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AUDIT REPORT

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REVIEW OF NASA'S EXPLOSIVES SAFETY PROGRAM

OFFICE OF INSPECTOR GENERAL



National Aeronautics and
Space Administration

Final report released by:



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Acronyms

CFR	Code of Federal Regulations
DDESB	Department of Defense Explosive Safety Board
DOT	Department of Transportation
ESO	Explosive Safety Officer
FBI	Federal Bureau of Investigation
GAO	Government Accountability Office
IFO	Institutional/Facility/Operational
NASA-STD	NASA Standard
NPR	NASA Procedural Requirements
OSHA	Occupational Safety and Health Administration
OIG	Office of Inspector General
TNT	Trinitrotoluene
UDMH	Dimethylhydrazine
USDA	U.S. Department of Agriculture

OVERVIEW

REVIEW OF NASA'S EXPLOSIVES SAFETY PROGRAM

The Issue

NASA Centers and Facilities routinely procure, store, transport, and handle explosive materials, pyrotechnics, and propellants (known as energetic materials) in support of Agency programs and projects. Energetic materials consist of any chemical compound or mixture that detonates or deflagrates when subjected to heat, impact, friction, or electrical initiation (see Figure 1).¹ Improperly transporting, storing, or handling these extremely hazardous materials can have catastrophic consequences, including loss of life, serious injury, damage to facilities and equipment, damage to the environment, and loss of mission capabilities.

Figure 1. Detonation testing of explosive materials at White Sands Test Facility



Source: NASA

For example, in July 2007 Scaled Composites, LLC, the prime contractor for Virgin Galactic's SpaceShipTwo, experienced an explosive mishap that killed three employees, seriously injured three others, and delayed development of a new hybrid rocket engine. The exact cause of the accident was never determined; however, Scaled Composites

¹ Detonation is a violent chemical reaction resulting in heat and a wave of pressure through the reacted material at supersonic speeds. Deflagration is a violent chemical reaction resulting in a wall of flame that travels at subsonic speeds away from its source of ignition.

attributes the explosion to mishandling of nitrous oxide, an oxidizer used in rocket motors.²

NASA has well-established and detailed safety standards to protect its personnel, facilities, and the general public.³ In addition, the Occupational Safety and Health Administration maintains standards relating to energetic and other hazardous materials and mandates that all employers develop the necessary expertise to implement and maintain an effective safety management program that can prevent or minimize the catastrophic effects of a mishap.⁴ Explosive Safety Officers (ESOs) at each NASA Center ensure that their Center Explosives, Propellants, and Pyrotechnic Safety Program (Explosives Safety Program) meet all applicable regulations and protect people and property from mishaps.

We initiated this audit to examine whether NASA's internal controls for the storage, handling, accounting, and transportation of energetic materials were adequate to protect Agency personnel, facilities, and the general public. The primary locations for this audit were Glenn Research Center (Glenn), Stennis Space Center (Stennis), Wallops Flight Facility (Wallops), and White Sands Test Facility (White Sands). Details of our scope and methodology can be found in Appendix A.

Results

We identified 155 separate instances of improper storage, handling, or other procedural violations involving energetic materials, some of which could have resulted in significant damage to facilities, injury, or death (see Appendix B). For example, we found incompatible explosive materials stored in the same location, unsafe distances between occupied buildings and storage facilities containing energetic materials, inaccurate or incomplete inventories of energetic materials, and improper inspection procedures for vehicles used to transport these materials. In our judgment, a lack of oversight, resources, and training at both the local and Headquarters level are the primary factors contributing to the deficiencies we identified.

To NASA's credit, personnel at each site quickly addressed issues we uncovered that presented an immediate threat to personnel and facilities. In this report, we note issues and recommend additional actions to improve NASA's Explosives Safety Program.

² An oxidizer is a substance that produces oxygen to support combustion.

³ NASA Procedural Requirements (NPR) 8715.3C, "NASA General Safety Program Requirements," March 12, 2008. NASA Standard 8719.12, "Safety Standard for Explosives, Propellants, and Pyrotechnics," January 29, 2010.

⁴ 29 Code of Federal Regulations Part 1910.119, "Process Safety Management of Highly Hazardous Chemicals."

The Safety of Personnel and Facilities are at Risk

Improper Storage and Handling. At each site visited, we identified unnecessary risks to personnel and property caused by the improper storage and handling of energetic materials. For example:

- A facility at Stennis not originally designed to store energetic materials was used to both store explosives and conduct tests involving electro-explosive devices.⁵ Although precautions to protect workers during testing were in place, they did not meet design requirements and were in direct violation of NASA safety standards, which require facilities to be specifically designed for concurrent operations involving energetic materials.
- Also at Stennis, we identified incompatible explosive materials stored in the same location. The ESO did not appropriately account for the combined effects of the materials, which resulted in the miscalculation of safe separation distances between the energetic materials and an adjoining building. According to our calculations, if the stored materials had detonated, more than 40 percent of the occupied building would have sustained structural damage and 15 percent of the personnel inside could have sustained fatal injuries.⁶
- At White Sands, we observed two shipping crates containing dextrinated lead azide that appeared to be decomposing and therefore had potentially become highly unstable.⁷ Had personnel attempted to transport or handle this shock sensitive material, it could have detonated, potentially resulting in loss of life, serious injury, or damage to equipment and facilities.
- Of all the sites we visited, Wallops had the largest quantity (approximately 100,000 pounds) of high-order, mass detonating explosive materials.⁸ We observed hundreds of rockets containing potentially explosive propellant stacked in close proximity to each other in bunkers. NASA personnel we spoke with had never assessed the physical condition of these rockets, all of which were

⁵ An electro-explosive device is an explosive or pyrotechnic that initiates an explosive, burning, electrical, or mechanical chain of events and is activated by the application of electrical energy.

