IAC-12-E6.1.6

THEORY BASED ANALYSIS OF THE COMMERCIAL CREW TO ORBIT TRANSPORTATION INDUSTRY STRUCTURE AND EVOLUTION

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With the retirement of the U.S. Space Shuttle program, transportation to Low Earth Orbit for American and ISS partner astronauts is solely reliant on Russian partners to provide. Current NASA policy dictates that crew transportation to orbit be transitioned to include a fleet of commercially developed and owned vehicles when they become available. This availability is in the process of acceleration through strategic government financial investments. Such government influence on the commercial crew to orbit transportation sector of the space industry serves to dramatically decrease the expected delivery timeline, but also has a substantial impact on the structure and evolution of an industry that will ultimately require multiple customers to thrive. Market driven concerns are a fundamental pre-requisite to the eventual growth of this sector and the work presented here will outline the industry's structure based on extensively vetted theory-based analyses. The foundation for this analysis is based on the work of Michael Porter and where appropriate certain emphasis is placed on aspects of this theory-based model which are particularly pertinent to this industry sector.

The sector in questions is currently in a dynamic phase of evolution with major government investments advancing technology and recent competitive awards shaping the near-term sector and its participants. The nature of this changing environment necessitates a continuous re-evaluation of analyses such as this work. Due to this fundamentally evolutionary attribute, this work will build on previous efforts to define this industry sector's structure and is intended as the basis for future discussion and further adaptation. As current programs begin to reach phases of integrated vehicle systems and comparatively long-term contracts are awarded, the structure and evolution of this sector will become more well-defined. With the resolution of these uncertainties comes the emergence of other market driven factors pertinent to customers beyond the U.S. Government: customers that must emerge for the industry to survive.

As the major players within this sector continue to approach the availability of complete system solutions for delivering crew to orbit, the ability to strategically serve alternative customers will, in many cases, dictate the sustainability of commercial efforts. The intent of the analysis presented in this paper is to provide a sector-wide perspective on the fundamental evolution of industry structure. Such information can be used by government and commercial decision-makers to inform subsequent more competitor specific strategy. Combined with data-based industry analysis, this work is provided publicly to encourage, facilitate, and promote the development of safe and sustainable commercial space transportation activities.

I. INTRODUCTION

Industry forces generated by competitors, suppliers, buyers, potential competitors, and substitute products or services drive the environment within which corporate strategy must be formed and constantly evolved. Just as none of these forces should be assumed constant, the strategy influenced by these forces cannot remain unchanged either. The specific competitive advantage of any one player is shaped by different perceptions, motivations, and valuations of the product or service in question. These highly proprietary plans are built individually within the broader context of an industry's structure. Many different constructs may be used to define such structure and the work that follows will be based on the theory outlined by Michael Porter[1]. This industry structural analysis was first published in 1980 and has since been updated and revised through usage in business schools and in corporations for more than three decades. It is the thoroughly vetted and well understood attributes of this theory which led to its selection for use in this case.

The industry sector in question for this analysis will be referred to as the Commercial Crew Orbital Transportation (CCOT) segment of the broader commercial space transportation industry. The product of this sector is the vehicle that provides for the delivery and return of humans to Low Earth Orbit (LEO) via transportation systems available for commercial purchase. This is not considered to necessarily include

[1] Porter, Michael E., Competitive strategy: techniques for analyzing industries and competitors, Free Press, New York : 1980

the launch vehicle itself as this has potential other uses and many vehicles can potential fly on multiple launch vehicles.

Potential customers of this segment include but are not limited to the United States Government through the National Aeronautics and Space Administration (NASA) to service the International Space Station (ISS) and commercial individuals or companies with an interest in traveling to LEO. Additional customers may emerge in the form of privately owned on-orbit facilities, some of which are currently in development.

The CCOT industry segment is progressing with a relatively high amount of uncertainty as compared to traditional commercial ventures. It is for this reason that strategically placed funds by government entities and early customer contracts are so valuable in accelerating the industry segment's development. Strategy thus plays a big role for industry segment competitors, new entrants, customers, and regulators. In scenarios such as this with limited data and incomplete precursory analogies, exclusively data-based analysis is prone to false signals and perceptions with regard to projections and strategy formulation.

As Clayton Christensen stated about theory based analysis, "The only way to look into the future is to use these sorts of theories, because conclusive data is only available about the past."[2] This is the specific motivation behind the work presented here. The industry structural analysis as described here is intended to serve as a basis for debate and discussion to refine its conclusions. It is difficult to find definitive conclusions or to place confidence on projections for the future. Thus the intent is to identify the key attributes and try to maximize the likelihood of success. From these conclusions, many different entities have the potential to benefit from observing how competitive forces result in different industry viability. Some of these strategic decisions require further analysis, while other broad strategic implications will be identified and discussed.

