SPACEX RESPONSES
QUESTIONS FOR THE RECORD
QUESTIONS POSED BY UNITED LAUNCH ALLIANCE

SENATE COMMITTEE ON APPROPRIATIONS
SUBCOMMITTEE ON DEFENSE

April 9, 2014

HEARING ON NATIONAL SECURITY SPACE LAUNCH PROGRAMS

1. SpaceX's manifest shows numerous launches for foreign countries and foreign entities. What export agreements and licenses has SpaceX obtained to conduct these missions? What controls does SpaceX have in place to protect sensitive technology and technical knowledge?

   RESPONSE: Launch vehicles, spacecraft, rockets, related parts and components, and associated technical data are classified as "defense articles" on the U.S. Munitions List ("USML") and subject to stringent national security regulations under the Arms Export Control Act, 22 U.S.C. § 2778a ("AECA"). Launch vehicles, spacecraft, and related equipment are controlled by the U.S. Government as "Significant Military Equipment" and "Major Defense Equipment". *See* 22 C.F.R. § 121.1(b)(3); 22 U.S.C. § 2794(6). These items are included within USML Categories IV (Launch Vehicles, Guided Missiles, Ballistic Missiles, Rockets, Torpedoes, Bombs, and Mines) and XV (Spacecraft Systems and Associated Equipment). The AECA is implemented by the ITAR, which provides a framework to regulate the manufacture, marketing, brokering, sale, and export of defense articles and defense services. Under the ITAR, a "defense service" includes, inter alia, the furnishing to foreign persons of any "technical data" controlled under the ITAR, whether in the United States or abroad. The ITAR is administered and enforced by the U.S. Department of State, Directorate of Defense Trade Controls ("DDTC"), in coordination with Congress, the Department of Defense, Department of Commerce, Department of Justice, the National Security Agency, and various other intelligence agencies. SpaceX is fully compliant with these regulations and has the requisite approvals and licenses for all customers.

2. Why is SpaceX looking for alternative launch sites for commercial launches? What is the problem with the current federal ranges in Cape Canaveral and Vandenberg? Does SpaceX anticipate launching DoD missions from these alternative launch sites? Mr. Musk, who will pay the infrastructure costs for these additional launch sites? Doesn't this add to an oversupply of costly to maintain infrastructure like we saw in the 1990s?

   RESPONSE: SpaceX is pursuing the world's first commercial launch site. SpaceX will fund the infrastructure costs for this facility, as we have done for all of our launch sites. SpaceX is establishing a commercial launch site to support future commercial launches and to reduce congestion and any possible schedule conflicts on the federal ranges. SpaceX will launch DOD payloads from the federal ranges, as we anticipate this will be the customer's wish. Since SpaceX does not require nor do we seek that the taxpayer fund 100 percent of our fixed costs—as ULA requires of the taxpayer at its launch sites—we fail to see how an additional, self-funded commercial launch site to support our commercial business would "add to an oversupply of costly to maintain infrastructure" [sic].

3. Mr. Musk, you said in 2011 in an interview with Space News "In the space business [a two-year delay] is on time" and Space X finances are heavily dependent on milestone payments from NASA. Mr. Musk, should the government be saddled with the extra carrying costs for storing a satellite, because you believe a "two year delay" is business as usual?

   RESPONSE: SpaceX does not believe a two-year delay is business as usual. The comment made was in jest as relates to typical space systems development schedules, not the execution of a recurring activity like launch services.

4. Mr. Musk, can you please explain the number of flight anomalies your company has experienced since 2003, the value of those contracts and the value of those payloads?

   RESPONSE: SpaceX has maintained a 100 percent success rate for the Falcon 9 launch vehicle. SpaceX has launched the Falcon 9 eight times to date. SpaceX has successfully launched ten times, including the last two flights of the Falcon 1 launch vehicle, a pathfinder launch vehicle that has been discontinued. The first three flights of the Falcon 1 resulted in failures. On its fourth flight in September 2008, SpaceX's Falcon 1, our prototype rocket, became the first privately developed liquid-fueled rocket to orbit Earth.

