

## **Commercial Avenues for Space Utilization** **Mary Lynne Dittmar, Ph.D.**

### **Abstract**

Interest in the commercial development and utilization of Low Earth Orbit (LEO) has increased significantly over the past ten years with the advent of relatively advanced technologies including telecommunication and satellite applications as well as high-resolution sensor development for topographical surveys, environmental impact studies and community planning. Access to space remains a challenge; both in the high cost to orbit and in the dearth of commercially-viable transport mechanisms which can fully address the varying analytical and physical integration needs of a burgeoning market. This paper addresses these concerns and posits an innovative business approach to commercial placement in LEO of scientific, engineering, and new product projects utilizing existing platforms and examines the promise of new commercial programs which will expand the resources available on-orbit.

### **Introduction and Background: The Commercial Space Act of 1998**

The 1998 Commercial Space Act was passed into law “To encourage the development of a commercial space industry in the United States...”. The Act, put forth and enacted by the 105<sup>th</sup> Congress, tasks Cabinet and other government officials together with the National Aeronautics and Space Administration (NASA) to define policies and processes encouraging industrial investment in the development of space, and to remove regulatory barriers that might hinder commercial ventures. The topics addressed in the Act range broadly from commercial use of the Space Station to commercial acquisition of space science data; the administration of the Commercial Science Centers (now known as Research Partnership Centers, or RPC’s) that encourage industry investment in specific technologies, products, and science programs; acquisition of commercial space transportation services; and studies on privatization of the Space Shuttle.

On whole, review of the Act indicates that the overall intention of Congress was to inject some vigor into existing dialogue on the U.S. presence in space by increasing the Federal Government’s emphasis on commercial space utilization, and by directing relevant offices and agencies to begin discussions, evaluations, and economic trade studies with an eye toward the eventual development of a cohesive national commercial space policy. The language of act suggests Congressional reticence to establish policies that might direct commercial space markets, preferring instead to allow free market forces and principles to shape this emerging sector. Indeed, there is no mention of or attempt to monitor the development of commercial space ventures, other than to require various offices to report back to Congressional subcommittees the results from those studies that were specified in the Act, none of which were further out than 180 days after enactment of the law. The open-ended nature of the Commercial Space Act, therefore, renders it inappropriate for use as an intended baseline or ground rule for establishing or evaluating the current commercial space industry. Its historical and economic significance lies in its

provisions for both government and private sectors to develop “free and competitive markets” for the utilization of space.

## **The Commercial Space Industry**

Five years after the Act there is no doubt that a commercial space sector exists. When attempting a discussion of the industry, however, the first challenge to any analysis is how to characterize what is now an international business. Metrics – data and statistics derived from measurement of variables such as production, investment dollars, return on investment, number of launches per year, etc. – are not standardized and suffer from problems of generalizability and comparative validity. A recent (2002) publication from the Office of Space Commercialization of the U.S. Department of Commerce neatly describes this problem:

“The space industry is now global, sharing statistical and data problems with many other industries. Foreign and international statistics may not be comparable in terms of completeness and have additional problems with cross-national comparisons. There is no coordination among industry definitions internationally. And, there is little comparability across nations in government budgets. Finally, foreign data are sometimes difficult to locate and translations as well as social and cultural differences complicate the understanding and analysis of the data.” (Hertzfeld, 2002).

The author goes on to note that agreement does not even exist within the United States as to what constitutes a “space sector” or precisely what that sector might be. This problem results in a layer of complexity and confusion that should be addressed but is often ignored in government- or industry-funded assessments of commercial space markets and industries. For example, two recent publications prepared for the Department of Commerce within 15 months of each other each address near-term trends in space commerce (DFI International, 2002; Futron, 2001) but parse the United States space “market” in different ways. The two reports overlap in identifying space transportation as an important sector but agree on little else, resulting in limited ability to compare or to draw conclusions from more than one report at a time. Despite the difficulties, however, it is possible to make some high-level statements about the current “state” of commercial space utilization, bearing in mind that these comments represent a fixed snapshot of a fast-changing and dynamic business environment.

## **Space Sectors**

### Commercial satellites

Futron (2001) identifies the following as major space sectors. These sectors grew at a rate of approximately 16% in aggregate from the years 1996-2002.

- 1) Space Transportation

- 2) Satellite Communications
- 3) Remote Sensing
- 4) G.P.S.

