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AUDIT REPORT

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REVIEW OF NASA'S ACQUISITION OF COMMERCIAL LAUNCH SERVICES

OFFICE OF INSPECTOR GENERAL

National Aeronautics and
Space Administration

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Acronyms

COTS	Commercial Orbital Transportation Services
CRS	Commercial Resupply Services
DOD	Department of Defense
EELV	Evolved Expendable Launch Vehicle
ELV	Expendable Launch Vehicle
ESMD	Exploration Systems Mission Directorate
GAO	Government Accountability Office
GLAST	Gamma-ray Large Area Space Telescope
IBEX	Interstellar Boundary Explorer
ICBM	Intercontinental Ballistic Missile
ICESat-II	Ice, Cloud, and Land Elevation Satellite
IDIQ	Indefinite-Delivery, Indefinite-Quantity
ISS	International Space Station
LADEE	Lunar Atmosphere and Dust Environment Explorer
LCROSS	Lunar Crater Observation and Sensing Satellite
LRO	Lunar Reconnaissance Orbiter
LSP	Launch Services Program
NLS	NASA Launch Services
OCO	Orbiting Carbon Observatory
OIG	Office of Inspector General
PPBE	Planning, Programming, Budgeting, and Execution
SMAP	Soil Moisture Active Passive
SMD	Science Mission Directorate
SOMD	Space Operations Mission Directorate
ULA	United Launch Alliance

OVERVIEW

REVIEW OF NASA'S ACQUISITION OF COMMERCIAL LAUNCH SERVICES

The Issue

Commercial U.S. launch services providers compete domestically and internationally for contracts to carry satellites and other payloads into orbit using unmanned, single-use vehicles known as expendable launch vehicles (ELVs). However, since the late 1990s the global commercial launch market has generally declined following the downturn in the telecommunications services industry, which was the primary customer of the commercial space industry. Given this trend, U.S. launch services providers struggling to remain economically viable have been bolstered by the Commercial Space Act of 1998 (Public Law 105-303), which requires NASA and other Federal agencies to plan missions and procure space transportation services from U.S. commercial providers to the maximum extent practicable.

In particular, the U.S. market for medium-class launch vehicles, which are suited for many NASA science missions, has suffered from lack of demand and foreign competition.[1] New launch vehicles in this class are currently under development as part of NASA's Commercial Orbital Transportation Services (COTS) Program, and NASA hopes to use these vehicles to resupply the International Space Station (ISS) on a commercially competitive basis. Although one such vehicle, Space Exploration Technologies Corporation's (SpaceX) Falcon 9, had successful test flights in June 2010 and December 2010, neither it nor any of the other vehicles currently under development are likely to be ready to launch NASA's science missions until late 2013 or early 2014. Consequently, until that time NASA faces limited domestic availability of medium-class launch vehicles for its science missions, a situation exacerbated by the Department of Defense's (DOD) decision to stop using the Delta II – the medium-class vehicle that has been NASA's launch vehicle of choice for nearly 60 percent of its science missions over the last decade. Moreover, without orders from DOD there is not enough demand for medium-class launch vehicles to sustain most domestic launch services providers.

For the past decade, NASA's Launch Services Program (LSP) Office has acquired commercial launch services using firm-fixed-price indefinite-delivery, indefinite-quantity (IDIQ) contracts under an overarching NASA Launch Services (NLS) contract initially awarded in June 2000 that expired on June 30, 2010. Pursuant to these contracts,

[1] Medium-class missions are typically satellite payloads between 1,500 and 3,200 kilograms (3,300 to 7,040 pounds), respectively, launched to a 675-kilometer (approximately 405 miles) orbit around the Earth.

U.S. service providers integrate, test, and launch NASA and NASA-sponsored payloads into orbit. Using these NLS contracts, NASA has launched science missions such as Kepler and the Gamma-ray Large Area Space Telescope (GLAST). Kepler is a NASA mission designed to survey the Milky Way Galaxy to detect and characterize Earth-size and smaller planets. GLAST, now known as Fermi, is a powerful space observatory that will explore some of the most extreme environments in the universe.

The objective of our audit was to evaluate whether NASA's LSP, through its implementation of NLS contracts, acquired ELVs within costs and timeframes established by the contracts. We also evaluated whether NASA's acquisition strategy for post-2010 ELV procurements as set forth in an August 2009 report to Congress is cost-effective and the most advantageous to the Government. Details of the audit's scope and methodology are in Appendix A.

Results

We found that NASA's LSP acquired ELVs from 2008 through 2009 that were within costs and timeframes established by the NLS contracts. However, we also found that NASA's published strategy for acquiring medium-class launch vehicles after 2010 may not be the most cost-effective or advantageous to the Government because it did not include as a possible option use of Minotaur, a launch vehicle that uses a U.S. Government-furnished rocket motor from decommissioned intercontinental ballistic missiles.

Our analysis shows that use of the Minotaur for certain NASA science missions offers significant savings when compared to the available commercially provided intermediate-class launch vehicles cited in NASA's report to Congress.[2,3] Moreover, it also would be less expensive than SpaceX's Falcon 9, which is still under development and not yet certified to carry NASA science missions. For example, if NASA used the Minotaur rather than Falcon 9 or the intermediate-class Atlas V for the Soil Moisture Active Passive (SMAP) mission scheduled for launch in November 2014, the Agency could save between $61 million and $156 million (see Appendix B).[4]

In response to this finding, NASA stated that use of the Minotaur for some of its science missions could have a negative impact on the domestic commercial rocket industry because it might discourage companies from entering the launch services market. However, as discussed above it is unlikely that reliable and competitively priced medium-class launch vehicles will be available in time for the SMAP mission. Accordingly, while

[2] Intermediate-class launch vehicles can carry payloads weighing more than 3,500 kilograms (7,700 pounds).

[3] "Strategy for Small- and Medium-Class Launch Services," August 2009 (see Appendix C).

[4] We based the estimated cost savings on the difference between the projected cost of a Minotaur IV, a Falcon 9, and an Atlas V ordered in 2012.

we appreciate the legal and policy reasons for promoting commercial launch providers, we believe that NASA should consider using the Minotaur as a launch vehicle for appropriate science missions until cost-effective and reliable commercial launch services are available.

Launch Services Provided within Costs and Timeframes under the 2000–2010 Contract

Based on our review of 5 out of 21 missions under the NLS contracts, we determined that the LSP acquired ELVs that were within established budget and negotiated contract costs.[5] Specifically, for the five missions in our sample that launched from June 2008 through June 2009, we compared the actual launch services costs with total mission costs and found that the total launch services costs were approximately 19 percent of total mission costs.[6] In addition, we found that the LSP's negotiated costs averaged 3 percent below what had been obligated by NASA.[7]

We also found that the LSP provided launch vehicles within the timeframes established by the contract. Specifically, for the five missions in our sample we compared the planned launch dates with actual launch dates and found that although all five missions experienced delays, these delays were related to technical issues with the project, not the acquisition or readiness of the launch vehicles.

NASA's Published Acquisition Strategy for Launch Vehicles Did Not Include the Use of Minotaur for Medium-Class Launches

In accordance with Section 621 of the NASA Authorization Act of 2008, NASA developed and submitted a report to Congress setting forth its acquisition strategy for providing domestic commercial launch services to support small- and medium-class missions of NASA's Exploration Systems, Science, and Space Operations Mission Directorates (see Appendix C).[8] The strategy involved extending the ordering period for existing NLS contracts from June 2010 through June 2020 to allow current launch services providers to offer launch vehicles that were not available at the time the initial contract was awarded and new launch services providers an opportunity to compete for

[5] See Appendix A for details of our sample.

[6] Includes basic launch services (standard launch vehicle hardware, range coordination, etc.), mission-unique services (requirements necessary to customize the basic vehicle to meet spacecraft and mission needs), integrated services (launch vehicle and payload processing, range safety, engineering and institutional support, and launch pad support), telemetry, and other costs such as pad infrastructure.

[7] This audit examined the LSP's implementation of the NLS contract and did not evaluate the reasonableness of contract prices or how those contracts were procured. The Boeing Company reached a settlement in June 2006 to resolve criminal and civil allegations that the company improperly used competitor's information to procure contracts for launch services from the Air Force and NASA, as well as unrelated allegations concerning Boeing's relationship with an Air Force employee. As part of the settlement, Boeing agreed to pay $615 million, $106.7 million of which went to NASA.

[8] NASA's "Strategy for Small- and Medium-Class Launch Services," August 2009.

future launch services contracts. NASA also plans to monitor development efforts of Orbital Sciences Corporation (Orbital) and SpaceX, the two commercial partners selected as part of the Agency's COTS Program, to develop a new cargo transport capability to resupply the ISS after retirement of the Space Shuttle. Although NASA listed the Minotaur as a possible option to launch small-class science missions, the acquisition strategy laid out in the report to Congress did not discuss the Minotaur as a possible launch vehicle for NASA's medium-class science missions. However, after the Office of Inspector General (OIG) provided NASA a draft copy of this report, the Agency informed us that "consistent with law and policy" it would consider using the Minotaur for medium-class missions.

NASA's published acquisition strategy assumes that in the next 4 years commercial companies will develop affordable medium-class launch vehicles under the COTS Program. Moreover, NASA anticipates that spreading fixed costs over a larger number of resupply flights for the ISS will result in competitively priced medium-class launch vehicles. Although launch vehicles developed for ISS resupply missions may indeed be feasible options for science missions requiring medium-class launch vehicles, none of these vehicles has yet been certified and there is a significant risk that delays and technical issues will arise during the certification process that will prevent their certification in time for the SMAP mission currently scheduled for 2014.

The competitive award process for a mission's launch vehicle typically results in a selection 30 months before a mission's scheduled launch date. If commercial companies are unable to timely provide vehicles that meet NASA's medium-class launch requirements, the Agency's plan calls for choosing between two United Launch Alliance (ULA) vehicles: the medium-class Delta II and the intermediate-class Atlas V.[9] However, there are significant issues with each of these options.

First, the Delta II may not be available for NASA missions after 2011 because the Air Force has stopped using the vehicle in favor of larger intermediate-class launch vehicles such as the Atlas V that provide greater lift capability. Consequently, many of the components for the standard configuration Delta II are no longer being produced. According to NASA officials, restarting the Delta II production line to service NASA's needs would be cost prohibitive.

Second, the remaining unsold Delta IIs in ULA's inventory are "7920 heavy" configuration models that can only be launched from Space Launch Complex 17B at Cape Canaveral Air Force Station in Florida. However, in order to reach polar orbit NASA launches most of its Earth science missions at the Western Test Range at Vandenberg Air Force Base in California. Heavy configuration Delta IIs could not be launched from this location without costly modifications to the launch pad infrastructure at Vandenberg.

[9] In December 2006, Boeing and Lockheed Martin Corporation combined their ELV businesses to form United Launch Alliance as a joint venture.

Third, if NASA uses the intermediate-class Atlas V instead of a medium-class launch vehicle, the Agency estimates that its costs will increase by an additional $100 million to $300 million per launch.[10]

In sum, the loss of the Delta II as a viable launch option means that NASA may be more likely to rely on intermediate-class launch vehicles like the Atlas V to meet its medium-class launch requirements until Orbital, SpaceX, or another commercial entity produces a more cost-effective medium-class launch vehicle. Our analysis of NASA's future medium-class launch manifest and launch vehicle options shows that using Minotaur launch vehicles would be significantly less expensive than using either an Atlas V or even SpaceX's yet-to-be certified Falcon 9 and could provide a viable interim solution for several of NASA's medium-class science missions planned from 2010 through 2020.[11,12]

As previously noted, although new medium-class launch vehicles are in development from commercial providers, NASA LSP officials anticipate the earliest these vehicles could complete the required NASA certification is between late 2013 and early 2014. LSP officials told the OIG that a launch provider can be awarded a launch service task order before certification of its vehicle. Currently, the Falcon 9 is the only medium-class launch vehicle included in the NLS II contract, and the Falcon 9 flew its first two successful test flights in June and December 2010.[13] However, if NASA selected the Falcon 9 for the SMAP mission prior to certification, the Agency would need to accept a significantly higher degree of risk and determine how to address potential cost increases and schedule delays that could result if technical issues were identified during the certification process. These potential cost increases are not included in the SMAP mission budget and if they materialized could affect the funding available for other Science Mission Directorate (SMD) missions. Figure 1 shows the various vehicles that could potentially be available for medium-class launches.

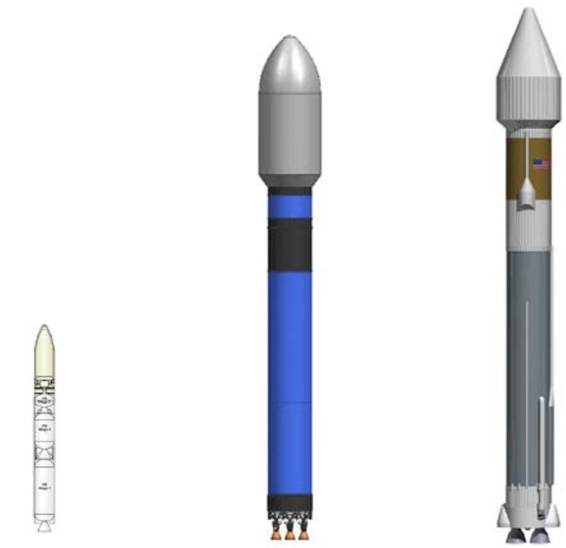
[10] NASA estimates included in NASA's NLS II Contract Limited Procurement Strategy dated April 2009 are based on 2009 launch vehicle prices with a 10 percent annual escalation.

[11] NASA's launch options are launch vehicles currently available for medium-class missions or vehicles that could be available in the near future if certified to fly NASA missions. The vehicle options include Taurus II, Falcon 9, Delta II Heavy, and Minotaur.

[12] The NLS II Projected Mission Model is a planning document used to project NASA launch services requirements from 2011 through 2020. NLS II refers to an extension of the ordering period under the NLS contracts from June 2010 through June 2020.

[13] The Falcon 9 configurations can meet medium- or intermediate-class launch requirements.

Figure 1. Current Launch Vehicles Potentially Available for Medium-Class Missions



Launch Vehicle	Minotaur IV	Falcon 9	Atlas V
Vehicle Class	Small to Medium	Medium to Intermediate	Intermediate
Projected Cost in 2012	$50 million	$111 million	$206 million
Approximate Mass Capability (600 kilometer, polar orbit)	1,100 kilograms	6,500 kilograms	6,800 kilograms

SMD personnel stated that launch requirements for some of the 13 medium-class missions included in the current NLS II Projected Mission Model potentially could be met by a Minotaur launch vehicle. We estimate the average cost of using Minotaurs for these science missions, currently scheduled for launch from 2012 through 2020, to be $63 million per launch as compared with $141 million per launch using a Falcon 9 and $264 million per launch for an intermediate-class Atlas V.[14] Accordingly, NASA could save an average of $78 million to $200 million per launch by using a Minotaur rather than a Falcon 9 or an Atlas V, respectively, for launches occurring through 2020.

[14] OIG estimates include basic launch services, mission-unique services, integrated services (e.g., launch vehicle and payload processing, range safety, engineering and institutional support, and launch pad support), and telemetry.