⁶ A subject matter expert from the Department of Defense Explosive Safety Board (DDESB) provided this assessment. The DDESB authors the Department of Defense Manual 6055.09-M Volume 1, "DoD Ammunition and Explosives Safety Standards: General Explosives Safety Information and Requirements," February 29, 2008; evaluates scientific data; reviews and approves explosives site plans; and inspects locations at which U.S. munitions are used and stored.

⁷ Dextrinated lead azide, an explosive material with strong fragmentation properties, is used by NASA in detonators and incorporated into spaceflight projects such as the Multi-Purpose Crew Vehicle. However, it is extremely sensitive to stray ignition sources (including static electricity) and becomes sensitive to vibration and mechanical shock if crystallized due to improper storage.

⁸ High-order mass detonating materials are those whose entire quantity can be expected to instantaneously detonate and produce a supersonic, over-pressurization shockwave. Trinitrotoluene (TNT) and explosives used in military weapons are examples of this type of material.

manufactured between the late 1950s and early 1970s. The stacked placement, coupled with the unknown condition of the propellant, increased the probability of a catastrophic event because if a single rocket were to ignite or explode this could set off a chain-reaction of detonations.

- At Glenn, a storage magazine containing pyrotechnics used in support of aircraft flight operations was in poor condition and located too close to an adjoining parking lot.

Improper Accounting and Transportation. We found that NASA's ESOs were not appropriately accounting for energetic materials or maintaining inspection records for vehicles carrying such materials. Specifically, inventory records were incomplete, did not include the type, class, or net weight of energetic materials, and materials could not be accounted for or reconciled with inventory lists. For example, at Wallops we found that 27 individual explosive components and assemblies, ranging from small arms ammunition to rocket motors, could not be accurately reconciled with inventory records. In addition, although our inspections revealed that the majority of vehicles used to transport energetic materials appeared to be properly maintained, no inspection records were kept and safety checklists were not used.

Internal Control Failures Contribute to Safety Deficiencies

Lack of Oversight. NASA policy requires annual inspections and assessments of all energetic materials and the facilities in which they are stored.⁹ However, we found a general lack of oversight that significantly reduces the effectiveness of NASA's Explosives Safety Program and increases the likelihood of a catastrophic event. For example, we found that ESOs at the sites we visited did not conduct appropriate annual inspections of energetic materials at their Centers or Facilities.

In addition, the ESOs at Stennis and Glenn did not provide adequate oversight of explosive materials owned and stored by tenants on NASA property.¹⁰ Although the tenants provided the ESOs with some information in accordance with lease agreements, the information was not sufficient to ensure that the tenants were properly storing energetic materials.¹¹ For example, the information provided to the ESO at Glenn indicated that a tenant at Glenn's Plum Brook Station may have stored incompatible explosive materials – such as mass detonating explosive materials with initiating devices – in the same location. However, the ESO did not take action to confirm the accuracy of the information or attempt to mitigate the potentially hazardous situation.

⁹ These inspections and assessments include the inspection of electrical grounding, random inventory accounting, hazard analyses, and condition evaluation of the energetic materials.

¹⁰ In this report, a tenant is a non-NASA organization that leases land or structures on NASA property.

¹¹ NPR 8715.3C requires that the ESO review all Memorandums of Agreement associated with explosive, propellant, and pyrotechnic operations and ensure that tenants comply with NASA requirements.

Furthermore, NASA Headquarters' did not conduct required audits, provide guidance, or perform appropriate oversight of Center Explosives Safety Programs and operations. Specifically, the NASA Safety Center is required to conduct a particular safety audit every 3 years.¹² NASA policy requires that this audit verify the implementation of Federal, state, and local safety and health regulations, as well as requirements contained in NASA policies and regulations. However, the Safety Center never conducted such an audit of the Explosives Safety Programs and Headquarters personnel had not conducted an audit or Explosives Safety Program review at the four sites we visited in more than 10 years.¹³

Lack of Dedicated Resources. Center and Facility ESOs did not have sufficient resources, including personnel, budget, and dedicated work-time, to carry out their assigned responsibilities. This affected their ability to conduct timely inspections and accurate inventories of stored materials.

At each of the sites we visited, the ESO duty was ancillary or a part-time responsibility. This was especially apparent at Wallops where the Safety Office Chief, who is responsible for all safety operations at the Facility, did not have an assigned ESO, leaving him solely responsible for carrying out the functions of the Explosives Safety Program. However, the official said that the majority of his time was devoted to carrying out his primary responsibilities, and therefore was unable to conduct hazard analyses, inspections, and inventories of the vast amounts of energetic materials and storage facilities under his purview. In our judgment, a single individual does not have adequate time to address both Safety Chief and ESO responsibilities, particularly at a site like Wallops.

