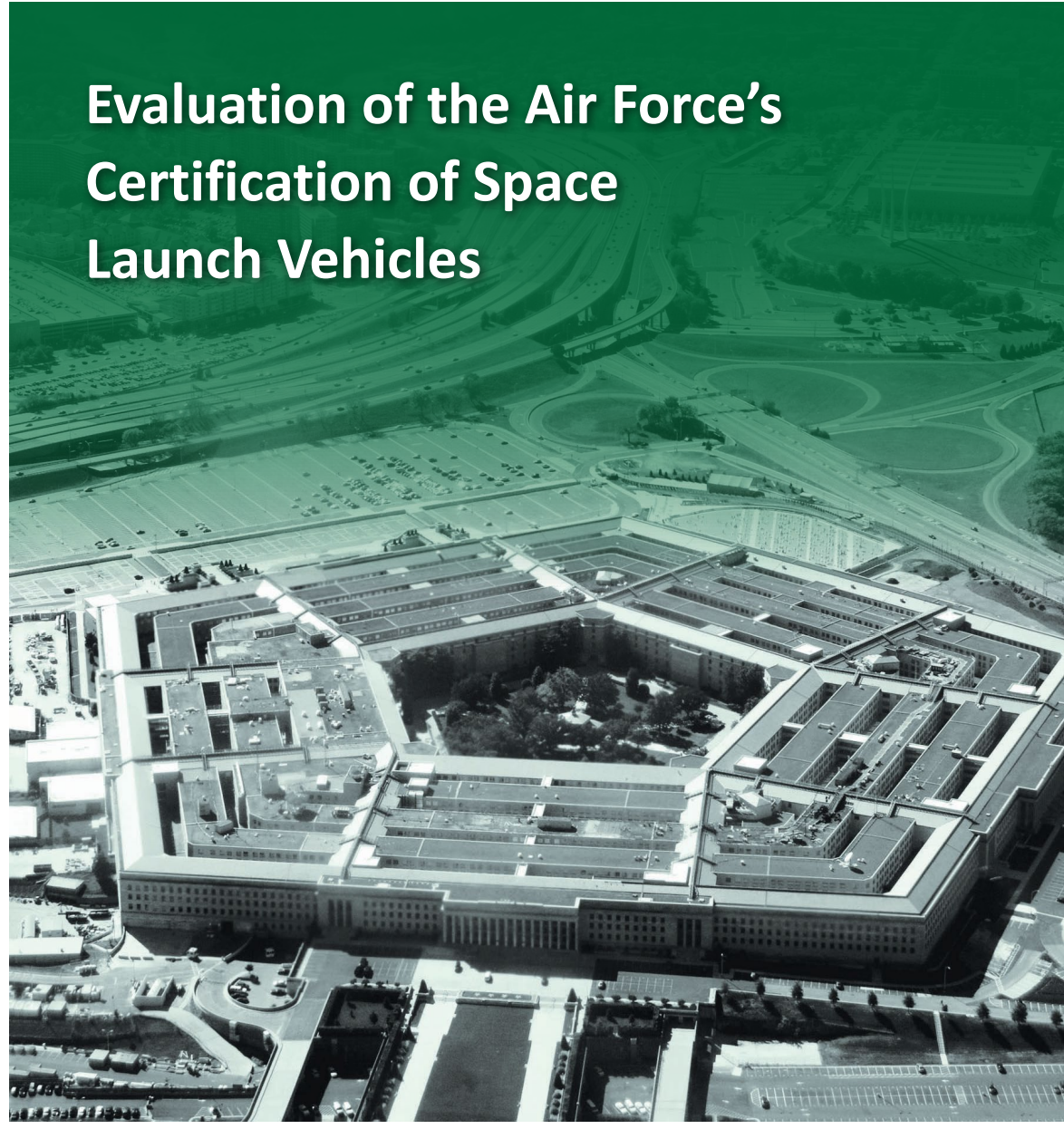


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# INSPECTOR GENERAL

*U.S. Department of Defense*

SEPTEMBER 4, 2020



## Evaluation of the Air Force's Certification of Space Launch Vehicles

INTEGRITY ★ INDEPENDENCE ★ EXCELLENCE

The document contains information that may be exempt from mandatory disclosure under the Freedom of Information Act.

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# Results in Brief

## *Evaluation of the Air Force's Certification of Space Launch Vehicles*

September 4, 2020

### Objective

The objective of this evaluation was to determine whether Air Force Space and Missile Systems Center (SMC) officials complied with the Air Force Launch Services New Entrant Certification Guide (NECG) when certifying the launch system designs for the National Security Space Launch (NSSL)-class (formerly known as the Evolved Expendable Launch Vehicle-class) SpaceX Falcon family of launch vehicles.<sup>1</sup> Additionally, during the evaluation we expanded the objective to also determine whether SMC officials applied the design validation approach in the NECG to three other space launch providers' new entrant launch vehicles that were in development: Northrop Grumman Innovation Systems, United Launch Alliance, and Blue Origin, LLC. During the evaluation, these three launch providers' certification processes were still in progress.

### Background

The NECG is a technical guide that provides a risk-based approach that the SMC uses to certify the capabilities of prospective new entrant launch service providers, as well as new launch vehicle configurations proposed by existing launch services providers, to launch safe and reliable national security space missions. The Space Exploration Technologies Corporation (SpaceX) was the first launch service provider to have a launch vehicle certified by the SMC in

<sup>1</sup> "United States Air Force Launch Services New Entrant Certification Guide (NECG)," October 27, 2011.

### Background (cont'd)

accordance with NECG criteria. Following SpaceX, three other prospective launch service providers submitted proposed launch vehicles for certification by the SMC in accordance with the NECG—Northrop Grumman Innovation Systems, United Launch Alliance, and Blue Origin, LLC.

SMC implements the NECG through Launch Enterprise Directorate Operating Instruction 17-001, "Air Force Launch Systems Maturity Assessment Process." According to SMC Operating Instruction 17-001, SMC officials may certify a new launch vehicle configuration based on a risk assessment. SMC Operating Instruction 17-001 also states that the NECG-required design validation assessments should be completed 12 months before the first launch of an operational payload.

### Finding

SMC officials generally complied with the Air Force's Launch Services NECG and its implementing instruction, SMC Operating Instruction 17-001, when certifying the capabilities of SpaceX and its Falcon family of launch vehicles. Additionally, in preparation for future launch vehicle contract competitions, SMC officials generally complied with the NECG to accomplish the design validation assessments of the three other potential launch vehicle providers' new entrant launch vehicles that were still in development. Those three additional providers were Northrop Grumman, ULA, and Blue Origin.

(FOUO) In May 2015 and June 2018, SMC officials certified two SpaceX Falcon family launch vehicles for NSSL missions. As a result, SpaceX is currently an approved launch vehicle provider. However, based on SMC's experience with SpaceX, we identified two areas where SMC officials could improve their oversight of future, potential launch vehicle providers and their assessment of launch vehicles with reused components. [REDACTED]



# Results in Brief

## Evaluation of the Air Force's Certification of Space Launch Vehicles

### Finding (cont'd)

(FOUO) [Redacted]

(FOUO) [Redacted]

Limiting the time to conduct independent verification and validation of a provider's launch vehicle could constrain SMC in determining whether a launch vehicle can reliably launch NSSL payloads at acceptable risk. Such constraints remain a concern for the SMC's independent verification and validation of other new launch vehicle configurations that have not yet been certified.

