitive reaction from incumbent firms. There are seven different BOEs identified by Porter.

  Force 2: Intensity of Rivalry Among Existing Competitors is affected by interacting structural factors identified in the ISA, including Number and Balance of Competitors, Rate of Industry Growth, Level of Fixed or Storage Costs (Relative to Value Added), Amount of Differentiation or Switching Costs, Increment Level of Augmented Capacity, Diversity of Competitors, Level of Strategic Stakes, and Level of Exit Barriers.

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Force 3: Pressure from Substitute Products can limit the profits of an industry. Substitutes are defined as other products that can perform the same function as the product of an industry. "The impact of substitutes can be summarized as the industry's overall elasticity of demand." \(^{14}\)

Force 4: Bargaining Power of Buyers decreases industry profitability by forcing down prices, bargaining for higher quality or more services, and playing competitors against each other.

Force 5: Bargaining Power of Suppliers is exerted over participants in an industry by threatening to raise prices or reduce the quality of purchased goods and services. Figure 1 shows a diagram of the five forces.

Each of the five forces as they apply to the sRLV research market is briefly discussed in subsequent sections of this report and assessed in strength. Stronger forces lower the overall profitability of the industry (and vice versa).

Assessment Methodology

Each of the five forces described above, and their component subforces, are assessed in this article as being High, Moderate, or Low. The assessed value judgments made by the authors were based on personal interactions with members of the sRLV research industry. Since each rating encompasses such a broad range, there was never a great disparity between the judgment assessments of the authors.

It is recognized that other analysts may come to slightly different assessments based on "information asymmetries"—differences in what each analyst knows of the industry. However, conclusions drawn by other analysts should not be drastically different than those presented here unless they possess drastically different insights and information about the industry members.

As previously mentioned, one of the main goals of performing this type of analysis is to encourage debate on the force-strength evaluations. As more attention is given to these emerging space transportation markets, and an increased understanding of management theory as applied here is acquired by the space community at large, it is hoped that the level of dialogue will be elevated beyond experienced observation toward constructive insight of these important markets.

It should finally be noted that this analysis is not a compilation of previous bodies of work. This is one of many analyses (such as Refs. 3–10) conducted to apply management theory of structure and innovation to industry. This study is based upon an in-depth ISA conducted on the sRLV research market,\(^ {15}\) but page limitations of this journal would not permit its full publication. Next, each of Porter's five forces as they apply to the sRLV research market are discussed.

**FORCE 1: THREAT OF ENTRY**

In addition to a component of competitive reaction, the strength of the Threat of Entry force is comprised of seven BOEs as identified by Porter. These are discussed and their strength is assessed below in the following order:

- Economies of Scale
- Product Differentiation
- Capital Requirements
- Switching Costs
- Access to Distribution Channels
- Cost Disadvantages Independent of Scale
- Government Policy

For each BOE, the type and size of firm it favors and the ability of firms to control it were included in the full analysis (available online)\(^ {15}\) but have not been included in this report for the sake of brevity. A discussion of the competitive reaction contribution to the estimated strength of Force 1 follows the seven BOE subsections.

**BOE: Economies of Scale**

The Economies of Scale BOE specifically refers to "declines in unit costs of a product (or operation or function that goes into producing a product) as the absolute volume per period increases."\(^ {14}\)

For the suborbital research market, the volume-per-period metric defined for this analysis was the number of flights sold per time interval (e.g., number of flights per day, per week, per month, or per year).

Regarding the BOEs related to common business functions,\(^ 7\) some firms in this market are multi-business companies and may have the benefit of scale economies associated with the operational process of purchasing (e.g., buying in bulk) but most do not. There were no other business function economies of scale barriers identified.

Other (nonbusiness function) considerations that are possessed by some sRLV research market segment firms but not others and therefore might provide economies of scale barriers to new entrants include

\(^7\)Common business functions were defined to include management processes, operational processes (such as purchasing, manufacturing, advertising and marketing, and sales), and supporting processes (such as accounting, recruitment, call center, and technical support).
include shared function of operations, joint cost benefits, the availability of exploitable intangible assets, and vertical integration economies. It was found that some, but not all, prominent sRLV operators have strong intangible assets to exploit. Also, vertical integration economies do exist in the sRLV research market. This advantage may be minimized, however, especially at the outset of operations when customers will be innovators and early adopters, willing to contribute significant levels of effort by "getting their hands dirty" and working directly with the operators to integrate and recover their payloads.