Of these, three are applications of satellite technologies and platforms. Two (satellite communication and remote sensing) will bear brief mention in this paper. Together, these three segments accounted for approximately \$477B of the \$517B total commercial space industry during this period (Satellite Industry Association, 2002). The remaining sector, Space Transportation, is currently considered to be largely comprised of commercial launch companies in service of the satellite industry, and thus could be considered a secondary market. As such, it is sensitive to fluctuations in the demand for new satellite placement which in the United States has recently suffered from a combination of saturation, extended life-on-orbit in LEO communications satellites, and in particular an increased regulatory burden. The resulting decline in demand has taken billions out the domestic commercial satellite market in spite of an increase in global demand, largely driven by direct satellite services. The resulting decline in projections for launch services in the U.S. may be a contributing factor for greater international cooperation in the launch market (for example, the multi-national program SeaLaunch; the general agreement between the Russian federation and the European Union; and more recently between Boeing, Mitsubishi Heavy Industries, and Arianespace) in an attempt to woo customers with increased options and greater flexibility in payload accommodations and supporting infrastructure (Reuters, 2003).

#### Remote Sensing: The Genesis of Commercialization

In 1984 Congress enacted the Land Remote Sensing Commercialization Act (Public Law 98-365) to correspond with the launch of LandSat-5 (30-m resolution imagery). Of the five purposes justifying the law, the first is to “guide the Federal Government in achieving proper involvement of the private sector by providing a framework for phased commercialization of land remote sensing and by assuring continuous data availability to the Federal Government”; in short, to enable commercialization of the LandSat program and provide a pathfinder for future programs. The law was clearly focused on opening a commercial market for space utilization – a market that was quickly to become international. In 1986 the French began selling imagery from SPOT-1 (20-m) which quickly overtook the LandSat imagery in sales due to its higher resolution. In 1987 the Russian government began selling black-and-white 5-m resolution imagery from its military Kosmos satellites, upping the ante in 1992 when it began sales of 2-m resolution imagery from Kosmos.

In response to the growing market, the Land Remote Sensing Act was updated in 1992. Title II of the Act was drafted in part to further enable and promote commercial use of remote sensing satellites and data and the growth of related industries in the United States. Certain exceptions were made that are related to national security programs. The Commercial Space Act of 1998 encouraged NASA to make commercial data buys (for example, from LandSat). More recently, the National Oceanic and Atmospheric Agency

(NOAA) issued regulations implementing Title II and laying the groundwork for commercialization of government owned remote sensing data (NOAA, June 31, 2000). Several companies have stepped forward to in an attempt to build a commercial market for the use of those assets now available to the private sector, including companies such as Space Imaging and Resource 21, and larger interests such as The Boeing Company.

The emerging remote sensing market totaled \$3.3B by 1998. The market is made up of three components: (1) Satellite systems, (2) aerial imaging (i.e., imaging from aircraft), and (3) value-added products and services, such as manipulation of imagery for specific applications, or geographical information systems (GIS) software (Futron, 2001). Continuing growth appears likely as additional uses for imagery are evaluated and marketed – dependent upon the regulations imposed on both the satellite and imagery markets as pertains to export and to national defense.

### Space Transportation

As defined in the Futron 2001 report, space transportation is largely a “trucking” concern, with commercial launch capabilities being directed largely at ferrying satellites to orbit. As previously mentioned, space transportation in this context is largely dependent upon demand for satellite services, and as a result has suffered in the United States due to a reduced market relative to widely-accepted projections circulating during the mid-1990’s. However, another report, commissioned by NASA’s Marshall Space Flight Center and focusing on the impact on commercial and government space sectors of new vehicles accessing LEO (namely a Reusable Launch Vehicle, or RLV) provides an alternate model for space transportation that focuses on an altogether different cargo. During the course of this detailed study, Futron (2003) reaffirmed an earlier survey that had determined that a viable business case exists for public space transportation – sometimes referred to rather disparagingly as “space tourism”.

Futron’s results suggest that, with the exception of increased public demand for access to space resulting from the commercial operation of some type of RLV, the launch market – and the commercial space market as a whole – is likely to remain relatively flat through the year 2021. Unlike previous work in this area, the Futron analysis addressed concerns mentioned earlier in this paper regarding the difficulties of analysis in commercial space by mapping space sector businesses into well-established categories used in the North American Industrial Classification System (NAICS). Proceeding from this standardized basis and what it termed “a dose of pragmatism” that rejected assertions of growth in industries that do not yet exist, Futron further demonstrated that lower launch costs will not significantly stimulate demand for launches or the associated utilization of space, either commercially or by government.

### **“No Magic Number”**

The “magic number” for access to space is widely considered to be a cost level for launches (sometimes referred to as “price per pound to orbit”) that acts as both a

threshold and a triggering mechanism, below which gates will open and demand for access to space – as well as markets for increased space utilization – will markedly increase. This belief assumes that existing launch prices are highly constrained. However, Futron’s analysis reveals wide variability in existing launch costs worldwide, ranging from \$1,946.00 per pound to \$46,120.00 per pound (Futron, 2003, p. 16). Wide variances also exist in launch costs across market sectors. Further, their model for existing commercial space markets (in aggregate) predicts that even a 75% reduction in launch prices would result in a negligible increase in the number of launches, and, one presumes, in associated utilization of space. (Existing space markets include space solar power [on-orbit use], television and radio markets, on-orbit sparing, and commercial satellite remote sensing.)

