SUBCOMMITTEE ON SPACE AND AERONAUTICS
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

The Emerging Commercial Suborbital Reusable Launch Vehicle Market

Wednesday, August 1, 2012
2:00 p.m. – 4:00 p.m.
2318 Rayburn House Office Building

Purpose

Suborbital launch operations - rockets that travel into space but do not have the energy to orbit the Earth - have traditionally been used to conduct missile tests and scientific research for the government sector. The introduction of new commercial suborbital reusable launch vehicles (SRVs) in the private sector has enabled the emergence of new markets. A number of these new companies are already testing their vehicles and plan to initiate commercial operations within a few years. This hearing will examine the potential launch markets and applications for SRVs, the unique benefits that SRVs offer the scientific community for research, and the regulatory uncertainties that currently have the most impact on the emerging commercial SRV industry.

Witnesses

- **Ms. Carissa Christensen**, Managing Partner, The Tauri Group
- **Dr. Alan Stern**, Chairman, Suborbital Applications Researchers Group
- **Mr. George Whitesides**, CEO and President, Virgin Galactic LLC
- **Mr. Bretton Alexander**, Director, Business Development and Strategy, Blue Origin
- **Mr. Andrew Nelson**, Chief Operating Officer, XCOR Aerospace
- **Dr. Stephan R. McCandliss**, Research Professor, The Johns Hopkins University

Overarching Questions

- What are the emerging launch markets for SRVs? When will the SRV companies begin commercial operations?
- What are the types of issues that need to be addressed when deciding on the merits of proposed research and the appropriate platform for that research (e.g. balloon, sounding rocket, ISS, SRVs)?
- What are the unique benefits that SRVs offer the scientific community and STEM education teachers?
- What is the current demand for research and development, scientific, and educational payloads on SRVs? What is the timeframe for flying these payloads?
- How does the SRV industry currently collaborate with the Federal Aviation Administration (FAA) in developing draft guidance for test flights and current operations?

SRV Quick Summary

- SRVs are spacecraft capable of reaching outer space for a short period of time, measured in minutes, but cannot orbit the Earth.
- Companies developing SRVs are planning commercial operations for human spaceflight and also cargo - such as scientific experiments and research – and some companies have announced plans to develop a capability to launch small satellites into orbit.
- SRVs could begin operational commercial flights within the next few years for both human spaceflight and cargo.

Background

The development of SRVs that could access outer space, return to Earth and be used repeatedly began to surge during the competition to win the Ansari X-Prize. The $10 million prize was a competition, modeled after 20th century aviation prizes, for the first non-government organization to launch a reusable manned spacecraft into space and repeat the launch within two weeks.

The prize was awarded to Mojave Aerospace Ventures in 2004, launching a reusable spacecraft called SpaceShipOne, which was developed primarily with funding provided by Microsoft co-founder Paul Allen. At the height of the competition for the Ansari X-Prize, there were 26 teams investing a total of $100 million to develop vehicles to win the prize.[1]

To date, six companies have made significant progress developing different concepts for SRVs that are all powered by rocket engines. Some of these concepts can be either launched vertically from a launch pad like a traditional rocket or horizontally from a runway similar to an airplane. Chart 1, provided below by the FAA,[2] illustrates the companies that have SRVs currently under development and are expected to begin commercial operations within a few years.

Reusable suborbital launch service providers overview

Company	Main Vehicle		Year of Test Flights	Launches From	# of Seats
Armadillo Aerospace		Hyperion	2014	Spaceport America	2
Blue Origin		New Shepard	TBD	West Texas	3+
Masten Space Systems		Xaero	2011	Mojave Air and Space Port	0
UP Aerospace		SpaceLoft	2006	Spaceport America	0
Virgin Galactic		SpaceShipTwo	2010	Spaceport America	8
XCOR Aerospace		Lynx	2012	Mojave Air and Space Port	2

Chart 1

Photo credits: (From top to bottom) Armadillo Aerospace, Blue Origin, Masten Space Systems, UP Aerospace, Virgin Galactic, and XCOR Aerospace.