In another example, the ESO assigned to White Sands is physically located at Johnson Space Center in Houston, Texas, and is responsible for five Explosives Safety Programs located in three different states. In addition to managing these geographically dispersed programs, this same individual was recently assigned responsibility for the Pressure Vessel and Systems Program at Johnson, another critical safety program.

Lack of Training and Experience. At the sites we visited, the assigned ESO generally did not demonstrate the knowledge or have the appropriate experience or training required to make programmatic and technical decisions regarding the Explosives Safety Program. Specifically, one ESO had attended only a basic explosive safety course and had no other work experience to serve in this capacity and others lacked current education and training.

¹² Per NPR 8705.6B, "Safety and Mission Assurance (SMA) Audits, Reviews, and Assessments," May 24, 2011, the NASA Safety Center at Brook Park, Ohio, is responsible for managing audits and assessments, including the Institutional/Facility/Operational (IFO) Safety Audit, on behalf of the Agency's Chief of Safety and Mission Assurance.

¹³ The four sites were Glenn (which includes both Lewis Field and Plum Brook Station), Stennis, Wallops (which includes both the Main Base and Wallops Island), and White Sands.

We also found inconsistencies in the training records of personnel who are responsible for handling energetic materials. Specifically, except for Wallops, training documentation was incomplete at the sites we visited. As a result, we are unable to confirm whether employees and contractors who handle energetic materials on NASA property have been adequately trained.

Management Action

We acknowledge the swift actions taken in response to the immediate hazards identified at the Centers and Facilities we visited. To further improve NASA's Explosives Safety Program, we recommended that NASA's Chief of Safety and Mission Assurance initiate a review of management, storage, and handling procedures at all Centers and Facilities to identify deficiencies, take corrective actions, and share best practices. In addition, we recommended that the Chief of Safety and Mission Assurance immediately require all ESOs to conduct an inventory of energetic materials and initiate an investigation of any missing materials. We also recommended that the Chief of Safety and Mission Assurance:

- ensure that tenants and contractors comply with NASA requirements pertaining to energetic materials;
- develop and require that an inspection checklist be used and retained for vehicles used to transport energetic materials;
- review and assign oversight responsibility of the Agency's Explosives Safety Programs to Headquarters personnel;
- review personnel and fiscal resource allocations for the Agency's Explosives Safety Programs; and
- review and correct deficiencies regarding the qualifications and training of assigned ESOs and other personnel who work in the Agency's Explosives Safety Programs.

In response to a draft of this report, the Chief of Safety and Mission Assurance concurred or partially concurred with our recommendations and proposed corrective actions to improve NASA's Explosives Safety Program. We consider the Chief's comments responsive and will close the recommendations upon verification that the planned actions are complete. Management's response is reprinted in Appendix F.

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INTRODUCTION

Background

The dangers of potentially hazardous material force us to realize things that have never happened before happen all the time.

-NASA Safety Center¹⁴

Energetic materials consist of any chemical compound or mixture that detonates or deflagrates when subjected to heat, impact, friction, or electrical initiation. Because energetic materials play an important role in many NASA programs, Agency personnel routinely store, transport, and handle these materials. Failure to follow proper safety procedures when dealing with energetic materials can have catastrophic consequences, including loss of life; serious injury; damage to facilities, equipment, and the environment; and loss of mission capabilities. The following examples illustrate the inherent dangers of storing and handling energetic materials.

- In May 1988, sparks from a repair crew's welding torch set ablaze a fiberglass structure at a Pacific Engineering Production Company plant in Henderson, Nevada. The flames engulfed a massive stock of ammonium perchlorate, an oxidizer used in solid fuel rocket boosters, creating the largest accidental domestic, non-nuclear explosion in recorded history. The explosion killed 2 employees, injured approximately 372 others, and affected structures within a 10-mile radius. Damages were estimated at \$100 million (see Figure 2).

¹⁴ NASA Safety Center, "From Rockets to Ruins: The PEPCON Ammonium Perchlorate Plant Explosion," November 4, 2012. <http://nsc.nasa.gov/SFCS/> (accessed March 26, 2013).

Figure 2. Pacific Engineering Production Company explosion and resultant damage

Source: NASA

- In August 2005, a tractor-trailer rollover 60 miles southeast of Salt Lake City, Utah, set off 35,500 pounds of high explosives, blasting a 30-foot-deep crater in the road and sending at least 20 people to the hospital. The force of the blast vaporized the truck, tore chunks of rock out of the canyon wall, and moved a nearby Union Pacific rail line 50 feet.
- In July 2007, Scaled Composites, the prime contractor for Virgin Galactic's SpaceShipTwo, experienced an explosive mishap that killed three employees, seriously injured three others, and delayed development of a new hybrid rocket engine.¹⁵ According to Scaled Composites, the explosion occurred due to mishandling of nitrous oxide, an oxidizer used in its rocket motors.
- In January 2010, a graduate student at Texas Tech University lost three fingers and suffered other injuries to his hands and face when an energetic chemical (nickel hydrazine perchlorate) detonated in a campus laboratory. An investigation by the Chemical Safety Board found that systemic deficiencies in the University's policies contributed to the incident, including the lack of risk assessment, oversight and safety management, and documentation of previous safety incidents.¹⁶

The energetic materials used by NASA fall into three general categories: explosives, pyrotechnics, and propellants.