II. BACKGROUND

The foundation of Porter's industry model is five forces of competition which include rivalry between established industry players, as well as contributions from potential new entrants, substitute products, buyers, and suppliers. These five competitive forces are outlined in Figure 1. The intent of an industry structural analysis is to investigate these five forces and outline the degree to which each shapes the competitive landscape of the market. Understanding this competitive landscape provides an opportunity to evaluate the behaviour of industry competition and success in the medium and long term.

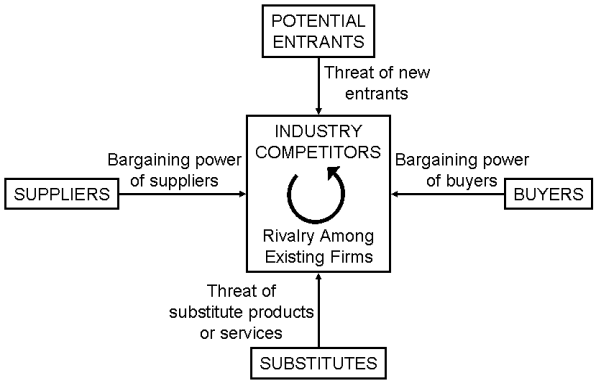

Figure 1. The five forces of competition

After the forces which affect competition are outlined and the underlying trends understood, the industry structural analysis product is leveraged by individual companies or entities to develop individualized strategy. In the case of a competing company, this information is built upon to evaluate individual weaknesses and strengths in comparison to the competitive environment of their chosen industry segment and heavily influenced by the weighting factors applied by ownership and/or management. This is further leveraged in subsequent stages of Porter's analysis to develop strategy that results in a defendable market position. With respect to other entities, such information on the competitive structure of an industry can be leveraged to assist in its development by identifying areas of high risk that are specifically holding back further growth of the industry.

As the CCOT industry segment currently stands, the only true incumbent option is for Russian Soyuz launches. These are currently purchased by NASA to fulfil international obligations for crew transportation to the ISS and are also available for sale to private commercial customers. These private commercial sales for individuals to fly on the Soyuz have been brokered by Space Adventures Limited.[3]

New entrants to this segment, representing companies currently in active development of this capability (as can be referenced publicly) include, The Boeing Company[4] with the CST-100, Space Exploration Technologies[5] with the Dragon Capsule, and Sierra Nevada Corporation Space Systems[6] with the Dream

[2] Christensen, Clayton M., Roth, Erik A., and Anthony, Scott D., Seeing What's Next: Using The Theories of Innovation to Predict Industry Change, Harvard Business Review Press; 1st Edition, September 21, 2004

[3] http://www.spaceadventures.com/

[4] http://www.boeing.com/defense-space/space/ccts/

[5] http://www.spacex.com/

[6] http://sncspace.com/space_exploration

Chaser. This is not exhaustive but represents those firms perceived as leading in the development of systems. It is relevant to note that this perception and the associated public information on their activities is primarily a result of recent awards from NASA through the Commercial Crew Integrated Capability round of funded Space Act Agreements (SAA).[7] The summary of awards from NASA through the Commercial Crew Program is outlined in Figure 2.

Additional potential entrants include, but are not limited to, the Liberty launch system as proposed by a partnership led by Alliant Techsystems Inc. (ATK)[8], as well as Blue Origin[9] with the Biconic Space Vehicle.

Company	CCDev 1	CCDev 2	CCiCap
Boeing	$18 M	$92.3 M	$460 M
SNC	$20 M	$80 M	$212.5 M
SpaceX	N/A	$75 M	$440 M
Blue Origin	$3.7 M	$22 M	N/A
ULA	$6.7 M	N/A	N/A
Paragon	$1.4 M	N/A	N/A

Figure 2. NASA Commercial Crew Program Funding

As an industry segment, transportation of crew to orbit is often and will in this paper be referred to as emerging. That title however does have specific meaning and definition particularly in terms of the phase of industry development. These are outlined by Porter as ranging through "emerging", "growth", "mature", and "decline". Such phases are based on many factors but lead to differing conclusions during certain analyses. This topic is given thorough coverage and discussion by Davidian et al.[10] and those readers seeking to further identify the impact of such designations are referred to this paper for more details. Davidian et al. concluded that the portion of the industry containing the CCOT segment draws only medium resemblance to an emerging segment and suggests that the growth phase may be further off than anticipated.

[7] http://www.nasa.gov/exploration/commercial/crew/cciciap-announcement.html

[8] http://www.libertyspace.us

[9] http://www.blueorigin.com/

[10] Davidian, K., Foust, J., Kaiser, D., and Christiansen, I., "Are Commercial Space Transportation Industries Emerging?" IAC-11-E6.2.7.

