

MARKET CHARACTERIZATION: LAUNCH OF VERY-SMALL AND NANO SIZED PAYLOADS
ENABLED BY NEW LAUNCH VEHICLES

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Recent yearly launch forecasts issued by the U.S. Federal Aviation Administration have identified emerging markets within the overall global launch industry. One such new market is launch of very small orbital payloads enabled by the emergence of nano to very small launch vehicle concepts. These concepts include:

- Virgin Galactic’s plans to use the White Knight Two vehicle as a platform of a small satellite launch vehicle
- The Canadian Space Agency’s expressed interest in developing a microsatellite launch vehicle
- Small launch vehicles in various stages of development at companies such as Interorbital Systems and Microcosm Inc.

This paper addresses the significance of an emerging new segment of space launch demand— launching of nano (10 kg) to very small (100 kg) class payloads into LEO via these launch vehicle concepts. The market segment targeted by these vehicle concepts is traditionally covered by multi-manifesting and secondary payloads. However, the interest in these sorts of vehicles may presage growth in this market segment within the context of the overall LEO and suborbital markets. This paper characterizes this emerging market segment, by loosely following the Industry Structural Analysis methodology. In characterizing this market segment the following factors are addressed:

- What factors are driving the emergence of the market?
- Who are the players in the market, both on the supply side (launch vehicle operators) and the demand side (payload operators)?
- How does this emerging market interact with and/or compete with other emerging markets, such as space tourism and commercial reusable sub-orbital launch services?
- Consideration of impacts to other aspects of LEO activities, including regulation and space traffic management.
- Military and security implications, including potential defense value of the launch vehicle concepts being discussed.

Emergence of a distinct launch market for payloads in this class would represent a segment previously not fully accounted for in industry forecasting and planning. Accordingly, early description of the characteristics of this market is an important first step towards understanding overall impacts and significance.

I. INTRODUCTION: A EMERGING MARKET FOR
ORBITAL LAUNCH OF NANO TO VERY-
SMALL PAYLOADS

II. Emerging Trends in the Launch of Nano to Very-
small Payloads

The 2010 Commercial Space Transportation Forecast issued by the U.S. Federal Aviation Administration (FAA) Office of Commercial Space Transportation identified the potential emergence of a new segment of launch services focused on launch of payload with a mass of less than 100 kilograms as a

developing new market in space transportation. The FAA Report indicates that the emergence of a competitively priced microsatellite launch vehicle market “may cause microsatellite payloads to shift from the multi-manifest approach to individual launch on these new vehicles. This would result in a larger number of launches.^{1”}

Providing qualitative support for the FAA’s identification of this new segment is the fact that a number of companies, governments and other space actors worldwide have either initiated development of launch vehicle concepts targeting the launch of nano to

very-small mass class payloads or are studying concepts in the market. These actors include:

- Virgin Galactic’s plans to use the White Knight Two vehicle as a platform for a small satellite launch vehicle.
- The Canadian Space Agency’s expressed interest in developing a microsatellite launch vehicle.
- Small launch vehicles in various stages of development at U.S organizations, both commercial and governmental, such as Interorbital Systems, Microcosm Inc., and the U.S. Army Space and Missile Defence Command.
- Various concept studies being pursued in Europe and Japan.

This paper will describe the structure of this emerging market, providing a definition of the market segment and identify the buyer and supplier groups and forces of interaction between them that will influence the development of the market. In doing so, the paper will use a concept known as Industry Structural Analysis as a thematic guide. This analysis will allow the concluding section of this paper to discuss how the forces shaping the emergence of this market segment will influence its interaction with more established areas of space activity.

I.II. Overview of Industry Structural Analysis

Industry Structural Analysis is a structured approach to the economic analysis of an area of industry activity that can be used to understand the structure of an industry and the competitive forces that affect interactions between suppliers in the industry and between buyers and suppliers in the market. Developed by Michael Porter Industry Structural Analysis focuses on the understanding the Five Forces that shape industry competition. Analysis of Porter’s Five Forces (rivalry among competitors, threat of new entrants, bargaining power of buyers, bargaining power of suppliers, and threat of substitute products or services) “reveals the roots of an industry’s profitability while providing a framework for anticipating and influencing competition over time.”² The resulting awareness of the factors affecting industry structure can be used both as tool to inform the strategy of individual companies and to understand dynamics shaping the industry as a whole.

