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

NASA's Commercial Crew Development Program: Accomplishments and Challenges

Wednesday, October 26, 2011
10:00 a.m. - Noon
2318 Rayburn House Office Building

Witnesses[1]

First Panel
Mr. John Elbon, Vice President and General Manager for Space Exploration, The Boeing Company, Houston, TX

Mr. Steve Lindsey, Director of Space Exploration, Sierra Nevada Space Systems, Louisville, CO

Mr. Elon Musk, CEO and Chief Technology Officer, Space Exploration Technologies Corp., Hawthorne, CA

Mr. Charlie Precourt, Vice President, ATK Launch Systems Group, Brigham City, UT

Dr. George Sowers, Vice President, United Launch Alliance, Englewood, CO

Second Panel
The Hon. Paul Martin, Inspector General, National Aeronautics and Space Administration

Mr. William H. Gerstenmaier, Associate Administrator, Human Exploration and Operations Mission Directorate, National Aeronautics and Space Administration

Introduction

Last year with the rollout of the FY11 budget request, the Administration announced significant changes to NASA's human space-flight program, including its intention to cancel NASA's *Constellation* program, and instead put the agency on the path of relying on commercial launch companies to ferry astronauts to and from the International Space Station. Congress did not fully embrace the agency's full set of proposals, especially in the areas of heavy lift and a deep space exploration program, but with passage of the NASA Authorization Act of 2010 (PL 111-267), policy provisions in the bill (Title IV) authorized the agency to expand efforts to develop a commercial crew launch industry.

NASA's rationale for embarking on the commercial crew option was predicated on a report written by the "Review of U.S. Human Spaceflight Plans Committee" chaired by Norman R. Augustine. Published in October 2009, the report – *Seeking a Human Spaceflight Program Worthy of a Great*

[1] Blue Origin, based in Kent, WA, was invited but chose not to attend. They were awarded a $22 million Space Act Agreement grant under NASA's Commercial Crew Development Program.

Nation – included a number of findings and recommendations, and asserted that the *Constellation* program was 'unsustainable,' that to maintain a credible human spaceflight program NASA needed to spend an additional $3 billion annually, and that commercial industry was mature enough to take on the task of ferrying astronauts to and from low Earth orbit at a lower cost[2], although this path did have some risk.[3] The report also stated that "It is crucial to the success of the program that multiple providers be carried through to operational service."[4]
(http://www.nasa.gov/pdf/396093main_HSF_Cmte_FinalReport.pdf).

A key component of the commercial cargo and crew programs is the mixing of private and federal funds to pay for design, development, testing, and certification. Instead of a classic acquisition with NASA paying a contractor to design and build a space vehicle to its own specifications, under the commercial concept private industries will have to invest substantial amounts of their funds to build vehicles of their own designs. NASA will share in the cost of the development, and in the event the company's design proves successful, meets NASA's performance and safety requirements, and is selected by the agency in a final competition, NASA would 'buy' seats to ferry astronauts back and forth to the space station. Thus the commercial model allows NASA to leverage its own funds to acquire launch capabilities at a reduced cost, and it allows the commercial company to sell seats to non-NASA passengers.

NASA began commercialization efforts in 2006 with the Commercial Orbital Transportation Services (COTS) program to develop a commercial cargo capability. COTS was also viewed as an opportunity to test new contracting methods to incentivize industry. According to NASA the "*COTS approach is designed to lower barriers to entry for entrepreneurial space transportation companies*," and act as a *"catalyst for technology demonstrations where the potential high return on investment outweighs the associated financial risk."*[5]

Congress endorsed the cargo program. However, designing, testing, and demonstrating the cargo capability has proven more difficult than anticipated. The two companies now under contract for delivery services, SpaceX and Orbital, have missed their original COTS demonstration flights by a period of two years and one year, respectively. Crew transportation services impose significant new design and performance complexities that will likely result in greater uncertainty about meeting development schedules going forward.

On February 1, 2010, NASA initiated the first phase of its Commercial Crew Development program (CCDev1), awarding $50 million under Space Act Agreements (SAA) to five companies. On April 18,

[2] "Commercial services to deliver crew to low-Earth orbit are within reach. While this presents some risk, it could provide an earlier capability at lower initial and life-cycle costs than government could achieve." Augustine Report, page 72.