As mentioned previously, the competitive award process for a mission's launch vehicle generally occurs 30 months before the scheduled launch date. Therefore, a late 2013 or early 2014 certification date for a new medium-class launch vehicle may be too late for the SMAP mission, which is scheduled to launch in November 2014. LSP officials stated that a launch service task order can be awarded prior to certification. However, there are inherent schedule and cost risks associated with choosing an uncertified launch vehicle. NASA's other science missions that will require a medium-class launch vehicle are scheduled for launch from 2015 through 2020 and therefore could potentially use new commercially developed medium-class launch vehicles such as the Falcon 9. However, if cost-effective commercial medium-class vehicles are not ready for flight in time for these other missions, NASA could save money by using Minotaurs instead of larger, more expensive Atlas V intermediate-class launch vehicle.

Obstacles to Using Minotaur

As noted above, after reviewing a draft of our audit report NASA officials told us that "consistent with law and policy" they will consider using the Minotaur for medium-class science missions on a case-by-case basis. They explained that for each mission they will first determine whether cost-effective commercial launch services that meet mission requirements are available and, depending on the results of that determination, may pursue using a Minotaur for a particular mission. They also expressed concern that using the Minotaur for multiple missions would threaten the viability of commercial providers of small- and medium-class launch services and may increase the number of bid protests on contract awards because commercial companies would argue that U.S. law and space transportation policy requires NASA to use U.S. commercial vendors to the maximum extent practicable.

However, in January 2009 the NASA Administrator signed a memorandum stating that use of a Minotaur launch vehicle for SMD's Lunar Atmosphere and Dust Environment Explorer (LADEE) met the requirements of the Commercial Space Act and National Security Presidential Directive-40, "U.S. Space Transportation Policy," December 21, 2004. Moreover, NASA successfully defended this decision against a subsequent bid protest.

The LADEE mission is a small, 284-kilogram satellite designed to orbit the Moon originally scheduled for a 2010 or 2011 launch. During its planning process, NASA evaluated a series of potential launch vehicles, including SpaceX's Falcon 9 and Falcon 1e, and determined that the Minotaur launch vehicle best met NASA's requirements. In October 2009, SpaceX filed a bid protest with the Government Accountability Office (GAO) claiming that the contract award to Orbital for the Minotaur violated the Commercial Space Act of 1998 because NASA unreasonably concluded that no cost-effective commercial launch services were available from U.S. providers. On February 1, 2010, GAO denied SpaceX's protest, stating that NASA reasonably concluded that cost-effective commercial alternatives to the use of the Minotaur for the

LADEE mission were not available. The LADEE mission is currently scheduled for launch in May 2013.

Finally, current law allows NASA to use excess intercontinental ballistic missiles under certain circumstances. The Commercial Space Act of 1998 requires the NASA Administrator to obtain approval from the Secretary of Defense to use a Minotaur as a space transportation vehicle and to certify to Congress that the use of the Minotaur would result in cost savings to the Federal Government, meet all mission requirements, and be consistent with international obligations of the United States. In addition, Title 42, United States Code (U.S.C.), Section 14734 (Use of excess intercontinental ballistic missiles) provides NASA the option of using space vehicles derived from excess intercontinental ballistic missiles, such as the Minotaur.

Management Action

We recommend that the Assistant Associate Administrator for Launch Services and the Associate Administrator for SMD evaluate whether cost-effective and mission-suitable commercial launch vehicles will be reasonably available when required for the SMAP mission scheduled for launch in November 2014. As part of this evaluation, they should consider whether the Minotaur could meet mission requirements and whether its use would result in a cost savings in accordance with the Commercial Space Act of 1998. In addition, the Assistant Associate Administrator and the Associate Administrator should conduct a similar evaluation for each future medium-class science mission.

In response to a draft of this report, the Associate Administrators for Science and Space Operations concurred with our recommendation and stated that the intent of the recommendation reflects NASA's current process. The Associate Administrators also expressed concern with the impact that use of the Minotaur could have on the commercial space transportation industry. Nevertheless, they indicated that NASA will consider the Minotaur as a launch option for its science missions consistent with law and policy (see the Agency's response in Appendix D). The Associate Administrators also provided technical comments to our draft report, which we incorporated into the report as appropriate.

We commend NASA for making clear its commitment to considering economical alternatives like the Minotaur for its medium-class launch services requirements, especially in the current fiscally constrained environment. We consider NASA's comments to be responsive to our recommendation and the recommendation to be resolved. We will close the recommendation upon completion and verification of the planned action.

CONTENTS

INTRODUCTION

Background

The Commercial Space Act of 1998. To encourage the development of a commercial space industry in the United States, Congress enacted Public Law 105-303 (Title 42, United States Code, Section 14701), the Commercial Space Act of 1998. Section 201 of the Act requires NASA and other Federal agencies to plan missions and procure space transportation services from U.S. commercial providers to the maximum extent practicable. However, the Act also provides exceptions that allow the Federal Government to acquire space transportation services from noncommercial sources, such as the Department of Defense (DOD), on a case-by-case basis. Specifically, the Act states that the Federal Government is not required to acquire commercial space transportation services if:

> on a case-by-case basis, the [NASA] Administrator or, in the case of a national security issue, the Secretary of the Air Force, determines that—
>
> (1) a payload requires the unique capabilities of the Space Shuttle;
>
> (2) cost effective space transportation services that meet specific mission requirements would not be reasonably available from United States commercial providers when required;
>
> (3) the use of space transportation services from United States commercial providers poses an unacceptable risk of loss of a unique scientific opportunity;
>
> (4) the use of space transportation services from United States commercial providers is inconsistent with national security objectives;
>
> (5) the use of space transportation services from United States commercial providers is inconsistent with international agreements for international collaborative efforts relating to science and technology;
>
> (6) it is more cost effective to transport a payload in conjunction with a test or demonstration of a space transportation vehicle owned by the Federal Government; or
>
> (7) a payload can make use of the available cargo space on a Space Shuttle mission as a secondary payload, and such payload is consistent with the requirements of research, development, demonstration, scientific, commercial, and educational programs authorized by the Administrator.

NASA's Launch Services Program (LSP) acquires launch services for NASA's Exploration Systems Mission Directorate (ESMD) and Science Mission Directorate (SMD) as well as for the national security community, the National Oceanic and Atmospheric Administration, and DOD. The principal objective of LSP is to provide safe, reliable, cost-effective, on-schedule processing, advanced analysis, integration, and launch services for NASA and NASA-sponsored payloads using expendable launch vehicles (ELVs).

ELVs are designed to launch NASA science, DOD, commercial, and Federal agency payloads into space, are only used once, and their components typically are not recovered after launch. ELVs generally use two or more rocket stages, which fall back to Earth when their engine burns are complete. Whatever an ELV carries above the final discarded stage is considered the payload.

A payload's weight, orbital destination, and purpose determine what size launch vehicle is required. Three classes of ELVs have traditionally been available to NASA: small, which can carry payloads weighing between 200 and 800 kilograms; medium, which can carry payloads weighing between 1,500 and 3,200 kilograms; and intermediate, which can carry payloads weighing more than 3,500 kilograms.

Depending on the size of the payload, LSP acquires ELV launch services and directs the management and operation of NASA-owned launch sites and payload processing facilities. LSP-acquired launch vehicles are scheduled by NASA's Flight Planning Board, which is composed of members from each of the NASA Mission Directorates, Office of Safety and Mission Assurance, and Office of the Chief Engineer. Through the Flight Planning Board process, all space access requirements and priorities are assessed to develop Flight Planning Board Manifests that meet the requirements and capabilities of the Agency.

NASA Launch Services Contract. LSP awards multiple NASA Launch Services (NLS) contracts to a variety of launch services providers. Once a year, existing and emerging domestic launch services providers may submit proposals to compete for launch services contracts. NLS contracts included firm-fixed-price indefinite-delivery, indefinite-quantity (IDIQ) contracts with negotiated not-to-exceed prices with United Launch Alliance (ULA) for Atlas and Delta launch services, Orbital Sciences Corporation (Orbital) for Pegasus and Taurus launch services, Space Exploration Technologies Corporation (SpaceX) for Falcon launch services, and Lockheed Martin for Athena launch services.

The ordering period for the NLS contract expired June 2010. In preparation for the award of follow-on contracts to the current NLS contracts, LSP decided to continue to use the IDIQ task order contract method and extended the ordering period under the existing NLS contract from June 2010 through June 2020.[15] Extending the ordering period allows current providers to offer launch vehicles currently under contract as well as new launch vehicles that were not available at the time of the award of the base contract.[16] The extension also gives new providers an opportunity to offer launch vehicles and compete to provide future launch services. Launch services for new missions are added through

[15] This extension is referred to as "NLS II."

[16] ULA's Delta II was not offered under NLS II.

the issuance of solicitations that result in the award of a firm-fixed-price launch service task order.

On September 4, 2009, NASA issued a request for proposals for potential launch services for launches scheduled from 2010 through 2020. Contractor proposals were received on October 19, 2009, and contract awards were made on September 23 and 24, 2010. The mission model in Table 1 below was included in the request for proposal to identify potential launch services requirements for the NLS II contract.

Table 1. Projected NLS II NASA Missions

Launch Vehicle Class	Projected Number of Missions by Launch Year											
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total	SMD[b]
Small	0	2	1	1	0	0	0	1	0	0	5	5
Medium	0	0	0	1	2	1	2	2	3	2	13	13
Intermediate	0	0	1	1	1	3	2	2	2	2	14	9
Total	0	2	2	3	3	4	4	5	5	4	32	27
Minotaur-possible missions[a]				1	1	1	1		1	1	6	6

[a] Medium-class missions that, as of summer 2009, SMD personnel stated may fit on a Minotaur launch vehicle.
[b] Number of SMD missions out of the total number of NASA missions.

NASA projects that the value of NLS contracts will increase from $5 billion to $15 billion under NLS II. NASA's projection was based on 2009 prices with a 10 percent annual escalation to estimate the cumulative maximum contract value of the NLS II contract through 2020. Under the previous contract, NASA computed an average of $115 million for each medium-class mission from 1999 through 2010.[17] According to NASA officials, medium-class launch vehicles are projected to cost approximately $200 million per launch under the NLS II contract, a 74 percent increase over 1999-2010 average launch costs.[18] Although actual contractor cost data was not available, industry studies and NASA officials stated that the cost of manufacturing launch vehicles, the overall decline in global demand, and the cost of developing and maintaining launch pad infrastructure contribute to the projected increase in launch services costs.

Declining Commercial Market. We found that the limited global demand for U.S. commercial launch vehicles and NASA's projected 13 medium-class launches for 2010 through 2020 may not provide enough business for U.S. launch providers to remain

[17] NASA's projection was included in the NLS II Contract Limited Procurement Strategy, April 28, 2009, which calculated the NLS medium-class contract value of $1.38 billion, divided by 12 medium-class missions resulted in an average of $115 million per mission.

[18] NASA's projection was included in the NLS II Contract Limited Procurement Strategy, April 28, 2009, which calculated the NLS II medium-class contract value of $3.00 billion, divided by 15 medium-class missions resulted in an average of $200 million per mission.

viable. For example, according to the Federal Aviation Administration only 4 of 23 (17 percent) commercial launches around the world from January through September 2009 used U.S. launch providers. The other 19 launches (83 percent) obtained services from foreign launch providers in Russia and Europe.

Federal Aviation Administration data and space industry studies show that foreign launch providers, some of which receive extensive government support, can offer launch services with the same or greater performance at a lower cost than U.S. launch providers. NASA and space industry studies indicate that launch vehicles from U.S. providers will remain more expensive than foreign launch vehicles as long as the worldwide demand for U.S.-manufactured launch vehicles continues to decline and U.S. launch providers are required to pay for launch pad infrastructure costs.

National Security Presidential Directive-40 allows the Secretary of Defense to provide funds for fixed costs incurred by launch services providers supplying intermediate-class launch vehicles as part of the Evolved Expendable Launch Vehicle (EELV) Program.[19] Currently, DOD pays the entire launch pad infrastructure cost for EELVs such as the Atlas V, vehicles capable of carrying intermediate and larger payloads. However, the U.S. Government does not provide the same financial support for small- and medium-class launch vehicles. Without Government funding for infrastructure such as launch pads, most U.S. vehicles will remain too expensive to compete with similar vehicles provided by other nations.

Program Oversight. The Assistant Associate Administrator for Launch Services, Space Operations Mission Directorate (SOMD), is responsible for oversight, program requirements, evaluation, and assessment of the LSP. In coordination with the Flight Planning Board, the Assistant Associate Administrator approves class of service, launch date, launch site, and publication of the monthly Flight Planning Board Manifest. A program manager and the LSP Office, located at Kennedy Space Center, assist in the execution of the LSP. Kennedy also provides personnel, facilities, and resources in support of LSP's procurements to include safety and mission assurance functions.

Objectives

The overall objectives of this audit were to evaluate whether NASA's LSP acquired ELVs within costs and timeframes established by the NLS contracts. We also evaluated whether the acquisition strategy NASA provided to Congress for post-2010 ELV procurements was cost-effective and the most advantageous to the Government. See Appendix A for details of the audit's scope and methodology, our review of internal controls, and a list of prior coverage.

[19] The EELV Program is jointly funded between the Air Force and the commercial space industry.

NASA's Launch Services Program Provided Launch Vehicles within Costs and Timeframes Established by Contract

NASA's LSP provided ELVs that were within negotiated costs and timeframes for launches between 2008 and 2009. Our review of the five NASA missions launched from June 2008 through June 2009 with services provided by LSP found that launch services costs were approximately 19 percent of total mission costs, which was below the 20 percent budgeted by the SMD.[20] In addition, launch vehicles for small-, medium-, and intermediate-class missions were available within timeframes specified by the contract.

Launch Vehicles Provided within Cost

To evaluate the costs of ELVs acquired by LSP, we selected 5 of the 21 missions scheduled to launch from 2008 through 2012.[21] These five NASA science missions launched from June 2008 through June 2009 and used the following launch vehicles and providers:

- Interstellar Boundary Explorer (IBEX) – Pegasus XL (Orbital),
- Orbiting Carbon Observatory (OCO) – Taurus XL (Orbital),
- Gamma-ray Large Area Space Telescope (GLAST) and Kepler – Delta II (ULA), for two launches, and
- Lunar Reconnaissance Orbiter (LRO) and Lunar Crater Observation and Sensing Satellite (LCROSS) – Atlas V (ULA).

To determine whether LSP provided ELVs within negotiated costs for these five missions, we compared the total mission costs with launch services costs. We found that the total launch services costs for the five missions were 19 percent of total mission costs (see Table 2 for details of the five missions' costs). Total mission costs for the five missions ranged from $185 million to $549 million, with launch services costs from

[20] Includes basic launch services (standard launch vehicle hardware, range coordination, etc.), mission-unique services (requirements necessary to customize the basic vehicle to meet spacecraft and mission needs), integrated services (launch vehicle and payload processing, range safety, engineering and institutional support, and launch pad support), telemetry, and other costs such as pad infrastructure.