Because no business function economies of scale barriers were identified, and the nonbusiness function barriers were uneven across the industry, the overall Economies of Scale BOE is estimated to be Low.

**BOE: Product Differentiation**

The product differentiation BOE is influenced by brand identification and customer loyalties stemming from product differences, past advertising, customer service, and simply being first to the industry.

Product differences between the sRLVs include differences in apogee altitudes, flight profiles, acceleration profiles, "hang" time, quality of the microgravity achieved, humans in the loop, non-researchers potentially onboard, mobility, optical quality of vehicle windows, and variety of payload sizes. Due to the wide variety of product differences each vehicle offers, the Product Differentiation BOE subcomponent is evaluated as High.

Product differentiation stemming from past advertising and customer service are all rated as being Low in strength. One sRLV firm may have very strong brand identification that may be directly applicable to the research market (e.g., Virgin Galactic is part of the Virgin family of companies, including their world-renown airlines). The other operators have no real product differentiation stemming from past advertising or customer service. Product differentiation attributable to being first to industry is evaluated as being Low in strength because none of the operators has yet begun commercial operations.

Because the Product Differentiation due to product differences is High but the other components of this BOE are Low (product differentiation stemming from past advertising, customer service, or being first to industry), the overall Product Differentiation BOE is estimated to be Moderate.

**BOE: Capital Requirements**

Capital requirements of the sRLV research market include financial capital, facilities, vehicle hardware (system and subsystem), and intellectual property.

The strength of the financial capital requirement is High because the costs of materials, labor, facilities, and infrastructure tend to be very high in the sRLV industry.

- The facility capital requirement is high. A major contributing factor to this requirement includes the availability and convenience of adequate spaceport facilities. Further, due to the hazardous nature of sRLV operations, facility hardware is highly controlled for material safety, manufacturing precision, and system reliability. These both contribute significantly to the High barriers of capital requirements.
- The vehicle hardware safety and reliability requirements are very stringent. Flight hardware has very high controls on material and manufacturing precision and quality. These contribute significantly to high barriers of vehicle hardware capital requirements.
- Intellectual capital requirements are very high. Rocket operations are still a very demanding activity that is extremely sensitive to off-nominal conditions or parameters. The theoretical and applied knowledge required for these activities is still considered to be fairly demanding with respect to the operation of other types of terrestrial vehicles.

Because the requirements of facility capital, vehicle hardware safety and reliability, and intellectual capital are all estimated to be High, the overall strength of the Capital Requirements BOE force is assessed to be High.

**BOE: Switching Costs**

The primary buyers (customers) for the sRLV research market include universities and private research organizations and government organizations (predominantly NASA but other USG agencies are also included). The university and private research organization is considered the buyer if the principal investigators (PIs) make the vehicle selection decision. However, if the sRLV selection decision is predetermined by the terms of the grant to the university PI, then the USG is considered the primary buyer.

The strength of the Switching Cost BOE would be High if a PI desired to use an sRLV that was not included in the terms of their grant with the USG. A change of launch vehicles by the buyer may incur switching costs of money or time, including waiting for the site to be properly licensed (requiring an environmental assessment that is costly and requires a lot of time to complete) and changing the payload to accommodate new flight vehicle environments (e.g., gravity duration, integration, pointing or flight profile modifications, etc.). Bringing a new supplier of payload integration services “up to speed” may also be a significant switching cost depending on the capabilities and expectations of the new vendor.

The impact of these switching costs has been minimized because sRLV suppliers have a demonstrated willingness to comply with USG process and procedures and because the USG as a buyer has demonstrated a high degree of flexibility and accommodation toward the new suppliers in their procurement processes. For example, NASA has demonstrated a great degree of flexibility and willingness to facilitate the acquisition process for the sRLV operators through the Flight Opportunities Program (FOP).

Without government concessions, the Switching Costs BOE would be estimated to be High, but because of the high level of cooperation by both the USG and research community, it is estimated that the Switching Cost BOE strength is Moderate.

**BOE: Access to Distribution Channels**

Distribution channels for some of the sRLV operators have not formally been established because they are too far from routine
commercial operations to mainstream customer groups. USG buyers and some university PIs could be considered “innovators,” and the lack of distribution channels are not an impediment to their decision to purchase sRLV research flights. Lack of distribution channels may be enough of an impediment to “early adopters” that keeps them from deciding to purchase sRLV research flights at this point of market maturity.