Industry Structural Analysis follows a series of steps:³

- 1) **Industry Definition:** In this step a basic characterization of the industry is developed, in which the products, and geographic scope of industry competition, are determined.

- 2) **Identification of Participants:** In this step buyers, supplier, competitors, substitutes and new entrants are identified. These groups serve as the basis to which the Five Forces apply.
- 3) **Assesses the Industry against the Five Forces:** In this step the underlying drivers of the industry are assessed in terms of the Five Forces, in order to determine which Forces are weak and which are strong, and why.
- 4) **Determine Overall Industry Structure:** In this step the results of the Five Forces analysis are put together into an integrated industry overview, which can then be tested for consistency. At this point the analysis can be used to inform company strategy as to competition and profitability.
- 5) **Analyze Trends:** In this step repetition of the Five Forces analysis over time will allow trends in each force affecting industry development and company strategy to be identified.
- 6) **Identify Aspects That Can Be Influenced:** In this final step companies utilize Industry Structural Analysis as a tool to identify market forces that can be influenced by the company, by its competitors, or by new markets.

Since this paper is concerned with the potential emergence of new market in the launch of nano to very-small payload class missions via dedicated vehicles, and not with the behaviour of individual firms, the analysis conducted herein will focus on how Porter’s Five Forces are at play in the development of this market; and will not address those steps of Industry Structural Analysis that pertain directly to company strategy.

Figure 1, below provides an overview of Porter’s Five Forces that shape industry competition.⁴

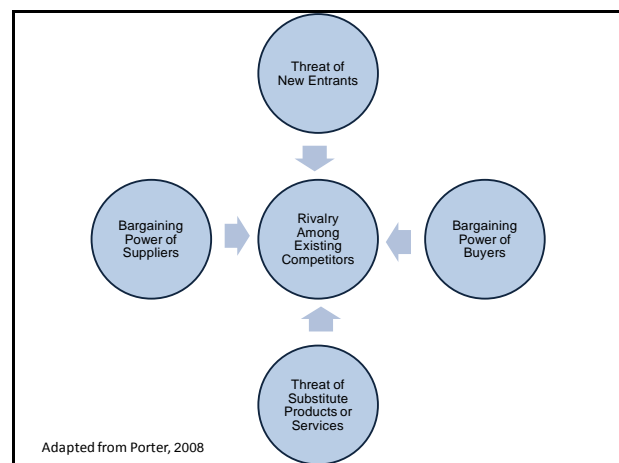


Fig.1 The Five Forces

Threat of New Entrants

This Force describes how easy it is to enter a new market. Factors considered within the analysis of this

force include (e.g.): loyalty to existing suppliers, costs of entry, government regulations, available resources and capital, learning curve, etc.

Bargaining Power of Buyers

This Force describes how much leverage buyers have in the market against suppliers. Factors considered within the analysis of this Force include (e.g.): price sensitivity, number of buyers in the market, volume of potential sales, etc.

Bargaining Power of Suppliers

As a counterpart to buyers' power, this Force describes how much leverage suppliers have in the market against buyers. Factors considered within the analysis of this Force include (e.g.): indispensability of the product to the buyers, number of suppliers in the market, degree of supplier differentiation, etc.

Threat of Substitute Products or Services

This Force describes the likelihood that a competitive substitute product will be available. Factors considered within the analysis of this Force include (e.g.): technology and innovation affecting product development, price performance of substitute, buyer ease in switching, etc.