Second, SMC officials did not assess the risk of allowing the use of previously used launch vehicle components on subsequent space launches with SpaceX's Falcon family of launch vehicles. This occurred because the SMC and SpaceX did not agree to reuse launch vehicle components on any NSSL missions to date although SpaceX's Falcon family of launch vehicles are designed for reuse. Additionally, SMC officials did not establish standards for assessing the reliability of reusable launch vehicle components until March 2019. If the Air Force intends to authorize SpaceX to include reused launch vehicle components on any future Air Force launch missions, the SMC should be proactive and perform the necessary NRDV assessments in accordance with the SMC launch vehicle reusability standards.

### Management Comments and Our Response

(FOUO) [Redacted]

(FOUO) In response to the draft report, the Director provided a copy of an Air Force Space Command Instruction that solidified the conditions upon which the SMC Commander makes a certification decision.

[Redacted]

### Deleted Recommendations

In a draft report provided to the Air Force for management comments, we made two recommendations to the Director of the SMC Launch Enterprise Directorate: 1) develop a plan to review the impact of a potential launch vehicle provider's noncompliance with negotiated timelines for the delivery of technical data to the SMC in support of flight worthiness certifications for NSSL missions; and 2) develop procedures to complete



# Results in Brief

## *Evaluation of the Air Force's Certification of Space Launch Vehicles*

### ***Recommendations (cont'd)***

the mission assurance activities necessary to fully assess the risk of authorizing launch vehicle providers to reuse launch vehicle components on NSSL missions.

In addition to his response to the draft report, the SMC Director also provided documentation that was not provided to us during the evaluation. We reviewed the documentation and concluded that, had we received and reviewed the documents during the evaluation, we would not have made these two recommendations in the draft report. Therefore, we deleted the recommendations.

Please see the Recommendations Table on the next page for the status of recommendations.

### **Recommendations Table**

<b>Management</b>	<b>Recommendations Unresolved</b>	<b>Recommendations Resolved</b>	<b>Recommendations Closed</b>
Director of the Air Force Space and Missile Systems Center's Launch Enterprise Directorate	None	None	None

**Note:** The following categories are used to describe agency management's comments to individual recommendations.

- **Unresolved** – Management has not agreed to implement the recommendation or has not proposed actions that will address the recommendation.
- **Resolved** – Management agreed to implement the recommendation or has proposed actions that will address the underlying finding that generated the recommendation.
- **Closed** – OIG verified that the agreed upon corrective actions were implemented.



**INSPECTOR GENERAL  
DEPARTMENT OF DEFENSE  
4800 MARK CENTER DRIVE  
ALEXANDRIA, VIRGINIA 22350-1500**

September 4, 2020

**MEMORANDUM FOR UNITED STATES SPACE FORCE AIR FORCE SPACE AND MISSILE  
SYSTEMS CENTER**

**SUBJECT: Evaluation of the Air Force's Certification of Space Launch Vehicles  
(Report No. DODIG-2020-126)**

This final report provides the results of the DoD Office of Inspector General's evaluation. We previously provided copies of the draft report and requested written comments on the recommendations. We considered managements' comments in finalizing the report and included them in the report. In response to the draft report, the Director of the Air Force Space and Missile Systems Center's Launch Enterprise Directorate provided management comments and also provided documentation that was not provided to us during the evaluation. We reviewed the documentation and concluded that, had we received and reviewed the documents during the evaluation, we would not have made the recommendations in the draft report. Therefore, we deleted the recommendations.

We appreciate the cooperation and assistance received during the evaluation. If you have any questions, please contact [REDACTED]

A handwritten signature in black ink, appearing to read "R. Stone", is written over a light blue horizontal line.

Randolph R. Stone  
Assistant Inspector General for Evaluations  
Space, Intelligence, Engineering, and Oversight

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# Introduction

## Objective

The objective of this evaluation was to determine whether Air Force Space and Missile Systems Center (SMC) officials complied with the Air Force Launch Services New Entrant Certification Guide (NECG) when certifying the launch system designs for the National Security Space Launch (NSSL)-class (formerly known as the Evolved Expendable Launch Vehicle-class) SpaceX Falcon family of launch vehicles.<sup>2</sup>

Additionally, we determined whether SMC officials applied the design validation approach in the NECG to three other space launch providers’ new entrant launch vehicles that were in development: Northrop Grumman Innovation Systems, United Launch Alliance, and Blue Origin, LLC. During the evaluation, these three launch providers’ certification processes were still in progress. Therefore, we determined whether SMC officials followed the NECG for each of the three launch providers, as of December 2019.

## Background

(FOUO) The NSSL program began as the Evolved Expendable Launch Vehicle program with the overarching objective of developing a national launch capability aimed at reducing the recurring cost of space launches, while maintaining launch vehicle reliability, operability, and capability levels. The Air Force identified NSSL program requirements (or key performance parameters) in August 1995 and updated those requirements throughout the subsequent decades. [REDACTED]

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[REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]<sup>3</sup>

<sup>2</sup> United States Air Force Launch Services New Entrant Certification Guide (NECG),” October 27, 2011.  
The “Falcon family of launch vehicles” includes the Falcon 9 configuration and the Falcon Heavy configuration.  
Fiscal Year 2019 National Defense Authorization Act, Section 1603(b)(1), states “effective March 1, 2019, the Evolved Expendable Launch Vehicle program of the [DoD] shall be known as the National Security Space Launch program.”  
<sup>3</sup> “Air Force Space Command’s Capability Production Document for Spacelift Systems,” May 31, 2016.  
A space “payload” is the total complement of equipment or spacecraft carried by a launch vehicle for the performance of a particular mission in space.

### ***Air Force Development of New Space Launch Vehicle Providers***

Prior to 2011, when the SMC decided to consider new entrants from industry to provide launch services to the Air Force, the SMC relied on a single launch vehicle provider to support NSSL program requirements. Specifically, the SMC contracted with the United Launch Alliance (ULA) to provide the DoD with space launch services.<sup>4</sup> The ULA provided the DoD with launch services through the use of two NSSL-class space launch vehicles—the Delta IV and the Atlas V. Each space launch vehicle supported military, intelligence, and commercial space launch mission requirements. According to SMC officials, the NSSL program provided the DoD with assured access to space for national security missions that required transporting medium and heavy payloads into various Earth orbits with high reliability and low risk. By 2011, the emergence of at least three new launch vehicle provider companies with promising designs (including SpaceX) and the Air Force’s desire to onboard those companies when they had proven they could meet NSSL key performance parameters and reliability requirements, prompted the Air Force to allow companies to apply for certification of their launch system. Also in 2011, the Air Force’s desire to stop using Russian-manufactured rocket engines (equipped on the ATLAS V launch vehicle) prompted the Air Force to revisit the process for seeking new commercial launch vehicle contractors capable of addressing NSSL key performance parameters.

### ***The Former Secretary of the Air Force and the Institute for Defense Analyses Address Fundamental Certification Issues***

In January 2015, the Secretary of the Air Force, as the DoD Executive Agent for Space, tasked the Institute for Defense Analyses to assemble an independent panel of experts to conduct a Broad Area Review summarizing lessons learned from the Air Force’s and the National Aeronautics and Space Administration’s (NASA) ongoing certification processes. The review panel was tasked with providing specific recommendations to improve the Air Force’s new entrant launch certification process.