III. COMPETITIVE FORCES

There is currently a lack of extensive established business throughput making this sector reminiscent of an emerging industry segment in that there exist broad similarities between forces effecting new entrants and currently emerging companies. In short, due to a relative absence of availability, the same influential forces that exist for existing competitors can be applied to recent entrants. It is expected that this will be true until the sector ultimately arrives at a growth phase in its development where existing competitors are able to lock in consistent demand and differentiate their product or service.

Threat of New Entrants

Barriers of Entry

Barriers of entry that are presented to a potential new entrant represent the primary driver of the threat level posed by new entrants to an industry sector. These barriers are outlined below and are particularly complicated due to the essence of having simultaneous entry facilitated by government support.

Economies of Scale

Traditional economies of scale, with an expected decline in unit cost of a product due to increases in volume of units produced, have not been demonstrated in this industry sector and are not expected in the near to mid-term due to small unit production numbers. Notwithstanding this absence of traditional economies of scale, this force is more subtly defined by the capability of competitors within a sector to leverage economies of scale through multi-business synergies. Similar benefit can also be found through vertical integration of sequential product lines.

In the CCOT industry sector, the existence of this integration either across business divisions or through the production process can be a **high strength force in keeping competition from entering the sector.** This is specifically the case in this industry sector where safety protocols and certification standards are very high. A new entrant without these benefits would struggle to compete with firms able to leverage these benefits in areas such as contracting, quality control, product testing, and certification.

Product Differentiation

Established or early entrants to this sector will have the advantage of customer loyalty through demonstrated safety record and certification acceptance. It may also be the case that early customers are willing to sign long-

term agreements to secure capacity or other contractual benefits. Certain customers may also have a preference in the operations of the flight. For example, landing in the ocean versus landing on land may lead some influential customers to influence the market with early purchases. This is particularly true by high visibility thought leaders from different potential segments.

Differentiated products similarly provide market opportunities for new entrants depending on the trend of where market developments lead. Current and emerging competitors are at a disadvantage based on the ongoing uncertainty of industry development. In this case strategic positioning of vehicle design and capabilities are predicated on projections of where demand might emerge and what attributes will be most valuable in this differentiation. New entrants may be able to capitalize on having information on these factors before they complete or even start designing a vehicle.

A critical component of any CCOT sector system is safety. This is expected to be a standardized requirement and is not currently a differentiable attribute of a vehicle. Although safety is unlikely to differentiate vehicles, the ability of a vehicle to provide certain levels of performance or redundancy beyond standardized requirements may provide an advantage.

At present this force is considered medium in strength due to the early entrant advantage in possible long term agreements and established safety records.

Capital Requirements

Capital requirements for new entrants into the CCOT sector are incredibly high and thus **this is a force with high strength at preventing new entrants.** Current competitors entering this sector are able to leverage significant financial support from government programs to advance technologies. This government involvement reduces the overall risk of the program into the level acceptable to private industry. It is highly unlikely that future entrants will have this benefit unless those competitors currently entering the market segment fail to deliver the safety and cost efficiencies required.

It is expected that as long as competition remains healthy in the market segment and consistent regulations are applied, future investment at this scale is unlikely by the government. It is worth specifically noting that in this context, healthy competition within the market segment presupposes additional demand above and beyond that of government contracts.

Switching Costs

The one-time cost for a customer to switch between providers as a barrier to preventing customers from entering is **highly variable**. The large established customers in this segment will likely operate with open and universal standards. Such standards are unlikely to present high barriers for potential new entrants as they will be well documented. This is particularly true when considering early government customers who will be providing the design specifications for interfacing with government entities such as ranges or on-orbit assets.

As customer segments become better defined, potential new entrants will be able to design for the segment needs to reduce these switching costs.

Access to Distribution Channels

The access to distribution channels for customers is increasing as a barrier for new entrants. The accessibility of the primary customer for this sector, the U.S. Government for civilian purposes through NASA, will be dependent on the structure of acquisition contracts ultimately used and their duration. This access aside, reaching alternate commercial customers through established **distribution channels will be a medium to high barrier for potential entrants.** This barrier will be become particularly potent as extensive existing networks are already established or leveraged by established or soon-to-be-established competitors.

Cost Disadvantages Independent of Scale

From the perspective of a possible new entrant there are certain disadvantages faced that are independent of scale. As was outlined earlier, traditional scale benefits are minimal but leveraging existing business lines and experiences does create a potential barrier of entry. The forces described by disadvantages independent of scale are primarily driven by proprietary technologies, access to key personnel, and government subsidy. Government subsidy was also discussed briefly under the term government investment in the capital requirements section.