Rivalry among Existing Competitors

This Force describes the extent of competition between existing firms in the industry. Factors considered within the analysis of this Force include (e.g.): price competition between firms, industry growth rate, number of competing firms, exit barriers, etc

Within this paper a rigorous application of Porter's Five Force's analysis is not applied, primarily because the industry being evaluated is somewhat of a niche market, for which limited scope prevents a full application. Instead this paper uses the theory as a loose guide through which the elements affecting the emergence of a market for the dedicated launch of payloads in the nano to very small class can be described. In doing so the paper will elucidate how the industry structure in this market will "grow out of a set of economic and technical characteristics that determine the strength of each competitive force."⁵ The analysis will reveal the competitive interactions, substitutes available, and buyer/supplier relationship that in turn help to define how this market segment interacts with the space industry writ large.

II. DEFINING THE INDUSTRY

As a segment of the overall launch industry (including for the sake of this paper, both competed launches and non-competed launches) the emerging market being considered here is defined by four characteristics: (1) the physical size of payload being launched, as bounds on the market segment, (2) the types of organization operating in this space as buyers (payload operators) or suppliers (launch vehicle providers), (3) the geographic extent of the market, and (4) a baseline assessment of the extant demand for launch services in this segment.

II.I. Payload Class

The U.S. FAA defines a microsatellite as a spacecraft with a mass of less than 100 kilograms; and a nanosatellite as a satellite with a mass of ten kilograms or less. Following from these definitions the 10 to 100 kilogram payload mass range considered in this paper can be defined as "microsatellite-class," and will be referred to as such throughout the remainder of this analysis.

II.II. Baseline Launch Demand

Futron's proprietary Electronic Library of Space Activities (ELSA) Database features over 20,000 interlocking records on all global past, current, and projected future space activity. ELSA contains comprehensive program and technical data on launch events, spacecraft, vehicles, launch sites, and space-related organizations. Historical launch data, maintained in ELSA, covering the period from 2000 through all projected 2010 launches, for launches to all inclinations in LEO, indicates that an average of 12 spacecraft in the microsatellite mass class (10-100 kilogram launch mass range) have launched worldwide per year. This figure does not include launch of nanosatellites with a mass of less than 10 kilograms, at least 54 of which were successfully launched during the period from January 2005 through August 2010. Futron's analysis of historical launch data therefore indicates a baseline of 12 launches per year as estimate for the amount of launch demand which might be accessed by microsatellite launch vehicles under development.⁶ Historically payloads in this mass class have not represented a significant driver of launch vehicle demand because due in part to the small size of the satellites and their developers' often limited budgets they have traditionally flown as secondary payloads.⁷ Figure 2 below shows the historical number of microsatellite-class launches per year.

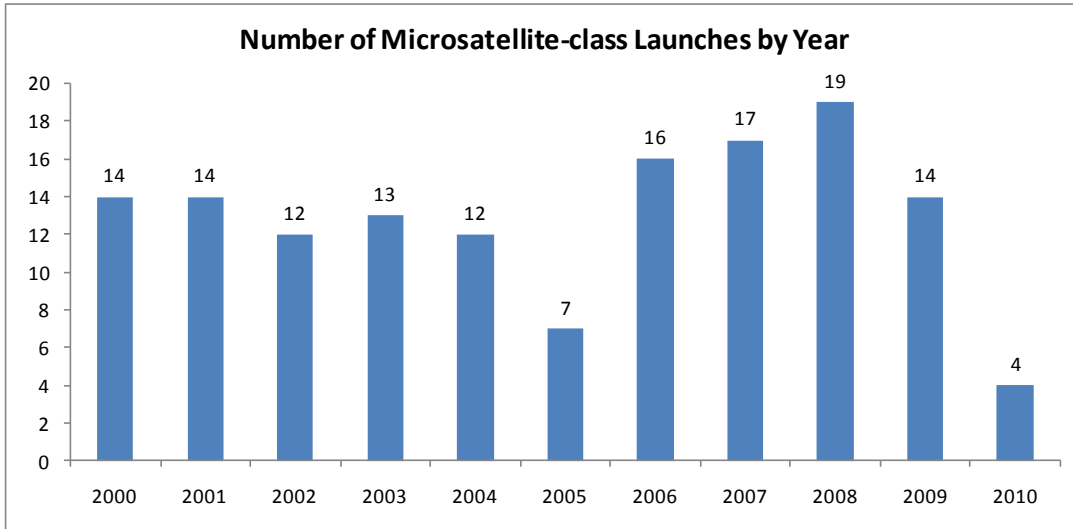


Fig 2. Historical Launch of Microsatellite-class Payloads by Year (2000-2010)