(FOUO) [REDACTED]

<sup>4</sup> On December 1, 2006, the Boeing Company and Lockheed Martin Corporation announced that they completed the transaction combining their respective expendable launch vehicle businesses, forming the joint venture called ULA.

(FOUO) [REDACTED]

(FOUO) [REDACTED]

(FOUO) [REDACTED]

In January 2016, the Secretary of the Air Force testified before the Senate Committee on Armed Services. In her opening statement, the Secretary stated that the Air Force had “contributed time, resources, energy, and expertise to help develop [new entrant] systems, understanding their needs, certifying them for Government applications, learning from their failures, and celebrating their successes.” The following companies are the current and potential launch vehicle providers cultivated by the SMC.

<sup>5</sup> According to SMC officials, launch vehicle providers like SpaceX formally agreed to each of these requirements as they began the launch vehicle certification process.

### Space Exploration Technologies Corporation

According to its website, the Space Exploration Technologies Corporation (SpaceX) is one of the world’s fastest growing providers of launch services, with over 100 space missions completed and over \$12 billion in commercial satellite launches in addition to U.S. Government missions.

(FOUO) [REDACTED]

The Falcon Heavy launch vehicle—designed and built based on the Falcon 9—shares many common components and systems with the Falcon 9. For example, the Falcon Heavy contains three first-stage booster rockets and one second-stage booster rocket (the Falcon 9 has a single booster rocket). Both vehicles are designed for reuse and are equipped with landing legs and grid fins for landing each of their first stage boosters.

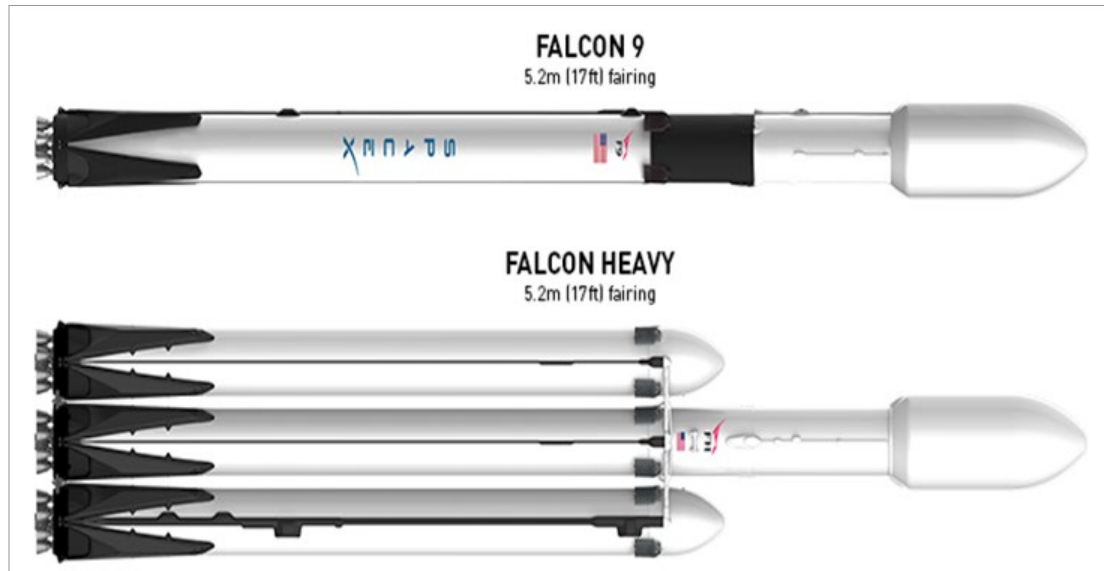


Figure 1. SpaceX’s Falcon 9 and Falcon Heavy Launch Vehicles  
Source: SpaceX, January 2020.

### ***Northrop Grumman Innovation Systems***

On June 6, 2018, Northrop Grumman Corporation announced its acquisition of Orbital ATK, Inc. Orbital ATK was renamed Northrop Grumman Innovation Systems (Northrop Grumman). Prior to the acquisition, Orbital ATK was a launch vehicle provider with active contracts for the Air Force, NASA, and commercial customers. Orbital ATK, through the heritage Orbital Launch Vehicle Group, developed 12 separate space launch vehicle systems and launched over 75 space missions (as of November 2015).

(FOUO) Northrop Grumman’s baseline next generation launch vehicle—the Omega—has a single-body configuration, consisting of three, basic, optimized propulsion stages (Figure 2). Stages 1 and 2 provide propulsion to suborbital velocity, with a high-energy 3rd stage that delivers the payload to its destination orbit, allowing tailoring of each mission and flight plan to meet specific spacecraft requirements without altering the design of the standardized propulsion system.



Figure 2. Northrop Grumman’s Omega Launch Vehicle (concept)  
Source: Space and Missile Systems Center, May 2019.

### United Launch Alliance

The SMC certified ULA's Delta IV and Atlas V space launch vehicles to launch national security payloads. In February 2015, ULA submitted a new space launch vehicle configuration for SMC certification—the Vulcan (Figure 3). According to ULA's website, the Vulcan rocket's design leverages the flight-proven success of the Delta IV and Atlas V launch vehicles while introducing new technologies and innovative features to ensure a reliable and affordable space launch service.

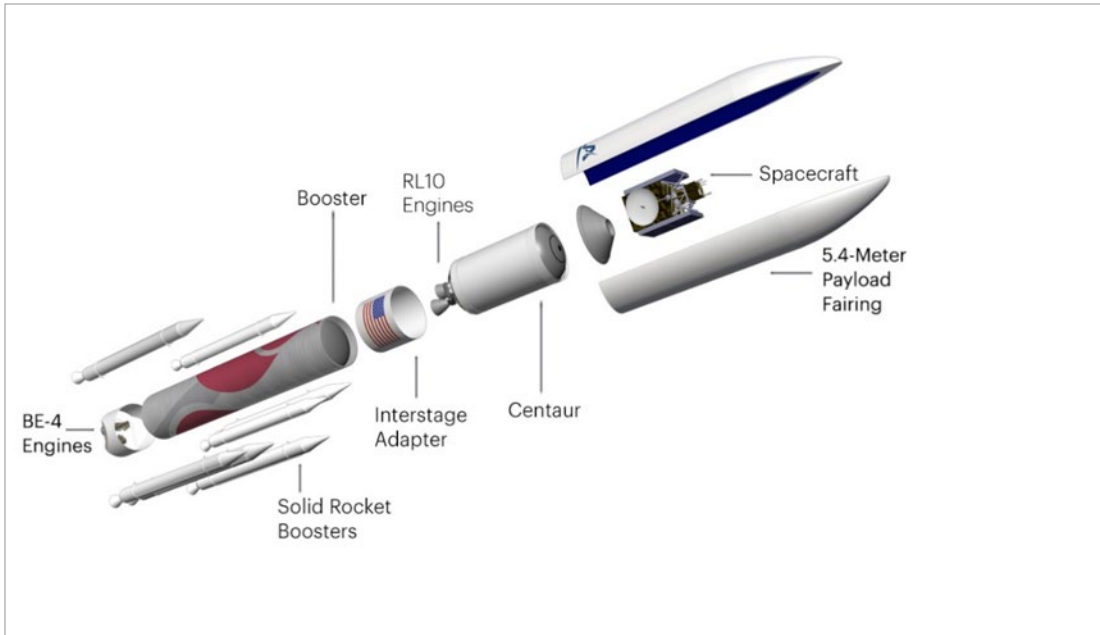


Figure 3. ULA's Vulcan Launch Vehicle (concept)

Source: ULA, January 2020.