In the CCOT industry segment, intellectual property is owned by the company's developing the vehicles even though extensive government funding is involved. This is a key provision of the Space Act Agreement construct upon which the program is established. These firms thus have a strong advantage over potential new entrants. Key personnel are also generally available due to recent realignments within the sector, however current graduation rates in key fields suggest this problem may emerge as an important force in years to come as retirement dwindles the pool of available workforce and fewer students are entering critical fields.

A major impact on this disadvantage for future entrants is the high level of government subsidy or investment that currently entering companies are receiving. As this amount of support increases, so does the barrier of entry represented here. For these reasons

cost disadvantages independent of scale is identified as a moderate to high strength force preventing new entrants.

Government Policy

Government policy is a low strength barrier due in large part to recent clarification issued by government organizations tasked with this role. Specifically the MOU signed between NASA and the Federal Aviation Administration Office of Commercial Space Transportation (FAA-AST) in June 2012 took the first step in clarifying the role to be played by NASA as the customer and FAA as the U.S. Government agency with jurisdiction to regulate the industry. If this coordination and joint effort is maintained with industry input then it is likely that government regulation will be able to promote the safe development of this industry sector in the United States and by extension the rest of the world. This specific area focusses on the government policy with regard to regulation. It should be noted that throughout this sector government involvement is pervasive and thus the policy and acquisition decisions of the government, particularly the U.S. Government, has the possibility to impact barriers of entry across a broad spectrum of forces. This conclusion is not meant to imply the government's involvement is low, to the contrary it is meant to show that the U.S. Government is working to resolve conflicts and uncertainty which would cause a high barrier for current and future players.

Expected Retaliation

There are many different factors that influence the degree to which incumbent firms will retaliate against new entrants. The current incumbent, the Russian Soyuz has little recourse to retaliate with the emerging capabilities in the United States beyond continuing to perform and deliver improved throughput capability for flights. Based on the stiff level of competition among competing firms in the U.S. for the current NASA funding, it is expected that any new entrants in the future will face strong opposition. This retaliation will be enhanced if sufficient additional demand does not materialize.

Furthermore, it is expected that future entrants would likely require government funding assistance or at least government backed loans. Such government assistance is likely to be fought tenaciously by the incumbent firms through the legislative process. Such activities will serve to protect what market share they are able to get and are not dissimilar to those seeking to prevent the emergence of this sector itself. It is for these reasons that **expected retaliation is a highly variable but generally moderate force serving as a barrier to entry.**

Threat of New Entrants Summary

In summary, **barriers of entry are found to be relatively high for new entrants.** This is potentially variable because new entrants may have certain advantages due to their ability to enter a more certain market segment. That being said the following barriers are likely to keep new entrants from posing a significant threat to whomever of the current developers is able to deliver the service of transporting crew to orbit with a high level of safety and at a low total cost.

Economies of scale are found to be a high barrier due to the advantages gained from cross business functions and vertical integration. Product differentiation is found to be a moderate barrier to entry primarily due to the early entrant advantage. Capital requirements, absent institutional assistance, are incredibly high and thus present a very high barrier of entry to potential entrants. This barrier is sufficient to prevent most new competitors from attempting to enter this sector. Switching costs are highly variable and are likely to be kept low as long as government customers are anchor tenants due to the nature of standardized requirements. Access to distribution channels is found to be a moderate to high barrier of entry, particularly for accessing private individuals as customers and even more so if government acquisition is done by long term agreement. Cost disadvantage independent of scale is found to be moderate to high mainly because of the influence of existing subsidy and the expected lack of such government assistance for future entrants in the United States. This may not hold for other countries, but in the absence of verbal interest this can be discounted in the near term. Government policy is found to be a low barrier of entry primarily due to the recent cooperation in regulatory and customer groups. The final barrier evaluated here, expected retaliation, is found to be moderate mainly due to the current lack of demand and the evidence of intense competition amongst current developers.

Intensity of Rivalry Among Existing Competitors

As outlined previously, the existing competitors for the sake of this analysis will include the established capability in the Soyuz as well as recent entrants who are publicly developing hardware either under agreements with investors or government partners.

Size and Relative Strength of Competitors

Strength of competition is currently driven by those competitors able to secure financial support for research

and development efforts. These funds from programs such as NASA's Commercial Crew Development (CCDev) and Commercial Crew Integrated Capability Program (CCiCap) are providing a differentiator that will allow certain competitors to develop and deliver capabilities more quickly. The lack of strength these recent entrants have in comparison to the established strength and size of the Russian Soyuz is normalized dramatically due to domestic politics and a need for redundancy. The ability to continue development for aspiring entrants who either did not apply for or did not receive awards during the CCiCap program has yet to be definitively demonstrated.