Explosives. Used extensively throughout NASA, explosives are chemical compounds or mixtures that greatly increase in volume, heat, and pressure when subjected to heat, friction, impact, detonation, or other types of initiation. For example, the Hypervelocity Test Laboratory at White Sands Test Facility uses explosives to initiate a gas gun that

¹⁵ SpaceShipTwo is a commercial space vehicle being developed by Virgin Galactic to fly crew and passengers into suborbital space.

¹⁶ NASA Safety Center, "Don't Mess with Excess: Texas Tech Laboratory Explosion," July 8, 2012. <http://nsc.nasa.gov/SFCS/> (accessed March 26, 2013).

propels objects at targets to simulate the damage that can be caused to shields, spacecraft, satellites, and spacesuits by flying debris.

Explosives are classified according to their hazardous characteristics and must be stored at a safe distance from personnel and other structures and adequately separated from non-compatible materials to prevent unintentional detonation. For example, the explosive material lead azide is not permitted to be stored with initiating devices. See Appendix C for the Explosives, Propellants, and Pyrotechnics Hazard Classification System and Appendix D for Explosives Storage Requirements.

Pyrotechnics. Pyrotechnics are small, electrically initiated explosives used to detonate higher-order explosive materials.¹⁷ These devices are mission critical to NASA and require near-perfect operational reliability. Pyrotechnics include ignition devices, explosive charges, train assemblies, functional component assemblies (explosive nuts, bolts, valves, and escape systems), and systems that provide electrical current to igniters and other parts of an explosive assembly.

Propellants. Propellants are liquid or solid materials used for propulsion or for producing power for missiles, rockets, and other related devices. Some propellants are highly toxic and can detonate unexpectedly under certain environmental conditions.

All space missions incorporate one or more of the energetic materials described above. For example, lifting a satellite into orbit using an Atlas V expendable launch vehicle begins with the electrical initiation of the propellant fuel – refined kerosene combined with liquid oxygen – feeding the first stage rocket engines. Subsequent points at which energetic materials are used include jettisoning the solid rocket boosters strapped to the main rocket once their fuel has been expended; separating the protective cover and nose cone covering the satellite payload; separating the first stage of the rocket from the second stage; and igniting the second stage engines.

Regulations Pertaining to Explosive Safety

The Occupational Safety and Health Administration (OSHA) established standards applicable to all highly hazardous chemicals including energetic materials to aid employers in their efforts to prevent or mitigate chemical releases that could result in a fire or explosion.¹⁸ In addition, Department of Transportation (DOT) regulations

¹⁷ High-order explosives produce a supersonic, over-pressurization shockwave. Trinitrotoluene (TNT) is an example of this type of explosive material.

¹⁸ 29 Code of Federal Regulations (CFR) § 1910.109 details the requirements for the storage and handling of explosive materials and 29 CFR § 1910.119 requires the conduct of a hazardous analysis for some highly hazardous materials.

establish transportation requirements for explosive materials and a classification system describing the hazards and compatibility of such materials.¹⁹

NASA standards incorporate the applicable laws and regulations pertaining to energetic materials, including those promulgated by OSHA and DOT.²⁰ The Standard states that safety must be an ongoing concern and given the highest priority in all program decisions involving energetic materials. In addition, it requires compliance with the cardinal principle for explosive safety: expose the minimum number of people to the smallest quantity of explosives for the shortest period of time consistent with the operation being conducted.

The NASA Headquarters Explosive Safety Manager is responsible for establishing the explosive safety requirements for the Agency's Explosives, Propellants, and Pyrotechnic Safety Program (Explosives Safety Program). NASA policy directs each Center Director to designate an Explosive Safety Officer (ESO) who is responsible for implementing and tailoring those requirements to meet Center operational objectives.²¹ The ESO is also charged with ensuring that the Center's Explosives Safety Program meets all applicable regulations and protects people and property from mishaps. ESOs are required to review, validate, and approve all energetic material operations and processes, facility site plans, and explosive site licenses.²²

NASA Centers and Facilities Visited and Their Use of Energetic Materials

NASA has 18 Centers and Facilities, including Headquarters, a large majority of which procure, store, handle, or transport energetic materials. The following locations were selected due to their direct involvement with NASA explosive operations; the quantity of the energetic materials stored; and contractor or tenant use of energetic materials on NASA property.²³

Glenn Research Center. Glenn Research Center (Glenn) is divided into two geographic locations – Lewis Field and Plum Brook Station. Located on 350 acres of land near

¹⁹ 49 CFR Chapter I, Subchapter C, Hazardous Materials Regulations, § 171–178, details the requirements for transporting, storing, and categorizing explosive materials.

²⁰ There is no OSHA standard applicable to launch vehicle propellants; therefore, NASA was required to create and submit for OSHA's approval NASA Standard (NASA-STD) 8719.12, "Safety Standard for Explosives, Propellants, and Pyrotechnics," January 29, 2010, as a supplement to 29 CFR § 1910.109.

²¹ NASA Procedural Requirements (NPR) 8715.3C, "NASA General Safety Program Requirements," March 12, 2008.