In some ways, NASA is playing the role of distribution channel through the FOP by paying for flights and recruiting payloads to take advantage of those flight opportunities. Similarly, the Southwest Research Institute is playing the role of distribution channel in three ways: (1) by encouraging the participation of academic PIs to develop payloads that can fly on sRLVs (like NASA); (2) by encouraging the sRLV operators to donate payload space on early flights that can be awarded to researchers (students or PIs) through competitions or lotteries of chance; and (3) by purchasing flights themselves.

The “distribution channels” mentioned above do indeed have excess capacity and are able to accommodate new clients. Because of the unique nature of the academic research community, it may not be reasonable to expect a commercial distribution channel to emerge to support the sRLV operators in the near future. Because of the cooperative actions of the USG and research community members to facilitate the identification of payloads and matching them to available vehicles, the overall Distribution Channel BOE is estimated to be Low.

**BOE: Cost Disadvantages Independent of Scale**

The Cost Disadvantages Independent of Scale BOE is comprised of the following contributing factors: proprietary technology, unfavorable access to raw materials, unfavorable access to test areas, access to government subsidies, operational experience, and lack of shared operations. The strength of the proprietary technology factor is estimated to be High because of the high level of technical difficulty in developing the proprietary technology. It could be argued that because the predominant technologies in these vehicles was developed many decades ago and have been flight qualified (equivalent to a test readiness level 9, or TRL9) the strength of this BOE factor should be Moderate. However, the strength of this factor is rated as High because the process of integrating the technologies into new vehicles reduces their TRL to a much lower level (e.g., TRL6), and demonstrating these newly integrated technologies in actual flight conditions is extremely difficult.

The strength of the unfavorable access to raw materials factor is estimated to be Low. This is because there are no known examples of individual firms having more favorable access to raw materials than any of their competitors. The strength of the unfavorable access to test locations factor is estimated to be Moderate. Some firms may have more favorable access to locations (i.e., spaceports or other facilities at which sRLV testing can take place) than other firms. Specifically, some firms own their own facilities, some lease suitable facilities, and some have their manufacturing facilities in one location and are required to transport their vehicles, operating infrastructure, and consumables considerable distances to a testing site.

The strength of the access to government subsidies factor is estimated to be Moderate because of the USG’s cooperative actions that help counter the industry’s high capital requirements. Examples of government subsidies for the sRLV research market can be found in the NASA FOP provided to those sRLV firms that competed and were selected to receive those awards. Not all firms in this market chose to compete, and all that competed were not necessarily selected.

The strength of the cost savings resulting from operational experience factor is estimated to be Low simply because the industry is not yet mature enough to realize these types of advantages. The strength of the lack of shared operations or related activities factor within the same company is estimated to be Low because of the low-volume, noncommercial nature of suborbital research.

In summary, despite the Low strength of the access to raw materials, operational experience cost savings, shared operations, the Moderate strength of favorable location, government subsidies, and the High strength of proprietary technology, the result is an overall strength rating of Moderate for the Cost Disadvantages Independent of Scale BOE.

**BOE: Government Policy**

Four prominent government policy BOEs have been identified. They are: International Trade in Arms Regulations (ITAR), licensing of sRLV operations by FAA AST, USG acquisition policy (referring to the programs that agencies decide to pursue and the way in which they are implemented), and USG acquisition regulations (referring to the Federal Acquisition Regulations (FARs) and the impact they have on the operations of the sRLV firms). The estimated strengths for these BOE subcomponents are discussed below.

The Government Policy BOE factor of ITAR is recognized (almost universally) as very High only if the operator is seeking customers or collaborators outside the United States. The sRLV research market may start out limited to domestic customers but will undoubtedly pursue international markets as soon as they can. Recent developments may decrease the strength of this government policy, but for the moment, the strength of ITAR barriers remains High.

The ability to surmount the sRLV licensing factor depends on the technical and financial capabilities of the sRLV operator. Anecdotal surveys regarding this barrier estimated to the licensing requirements imposed by FAA AST to be reasonable. It is estimated that this barrier is Moderate in strength. It should be noted that sRLV permitting is not discussed here because an sRLV permit is issued for purposes of data-gathering and operational experience in support of subsequent application for a license and does not allow commercial operations by the operator.