[3] "The Committee recognizes that the development of commercial services to transport crew come with significant programmatic risks. Among these are the development of this capability will distract current potential providers from the near-term goal of successfully developing commercial cargo capability. Second, the commercial community may fail to deliver a crew capability in mid-program, and the task would revert to NASA. This could be caused by either a technical failure or a business failure…" Augustine Report, page 71.

[4] Augustine Report, page 72.

[5] Commercial Crew and Cargo Briefing to Congress, 4 December 2007.

2011, second round awards (CCDev2) were announced, totaling $269.3 million to four companies.[6] Two companies that were not selected as part of CCDev2 later chose to participate through "unfunded" agreements.[7] This hearing will give both the funded and unfunded companies participating in CCDev2 and NASA an opportunity to describe their launch systems, accomplishments, and challenges confronting the Commercial Crew Program.

In the meantime, until a commercial crew launch system becomes operational in the planned 2017 timeframe, NASA will be reliant on Russia's Soyuz launch system to ferry astronauts to and from the ISS. NASA currently has a contract with the Russians to purchase Soyuz seats including all necessary training and preparation for launch, crew rescue and landing, and limited crew cargo delivery to and from the ISS through July 1, 2016. The current contract costs approximately $56 million per seat thru 2013, increasing to approximately $62.7 million in 2014 and 2015 to cover general inflation in Russia. In total, from FY2012 – FY2016, NASA expects to spend about $1.4 billion if it fully exercises all contracts.

Sec. 501 of the 2010 NASA Authorization Act directs NASA to support 'full and complete utilization of the ISS through at least 2020.' Under NASA's current schedule estimates, the Commercial Crew Program expects to have a commercial crew capability in place by early 2017. Agency plans call for two flights a year using commercial providers to rotate station crews; thus, NASA's demand for services will number about six or seven flights total. That projection could increase if ISS utilization is extended, or diminish if station is restricted to a crew size of less than six.

In the FY2012 budget request, NASA asked for $850 million for each of the years 2012 – 2016 for the Commercial Crew Program ($4.2 billion total). Last week senior NASA officials publicly stated that the agency requires its full request of $850 million in FY2012 if it's to meet a 2017 operational readiness date. However, the budget request did not provide meaningful detail at the project or activity level about how funds would be spent and the rationale for the amount requested, other than highlighting agency plans to begin the phase 3 (IDC) contract awards.[8]

Current State of Commercial Crew Funding

	PL 111-267 Authorization	FY12 PBR	FY12 House	FY12 Senate
Commercial Crew	$312M*	$850M	$312M	$500M

*NASA Initial FY11 Operating Plan dated 6/15/2011 - Commercial Crew Development funded at authorized levels.

[6] See Appendix A for a list of the CCDev2 companies.

[7] A third unfunded participant, Excalibur Almaz, Inc., signed a SAA on Oct. 17. However, no information was made available about their schedule and milestones at the time this charter was written.

[8] In a briefing earlier this month to subcommittee staff, charts provided by the agency stated: "NASA has been told consistently, by a broad range of potential providers, that private sector partners expect to be able to achieve a capability of providing commercial spaceflight services to the ISS within 3-5 years from initial development start…NASA's FY2012 budget request of $850M for commercial crew would provide that initial start in FY2012 for development of commercial crew transportation systems which would enable services to ISS to be possible in the 2016 timeframe." The briefing charts also stated that the House FY2012 CJS appropriations mark for commercial crew services - $312 million, the amount authorized in the 2010 NASA Authorization Act – would cause the agency to reconsider its acquisition approach.