²² NASA-STD-8719.12 requires that the facility site plan show how protection is provided against explosion propagation between adjacent storage areas or buildings in order to protect personnel from serious injury or death. NASA requires a site license for all facilities storing or using energetic materials and serves as formal documented permission from the ESO to operate an explosives facility.

²³ The tenant lease is not for the purpose of contracted delivery of services, support, or tangible products for NASA programs.

Cleveland Hopkins International Airport, Lewis Field is Glenn's main campus with more than 150 buildings and an airfield. Lewis Field facilities include wind tunnels, drop towers, vacuum chambers, and an aircraft hangar. The explosives stored at Lewis Field are used primarily in support of aircraft operations.

Plum Brook Station is situated on 6,400 acres of land located 50 miles west of Cleveland in Sandusky, Ohio and has several unique test facilities that simulate the environment of space. During World War II, explosive materials, including trinitrotoluene (TNT), were manufactured at Plum Brook Station, and the Army built 99 bunkers at the site to store the material. NASA organizations, contractors, and tenants still use some of these bunkers to store hazardous chemicals and explosives (see Figure 3). While both of the Glenn locations store energetic materials, the majority are owned and stored by tenants physically located at Plum Brook.

Figure 3. Hazardous chemical bunker (left) and explosive material bunker (right)



Source: NASA OIG and Glenn ESO, respectively

Stennis Space Center. At 13,800-acres, Stennis Space Center (Stennis) is the Nation's largest rocket engine test facility. The facility has access to water through canal waterways from the Pearl River and the Gulf of Mexico, and provides a 125,000 acre protective safety and sound buffer zone ideal for transporting and testing large rocket stages, components, and propellants. The Center also leases property and buildings to more than 30 Federal, state, academic, and private organizations.

Stennis primarily uses explosives and propellants in support of large and small scale rocket engine testing. Stennis test facilities use propellants such as liquid oxygen, liquid hydrogen, isopropyl alcohol, and methane for its engine testing programs and the Center has a High Pressure Gas Facility that stores and provides gaseous variants of helium, nitrogen, and hydrogen to support operations.

Wallops Flight Facility. Wallops Flight Facility (Wallops), located on Virginia's Eastern Shore, is a component Facility of the Goddard Space Flight Center. As one of the oldest launch sites in the world, more than 14,000 rockets have been launched at Wallops since 1945. Currently, Wallops is NASA's principal Facility for the management and implementation of suborbital research programs.

Divided into the Main Base and Wallops Island, the Facility uses both solid and liquid propellants in its rocket launches. Of the Centers we visited, Wallops had the largest quantity of high-order, mass detonating explosive material – approximately 100,000 pounds. To put this into perspective, the 1995 Oklahoma City bombing involved 4,000 pounds of a similarly classified explosive material.

White Sands Test Facility. White Sands Test Facility (White Sands), a component Facility of the Johnson Space Center located near Las Cruces, New Mexico, conducts simulated flight-mission testing to develop full-scale propulsion systems. The scientific investigation of explosion phenomena at White Sands is aimed at improving safety at launch facilities and other areas where energetic materials are used. Although White Sands is primarily responsible for supporting NASA programs, in recent years the Facility has taken on the additional task of helping industrial firms design, test, and operate hazardous systems utilizing energetic materials. White Sands receives requests for technical services from other NASA Centers, private industry, the Department of Defense, and other Government agencies. White Sands uses some explosives and propellants and performs extensive tests utilizing cryogenic and hypergolic propellants such as liquid oxygen, hydrocarbon, hydrazine, monomethylhydrazine, nitrogen tetroxide, gaseous and liquid methane, and solid rocket propellants (see Figure 4).

Figure 4. Destructive test of solid rocket motor



Source: NASA

Objectives

We initiated this audit to examine whether NASA's internal controls for storage, handling, transportation, and accounting of energetic materials were adequate to protect Agency personnel and facilities, and the general public. See Appendix A for details of the audit's scope and methodology, our review of internal controls, and a list of prior coverage.

NASA'S EXPLOSIVES SAFETY PROGRAM EXPOSES PERSONNEL AND PROPERTY TO UNNECESSARY RISK

We found that NASA's Explosives Safety Program was poorly managed and exposed personnel and structures to unnecessary risk. Specifically, we identified 155 violations of regulations, policies, procedures, and processes involving unsafe conditions and practices at the sites we visited – some of which could have resulted in significant damage, injury, or death to NASA personnel, contractors, and potentially to the public (see Appendix B). Systemic deficiencies we observed included incompatible explosive materials stored in the same space, inaccurate or incomplete inventories of materials, and improper inspection procedures for transport vehicles. In our judgment, a lack of oversight, resources, and training at both the Center and Headquarters levels contributed to the deficiencies we identified.

We promptly notified appropriate officials at each of the sites we visited of issues that posed an immediate safety concern, and responsible personnel addressed those issues in a timely manner. However, in this report we recommend additional actions NASA should take to improve its Explosives Safety Program.

The Safety of Personnel and Facilities are at Risk

Improper Storage and Handling of Energetic Materials. We identified multiple instances at each of the sites we visited where critical internal controls for safe storage and handling of energetic materials had not been implemented or were inadequate. As a result, we found that NASA had potentially placed Center personnel, facilities, and the public at unnecessary risk.

Below we discuss several examples of improper storage and handling of energetic materials we uncovered.