II.III. Geographic Extent of Market

Within the historical baseline shown in Figure 2, Futron identifies payloads operated by 24 countries on five continents; indicating that the potential geographic extent of the microsatellite launch market is global. This conclusion is supported by an assessment of the geographic origins of organizations with expressed interest in developing dedicated launch vehicles targeted at this class of payloads. Interest in developing and operating such a vehicle has been expressed by governments and/or companies in locations including Canada, Europe, Japan and the United States. Table 1, below, includes a summation of expressed interested in dedicated microsatellite launch vehicles, including country of origin.

II.IV. Type of Organizations Operating Payloads in this Class

Within the historical baseline shown in Figure 2, payload operators are found within many sectors of the space community. These include civil and military government organizations, universities, non-profit organizations and research institutes, and for-profit companies. These operator groups represent the target buyer (or user, for government provide non-commercial launch) markets for those actors interested in supplying launch services in this industry segment. Table 1, below, includes a summation of targeted markets, where known, for dedicated microsatellite launch vehicles in development or planning.

Table 1: Characteristics of Prospective Microsatellite Launch Vehicles and Operators

Vehicle Name	Organization (Country)	Max Payload Capacity (LEO)	Development Status	Target User/Buyer Markets
Aldebaran ⁸	CNES, DLR, CDTI (France, Germany, Spain)	Up to 300kg	Concept Study	Non-commercial, government science and tech. demo missions
Microsatellite Launch Vehicle ⁹	Canadian Space Agency (Canada)	Up to 150 kg	Market Study	
Multipurpose Nanomissile ¹⁰	U.S Army Space and Missile Defense Command (United States)	Apx 23kg	In design phases	U.S. Government military payloads, operationally responsive space
Neptune 30 ¹¹	Interorbital Systems (United States)	30kg	In-development	CubeSats, universities and non-profits
Scorpius/Mini-Sprite ¹²	Microcosm Inc. (United States)	225kg	Design	1) U.S Military and operationally responsive space 2) U.S Civil Government 3) Educational Organizations
Nano-Launcher ¹³	IHI Aerospace, USEF, CSP Japan (Japan)	100kg	Concept Study	Academia and government missions
Virgin Galactic Small Satellite Launch Vehicle	Virgin Galactic (United States)	100kg	In development	Science missions
NA	NASA NanoSat Launch Challenge (United States)	>1kg, twice in one week	Innovation Prize	Cubesats

Industry Definition Statement

This paper analyzes the structure of the emerging microsatellite-class launch industry; the global provision of launch services for payloads in the 10-100 kilogram class, using dedicated vehicles.

III. FIVE FORCES ANALYSIS OF EMERGING DEDICATED MICROSATELLITE LAUNCH SEGMENT

Having defined the Industry in Section II the next step in this analysis is to view the emerging microsatellite launch market through the lens provided by Porter’s Five Forces.

III.I. Threat of New Entrants

This Force addresses the ease which with new entrants can access the market. Typically barriers to entry assessed here include high fixed costs, capital requirements, learning curve, government restrictions, resource availability, and incumbency advantage. The

majority of companies and organizations (see e.g. Table 2) considering the development of dedicated microsatellite launch vehicles are not new entrants to the space business; or are developing this capability as a secondary aspect of a primary capability or system. While a dedicated launch vehicle focused solely at the microsatellite would be a relatively novel capability, the technology to enable such a system is not complex, and the technical learning curve is not seen as a barrier.