[21] The 21 launches scheduled from 2008 through 2012 included NASA, Air Force, and National Oceanic and Atmospheric Administration missions. Of the 9 missions launched from June 2008 through June 2009, 5 were NASA missions.

$39 million for a small-class launch vehicle to $128 million for an intermediate-class launch vehicle.[22]

Table 2. Launch Services Costs and Total Mission Costs					
Mission	**Launch Vehicle Class**	**Launch Date**	**Mission Costs**	**Launch Services Costs**	**Launch Services' Portion of Mission Costs**
			(Dollars in millions)		
GLAST	Medium	June 11, 2008	$503.4	$ 80.4	16 percent
IBEX	Small	Oct. 19, 2008	185.0	39.1	21 percent
OCO	Small	Feb. 24, 2009	271.9	52.3	19 percent
Kepler	Medium	March 6, 2009	472.5	82.3	17 percent
LRO/LCROSS	Intermediate	June 18, 2009	549.4	128.4	23 percent
Average			**$396.5**	**$ 76.5**	**19 percent**

As shown in the table, three of the five launches we reviewed were below the 20 percent of the overall mission costs budgeted by SMD, as was the overall average of all five missions. Further, we compared launch service task order costs with the net obligation authority in the planning, programming, budgeting, and execution (PPBE) documents for the five missions in our sample.[23] We found that the average launch service task order costs for all five launches from June 2008 through June 2009 were 3 percent below basic launch services and mission-unique costs established by the net obligation authority in the planning documents.

Launch Vehicles Provided on Time

LSP acquired and made available ELVs for small-, medium-, and intermediate-class missions within timeframes established by the NLS contracts. Our review of NASA's 2009 Major Program Annual Report concerning delayed launches confirmed that the delays in the missions were due to technical issues with the projects and not related to the acquisition or readiness of the LSP-provided ELVs. Table 3 compares planned launch dates with actual launch dates for the five NASA missions that we reviewed.

[22] Total mission costs consisted of basic launch services plus mission-unique costs, integrated services, telemetry, and other costs.

[23] Launch service task order costs consist of basic launch services and mission-unique costs. Also, net obligation authority is the amount that NASA obligated to cover launch service task order costs.

Table 3. Initial Launch Dates and Actual Launch Dates				
Mission	**Initial Launch Date**	**Actual Launch Date**	**Delay (Days)**	**Cause of Delay**
GLAST	Sept. 30, 2007	June 11, 2008	255	project development
IBEX	June 15, 2008	Oct. 19, 2008	126	project testing
OCO	Sept. 30, 2008	Feb. 24, 2009	147	project development
Kepler	June 30, 2008	March 6, 2009	249	project development
LRO/LCROSS	Oct. 30, 2008	June 18, 2009	231	project testing
Average delay			**202**	

NASA's 2009 Major Program Annual Report stated that project development and testing delayed mission launches by an average of 202 days for the five missions we examined. For example:

- The GLAST Project was rebaselined due to cost overruns and schedule delays associated with the development of the avionics system, the Large Area Telescope instrument, and the Command and Data Handling subsystem.
- The IBEX Project was rebaselined on September 6, 2006, for launch in the third quarter of 2008 to accommodate favorable Moon geometry.
- The OCO Project experienced difficulties with the subcontractor for its primary instrument, which resulted in a 4-month launch delay.[24] As a result, NASA decided to finish the instrument work in-house at the Jet Propulsion Laboratory, which contributed to increases in cost and schedule delays.
- The Kepler Project underwent a major restructuring during fiscal year 2006 because of cost overruns and contractor workforce problems. The contractor's inefficiencies resulted in increased programmatic costs and schedule delays.
- The LRO/LCROSS Project was delayed because of a nutation problem with LRO (nutation is an attitude stability problem that could cause spacecraft pointing errors or even result in tumbling and loss of spacecraft). Because Delta II's upper stage is spin-stabilized, which could initiate a nutation problem with LRO, the launch vehicle was changed from a Delta II to an Atlas V, increasing the LRO budget by $15 million.

[24] The OCO Project was a NASA satellite mission that launched on an Orbital Taurus XL. On February 24, 2009, the OCO mission was lost in a launch failure when the fairing failed to separate from the Taurus launch vehicle during ascent.

NASA's Acquisition Strategy for Medium-Class Launch Vehicles Did Not Include the Use of Minotaur Launch Vehicles

NASA's acquisition strategy for medium-class launch services is based on an assumption that commercial partners will be able to develop affordable medium-class launch vehicles to replace the Agency's vehicle of choice, the Delta II, which is no longer in production. According to NASA officials, contingency plans would choose between the five available 7920 heavy configuration Delta IIs remaining in ULA's inventory and the more powerful and expensive Atlas V, an intermediate-class launch vehicle, until commercial U.S. launch providers can develop a new medium-class launch vehicle. However, heavy configuration Delta IIs can only launch from Cape Canaveral Air Force Station, not the location from which NASA science missions are typically launched. Therefore, NASA would likely use intermediate-class launch vehicles until an affordable commercially provided medium-class vehicle is available. NASA officials estimated in the NLS II Contract Limited Procurement Strategy Meeting, April 28, 2009, that the cost of an intermediate-class launch vehicle like the Atlas V will be approximately $300 million as opposed to an estimated $200 million for a medium-class launch vehicle like the Delta II.

We found that in its acquisition strategy and related contingency plans, NASA did not identify the Minotaur launch vehicle as a possible option to meet its medium-class launch needs during this interim period. DOD uses Minotaur launch vehicles, which are derived from the motors of decommissioned U.S. intercontinental ballistic missiles (ICBMs), to satisfy some of its small- and medium-class mission requirements. Including the Minotaur in NASA's acquisition strategy for medium-class missions could provide NASA a less expensive alternative than an intermediate-class vehicle and could be a viable interim solution for some of its medium-class science missions scheduled for 2010 through 2020.

Our analysis shows that launch services costs in 2012, using a Minotaur IV would be between $61 million and $156 million less per launch than using Falcon 9 or Atlas V intermediate-class launch vehicle.[25] As a result, NASA could realize substantial savings by using Minotaur for appropriate medium-class science missions scheduled for launch through 2020 if cost-effective commercial alternatives are not available.

NASA's reluctance to consider the Minotaur revolves around its concern that use of Minotaurs may discourage commercial providers from entering or participating in the

[25] $61 million to $156 million is the difference between the price of ordering a Falcon 9 or an EELV in 2012, estimated at $111 million and $206 million, respectively, and the Minotaur price of $50 million.

launch services market. Most commercial providers enter the market with small-class vehicles for which demand is limited. According to NASA officials, if potential commercial launch providers perceive a further lack of launch opportunities due to the Government's use of existing Minotaurs in the small- and medium-class market, they may be reluctant to bid on launch services contracts in the future. In addition, NASA officials said that commercial launch providers would likely protest any contract award for a Minotaur launch vehicle on the ground that U.S. law and transportation policy requires NASA to use U.S. commercial vendors to acquire space transportation services to the maximum extent practicable.

NASA's Acquisition Strategy

Section 621 of the NASA Authorization Act of 2008 required NASA to develop a strategy for providing domestic commercial launch services in support of small- and medium-class missions of NASA's Exploration Systems, Science, and Space Operations Mission Directorates. As set forth in an August 2009 report to Congress (see Appendix C), NASA's strategy for small-class launch services is to seek competition through a mix of existing providers under contract and new providers currently working to demonstrate that they are able to meet NASA's mission requirements.

Strategy for Small-Class Launch Services. In September 2009, NASA extended the ordering period under existing NLS contracts from June 2010 through June 2020. The extension, referred to as NLS II, gives both current and new providers an opportunity to offer launch vehicles through June 2020. According to NASA officials, small-class launch vehicles are important because, historically, new commercial launch services providers have started with smaller vehicles before moving on to develop larger ones. Orbital and SpaceX provide small-class launch vehicles – the Pegasus and Taurus (Orbital) and Falcon 1 (SpaceX) – under NLS contracts. Under NLS II contracts, existing and new launch services providers that meet minimum contract requirements can submit proposals to furnish launch services for NASA and NASA-sponsored payloads. However, NASA officials said there may not be enough business in this class of launches to sustain more than one or two commercial providers. For example, NASA's NLS II Projected Mission Model identifies only five small-class missions from 2010 through 2020. NASA estimates that each launch using a small-class launch vehicle will cost approximately $100 million under NLS II contracts.[26] Under the previous NLS contracts, each launch using a small-class launch vehicle cost approximately $48 million.[27]

[26] NASA's projection included in NASA's NLS II Contract Limited Procurement Strategy, April 28, 2009, is based on 2009 launch services prices with a 10 percent annual escalation.

[27] OIG cost projection based on the average cost of four small-class NASA missions scheduled to launch from 2008 through 2012. The IBEX mission cost $39.1 million and flew on a Pegasus. The OCO mission cost $52.3 million and flew on a Taurus XL. The NuSTAR mission, estimated to cost $35.8 million, and the Glory mission costing $64.4 million had not flown as of January 2011.

Strategy for Medium-Class Launch Services. NASA's strategy for medium-class launch services is linked to development activities currently underway as part of the Agency's Commercial Orbital Transportation Services (COTS) Program. The COTS Program is a partnership between NASA and two commercial partners (Orbital and SpaceX) to develop a new cargo transport capability to resupply the International Space Station (ISS) after termination of the Space Shuttle Program. In December 2008, the Agency awarded both companies Commercial Resupply Services (CRS) fixed-price contracts. At the time of award, NASA ordered eight flights valued at about $1.9 billion from Orbital and 12 flights valued at about $1.6 billion from SpaceX. NASA anticipates that spreading fixed costs over a larger number of resupply flights for the ISS under the CRS contracts will result in competitively priced medium-class launch vehicles.

However, COTS Program management told the OIG that Orbital and SpaceX were not currently developing launch vehicles with all of the capabilities typically required by NASA science missions. Therefore, launch vehicles developed for ISS resupply missions will need additional capabilities before they can fully meet requirements to serve as launch vehicles for NASA's medium-class science missions.

Moreover, launch vehicles currently under development for ISS resupply missions are unlikely to be certified in time for at least the first of NASA's upcoming medium-class science missions. NASA policy requires that new launch vehicles pass a launch vehicle certification process to ensure the launch vehicle meets NASA's risk category requirements and that those risks are mitigated.[28] SpaceX's Falcon 9 is currently the only medium-class launch vehicle available on the NLS II contracts and LSP officials said they expect it to be certified for science missions between late 2013 and early 2014. LSP and SMD officials told us that standard practice is for NASA to competitively award a contract for a mission's launch vehicle 30 months before a mission's scheduled launch date. Therefore, under that timetable NASA should award a launch vehicle contract for the Soil Moisture Active Passive (SMAP) mission, which is planned for a November 2014 launch, in May 2012, two years before the Falcon 9 is expected to be certified. Consequently, it appears unlikely the Falcon 9 or any other medium-class launch vehicle currently under development will be certified prior to making a decision on a launch vehicle for the SMAP mission.

LSP officials stated that a launch service task order can be awarded prior to certification. However, there are inherent schedule and cost risks associated with choosing an uncertified launch vehicle. If the Falcon 9 is selected for the SMAP mission prior to certification, NASA would need to determine how to address potential cost increases and schedule delays that could result from technical issues identified during the certification

[28] NASA Policy Directive 8610.7D, "Launch Services Risk Mitigation Policy for NASA-Owned and/or NASA-Sponsored Payloads/Missions," January 31, 2008, requires the Agency to certify that new launch vehicles meet NASA's risk category requirements, to include the completion of three successful flights and performance parameters. Two of the three successful flights are required to be consecutive.

process. These potential increases are currently not included in the SMAP mission budget and could affect the availability of funds for other science missions.

NASA had 13 medium-class missions forecast for launch from 2010 through 2020.[29] ULA's Delta II is the only medium-class launch vehicle currently available under the original NLS contracts and only five Delta IIs remain available for NASA missions. Moreover, these remaining Delta IIs are the heavy configuration models, the highest performance Delta II. This version of the Delta II can only be launched from Space Launch Complex 17B at Cape Canaveral Air Force Station in Florida, which does not allow launches to polar orbits. Missions requiring polar orbits (including SMAP and the Ice, Cloud, and Land Elevation Satellite [ICESat-II]) must be launched elsewhere, such as Vandenberg Air Force Base in California. In addition, NASA officials said they expect that in 2012 the total cost of the Delta II heavy launch vehicle will be approximately the same as a larger Atlas V intermediate-class launch vehicle.

NASA uses the Atlas V for its intermediate-class missions. The Atlas V is part of a group of EELVs jointly funded between the Air Force and the commercial space industry that are capable of carrying intermediate and higher-level payloads. We project the average cost of Atlas V intermediate-class launch services under NLS II contracts beginning in 2012 will be approximately $206 million per launch compared with the cost of approximately $161 million per launch under the previous NLS contracts.

We assessed the costs of using Atlas V intermediate-class launch vehicles to satisfy launch requirements of NASA's medium-class missions using an interactive mission cost analysis tool developed by the OIG (see Appendix A for details of the tool). Our analysis found that SMD would need to increase its annual budget by approximately $6 billion over 10 years or eliminate 8 of the 34 missions (24 percent) planned for 2010 through 2020 to satisfy its medium-class launch requirements if it used intermediate-class launch vehicles. Based on our analysis, in late August 2009 the SMD revised its Projected Mission Model and reduced NASA's launch manifest for science missions for 2010 through 2020 from 34 to 27 missions.

Currently, DOD pays the entire launch infrastructure cost for EELVs. However, NASA may be required to pay a share of costs associated with base support and infrastructure for EELVs after 2012. National Security Presidential Directive-40, "U.S. Space Transportation Policy," December 21, 2004, requires the Secretary of Defense, the Director of Central Intelligence, and the NASA Administrator to evaluate the long-term requirements, funding, and management responsibilities for EELVs and infrastructure. The Directive states:

> That evaluation shall include recommending a proportionate shift of the existing funding responsibility of the Secretary of Defense to reflect any change to the balance

[29] NASA's NLS II Projected Mission Model for 2010 through 2020 as of August 31, 2009, identified 5 small-class, 13 medium-class, and 14 intermediate-class missions.

between national security and civil missions employing an Evolved Expendable Launch Vehicle.

If the decision is made to have NASA share in the funding for launch services infrastructure, we estimate that it could result in an average increase of $100 million for each NASA EELV mission (see Appendix B).

Use of Minotaur IV Launch Vehicles Less Costly for NASA's Medium-Class Missions

NASA's "Strategy for Small- and Medium-Class Launch Services" lists the Delta II and Atlas V launch vehicles as alternatives for providing medium-class launch services until commercial partners are able to develop affordable medium-class launch vehicles. NASA's strategy did not include using Minotaur IV launch vehicles to satisfy launch requirements for medium-class missions projected for 2010 through 2020. We concluded that the Minotaur launch vehicle would be a less expensive alternative for medium-class launch services for select NASA science missions from 2012 through 2020 at an average cost of approximately $63 million per launch.

DOD uses Minotaur launch vehicles to satisfy some of its small- and medium-class mission launch requirements. Although manufactured in the United States by Orbital, Minotaur launch vehicles are not considered commercial ELVs and are less expensive because they use Government-furnished solid-fueled rocket motors from decommissioned Peacekeeper ICBMs.

