Growing the Space Economy

GEORGE F. SOWERS JR.

Thank you for that kind introduction and thanks to SEDS for inviting me to speak this afternoon. I always like coming up to Boulder, one of my favorite towns. I spent five fruitful years here in graduate school, although I probably spent more time in Eldorado Canyon rock climbing than I did in class.

The theme of this conference is the interaction of space policy, technology and entrepreneurship. That's a very complex set of topics. What's left unsaid in a theme like that are the overarching goals. What are we expecting from the interaction of policy, technology and entrepreneurism as it regards space? What are we looking to do?

I take it as given that one of the salient goals of humankind ought to be expanding our presence into space. This spring I gave a speech in at the University of Alabama outlining reasons for humankind to pursue space exploration and colonization, which I won't repeat here. Suffice it to say that I believe the case for human expansion into space is a compelling one. The Augustine commission, chartered two years ago to examine America's space program, agreed that the overarching goal ought to be the establishment of a permanent human presence beyond Earth. But, though the government can lead the way, a permanent human presence beyond earth requires, in my opinion, the horsepower of the free market economy. It requires the assistance of Adam Smith's invisible hand to both push free market economic activity outward into first cis-lunar space and then the greater solar system, and to pull humans and their economic energy along with it in a permanent way.

Hence, the goal becomes one of expanding human economic activity and the energy of the marketplace beyond Earth, to establish a economy based on space, generating goods and services in space, eventually driven by consumers and customers located beyond earth. And to establish a free market economy in space, we must answer the simple question: How can we make money in space? And the related questions: What are we selling? And who are our customers?

1. The Current State of Space Commerce

Now it's a fact that a lot of money is currently being made in space or in space related activities. According to the Space Report, the global space economy is over $275B in size. Let's examine the nature of these current markets. First, all people—all consumers—are currently located on Earth. This sounds like a trivial point, but it implies that space economic activities must be directed earthward. In other words, space activities are aimed at providing services for people on earth, services like security or information or communications. One of the most familiar is navigation and the sale of personal navigation devices is one of the fastest growing commercial sectors of the space economy.

Second is the extreme cost to get mass into space. This is driven by the physics of living at the bottom of a gravity well. The amount of energy required to get to Low Earth Orbit is simply enormous, 32 million joules per kg. In a pure energy sense, one metric ton to orbit requires the entire power output of Hoover Dam for 15 sec. Harnessing that much power in a rocket is difficult and expensive. In economic terms, the current cost to deliver one kg to LEO averages around $10,000.

The high cost of launch and the limitation that an economically viable use of space must be earth directed has led—with one notable exception—to governments being the primary customers for space based services. Geo-politics and the prestige of nations dominate space markets. For the military, space has become the new high ground and the US has achieved a dominant position. Military uses include communications, navigation and intelligence gathering. Current civil government uses include weather and environmental monitoring and science.

The one non-governmental use of space that has been able to achieve viability is communications. Communication satellites for commercial use first flew in the late 1980's. This was the first wave of commercial space and spurred the development of the first commercial launch vehicles and companies. Arianespace got its start then and with the backing of the French Government and the European Space Agency, it survived intense growing and learning pains to become one of the major players today.

Commercial Titan was fielded by Martin Marietta but flew only four times with one failure. I spent several interesting years on that program. But the risk of the commercial launch market was too great for fiscally conservative Martin Marietta to stomach. Commercial Atlas first launched in 1990 with a rocky start, losing three of the first nine missions. In part because of those failures, General Dynamics sold its space division to Martin Marietta who really only wanted the Titan Centaur. Atlas was thrown in for pennies on the dollar. However, since 1994, Atlas has achieved an impressive record of 98 consecutive successes, best in the world and the Atlas V is one of the pillars of the AF EELV program.

The second wave of commercial space occurred in the late 1990's with the advent of the big LEO constellation. These constellations would provide wireless broadband access anywhere in the world. Names like Celestri, Skybridge and Teledesic have now faded into obscurity. I personally worked with Teledesic for several years. It was a venture started by billionaire Craig McCaw and had the backing of Bill Gates. They were planning a constellation of 908 spacecraft in low earth orbit. We were going to launch them 12 at a time on the Atlas V 551. In fact, we added SRBs to Atlas V in anticipation of the demand to deploy the big LEO constellations.