### Blue Origin

(FOUO) [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]



### ***Air Force's New Entrant Certification Process***

In 2011, the Air Force, the National Reconnaissance Office, and NASA coordinated on a certification strategy for new entrant launch vehicles. Each organization agreed to adopt a common, risk-based framework and methodology for certification of new launch vehicles.<sup>6</sup> To implement this strategy, the SMC created the New Entrant Certification Guide (NECG). The NECG is a technical guide that provides a risk-based approach that the SMC uses to certify the capabilities of prospective new entrant launch service providers, as well as new launch vehicle configurations proposed by existing launch services providers, to launch safe and reliable national security space missions. The NECG defines launch vehicle certification as the “formal verification of the non-recurring portion of the launch vehicle mission assurance process.” SMC certification establishes that a “launch vehicle is qualified to launch operational, national security spacecraft, and that the [provider of that launch vehicle], from a technical perspective, is regarded as a responsible [launch vehicle provider] for future missions.”

<sup>6</sup> The scope of this evaluation did not include an assessment of the National Reconnaissance Office's or NASA's implementation of the coordinated strategy. We did not contact either organization for comments on the Air Force's certification criteria and did not request space launch vehicle certification strategies equivalent to the Air Force.

The SMC implements the NECG through Launch Enterprise Directorate Operating Instruction 17-001.<sup>7</sup> SMC Operating Instruction 17-001 states that SMC officials may certify a new launch vehicle configuration based on a maturity assessment. SMC Operating Instruction 17-001 also states that the NECG-required design validation work should be completed 12 months before the first launch of an operational payload.

The NECG states that potential launch vehicle providers entering the SMC's launch vehicle certification process must ensure that the proposed launch system meets specific requirements related to payload lifting, reliability, system interface, and manufacturing. According to SMC officials, the NECG was designed to provide a variety of entry points to the launch vehicle certification process to encourage competition. The NECG also states that evaluating the potential launch vehicle providers' capabilities requires the Air Force to verify whether the launch vehicle provider has performed one or more successful launches of the proposed launch vehicle, has previous experience as a space launch vehicle provider, or can demonstrate the capability to be an established manufacturer of space launch propulsion systems.<sup>8</sup> A statement of intent, a negotiated certification plan, and a formal or contractual agreement between the SMC and a potential launch vehicle provider document each new entrant's launch vehicle capabilities and establishes the criteria used by the SMC for each potential providers' launch vehicle certification assessment.

### ***The Statement of Intent Documents the Potential Launch Vehicle Provider's Qualifications and Initiates the SMC Evaluation Process***

The Statement of Intent documents the potential launch vehicle provider's qualifications and initiates the SMC evaluation process. The potential launch vehicle provider submits a written statement of intent to the SMC for approval of the provider's qualifications and proposed strategy for implementation and certification of its proposed launch system. The NECG states that the statement of intent is required to identify the payload capability of the proposed launch system, the new entrant's proposed certification alternative, and the new entrant's plan for completing the certification criteria (prior to the launch vehicle's first NSSL mission) and any proposed tailoring of the criteria.

---

<sup>7</sup> AF/SMC Launch Enterprise Directorate Operating Instruction 17-001, "[Air Force] Launch System Maturity Assessment Process," April 2, 2018 (referred to as SMC Operating Instruction 17-001). SMC officials incorporated recommendations from the January 2015 Institute for Defense Analysis Broad Area Review report in this operating instruction.

<sup>8</sup> NECG, Section 5.1.1.



SMC does not provide a template for the statements of intent; however, we observed that each new entrant's statement of intent included brief details on the proposed launch vehicle's performance capabilities; design, reliability, and accuracy; and the estimated development schedule. The SMC Commander's signature on the statement of intent initiates SMC's assessment of the potential launch vehicle provider.

The primary element of the statement of intent is the identification of the proposed launch vehicle's certification approach that leads to low risk launch system certification. The coordinated certification strategy between the Air Force, the National Reconnaissance Office, and NASA included the adoption of a common approach to certifying launch vehicles based on space launch payload risk. Payload risk is determined by several factors, including the level of importance of the launch vehicle's payload, as well as the cost and complexity of the payload; ultimately, these factors define the acceptable level of launch vehicle risk for a particular payload. Launch vehicle risk is then categorized based on the SMC's assessment of how successful a particular launch vehicle will be in delivering that payload to its intended orbit.

The coordinated certification strategy also included the establishment of common launch vehicle risk terminology: Category 1 (high risk), Category 2 (medium risk), or Category 3 (low risk). Each risk level equates to SMC's confidence in the launch vehicle's capability to successfully complete an NSSL mission. SMC requires launch vehicles applying for NSSL missions to be certified at Category 3 (98-percent launch vehicle design reliability), indicating that the possibility of a launch system failure is 2 percent or less. Certification at Category 1 or Category 2 is available for new launch vehicles seeking flight experience through non-NSSL missions. The NECG details several certification approach options or "alternatives," including four alternatives to certification for low-risk launch vehicles. For example, the first alternative relies primarily on the proposed vehicle's flight experience; according to the NECG, the proposed launch vehicle should have completed 14 consecutive successful flights of the same configuration. Meanwhile, the fourth alternative relies primarily on the potential launch vehicle provider supplying the SMC with extensive reviews of the contractor's process, design, and testing data in balance with minimal flight experience (a minimum of two consecutive successful flights).

### ***The Certification Plan Contains the Agreed Upon Tailored Approach for Certifying the Potential Launch Vehicle Provider***

According to the NECG, certification plans contain the agreed-to and approved tailored certification approach between the potential launch vehicle provider and the SMC. Following the disclosure and establishment of the potential launch vehicle provider's capabilities in the statement of intent, the SMC and the potential launch vehicle provider negotiate and agree to the terms by which the SMC will assess the proposed launch system.

SMC Operating Instruction 17-001 states that an overview of the activities included in non-recurring design validation (NRDV) are provided in the NECG, while specific NRDV activities for a given launch system are detailed in the new entrant's agreed-to certification plan. NRDV consists of validating a launch vehicle's design as well as the potential launch vehicle provider's engineering, manufacturing, and integration processes.

### ***The Formal Agreement With the Potential Launch Vehicle Provider for Launch Vehicle Certification***

According to the NECG, SMC incorporates the agreed-to and approved, tailored certification approach between SMC and the potential launch vehicle provider into a formal agreement.<sup>9</sup> Prior to certification of a launch vehicle and awarding a launch contract, the SMC uses cooperative research and development agreements (CRADAs) to facilitate the accomplishment of NRDV and to protect the intellectual property owned by both parties. According to Air Force Instruction 61-302, a CRADA is an agreement between one or more Federal laboratories or technical activities and one or more non-Federal parties to share intellectual property in all aspects of a product or system life cycle where research, development, test, and evaluation activities occur.<sup>10</sup> Based on CRADAs from the four current and potential launch vehicle providers and interviews with SMC officials, SMC's strategic intent for engaging in CRADAs was to promote the viability of multiple domestic launch vehicle providers as soon as feasible, while protecting contractor data and giving the Air Force insight into the contractors' designs. Additionally, the SMC uses Other Transaction Authorities in accordance with section 2371, title 10, United States Code (10 U.S.C. § 2371) to facilitate the accomplishment of NRDV.<sup>11</sup>

<sup>9</sup> SMC's Launch Configuration Control Board, chaired by the Launch Enterprise Director, will review the potential launch vehicle provider's proposed certification approach and make the final determination as to whether the potential launch vehicle provider's system will enter the certification process.