If NASA were to use Minotaurs for its projected science missions during the next 10 years, launch services costs would average between $78 million and $200 million less per launch compared to using a Falcon 9 or an Atlas V intermediate-class launch vehicle.

Including the Minotaur in NASA's acquisition strategy for medium-class missions would provide NASA with a cost-effective and proven launch option. Table 4 and the following paragraphs provide a comparison of Orbital's Minotaur IV, SpaceX's Falcon 9, and ULA's Atlas V and Delta II launch vehicles.

Table 4. NASA's Available Alternatives for Medium-Class Launch Requirements in 2012				
	Minotaur IV	**Falcon 9**	**Atlas V**	**Delta II**[a]
Class	Small to medium	Medium to Intermediate	Intermediate	Medium
Performance Risk	Low	Unknown	Low	Low
Pad Infrastructure	California, Florida, Alaska, Virginia	Florida	California, Florida	Florida[b]
Infrastructure Costs (2009)	None, portable	Unknown	DOD pays $161 million/year	NASA pays $50 million/year
Launch Schedule	Open	N/A	Backlogged	Open
Average Cost 2012-2020	$63 million	$141 million	$264 million	$200 million[c]

[a] Many Delta II components are no longer in production.
[b] The five remaining Delta II rockets are the 7920 heavy configurations that can only launch from Florida.
[c] NASA's projection based on 2009 launch services prices with a 10 percent annual escalation.

Minotaur IV. NASA considers the Minotaur IV a small-class launch vehicle. However, SMD personnel stated that some of the 13 medium-class missions included in NASA's NLS II Projected Mission Model for 2010 through 2020 could potentially fit on a Minotaur IV launch vehicle. In addition, the Minotaur has a significant flight history with an excellent success rate. NASA has also assessed Minotaur IV schedule risk and considered it low. Lastly, we determined that the cost for launch services in 2012 using Minotaur IV launch vehicles would be approximately $50 million per launch.

Falcon 9. SpaceX's Falcon 9 is a medium- to intermediate-class launch vehicle that is still in development. SpaceX has had two successful flights of the Falcon 9, in June 2010 and December 2010, and the vehicle is included in NASA's NLS II contracts. Currently, SpaceX does not have a launch facility at Vandenberg and a determination of performance risk for the vehicle has not yet been made. The estimated cost in 2012, for a Falcon 9 is approximately $111 million per launch.

Atlas V. ULA's Atlas V is an intermediate-class launch vehicle and NASA's contingency plan is to use the Atlas V for future medium-class missions if new medium-class launch vehicles currently in development are not available in time. The Atlas V can meet the technical requirements for mass and trajectory for all 13 projected medium-class missions. In addition, NASA officials said the Atlas V's performance risk is low because it is certified to carry high-priority payloads and has a significant flight history with an excellent success rate. We estimated that launch services costs in 2012, using an Atlas V launch vehicle will be approximately $206 million per launch under NLS II contracts.

Delta II. ULA's Delta II is a medium-class launch vehicle. Delta II was the only medium-class launch vehicle available under the original NLS contracts. However, there is no Delta II under the NLS II contract and only five Delta IIs remain in ULA's inventory, and all five are the heavy configuration that can only launch from Cape Canaveral Air Force Station. Delta II can meet the technical requirements for mass and trajectory for some of the 13 projected medium-class missions. In addition, the Delta II has been NASA's launch vehicle of choice for nearly 60 percent of its science missions. It is certified to carry high-priority payloads and has a significant flight history with an excellent success rate. NASA projected that using medium-class Delta II launch vehicles could cost approximately $200 million per launch.

As noted earlier, Delta IIs are no longer being produced. Accordingly, if NASA wanted to continue using the Delta II after the unsold inventory is depleted, ULA would need to restart production of the major components of the Delta II launch vehicle, which would increase the cost and delay the schedule for medium-class missions. NASA officials estimate that the costs of restarting and sustaining production lines and launch pad infrastructure for the Delta II would make the total cost for that vehicle approximately the same as using the larger Atlas V.

Obstacles to Using Minotaur Launch Vehicles

U.S. law and space transportation policy require NASA to use U.S. commercial vendors to acquire space transportation services to the maximum extent practicable. However, Title 42, United States Code (U.S.C.), Section 14734 (Use of excess intercontinental ballistic missiles) provides NASA the option of using space vehicles derived from excess ICBMs, such as the Minotaur. In accordance with the Commercial Space Act of 1998, the NASA Administrator can seek approval from the Secretary of Defense to use a Minotaur as a space transportation vehicle. However, the Administrator must certify to Congress that the use of the Minotaur would result in cost savings to the Federal Government, meet all mission requirements, and be consistent with international obligations of the United States.

In January 2009, the NASA Administrator signed a memorandum stating that the use of a Minotaur launch vehicle for the LADEE mission met Commercial Space Act and U.S. Space Transportation Policy requirements. This mission required launch services to transport the LADEE spacecraft into a circular lunar orbit to analyze the lunar atmosphere and to test communications capabilities from lunar orbit. NASA evaluated potential launch vehicles for this mission based on four criteria: technical capability, risk, schedule, and cost. NASA's launch vehicle evaluations included the Minotaur V, a five-stage launch vehicle consisting of three stages that use Government-furnished components from decommissioned Peacekeeper ICBMs, and two launch vehicles offered by SpaceX – the Falcon 1e and Falcon 9. NASA concluded that the Minotaur V and Falcon 9 launch vehicles could meet the LADEE mission's technical requirements, but the Falcon 1e launch vehicle was not capable of achieving the required trans-lunar orbit.

Although neither the Minotaur V nor the Falcon 9 has a NASA flight history, NASA concluded that the Minotaur V had the lowest technical and schedule risk given the Government's experience with the Minotaur V's design and the scheduled launches of its predecessor, the Minotaur IV. NASA concluded that the projected costs for the Falcon 9, in light of the anticipated Government oversight required to ensure a successful mission, would be approximately twice those for the Minotaur V. Based on these findings, NASA concluded that there were no cost-effective commercial launch services available from U.S. providers for the LADEE mission.

In August 2009, the Air Force issued a delivery order to Orbital under its IDIQ contract for launch services for the LADEE mission using a Minotaur V.[30] SMD personnel stated that Air Force launch services costs for the LADEE mission would be approximately $46 million, which is comparable to costs for launch services provided by LSP under the NLS contracts.

In October 2009, SpaceX filed a bid protest with the Government Accountability Office (GAO) claiming that the contract award to Orbital for the Minotaur V violated the Commercial Space Act of 1998. SpaceX argued that NASA unreasonably concluded that no cost-effective commercial launch services were available from U.S. providers. On February 1, 2010, GAO denied SpaceX's protest, stating that NASA reasonably concluded that cost-effective commercial alternatives to the use of ICBM assets for launch services were not available.

Conclusion

Under NASA's published acquisition strategy for launch services, the Agency indicated it may use more costly intermediate-class launch vehicles for its medium-class science missions planned for 2010 through 2020. Our analysis shows that Minotaur launch vehicles could provide NASA a significantly less expensive alternative than these intermediate-class vehicles and therefore should be considered. Moreover, the Falcon 9, the only medium-class commercial vehicle currently in a position to be certified within the next several years, would cost at least twice as much as a Minotaur and therefore NASA would need to carefully consider whether its use is "cost effective" as that phrase is used in the Commercial Space Act of 1998.

[30] Minotaur launch vehicles are available through the U.S. Air Force's Orbital/Suborbital Program 2 contract. The contract is administered by the U.S. Air Force Space and Missile Systems Center, Space Development and Test Wing, located at Kirtland Air Force Base, New Mexico.

Recommendation, Management's Response, and Evaluation of Management's Response

Recommendation. The Assistant Associate Administrator for Launch Services and the Associate Administrator for SMD should evaluate whether cost-effective and mission-suitable commercial launch vehicles would be reasonably available when required for the SMAP mission scheduled for launch in November 2014. As part of this evaluation, they should consider whether the Minotaur could meet mission requirements and whether its use would result in cost savings in accordance with the Commercial Space Act of 1998. In addition, the Assistant Associate Administrator and the Associate Administrator should conduct a similar evaluation for each future medium-class science mission.

Management's Response. The Associate Administrators for Science and Space Operations concurred with our recommendation and stated that the intent of the recommendation reflects NASA's current processes. The Associate Administrators also expressed concern with Minotaur's impact on the commercial space transportation industry; however, they stated that Minotaur will continue to be considered as a launch services option consistent with law and policy.

Evaluation of Management's Response. The Associate Administrators' planned action is responsive. The recommendation is resolved and will be closed upon completion and verification of the proposed action.

APPENDIX A

Scope and Methodology

We performed this audit from March 2009 through November 2010 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

We interviewed management officials from LSP, the Commercial Crew and Cargo Program Office, SMD, SOMD, and ESMD. We discussed areas related to LSP's future acquisition strategy; NLS contract costs, technical performance, risk, and schedule requirements; the status of ISS CRS contract efforts; and SMD's and ESMD's budget estimates and future mission requirements.

Evaluation of ELVs Provided under the NLS Contract. To evaluate costs and timeliness of ELVs provided by NASA's LSP, we selected 5 out of 21 missions scheduled to launch from 2008 through 2012. The five missions we selected for our sample were NASA-only missions, with services provided by LSP. We also ensured that our sample included all classes of launch vehicles covered under the previous NLS contract. Our sample consisted of the following:

- two small-class missions,
    - one using a Pegasus XL (Orbital) launch vehicle,
    - one using a Taurus XL (Orbital) launch vehicle;
- two medium-class missions using Delta II (ULA) launch vehicles; and
- one intermediate-class mission using an Atlas V (ULA) launch vehicle.

To evaluate whether LSP acquired ELVs that were cost-effective for the five missions, we compared the total launch services costs from the May 5, 2009, "Planning, Programming, Budgeting, and Execution (PPBE)" data with total mission cost from the Major Annual Program Report data in the 2010 NASA Budget.

We also compared the individual launch service task order costs with the net obligation authority for basic launch services and mission-unique costs in the May 2009 PPBE data.

To evaluate whether LSP-provided ELVs were timely for the five missions, we reviewed and compared NASA's 2009 Major Annual Program Report's initial launch dates with actual launch dates.

Evaluation of Post-2010 Strategy. To evaluate whether NASA's acquisition strategy for ELVs after 2010 is cost-effective and the most advantageous to the Government, we reviewed the draft and final NASA reports, "Strategy for Small- and Medium-Class Launch Services," dated February and August 2009, respectively (the final report is in Appendix C). In addition, we requested that SMD personnel identify medium-class missions included in NASA's NLS II Projected Mission Model for 2010 through 2020 that could be potentially satisfied with Minotaur IV launch vehicles. We also compared NASA's projected costs for small-, medium-, and intermediate-class launch vehicles under the NLS II contract with FY 2009 budget data from SMD and the U.S. Air Force for Minotaur IV launch vehicles. See Appendix B for details on the potential monetary benefits that we identified.

To assess the cost of using intermediate-class launch vehicles to satisfy launch requirements of NASA's medium-class missions, we developed an interactive mission cost analysis tool that compares mission and launch vehicle cost data with budgets. The tool uses NASA contract requirements, annual budgets, project development inflation, technological change costs, inflationary schedule change, project size, number of projects, average years to develop projects, average launch services costs, and assignment of launch vehicles to projects. In addition, the tool computes budget requirements to cover future mission costs, formulates cost avoidance based on assignment of launch vehicles, predicts impact on the number of future missions, and displays the cumulative budget deficit or gain. We used the tool to analyze the NLS II Projected Mission Model, dated August 3, 2009, that included 38 (34 SMD) ELV missions. On August 28, 2009, we provided SMD and LSP officials our cost analysis tool and shared our results. On August 31, 2009, SMD personnel provided us a revised Projected Mission Model that reduced NASA's launch manifest from 38 to 32 (27 SMD) missions for 2010 through 2020.

Launch Vehicles under Development. To determine whether commercial launch vehicles under development would be available and certified for NASA's medium-class science missions when required, we discussed the issue with LSP and SMD officials. We compared Orbital and SpaceX's COTS development milestones on file in the COTS Program Office with the scheduled launches of medium-class science missions included in NASA's mission model for 2010 through 2020. Using COTS milestones, we developed a timeline that estimated the launch vehicle selection and certification dates for the SMAP mission. We compared SMAP's estimated launch vehicle selection dates with LSP's estimated launch vehicle certification dates to determine whether developmental launch vehicles would be available for the SMAP mission when required.

Use of Computer-Processed Data. We assessed the reliability of computer-processed data used to perform this audit by comparing contract cost data, PPBE data, and cost data in NASA's Business Warehouse application from LSP, SMD, and ESMD. We also analyzed Air Force budget data for FY 1999 through FY 2013, contained in Exhibit R-2, "RDT&E [Research, Development, Test, and Evaluation] Budget Item Justification," February 2008, which we obtained from the Defense Technical Information Center in May 2009. We compared the Air Force budget data with budget information in NASA's procurement strategy documents. Although we did not test the general or application controls of any of these systems, we did compare the data with contract data and procurement strategy documents and determined that the data was valid and reliable to support our objectives and conclusions.

Review of Internal Controls

We reviewed and evaluated the internal controls associated with documentation of launch services requirements, the achievement of milestones, and cost reviews. We found no internal control deficiencies in any of the three areas.

Prior Coverage

During the last 5 years, GAO has issued seven reports related to the subject of this report. These reports can be accessed at http://www.gao.gov.

Government Accountability Office

"NASA: Medium Launch Transition Strategy Leverages Ongoing Investments but Is Not Without Risk" (GAO-11-107, November 22, 2010)

"NASA: Commercial Partners Are Making Progress, but Face Aggressive Schedules to Demonstrate Critical Space Station Cargo Transport Capabilities" (GAO-09-618, June 16, 2009)

"NASA: Assessments of Selected Large-Scale Projects" (GAO-09-306SP, March 2, 2009)

"Space Acquisitions: Uncertainties in the Evolved Expendable Launch Vehicle Program Pose Management and Oversight Challenges" (GAO-08-1039, September 26, 2008)

"Space Acquisitions: Actions Needed to Expand and Sustain Use of Best Practices" (GAO-07-730T, April 19, 2007)

"Space Acquisitions: DOD Needs to Take More Action to Address Unrealistic Initial Cost Estimates of Space Systems" (GAO-07-96, November 17, 2006)

Government Accountability Office (continued)

"Space Acquisitions: Improvements Needed in Space Systems Acquisitions and Keys to Achieving Them" (GAO-06-626T, April 6, 2006)

POTENTIAL MONETARY BENEFITS

The use of Minotaur IV launch vehicles, derived from the rocket motors of decommissioned ICBMs, could be a cost-effective interim solution for some of the 13 medium-class science missions planned in NASA's NLS II Projected Mission Model through 2020. We learned, through discussions with SOMD officials, that the Air Force had 35 to 38 Minotaurs in its inventory as of November 2010. In the summer of 2009, SMD personnel stated that some medium-class missions included in the NLS II mission model may fit on a Minotaur IV launch vehicle. By using a Minotaur for SMAP instead of a Falcon 9 or an Atlas V, NASA could potentially save between $61 million and $156 million per launch if NASA determines that a Minotaur IV meets mission, technical, risk, and schedule requirements.