Questions and Overarching Issues

- What are the major accomplishments to date by industry on efforts to develop a commercial crew launch capability? What are the remaining major technical challenges that must be addressed?
- From industry's perspective, what are the biggest programmatic challenges with NASA's Commercial Crew Program regarding (1) the agency's procurement strategy and (2) its approach to insight and oversight?
- What are the industry's assumptions about the size and vitality of the commercial market (non-US government) for launching astronauts to low Earth orbit?
- What are the likely sources of non-Government passengers that are willing and able to afford the high cost of a trip to space?
- What are NASA's plans to acquire one or more operational commercial crew systems for ferrying astronauts to and from the International Space Station?
- What does NASA consider to be the biggest challenges confronting commercial crew developers as they attempt to develop and demonstrate their launch vehicle and crew systems?
- Have clear lines of responsibility and accountability been established to ensure safe and successful design, development and operation of human systems?
- What requirements and processes is NASA adopting to maintain the highest level of crew safety, including design and reliability standards for a launch abort system? What steps is NASA taking to coordinate requirements and regulations with the Federal Aviation Administration to ensure compatibility?
- What level of federal investment does NASA require to ensure that at least two commercial providers will be certified and sufficiently funded?

Background

Commercial Crew Development Program Acquisition Strategy

NASA initiated the Commercial Crew Development (CCDev) Program during FY2010, and divided it into four phases: CCDev1 (funded in FY2010 and completed April 2011) awarded grants to five companies; CCDev2, now underway with four funded and two unfunded participants (final milestones scheduled to be completed between May - July 2012); the third phase called the Integrated Design Contract (IDC) – to be awarded in July 2012 with a final integrated system design due April 2014; and the fourth phase known as Development/Test/ Evaluation/Certification (DTEC) that will, at its completion, provide a fully operational and certified commercial launch system. NASA's goal is to have at least two companies complete all four phases by early FY2017.

The CCDev1 and CCDev2 funded recipients received their awards under Space Act Agreements (SAA), which is another name for 'Other Transaction Authority'. Funded SAAs are much less onerous than traditional federal acquisitions, allowing NASA the flexibility to negotiate individual contracts with unique milestones, schedules, and payments for each grant recipient. There are no penalties for failure to deliver under an SAA, other than the recipient doesn't get paid for milestones that are missed. Just as importantly, accounting and audit standards are not required under an SAA. Companies prefer to perform under an SAA rather than following the usual FAR-based (Federal Acquisition Regulations) rules, which are expensive and cumbersome but are designed to ensure that companies meet rigorous accounting and performance standards.

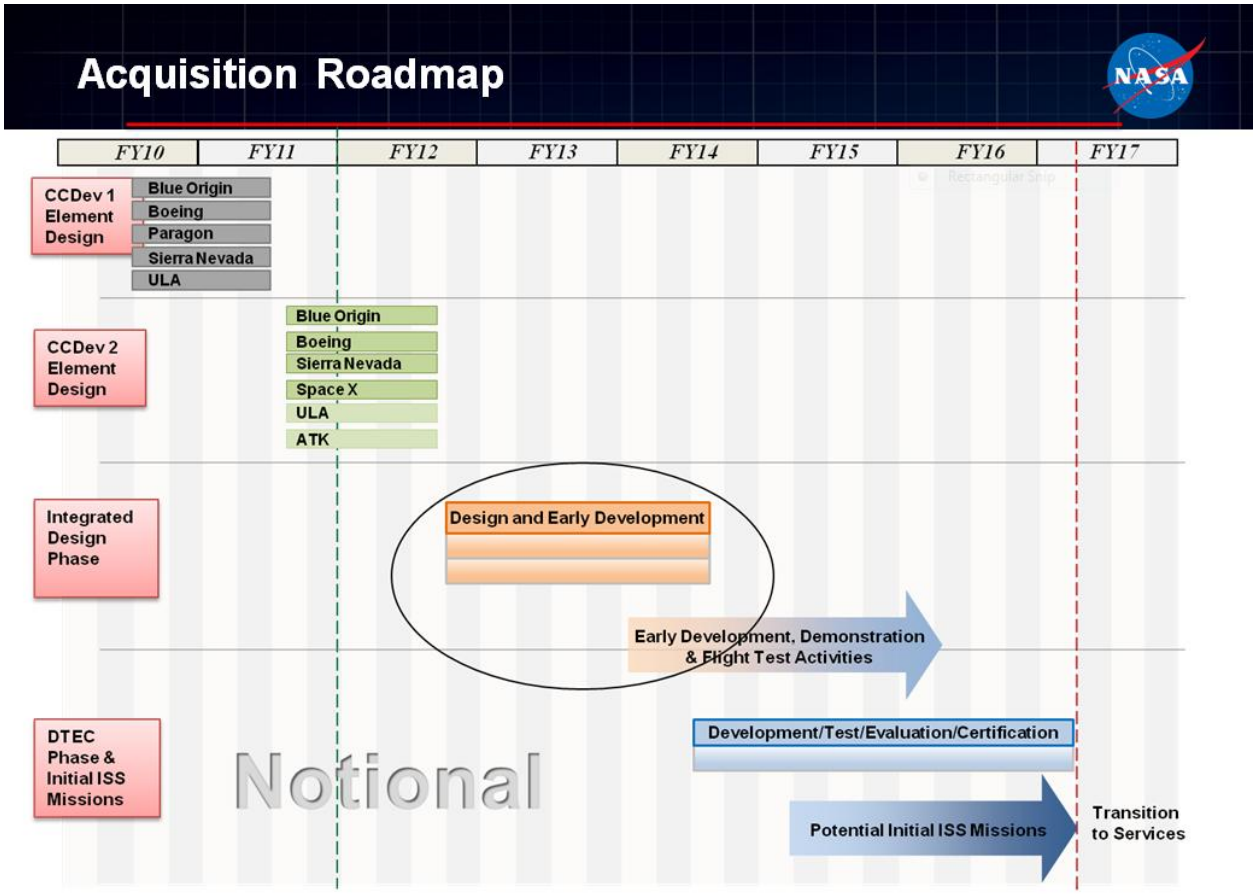
SAAs can be used for research and development activities, and for the acquisition of technologies in support of agency missions such as seeding development of commercial cargo and crew launch by private industry. However, SAAs cannot be used to acquire actual services; those must be purchased using the FAR. NASA intends to use the FAR with SAA-like exceptions for the Integrated Design Contract and the Development/Test/Evaluation/Certifications phases of the Commercial Crew Program.