Looking at the recent CCiCap funded participants SpaceX, Boeing, and SNC there is a large variation in both size and relative strength. Additionally there are alternate programs upon which the competitors for commercial crew contracts are cooperating as partners. **This disparity and interdependence balance to result in a moderate force driving competition**. This is reinforced as moderate due to the likelihood that future funding rounds will support less entities than the current program does.

Although generally foreign competition can be considered as equally competitive in a generic industry structural analysis, in this case the drive to develop domestic capability renders foreign competition at a significant disadvantage.

Rate of Industry Growth

The rate of industry growth is extremely uncertain and its uncertainty itself leads to a **moderate to high force driving competition between firms.** With a more robust growth in demand, the decisions and awards from the U.S. Government would not be as critical. If demand is able to show modest growth beyond the U.S. Government demand then those competitors currently in developmental stages have a chance to survive. More robust future growth will reduce competition and may also reduce the financial business risk of entering the industry sector.

High Fixed Costs

Fixed costs for this sector are a moderate driver of competition. The cost of infrastructure and organizational maintenance are extensive in the CCOT industry segment due to the generally low flight rates and the requirement for a highly trained and reliable workforce. When comparing the high fixed cost of these assets with the high value added, they are expected to result in a moderate driver of competition. In the context of these fixed costs relative to total costs it would likely be more significant.

Using subcontractors during development is an example of how competitors may reduce the long term fixed cost of having a large workforce. Additional savings can be derived if opportunities to leverage dual-use infrastructure can be successfully accomplished. Other opportunities exist to lower this fixed cost if any part of the integrated crew system can be re-used or used to serve another need. Examples include the use of the crew transfer vehicle for other missions (un-crewed) or the use of launch vehicles for other missions such as delivering satellites or other vehicles to orbit. In these two examples the high fixed cost of operating infrastructure is covered by multiple activities and thus enables more economical operations for the competitor.

Any sort of re-usability provides a similar advantage. A competitor able to reduce these fixed costs will have a significant competitive advantage and will benefit from an effective reduction in competitive forces.

Differentiation and Switching Costs

The ability to differentiate products allows for competition on attributes beyond price. In the cases where vehicle designs and capabilities are unique or superior, such differentiation distorts competition and may provide competitive advantages. Specific examples of these differentiating factors include: land versus ocean landing; capsule versus lifting body; expendable versus re-usable launch vehicle; and solid motors versus liquid motors, among others.

Switching costs are likely to remain low due to the standardization required for servicing government customers. **The combination of potentially high differentiation and likely low switching cost results in a moderate lack of differentiation or switching costs which results is a moderate force driving competition within existing competitors**.

Diverse Competitors

The primary entities involved with this sector have very different goals and objectives. This variation of intent between the competitors in this industry segment has the potential to increase or decrease rivalry. On one hand the industry segment stands together and requires the success, or absence of failure, of others to preserve confidence in the overall segment. For this reason there must be some coordination on safety. Additionally there are interests which would prefer this industry di not exist, in this case again the industry must cooperate for its own survival. On the other hand, the variation in motive and business approach can increase rivalry as competing firms may perceive business objectives and tactics differently. Further compounding the diversity of competition are the personalities of those leading each

competitor. **These variations in personality as well as the variations across the sector result in a moderate force driving competition.** As with previous sub-forces, this force currently tends to balance out.

High Strategic Stakes

As with the diversity of competitors, the strategic value of the commercial crew to orbit sector is difficult to consistently identify. It is clear that some competitors see this as purely an intelligent business decisions while others view it as a core reason for their corporate venture. Due to the variability of this intent which can lead to instability in the market, **the strategic importance of the CCOT industry segment is considered moderate in driving competition.**

High Exit Barriers

The current lack of competing capabilities within this sector results in a difficult evaluation of exit barriers. In past evaluations these exit barriers were evaluated from the mind-set of operating entities. Those currently entering the market and developing vehicles however are in a unique situation. The high rate of government subsidy results in a moderately high exit barrier for individual competitors. This is mostly a result of the ability for competitors to reallocate the highly trained workforce and specialized equipment upon need to depart this sector. While some competitors may maintain a position even at a loss due to the prestige and personal belief in such a capability, the general sense is that business forces will strive to maintain at least economic parity during operations and thus will not permit long-term losses from the operations of a CCOT industry segment competitor.

While exit barriers are expected to be of moderate strength individually, once developed it is expected that exit barriers will be extremely high for last competitor due to overall importance of the capability in terms of national policy and industry viability. This barrier is likely so high that government and/or commercial customers would likely prevent exit for the final company by any means necessary.