The strength of the government acquisition policy factor is estimated to be Moderate because it has proven to be reasonable as executed by the NASA FOP. However, these policies are directed toward meeting mission goals and are not necessarily designed to best develop the emerging sRLV research industry. Consequently, firms may be distracted by specific USG program goals from pursuing activities that would be of maximum benefit for firm or industry development (i.e., being sales-driven instead of market-driven). For the same reasons as detailed in the Switching Costs BOE section above, this policy BOE is estimated as being of Moderate strength.
The strength of the government acquisition regulation factor is estimated to be Moderate because it has proven to be difficult for new-entrant companies to overcome but is not an insurmountable hurdle. Some firms resist FAR contracts because of the resulting accounting and process implications on company operations.

Because the ITAR factor is evaluated as High while the remaining factors (licensing, USG acquisition policy, and USG acquisition regulations) are estimated to be Moderate, the overall Government Policy BOE is estimated to be of Moderate strength tending toward High.

**Competitive Reaction**

At the time of this writing (February 2013), there are no sRLV firms conducting commercial operations. It is not expected that the first firms entering the market will face a negative competitive response because that would be perceived as detrimental to the overall industry. This situation may change as the industry matures, but in its current stage of formulation, competitor reaction is not expected to impede entry of new firms into the sRLV market and so is estimated to be of Low strength.

**Summary of Force 1**

The seven BOEs and the Competitive Reaction are sorted below in categories of High, Moderate, and Low strength.

- High: Capital Requirements
- Moderate (toward High): Cost Disadvantages Independent of Scale, Government Policy
- Moderate: Product Differentiation, Switching Costs
- Low: Economies of Scale, Access to Distribution Channels, Competitive Reaction

Not surprisingly, the strongest BOE is the High capital requirement of this industry. However, it may be noteworthy that the strengths of the remaining BOEs are not necessarily Low. This distinction can help new entrant sRLV firms focus their attention on the BOEs of Moderate strength, namely Cost Disadvantages Independent of Scale, Government Policy, Product Differentiation, and Switching Costs. Taken as a whole, it is estimated that the contribution of all BOEs and Competitive Reaction to Force 1 is Moderate with a tendency toward High.

**FORCE 2: INTENSITY OF RIVALRY AMONG EXISTING COMPETITORS**

The Intensity of Rivalry Among Existing Competitors force depends on the evaluation and analysis of the interacting structural factors in the sRLV market. Eight factors contribute to this force:

- Number and Balance of Competitors
- Rate of Industry Growth
- Level of Fixed or Storage Costs (Relative to Value Added)
- Amount of Differentiation or Switching Costs
- Increment Level of Augmented Capacity
- Diversity of Competitors
- Level of Strategic Stakes
- Level of Exit Barriers

Discussion of these factors is provided below.

Because there are few competitors in the domestic suborbital research vehicle market with different relative strength, and because of the very low level of activity of foreign competitors at the present time, firms will target and appeal to different market niches, thereby leading to a Low strength contribution due to Number and Balance of Competitors. Because the sRLV research market has not yet entered the growth phase, the strength of the Rate of Industry Growth factor is Low.

There is a high initial capital cost in the development of the vehicles, but once that investment has been made and the vehicle design, fabrication, and testing has been completed, the fixed costs should be reduced almost entirely to facility rents and wages. The combination of fixed and storage costs may be a strong function of the size of the payroll. The most prominent of the current set of sRLV firms have relatively large payrolls and facilities, so it is estimated that the fixed and storage costs are indeed relatively high compared to the value (that will someday be) added. These high fixed costs create strong pressures to fill capacity further leading to price cutting when excess capacity exists. Price cutting will lead to a deterioration of industry profits. This leads to an estimation of High strength for the Level of Fixed or Storage Costs (Relative to Value Added) factor.

The overall strength of the Switching Cost BOE is estimated to be Moderate (as described in the BOE: Switching Costs section above), which diminishes the level of intensity of rivalry of this structural factor. However, the overall Product Differentiation BOE is estimated to be Moderate (as described in the BOE: Product Differentiation section above), thereby creating impediments to competitive attacks because of buyer loyalties and preferences. Because of this, the overall strength for the Amount of Differentiation or Switching Costs factor is estimated to be Moderate.