Although the government is funding much of the development, private companies will ultimately own and operate the designs and systems. Instead of the government defining what is needed, the private companies will propose specific designs, development activities and schedules in meeting NASA's objectives. There is no requirement for the government to receive certified cost or pricing information. The government will not retain the Intellectual Property and data rights. Additionally, as a cost saving measure, NASA will delegate to the companies the responsibility to ensure that lower-level suppliers provide components meeting specified performance requirements. Previously, NASA would take on this oversight role, but by actually specifying parts and processes to be used. In this way NASA will no longer control *how* the government's requirements are met, and instead give that responsibility to the private companies.

Rather than require companies to comply with detailed NASA standards, NASA now intends to use 'embedded insight teams' in an attempt to determine whether the private company's designs, components, and systems "meet the intent" of NASA's standards and practices.

The chart that follows (taken from a NASA presentation) reflects the agency's strategy and schedule going forward. According to NASA the schedule shown assumes funding of $850 million per year for the program; for FY2012 the House CJS mark is $312 million, the Senate mark is $500 million.

As reflected in the chart, NASA is currently in the middle of the CCDev2 phase, with the IDC phase due to begin in July 2012. One issue that bears highlighting in this plan is that the agency intends to require interested applicants – presumably including some or all of the CCDev2 participants – to submit final IDC applications before they've completed their CCDev2 milestones. As a result, companies may be unable to fully characterize their achievements prior to NASA awarding IDC contracts. Based on current schedules, CCDev2 milestones for two funded companies won't be completed until the end of July 2012. The other two CCDev2 funded companies won't complete their milestones until early May 2012, after the April application deadline has expired. Consequently, there is a concern that those companies could be disadvantaged in the subsequent competition.



Note too that the number of horizontal bars for the IDC phase is less than the number for CCDev2 participants, an indication of NASA's plan to down-select (fund fewer companies in later phases). And going to the DTEC (final) phase, it appears that no more than two applicants are contemplated to be funded.