Atlas V to Satisfy NASA's Medium-Class Launch Requirements

Based on our evaluation of LSP's presentation, "NLS II Contract Limited Procurement Strategy Meeting (PSM)," April 28, 2009, NASA determined the maximum average cost over the next 10 years of using an intermediate-class Atlas V at approximately $300 million per mission.

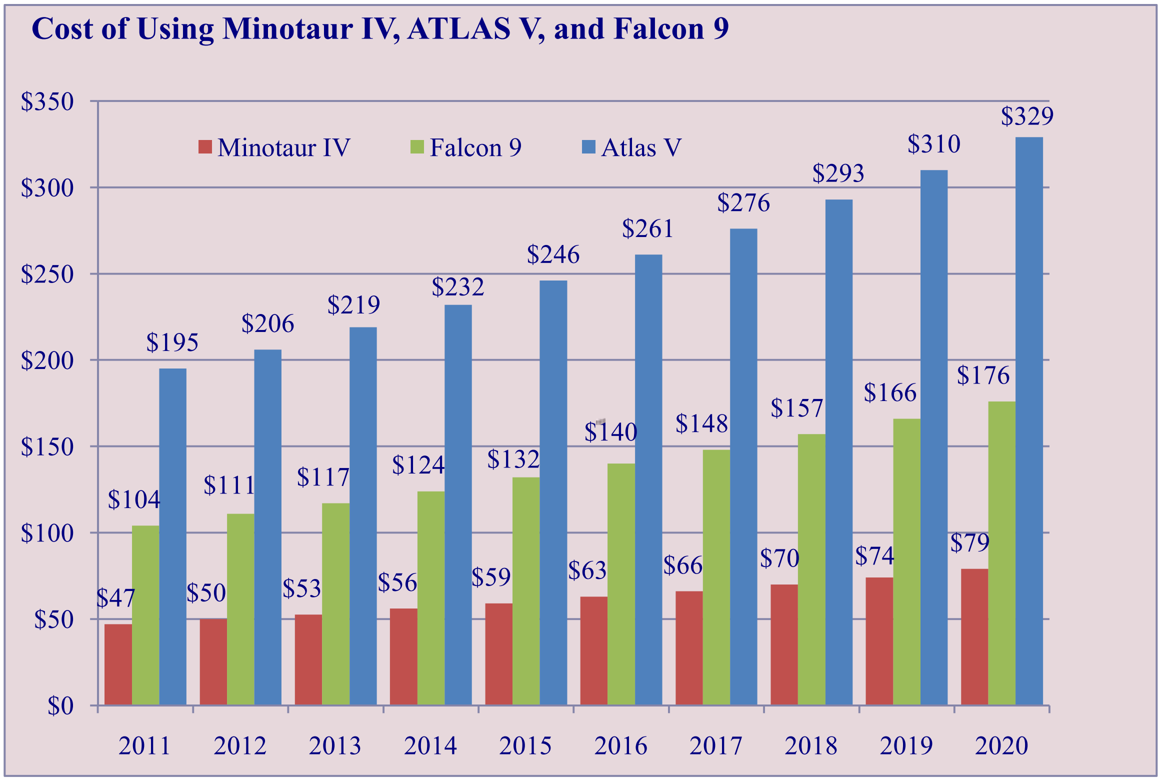
We performed a detailed analysis of LSP's PPBE using the maximum net obligation authority from May 26, 2009, for two missions: SMAP and ICESat-II. These missions were identified by SMD as two missions that were possible candidates for a Minotaur IV.[31] To project the price of what an Atlas V would cost for SMAP ordered in 2012, we used an annual escalation of 6 percent (inflation) that projected the average at $206 million.

However, we noticed that the PPBE estimates did not include Atlas V launch pad infrastructure costs. Because the Air Force charged NASA a user fee to cover infrastructure costs for Delta II launches, we believe that the Air Force may charge a similar user fee for Atlas V. Based on the ULA's not-to-exceed NLS II prices, the Atlas V pad infrastructure costs for the SMAP mission could reach $128 million, for a total cost of $334 million for the SMAP mission using Atlas V.

The following cost comparison chart also illustrates the cost trend for SMAP (ordered in 2012 and expected to launch in 2014), ICESat-II (ordered in 2013 and expected to launch

[31] Following the issuance of the draft of this report, SMD officials stated that ICESat-II now exceeds the capability of Minotaur IV.

in 2015), and other (2014–2020) medium-class missions without Atlas V pad infrastructure costs.



Meeting Launch Requirements for Medium-Class Missions

Based on our review of launch services costs related to the LADEE mission scheduled for launch in May 2013, and considering inflation, we believe that launch services costs for SMAP on a Minotaur IV will be approximately $50 million per launch as opposed to the $111 million for a Falcon 9 and $206 million projected for an Atlas V. If NASA determines that a Minotaur IV meets technical, risk, and schedule requirements for the medium-class missions included in the NLS II Projected Mission Model, NASA could avoid spending between $61 million and $156 million per launch, depending on the launch vehicle.

In December 2008, SMD, in collaboration with SOMD, recommended the Minotaur V launch vehicle for the LADEE mission. Through discussion with SMD officials, we estimated costs for LADEE at approximately $46 million, which is comparable to costs for launch services provided by LSP under the NLS contract. Services encompassed basic launch services, mission-unique services, integrated services (e.g., launch vehicle and payload processing, range safety, engineering and institutional support, and launch pad support), and telemetry.

We based our cost estimate of using a Minotaur IV for future launch services on LADEE's mission cost of $46 million. We applied an annual escalation of 6 percent (inflation) to estimate that the average cost of using a Minotaur over the next 10 years would be approximately $63 million per launch.

Although new medium-class ELVs (Falcon 9 and Taurus II) are in development, LSP officials anticipate the earliest one could complete certification is April 2014. An April 2014 certification date may be too late for the SMAP mission, scheduled for November 2014. In addition, LSP and SMD officials stated that the competitive award of a launch vehicle for a mission should occur 30 months before the mission's scheduled launch date. This report recommends that LSP and SMD consider using a Minotaur IV for the SMAP mission, which is planned for launch in November 2014, as well as the other medium-class missions identified by SMD. If NASA determines that a Minotaur IV can satisfy the mission, technical, risk, and schedule requirements of these medium-class missions, and an affordable U.S. commercial medium-class launch vehicle is not available approximately 30 months before the missions' planned launch dates, the potential monetary benefits could range from $78 million to $200 million per launch.

STRATEGY FOR SMALL- AND MEDIUM-CLASS LAUNCH SERVICES

Strategy for Small- and Medium-Class Launch Services

pursuant to

Section 621 of the NASA Authorization Act of 2008 (P.L. 110-422)

August 2009

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EXECUTIVE SUMMARY

Section 621 of the NASA Authorization Act of 2008 (P.L. 110-422) directs that NASA submit a report to Congress outlining a strategy for the provision of domestic commercial launch services to support the Agency's small- and medium-size Science, Space Operations, and Exploration missions, including the results of NASA's Request for Information (RFI) on small- to medium-sized launch services, released on April 22, 2008.

Following the significant downturn in commercial space activities in the late 1990s, current trends in the global commercial launch services market indicate that there is not sufficient business for U.S. commercial launch vehicle suppliers to continue participating in this sector if the Government were not required to purchase domestic launch services. This also is the case worldwide, where non-market economy conditions, government subsidies, or a combination of the two, are currently the only means for attracting commercial launch customers (mainly for intermediate and larger, geosynchronous-orbit commercial communication satellites). For the present time, government funding in some form continues to be needed to maintain certain launch capabilities. Without such funding, or government sustainment of infrastructure (such as launch pads), most U.S. vehicles are too expensive in comparison with those provided by other nations to compete in this sector. Unfortunately, NASA believes this trend will continue until a major application materializes that shifts the current paradigm.

The U. S. Government has followed a strategy of supporting intermediate-class launch vehicles in the Evolved Expendable Launch Vehicle (EELV) program. The lack of comparable government programs for small- and medium- class launch vehicles has resulted in the atrophying of the small- and medium-class capability, as there is only a very small commercial market for these vehicle classes. However, new launch vehicles in this class and the medium class are in development, with the new medium class entrants supported by NASA's Commercial Orbital Transportation Services program. NASA also expects its recent International Space Station (ISS) Cargo Resupply Services (CRS) contract to provide a sufficient baseline to enable commercial providers to offer commercial services at competitive prices.

If CRS is not successful in delivering reliable and cost-effective launch vehicles that can also be used with upgrades for NASA science missions, the Agency may be faced with a lack of proven, cost-effective domestic launch capabilities in the medium- performance vehicle class. NASA would view such a scenario as a significant concern.

BACKGROUND

Section 621 of the NASA Authorization Act of 2008 (P.L. 110-422) directs NASA to submit a report to Congress outlining a strategy for the provision of domestic commercial launch services to support its small- and medium-size missions, and including the results of the Request for Information (RFI) on small- to medium-sized launch services released on April 22, 2008 (provided in Appendix A). Section 621 reads as follows:

SEC. 621. LAUNCH SERVICES STRATEGY.

(a) In General.—In preparation for the award of contracts to follow up on the current NASA Launch Services (NLS) contracts, the Administrator shall develop a strategy for providing domestic commercial launch services in support of NASA's small and medium-sized Science, Space Operations, and Exploration missions, consistent with current law and policy.

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(b) Report.—The Administrator shall transmit a report to the Committee on Science and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate describing the strategy developed under subsection (a) not later than 90 days after the date of enactment of this Act. The report shall provide, at a minimum—

(1) The results of the Request for Information on small- to medium-sized launch services released on April 22, 2008;

(2) An analysis of possible alternatives to maintain small and medium-sized lift capabilities after June 30, 2010, including the use of the Department of Defense's Evolved Expendable Launch Vehicle (EELV);

(3) The recommended alternatives, and associated 5-year budget plans starting in October 2010 that would enable their implementation; and

(4) A contingency plan in the event the recommended alternatives described in paragraph (3) are not available when needed.

NASA relies on the U.S. commercial market to provide launch services for its space and Earth science missions, and, in the future, the Agency will rely on U.S. commercial vendors to provide resupply services to the ISS. NASA procures launch services in accordance with all applicable U.S. laws, regulations and policies, including, but not limited to, the U.S. Space Transportation Policy of 2004, the Commercial Space Act of 1998 (P.L. 105-303; 42 U.S.C. 14701 et seq.), and the Commercial Space Launch Amendments Act of 2004 (P.L. 108-492, 49 USC Chapter 701). NASA competitively procures launch services for science missions using the NASA Launch Services (NLS) contract, which has been in place since 2000 and is nearing the end of its 10-year ordering period. Three performance classes of Expendable Launch Vehicles (ELVs) have traditionally been available to NASA: small (200-800 kg to 675 km), medium (1,500-3,200 kg to 675 km), and intermediate (>3,500 kg to Geostationary Transfer Orbit). It is difficult to examine U.S. launch services for NASA in isolation, since the market is also affected by national security requirements and the extent of commercial activities. At this time, the commercial market for U. S. commercial ELVs is facing significant challenges, and the outlook is different for each performance class.

Currently, the small-class launch services market is experiencing an abundance of launchers, with five currently available U. S. launch vehicles (this number may grow to seven). Since the early 1990s, there have never been more than nine U.S. small-class launches in any one year -- the average is three to four missions per year. Because the U.S. commercial small class consists of a mix of existing providers with increasing unit and infrastructure costs, and new vendors that have not fully demonstrated the reliability of their vehicles, NASA must maintain procurement options. NASA will seek competition without encouraging oversupply. The Agency would prefer lower costs, which may require competition in this class, while taking into account supply and demand considerations in the overall market. Sustaining a viable commercial product in this class may be more difficult due to the U.S. Government's use of the Minotaur, which is not commercially available due to its Government-furnished Intercontinental Ballistic Missile (ICBM) booster motors. It should be noted that there is currently no commercially-available product in the upper end of the small class, which the Minotaur IV/V is beginning to serve. Accordingly NASA believes that further U.S. Government analysis on this matter should be considered.

NASA's approach to sustaining medium-class launch capability is to provide a business base via ISS resupply services. In addition, NASA will need to pay for specific capabilities to meet science mission requirements and improve the risk posture because the development of ISS commercial cargo resupply services alone will not result in vehicles fully capable of meeting NASA's science needs. On December 23, 2008, NASA awarded ISS CRS contracts to two vendors: Orbital Sciences Corporation (OSC) and Space Exploration Technologies (SpaceX). The two companies will develop the capability

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to transport cargo to the ISS after the retirement of the Space Shuttle. This will establish a larger business base for medium-class launch vehicles, which should help reduce launch prices for NASA's space and Earth science missions in this class. Without this contract, demand for U.S. medium-class launch vehicles may not be sufficient to sustain a commercially-viable service. If that occurred, NASA could become the only user of U.S. medium-class launch vehicles. The Agency's current demand for science missions in this class averages about one mission per year, though historically it had been as high as two to three. The ISS resupply requirements will add several more medium-class launches per year. Without such additional missions to increase the launch rate, a supplier's fixed costs for producing a reliable launch vehicle would increase launch costs to a point where they could significantly limit the number of NASA science missions that could be performed. This is what has happened with Delta II in recent years. This medium-class strategy will not address NASA's requirements for small-class launch services noted above. Even reasonably priced medium-class launch services are too expensive for NASA small class missions, if they are launched individually.

The domestic demand for intermediate-class launch vehicles, the Delta IV and Atlas V Evolved Expendable Launch Vehicles (EELVs), is dominated by Department of Defense (DOD) missions, with a DOD/NASA combined launch rate of 8-12 missions per year. Even with this higher launch rate, the DOD is investing significant funds to sustain the EELV capability. From NASA's perspective, some level of investment to sustain the medium class also may be necessary given broader launch market conditions and the limited demand for this performance class. NASA's current approach to addressing this issue is to provide a business base via ISS resupply services and to pay for specific capabilities to meet science mission requirements and risk posture.

1.0 SMALL-CLASS LAUNCH VEHICLES

Currently, two vendors provide small-class launch services under NLS: OSC, with the Pegasus and Taurus launch vehicles, and SpaceX with the Falcon-1 launch vehicle. However, given the low annual launch rates in this class (commercial launches have been essentially non-existent, NASA missions have been few, and the DOD has been using the non-commercial Minotaur family of launch vehicles), prices have risen and the sustainability of this class of commercially-available launchers is in question.