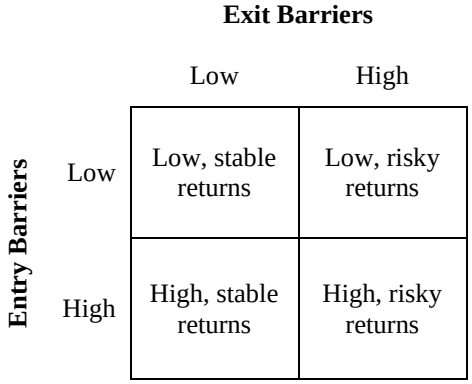

Figure 3. Barriers and Profitability. Replicated from Michael Porter's Competitive Strategy (pg 22).

Overall the level of competition within existing and currently entering competitors is expected to be moderate to high. Further evaluating the entry and exit barriers, it is expected that given modest demand growth beyond the U.S. Government civil space program, **the entry barriers should be sufficiently high and the exit barriers sufficiently moderate to have high and moderately stable returns.** This is a good place for the industry segment to be, however it is predicated on demand growth from other customers beyond NASA. This projection is uncertain and thus a complete analysis here is not possible.

Pressure from Substitute Products

As defined by Porter, substitute products represent the third force driving competition within an industry. A substitute product is further defined here as any product or service that can replicate the function or replace the need for an industry's product. In the case of the CCOT industry segment this would be another product that can deliver crew to orbit or another way of satisfying the need without going to orbit.

The only credible threat of a replacement capability to get to LEO would be a government developed capability. This substitute would only satisfy as such if the nominal evaluation metric of cost was not properly or appropriately accounted. It is not possible for the government to furnish a system to access LEO with crew at a price lower than any individual private company can. Private investment and cost advantages due to design control primarily drive this reality. For this reason the threat from a government furnished capability is only realistic if the metrics upon which it is chosen are skewed by other factors beyond cost, schedule, and safety.

Due to recent actions and the realities of uncertain or reduced funding within other segments, this possible pressure from a substitute product is

considered a moderate force contributing to competition.

The ability to truly replace the need for transporting humans to space is not expected within the context of this evaluation and thus is not considered to contribute to the competitive landscape within the Commercial Crew Orbital Transportation segment.

Bargaining Power of Buyers

Buyers in a traditional industry are a critical component driving competition. The relative strength and position of buyers directly dictates the power they have to drive competition amongst industry players. In the case of the CCOT industry segment, buyers can be classified into two generic categories. The first of these categories is the U.S. Government through NASA which has a direct need for the services of this sector and is currently providing funds to accelerate its development. The second category is commercial demand from individuals, corporations, or nation states. This need is less well known and this category of customers is not actively supporting the development of the industry segment.

Splitting the buyer categories is important because the strength of each may vary widely. As the second category grows with additional customers, the power of NASA as a buyer will be incrementally reduced and may eventually become low as the volume bought by NASA relative to industry sales may quickly become small. Currently there is limited additional demand because the capability does not yet exist. It is this uncertainty which fundamentally drives the high level of business risk in this sector. Government in this case is buying down this business risk to meet its mission objective for a reduced cost. This cost will be further reduced as additional customers are brought online.

The bargaining position of a buyer can be defined by three broad factors: the volume bought relative to total industry sales, product standardization, and threat of backward integration.

In terms of the first of these factors, NASA currently represents a large volume of purchases relative to the sectors potential sales. Without a true representation of alternate demand, NASA has a high or strong bargaining power both as a buyer but also as a subsidizing entity during the development phase for competitors. The only influence reducing this power is the terms of the individual SAA's which do not require ultimate delivery of a system by the commercial providers. Since it hasn't yet materialized, other commercial customers have a very low or weak bargaining position.

With regard to standardization of products, it is fully expected that providers will follow commonly accepted industry standards with regard to interfacing and operating. This standardization will result in a strong bargaining position for all buyers due to their ability to easily play competitors against each other.

The final factor selected for consideration of buyer bargain position is whether the buyer poses a credible threat of backward integration. This threat generally represents the buyer creating the capability in-house as an alternative to buying from the industry segment. As was outlined in the substitute product section, in terms of NASA as a buyer this is emerging as a credible threat and thus provides again a high or strong bargaining position for NASA. Contrary to this, no other customer truly possesses a credible threat to backward integration and therefore has a low to moderate position in these terms.

To summarize, **NASA possesses a significant amount of bargaining power and this is expected to result in a high contribution to competition within the industry, particularly the U.S. domestic industry.** That being said, **all other customers have a moderate to low contribution to competition through a relatively weak bargaining power.**

Bargaining Power of Suppliers

The fifth and final force identified by Porter as being a driver for competition within an industry is that of the suppliers. With respect to the CCOT industry segment, suppliers may include launch vehicles, life support sub-systems, crew training, operations support, or other components. There are two primary ways that CCOT industry competitors are able to reduce the bargaining power of suppliers. The first of these is vertical integration which reduces or eliminates suppliers. This has the advantage of providing control to cost and schedule but is at the expense of carrying very large overhead for manufacturing facilities and personnel. The second way to mitigate the bargaining power of suppliers is to have the ability to utilize more than one. Being supplier agnostic reduces the specific influence any one supplier can have on the system development or recurring costs.

