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Identifying Space Industrial Base Issues

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This paper characterizes the unique business environment of the space industry and presents methodologies for identifying potential threats to acquisition program success within the U.S. space industrial base. The U.S. space industrial base consists of systems integrators, subsystem suppliers, and component manufacturers who support the development and construction of space systems. Because of the essential contributions space suppliers make to acquisition program success, identifying problems within the U.S. space industrial base is critical. Given the unique nature of the space industry—often characterized by niche markets, complex products, and low-volume demand—separating the characteristics of the space industry from true industrial base concerns can be challenging. Therefore, The Aerospace Corporation has developed a set of methodologies to identify when an actual industrial base concern exists. Many observers often misidentify common characteristics of the space industry as industrial base concerns. Issues such as a sole-supplier, limited commercial investment, or pressure from foreign competitors do not necessarily pose an industrial base problem, per se. However, when a firm faces a combination of these issues, and exhibits signs of financial difficulty or diminishing market influence, then the existence of an industrial base concern becomes likely. This paper will examine the unique economic characteristics of the space industry, and present key criteria that can be used to identify problems within the U.S. space industrial base. This discussion will enable the reader to better identify industrial base concerns, and ultimately place the issue within a broader economic perspective.

I. Introduction

THIS paper focuses on the U.S. space industrial base, specifically the collection of U.S. companies throughout the supply chain that provide space products and services to commercial industry and the U.S. Government. This industrial base is evaluated and analyzed to determine if contractors will be capable of delivering necessary products or services within U.S. Government requirements, and to ensure that U.S. capabilities in space remain competitive with or well ahead of other nations'.

In 2007, the U.S. Government spent approximately $600 billion on national defense; of this amount, nearly 5% (roughly $25 billion) was spent on military space.[3,4] Although representing only one-twentieth of total U.S. defense expenditures, U.S. military space spending was nevertheless several times larger than that of all other nations combined. Despite this funding disparity, some in the space industry believe that the U.S. is falling behind its international competitors, has lost its position as a leader in space, and that the overall health of the U.S. space industrial base is in decline.

In the 1960s and 1970s, the U.S. space program led the drive for innovation in numerous fields, including medicine, materials science, and computers, due in part to the substantial technological demands of the Apollo missions. Since then, the space industry has increasingly lagged behind non-space industries in innovation. Given a choice between space and non-space business, many companies have moved resources away from developing space products and into the larger and more profitable market of consumer goods and services.

As a result of the decrease in attractiveness of space opportunities, waves of consolidation have reduced the number of U.S. prime contractors over the past two decades. In addition, as prime contractors focus on more

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profitable integration and information technology work, they have shed less profitable component-manufacturing businesses, which has helped create a stratification of contractors into "tiers." Prime contractors like Boeing, Lockheed Martin, and Northrop Grumman make up the first tier. The second tier consists of subcontractors like Honeywell, Ball Aerospace, and ITT Industries, which produce major subsystems that are then delivered to and integrated by first tier contractors. The third tier is generally the least profitable of the top three tiers, and typically consists of specialty component manufacturers, such as Symmetricom, JDS Uniphase, and Vectron. Most industrial base concerns occur at and below the third tier contractor levels. These contractors face significant business challenges – including a highly cyclical and low-demand business climate – and often have the fewest resources available to address them. The health of these third tier suppliers is a major industrial base concern, as the majority of the technical knowledge and process skills for key space technologies resides at this level.

Complicating the situation, some U.S. policies (e.g., export controls) have placed some U.S. space companies at a competitive disadvantage vis-à-vis their international rivals, restricting the potential customer base for U.S. space products. With already fewer U.S. companies interested in producing parts for space systems, and the market for such parts becoming ever more limited, some U.S. policies have provided U.S. producers with even less incentive for maintaining their space product lines, as well as given rise to an indigenous space industrial base in Europe and Asia.

II. Common Misconceptions about the U.S. Space Industrial Base

Many observers often misidentify common characteristics of the space industry as industrial base concerns. Issues such as a sole-supplier, limited commercial investment, or pressure from foreign competitors are frequently brought to the attention of the Economic and Market Analysis Center for further investigation. However, while some of these issues may be cause for concern, many of these issues are simply characteristics of the space industry, and reflective of market conditions.