[1] FAA Report, The U.S. Commercial Suborbital Industry: A Space Renaissance in the Making, October 2011

[2] Ibid, page 5

In addition to the vehicles illustrated in Chart 1, there are a number of U.S. and international companies that are in the early development stages for their own SRVs. The U.S. companies include Rocketplane Global, Sierra Nevada Corporation, Space Exploration Technologies Inc. and Whittinghill Aerospace. Additionally, three European companies are developing SRVs including Copenhagen Suborbitals, Dassault Aviation and EADS Astrium.

Funding

According to the FAA, total investment in suborbital ventures is estimated to be approximately $500 million.[3] The primary source of funding for the development of commercial SRVs has come from company founders and individual investors. John Carmack invested $2 million starting Armadillo Aerospace, Microsoft co-founder Paul Allen invested approximately $20 million in SpaceShipTwo, Sir Richard Branson has invested about $100 million in Virgin Galactic, and Amazon founder Jeff Bezos has contributed to Blue Origin.[4]

The companies that intend to offer human spaceflight opportunities have also received deposits from individuals for future flights, sometimes referred to as space tourism. To date, more than 900 people have reserved seats and paid deposits with companies developing SRVs for future suborbital flights. Additionally, some of the SRV companies have also signed contracts and agreements with organizations and corporations that want to use their service for science applications.

SRV companies have also received government funding from NASA, the Department of Defense, and the FAA. NASA's Flight Opportunities Program has allocated $10 million over two years for SRV flights and DoD small business contracts have provided about $2 million in funding for technology development at three SRV companies.[5]

On July 2nd, NASA announced the selection of 14 technologies for development and suborbital flight demonstrations under the Flight Opportunities Program. The new technologies will develop such areas as active thermal management, advanced avionics, precision landing, and advanced in-space propulsion. NASA is planning to spend nearly $3.5 million on the payloads (approximately $125,000 to $500,000 each) which are expected to launch in 2013 and 2014.

As mentioned, prizes have also facilitated the development of SRV technology. The Ansari X-Prize in 2004 and the Northrup Grumman Lunar Lander X Challenge in 2008 and 2009 provided approximately $12 million in total awards to companies developing SRV specific technology.

Spaceports

The FAA's Office of Commercial Space Transportation (AST) licenses commercial spaceports and operations in the United States. These sites are dedicated facilities traditionally used to launch orbital and suborbital spacecraft. To avoid conflicts with air traffic and ensure safety,

[3] FAA Report, The U.S. Commercial Suborbital Industry: A Space Renaissance in the Making, October 2011
[4] Ibid, page 32
[5] Ibid, page 34

spaceport operations are supported by the FAA's air traffic control (ATC) and typically use a dedicated U.S. Air Force range that is cleared of aircraft prior to a launch.

In the United States, there are currently eight FAA-licensed spaceports that support orbital, suborbital or both types of launches. Of these, five can conduct suborbital flight operations that support SRVs. They are: Cape Canaveral Spaceport, Florida; Cecil Field Spaceport, Florida; Oklahoma Air and Space Port, Oklahoma; Spaceport America, New Mexico; and Mojave Air and Space Port, California.

Experimental Permits and Licensing

The Commercial Space Launch Act of 1984 (CSLA), as amended, authorizes the Secretary of Transportation to oversee, license and regulate commercial launch and reentry activities carried out by U.S. citizens or within the United States. In 2004, the Congress enacted the Commercial Space Launch Amendments Act of 2004 (CSLAA 2004) which expressly authorized the Secretary to regulate and promote commercial human spaceflight. However, in order to allow the SRV industry to develop an experience base upon which FAA could fashion reasonable regulations, the same bill imposed an eight year moratorium on issuance of final regulations on SRVs. Industry officials frequently refer to the moratorium as a 'learning period.' Like all commercial space transportation oversight, the Secretary has delegated this authority to the FAA's Office of Commercial Space Transportation (AST).