The addition of each new sRLV risks disrupting the market supply/demand balance for the smaller (but not the larger) payload market niche. (This is because a single new sRLV can accommodate a large number of small payloads.) In turn, this may lead to the price-cutting market behavior and high level of rivalry discussed above. The intensity of rivalry is estimated to be influenced by the smaller payload market due to sheer numbers. Therefore, the Increment Level of Augmented Capacity factor is estimated to be of Moderate strength.

Reading the intentions of diverse competitors is not yet an issue because none of the current firms have started commercial operations. Because of this, the Diversity of Competitors factor strength is estimated to be Low.

The sRLV firms that have the most funding at stake in their ventures also have the highest tolerance to losing their investment. It is estimated that no small firms would undertake an elevated intensity of rivalry under dire circumstances. Therefore, the Level of Strategic Stakes factor strength is Low.

High requirements for specialized assets, moderate emotional barriers and strategic interrelationships, and low fixed costs of exit and government and social restrictions result in an overall Moderate strength (with a tendency toward Low) for the Level of Exit Barriers factor of this force.
The eight interacting structural factors are sorted below in categories of High, Moderate, and Low strength.

- High: Level of Fixed or Storage Costs (Relative to Value Added)
- Moderate: Amount of Differentiation or Switching Costs, Increment Level of Augmented Capacity, Level of Exit Barriers
- Low: Number and Balance of Competitors, Rate of Industry Growth, Diversity of Competitors, Level of Strategic Stakes

Summary of Force 2
Because the Level of Fixed or Storage Costs is the sole factor with a High strength evaluation, the overall estimated strength of the Intensity of Rivalry force is estimated to be Moderate.

Industry Profitability
Porter provides a correlation of an industry’s profit potential as a function of entry and exit barriers as shown in Table 1. The overall strength of the entry barriers was evaluated to be Moderate to High while the evaluation of exit barriers was evaluated to be Moderate to Low. Based on the first-order results, the preceding analysis (both rated as Moderate strength) would place the sRLV research market directly in the middle of this table, providing limited insight into the expected profitability and risk.

By recognizing the second-order tendencies of these forces as the market evolves and matures (High for entry barriers and Low for exit barriers), the sRLV research market can expect high, stable returns as the gray cell in Table 1 indicates, driven in part by the High Capital Requirements BOE and low exit costs.

FORCE 3: PRESSURE FROM SUBSTITUTE PRODUCTS
The existing sRLV research market consists of service providers giving access to (a) time in a microgravity environment; (b) access to various launch and/or space environments (e.g., time at altitude, radiation levels, launch conditions, etc.); and (c) capabilities that are not currently available from the established suborbital research launch providers (e.g., sounding rockets), including humans in the loop, cleaner microgravity environments, repeatable flights, and quicker payload access after a successful flight. Depending on the desired job to be performed, there are different substitute products available to the research customer.

For time in a microgravity environment, drop towers and parabolic-trajectory aircraft are the extant substitutes considered in this report. Drop towers are Earth-based facilities that permit approximately 10–15 seconds of microgravity environment within controlled conditions. Parabolic-trajectory aircraft can provide access to a microgravity environment for periods of time lasting between 20–30 seconds.

Technologies such as small rotary cell culture tumble chambers have been developed to simulate the microgravity environment for very small-sized payloads, but these are not considered a substitute to the sRLV research market segment because the time duration these chambers can provide far exceed the time in microgravity that even high-altitude sounding rockets can deliver. For the same time-in-microgravity reason plus the vastly more complex processes of payload integration and retrieval, the International Space Station is also excluded from consideration as a substitute in this study.

For access to the altitudes commonly associated with “space,” expendable sounding rockets could be the only substitute, but only for payloads with smaller form factors (typically limited by the rocket’s 70-cm diameter).

Porter notes that “Substitute products that deserve the most attention are those that (1) are subject to trends improving their price-performance tradeoff with the industry’s product, or (2) are produced by industries earning high profits.” Since sRLVs are not currently part of a high-profit industry nor would the positive price-performance trade-off of sRLVs be mimicked by drop towers or parabolic-trajectory aircraft, neither of these substitutes would be considered an imminent competitive threat that require dedicated resources to address.

Expendable sounding rockets could potentially benefit from a price-performance trade-off of sRLVs due to similarities of launch vehicle designs and operations. Therefore, sRLV firms should pay attention to the operators of expendable sounding rockets as a substitute product threat.