A. Having only one supplier is bad

One oft-cited industrial base issue is the existence of a single supplier for a particular space product. Instinctively, this causes concerns that should the supplier decide to exit the business, the Government will be without any supply whatsoever. In addition, maintaining only a single supplier is often seen as a "monopoly" situation, where alternative products may not exist, the lack of substitutes could enable the suppliers to dictate the price of the product, and a supplier will no longer feel competitive pressures to be responsive or innovative.[5]

Frequently, the U.S. Government has responded to sole-supplier situations by calling for—and often funding—a second supplier, with the intention of reducing risk to Government programs. This course of action results in greater aggregate cost to the U.S. Government. While the exit of a sole-supplier from a market could indeed have serious consequences for a space program relying on its products exclusively, introducing a second supplier into an already small market only serves to offer even less incentive for the original supplier to continue production. In addition, new suppliers commonly struggle with quality and manufacturing issues, as they lack the heritage and experience that the original supplier has built up over many years of operation. Furthermore, should the established supplier eventually choose to exit the market, it will take with it key product and process knowledge and, unfortunately, leave the Government in yet another sole-supplier situation.

In many cases, especially for space businesses characterized by low volume and unique products, having only one supplier is not necessarily a problem; one healthy supplier is a far better scenario than two to three weak suppliers for the U.S. industrial base and U.S. Government space program acquisition success. However, as is the case with all industrial base analyses, other attributes and financial metrics need to be examined to place the issue of a single supplier in the proper context.

B. Reliance on a foreign supplier is bad

The U.S. Government's general preference toward buying products and services from domestic providers is deep-seated. This preference results from a number of motivations, including the U.S. Government's commitment to foster domestic industry, as well as being risk adverse toward reliance on a foreign supplier. Some in the U.S. Government have noted that a lack of access into foreign supplier operations can limit visibility typically available from domestic providers.

Given the interconnectedness of the world economy today, as well as the diverse set of materials and products required for space systems, it is extremely difficult – if not impossible – for the U.S. Government to rely entirely on

[5] Wikipedia. Monopoly. http://en.wikipedia.org/wiki/Monopoly. 7/19/2007.

domestic suppliers at every level of the supply chain. Additionally, there is often only enough global demand for a given space product to warrant a single supplier, and that supplier may be located in the U.S. or abroad.

Although the dynamics of the world marketplace no longer favors a U.S.-only space industry, industrial base issues related to foreign suppliers still need to be evaluated on a case-by-case basis. A number of instances exist where key space products are now manufactured mainly overseas; for example, semiconductors and solar cell substrates are largely produced in Taiwan and Belgium, respectively. While a Belgian substrates supplier may not pose a problem, the U.S. may be concerned about China's influence over a Taiwanese semiconductor manufacturer.

C. Competition is the answer

Competition is often cited as an industrial base issue – either too much of it, or not enough. While most economists believe strongly in the power of perfectly competitive markets to reduce cost and drive innovation, this depends upon a number of conditions, including:[6]

1) Homogeneity: the goods and services produced by the various market players must be perfect substitutes; in other words, Supplier A and Supplier B must be selling identical products
2) Perfect and complete information: all suppliers and consumers must know the prices set by all other firms; in other words, total transparency of pricing
3) No barriers to entry or exit: anyone may choose to become a supplier, or any supplier may exit the market, at zero cost

These conditions are rarely present in any form in the space industry. Space products are rarely interchangeable and typically unique; often, this uniqueness stems from a competitive advantage such as an exclusive supply contract, or a patented or secret production process. This "secret sauce" that helps to determine a space supplier's success also acts as a barrier to entry to ward off further competition.

Most importantly, many space suppliers (especially those in the third or fourth tiers) serve small, cyclical, and slow-growth markets, which results in a single supplier for some space products. However, many types of monopolies exist, and it is important to draw distinctions between them. Coercive monopolies, which often result from government grants of exclusive privileges, are generally undesirable. On the other hand, one may consider individual space component markets, when served by single suppliers, to be natural monopolies – only one supplier exists because the market it serves is too small or otherwise not appealing enough to draw in additional players. These types of monopolies should be respected, as they occur as natural consequences of supply and demand.

D. High prices translate into large profits

Major national security space satellite contracts are typically structured as multiyear, multibillion dollar development contracts. However, despite the large contract values associated with major space systems, the contractors' space divisions executing these contracts are often a drag on prime contractor profitability levels. For example, when Boeing, Lockheed Martin, and Northrop Grumman reported full-year 2006 earnings, each company's respective space division underperformed the average division operating margin; in the case of Boeing, its Network and Space Systems division reported the *lowest* operating margins of any of the company's four business units.