Unfortunately, the second wave of space commercialization fell victim to the bursting of the global telecom bubble. But more fundamentally, the rapid spread of land based broadband, primarily fiber, eliminated the need for these big constellations. A lot of money was lost in the second wave of space commercialization including hundreds of millions on the development of Atlas V and Delta IV. You could say that the existence of my company, ULA, is one fall out of this business disaster. Atlas V and Delta IV were developed by Lockheed and Boeing in part to respond to the demands of this imagined market. When that market collapsed, the only remaining customer was the US Government. Without enough market to sustain two healthy competitors, merging was the solution. In the last several years, ULA has eliminated much of the capacity created to serve the market that never was.

So in summary, after three decades of commercial space, there is still only one solid business sector, communications, which has resulted in a steady demand of 15 to 20 satellites per year. A little money has been made, but far more money has been lost. I

hate to be so gloomy, but those are the facts. It's important for you who aspire to get into this business to understand the hard lessons of the last three decades and learn from them.

2. Near term prospects

So what are the prospects for the near future? I believe there is some cause for optimism. We may be entering into a third wave of space commercialization, this time driven by human spaceflight.

The reason for my optimism is twofold. First, NASA has made a concerted effort to move in the direction of purchasing commercial services to maintain the International Space Station. NASA's investments in COTS, CRS and now commercial crew have enabled the development of systems and capabilities that have the potential to enable new markets and stimulate true commercial demand. This is a major change of direction for NASA and one that has been controversial both within the agency and in congress. The debates have been especially contentious with regards to the commercialization of crew delivery. Since the beginning of human spaceflight in this country, NASA has owned and operated those rockets and the spacecraft. Mercury, Gemini, Apollo and Space Shuttle represent the very essence of the agency. Letting go has been very-very difficult. But it's time. There is no doubt in my mind that the private sector has the capability to field safe and affordable human spaceflight systems. Earlier this week, I testified to congress to that effect.

My second reason for optimism is that an investment by NASA in this capability has the potential to stimulate the development of a new economic sector—commercial human spaceflight, be it for industrial purposes, national objectives, or simply tourism. My good friend Bob Bigelow is a visionary with a dream to have a fleet of private space stations in Low Earth Orbit. His customer base will be countries who want a space program but cannot buy or beg time on the ISS. But Bob needs a reliable and affordable transportation system to LEO. NASA is in a unique position to create a transportation system that can address their needs for access to ISS, and unleash the power of the American entrepreneur in Low Earth Orbit.

Key to establishing any new space market is lowering the cost to deliver mass to orbit. We need to lower launch cost. The economics of launch are driven by fixed costs. Rockets to deliver people or satellites to orbit are necessarily very large complex objects. They require an extensive supply chain making unique parts, large factories for assembly and test, extensive transportation infrastructure to get the pieces to the launch site and large facilities like assembly buildings and launch pads to launch them. In addition, because it is rocket science after all, you need a unique and highly trained workforce to sustain and operate the systems. These are all elements of fixed cost. These costs accrue year over year irrespective of how many launches are performed. At ULA's current launch rate fixed costs comprise roughly 75% of our total cost.

The conclusion is that the single best way to reduce launch costs is to increase launch rates. NASA's decision to purchase crew and cargo delivery services from the private sector is a step in the right direction, putting additional demand into systems that service other government and commercial customers. And the success of a project like Bob Bigelow's has the potential to push demand to a completely new level, moving the industry into a regime of production and launch efficiencies that will dramatically lower costs. This will result in a robust and vibrant industrial base and dramatically increase the pace of innovation. A virtuous circle will be established that will enable even more commercial space business, and lead us to the fourth wave of space commercialization.

3. Longer term prospects

What are the prospects for the fourth wave of space commercialization? To stimulate your thinking, I'll mention two possibilities.