   In October of 2012 SpaceX experienced a first stage engine anomaly, resulting in the Falcon 9 commanding an early shut down of the engine. As designed and consistent with the redundant 9 engine configuration that enables engine-out capability, the Falcon 9 corrected its trajectory and delivered the Dragon spacecraft to its intended orbit, resulting in mission success. The issue was eliminated with the Merlin 1D engine.

   In September of 2013, SpaceX successfully launched the CASSIOPE payload to its intended orbit. After the primary mission was successfully concluded, SpaceX attempted a planned demonstration of a restart of the second-stage engine after a long duration coast. The restart attempt was not successful. Following an investigation, SpaceX determined that this resulted from the lines housing the liquid TEA/TEB being exposed to colder than expected temperatures, ultimately causing some of the TEA/TEB to freeze. As it was designed to do, the flight computer recognized the off-nominal start and the engine was subsequently shutdown. To ensure the TEA/TEB lines are not unexpectedly cooled going forward, SpaceX has installed additional thermal insulation. This resolution was successfully demonstrated on subsequent flights to Geostationary Transfer Orbit (GTO).

5. Will you be able to support all of the original requirements of the EELV Systems specification (SIS)? [sic] If so when will you be fully capable to support the entire mission manifest requirements of the DOD and National Security constellation?

   RESPONSE: SpaceX designed the Falcon 9 and its follow-on, the Falcon Heavy, from the outset to meet the EELV design specifications, including the EELV Standard Interface Specification (SIS) and System Performance Requirements Document (SPRD), at no charge to the U.S. Air Force.

   SpaceX today can support approximately 60 percent of the EELV launches planned through 2019. SpaceX will be able to support 100 percent of the EELV launch requirements with both Falcon 9 and Falcon Heavy prior to the Phase II Acquisition, beginning in 2018.

6. You have been an advocate of fair and open competition. Should all competitors be required to meet the same level of requirements and standards? If so, when will your company be able to meet all the requirements and standards the other EELV Provider currently meets?

   RESPONSE: Yes, SpaceX supports fair competition; we are opposed to monopolies as they create negative impacts for cost, customer service, and innovation. SpaceX will meet all of the mission assurance requirements imposed by the EELV Program. SpaceX and ULA currently compete against each other for NASA launches on a level competitive playing field, with NASA competitively sourcing launches on a FAR Part 12 Commercial Item basis, using firm fixed-price contracts for launch services and associated mission assurance tasking. This approach demonstrates the viability of creating a fair and level playing field in a competitive procurement environment.

   However, for a competition to be truly fair and open in the EELV Program, ULA will need to account for its $1B annual SELC payments and offer a fully-burdened launch service price, until such time as the Launch Capability funds are eliminated. Further recommendations as to how to structure a fair and level competition as the EELV Program exists its sole source acquisition environment are in the written statement provided to the Committee.

7. How have previous mission anomalies affecting the Falcon launch vehicle and the Dragon capsule been resolved? What were the causes? What corrective actions have been taken? Which outside organizations participated in these anomaly reviews?

   RESPONSE: Yes, previous mission anomalies have been resolved per SpaceX's established processes. The causes are proprietary in nature, export controlled under the ITAR, and cannot be disclosed. The causes have been addressed by component changes and improved processes as necessary. NASA (Launch Services Program and Commercial Crew Program Offices) and the Air Force have participated in major anomaly reviews and are briefed on all in-flight anomalies. This process is likely very similar to ULA's anomaly investigation and resolution processes, such as with the recent upper stage engine anomaly on the Delta IV launch of the GPS 2F-3 satellite in October 2012, and other such anomaly investigations ULA has had to undertake.

   The other questions posed here have been answered above or below.

8. Mr. Musk, given the observed anomalies on some of your Falcon 9 launches – debris falling from the thrust section of the vehicle's first stage, engine nozzle impacts during 2nd stage separation, and failure to properly inject a secondary payload into orbit, can you describe the system reliability of the Falcon 9 when compared to the reliability of the current EELV family of launch vehicles?