Report by the NASA Office of Inspector General

On June 30, 2011, NASA's OIG issued an audit report entitled: "NASA's Challenges Certifying and Acquiring Commercial Crew Transportation Services."[9] As the title suggests, the report highlights five programmatic challenges that must be addressed if NASA is to successfully develop a commercial space industry that could meet the agency's needs to low Earth orbit. They are:

- modifying NASA's existing safety and human-rating requirements for commercially developed systems;
- selecting the acquisition strategy for commercial crew transportation services;
- establishing the appropriate insight/oversight model for commercial partner vehicle development;
- relying on an emerging industry and uncertain market conditions to achieve cost savings; and
- managing the relationship between commercial partners, the Federal Aviation Administration (FAA), and NASA.

[9] (http://oig.nasa.gov/audits/reports/FY11/IG-11-022.pdf).

The IG report cautioned that assumptions about the size and growth of non-Government commercial markets are largely unknown.[10] As an example, the report pointed to the failed commercialization attempt by the Department of Defense Evolved Expendable Launch Vehicle (EELV) program. When expected commercial demand for EELV vehicles did not materialize, the costs grew 77 percent in 1 year. The two commercial providers formed a single entity in an effort to control costs, which eliminated competition.

The report concluded by stating:

> "While we are not making specific recommendations for corrective action, we believe NASA must pay particular attention to the challenges highlighted in this report. Specifically, NASA should:
>
> • clearly articulate to its commercial partners as soon as possible all requirements for commercially developed systems and the processes NASA will use for certifying such systems;
>
> • maintain robust communication with the emerging commercial spaceflight industry to ensure that Agency contracting mechanisms include the appropriate balance between insight and oversight that will provide NASA with sufficient information to assess and certify commercial partners' systems while providing companies the flexibility to be innovative;
>
> • clearly articulate how it will mitigate potential conflicts of interest that may arise as a result of analysis that could provide an unfair competitive advantage to a NASA partner; and
>
> • expand coordination with the FAA to avoid the potentially serious business impacts that would result if commercial companies were required to operate in an environment that included inconsistent sets of standards for NASA certification and FAA licensing of the same vehicle."

Commercial Crew Market Studies and Demand Projections

Two government-sponsored reports have been issued in the last 15 months that speak to the size and vitality of commercial (non-US government) demand for seats on commercial crew launch systems. The Federal Aviation Administration, through its office of Commercial Space Transportation, issued "A Report of the Commercial Human Spaceflight Workshop" that was held August 4 – 6, 2010. (http://www.faa.gov/about/office_org/headquarters_offices/ast/media/Report%20of%20the%20Commercial%20Human%20Spaceflight%20Workshop.pdf)

[10] See appendix B.

Section 403 of the 2010 NASA Authorization Act required NASA to do "…an assessment, conducted in coordination with the Federal Aviation Administration's Office of Commercial Space Transportation … of the potential non-Government market for commercially-develop crew and cargo transportation systems and capabilities…" NASA's study, "Commercial Market Assessment for Crew and Cargo Systems" was issued April 27, 2011. (http://www.nasa.gov/pdf/543572main_Section%20403(b)%20Commercial%20Market%20Assessment%20Report%20Final.pdf)

Of the two studies, the FAA report is clearly more sober – if not pessimistic – in its assessment about the size of the non-government markets, and the business case confronting companies seeking to serve them. Two paragraphs excerpted from the Executive Summary follow:

> "The workshop discussions demonstrated that no traditional business case exists that would allow companies to support near term orbital human transportation as fully commercial activities, utilizing company investment and servicing commercial customers, at a price point that can reasonably be expected to generate true commercial sales. This is true because there is insufficient market, including both government and non-government customers, to repay the steep investment required. However, if government interests are considered broadly (including stimulating economic growth and ensuring the health of the vital space industrial base) there may be a non-traditional "business case" that serves both national needs for access to low Earth orbit and the needs of the nascent commercial industry.
>
> Despite some optimistic claims to the contrary, there is little evidence of a commercial human orbital market at the current price point of orbital space flight. Although a few individuals have purchased commercial flights on Russian spacecraft, their ticket price only had to cover the marginal cost of a fully developed system supported by a stable government business base. No such system or government business base exists in the US, and when amortization of development costs and fully-loaded operational costs in a new start program are accounted for, the per seat cost soars to a price point which makes a commercial market vanishingly small. However, the workshop identified several approaches and considerations that may bring the price point down to a level where a commercial market can develop."