However and by contrast, evolving commercial markets do and will continue to exhibit a high degree of sensitivity to and benefit from reductions in launch prices. (Evolving markets include orbital salvage, space product promotion, and public space travel [transportation and tour operators]). The prediction regarding elasticity in evolving markets as a function of launch costs is largely driven by previous analysis concerning the demand for public space travel. The study goes on to find that the introduction of an RLV would profoundly impact both the launch and evolving commercial markets, assuming that the RLV is capable of delivering on promises to operate at lower cost with faster (30 days) turnaround in a highly reliable manner (Futron 2003). The predicted growth in market associated with an RLV also driven by public space transportation estimates. Another commercial venture assumed to be impacted by an RLV include a Commercial Module for the International Space Station. The CM would serve as an orbiting asset from which to expand markets associated with science, technology (product) development, and broad consumer businesses such as entertainment and brand-name advertising (Futron, 2003; European Space Agency, 2003).

## **Innovation**

At this point it is clear that, while longstanding challenges to space industries still exist, the presumed impenetrability of launch costs is not as rigid as widely believed, nor does it overconstrain all aspects of commercial space development. Rather, previous approaches to the business case for commercial space endeavors may have relied on poorly-understood market sector analyses or upon conventional wisdom regarding the “magic number”. Since the market itself is relatively small, an additional dampening effect arises when bone fide predictions of growth in a given sector fail to materialize as a result of our inability to foresee significant changes to economic, political and technical landscapes (such as in the case of satellites). In short, the tools that have been brought to bear in constructing expectations of success in commercial space endeavors may not be appropriate to the case at hand, and some of the assumptions underlying various assessments of commercial space markets may not be well-founded.

As has historically been the case of immature or evolving markets, real change occurs through innovation and risk-taking, frequently in small steps. Market sectors such as

launch services, satellite services, and remote sensing services can be considered “large scale”, but there is also a “small scale” market. Entrepreneurial approaches to the space industry have been extant both within and without the government and have variously made use of existing programs (Technology Transfer, Space Act Agreements) or attempted to “go it alone” (Creedon, 1992; Ulrich, 2001). Boeing has recently undertaken an approach that can be best described as “entrepreneurial” even though that moniker is usually associated with small companies or “garage-based” start-ups. It has developed in three steps: (1) Assessment of the needs of commercial developers, (2) development of a plan to facilitate placement of commercial payloads in LEO that leverages (and is consistent with) government programs, and (3) execution.

### **Assessment**

In 2001, Boeing carried out a payload (“user”) survey designed to provide information to the company in support of a number of initiatives (Dittmar, 2001). The results were subsequently shared with NASA’s Associate Administrator of the Office of Biological and Physical Research and also with representatives of the NASA ISS community. The populations sampled were broad: Professional societies, associations, groups and universities; previously-flown experimenters (both ISS and Shuttle); and currently-manifested developers and experimenters. Of the more than 200 individuals contacted, 76 responded, yielding a response rate of 30%. A breakdown of the respondents follows:

- 55% were NASA-sponsored university-based researchers
- 11% were CSC (now RPC) developers/researchers (commercial)
- 8% were U.S. Government (non-NASA) researchers
- 8% were industry researchers (commercial)
- 18% were mixed educational, Detailed Test Objective (DTO) in-flight prototypes, or engineering development payloads

### **Results: Summary**

90% of respondents had prior space-based research or development experience. Of those, 35% had no ISS payloads approved, nor did they intend to make a proposal for ISS research. 75% expressed a desire for improvement in the processes involved in getting to orbit. The most desired improvements (in ranked order) were: (1) shortened template (time to orbit), (2) a streamlined process. A total of 86% of respondents desired an “expedited process” for flight (nominal time to orbit between 12 and 24 months).

### **Results: Commercial users**

Commercial concerns overlapped those of the total sample, with some important exceptions. Commercial development projects (science, engineering or technology development) require quick time-to-orbit and quick turnaround for reflight (6 to 12 months) due to the sensitivity of the effort and the speed of commercial market development. To remain competitive, commercial ventures also require predictable

launch schedules, or at minimum a definable interval (“window”) within which they can reasonably expect to launch. Other issues include clear policies for intellectual property protection whether the launch service is commercial or governmental, clear criteria for selection of commercial projects to be flown in the case of NASA, and a general belief that industry representatives should be involved in evaluating the business case and market potential of commercial R&D payloads to be flown on NASA assets (Dittmar, 2001).