   RESPONSE: SpaceX has maintained a 100 percent mission success rate for the Falcon 9 launch vehicle. SpaceX's success rate to date is equivalent with current EELV providers, albeit with fewer launches so far. The gap in heritage will be reduced over time inevitably. SpaceX has *substantially greater actual flight heritage* of its propulsion systems than the Atlas V, the Delta IV, or the Delta IV Heavy when launch contracts were awarded using these systems at the beginning of the EELV Program. The flight heritage on SpaceX's Merlin engines *today surpasses* the flight heritage of any engine used on the current EELV family of launch vehicles—including the Russian-made RD-180 engine.

In any discussion of anomalies, it is important to point out that the current EELV launch vehicles have had *multiple* anomalies over time, including a significant anomaly with the RL-10B uppers stage engine in 2012, which led to a lengthy Air Force Accident Investigation Board review; an Atlas V upper stage anomaly in 2007 that placed two NRO satellites into the wrong orbit (John Kelly, *Florida Today*, June16, 2007); and a 2004 first stage anomaly of the Delta IV Heavy rocket, which resulted in the demonstration satellite on the mission not reaching its intended orbit.

In terms of system reliability, the Falcon 9 is designed for the highest reliability starting at the architectural level. Because 91 percent of launch vehicle failures in the past two decades can be attributed to engine failures, avionics failures or stage separation anomalies, the Falcon 9 design incorporates robust, fault-tolerant propulsion systems, fault-tolerant avionics and controls systems with internal triplication and redundant harnessing, and a minimum number of separation events. With its nine-engine configuration, Falcon 9 features a unique engine-out capability, and is designed to permit the loss of up to two engines in flight without compromising the mission. The Falcon 9 is the only American rocket since the Saturn V with any engine-out capability; any other launch vehicle in the world, including the current EELV fleet, that encounters a major engine anomaly on ascent will almost certainly fail its mission.

The Merlin engine—which is designed and manufactured by SpaceX and powers the Falcon 9 first and second stages—is a human-rated engine with high structural margins and a highly reliable, redundant ignition system. A hold-before-release system verifying nominal operations of the first-stage engine before liftoff has been successfully demonstrated multiple times. Rigorous qualification and acceptance testing from the component to the vehicle system level are part of SpaceX's "test what you fly" approach, and the company uses liquid-fueled engines and non-pyrotechnic, resettable separation systems that allow testing of actual flight hardware before flight.

9. A key requirement of all USG payloads is to be vertically integrated on the LV, yet your system requires horizontal integration, which in turn means potentially billions spent in redesigning all USG satellites. When will Space-X comply with the current requirements? If not Mr Musk, is it SpaceX's position that the USG must shoulder the cost burden of redesigning its spacecraft to enable horizontal integration because the Falcon 9 cannot accommodate vertical integration of payloads?

   RESPONSE: SpaceX has committed to vertically integrate payloads. The requirement for having the capability for vertical integration is contained in the EELV Program's EELV Standard Interface Specification (SIS), System Performance Requirements Document (SPRD), and in the New Entrant Certification Guide (NECG). We would be interested in understanding the basis for the assertion as relates to "billions of dollars [being required] in redesigning all USG satellites" and would request an official and independent analysis to support the assertion made in the question.

10. Many launch companies have provided low initial prices, and based their sustainment of those prices on high launch rates. Mr Musk, can you provide a single example of a Falcon 9 procurement that was actually sold to the government for the price advertised on your website?

    RESPONSE: SpaceX's commercial price for the Falcon 9 launch vehicle is roughly $60M. SpaceX is the only launch services company in the world that is fully transparent about its pricing. SpaceX's prices to the Government are consistent with our published commercial launch service prices, which are adjusted to reflect the added Government requirements and mission-

unique services identified in the respective Requests for Proposals (RFP). SpaceX charges for these additional tasks on a firm, fixed-price basis. Even with the additional government requirements, SpaceX's prices to the Government are a fraction of ULA's prices, and SpaceX neither needs nor desires the $1B annual SELC subsidy ULA receives to cover 100 percent of its fixed costs and business overhead.