The FAA report does suggest, however, that "While a traditional business case (privately funded development with broad commercial and government customer base) could not be found, we believe that given the right assumptions a sufficient case can be built to justify NASA transitioning to the use of commercial human space transportation."[11]

The report concluded: "While appropriate, the move to transition human space transportation to the private sector is a high risk undertaking. If made, its risk means the government must recognize the full set of consequences and incorporate appropriate risk management in its planning and execution. It also means that the industry's growth can be accelerated substantially by the wise use of government policies and acquisition strategies."[12]

NASA's report, "Commercial Market Assessment for Crew and Cargo Systems", looks at both crew and cargo, but without taking into account NASA ISS crew and cargo needs. The report breaks down its projections into four categories; National Interests (nations without an indigenous human spaceflight capability that have sent astronauts to orbit using another nation's launch system); Space

[11] Report of the Commercial Human Spaceflight Workshop. FAA. Page 3.
[12] Ibid. Page 18.

Tourism; Applied Research and Technology Development; and Other Markets (e.g., satellite servicing).

For purposes of this hearing – focusing on non-government crew – it provides ten year projections using estimates for a 'Lower End of Range' and a corresponding 'Upper End of Range' number of seats. The associated cargo estimate reflects the amount of food, water and other consumables required to sustain the astronauts, relying on ISS astronaut consumption rates at 10.3 pounds per day per crew member.

NASA Non-Government Estimates (Over ten years)

	Lower Range	Upper Range	Amt. of Cargo
National Interests	36	186-216	6,180 – 28,430 lbs.
Space Tourists	8	143	990 – 17,700 lbs.

According to the NASA report, the variability of the National Interests estimate largely depends on whether one private company, Bigelow Aerospace, successfully launches an inflatable "commercial" space station as an alternative destination to ISS. With respect to Space Tourism, estimate variability is determined by the availability of crew transportation systems for non-professional astronauts, cost, and the current lack of a destination besides the ISS. One question for Congress to consider is the role of the ISS as a tourist destination.

The NASA report concludes by stating:

> "If successful, NASA's Commercial Crew Program will provide assured access to the ISS. It will end the gap in the US-provided human access to space and ensure we do not cede the US leadership role in space. It will also allow NASA to concentrate its limited resources on exploration beyond LEO, enabling NASA to go further faster in the exploration of the solar system. It benefits US private industry by strengthening the US industrial base, enhancing our capabilities, and capturing market share of a new high technology industry. In addition, it benefits the Nation with more jobs, economic growth, and opportunities for human spaceflight for a variety of people (e.g., astronauts, international partner personnel, scientists, spaceflight participants) for a variety of reasons (e.g., science, research, ISS operations, tourism).
>
> For these reasons, it is important that the Congress support NASA's commercial cargo and crew efforts. Delays in the availability of commercial spaceflight capabilities negatively affect the markets described in this report and degrade the business case for commercial providers. Catalyzed by a successful Commercial Crew Program, a stable commercial non-Government market is likely to emerge. Without this catalyst, prospects for such a market emerging are considerably lessened. New potential suppliers are poised to try, and now is the time to open this new vista for American industry."

The first panel of funded and unfunded CCDev2 companies will have an opportunity to describe their proposed plans for launch and crew systems, and the challenges they face. The second panel consisting of NASA's Inspector General and the Associate Administrator for Human Exploration and Operations will discuss the issues confronting the agency as it moves forward with the unique acquisition strategy to develop commercial crew vehicles as well as stimulating and supporting the market as the anchor tenant.

Appendix A

On April 18, 2011, NASA awarded approximately $270 million to four commercial companies to continue development of commercial rockets and spacecraft capable of safely flying astronauts into orbit and to the International Space Station. The award was the second phase of the agency's Commercial Crew Development effort, known as CCDev2, proposals selected were:

- Blue Origin: $22 million. The company is working on a space vehicle design development for their biconic "New Shepard" spacecraft, designed to take off and land vertically.