<sup>10</sup> Air Force Instruction 61-302, "The Domestic Technology Transfer Process and the Offices of Research and Technology Applications Cooperative Research and Development Agreements," September 16, 2019.

<sup>11</sup> 10 U.S.C. § 2371 provides the Secretary of Defense and the Secretaries of the Military Departments the authority to enter into transactions other than contracts, cooperative agreements, and grants to carry out research projects.

### ***Air Force Launch Vehicle Reusability Criteria***

In January 2018, the National Defense Authorization Act (NDAA) required SMC,

in carrying out the [NSSL] program...to provide for [the] consideration of both reusable and expendable launch vehicles with respect to any solicitation occurring on or after March 1, 2019, for which the use of a reusable launch vehicle is technically capable and maintains risk at acceptable levels.<sup>12</sup>

The 2018 NDAA further required the Secretary of Defense to conduct a risk and cost impact analysis with respect to launch services that use reusable launch vehicles. The analysis, according to Congress’s instructions,

shall include—(a) an assessment of how the inspection and certification regime of the Air Force for previously flown launch vehicles will ensure increased responsiveness and operational flexibility while maintaining acceptable risk; and (b) an assessment of the anticipated cost savings to the Department of Defense realized by using a previously flown launch vehicle or [launch vehicle] components.

Prior to the 2018 NDAA, the Air Force did not allow reusable components on launch vehicles performing NSSL missions. The SMC Launch Systems Enterprise Directorate (SMC/LE) responded to Congress in March 2019 by publishing Launch Enterprise Supplement 10 (LE-S-010), which supplements the NECG and other existing standards, providing requirements and guidance for reusable launch systems.<sup>13</sup> Specifically, the LE-S-010 requires:

- (FOUO) [REDACTED]
- (FOUO) [REDACTED]
- (FOUO) [REDACTED]

<sup>12</sup> Public Law No 115-232, “John S. McCain National Defense Authorization Act for Fiscal Year 2019.”

<sup>13</sup> SMC LE-S-010, “Supplemental Requirements for Reusable Launch Systems,” March 27, 2019.

(FOUO) [REDACTED]  
[REDACTED]  
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[REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]

## Finding

### **SMC Generally Complied With the Launch Services NECG, but Should Complete Design Validation Assessments Earlier in Advance of Initial Launch Capability and Include Requirements for Reusable Components in Its Assessments**

SMC officials generally complied with the Air Force’s Launch Services NECG and its implementing instruction, SMC Operating Instruction 17-001, when certifying the capabilities of SpaceX and its Falcon family of launch vehicles. Additionally, in preparation for future launch vehicle contract competitions, SMC officials generally complied with the NECG to accomplish the design validation assessments of the three other potential launch vehicle providers’ new entrant launch vehicles that were still in development. Those three additional providers were Northrop Grumman, ULA, and Blue Origin.

(FOUO) [REDACTED]

Limiting the time to conduct independent verification and validation of a provider’s launch vehicle could constrain SMC in determining whether a launch vehicle can reliably launch NSSL payloads at acceptable risk. Such constraints remain a concern for the SMC’s independent verification and validation of other new launch vehicle configurations that have not yet been certified.

Second, SMC officials did not assess the risk of allowing the use of previously used launch vehicle components on subsequent space launches with SpaceX's Falcon family of launch vehicles. This occurred because the SMC and SpaceX did not agree to reuse launch vehicle components on any NSSL missions to date although SpaceX's Falcon family of launch vehicles are designed for reuse. Additionally, SMC officials did not establish standards for assessing the reliability of reusable launch vehicle components until March 2019. If the Air Force intends to authorize SpaceX to include reused launch vehicle components on any future Air Force launch missions, the SMC should be proactive and perform the necessary NRDV assessments in accordance with the SMC launch vehicle reusability standards.

### **SMC Officials Generally Complied With the NECG When Conducting Design Validation Assessments for Potential Launch Service Providers**

SMC officials generally complied with the Air Force's Launch Services NECG and its implementing instruction—SMC Operating Instruction 17-001—when conducting design validation assessments of SpaceX and its Falcon family of launch vehicles. Additionally, in preparation for future launch contract competition, SMC officials generally complied with the NECG to accomplish the design validation assessments of the three other potential launch vehicle providers—Northrop Grumman, ULA, and Blue Origin. To make this determination, we systematically compared the certification plans for each launch vehicle to the NECG to verify that all requirements of the NECG were addressed in each of the certification plans, and we reviewed NRDV status information for each launch vehicle development effort to determine whether there were any deviations from the certification plans.

#### ***SMC Complied With the NECG When Validating the Design of the Falcon 9 Launch Vehicle***

(FOUO) [REDACTED]

(FOUO) [Redacted text block]

(FOUO) [Redacted text block]

- (FOUO) [Redacted list item]
- (FOUO) [Redacted list item]
- (FOUO) [Redacted list item]

<sup>14</sup> The launch verification matrix is a database used to define the non-recurring design validation activities and recurring mission assurance activities for a specific launch vehicle configuration. The launch verification matrix is also used to document completion of the activities, analyses, and assessment results produced during the certification process and launch campaign.

### ***SMC Complied With the NECG When Validating the Design of the Falcon Heavy Launch Vehicle***

(FOUO) [Redacted]

(FOUO) [Redacted]

(FOUO) [Redacted]

<sup>15</sup> The details of the certification activities for the Falcon Heavy were documented in a “joint work plan” that was attached to the Falcon Heavy certification plan. The joint work plan, which constituted a part of the formal agreement between the SMC and SpaceX, details the property, equipment, reports, products, and other deliverables expected to be produced or provided by the SMC and SpaceX in support of the certification of the Falcon Heavy launch vehicle.



**SMC Complied With the NECG When Validating the Design of the Omega Launch Vehicle**

(FOUO) [REDACTED]

(FOUO) [REDACTED]

(FOUO) We also compared the content of the Omega certification plan from the Northrop Grumman CRADA to the Omega certification plan from the launch services agreement to identify any changes to the SMC's initial certification approach. Prior to the Northrop Grumman acquisition of Orbital ATK, Orbital ATK and SMC leadership signed a CRADA. After Northrop Grumman acquired Orbital TK, Northrop Grumman upheld the terms of the CRADA. [REDACTED]

(FOUO) [REDACTED]  
SMC's reports on the status of the completion of NRDV activities for the Omega launch vehicle provided a snapshot of SMC's oversight of Northrop Grumman.