Summary of Force 3
The strength of Force 3 is estimated to be Low with a secondary tendency toward Moderate; Low because there is little pressure from the drop-tower substitutes and a tendency toward Moderate because the profitability of the sRLV research market is not very high despite the fact that expendable sounding rockets could possibly benefit from a price-performance trade-off of the industry.

FORCE 4: BARGAINING POWER OF BUYERS
A buyer group is considered powerful if the following circumstances hold true:

- The specific buyer group is concentrated or purchases large volumes relative to seller sales.
- The products it purchases from the industry represent a significant fraction of the buyer’s costs or purchases.
- The products it purchases from the industry are standard or undifferentiated.
- It faces few switching costs.
- It earns low profits.
- It poses a credible threat of backward integration.
- The industry’s product is unimportant to the quality of the buyer groups’ products or services.
- The buyer group has full information.

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</tbody>
</table>
The buyer groups in the sRLV research market include USG entities, PIs of university or private research organizations, schools (kindergarten through 12th grade), and private individuals or entities (purchasing services for novelty projects such as sending wedding rings to “space”). A narrative analysis for each of these buyer groups and each of the circumstantial cases listed above is given in the literature\(^1\) and are summarized in Table 2.

The most powerful buyer group is the USG. This represents a challenge to the industry since the USG customers will naturally (and justifiably) steer the development of the sRLV market to meet their needs. As discussed in the BOE: Government Policy section above, the mission focus of USG acquisition policy may not coincide with goals that maximize the chances of long-term industry viability.

Since this is a nascent industry, there is no prior time period with which to compare the buying power of this group. As the industry develops, component power shifts for each buyer group should be reexamined. The purchasing power of foreign governments and research organizations may also evolve to become separate buyer groups in future analyses.

### Summary of Force 4

Despite the fact that three of the four buyer groups are estimated to have low buyer group power overall, the USG buyer group power is so strong, this raises the overall power of all buyer groups to High. Universities, research organizations, educational organizations, and private individuals within the United States are all estimated to be buyer groups of Low power, but these may strengthen over time, and foreign organizations may become significant players in this market segment as well.

### FORCE 5: BARGAINING POWER OF SUPPLIERS

A supplier group is powerful if it possesses the following characteristics:

- It is not obliged to contend with other substitute products for sale to the industry.
- The industry is not an important customer of the supplier group.
- The suppliers’ product is an important input to the buyer’s business.
- The supplier group’s products are differentiated or it has built up switching costs.
- The supplier group poses a credible threat of forward integration.
- Suppliers of mechanical components such as valves, plumbing, solenoids, cabling, tubing, propellant tanks, etc.
- Suppliers of composite materials used for construction of structures such as spacecraft fuselages and nosecones.
- Machining equipment providers.
- Suppliers of bulk and sheet metal materials for structures.
- Skilled and unskilled labor.
- Suppliers of solid consumables such as solid propellants, etc.
- Suppliers of liquid or gaseous consumables such as liquid or gaseous propellants, working fluids, etc.
- Suppliers of electronic components for avionics.
- Operating ranges such as spaceports.

A narrative analysis for each of these supplier groups and each of the circumstantial cases listed above was developed, and the results are given in the literature.\(^1\) A summary of those results are shown in Table 3. The factors of market concentration and contention of substitute products were not addressed in this analysis.

It can be noted that typical spaceflight issues of space-qualified hardware or radiation-hardened components are not currently perceived as a limiting concern for the sRLV research market segment due to the limited amount of time spent in the harsh environment of space.

Assessing the potential power of labor as a supplier group is done in a similar fashion as for the other supplier groups. The key additions in assessing the power of labor are its degree of organization and whether the supply of scarce varieties of labor can expand.

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**Table 2. Summary Results of Force 4: Bargaining Power Strength Of Buyers**

<table>
<thead>
<tr>
<th>Buyer group</th>
<th>Large-volume purchases</th>
<th>Significant % of buyers’ costs</th>
<th>Standard products</th>
<th>Switching costs</th>
<th>Earns low profits</th>
<th>Backward integration threat</th>
<th>Importance to buyers’ quality</th>
<th>Buyer has full info</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. gov’t entities</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>University and private researcher organs</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>K-12 schools (education)</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Private individuals (novelty)</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>
Summary of Force 5

The sRLV research market supplier groups discussed above are sorted below into categories of High, Moderate, and Low strength.