These low operating profit margins filter down throughout the supply chain, as prime contractors attempt to keep as much profit as possible while flowing down 60-70% of typical contract value to lower tier suppliers.[7] Prime contractors, in fact, have very little choice: Wall Street expects certain levels of earnings from these contractors, and anything less would result in shareholder dissatisfaction, potentially affecting share price. Certainly, though, there are some companies that have discovered ways to satisfy both shareholders and suppliers; for example, in addition to being the world's most profitable manufacturing company, Toyota is also famous for its exceptional supplier relations.

E. Space parts are a *commodity*

Commodities, by definition, are items of value possessing uniform quality such that they can be supplied in large quantities by numerous producers.[8] According to economic theory, if these products are supplied in a competitive market, they will be offered to consumers at the lowest possible price with respect to the suppliers' production costs. In these circumstances, it is impossible for a supplier to generate abnormally large profits.

[6] Wikipedia. Perfect Competition. http://en.wikipedia.org/wiki/Perfect_competition. 7/19/2007.
[7] The Aerospace Institute. Smarter Buyer Course. 2007.
[8] Wikipedia. Commodity. http://en.wikipedia.org/wiki/Commodity. 7/19/2007.

While parts for space systems are clearly highly complex, unique, low-volume products, many lower-tier suppliers have stated that the U.S. Government has unfortunately developed a reputation for purchasing space parts like commodities. Aside from the slim profit margins of space suppliers, persistent U.S. Government concerns over a lack of competition (or alternative suppliers) can often introduce additional problems. Sometimes, concerns arise that a second supplier of a given space product is necessary should the original supplier experience meaningful and unexpected production disruptions.

While these concerns are not entirely unfounded, it is important to realistically evaluate the costs and benefits of introducing additional suppliers to a given market. Space parts are not commodities. Many of the companies that supply them – especially third tier suppliers – have developed specialized production techniques over decades of years that cannot be easily replicated. Such suppliers are sometimes the only companies in the world with the necessary facilities, personnel, and knowledge to successfully manufacture certain space parts. In a free, competitive market, these suppliers would be paid a premium for their specialization, not face intense pricing pressure as though a substitute product could be easily manufactured by other firms.

III. Analyzing the U.S. Space Industrial Base

Since the above mentioned issues do not always signal or dismiss an industrial base issue, how does one identify when an actual issue does exist? The Aerospace Corporation's Economic and Market Analysis Center provides economic insight into the issue by examining various financial metrics, as well as technical and other characteristics of the business and the market in which it participates; only after assessing this collection of attributes in context can a potential industrial base issue be identified. Nine such attributes are identified and described in this paper.

A. Financial Metrics

Financial measurements are critical when analyzing the health and viability of a company or business unit. Naturally, revenue and profit (either operating profit or net income) are important metrics, and a healthy company should report growth in both areas. In addition, dividing operating income by revenue yields operating margin. For a healthy space supplier, this number should be 8% or greater, considering that risk-free U.S. Government bonds offer more than a 5% return. Note that operating margins can vary widely across industries; General Electric, for example, reported operating margin for the most recent twelve months of 15.11%, while Google reported an astounding 33.62%.[9,10]

In addition, revenue per employee (sales divided by number of employees) is an important measure of a supplier's productivity, and a healthy space supplier may report a number of $200,000 or greater. Growth in this measurement is indication that the company is able to "do more with less," although it must also be considered whether the company is putting excessive pressure on its workforce. As a comparison to other industries, General Electric reported revenue per employee for the last twelve months of $511,000, while United Airlines reported $350,000.[11,12]

Finally, research and development (R&D) expenditures as a percentage of revenue are an important indication that a company is investing in its future growth. In this measurement, space industry suppliers fare abysmally, often investing less than 3% of their revenue into R&D. This level of R&D funding is especially worrisome considering most of the funding goes toward reducing risk or increasing competitiveness on near-term opportunities rather then investing in advanced technologies with long-term rewards. With cutting-edge technology companies like Microsoft investing 15% of revenue into R&D, or Intel, at nearly 17%, there are clearly opportunities for technical breakthroughs at space suppliers if only the dollars were available.[13,14]

B. Market Share

The percentage of a given space market that a company supplies is a key indicator of the health of its business. A declining or expanding market share can signal a failing or improving business outlook, respectively.

[9] General Electric. SEC Form 10-K. 2007.
[10] Google. SEC Form 10-K. 2007.
[11] General Electric. SEC Form 10-K. 2007.
[12] United Airlines. SEC Form 10-K. 2007.
[13] Microsoft. SEC Form 10-K. 2006
[14] Intel. SEC Form 10-K. 2007.