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[REDACTED]  
[REDACTED]

(FOUO) [REDACTED]  
[REDACTED]

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[REDACTED]  
[REDACTED]  
[REDACTED]

***SMC Complied With the NECG When Validating the Design of the Vulcan Launch Vehicle***

(FOUO) [REDACTED]  
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[REDACTED]  
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[REDACTED]  
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[REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]

<sup>16</sup> (FOUO) [REDACTED]  
[REDACTED]

(FOUO) [REDACTED]

(FOUO) We also compared the content of the Vulcan certification plan from the ULA CRADA to the Vulcan certification plan from the launch services agreement to identify any changes to the SMC's initial certification approach. [REDACTED]

[REDACTED]

(FOUO) SMC's reports on the status of completion of NRDV activities for the Vulcan launch vehicle provided a snapshot of SMC's oversight of ULA. [REDACTED]

[REDACTED]

(FOUO) [Redacted]  
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[Redacted]  
[Redacted]

***SMC Complied With the NECG When Validating the Design of the NGLS Launch Vehicle***

(FOUO) [Redacted]  
[Redacted]  
[Redacted]  
[Redacted]  
[Redacted]  
[Redacted]  
[Redacted]  
[Redacted]  
[Redacted]  
[Redacted]

(FOUO) [Redacted]  
[Redacted]  
[Redacted]  
[Redacted]  
[Redacted]  
[Redacted]  
[Redacted]  
[Redacted]  
[Redacted]  
[Redacted]

(FOUO) [REDACTED]

(FOUO) We also compared the content of the NGLS certification plan from the Blue Origin CRADA to the NGLS certification plan from the launch services agreement to identify any changes to the SMC's initial certification approach. [REDACTED]

[REDACTED]

(FOUO) [REDACTED]

- (FOUO) [REDACTED]
- (FOUO) [REDACTED]
- (FOUO) [REDACTED]

<sup>17</sup> (FOUO) [REDACTED]

(FOUO) [Redacted]

(FOUO) [Redacted] the operational launch date was December 23, 2018.

SMC Operating Instruction 17-001 states that new entrant certification requires the completion of enough of the major NRDV requirements to provide the SMC commander with confidence in the new entrant's ability to complete the remaining NRDV work in time to meet launch timing and flight readiness requirements. The SMC operating instruction further establishes a nominal timeline of 12 months for completing all NRDV prior to a vehicle's initial launch capability but notes that this timeline is tailorable depending on mission requirements.

(FOUO) [Redacted]

- (FOUO) [Redacted]
- (FOUO) [Redacted]
- (FOUO) [Redacted]

- (FOUO) [Redacted]

(FOUO) [Redacted]

**(FOUO)** [Redacted]

(FOUO) [Redacted]

(FOUO) [Redacted]

(FOUO) [Redacted]

(FOUO) [Redacted]

(FOUO) [Redacted]

(FOUO) [Redacted]

(FOUO) [Redacted]

According to the NECG, flight worthiness certification is essential to declaring the launch vehicle's operational readiness for a safe and successful launch. If SMC was unable to complete its independent analysis, the SMC commander would not have had sufficient information to ensure that risks associated with an NSSL mission were identified and adjudicated. If this occurred, the launch would be



rescheduled or canceled. It is critical for SMC to have sufficient time to complete its independent analysis of launch vehicle provider technical data, in accordance with the certification alternatives described in the NECG.

Space launch scheduling requires precision and flexibility, due to the limited number of launch vehicle platforms within the United States. If SMC officials are relying on contractor launch vehicle design and test data to provide assurance of mission success, contractors must provide timely launch vehicle data to not only avoid delaying SMC's ability to certify the spaceflight worthiness of the launch vehicle, but to avoid delaying other launch vehicle platform users such as NASA or other commercial contractors.

(FOUO) [REDACTED]

(FOUO) [REDACTED]

(FOUO) SMC certified the SpaceX Falcon 9 and Falcon Heavy launch vehicles in May 2015 and June 2018, respectively.<sup>18</sup> [REDACTED]

<sup>18</sup> SpaceX and the Falcon 9 launch vehicle were the first launch service provider and launch vehicle to be certified by SMC in accordance with the NECG.

(FOUO) [REDACTED]

(FOUO) [REDACTED]

[REDACTED] Reusable launch vehicle components experience longer usage durations, multiple environmental cycles, and additional loads and stresses that result from flight as well as from reentry, recovery, transport, and refurbishment. If such launch vehicle components are unable to withstand the stresses of reuse or are unable to be refurbished to the qualified configuration prior to reuse, this could result in degradation or failure of the component on subsequent launches, and, consequently, degraded launch vehicle performance or potential mission failure.

Prior to March 2019, SMC only used expendable launch vehicles for NSSLs. As a result of SMC's coordination with NASA and industry partners to create standards for certifying launch vehicles containing reused components for NSSLs (in accordance with the 2018 NDAA), SMC issued the initial release of its launch vehicle reusability standards, LE-S-010 in March 2019. In addition, prior to SpaceX's entry into the Air Force's certification process, the SMC Launch Enterprise Directorate did not have experience with launch vehicles containing reused components and did not allow component reuse in the NSSL program. The SMC's launch vehicle reusability standards establish requirements for validating a launch vehicle's design, as well as the provider's engineering, manufacturing, and integration processes (supplemental to the requirements set forth in the NECG) to specifically address the issues peculiar to the reuse of space launch vehicle components.<sup>19</sup>

If the Air Force intends to authorize SpaceX to include reused launch vehicle components on any Air Force launch missions, SMC should perform the necessary NRDV assessments for SpaceX's Falcon family of launch vehicles in accordance with the SMC launch vehicle reusability standards. For SMC to ensure that a launch vehicle will provide the required mission reliability and performance capability, SMC should assess the reusable launch vehicle design in accordance with the NECG, as supplemented by LE-S-010. Without assessing launch vehicles containing reused components in accordance with SMC reusability standards, SMC officials may

<sup>19</sup> According to SMC officials, SMC's launch vehicle reusability standards are in place for Phase 2 of SMC's launch vehicle provider source selection (which allows reusable systems) and will be a part of the certification plan for every launch services agreement SMC awards.

not have the necessary assurances that launch vehicles used for NSSL-program missions can reliably and consistently deliver high-value national security space payloads to their intended orbits.

### Deleted Recommendations, Management Comments, and Our Response

In a draft report provided to the Air Force for management comments, we made two recommendations to the Director of the SMC’s Launch Enterprise Directorate: 1) develop a plan to review the impact of a potential launch vehicle provider’s noncompliance with negotiated timelines for the delivery of technical data to the SMC in support of flight worthiness certifications for NSSL missions; and 2) develop procedures to complete the mission assurance activities necessary to fully assess the risk of authorizing launch vehicle providers to reuse launch vehicle components on NSSL missions.

In addition to his response to the draft report, the Director also provided documentation that was not provided to us during the evaluation. We reviewed the documentation and concluded that, had we received and reviewed the documents during the evaluation, we would not have made these two recommendations in the draft report. Therefore, we deleted the recommendations. The following discussion describes the additional documentation that was provided in response to the draft report and our analysis of that documentation.

#### *The Director of the Air Force Space and Missile Systems Center’s Launch Enterprise Directorate’s Comments on the Impact of Potential Launch Vehicle Compliance with Negotiated Timelines for the Delivery of Technical Data*

(FOUO) [REDACTED]

<sup>20</sup> Air Force Space Command Instruction 13-610, “Air Force Nuclear, Space, Missile, Command And Control,” May 14, 2018.

***Our Response***

(FOUO) In response to the draft report, the Director provided additional documentation which SMC did not provide us during the evaluation. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED] The comments and additional documentation from the Director addressed our concern on procedures to ensure delivery of technical data to SMC. If we had reviewed SMC's documentation prior to issuing a draft report, we would not have made a recommendation. Therefore, we deleted the recommendation.