- **High**: Labor, Solid Consumables, Spaceports
- **Moderate**: Machining Equipment
- **Low**: Mechanical Components, Composite Materials, Bulk & Sheet Metals, Liquid & Gas Consumables, Electronic Components

Prioritizing the supplier categories by strength is not attempted at this time, but the overall strength of this force is estimated to be Moderate tending toward Low.

CONCLUSIONS

Table 3 is a “scorecard” for the ISA conducted on the sRLV research market, summarizing the results of this analysis. Following this is a final set of overview analysis questions to complete the ISA.

The initial observation is that only one of the five main forces, the Bargaining Power of Buyers, are considered to be High in strength, due exclusively to the strength of the USG as a buyer group.

Looking more closely at the five main forces, the following components of the main forces were rated as High.

- **Force 1: Threat of Entry by Potential Entrants**
  - BOE due to Product Differentiation, product differences factor.
  - BOE due to Capital Requirements, all factors (financial, facility, hardware, and intellectual capital requirements).
  - BOE due to Cost Disadvantages Independent of Scale, proprietary technology factor.
  - BOE due to Government Policy, ITAR factor.
- **Force 2: Intensity of Rivalry Among Existing Competitors**, Level of Fixed or Storage Costs (Relative to Value Added) factor.
- **Force 3: Pressure from Substitute Products**
- **Force 4: Bargaining Power of Buyers**, USG entities buyer group.
- **Force 5: Bargaining Power of Suppliers**, labor, solid consumables, and spaceports supplier groups.

There are no sRLV operators that are currently conducting commercial operations, but it is clear that multiple firms are in the research, testing, and development stages of activity. With the support of USG and activities of universities and research organizations, it is expected that one or more of the sRLV firms will begin commercial operation in the near future.

Within Force 1, Threat of Entry, the overall BOEs strength is estimated to be Moderate (with a secondary tendency toward High), and the Competitive Reaction strength is estimated to be Low. However, the need for large amounts of capital to enter the industry is a BOE factor that must be overcome by all entrants, so the strength of this one factor is estimated to be High. BOE factors that were estimated to have Moderate strength include Product Differentiation, Switching Costs, Cost Disadvantages Independent of Scale, and Government Policy.

Force 2, Intensity of Rivalry among Existing Competitors, is estimated overall to be Moderate in strength, although the Fixed or Storage Costs (Relative to Value Added) factor was estimated to be High.

Force 3, Pressure from Substitute Products, is estimated to be Low in strength (with a secondary tendency toward Moderate) but sRLV firms should pay attention to the operators of expendable sounding rockets as a possible substitute product threat.

Force 4, Bargaining Power of Buyers, is considered to be of High strength overall due solely to the bargaining power of the USG as a buyer group. This force should be addressed strategically by sRLV firms to ensure long-term industry viability is not undermined by USG mission goals that may unintentionally conflict with market goals.

### Table 3. Summary Results of Force 5: Bargaining Power Strength of Suppliers

<table>
<thead>
<tr>
<th>Supplier group</th>
<th>Importance of customer</th>
<th>Important to buyers’ business</th>
<th>Differentiated or switching costs</th>
<th>Credible threat of forward integration</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical components</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Composite materials</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Machining equipment</td>
<td>High</td>
<td>High</td>
<td>Mod</td>
<td>Low</td>
<td>Mod</td>
</tr>
<tr>
<td>Bulk &amp; sheet metals</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Labor</td>
<td>?</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Solid consumables</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Liquid &amp; gas consumables</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Electronic components</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Spaceports</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
Force 5, Bargaining Power of Suppliers, is considered to have an overall Moderate strength. The labor, solid consumables, and spaceports supplier groups are estimated to be High in strength, but the Moderate and Low strength of the remaining supplier groups gives this force a secondary tendency of Low.

Based on varying strengths of these five forces that are estimated overall to be Moderate, the profitability of the sRLV research market could be expected to be moderate as well. Even this level of profitability could entice new companies to enter the market segment in pursuit of profits, increasing the market forces and ultimately driving industry profitability down.

This information can be used by policymakers in government to help more clearly identify a comprehensive set of challenges that need to be addressed in an attempt to encourage the development of this important emerging market segment.