Stennis. At Stennis we identified safety issues at a building that was being used to both store and test energetic materials (see Figure 5). First, the building did not meet basic requirements to serve as an explosives storage facility. For example, it lacked adequate firewalls, operational shields, a blast-resistant roof, or containment structures. In addition, the building's walls were not designed to withstand overpressure from an inadvertent detonation of the quantity, type, and class of energetic materials stored there.

Second, incompatible energetic materials were stored in the building. The ESO did not appropriately account for the combined effects of the materials, which resulted in a

miscalculation of the safe separation distance between the energetic materials and other occupied buildings. Specifically, high-order, mass detonating explosive material was improperly co-located with pyrotechnic explosive devices sensitive to ignition. Personnel and property were placed at great risk because the quantity and type of explosive materials exceeded the design constraints of the building and the facility was located too close to an adjoining building. Based on calculations by a Department of Defense subject matter expert, if the stored material detonated, 42 percent of a nearby occupied building would have sustained structural damage and 15 percent of the personnel inside could have sustained fatal injuries.²⁴

Figure 5. Explosives storage facility building



Source: NASA OIG

Third, testing was being performed with energetic materials that were incompatible with the materials stored in the building. Specifically, the building was being used to conduct testing involving electro-explosive devices. Although personnel were protected by a bullet-proof shield, the design did not meet NASA standards for concurrent operations.

Fourth, pyrophoric material was being improperly stored outside of the building; specifically, the material was not stored in fire-proof containers. Moreover, the storage area violated the required safe separation distance from the explosives stored within the building.²⁵ Pyrophorics are toxic, extremely volatile, and highly reactive chemicals that can spontaneously combust when exposed to moisture in the air. If this material ignited unintentionally, the ensuing fire could potentially spread to the area in the inadequately designed building where other explosive materials were stored.

Operations and testing with energetic materials should not take place in the same location where explosives are stored. Moreover, NASA requires that operating locations only store the minimum quantity of explosive materials necessary to carry out operations in a safe, efficient manner. Because the ESO did not consider that the building would be used for testing when making a determination regarding its suitability as a storage facility, he did not consider such important design features as appropriate lightning protection and

²⁴ As part of our review, a subject matter expert from the Department of Defense Explosive Safety Board (DDESB) provided this assessment. The DDESB authors the Department of Defense Manual 6055.09-M Volume 1, "DoD Ammunition and Explosives Safety Standards: General Explosives Safety Information and Requirements," February 29, 2008; evaluates scientific data; reviews and approves explosives site plans; and inspects locations at which U.S. munitions are used and stored.

²⁵ The pyrophoric was identified as triethylaluminum-triethylboron – UN2003. Acute exposure causes severe burns to the eyes, nose, throat, mucous membranes, and lungs, while chronic exposure can cause permanent damage to the central nervous system and liver.

electrical surge suppression, overpressure protection from explosions or chemical releases, and prohibitions on potential ignition sources from radio antennas and highly flammable, toxic chemicals used and stored both inside and outside the structure. As part of the ESO's hazard analysis and review, he should have considered the building's previous use as a test facility and made recommendations on procedural and engineering changes to conform to requirements for energetic materials storage and protection of personnel and assets. Alternatively, the ESO could have identified an alternate location for storage or testing.

The ESO is required to review, validate, and approve all energetic material operations and processes, facility site plans, and explosive site licenses. However, the ESO's lack of knowledge and experience in explosives safety, in our judgment, not only contributed to these violations, but permitted these deficiencies to remain uncorrected.

Following our visit, Stennis personnel removed the high-order explosive materials from the facility, thereby negating the immediate threat to other buildings and personnel. Additionally, inappropriate indoor storage magazines were being replaced, the grounding system reevaluated, and the surge and lightning protection system redesigned. Furthermore, measures were underway to improve the outdoor storage area for the pyrophoric materials and to install an appropriate fire wall to separate the storage area from the rest of the facility.

White Sands. We observed two wooden shipping crates containing dextrinated lead azide (lead azide), the quantity and condition of which was unknown by site personnel (see Figure 6). Lead azide is a highly toxic, high-order, mass detonating explosive that is extremely sensitive to impact, friction, and static electricity and can detonate if dropped from heights as low as 6 inches. Many energetic materials, including lead azide, become increasingly unstable and more susceptible to detonation as they age. However, it is extremely difficult to predict at what point the material becomes so unstable that it could explode.

The ESO opened the crates, each of which contained 25 separate compartments. All 25 compartments in the first crate were filled with sealed bags containing 50 grams each of lead azide. The second crate had 19 compartments containing lead azide, 18 of which were filled with bags containing 50 grams and 1 filled with 2.6 grams of the material. A few of the bags were inflated similar to a balloon, causing concern regarding the condition of the chemical.

The DOT Code of Federal Regulations requires that lead azide be shipped and stored in a "wetted" condition – not less than 20 percent water or a water-alcohol mixture – and cautions that once the material dries out it becomes highly unstable and sensitive to detonation. Some of the bags appeared to contain yellowish brown residue, indicating

Figure 6. Lead azide crate



Source: NASA OIG

that the material may have dried out and possibly crystallized. Lead azide is most sensitive to detonation in this state.