Porter notes that a need to invest financial resources may deter new entrants into a market.¹⁴ Costs of developing an initial operating vehicle in this class are not insignificant, estimated in the \$10’s of millions.¹⁵ However developers expect that those vehicle development costs can be quickly recovered through increased launch tempos and economies of scale realized in the production of many individual vehicles. One such developer, Microcosm Inc, identifies potential launch market-wide savings of more that \$15 billion in a 12-year period, resulting from the development of a low-cost responsive launch vehicle focused on the

SmallSat (a slightly larger mass class than considered that in this paper) market.¹⁶ In short, cost is not viewed by potential suppliers as a significant hurdle; from a system-wide viewpoint an increase in the use of SmallSats and associated launch vehicles is seen be potential entrants to this market not as drain on scarce resources in the space industry but as way to increase efficiency and reduce costs.¹⁷

Nonetheless for those potential suppliers which are not established actors in the space industry, start-up costs are a potential barrier. Virgin Galactic, whose interest in a satellite launch vehicle is secondary to their space tourism business, has been successful in securing some private-capital investment in the initial development of the capability. Elsewhere, government programs, such as NASA's recently-announced Nano-Satellite Launch Challenge which provides a \$2million prize for placing a small satellite into Earth orbit twice in one week, provide some economic stimulus for new entrants.

A additional barrier worth addressing here, is systemic inertia within the space community regarding the use and capabilities of microsatellites. Many potential customers for services capable of being provided by micro and small satellites have a low level of familiarity with these systems and their capabilities.¹⁸ There remains scepticism as to the utility of satellites in this class; and therefore of the need for a dedicated launch capacity.¹⁹ This scepticism, to the extent that it inhibits demand for satellites in this class (and by extension launch services) is potentially significant barrier to new launch operators becoming involved in this area of activity.

III.II. Bargaining Power of Buyers

This Force assesses how much pressure buyers (satellite operators) can place on suppliers (microsatellite launch service providers). Key factors analyzed here include the number of buyers, buyer volume, buyer price sensitivity, and indispensability of the product to the buyers (i.e. can the buyers due without the product for a long period of time?). As a top-level description of markets characterized by a high degree of buyer power are those where.²⁰

- there are relatively few buyers and/or buyers are making large volume purchases,
- buyers are price sensitive and capable of pressuring for price reductions
- buyers can switch vendors easily
- suppliers products are standardized and interchangeable

A 2006 study conducted by Futron on behalf of the Air Force Research Laboratory indentified over 30 markets in 6 principle areas for services provided by low-cost satellites in the 100-200 kilogram class. The principle areas identified were:

- Military: science and technology
- Military: intelligence, surveillance and reconnaissance
- Civil/commercial communications: polling of unattended sensors
- Civil/commercial communications: remote site communications
- Civil/commercial remote-sensing: high-resolution Earth observation
- Civil/commercial remote-sensing: Land-sat class data for environmental monitoring

Within these markets the study indentified addressable commercial launch opportunities of 40-75 satellites per year, in the 100-200 kilogram class.²¹ This group of markets can likely be extrapolated to the microsatellite class, at a lower launch demand, as the source of the buyer organizations.

Within the 10-year historical microsatellite launch rates identified in Figure 2, Futron identifies more than 60 different satellite operator organizations.²² These operator organizations include universities, civil and military government organization, non-profit organizations, and for-profit companies. Collectively this data indicates a diverse buyer community, with a large number of potential buyers.

Traditionally launch is not seen as a main driver of mission costs for typical space missions. This is not the case for microsatellite missions; SmallSats "are typically built for \$1million to \$10million; and there is no dedicated launcher available for less than \$10million."²³ Costs of developing a mircosatellite are less that of a SmallSat. This launch cost and availability situation has generally meant that microsatellite operators have sought launch opportunity as secondary payloads or as groups of small and microsatellites to fill a small launch vehicle launch. Difficulty of launch access means that these operators often have little control over launch schedule, and although missions are often designed to be capable of switching launch providers satellite operators in this class often remain beholden to primary payloads for launch opportunities. Furthermore many microsatellite developers operate within tightly constrained budgets, and are highly price sensitive to launch costs. However the combination of low buying volume, a relatively large number of buyers as compared to suppliers, and a lack of alternative microsatellite launch options means that, despite high prices sensitivity, buyers in this market have little ability to negotiation launch prices

The emerging microsatellite launch segment is characterized by low buyer power.