### Table 4. Suborbital Reusable Vehicle Research Market ISA Scorecard

<table>
<thead>
<tr>
<th>Force</th>
<th>Overall Strength</th>
<th>Component Strengths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force 1: Threat of Entry by Potential Entrants</td>
<td>Moderate (High)</td>
<td>• Compilation of all BOE influence factors and competitor reaction factors.</td>
</tr>
<tr>
<td>• BOE - Economies of Scale</td>
<td>Low</td>
<td>• Moderate: operational process of purchasing of consumable goods. • Low: all the other business functions (management processes of corporate governance and strategic management, operational processes of manufacturing, advertising, marketing and sales, and support processes of accounting, recruitment, customer service, and technical service).</td>
</tr>
<tr>
<td>• BOE - Product Differentiation</td>
<td>Moderate</td>
<td>• High: product differences. • Low: past advertising, customer service, being first in the industry.</td>
</tr>
<tr>
<td>• BOE - Capital Requirements</td>
<td>High</td>
<td>• High: financial, facility, hardware, and intellectual capital requirements.</td>
</tr>
<tr>
<td>• BOE - Switching Costs</td>
<td>Moderate</td>
<td>• NASA, being the predominant buyer of the suborbital research rides, has complex acquisition processes to overcome but has also gone to great effort to ease the process as much as possible.</td>
</tr>
<tr>
<td>• BOE - Access to Distribution Channels</td>
<td>Low</td>
<td>• Low: government agencies and nonprofit organizations currently act as effective distribution channels.</td>
</tr>
<tr>
<td>• BOE - Cost Disadvantages Independent of Scale</td>
<td>Moderate</td>
<td>• High: proprietary technology. • Moderate: government subsidies, favorable locations (to testing and manufacturing). • Low: access to raw materials, operational experience cost savings, shared operations.</td>
</tr>
<tr>
<td>• BOE - Gov’t Policy</td>
<td>Moderate (High)</td>
<td>• High: ITAR. • Moderate: licensing, USG acquisition policy, USG acquisition regulations.</td>
</tr>
<tr>
<td>• Competitive Reaction</td>
<td>Low</td>
<td>• No firms conducting commercial operations.</td>
</tr>
<tr>
<td>Force 2: Intensity of Rivalry Among Existing Competitors</td>
<td>Moderate</td>
<td>• High: level of fixed or storage costs (relative to value added). • Moderate: amount of differentiation or switching costs, increment level of augmented capacity, level of exit barriers. • Low: number and balance of competitors, rate of industry growth, diversity of competitors, level of strategic stakes.</td>
</tr>
<tr>
<td>Force 3: Pressure from Substitute Products</td>
<td>Low (Moderate)</td>
<td>• Low because there is little pressure from the drop-tower substitutes. • Secondary tendency toward moderate because profitability of the sRLV research market is not very high despite the fact that expendable sounding rockets could possibly benefit from a price-performance trade-off of the industry.</td>
</tr>
<tr>
<td>Force 4: Bargaining Power of Buyers</td>
<td>High</td>
<td>• High: USG entities. • Low: university researchers, education (K–12), private individuals (novelty).</td>
</tr>
<tr>
<td>Force 5: Bargaining Power of Suppliers</td>
<td>Moderate (Low)</td>
<td>• High: labor, solid consumables, spaceports. • Moderate: machining equipment. • Low: mechanical components, composite materials, bulk &amp; sheet metals, liquid &amp; gas consumables, electronic components.</td>
</tr>
</tbody>
</table>
Future Work

Specific questions not addressed in this report are listed in the expanded analysis. These questions should be considered in subsequent ISAs of this market segment. Also, the sRLV market segment will evolve over time and subsequent ISAs should be performed to identify how the five forces also change over time.

Another perspective that could be investigated based on the results of this ISA would identify the positions of competitive disadvantages that new entrant firms should avoid. For example, since the Capital Requirements BOE is High, entering this market without sufficient funding to overcome that barrier should be avoided.

AUTHOR DISCLOSURE STATEMENT

No conflicts of interest exist.

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12. This list was compiled in 2010 by querying the JSR Launch Vehicle Database (www.planet4589.org/space/lvdb) for vehicles that have launched at least once since the year 2005.

Address correspondence to:

Ken Davidian
Office of Commercial Space Transportation
Federal Aviation Administration
800 Independence Avenue SW
Washington, D.C. 20591
E-mail: ken.davidian@faa.gov