Predominantly it is advisable for industry competitors to have mutually beneficial relationships with suppliers just as it is preferable for them to have mutually beneficial relationships with buyers. The degree to which suppliers are able to obtain bargaining power can be broadly dictated by several factors including the concentration relative to the industry, if the industry is an emerging customer, if the product is important to the industry, and if there is a credible threat of forward integration.

In a case where the supplier is concentrated relative to the industry it is serving, it can leverage the lack of alternate options to its benefit. In the CCOT industry segment this is often the case, but its influence is

mitigated by the large benefit to suppliers of this customer for most suppliers. As an example, launch vehicles are critical to the industry and suppliers of certified systems are in short supply. This would lend itself to a strong position for the suppliers until the incremental benefit to the supplier of each launch is considered. Thus **concentration relative to the industry is considered a moderate to low contributor to the position of suppliers.**

This counterbalance to the concentrated position is further leveraged by the CCOT industry sector in terms of the potential value purchases would represent to suppliers in the future. For most suppliers to this industry segment the potential rate of flight and system purchase would represent a large amount of business. For this reason the suppliers will seek generous terms in order to retain business in the future. This is a low contributor to the bargaining power of the suppliers.

The relative importance of what the supplier is delivering has a strong impact on the power with which the supplier is able to bargain. In terms of certain subsystems for the CCOT industry, the product is absolutely critical. To return to the launch vehicle examples, the system to deliver crew to orbit is useless without a rocket to accelerate it into space. This example can be extrapolated to various other suppliers and **this importance results in a moderate to high contributor to the bargaining position of suppliers.**

As with buyers, a final factor guiding the bargaining power of suppliers is the credibility they present of forward integration. For the case of almost all suppliers to CCOT industry segment **there is very little credibility in forward integration resulting a low contribution to the bargaining position of suppliers.**

In summary, **the bargaining power of suppliers is generally low due to the standardization, threat of vertical integration, and importance this segment represents for most suppliers.**

IV. INDUSTRY INSIGHT THROUGH STRUCTURAL CHARACTERISTICS

Industry Opportunities and Threats

Reviewing the structural analysis of the CCOT industry segment provides an opportunity to identify certain key opportunities and threats. These are in many cases generic and are intended to spark on-going dialogue. As was outlined in the introduction, this analysis can be further developed for competitor specific strategy formulation which will not be done here due to the proprietary nature of such evaluations.

Infrastructure

As seen through the large impact of fixed costs, this industry segment requires extensive infrastructure. Reusability and high flight rates can help alleviate such costs. The extent to which further public-private partnership can be established for utilizing existing capabilities will dictate much about where operations are located and the competitiveness of the industry players involved. Intelligent and common-sense approaches should be used when dealing with facilities that the government no longer needs and must pay to maintain or remove. If it is possible for a commercial provider to update and utilize these facilities, all effort should be expanded to make this happen. Beyond taking over infrastructure it would also present a broad benefit if private entities were able to invest in the improvement of infrastructure such as the infrastructure at launch ranges. Investments such as these by commercial partners could enable modernization at a reduced cost to the government and with immediate return on investment to the commercial entity.

Regulatory Approval

Regulatory uncertainty is a significant threat to industry development and has the potential to drive intense competition. As was highlighted previously, continuation of dialogue and coordination between the FAA as regulator and NASA as customer are very important. Future regulatory support is also likely to be required in the realm of on-orbit traffic coordination. Evaluating the likelihood of collision between space objects is a challenge and infrastructure intensive activity. It is also an activity that requires thorough communication and partnership between military, civil, and commercial entities. Based on these factors a civil organization is likely preferable to lead in these efforts. Such coordination would do much to increase the safety of orbital operations and minimize the risk of catastrophic on-orbit collisions.

Innovation, Information and Safety

A further word on safety is appropriate given the high technology nature of this industry sector. Human spaceflight has been in development for over fifty years. Throughout this time, predominantly government programs have made large strides in technological understanding. It is through these studies and the development work of national space programs that the current fleet of CCOT vehicles have emerged.

Recognizing this heritage and institution knowledge the exchange of information and the fostering of innovation by NASA has been noteworthy. Through Technical Interchange Meetings (TIMs) and other

coordinated efforts, topic experts from NASA are able to provide technical input to commercial partners.[11] This information sharing partnership extends beyond face-to-face technical interchanges to access to technical documentation on NASA systems. Data and lessons learned from government run development for Shuttle and Orion programs have been utilized to reduce risk and develop safe commercial systems.[12]

A final example of how NASA is able to partner with commercial crew companies is through Space Act Agreements that companies have signed with NASA centers to directly employ government experts to solve and address critical problems through the development cycle of the commercial vehicles. It is through partnerships such as these that commercial providers are able to gain access to the best and brightest and thus develop safer and more robust systems.