***The Director of the Air Force Space and Missile Systems Center's Launch Enterprise Directorate's Comments on Assessing the Risk of Authorizing Launch Providers to Reuse Launch Vehicle Components***

(FOUO) The Director of the SMC's Launch Enterprise Directorate provided comments on the draft report on SMC procedures to assess the risk of authorizing launch vehicle providers to reuse launch vehicle components on NSSL missions.

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

(FOUO) [REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED] high reliability regardless of whether the flight hardware is expendable or reused.

***Our Response***

In response to the draft report, the SMC Director provided additional documentation which SMC did not provide us during the evaluation. These new documents provided more details on SMC procedures and processes to guide mission assurance activities for launch vehicle hardware reuse. After reviewing the new documents provided by the Director, we concluded that, had we obtained and reviewed the procedures developed by the Launch Enterprise Directorate during the evaluation, we would not have made a recommendation. Therefore, we deleted the recommendation.

## Appendix

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### Scope and Methodology

We conducted this evaluation from February 2019 through December 2019 in accordance with the “Quality Standards for Inspection and Evaluation,” published in January 2012 by the Council of Inspectors General on Integrity and Efficiency. Those standards require that we adequately plan the evaluation to ensure that objectives are met and that we perform the evaluation to obtain sufficient, competent, and relevant evidence to support the findings, conclusions, and recommendations. We believe that the evidence obtained was sufficient, competent, and relevant to lead a reasonable person to sustain the findings, conclusions, and recommendations.

We evaluated the Air Force’s completed and ongoing new entrant launch vehicle certification efforts undertaken since issuance of the NECG in 2011. Launch vehicles within the scope of our evaluation included SpaceX’s Falcon 9 and Falcon Heavy, Northrop Grumman’s Omega, ULA’s Vulcan, and Blue Origin’s NGLS. We conducted a site visit to Los Angeles Air Force Base, California, to meet with the SMC’s Launch Systems Enterprise Directorate staff.

We interviewed the Director, Deputy Director, and Chief Engineer of SMC’s Launch Enterprise Directorate, as well as subject matter experts from SMC’s National Security Space Launch (NSSL) program, to gain an understanding of the new entrant launch vehicle certification process, including the sequence of events for completed certification efforts and the status of ongoing certification efforts.

We reviewed the Air Force Launch Services NECG and SMC’s NECG implementing instruction to identify SMC’s flight certification criteria for potential launch vehicles and potential launch vehicle providers contracted by SMC to perform NSSL missions.

We requested flight certification status briefings from subject matter experts in SMC’s Launch Enterprise Directorate on SpaceX’s Falcon family of launch vehicles, Northrop Grumman’s Omega Launch Vehicle, United Launch Alliance’s Vulcan Launch Vehicle, and Blue Origin’s New Glenn Launch System. In addition to the status briefings, we requested supporting documentation for each potential launch vehicle provider in accordance with the NECG and SMC’s implementing instruction, such as statements of intent, cooperative research and development agreements, certification plans, launch service agreements, and—specific to the Falcon family of launch vehicles—conditional certification letters.

We reviewed the flight certification status briefings for the status of completion of NRDV activities to the associated certification plans and the NECG to determine whether completed and ongoing launch vehicle certification efforts complied with the NECG.

We compared similar supporting documents from each potential launch vehicle providers' flight certification status briefing to identify inconsistencies in SMC's flight certification methodology (as defined in the NECG) that would potentially provide an unequal advantage to one or more of the potential launch vehicle providers.

~~(FOUO)~~ We analyzed the launch verification matrix for the GPS III-2 NSSL mission performed by SpaceX to identify SMC's tailored criteria for SpaceX (in accordance with the NECG) and to identify the timeliness of SpaceX's data submissions to SMC in order for the SMC commander to authorize the GPS III-2 mission. [REDACTED]

## Use of Computer-Processed Data

We did not use computer-processed data to perform this evaluation.

## Prior Coverage

During the last 5 years, the DoD Office of Inspector General (DoD OIG), the National Aeronautics and Space Administration (NASA) Office of Inspector General (OIG), and the Government Accountability Office (GAO) issued three reports discussing the evolved expendable launch vehicle program, the June 2015 SpaceX launch failure, and space launch vehicle competition.

### ***DoD OIG***

Report No. DODIG-2018-045, "Evaluation of the Evolved Expendable Launch Vehicle Program Quality Management System," December 20, 2017

The DoD OIG performed this self-initiated evaluation to determine whether the DoD's Evolved Expendable Launch Vehicle prime contractors—United Launch Alliance and Space Exploration Technologies—and the primary sub-contractor—Aerojet Rocketdyne—performed adequate quality assurance management for the Evolved Expendable Launch Vehicle program. The OIG determined that the three contractors were not performing adequate quality assurance management that could potentially increase costs, delay launch schedules, and increase the risk of mission failure.

**NASA OIG**

Report IG-16-025, "NASA's Response to SpaceX's June 2015 Launch Failure: Impacts on Commercial Resupply of the International Space Station," June 28, 2016

NASA OIG's Office of Audits examined NASA's response to the June 2015 SpaceX failure and its impact on commercial resupply of the International Space Station (ISS). The NASA OIG determined that NASA's risk management approach for commercial cargo launches deviated from existing procedures for evaluating launch risks. NASA staff classified all commercial resupply missions at the lowest level of risk, irrespective of the mission's value, and relied on commercial partners (such as SpaceX and Orbital) to evaluate and mitigate launch risks.

**GAO**

GAO-14-377R, "Space Launch Vehicle Competition," January 28, 2014

The GAO performed this congressionally-requested evaluation to examine four specific aspects of the Air Force's launch vehicle vendor selection process. The GAO found that a consequence of the Air Force's pre-2013 contracting structure was that the DoD had difficulty determining the cost of an individual launch since direct launch costs were not itemized by the contractor. The GAO reported that, starting in December 2013, the DoD began to leverage better insight into contractor costs to negotiate lower contract prices and began incentivizing current launch contractors (such as ULA) to increase efficiencies.



# Management Comments

## Air Force Space and Missile Systems Center

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**DEPARTMENT OF THE AIR FORCE**  
UNITED STATES SPACE FORCE

22 July 2020

MEMORANDUM FOR DEPARTMENT OF DEFENSE INSPECTOR GENERAL

FROM: SMC/ECL  
483 N. AVIATION BLVD  
EL SEGUNDO, CA 90245

SUBJECT: Air Force Response to DoD Office of Inspector General Draft Report, "Evaluation of the Air Force's Certification of Space Launch Vehicles" (Project No. D2019-D000PT-0059.000)

- References:
- (a) AFSPCI 13-610, 14 May 2018, *Launch and Range Operations*
  - (b) LE-S-010, March 2019, *Supplemental Requirements for Reusable Launch Systems*
  - (c) LE-P-018, March 2019, *NSSL Guide for Reusable Launch Systems*
  - (d) LE-T-013, March 2019, *Dynamic Environments Tailoring and Guidance to SMC-S-016 for Expendable and Reusable Launch Vehicles*
  - (e) TOR-2018-01562, August 2018, *Dynamic Environments Tailoring and Guidance to SMC-S-016 Standard for Expendable and Reusable Launch Vehicles*

1. This is the Department of the Air Force response to the DoDIG Draft Report, "Evaluation of the Air Force's Certification of Space Launch Vehicles" (Project No. D2019-D000PT-0059.000). The Air Force non-concurs with the report as written and thanks you for the opportunity to review the draft report and your comprehensive evaluation of our program. I am pleased that you determined the Space and Missile Systems Center (SMC) Launch Enterprise team complied with the New Entrant Certification Guide while validating the designs of all the launch systems. However, I respectfully disagree with the assumptions that underpin the two recommendations the report provides.