Under the CSLAA, the FAA can issue experimental permits on a case by case basis rather than licenses for the launch and reentry of reusable suborbital rockets for the purpose of vehicle testing and other non-revenue flights. FAA also allows smaller vehicles to fly under an "amateur rocket" exemption from the requirement to obtain a license or permit, but they cannot carry a human being.

In May 2005, the FAA issued the Guidelines for Experimental Permits for Reusable Suborbital Rockets document specifying key aspects of the permit regime. The guidelines identify the safety measures that the FAA would expect a company with an experimental permit to comply with during flight test operations. The guidelines include a variety of safety measures that protect the public including; hazard analysis, operating area containment, key flight-safety event limitations, and anomaly reporting.

Under an experimental permit, a company may test new design concepts, equipment or operating techniques, and demonstrate how their system complies with safety requirements. The company may also conduct crew training but is prohibited from generating revenue (i.e., selling seats) from permitted flights. While companies must still demonstrate financial responsibility for third party damages, they are not eligible for regular launch and reentry indemnification while conducting testing under an experimental permit.

Companies will be required to obtain a license prior to initiating a commercial service. Once a test program is completed, the operator can apply for either a launch license or an operator license. The key difference between the two is that a launch specific license authorizes only a specific number of launch or reentry activities.[6]

[6] FAA's Implementation of the Commercial Space Launch Amendments Act of 2004 – The Experimental Permit

The regulatory strategy currently used by the FAA to license the launch of SRVs combine safety approaches to protect the public through three different means.

- A licensee must demonstrate that the risk from a launch falls below specified quantitative collective and individual risk criteria,
- A licensee must have a comprehensive system safety program consisting of both system safety management and system safety engineering, to identify hazards and reduce risks to the public, and
- A licensee must comply with several operating requirements, developed by the FAA from lessons learned in the launch vehicle industry.[7]

Crew and Spaceflight Participant Safety

The CSLAA established an informed consent regime in which licensees must provide passengers that have purchased tickets for suborbital flights (referred to as spaceflight participants) with information about the safety record of their vehicles and other risks, must ensure that participants meet basic health standards, provide them basic training regarding their vehicle, and inform them that the federal government does not certify the vehicle to be safe, after which participants must sign a legal consent document.

The current "learning period" was recently extended as a provision of the FAA Modernization and Reform Act of 2012. The law stipulated that a final regulation could not be issued until October 2015 but the legislative report language accompanying the bill stated that "nothing in this provision is intended to prohibit the FAA and industry stakeholders from entering into discussions intended to prepare the FAA for its role in appropriately regulating the commercial space flight industry when this provision expires."[8]

As a result of the Congressional intent in the legislative report, the FAA has initiated a collaborative dialogue with industry to begin collecting technical data and inputs from the companies that are currently testing (or planning to begin testing) their vehicle designs. In a recent Space News article, the FAA/AST senior technical advisor Pam Melroy explained how the FAA would collaborate with industry.

> "We're going to be setting up monthly public telephone calls to ask [industry] about certain topics," Pam Melroy, former NASA astronaut and senior technical adviser in the Federal Aviation Administration's (FAA) Office of Commercial Space Transportation (AST), said in a July 16 interview. "We do plan on having these once a month for the foreseeable future. We really want maximum participation, and we want technical people to really help us understand what the thinking is out there."[9]

The FAA intends to share findings from the industry collaboration with the Commercial Space Transportation Advisory Committee (COMSTAC) on an ongoing basis, beginning this October.