  Blue Origin was founded in 2000 by Jeff Bezos, the CEO of Amazon.com, in Kent, WA and is privately funded. Originally focused on suborbital flights, the company has begun development of an orbital spacecraft with funding from NASA's CCDev awards. also

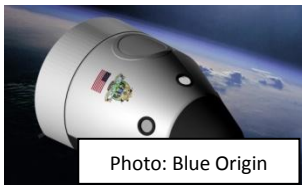


Photo: Blue Origin

- Sierra Nevada Corp.: $80 million. Sierra Nevada is designing a lifting body crew capsule called "Dream Chaser."

  Sierra Nevada Corp's Space Exploration Systems (SES) product line is developing the "Dream Chaser" spacecraft, which it acquired in the 2008 purchase of SpaceDev. Work on the vehicle is based in Louisville, CO with additional offices in Houston, TX. Corporate wide, Sierra Nevada Corp has seven business units located at 29 different locations.

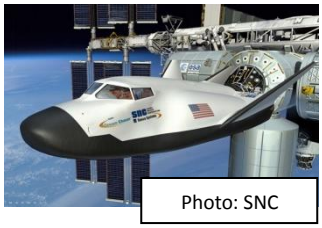


Photo: SNC

- Space Exploration Technologies (SpaceX): $75 million. SpaceX plans to use the award to develop an escape system for a crewed version of its Dragon capsule, an uncrewed version of which has already flown.

  SpaceX was founded in 2002 by Elon Musk, who also co-founded PayPal, Tesla Motors and serves as Chairman of SolarCity, with the goal of developing low cost access to space.

  SpaceX headquarters is located in Hawthorne, CA where it manufactures the Falcon 9 rocket and the Dragon capsule.

Photo: SpaceX

Appendix A

- The Boeing Company: $92.3 million. The Boeing Company will continue development of the CST-100 crew capsule, including maturation of the design and integration of the capsule with a launch vehicle.

  The CST-100 development work is a project under the Space Exploration unit of the Network and Space Systems business line primarily conducted by offices in Houston, TX.

Photo: Boeing

NASA has also awarded two unfunded Space Act Agreements that has allowed the agency to collaborate with two additional rocket providers on the CCDEV2 program.

- United Launch Alliance (ULA): for the CCDev2 program, provide data on the Atlas V rocket, a flight-proven expendable launch vehicle used by NASA and the Department of Defense for critical space missions.
  NASA will share its human spaceflight experience with ULA to advance crew transportation system capabilities and the draft human certification requirements. ULA will provide NASA feedback about those requirements, including providing input on the technical feasibility and cost effectiveness of NASA's proposed certification approach.

Photo: ULA

- Alliant Techsystems (ATK): for the CCDev2 program, collaborate on the development of the Liberty Launch System.

  NASA and ATK will review and discuss Liberty system requirements; safety and certification plans; computational models of rocket stage performance; and avionics architecture designs. The agreement outlines key milestones including an Initial System Design review, during which ATK will present to NASA officials the Liberty systems level requirements, preliminary design, and certification process development.

  The Liberty rocket is similar to the canceled Ares 1 rocket that was under development at NASA within the Constellation program. The Ares 1 rocket used an ATK 5-segment solid rocket booster motor as a first stage. The Liberty rocket would use the same 5-segment rocket motor for a first stage and use the main liquid engine from the Ariane-5 rocket built by the French company Arianespace as the upper stage.

Photo: ATK

Appendix B

Excerpts from
"NASA's Challenges Certifying and Acquiring
Commercial Crew Transportation Services"
NASA Office of the Inspector General
Report No. IG-11-022, June 30, 2011

Lessons Learned from the Evolved Expendable Launch Vehicle Program.
Historically, past predictions of the demand for commercial launch vehicles have been overly optimistic. Moreover, competition in a demand-constrained environment can have unintended consequences. For example, Lockheed Martin and the Boeing Company were rival launch vehicle service providers in the Department of Defense's Evolved Expendable Launch Vehicle (EELV) Program. When expected demand for EELV launch vehicles did not materialize, estimated prices for launch services increased 77 percent in 1 year. In an effort to provide more cost-effective and reliable launch vehicles in the face of limited demand for their services, the companies combined their EELV operations in December 2006 to form United Launch Alliance, LLC. The formation of United Launch Alliance eliminated competition and forced the Government to rely on a single provider of launch services to meet its intermediate- and heavy-class launch vehicle requirements. Consequently, near-term limited demand can stifle competition – a cornerstone of NASA's commercial crew services goals. (Page 19.)