III.III. Threat of Substitutes

This Force assesses the type and threat of substitute products in the market. In the cast of microsatellite launch, substitutes can be defined as products which

provide suitable access to space, allowing completion of mission objectives, for payloads which might be carried on a microsatellite busses. There are three primary substitutes available for a dedicated microsatellite launch capacity: one established capability – the launch of secondary payloads on traditional launch vehicles; and two emerging capabilities – hosted payloads, and commercial reusable suborbital spaceflight.

The launch of microsatellites as secondary or co-manifested payloads has been the traditional method of access to space for systems in this class. This method is well understood by both payload developers and launch operators; and accordingly is relatively easily taken into account in mission planning. Disadvantages, from the perspective of the microsatellite operator include a lack of schedule control and a potential lack of ability to operate in the most desirable orbit.

Hosted payloads are an emerging business model where “available capacity on commercial satellites is used to accommodate additional transponders, instruments or other spacebound items.”²⁴ Hosted payloads have the potential to fly systems that might have otherwise been considered for SmallSats or microsats. Most hosted payloads to date have been government systems (e.g. CHIRP, IRIS, WAAS). Hosted payloads are characterized by many of the same aspects as launching as secondary payloads, in terms of optimization of mission parameters and schedule. However utilization of this method of access to space instead of a microsatellite may offer cost and efficiency advantages.²⁵

For payloads that do not need sustained exposure to the space environment (typically experimental or technology development), suborbital flight opportunities may prove a viable substitute to dedicated microsatellite launch. Suborbital vehicles in development at Armadillo Aerospace, Blue Origin, and Masten Space Systems, among others, offer repeatability and reusability at a low cost. These features may be more attractive to certain buyers than a dedicated satellite.²⁶

Microsatellite launch vehicles suppliers and suppliers of these substitute products must find a way to differentiate their products. For launch as a secondary payload this differentiation is based on an incumbency advantage of well-understood processes and market inertia. For hosted payloads this differentiation might be based on cost and efficiencies of scale. For suborbital vehicles it might be based on repetition and responsiveness. For dedicated launch vehicle this differentiation will likely be found in providing microsatellite operations with a means of access to space that optimizes cost, flexibility and adherence to optimum mission parameters.

III.IV. Bargaining Powers of Suppliers

This Force assesses how much pressure suppliers (microsatellite launch service providers) can exert over buyers (satellite operators). Key factors analyzed here include the industry concentration of suppliers relative to buyers, diversity of supplier revenue sources, availability of substitute products, supplier pricing power, and supplier product differentiation. As a top-level description, markets characterized by a high degree of supplier power are those where:²⁷

- Suppliers are more concentrated (in number) than the group they are selling to,
- Suppliers hold pricing power in the market
- Suppliers do not depend heavily upon a single product or service market for revenue
- There are no substitute products for what the supplier is selling.

The launch services sector of the space industry (supplier) has traditionally been more concentrated than the satellite operators and manufacturer sectors (buyer) of the industry. Launch services have typically been provided by a comparatively smaller number of firms or governments than the number of organizations seeking launch opportunities. It is likely that this structure will persist in a microsatellite launch vehicle market. Given the relatively large number of organizations operating satellites in this class and the relatively small number of organizations considering vehicle development (see e.g. Table 1) it is reasonable to expect that suppliers of dedicated microsatellite launch services will remain more concentrated than buyers of that service.

The ability of microsatellite launch providers to set prices for launch services is complicated by several factors. The presence of substitutes in market, including the traditional method of secondary payloads, means that prices cannot be set independently of those substitutes. The high price sensitivity of buyers means that, although the launch suppliers have more pricing power than the buyers, they are still limited in that pricing by the sensitivity of the buyers.