So here we are in Boulder, Colorado (which we used to call Berkeley east) one of the hotbeds of green thinking in the nation. So what would you think of an energy source that emits no greenhouse gases whatsoever, that produces no hazardous waste, that can be available 24 hours a day, seven days a week, regardless of cloud cover, daylight or wind speed, and is inexhaustible? Sound too good to be true? But that's the promise of space based solar power. The basic idea is straightforward. A satellite in geosynchronous orbit is equipped with massive solar arrays, collects power, converts it to a tightly focused

beam of microwaves and beams it to a collector on the earth's surface where it is converted to electrical power and either added to the grid or used to power some local device. There are variations on this theme: different orbits, focusing the solar radiation with mirrors, thermal conversion, and infrared lasers versus microwaves. These details can be left for the marketplace to sort out.

Now of course there are major challenges. Coal based power costs roughly two cents per kilo-watt-hr. Based on current launch costs and making other reasonable assumptions about the cost to construct large scale solar power satellites, a rough estimate of space based solar power is forty cents per kwh, a factor of twenty higher. How can we close the gap? As I mentioned earlier, increased launch rates from programs like Bigelow's can bring launch costs down a factor of two or more. The enormous rate required to deploy solar power satellites could bring costs down another factor of two. Advances in solar collection and transmission technology will increase efficiency. And of course, the costs of fossil fuel based power are bound to increase, either due to increased scarcity and increased costs to extract or through artificial means like a cap-and-trade system.

In any event, there will come a time when space based solar power will be cost competitive and a multi-trillion dollar space industry will emerge. In the longer term, the materials to construct space-based solar power plants will come from the moon or asteroids, alleviating the need to transport such large masses from the earth's surface.

Which brings me to the second potential for space commercialization, mining asteroids. Just as earth bound energy resources are finite and diminishing, so are earth bound mineral resources. The asteroid belt on the other hand is a fairly accessible region teeming with mineral and other resources. For example, the asteroid 16 Psyche is thought to contain 10,000 trillion metric tons of nickel-iron, several million times the current world production rate. A relatively small metallic asteroid contains over 20 trillion dollars of industrial and precious metals. Many of these materials, like antimony, zinc, tin, silver, lead, indium, gold and copper are expected to become very scarce in the next 50 years and are essential for critical technologies and industrial processes. Other asteroids are icy, like comets, and could be used to mine hydrogen and oxygen propellants.

Many asteroids are reasonably accessible and humankind is now beginning a more detailed exploration of these potentially lucrative objects. Several have already been visited by robotic probes. The Japanese Hayabusa mission landed on the asteroid Itokawa in 2005, collected some tiny samples, and returned to Earth last year. NASA's Dawn mission just arrived at the Asteroid Vesta in July where it will remain until next July, then depart for a visit to the Asteriod Ceres. Vesta and Ceres are the largest of the Asteriods and like Pluto are now classified as dwarf planets.

The delta velocity required to reach a near earth asteroid (like Itokawa) from LEO is about 30% less than that required to get from earth to LEO and 20% less than required to reach the surface of the moon. NASA plans are to send a human expedition to an asteroid in the middle of the next decade.

At present, the business case doesn't close for bringing metals back to earth from an asteroid. The costs of launch and in-space transportation are just too high. But as those costs decrease, as I discussed earlier, and as prices on earth rise due to scarcity, the business case will become more promising. Asteroids will certainly be used as a source of material for in-space manufacturing. The high cost of launching from earth coupled with a demand for in-space manufactured goods, like solar power satellites, could turn the corner in the business case. And once we have the capability to mine materials and manufacture goods in space, we will be well along the road to establishing a true space faring civilization

4. Conclusions

In the next century, I believe space will become the dominant venue for commerce. The scarcity of earth bound energy and mineral resources virtually guarantees it, in my mind, in spite of a general disinterest in space among the current population. The near term problem is how to get over the hump. The first step is to get launch rates up so we can get costs down. And that can happen if projects like Bob Bigelow's take off. That depends, in turn, on NASA following through with the commercial crew program. Earlier this week, I joined a group of industry officials to testify to Congress about the capabilities of the private sector to safely and affordably

deliver crew to orbit. But I have to tell you that the support in Congress is not strong and funding is in jeopardy.

Ultimately, our future in space depends on you. It will be your ideas—ideas for how to make money in space—that will spur the growth of the space economy. It will be your creativity, your ingenuity—operating in a free market—that will provide the engine, the energy, to move humanity beyond the shores of our lonely home planet and out into the wide cosmos.

Thank you and I believe we have time for a few questions.