In our opinion, had the ESO not opened the crates, the condition of the lead azide would have remained unknown, placing personnel attempting to transport or handle this sensitive material at high risk. Any sudden movement would likely have resulted in an explosion causing death, serious injury, or damage to equipment and facilities. Given the severity of the hazard, on-site safety personnel destroyed the material after our departure from the facility.

Wallops. Of the four sites that we visited, Wallops stored the largest quantity (approximately 100,000 pounds) of high-order, mass detonating explosive material. Most of this material was in the form of propellant in rockets which NASA received from the U.S. military. The manufacture dates of these rockets ranged from the late 1950s to the early 1970s. The propellant's sensitivity to detonation or deflagration increases as the material ages.

We observed hundreds of rockets stacked closely together in bunkers, test, and storage facilities, most of which had not been inspected by the ESO in at least the past 2 years (see Figure 7). The stacked placement increased the probability of a catastrophic event because if a single rocket were to ignite or explode it could set off a chain-reaction or series of multiple detonations. The ESO stated that he did not have the resources to inspect and evaluate the rockets.

Figure 7. A rocket storage facility (left) and rocket motor igniters packaged in 1972 (right)



Source: Wallops ESO and NASA OIG respectively

We also observed numerous instances of improper electrical grounding and lightning protection in buildings in which rockets were stored. For example, we found a storage bunker with a large ground cable improperly routed just below the roof line. Because the cable passed directly through the wall of the bunker and was in close proximity to explosive material, the possibility existed that a lightning strike could cause an electrical arc and ignite the explosive material resulting in an explosion. Lightning protection is

critically important in the Wallops area because of the frequency and intensity of summer thunderstorms.

Glenn. At Lewis Field, we observed a portable storage magazine that was in poor condition, and inappropriately positioned along the fence line of a parking lot where it posed a potential danger to personnel and vehicles (see Figure 8). In addition, we identified improper grounding of the electrostatic discharge workstation used to service aircraft ejection seats and canopies. In the same area, we observed prohibited items such as plastic packaging materials and tape capable of producing a static charge that could cause inadvertent detonation of static-sensitive pyrotechnics or electro-explosive devices.

Inaccurate Inventories and Control of Energetic Materials. The Government Accountability Office (GAO) states that proper internal monitoring includes regularly checking inventory levels of materials, supplies, and other assets; correcting differences between recorded and actual amounts; noting the causes for all discrepancies; and taking appropriate steps to preclude recurrence.²⁶ NASA policy requires that hazardous material inventories be conducted at least annually.²⁷ We requested a copy of the inventories at each Center and Facility visited and judgmentally selected a sample to validate completeness and accuracy.

Figure 8. Explosive storage and adjacent parking lot



Source: NASA OIG

We found that the ESOs at the four sites we visited had never verified the completeness or accuracy of their inventory records. Accurate accounting of stored explosives is critical for determining safe separation distances between storage facilities and occupied buildings. Likewise, without an accurate accounting of the type, class, and net weight of stored explosive material, an ESO cannot determine whether incompatible materials are stored together (see Appendices C and D for the hazard classification system and storage requirements, respectively).

At Wallops and White Sands, we found energetic materials that could not be accounted for or reconciled with inventory records. For example, at Wallops we found that 27 individual explosive components and assemblies, ranging from small arms ammunition to rocket motors, could not be accurately reconciled with inventory records. At White Sands, we found 11 boxes of explosive initiators stored in a magazine that were not accounted for in the inventory records. In addition, inventory records reflected

²⁶ GAO, “Internal Control Management and Evaluation Tool” (GAO-01-1008G, August 2001)

²⁷ Typical hazardous materials are those that may be highly reactive, poisonous, explosive, flammable, combustible, corrosive, and radioactive; produce contamination or pollution of the environment; or cause adverse health effects or unsafe conditions.

408 pounds of the toxic and highly reactive propellant dimethylhydrazine (UDMH) in storage when the actual amount was 1,996 pounds.²⁸ We questioned White Sands personnel on the discrepancy and they discovered that it was a mathematical error on the spreadsheet.

The inventory discrepancies identified at Wallops and White Sands are summarized in Table 1 below.

Table 1. Summary of Inventory Discrepancies			
Center or Facility	Part Description	Inventory Record	Physical Count
Wallops Main Base	Black Brant Mk2	5	4
	Improved Malemute	4	3
	M5E1 Nike	21	22
	9mm Ammunition (1000/box)	18	15
	MK11TALOS	7	10
	MK 70 Terrier/MK 12 Terrier	22	21
	M112 Imp ORION	47	64
Wallops Island	M58 Taurus Igniter	5	7
	Spin Motor Grains	0	1
	Thrust Terminator	0	2
	Detectors Electronics	0	5
	Rocket Motor MK 40	0	17
	Viper IIIA	0	1
	Rocket Motor	0	1
	M37E1 Spin Motor	4	0
	Mk70 Terrier	5	0
	Improved Malemute	2	0
	Improved Orion	2	0
	Box of unknown part	0	1
	Box of (0.6 kg) power devices	0	1
	Box of (2.26 kg) fuses	0	1
	Box of (11.33 kg) fuses	0	2
	Box of 10 lbs fuses	0	1
	Box of 2.26 kg power devices	0	1
	Box of 15 lbs fuses	0	1
	Squibs	0	1
	Motor igniters	0	1
White Sands	Box of J-2X Initiators	0	11
	UDMH (lbs)	408	1,996

lbs - pounds

kg - kilograms

²⁸ UDMH is a high-energy propellant used in liquid-fueled rockets and small electrical power-generating units. It is an irritant, highly toxic, causes blood anemia, and is corrosive.