A final question to analyze in this Force is the degree to which Suppliers do not or do not depend heavily upon a single product or service market for revenue. This is an important question of firm strategy, for those commercial entities interested in this market sector. Virgin Galactic for example has chosen to pursue a small satellite launcher as a secondary line of business to its suborbital space tourism operations. Microcosm, Inc. is expanding its industry concentration in pressure volumes, space-qualified components, and space mission engineering into small launch vehicles. Microcosm expects production and cost efficiency realized by the use of small satellite launch vehicles to drive growth in the market.²⁸ The degrees which suppliers serve multiple industries (or distinct industry segments) influence the amount of profit they can extract from each industry; the more industries served

the more price flexibility.²⁹ Therefore as dedicated microsatellite launch services continues to develop as a distinct segment of the launch industry, the degree to which this activity develops as main or secondary lines of business for suppliers will be a strategy question that has significant bearing on how supplier's positioning develops in the emergence of the market.

Suppliers in this industry have more bargaining power than do buyers, but nonetheless the emerging microsatellite launch segment is not characterized by low buyer power.

III.V. Rivalry among Existing Competitors

This Force assesses the intensity and basis of competition between existing firms in the industry. Competition is assessed by:

- The number of competing firms in the industry
- The rate of growth
- Exit barriers
- Familiarity of firms with each other
- Is competition based on price or other dimensions (e.g. service quality)
- Capacity of the market

For an emerging market like microsatellite launch services, it is difficult to assess rivalry among existing competitors for the simple reason that inter-organization and inter-firm relationships have yet to develop.

Nonetheless is possible to identify issues which might shape the emergence of competition dynamics within the industry. For this paper, competition is most likely within the supplier group, not buyers.

- As seen in the Bargaining Powers of Suppliers section, the number of firms acting as suppliers in this industry segment is expected to be low; this is a barrier to rivalry.
- Industry growth is likely to be slow, due to inertia in the market and presence of substitutes. Competing firms are likely to be offering similar services to one another. These factors precipitate competition over market share.³⁰
- Suppliers hold some pricing power, but buyers have high price sensitivity. Competition is therefore likely to not be based on price, but more likely to be based on service quality, at least during the initial emergence of the market.

III.VI. Summary of Porter's Five Forces Applied to the Emerging Microsatellite Launch Services Industry

Figure 3, below, provides a summary of the findings when Porter's Five Forces are applied as an analytical lens to the emerging market for dedicated microsatellite launch services.