Distribution Paths

A final observation from this analysis is the importance of distribution channels for CCOT industry segment competitors. It has been identified throughout this paper that the industry requires additional demand beyond NASA in order to deliver on the cost and business justifications which led to its creation. Access to these other customers will be a critical differentiator for providers. Tapping into existing networks to market and distribute individual tickets to space is critical and such activities are rarely a core competency of a spaceflight operations company.

Service contracts for early private on-orbit destinations could make a dramatic difference for an operator. An anchor tenant such as this could go far to close the business case. To develop these opportunities on orbit for industrial use, companies will benefit from partnerships with research organizations that can create a throughput of valuable scientific experiments or industrial research and development.

These distribution paths will represent one of the primary strategic factors to sector strength for competitors. Taking safe operations as a given, without which there will be no segment, then access to distribution paths for seats or vehicles will be the single biggest driver of success for CCOT industry segment competitors. Having access to the customers and the ability to provide sufficient availability, at a competitive price with exceptional safety standards, will be the recipe for success in this sector.

[11] NASA's Return on Investment Report, Issue 5, February 2012 [http://www.nasa.gov/exploration/commercial/document_library.html]

[12] NASA's Return on Investment Report, Issue 6, April 2012

V. CONCLUSIONS/FUTURE WORK

Current Industry Structure

Outlined in section 4 above are samples of the conclusions that can be drawn from reviewing an industry structural analysis for the commercial crew orbital transportation industry segment. These core observations focus on infrastructure, regulation, technical communication, and access to distribution channels.

The industry forces and their evolution over the past three years will be explored in the figures to follow, but overall this analysis has shown that the threat of new entrants is low due to high barriers of entry, there is moderate intensity of rivalry among competitors, high bargaining power for NASA as a customer but low bargaining power for other buyers, and suppliers in general have a low bargaining power. Overall the industry is positioning itself well and as uncertainties settle out on the supply side the demand side will need to materialize.

Industry Evolution

The following figures review the evolution of specific factors and general forces covering the analysis done in 2010,[13] 2011,[14] and this report.

Barriers to Entry	2010	2011	2012
Scale	H	H	H
Differentiation	L	L	M
Capital Reqs	H	H	H
Switching Costs	H	L-H	L-H
Distribution	L	M	M-H
Cost Disadvantages	L-H	M	M-H
Gov. Policy	M	L	L
Exp. Retaliation	-	L	M

Rivalry	2010	2011	2012
Size & Strength	-	L-M	M
Rate of Growth	H	M-H	M-H
Fixed Costs	H	M	M
Diversity	M	M-H	M

[13] Cheetham, B.W., "Industry Structural Analysis of Commercial Crew to Orbit Sector," IAC-10-E6.3.1, 61st International Astronautical Congress, Prague, Czech Republic, September 27 – October 1, 2010.

[14] Cheetham, B.W., "Strategic Evaluation of Commercial Crew to Orbit Transportation Industry Structure and Status," IAC-11-D4.2.1, 62nd International Astronautical Congress, Cape Town, South Africa, October 3-7, 2011.

Strategic Stakes	M-H	M-H	M
Exit Barriers	H	H	M

Forces	**2010**	**2011**	**2012**
Threat of Entry	L	L	L
Rivalry	H	M	M-H
Substitute	L	L	M
Buyers – NASA	H	M-H	H
Buyers - Other			L
Suppliers	H	M	L

Nature of Analysis and Future Work

This paper represents the third paper covering this topic and is intended to build on the previous publications based on changing dynamics within the industry segment itself. As the segment continues to evolve and progress further revisions are expected. This paper represents a single perspective on the industry structure. Further discussion and work is the preferred product of this effort. As theoretical implementations of industry structure can be used to compliment data-based analyses then decision-makers and industry competitors can best plan, prosper, and react to industry evolution.

VI. ACKNOWLEDGEMENTS

I would like to thank Ken Davidian of the FAA Office of Commercial Space Transportation who has promoted the application of academically rigorous theories and frameworks, including Porter's Industry Structural Analysis, as a way to encourage, facilitate, and promote the emerging commercial space industry.

I would also like to thank Dr. George Born, Director of the Colorado Center for Astrodynamics Research, for his support of these research activities.

Although the FAA has sponsored this project, it neither endorses nor rejects the findings of this research. The presentation of this information is in the interest of invoking technical community comment on the results and conclusions of the research.