C. Government vs. Commercial Customers

The breakdown between government and commercial business, and space and non-space products, can indicate where the company may devote research, development, and production resources. Although some companies enjoy being niche government suppliers, many companies focus on addressing the largest and most profitable market for their products. In many cases, this is the commercial market, and typically, commercial customers have very different requirements than government customers. Those companies that do identify more lucrative opportunities in commercial markets are apt to pursue this business at the cost of foregoing government business, therefore increasing the U.S. Government's risk of losing a key supplier.

D. Market Cyclicality

A major obstacle for the space industrial base, especially suppliers at and below the third tier, is the cyclicality of the space market. When a large space contract is awarded, a supplier must invest in capital, hire new employees, and improve its internal processes. These are costly activities. On the contrary, if a consistent level of business is not maintained, then equipment must be sold and employees laid off; this too is expensive. When a company cannot survive the trough in its business cycle, it is often forced to exit the business, taking with it years of product and process knowledge. Some factors could mitigate these effects, however: if the company has an expansive product line, it may be able to shift resources into other areas on a temporary basis.

E. Demand

With more units demanded and supplied comes production improvements as well as economies of scale. Low unit volumes of a product are often a sign of a potential industrial base issue. Without sufficient production throughput, it may be difficult for a company to justify continued operations.

F. Parent Company

In many instances, the producers of key space technologies are subsidiaries of or business units within larger parent companies. While operating within a parent company sometimes offers businesses the ability to draw on additional capital and expertise, it also exposes the business to corporate-wide impacts. When a parent company loses interest in a business unit—whether due to poor performance, realignment of the corporate portfolio, or a change in the strategic direction of the company—it could choose to reduce the unit or divest the unit altogether. Careful attention must be paid to the goals and strategies of corporations with space business subsidiaries, and to how those subsidiaries are viewed within the organization.

G. Commercial Technology

Assessing the relationship between space technology and commercial (or non-space) applications can help identify industrial base issues. If a space technology has lucrative applicability in a terrestrial or commercial market, then most likely this demand will dwarf any opportunities in space, causing the supplier to shift research, development, and production resources toward this business. On the other hand, if a terrestrial or off-the-shelf commercial technology can serve as a substitute for space technology, there may be opportunities for cost savings within a given space program.

H. Supply Chain

In addition to examining a particular company for industrial base issues, it is often necessary to expand the analysis to its supply chain. A fragile supply chain is often the culprit in production or quality problems at higher levels. Supply chain issues may include a supplier delivering a poor quality component, or the unavailability of raw materials. Analyzing the supply chain can not only highlight existing industrial base issues, but also identify areas for risk management.

I. Production

Industrial base issues often emerge from an inability to produce (and reproduce) specialized space components. Many space technologies, such as semiconductors, atomic clocks, solar cells, and gyroscopes, rely on "black arts", in which the science behind the technologies is well understood, but the processes involved with producing consistently high quality components are very difficult to master, and can only be perfected through years of experience. These processes often require a highly skilled workforce, which, when lacking, can severely impact production, quality, and throughput.

Another potential industrial base issue exists when a business has difficulty repeating the production of identical space components. In these cases, it is possible that a supplier has "lost the formula" to produce a particular

component, due often to cyclical attrition or retirement of key personnel. Situations such as these can often result in months or years and millions of dollars of research to recover.

IV. Conclusion

While the U.S. space industry certainly faces challenges, it nevertheless benefits from having the most technologically advanced, developed, capable, and well funded industrial base in the world. However, even though the U.S. spends significantly more in space than any other country, this does not make the U.S. immune from space industrial base concerns. Therefore, discerning between legitimate and perceived risks with the space industrial base, and then being able to mitigate them, is critical to maintaining key space capabilities.

Distinguishing between the legitimate and perceived issues with the industrial base is often very difficult, since the nature of the space industry can lead to misconceptions about what constitutes an actual industrial base issue. This paper discussed several characteristics of the space industry that are frequently misidentified as signs that an industrial base issue exists. By understanding that such characteristics are simply attributes of the space industry and do not necessarily warrant concern, one can then utilize the collection of financial, technical, and market metrics discussed in this paper to correctly identify legitimate industrial base issues.

Using these tools, The Aerospace Corporation's Economic and Market Analysis Center helps various U.S. Government customers assess potential industrial base issues, narrow these issues down to a limited number of at-risk capabilities, and therefore maximize the ability of the U.S. Government to address and mitigate these legitimate industrial base issues.