2. SMC/ECL in coordination with SAF/AQS intends to address the assumptions identified in this report and outlined in the following recommendations:

**RECOMMENDATION 1:** "The DoDIG recommends that the Air Force develop a plan to review the impact of a potential launch vehicle provider's noncompliance with negotiated timelines for the delivery of technical data to SMC in support of flight worthiness certifications for NSSL missions.

a. An assessment of the risk to National Security Space Launch (NSSL) missions (including technical risk associated with incomplete nonrecurring design validation activities, as well as NSSL mission scheduling impacts) resulting from late delivery of required technical data from the potential launch vehicle provider and unplanned constraints imposed on SMC's independent analysis of the technical data.

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## Air Force Space and Missile Systems Center (cont'd)

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b. Procedures for escalation in the event of a potential launch vehicle provider's noncompliance with negotiated timelines, such as discussions with potential launch vehicle provider leadership, renegotiation of data agreements, or withholding performance-based contractor progress payments."

**AIR FORCE RESPONSE:** The Air Force nonconcur due to the assumptions behind this recommendation.

a. This recommendation and its associated finding imply that SMC potentially compromised mission success or increased risk to launch the Global Positioning System (GPS) III-2 mission on schedule. This characterization is inaccurate, and our space flightworthiness process (directed by Air Force Space Command Instruction (AFSPCI) 13-610 and codified in our command media) explicitly prevents this situation. Our processes have resulted in an unprecedented record of 100% launch success since program inception. SMC has repeatedly demonstrated our willingness to delay a launch to accomplish the appropriate mission assurance activities to achieve acceptable risk. However, we will also make all efforts to maintain launch schedules because the capability is required on orbit in support of National Security and the warfighter. In the case of the GPS III-2 mission discussed in the report, for the items listed as open during the Flight Readiness Review (FRR), the vast majority of the technical work was complete before the FRR and it was only the final formal documentation sign offs in our database systems that occurred post FRR. Additionally, this GPS III-2 mission's launch date was previously delayed from May 2018 to December 2018 in part to enable additional time to complete the required technical work.

b. The first NSSL mission on a new launch vehicle is a complex and technically challenging endeavor. It requires close coordination between the Government and the Launch Service Provider (LSP) and the use of all tools available to launch the capability as soon as possible after the risks are mitigated to an acceptable level. Contractual compliance is just one of these tools.

c. Senior SMC and Launch Enterprise leaders establish working relationships with corresponding LSP leaders to address issues during contract execution and launch. For the GPS III-2 contract, while we used the mechanisms in place on that contract to ensure the launch occurred as soon as we had mitigated the risks to an acceptable level and held the contractor accountable for their performance, we also worked closely with contractor leadership to ensure we launched successfully at low risk.

d. Per AFSPCI 13-610, *Launch and Range Operations*, the SMC Commander certifies flightworthiness. This decision is made at the FRR between two and four weeks before a planned launch date and incorporates a comprehensive risk assessment of the launch vehicle, space vehicle, and mission. This assessment takes into account any data required from the LSP and our associated independent analysis. More importantly, if the risk cannot be mitigated in support of the planned launch date, the FRR is also delayed to allow the technical work to be completed before Spaceflight Worthiness Certification is provided. If there are significant open issues at the FRR, it is common for the SMC Commander to withhold certification until the issues are resolved instead of certifying with liens.

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## Air Force Space and Missile Systems Center (cont'd)

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e. We request that this recommendation be removed from the report because the aforementioned processes and procedures are in-place and in-use. We recommend further background, insight and discussion as necessary to assist before publishing the final report.

**RECOMMENDATION 2:** “The DoDIG recommends that the Air Force develop procedures to complete the mission assurance activities necessary to fully assess the risk of authorizing launch vehicle providers to reuse launch vehicle components on national security space launch missions.”

**AIR FORCE RESPONSE:** The Air Force agrees that procedures for the mission assurance activities necessary to fully assess the risk of authorizing launch vehicle providers to reuse launch vehicle components on national security space launch missions are required, however we do not concur with the findings as written. We can concur if the modifications submitted in item “e” below are implemented.

a. This recommendation incorrectly implies that SMC failed to assess reusable launch systems when in fact SMC is following a long-standing plan and schedule for reusable systems. SpaceX did not request certification for previously flown hardware during Phase 1A competitions; therefore, SMC did not need to assess this area as an element of GPS III-2 certification.

b. The Launch Enterprise has embraced reusability and explicitly enabled it as part of the ongoing Phase 2 competition. We also have recently amended existing GPS III contracts to enable booster recovery after carefully considering risks and ensuring a portion of the savings is returned to the Government. (FOUO) [REDACTED]

c. The Launch Enterprise has developed procedures and processes, including technical guidance and command media, to guide mission assurance activities for hardware reuse. These include the Launch Enterprise Specification LE-S-010, *Supplemental Requirements for Reusable Launch Systems*, listed in the report. Other published documents include:

(1) LE-P-018, March 2019, *NSSL Guide for Reusable Launch Systems*

(2) LE-T-013, March 2019, *Dynamic Environments Tailoring and Guidance to SMC-S-016 for Expendable and Reusable Launch Vehicles*

(3) TOR-2018-01562, August 2018, *Dynamic Environments Tailoring and Guidance to SMC-S-016 Standard for Expendable and Reusable Launch Vehicles*

d. Our Launch Verification Matrix (LVM) contains all mission assurance tasks used to assess risk and support a space flightworthiness determination. We plan to tailor LVM items via a formal Configuration Control Board (CCB) as appropriate for any reusable launch service, utilizing the approved command media.

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## Air Force Space and Missile Systems Center (cont'd)

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e. We request that this recommendation be removed from the report because the aforementioned processes and procedures are in-place and in-use. Alternatively, this recommendation could remain if clearly introduced as a supplemental item that is not the result of a finding or deficient area (since reuse was intentionally not part of any Falcon certification efforts), and if recognition is made of our progress to date on enabling reuse. We recommend further background, insight and discussion as necessary to assist before publishing the final report.

f. Once again, thank you for the report and the chance to comment. My representative for discussing technical risk evaluation is [REDACTED].

BONGIOVI.ROBE  
RT.P [REDACTED]

ROBERT P. BONGIOVI, Colonel, USAF  
Director, Launch Enterprise

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## Acronyms and Abbreviations

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<b>CRADA</b>	Cooperative Research and Development Agreement
<b>NASA</b>	National Aeronautics and Space Administration
<b>NECG</b>	New Entrant Certification Guide
<b>NGLS</b>	New Glenn Launch System
<b>NRDV</b>	Non-recurring Design Validation
<b>NSSL</b>	National Security Space Launch (formerly Evolved Expendable Launch Vehicle)
<b>SMC</b>	Space and Missile Systems Center
<b>ULA</b>	United Launch Alliance



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