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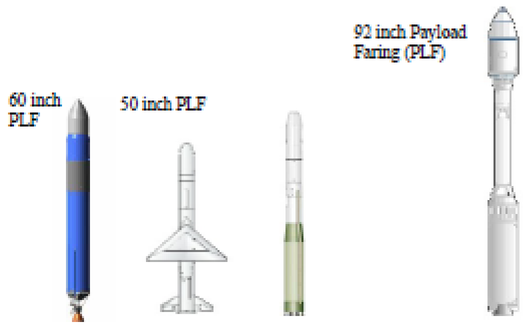
Small-Class Launch Vehicles with Flight History
(vehicles below approx. to scale)



Vehicle/Orbit	Falcon 1	Pegasus XL	Minotaur I	CAPABILITY GAP	Taurus XL
600 km, 90-degree orbit	200 kg	250 kg	375 kg		900 kg
675 km sun-synchronous orbit		225 kg	325 kg		750-800 kg
C3=0 ***	n/a	n/a	n/a		~280 kg*
Performance Risk	Low to Medium (5% risk)	Low	Low		Low

NOTES:
* - Requires additional upper stage for high energy missions.
*** - C3 is a measure of launch energy for missions escaping Earth orbit. C3=0 provides the energy for escape and slightly envelopes the requirement for Lunar missions. C3=10 is representative of a mission to Mars.
Low Peformance Risk indicates there is a potential for a 5 percent or less reduction to payload capability.
Medium Performance Risk indicates there is a potential for a 5-15 percent reduction to payload capability.
High Performance Risk indicates there is a potential for a 15 percent or more reduction to payload capability.
Vehicle sizes are approximately to scale.

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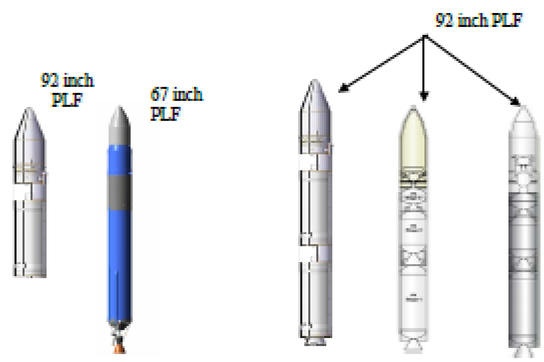
<u>Small-Class Launch Vehicles in Development</u>
(vehicles below approx. to scale)



Vehicle/Orbit	SLV-A	Falcon 1E	CAPABILITY GAP	SLV-B	Minotaur IV	Minotaur V
600 km, 90-degree orbit	~300 kg	~625 kg		~1,150 kg	~1,200 kg	n/a
675 km sun-synchronous orbit					1,100 kg	n/a
Trans Lunar	n/a	* n/a		~425 kg*	n/a	~390 kg
Performance Risk	Medium	Medium		Medium	Low	Low

NOTES:
* - Requires additional upper stage for high energy missions.
Low Peformance Risk indicates there is a potential for a 5 percent or less reduction to payload capability.
Medium Performance Risk indicates there is a potential for a 5-15 percent reduction to payload capability.
High Performance Risk indicates there is a potential for a 15 percent or more reduction to payload capability.
Vehicle sizes are approximately to scale.

Table 1.

For small-class launch services, NASA's strategy seeks to enable competition in a sensible manner. NASA's solution for obtaining small-class launch services will not be addressed by the ISS CRS contracts noted earlier or by the Agency's Commercial Orbital Transportation Services (COTS) efforts, because the expected cost of the new medium-class launch vehicles that will support ISS CRS and COTS will be too high for small-class missions.

In addition, the commercial industry has yet to develop a cost-effective vehicle at the upper end of the small class. Lockheed Martin was unable to build a viable business case for its Athena II vehicle, and OSC's Taurus Standard and XL launch vehicles have had only eight launches in over 15 years. With the loss of the Delta II 7300 Series vehicle and the Delta II Dual Payload Attach Fittings (DPAF), there may be some need from NASA for launches in the performance gap between Taurus XL and any new medium-

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class vehicle. However, demand will never be considered large, and low flight rates are a significant contributor to high costs, which then generally result in even lower launch rates. The lack of sustained business from NASA, DOD, or commercial enterprises for the U.S. commercial small-class launch vehicles allows this cycle to continue.

NASA investigated previous and projected launch rates in order to understand the demand in this class. The maximum number of U.S. small-class launches in any one year from 1990 to date has been nine. Nine missions are planned for 2009 alone, but five of them are on the non-commercial Minotaur IV. However, over the last ten years, the annual average number of launches in this class was only three to four. Some commercial companies have concluded that five to nine launches per year is the sustainable demand, however NASA believes the average may be closer to two to four per year. NASA currently projects its own use as one launch annually.

NASA has identified the vehicles which are available, or may become so in the near future. If ATK introduces the SLV-A and SLV-B (or Athena) launch vehicles into the market as planned, there would be seven operational vehicles. Four would be at the lower end of the small class (200 – 600 kg spacecraft) and three at the upper end of the small class (900 – 1,200 kg spacecraft). As shown in Table 1, there is a significant difference in payload capability between these ranges. These seven vehicles would be competing for two to four missions per year (NASA's demand is usually 0 to 1 per year). This oversupply for NASA's level of demand is partially created by the existence of the Minotaur I and IV, which are significantly cheaper than most comparable commercial products due to the use of existing boost-stage solid rocket motors inherited from excess ballistic missiles. Minotaur is not available commercially and is considered "use of excess ballistic missiles." As such, NASA may use Minotaur, but only subject to approval on a case-by-case basis.

Both legislation and the U.S. Space Transportation Policy address the use of Minotaur vehicles for space launch services, as noted below:

> *42 U.S.C. § 14734 prohibits the conversion of ICBMs to a space transportation vehicle configuration by the Federal Government unless the Agency (the Department of Defense) seeking to use the missile certifies to Congress that the use of such missile:*
>
> *(A) would result in cost savings to the Federal Government when compared to the cost of acquiring space transportation services from United States commercial providers;*
> *(B) meets all mission requirements of the agency, including performance, schedule, and risk requirements;*
> *(C) is consistent with international obligations of the United States; and*
> *(D) is approved by the Secretary of Defense or his designee.*
>
> *42 U.S.C. § 14731(b)(2), a determination must be made that the acquisition of space transportation services directly from a U.S. commercial provider is not required because, "cost effective space transportation services that meet specific mission requirements would not be reasonably available from United States commercial providers when required."*
>
> *Commercial Space Act of 1998 (the Act), Pub. L. 105-303, 112 Stat. 2843,42 U.S.C. §§ 14701, et seq.,*
> *cost effective space transportation services that meet specific mission requirements would not be reasonably available from United States commercial providers when required;*
>
> *U.S. Space Transportation Policy*
> *Excess U.S. ballistic missiles shall either be retained for government use or destroyed. United States Government agencies may use such assets to launch payloads into*

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orbit on a case-by-case basis, with the approval of the Secretary of Defense, when the following conditions are met: (1) the payload supports the sponsoring agency's mission; (2) such use is consistent with the obligations of the United States under treaties and other international agreements to which the United States is a party, including the Missile Technology Control Regime guidelines, the Strategic Arms Reduction Treaty, and the Intermediate Nuclear Forces Treaty; and (3) the sponsoring agency certifies that such use results in a cost savings to the United States Government compared to the use of available commercial launch services that would also meet mission requirements, including performance, schedule, and risk, and limits the impact on the U.S. space transportation industry;

It should be noted that continued use of the Minotaur vehicles creates a lower level of demand for commercially available launch vehicles. This could result in only one to two NASA and commercial missions per year available for launch on the other five launch vehicles, which is not likely to be a sustainable business case.

NASA concludes that there is not enough business to sustain more than one to two providers in this class. It is not clear if this means only two separate launch vehicle choices, or if synergy between products from the same provider would result in more options. In addition, NASA believes that this class is important because, historically, new launch service providers have tended to start with smaller vehicles before moving on to develop larger ones.

NASA continues its work to determine how the NLS follow-on contract effort will address this small-class issue. It remains to be seen whether Falcon 1 will provide the corresponding reliability, performance, and price needed to increase demand in this class. However, even the Falcon 1-E will not have the performance of the Taurus XL, SLV-B/Athena II, or Minotaur IV. Therefore, it does not appear possible for one commercial launch vehicle to support the entire range of small-class performance requirements at an affordable price for NASA. As noted above, with the loss of the Delta II 7320 launch vehicle, the performance gap between the small class and the medium class is now very large. NASA must assess its demand and performance requirements in the small-class against the available launch vehicles. This is very difficult today, due to the following factors:

- uncertainty in projected costs of Pegasus XL and Taurus XL after NLS contract expiration and a launch gap of at least three years;
- limited performance record of the Falcon 1, and uncertainty in the price, performance and cost of the Falcon 1E, which is due to replace Falcon 1 in 2010;
- lack of any launch history and uncertainty in the price and the availability of the SLV-A and SLV-B; and,
- uncertainties concerning Minotaur, including NASA's future ability to obtain Minotaur launch services, impact to the commercial market due to the continued use of Minotaur, and whether the U.S. Government would abandon Minotaur in favor of supporting a fully commercial small-class market.

2.0 MEDIUM-CLASS LAUNCH VEHICLES

In the medium class of launch vehicles, NASA's workhorse has long been the United Launch Alliance's (ULA) Delta II, which has launched 60 percent of NASA's science missions over the last decade. Delta II is the only medium-class launcher currently available under the NLS contract. The U.S. Air Force (USAF) is scheduled to conduct its final Delta II launch in 2009. NASA has Delta II vehicles on contract for launches through 2011, and ULA has enough parts in inventory to build

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several more Delta II launch vehicles, which NASA will consider for use on future missions. However, as the USAF moves most of its payloads to the larger Delta IV and Atlas V vehicles, the medium-class market will be insufficient to sustain the Delta II line at prices traditionally paid. Therefore, the Delta II will likely cease to be available for NASA missions beyond 2011, due to costs of the overall program, such as the launch pad infrastructure costs formerly borne by the USAF, and higher prices for the Delta IIs themselves. Even if funding were available, this would only constitute a temporary solution, as many of the components for the standard configuration Delta II are out of production, and the cost of restarting and continuing production would be additional significant expense beyond NASA's budget.

Table 2, below, shows the commercially-available launch vehicle alternatives for the medium class. The EELV launch vehicles are not included, as they are intermediate-class launchers, but their ability to supply services for the NASA medium-class science missions is addressed in the "options" section of this report.

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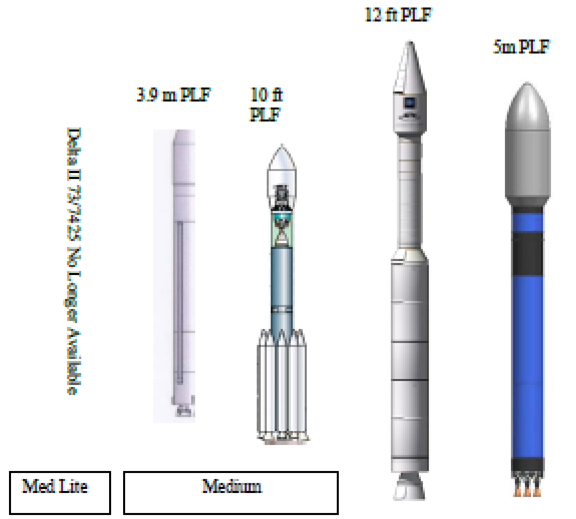
Potential Medium-Class Launch Vehicle Alternatives
(vehicles below approx. to scale)



Vehicle/Orbit	Delta II 7320/5	Taurus 2 (from WFF)	Delta II 7920 H	Athena IIIA**	Falcon 9 Block 1****
C3=0 ***	750 kg*	1,150 kg*	800 kg	1,850 kg	2,000 kg
C3=10 ***	650 kg*	950 kg*	*	1,350 kg	1,350 kg****
675 km sun-synchronous orbit	1,550 kg	Not achievable from WFF	Not achievable from CCAFS	800 to 3,500 kg	Not achievable from CCAFS
Initial Launch Capability		Dec. 2010		~2011	2nd Quarter, 2009
Performance Risk	Low	High	Low	High	Medium

NOTES:
WFF - Wallops Flight Facility, Virginia
CCAFS - Cape Canaveral Air Force Station, Florida
* - Requires additional upper stage for high energy missions.
** - Launch site development not started for this vehicle.
*** - C3 is a measure of launch energy for missions escaping Earth orbit. C3=0 provides the energy for escape and slightly envelopes the requirement for Lunar missions. C3=10 is representative of a mission to Mars.
**** - Block 1 is an early version with lower performing engines, a higher performing Block 2 upgrade is planned.
Low Peformance Risk indicates there is a potential for a 5 percent or less reduction to payload capability.
Medium Performance Risk indicates there is a potential for a 5-10 percent reduction to payload capability.
High Performance Risk indicates there is a potential for a 15 percent or more reduction to payload capability.

Table 2.

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It should be noted that no U.S. commercial company is developing a new "medium light"-class launch vehicle. Therefore, the kinds of missions that have historically utilized the lower-end of the Delta II cost and performance range will confront the capability gap between new medium-class alternatives and the small-class alternatives.

There are several options for providing medium-class launch capability in the future; these are outlined and assessed below.

2.1 Option One: Utilize Remaining Delta II Inventory

Currently, the remaining unsold Delta II inventory is available under the NLS contract only with GEM-46 (Graphite Epoxy Motor-46 inch) motors, which are used only for the "heavy" configuration of the Delta II. The "heavy" is the highest performance Delta II configuration. It can be launched only from Space Launch Complex (SLC) 17B at Cape Canaveral Air Force Station on the East Coast. Costs for missions requiring launches from Vandenberg Air Force Base in California (e.g., many Earth observing missions) are undetermined at this time. In addition, ULA currently offers only the two-stage configuration under NLS – the three-stage version is no longer available under the contract. While it is likely that a Star 48 third stage (used to achieve Earth escape velocities used by many medium-class missions) could be purchased for a NASA mission, the cost of doing so has not been determined by ULA due to lack of demand. Once the unsold inventory is used, ULA would have to restart production of the major elements of the Delta II in order to maintain this capability. NASA has evaluated the cost impacts of restarting Delta II production. When combined with the cost of the basic vehicle and infrastructure maintenance and repair, this approach is not considered to be fiscally acceptable. Therefore, Delta II is not considered a viable long-term option for NASA's medium-class science missions.

After the USAF fly-out of the last Global Positioning System (GPS) mission in FY 2009, NASA will bear sole responsibility for maintaining Delta II launch site infrastructure. The facilities are government-owned, and the cost to maintain them will be paid by NASA. This infrastructure includes not only the launch pads, but also all of the processing facilities used for the Delta II. In addition, NASA is charged for post-production support costs for major supplier hardware in cases where those suppliers have stopped production. Infrastructure and production sustaining costs in 2010 and 2011 are being paid by NASA missions already on contract. Without this funding, ULA could not continue to launch the remaining Delta II inventory. The contract value of maintaining the ability to launch the Delta II heavy inventory from the East Coast is just over $25M in 2012. Out-year costs are unknown, but are projected to increase to over $40M per year from 2013 through 2015. The increase is based on expected infrastructure deterioration and increased sustaining engineering costs. When this cost is added to the Delta II launch service price in the current NLS contract, the cost to NASA of using a Delta II in 2012 would be approximately the same as that of using the Atlas V EELV, which has a significantly higher payload capacity. Each year that NASA does not buy Delta II launch services (such as 2012, when there is no medium-class mission in the NASA mission model), the cost advantage of using an EELV over a Delta II improves because of the cumulative nature of the annual Delta II sustaining costs. As a result of studying Delta II and EELV projected costs since 2006, NASA has decided to use Delta II only to the extent that it makes financial sense to do so.