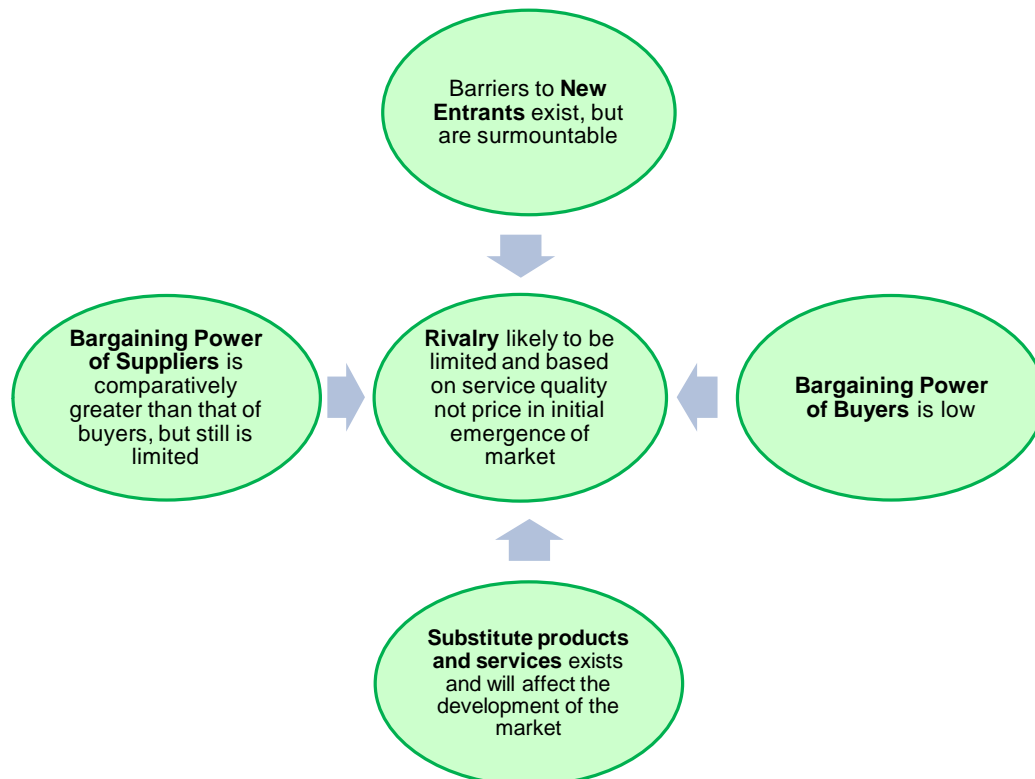


Figure 3: Summary of Five Forces Analysis Applied to the Emerging Microsatellite Launch Services Industry

IV. CONCLUSION: OVERALL IMPLICATIONS OF THE EMERGENCE OF THIS MARKET

If a robust dedicated microsatellite launch market were to emerge a more robust analysis using Porters Five Forces could be applied. This more robust analysis could then be used to inform company or organization market strategy on either the buyer or supplier side of the industry; it could also be used as a jumping off point for assessment of the impacts and interactions of the new market segment with the overall space industry. However the level of analysis presented in this paper does not allow the identification of a number of implications the emergence of this market presents vis-à-vis the global space community.

IV.I. Access to Space

Access to space remains a major problem for the SmallSat and microsat operator communities.³¹ Development of a dedicated launch capability- at accessible prices- for vehicles in this segment would potentially lead to increased utilization of space via satellites of this mass class. This combined with government programs such as NASA's Franklin and Edison SmallSat concept and technology programs, would increase the awareness of the capabilities of satellites in these classes. Combining increased access with increased awareness potentially leads to a diversification of space as utilization increases.

The technical capabilities of launch vehicles in the emerging microsatellite payload class have implications for regulatory regimes. These vehicles are likely to be very small in size and are being designed with portability in mind; launch readiness time may be as short as 24 hours.³² These capabilities mean that the vehicles may not require traditional spaceports (with associated legal regimes) to launch.

IV.II. Military Implications

Many of the vehicles being developed in this class are focused on military markets, such as the development of operationally responsive space capabilities. The development of military attention to operationally responsive space will inherently affect the market prospects of these vehicles. Additionally the portability and quick-launch capability of some of the proposed vehicles means that they may have secondary utility as tactical weapons. For these reasons the interaction of development of these vehicles with military markets bears further analysis and tracking as this industry segment emerges.

IV.III. Orbital Debris

Prospects of increased utilization of space via SmallSats and microsatellites have led to some concern over how that increase might contribute to the growing

orbital debris problem.³³ However satellites in these classes typically fly in lower orbits where debris does not accumulate due to drag.³⁴

V. FUTURE DIRECTIONS

This paper provides the basis for a continued analysis of the emerging dedicated microsatellite launch vehicle industry. The Industry Structural Analysis methodology, if repeated over time as an industry segment develops, allows tracking and analysis of trends in the development of an industry segment. As the industry segment develops and becomes more mature increasingly robust Structural Analysis is possible. The initial analysis of the structure of the microsatellite launch vehicle industry segment contained in this paper identifies the initial set of issues, factors, and relationships shaping the emergence of the industry segment that would be the subject of refined analysis in future iterations. From that refined analysis implications for companies' and governments' strategy could be further developed; as could further discussion of effects and interplay of the emergent area of space with the development of global space activities writ large.

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