## **The Plan**

### Outreach

The first part of the plan, begun in the winter of 2003, is focused on engendering further discussion among commercial developers as to innovative ways to utilize space. Boeing’s vision is to serve as a “one-stop shop”; providing an express lane for commercial space science, engineering and technology development. The idea is to find ways to get into orbit and to access all low-earth orbiting platforms. Boeing proposes to serve as a broker and agent to commercial users, working directly with both the U.S. space agency and domestic or international commercial users to expand existing pathways to LEO (Bush, 2002; DFI International, 2002; European Space Agency (ESA), 2003; NASA, 1998; Vickroy, 2003). In this role, the company develops agreements with the space agency, develops and validates business cases, taps advanced engineering and technology consulting from across the company, provides payload integration services, and negotiates access with NASA, other space agencies, or with commercial vendors. These services are provided commercially, allowing the company to leverage its expertise as the builder of the ISS and primary subcontractor for the Space Shuttle. This approach offers commercial customers the benefits of years of space experience and development which have been previously established, as well as access to the entire gamut of capabilities of a multinational aerospace company. Boeing is seeking input to this model from industry.

### Developing the Business Case: Two Approaches

In general, two approaches to building business cases for small commercial projects have emerged in the early development of this program. The first, which is currently underway, is to identify projects that appear to have market potential, and then to find funding for them (the “case by case” approach). Examples include highly specialized business such as space-based cultivation of crops, or specific technology development. The second approach is something like the reverse of the case-by-case approach in that it focuses on identifying funding sources by business sector and then searching for flight candidates. This approach is by definition broader in approach and focuses on specific and pre-existing sectors such as materials development, remote sensing, nanotechnology, biotechnology, etc. This approach necessarily long-term in its conception and follows a more tradition “market building” profile. For the purposes of this paper, then, we will focus briefly on the “case by case” approach to demonstrate how it might work.

### The Case-By-Case Approach: A real-life example

In this case, shortly after Boeing announced the Space Utilization Program (early January, 2003) a small company indicated their interest in flying a small passive payload aboard the Space Shuttle. Little or no crew time was required to maintain it. Commercial services were desired (i.e., payload analytical integration), but the company could not afford launch costs. The company was aware of the Space Act Agreement (NASA, 2002) program - a “like-kind exchange” program wherein a commercial entity and the space agency exchange resources for the purposes of developing science or technology - but was inexperienced in the development of such agreements. Without such support, the company faced a long wait until their payload could be manifested – a wait that would have a negative impact to product development.

### The “One Stop Shop”

In this case, Boeing acted as an agent for the smaller company by working with NASA to identify needs of the agency – i.e., to identify resources for insertion by the smaller company into a Space Act Agreement. Had the agreement been completed (it was interrupted by the Columbia accident), the company would purchase the resources (in this case, hardware) from Boeing and include them as part of the “like-kind” exchange in the Space Act Agreement. NASA’s contribution would be associated with manifesting – i.e., a launch opportunity, as it would benefit from flight of the payload. Boeing would broker the agreement and provide payload analytical and engineering integration at commercial rates (leveraging existing processes and infrastructure). At the time it was anticipated that the flight would be manifested within 12 months of completion of the Space Act Agreement; a savings of 2-3 years to flight for the small company.

### Impact of the Columbia Accident

The case-by-case approach was defined and three customers had entered into the process between January 1 and January 25, 2003. These preliminary arrangements thus occurred prior to February 1 and the breakup of the Space Shuttle Columbia. The consequences of the accident, as they apply to this program, revolve around 3 issues: (1) return to flight uncertainty, which adversely affects one of the primary goals of the program - namely to provide a path to flight opportunity that is more predictable for the customer; (2) the reduction of flight opportunities overall due to the downsizing of the Orbiter fleet to 3 and the priority placed on completion of the ISS assembly sequence; and (3) a likely shift away from commercial payload prioritization as a result of the increased pressure on flight manifests for science and technology payloads.

### **Execution: A Work in Progress**

As a result, and until these uncertainties are resolved, the Space Utilization Program has shifted asset utilization development initiatives toward non-human-tended platforms and

remote sensing technologies. Outreach continues to the broad commercial community with special emphasis on identification and assessment on satellite and related-technologies. Education initiatives focusing upon Earth science curricula are underway. Finally, alternate access to the International Space Station for commercial users is under consideration.

## Summary

Efforts to characterize the commercial space industry are slowly coming of age. Most recently in the analyses carried out by Futron Corporation and others, business sectors are becoming better defined as are the challenges that face them, particularly the predictions of relatively flat launch profile over the next 20 years. These assessments have led Boeing Space Utilization to develop a dual approach: One that emphasizes market building of pre-existing space sectors and one that is intended to enable the entrepreneurial spirit of space science, technology development and engineering R&D. Boeing continues to invite discussion, input, requirements definition, and entrepreneurial interests to engage in molding a multifaceted approach to space utilization.

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