2.2 Option Two: Utilize EELV

To date NASA has selected Atlas V only for its intermediate-class missions. As the launch service acquisition agent for NOAA, NASA has selected the Delta IV vehicle for two of NOAA's Geostationary Environmental Operational Satellites (GOES). Atlas V has won NLS contract awards based on a competitive best value determination by NASA. After 2011, EELV launchers are expected to cost the same or less for NASA to use than Delta II. Another advantage of EELVs over the existing Delta II inventory is that EELVs can be launched from either the East or West Coast, reaching orbits

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that meet all medium-class mission requirements, which is critical to NASA's Earth science program that require launches from the West Coast in order to place each mission in the proper orbit to successfully conduct science. However, EELV launch service costs are much higher than what medium-class missions expect to pay. In addition, these costs are anticipated to increase substantially when the NLS contract expires. With an estimated 30-percent increase for NASA Atlas V launch services beginning in 2013, Atlas V is about as expensive as Delta II when infrastructure costs are included. If NASA were left with only this alternative, the mission model shown in Appendix A as part of the NLS II RFI would have to be reduced, as costs would be too high to perform the same number of missions. In addition, there is concern that a spacecraft could have a tendency to grow to take up the excess performance available from the launch vehicle, and potentially increase overall mission costs.

The second concern for NASA in using EELV is the uncertainty related to the DOD EELV Launch Capability (ELC) contract costs for infrastructure support, and what that might mean for future NASA launch costs. Under the U.S. Space Transportation Policy, the DOD pays the entire annual fixed infrastructure cost for EELVs. This will be reviewed before 2010, and there is concern over the potential for a reallocation of costs for the base capability and infrastructure related to both EELVs in the future.

A third concern with using EELV is the potential for overcrowding the launch manifest. This concern is related to the current launch throughput, with a stated schedule requirement of 60 days between launches from the same pad. Currently there is a backlog of EELV missions due to a combination of launch vehicle and spacecraft delays. This situation will continue until at least 2012, or until the backlog can be cleared. To minimize the impact, the DOD has recently paid the vendor additional funds to decrease Atlas V processing time from 60 days to 45 days.

2.3 Option Three: Resize Spacecraft and/or Co-Manifest Payloads

NASA has assessed the benefits and issues of co-manifesting multiple missions on large launch vehicles. In 2007, NASA's Science Mission Directorate (SMD) studied (using representative Earth observation instruments, based on the CloudSat and CALIPSO missions) the schedule, cost, and risk trade-offs among: 1) launching multiple, small missions on small, expendable launch vehicles (e.g., Taurus 2); 2) co-manifesting satellites on a single large, expendable launch vehicle; and, 3) integrating instruments on a single spacecraft bus for launch on a large expendable launch vehicle. SMD concluded that the optimal strategy is closely tied to the specifics of individual programs. There is no "one size fits all" solution to the challenge presented by the loss of medium-class launch capabilities. This study indicated the need to evaluate options on a program-by-program basis due to specific factors, including the possibility of missions to similar locations (i.e., opportunities to co-manifest or combine investigations on a common spacecraft bus), and the time criticality of the measurements (e.g., data continuity requirements for climate monitoring, solar irradiance trends, risk tolerance, etc.).

NASA has also examined several options for flying multiple payloads on EELVs to determine whether this could offer a cost savings for the Agency's small- and medium-class missions. ULA has proposed a concept for a twin-payload deployment system based on existing Atlas V hardware. This Dual Spacecraft System, which is based on the Centaur equipment module design, has passed Preliminary Design Review (PDR) and is proceeding toward Critical Design Review (CDR). However, it does not have a first customer for a desired mid-2011 launch date. In addition, NASA has design concepts for Dual Payload Attach Fittings (DPAF), but the $20-50M development cost and two-to-four-year development schedule for the device would be challenging. Finally, the USAF's EELV Small Payload Adapter (ESPA) has already been developed and flown. NASA is working with the USAF to standardize the interface for small payloads that could be flown as missions of opportunity on regularly scheduled (i.e., once per year) USAF or NASA EELV missions that can accommodate an ESPA.

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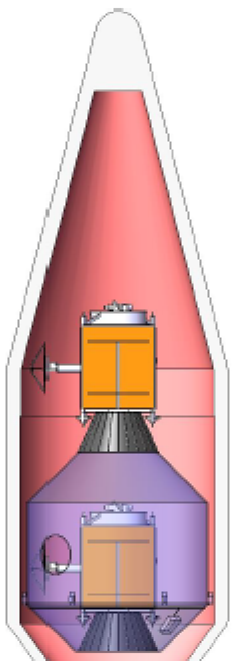
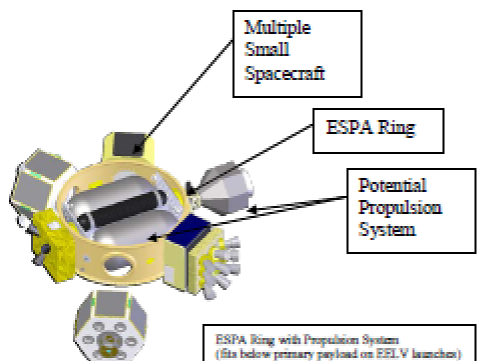
In all cases, the greatest challenges facing multiple-payload launches are: 1) compatibility between the missions; 2) development time for a new carrier; 3) the cost of a new carrier; and, 4) the risk of a strategy that generates more EELV missions, thereby increasing NASA's share of the DOD EELV sustaining costs and adding to an already crowded manifest. DPAF and ESPA are not complete solutions given the small size of the payloads that can be accommodated and the infrequency of flights using the system, but provide another viable alternative to launching certain NASA science missions. Instead, NASA believes that development funds would be better spent on reliability upgrades for those medium-class launch vehicles which will be used for ISS resupply and science missions (see Option Four, below).



Conceptual DPAF on EELV Class Launch Vehicle



ESPA Ring with Propulsion System
(fits below primary payload on EELV launches)

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2.4 Option Four: Utilize Medium-Class Vehicles in Development

NASA's NLS contract allows the use of new medium-class launch vehicles. Newly developed launchers in this class are expected to ultimately provide commercial resupply services to the ISS from the Eastern Test Range (encompassing Cape Canaveral Air Force Station and Kennedy Space Center) and/or Wallops Test Range (at Wallops Flight Facility), and may eventually be capable for science missions from both the Eastern Test Range and the Western Test Range at Vandenberg Air Force Base. The latter capability is critical, but not yet available or funded for NASA's Earth Science missions, which must be launched into polar orbit to achieve their science objectives.

Under the current NLS contract, companies have been able to offer new launch service capabilities during the biannual "on ramp" opportunities. In 2006, NASA modified the NLS contract to allow new vehicles with no previous flight history to receive an Indefinite Delivery Indefinite Quantity (IDIQ) contract award. Previously, vehicles had to have performed at least one successful flight to submit a proposal. In order to limit risk when selecting an unproven launch vehicle for a specific mission task order, NASA retained the requirement that the new vehicle be flown successfully before Authority to Proceed (ATP) is provided for the awarded mission. NASA is considering further risk reduction by making it a requirement to have the new vehicle flown before the mission is awarded.

Substantial U.S. Government participation during launch vehicle development has historically increased the reliability of launchers, while vehicles without significant U.S. Government involvement have attained a measurably lower level of reliability. This participation approach has been partially modified for the Agency's COTS and ISS CRS efforts. In both, NASA will be using FAA-licensed commercial launchers without the full complement of NASA technical reviews required for high-value NASA science missions. For COTS, NASA has an advisory team to understand each participating system's development, but the team is more focused on the interface to the ISS than the development of the ELV itself. One of the COTS goals is to allow industry to demonstrate the capability to achieve low-Earth orbit transportation with minimal Government oversight. For ISS CRS, the Agency will perform technical assessments of the new launch vehicle only in specific technical areas that have historically contributed to failures.

NASA has begun initial evaluation of the SpaceX Falcon 1 and 9 under the recently-awarded NLS contract. However, without an awarded mission, and in keeping with the COTS philosophy, NASA has not had significant technical interaction with SpaceX during the development of these two launch vehicles. Therefore, NASA's evaluation is being offered to, rather than imposed upon, SpaceX. At this point, Falcon 9 is well into its development cycle, and Falcon 1 made its first two launch attempts before SpaceX was on the NLS contract. It is expected that the vehicles will benefit from a full NASA technical assessment once a science mission is finally awarded.

OSC's Taurus 2 and ATK's SLV-A and B are earlier in their development cycles, and both companies have requested NASA technical interaction. In response, the Agency has issued unfunded Space Act Agreements (SAAs) with these companies to provide that support. The agreements stipulate that these companies share data with NASA in return for specific, focused evaluations. At the present time, NASA is not involved at the level of ensuring mission success for these vehicles, nor is it completing a full technical evaluation of them. For purposes of future competitive procurements, NASA is making its resources available in an equitable manner to SpaceX, OSC, and ATK when responding to their requests for interaction. It should be noted that the agreement with ATK does not cover their Athena IIIA medium-class vehicle because it is not at a sufficient level of maturity at the present time.

The most rigorous launch vehicle certification (under NASA Policy Directive NPD 8610.7D) requires three successful launches and a rigorous NASA technical evaluation at a minimum, before NASA utilizes a launch vehicle for one of its typical medium-class missions. These high-value NASA science missions require the most reliable launch services available within practical limits. While this

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level of certification can be met in approximately three years (allowing for some schedule margin before final launch preparations begin), the resolution of technical issues found by NASA may not be achievable within this timeframe. In addition, history shows that significant launch delays are common for new launch vehicles. The average delay in the third successful launch of a new vehicle is 31 months from the manifested date of the third launch. This is based on vehicle histories from OSC, SpaceX, and ULA when they were within approximately one year of the planned first launch of the new vehicle.

As noted, some technical interaction between NASA and new providers has been initiated. The Agency's intention under these unfunded SAAs is to encourage companies to seek NASA experience on items directly related to certification elements. However, there is no better motivation for NASA and the commercial supplier to complete certification than having a mission on contract with a specific launch date to meet. With the initiation of the specific technical assessments required under CRS, and assuming NLS continues to provide the capability for standard on-ramp periods, NASA has a reasonable chance of completing certification of at least one of these new launch vehicles by the end of 2013.

3.0 INTERMEDIATE-CLASS LAUNCH VEHICLES

The intermediate class of U.S. launch vehicles consists of the SpaceX Falcon 9 and ULA's Delta IV and Atlas V EELVs. The schedule for the first launch of the Falcon 9 is not advertised by SpaceX at this time, but is anticipated to be in the fourth quarter of CY 2009. The two EELV vehicles are currently stable, due to DOD funding, although the large payload capability of these launchers and their high prices have resulted in their more limited use by NASA than the medium-class vehicles. DOD funding of EELV is described in the U.S. Space Transportation Policy, which states:

> "a) The Secretary of Defense shall maintain overall management responsibilities for the Evolved Expendable Launch Vehicle program and shall fund the annual fixed costs for both launch services providers unless or until such time as the Secretary of Defense, following coordination with the Director of Central Intelligence and the Administration of the National Aeronautics and Space Administration, certifies to the President that a capability that reliably provides assured access to space can be maintained without two Evolved Expendable Launch Vehicle providers;
>
> b) Not later than 2010, the Secretary of Defense, the Director of Central Intelligence, and the Administrator of the National Aeronautics and Space Administration shall evaluate the long-term requirements, funding, and management responsibilities for the Evolved Expendable Launch Vehicle system(s) and infrastructure. That evaluation shall include recommending a proportionate shift of the existing funding responsibility of the Secretary of Defense to reflect any change to the balance between national security and civil missions employing an Evolved Expendable Launch Vehicle."

In its implementation of the U.S. Space Transportation Policy, the USAF EELV contract is comprised of two parts: 1) the EELV Launch Support (ELS) contract, and 2) the ELC contract. Among other items, the ELC provides for the entire EELV infrastructure necessary to sustain both vehicles. If the decision were made to have NASA provide a proportional share of the funding for the infrastructure, it would result in significantly increased costs to NASA for its missions. Currently, NASA missions are charged an amount commensurate with what a commercial mission pays when using an EELV. Even without funding infrastructure, NASA expects that the price it pays for launch services will increase for launches after 2012. NASA believes that some level of funding to sustain the EELV infrastructure contract should continue to ensure continued availability of U.S. intermediate and heavy launch vehicles to meet U.S. government needs.

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4.0 NASA RECOMMENDATIONS BY LAUNCH VEHICLE CLASS

4.1 Small-Class

NASA's near-term strategy is to continue to utilize the IDIQ methodology currently employed. This strategy will be employed due to the factors previously listed and to allow the market to stabilize over the next few years. This is most important at the low end of the small class, where there is more than one commercially available option. NASA will continue to pursue science missions in this class. Depending on demand, NASA may consider block buys as it does in other classes to support the industrial base.

NASA is concerned that use of Minotaur I may put a commercial provider out of business, given that NASA's next mission in this class is not until 2011. This usage limits the number of missions to be made available in this class for commercial providers, which results in higher launch prices for NASA missions. This is the class of service where most new providers begin before moving on to building and developing launchers in the larger classes. Accordingly NASA believes that industry and market developments in this class – as well as the use of Minotaur I by U.S. Government agencies – should be monitored carefully by involved agencies, and that further U.S. Government policy reviews on this matter should be considered.

4.2 Medium-Class

The recommended NASA strategy for providing domestic commercial launch services in support of NASA's medium-class missions is linked to the ISS CRS contracts that were awarded on December 23, 2008. CRS leverages the COTS effort, which provides NASA funding and/or technical assistance to encourage the commercial development of space transportation for supporting the ISS. The companies selected for funded COTS Space Act Agreements (SAAs), which also are participating in the CRS procurement, are developing vehicles that could be available for medium-class NASA science missions on an NLS-type contract, for potential launches in the 2013-2014 timeframe. This estimate allows time for an initial successful launch and then a roughly three-year period from launch service award to launch, as well as the required NASA technical evaluation. With the possible exception of one mission in 2012, this timeline accommodates NASA's medium-class science missions identified in the RFI mission model shown in Appendix A. It is nearly certain that only the winners of the ISS resupply contract will have a sufficient mission baseline from which to offer medium-class launch services at a lower price than the Delta II or EELV for science missions. Without CRS missions, the business base in this class is likely too small to be viable. With CRS, NASA has awarded multiple missions (i.e. a block buy), which should support the supply chain for these vehicles.

It is important to note that the winners of the CRS contract are not currently developing the full range of capabilities (e.g., high inclination launch site, upper stage for Earth escape missions, Dual Payload Attach Fitting) typically utilized by NASA science missions. Therefore, some additional costs will be incurred to fully meet NASA's science needs. For example, Rough-Order-of-Magnitude (ROM) estimates for a West Coast launch site are on the order of $50-100 million and would vary depending upon the launch provider. A DPAF might be needed if a suitable vehicle at the upper end of the small-class is not available. NASA has not yet finalized the funding estimate for these capabilities, but the contract(s) which follows NLS will be used to definitize service options to meet NASA's science needs. At present, this strategy cannot be executed due to higher priorities and limited funding available to pay for these capabilities. Without sufficient demand, commercial companies will likely pass the total cost on to the first mission needing the capability. In doing so, the cost impact to the mission would be too large for its budget.