Impacts of Near-Term Limited Demand.
Because of the near-term limited demand for commercial crew transportation services, it is likely that NASA's commercial partners will attempt to augment their business with commercial and Government satellite launches. For example, SpaceX is developing rockets that can transport satellites to orbit, including a rocket to compete with United Launch Alliance in the EELV market. However, FAA predictions for satellite launch vehicle demand through 2019 remain flat or slightly decline, although the FAA points out that opportunities for growth in the overall launch vehicle market could occur if a viable, commercial human spaceflight market emerges. (Page 19.)

Appendix C

"Report of the Commercial Human Spaceflight Workshop"

FAA Office of Commercial Space Transportation
Workshop Held August 4 – 6, 2010

Key Findings

- While a traditional business case (privately funded development with broad commercial and government customer base) could not be found, we believe that given the right assumptions a sufficient case can be built to justify NASA transitioning to the use of commercial human space transportation.

- The workshop participants expressed a general confidence that a commercial human space flight market will develop over time. They had considerably less confidence in the near term viability of human space flight as a purely commercial enterprise. The more experienced space flight companies unanimously agreed that they cannot see a viable business case for their companies unless specific government actions are taken to reduce the level of corporate investment required, limit financial liability, and guarantee a stable market. They cited consistently over-estimated markets and under-estimated technical challenges in past space flight programs. One entrepreneurial company with limited space flight experience felt optimistic that it could lower its costs to a point where significant government investment would not be required.

- The first principles financial considerations of a satisfactory business case are defined by straightforward mathematics (see appendix C). Analyses performed in the course of this work show that the currently defined market, including both commercial and government customers, is simply too small and speculative to give confidence that privately funded efforts can achieve an acceptable rate of return on the investment. Absent significant government investment in system development or the emergence of a non-government customer significantly larger than NASA, the required price significantly exceeds the cost of purchasing seats from Russia.

- The enormous uncertainties in market size and sustainability further undermine the business case for investment. The current absence of NASA requirements or declared intentions to fly humans in LEO post 2020 is both critical and easily remedied. An assured market limited to ten missions, potentially split between multiple providers, does not provide a sufficient sales volume to repay the significant investment required.

- Industry also has significant concerns about liability, the availability of funding for system development, and the challenge of repaying that investment in a reasonable period at fair market rates of return.

- The commercial aerospace industry possesses the engineering skills and manufacturing capabilities to deliver high quality launch vehicles and spacecraft. However, none of these companies has experience conducting human space flight operations. Thus NASA will want to remain closely involved in operations of complex human missions conducted on its behalf.

- As a result of these issues, industry and the panel agree that if policy makers decide that a transition to commercial launch services is in the national interest, the government must take aggressive measures to support the development of the industry, such as the following:

    a. Act as the anchor tenant customer for the foreseeable future, including guaranteeing a market greater than five years of ISS support.

    b. Invest in system and/or infrastructure development to limit capital require-ments and shorten payback periods. Several companies required that the government fund at least part of the development of the human system as a condition of their participation.

    c. Offer or facilitate limitations on liability.

    d. Provide mature, stable requirements, including human rating requirements, as soon as possible.

    e. Ensure that NASA and the FAA agree on a coherent set of requirements and regulations that enable fielded systems to serve both government and non-government customers.

    f. Insulate commercial providers from financial penalties associated with schedule impacts that may arise from conservative decisions required to operate safely.

The panel believes that moving human space flight to a commercial business model is appropriate and timely, but possible only under three pivotal assumptions:

- That there is a compelling national interest in the government continuing to fly humans to low earth orbit beyond 2020 and that such interest is codified in policy and budget planning.

- That there is a compelling national interest in investing in commercial human space capabilities, even at a cost significantly greater than Soyuz rates initially, or alternatively, with the government bearing a significant portion of the system development costs.

- That the government ensures that NASA requirements and FAA regulations are written to guarantee that flight systems developed for government missions are also acceptable and affordable for commercial customers.