[7] Ibid
[8] House report 112-381
[9] SpaceNews, *FAA Commercial Space Office Navigates Legal Maze To Start Safety Dialog,* July 20, 2012

The COMSTAC is the FAA's federal advisory committee comprised of industry experts that provide policy and programmatic recommendations to the Associate Administrator for Commercial Space Transportation at the FAA.

According to the FAA, once the learning period is over in October 2015, it could take more than a year to finish gathering the necessary technical data to write final regulations.

Market

The market for SRVs is expected to mature as vehicle development advances from flight testing to licensing and commercial operations. Customer demand for space tourism is already building. To date, there are more than 900 individuals who have made deposits and reservations for commercial human spaceflights aboard SRVs and this sector of the market is providing substantial funding to some of the SRV companies. The "early adopters" of commercial human spaceflight include private individuals and researchers from corporations, academia, and institutions which are enabling the development of other potential market sectors for SRVs by partially funding the development of the vehicles.

While costs remain high and competing alternatives to SRVs already exist in many sectors, the market that analysts expect to emerge for suborbital SRVs consists of a combination of commercial human spaceflight, basic and applied research, aerospace technology test and demonstration, remote sensing, education, media and public relations and point-to-point transportation.

- Commercial Human Spaceflight - Individual consumers (spaceflight participants), in-space training for astronauts and crew, and government or corporate sponsored human tended research.
- Basic and Applied Research - Scientists, researchers, and engineers seeking access to the space environment, upper atmospheric regions, and microgravity for investigations of biological and physical R&D, Earth science and human research.
- Aerospace Technology Test and Demonstration - Demonstrations and testing of aerospace engineering payloads and components.
- Remote Sensing - Imagery acquisition that cannot be met with traditional satellite or aerial surveillance platforms. SRVs may provide a unique resolution or field of view for certain applications.
- Education - Flight opportunities for STEM education and training within K-12 and undergraduate education budgets.
- Media and Public Relations - Public relations and media firms, filmmakers, and broadcasters promoting products or brand awareness.
- Point to Point Travel - High-speed transportation of cargo or people.

In addition to the market sectors listed above, several SRV companies have recently announced plans to build dedicated small satellite launcher systems. The launch systems would utilize the SRV to place satellites ranging from 1 kg to 500 kg into low Earth orbit at a price per kilogram that is predicted to be less expensive than traditional expendable rockets.

Science Applications

Suborbital expendable sounding rockets have been a critical component of scientific research for over 50 years, yet the emergence of new SRVs offers the potential for new research applications in astronomy, physics, planetary science, atmospheric science, biology and human research. Commercial SRVs have significant potential for use by the scientific community to obtain measurements unavailable by other means or to collect data in a low cost, more time responsive, and routine manner.

The operating characteristics of the various SRVs under development could offer the scientific community a unique opportunity to obtain measurements in and from a region of the atmosphere currently not well understood. SRVs could enable scientific investigations in relatively unexplored regions of the atmosphere that is defined as the upper reach of high altitude balloons to the lower reach of orbital satellites.

SRVs could also enable in situ measurements in the upper stratosphere and mesosphere at altitudes rarely sampled by any vehicle. These in situ measurements include sampling of the gas and particle populations along the vehicle flight path. Aircraft and balloon borne observations have proven decisive to our understanding of the atmosphere and climate. However, many critical chemical and dynamic atmospheric processes and phenomena occur in the region of the atmosphere that is commonly referred to as the “Ignorosphere” because it is not sampled on a regular basis.

While ground and space based observations have provided important data on some of these processes, in situ measurements at specific locations may help scientists fully understand the various processes and validate models. An increased geographical availability could also be an important variable for science applications. If the SRV market expands, the number and location of spaceports could be global while some SRVs could operate from any sufficiently large airport. SRVs may be able to repeat flights to the same region of the upper atmosphere on a regular basis and provide a constant record for a particular investigation. As a result, there may be a complementary and supportive nature of SRVs to the existing research conducted by sounding rockets, satellites and ground based instruments.