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4.3 Intermediate-Class

As noted in the 2005 U.S. Space Transportation Policy, "To assure access to space for United States Government payloads…the United States Government must provide sufficient and stable funding for acquisition of U.S. space transportation capabilities in order to create a climate in which a robust space transportation industrial and technology base can flourish." Increased commercial launch activity in the U.S. also would help create such a climate by improving our working knowledge of our vehicles and helping to sustain the industrial base that provides the critical components for these vehicles. It is recognized that providing this range of service commercially will be difficult, but if U.S. industry cannot compete with vehicles like Ariane, Proton, Long March, etc., then it is unlikely that true U.S. commercial space access – and the innovation expected to accompany it – will be able to survive on its own.

5.0 BUDGET PLAN FOR NASA-RECOMMENDED ALTERNATIVES

Given the recommended strategy above, NASA cannot prescribe a specific budget runout. Expenditures will be driven by specific ISS resupply services and science mission requirements as well as by competitive selections. Below are examples of the costs that may be incurred for emerging capabilities, or that could form the basis for investment in ensuring robust capabilities.

NASA's experience with existing launch vehicle fleets is that funds are required to resolve technical issues identified by the Agency through its evaluation and certification process. These funds are higher during the initial 3-5 years of a vehicle's flight history and are not currently provided for in the existing budget. NASA estimates that it takes approximately $5M per year for each new launch vehicle for modifications and upgrades to ensure mission success for Agency missions in the small or medium class. Previous experience from NASA's early efforts on OSC's Pegasus vehicle shows that this type of funding is essential for minimizing cost, schedule, and technical risks associated with the development of new launch vehicles. Funding would be used to pay for additional analyses, qualification testing, and vehicle modifications that NASA's existing service contracts (i.e., NLS) allow under the technical insight provisions. Such provisions enable the Agency to form a technical opinion of a provider's service and pay for improvements in areas important to NASA's flightworthiness assessment. The $5M per year estimate includes $1-2M for a significant component qualification test; $0.1-1M for mission-unique, non-standard services; and roughly $0.2-0.5M for various analyses. Therefore, 1-2 significant test items could be accomplished in each year, along with 4-5 analyses or non-standard service developments.

As noted earlier, none of the winners of the CRS contract are actively developing the full range of capabilities (e.g., high inclination launch site, upper stage for Earth escape missions, Dual Payload Attach Fitting) typically utilized by science missions. Therefore, some additional costs will need to be incurred to fully meet NASA's needs. The Agency has not yet finalized the funding estimate for these capabilities, but the contract which follows up the current NLS contract will be used to define service options to meet NASA's science needs. At present, this strategy cannot be executed due to higher priorities and limited funding available to pay for these capabilities

6.0 CONTINGENCY PLAN

Following the significant downturn in commercial space activities in the late 1990s, current trends in the global commercial launch services market indicate that there is not sufficient business for U.S. commercial launch vehicle suppliers to continue participating in this sector if the Government were not required to purchase domestic launch services. This also is the case worldwide, where non-market economy conditions, government subsidies, or a combination of the two, are currently the only means for attracting commercial launch customers (mainly for intermediate and larger, geosynchronous-orbit commercial communication satellites). For the present time, government funding in some form continues to be needed to maintain certain launch capabilities. Without such funding, or government sustainment of infrastructure (such as launch pads), most U.S. vehicles are too expensive in comparison with those provided by other nations to compete in this sector. Unfortunately, NASA believes this trend will continue until a major application materializes that shifts the current paradigm.

While the U. S. Government has followed a strategy of supporting intermediate-class launch vehicles in the Evolved Expendable Launch Vehicle (EELV) program, it is not currently providing the same support to small- and medium-class launch vehicles. If reliable and cost effective medium-class launch services do not materialize from ISS CRS providers, and if the small-class continues its struggles due to lack of demand and/or oversupply, NASA options are limited, and all involve significant additional funding or major cuts in the number of science missions flown.

In the event such a scenario materializes, there currently is only one suitable contingency option for NASA in the area of small-class services. Specifically, NASA would have to consider using the Minotaur vehicles as the most cost-effective and reliable launch vehicle solution for missions in this class. Even if Minotaur I is limited for use now, this option could be made available reasonably quickly (i.e., more quickly than the development of a commercial launch vehicle) in the future. Since there is no commercial vehicle currently available between the small and medium classes, it may be advisable to make Minotaur IV more readily available until those assets are depleted or until small-class viability becomes more evident.

Another potential option is for the U.S. Government to consider measures, consistent with U.S. law and policy, for sustaining a single U.S. commercial launch vehicle in both the small and medium classes. The intent would be to enable the return of commercial missions to U.S. launch vehicles while providing consistent and reliable services. NASA suggests investigating an approach that would enable a reduction in the per-mission costs of small and medium vehicles so they would compete with vehicles like Soyuz, Dnepr, Rokot, or Vega.

Another option is to choose between using the remaining Delta II inventory (though only five remain in inventory before new production would be required) or EELV for medium-class missions. In the case of Delta II, the full range of medium-class science missions could only be supported if the SLC-2 launch complex at Vandenberg Air Force Base were maintained; otherwise, this option would not provide the capability to launch key Earth science missions, most of which must use the Western Test Range at Vandenberg to reach polar orbits. The cost of Delta II or EELV is higher than what typical medium-class missions generally pay. This would lead to an overall reduction in the number of science missions performed. If NASA is required to pay a significant portion of the DOD ELC costs for EELV, then the purchase of additional 40-inch GEM motors for Delta II and maintenance of SLC-2 could be less expensive for these Earth observing missions. However, waiting for the success or failure of the CRS launch service capabilities would preclude this option.

As a last measure in the medium class, if CRS is not successful in delivering reliable and cost-effective launch vehicles, which can also be used for NASA science missions, and if no funds are available for sustaining commercial launch vehicles, NASA may need to increase its use of foreign launch capabilities in this class in a manner consistent with applicable policy.

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Appendix A: NASA Launch Services II - Request For Information (RFI) Results

The NLS II Request for Information (RFI) was released on April 21, 2008, with responses due on May 27, 2008. The purpose of the RFI was to solicit information from industry that could potentially enhance NASA's approach for the NLS Follow-On Acquisition. The RFI included a proposed Mission Model containing small- and medium-class missions and potential Acquisition Strategies. Comments related to, but not limited to, the following topics were requested:

- Technical Capability;
- Launch Vehicle Certification;
- NLS Contract Terms and Conditions; and
- Infrastructure.

Responses were received from AirLaunch, ATK Launch Systems (ATK), OSC, SpaceX, and ULA. OSC, SpaceX and ULA are service providers under the current NLS Contract, while AirLaunch and ATK are not.

The primary themes of the RFI responses varied widely, based upon the provider. AirLaunch suggested that NASA provide the flexibility to tailor contract requirements in line with the level of risk, in order to maximize opportunities for new providers. ATK proposed their new Small Launch Vehicle (SLV) and Medium Launch Vehicle (MLV) as viable solutions for small- and medium-class markets and outlined their preference for a new NLS contract; in order to give ATK "…the fairest and best chance to compete with established NLS offerors." OSC sought to recreate separate contracts and contract requirements unique to these launch vehicle classes, much like the previous NASA Small Expendable Launch Vehicle Services (SELVS) contract. SpaceX recommended a number of clarifications and enhancements to the current NLS Request for Proposal (RFP), based upon their recent experience "on-ramping" to the NLS contract. ULA advocated using proven launch vehicles by either re-establishing the Delta II production capability or co-manifesting small- and medium-class missions on the Atlas V or Delta IV EELVs. ULA also intimated that new launch vehicles should be utilized only as a last resort, although they did discuss an option for two potential new launch vehicles -- an Atlas V Small and a Delta IV Small.

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Each provider, with the exception of AirLaunch, addressed the Mission Model in the RFI. The total numbers of missions in the medium class are reduced from those in a 2007 NASA study of Delta II and alternate launch provides. Their inputs are summarized in the table below.

Mission	Mission Name (Class)	Launch Date (orbit)	ATK	OSC	SpaceX	ULA
1	SMAP (Small Plus)	2012 (high inclination)	SLV-B	Taurus XL or II	Falcon 9 Blk 2	Triple-Manifest on EELV
2	SMEX 12 (Small)	2012 (high inclination)	SLV-A	Pegasus, Taurus XL or II	Falcon 1e	Triple-Manifest on EELV
3	SMEX 13 (Small)	2013 (medium inclination)	SLV-A	Pegasus, Taurus XL or II	Falcon 1e	Co-Manifest on EELV
4	ILN-1/ILN-2 (Small Plus)	2013 (lunar)	MLV	Taurus XL or II	Falcon 9 Blk 2	Delta II
5	MARS Scout 2 (Medium)	2013 (escape)	MLV	Taurus II	Falcon 9 Blk 2	Delta II
6	GPM Constellation (Small Plus)	2014 (medium inclination)	SLV-B	Taurus XL or II	Falcon 1e	
7	Venture (Small)	2014 (high inclination)	SLV-A	Pegasus, Taurus XL or II	Falcon 1e	Co-Manifest on EELV
8	Discovery 12 (Medium)	2014 (escape)	MLV	Taurus II	Falcon 9 Blk 2	Delta II
9	JDEM (Medium)	2015 (near escape)	SLV-B	Taurus II	Falcon 9 Blk 2	Delta II
10	ICE-SAT II (Medium Lite)	2015 (high inclination)	SLV-B	Taurus XL or II	Falcon 9 Blk 2	Atlas V 401
11	SMEX 14 (Small)	2015 (high inclination)	SLV-A	Pegasus, Taurus XL or II	Falcon 9 Blk 2	

The 2011 NASA science missions - Gravity Recovery And Interior Laboratory (medium class) and NuStar (small class) – and the 2012 Landsat Data Continuity Mission (medium class) are not included in the mission model, because they either already had a launch service under contract, or were planned to be accommodated under the existing NLS contract period of performance.

Each provider also addressed the alternative acquisition approaches suggested in the RFI. OSC, SpaceX and ULA all advocated the extension of the current NLS contract, citing the efficiency and effectiveness of such a solution. AirLaunch was neutral as to whether or not NASA pursues a new contract, while ATK desired a new contract mechanism with the expectation that this might provide a more level playing field.

The RFI responses included several areas for consideration for the NLS follow-on contract, including advocacy of extending the current NLS contract ordering period and period of performance. Based on the RFI responses, NASA will reconsider some of the terms and conditions in the NLS RFP, such as payment schedules, mission success incentives, and the clarification of launch delay penalty provisions. NASA will also address the advantages and disadvantages of -- as well as alternatives to -- co-manifesting multiple missions on a single launch vehicle.

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For completeness, this appendix also provides a high level summary in one of the areas responded to under the ISS Commercial Resupply Services RFI that was issued to industry in the fall of 2007. While this RFI was focused on services to carry cargo to the ISS, it did contain questions that have some applicability to the launching of NASA science missions using commercial services. When asked about what things might provide incentives for commercial companies to provide cost-effective and reliable launch services, respondents advocated the creation of understandable performance goals/milestones, retaining competition to provide incentives to retain business (or not lose future business), but somehow finding a way to make block purchases (or have a long-term commitment and regular services).

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Appendix B: Acronyms

ATK – Alliant Tech Systems
COTS – Commercial Orbital Transportation Services
CRS – Commercial Resupply Services
CSA – Commercial Space Act
DPAF – Dual Payload Attach Fitting
DoD - Department of Defense
EELV – Evolved Expendable Launch Vehicle, (Atlas V and Delta IV launch vehicles)
ELC – EELV Launch Capability (contract)
ELS – EELV Launch Support (contract)
ESPA – EELV Small Payload Adapter
ICBM – Intercontinental Ballistic Missile
IDIQ – Indefinite Delivery Indefinite Quantity
ISS - International Space Station
MLV – Medium Launch Vehicle
NASA - National Aeronautics and Space Administration
NLS – NASA Launch Service (contract)
NSPD – National Security Presidential Directive
OSC – Orbital Sciences Corporation
PDR – Preliminary Design Review
PLF – Payload Faring
RFI – Request for Information
RFP – Request for Proposal
ROM – Round Order of Magnitude
SAA – Space Act Agreement
SLV – Small Launch Vehicle
SMD – Science Mission Directorate
ULA – United Launch Alliance
USAF – United States Air Force
SpaceX – Space Exploration Technologies Corporation

MANAGEMENT COMMENTS

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

February 8, 2011

Reply to Attn of: Space Operations Mission Directorate

TO: Assistant Inspector General for Audits

FROM: Associate Administrator for Science Mission Directorate
Associate Administrator for Space Operations Mission Directorate
Deputy Associate Administrator for Space Operations Mission Directorate

SUBJECT: Response to the Draft Audit Report, "Review of NASA's Acquisition of Commercial Launch Services" (Assignment No. A-09-011-00)

We have reviewed the draft audit report, "Review of NASA's Acquisition of Commercial Launch Services" (Assignment No. A-09-011-00), dated February 1, 2011. The following comments summarize our concurrence and concerns with various aspects of the draft audit report. In addition, several technical inaccuracies of the report are described in the enclosure.

1. We concur with the results/findings of the audit objective titled "NASA's Launch Services Program Provided Launch Vehicles within Cost and Timeframe Established by Contract."
2. We concur with the intent of both portions of the management action and recommendation resulting from the audit objective titled "NASA's Acquisition Strategy for Medium Class Launch Vehicles Did Not Include the Use of Minotaur Launch Vehicles." Our understanding is that the intent of the action reflects our current process. We do not see a need for this specific recommendation as it describes an action that NASA is already performing.

We continue to be concerned with the lack of consideration given to limiting the adverse impact of the use of excess ballistic missiles on the U.S. Commercial Space Transportation Industry as stated in the U.S. Space Transportation Policy, dated December 4, 2004. As background, the policy states:

- "Today, vital national security, homeland security, and economic interests are increasingly dependent on United States Government and commercial space assets. U.S. space transportation capabilities are the critical foundation upon which U.S. access to and use of space depends…."
- "United States Government agencies may use [excess ballistic missile] assets to launch payloads into orbit on a case by case basis…. [when such use] limits the impact on the U.S. space transportation industry."

In the final quote above, it is clear that the President understood the potential impact that use of the relatively inexpensive Minotaurs could have on the commercial industry if allowed to be used without restraint.

Although this draft has corrected many of the more significant inaccuracies cited previously by NASA, there remain inaccuracies and inconsistencies in cost estimates. These are described in the enclosure.

Since NASA has, and will continue to, consider the use of Minotaur in our launch service options, consistent with law and policy, we recommend closure of this audit.

This response has been coordinated with the Office of Procurement and the Office of General Counsel.

We appreciate the opportunity to review and comment on the revised draft audit report.

Edward J. Weiler

William H. Gerstenmaier

Lynn F. H. Cline

Enclosure

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