We also identified inventory records that were not complete. For example, inventory records at White Sands did not include the type, class, or net weight of materials. Further, inventory records at all the Centers and Facilities we visited did not reflect the date of manufacture or the shelf life of stored energetic materials. Without this information, ESOs cannot ensure that stored energetic materials have not surpassed their shelf lives.

No Record of Vehicle Inspections. NASA policies establish detailed safety standards, requirements, and guidelines for vehicles used to transport energetic materials. The presence of potential ignition sources (heat or electrical spark) and exposure to mechanical vibration and shock during motor transport necessitate that all vehicles used to transport energetic materials be inspected prior to use. We inspected vehicles used to transport energetic materials to determine whether they met requirements that ensure the safety of drivers and passengers, the energetic materials, surrounding personnel, and the environment. Except for minor discrepancies such as illegible placards, the majority of vehicles met the requirements and appeared to be properly maintained (see Figure 9). However, no inspection records were being kept for these vehicles.

Figure 9. Illegible placards on vehicles that are used to transport energetic material



Source: NASA OIG

The ESOs told us that vehicle inspections are performed prior to loading and transporting energetic materials. However none of the sites we visited could produce inspection records or checklists of these inspections. The Department of Defense has a general vehicle safety checklist that meets the DOT requirements for transport of hazardous materials.²⁹ In our judgment, it would be a best practice for NASA to utilize a similar checklist to help ensure that critical safety systems on vehicles used to transport energetic materials are in safe working order.

²⁹ Department of Defense Form 626, “Motor Vehicle Inspection (Transporting Hazardous Materials),” October 2011, is available at <http://www.dtic.mil/whs/directives/infomgt/forms/eforms/dd0626.pdf> (accessed March 26, 2013) and reprinted in Appendix E.

Improvements Needed in Oversight, Resources, and Training

NASA policy and procedures require annual inspections and assessments of all energetic materials and storage facilities. However, we found a general lack of oversight, resources, and training that significantly reduces the effectiveness of NASA's Explosives Safety Programs and increases the likelihood of a catastrophic event.

Lack of Center Oversight. Center ESOs are required to conduct an annual inspection, inventory, and hazard analysis of all energetic materials and storage facilities located at their sites. NASA-STD-8719.12 requires an audit system that routinely evaluates adequacy, availability, currency, and compliance with NASA policies and procedures and details specific inspections needed to ensure the adequacy of program execution, such as semiannual inspection of lightning protection systems and annual testing of the continuity and adequacy of electrical grounding.

Each Center and Facility that we visited also established internal operating procedures intended to augment the ESOs' responsibilities as defined in NASA's general safety policy and NASA-STD-8719.12. For example, White Sands requires a 100 percent physical inventory and inspection be conducted on a quarterly basis. At Glenn, the explosives inventory is to be audited annually by the ESO and the inventory database is required to be updated by users when explosives are removed from or added to storage facilities. Stennis requires the ESO to conduct annual audits (including a site walkthrough) of all explosive operations.

Despite these requirements, none of the sites we visited performed appropriate annual inspections and none of the inspection records we examined included a physical count of individually packaged explosive devices or an evaluation of the condition of these materials. While Center ESOs stated that general maintenance inspections of their facilities were conducted, none of the sites properly documented these inspections and no ESO had checked their accuracy or the physical condition of inventoried items.

We also found that the ESOs at Stennis and Glenn did not provide adequate oversight of the explosive materials owned and stored by tenants who lease property at their respective Centers.³⁰ NASA's general safety policy states that the Center ESO is responsible for assuring oversight of NASA-STD-8719.12 requirements and for reviewing all Memorandums of Agreement regarding energetic materials. The policy also states:

If the ESO represents NASA as the Host [of a tenant organization], the ESO assures compliance with all appropriate elements of this NPR. In all cases, the ESO assures that agreements are formalized to maximize the health and safety of NASA employees and facilities.

³⁰ Wallops and White Sands did not have tenants that stored energetic materials.

However, except for one tenant at Stennis, neither Center ESO validated inventory records, conducted safety inspections, or assured compliance of their tenants’ facilities with NASA’s policies. Tenants at Stennis and Glenn include the U.S. military, other Federal agencies, private industry, and academia. Table 2 summarizes the level of oversight provided by the ESO to the tenants at Stennis and Glenn.

Table 2. Summary of NASA’s ESO Oversight of Tenants

Center	Tenant	Safety Clause in Agreement	Inspection Access Allowed	Inspection Performed
Stennis	⁺ Mississippi State University	Yes	Yes	No
Stennis	Pratt-Whitney Rocketdyne	Yes	Yes	Yes
Stennis	⁺ Rolls-Royce	Yes	Yes	No
Stennis	U.S. Navy	Yes	No	No
Glenn	*FBI	Yes	Yes	No
Glenn	**USDA	Yes	Yes	No

⁺ Does not currently store energetic materials
 * Federal Bureau of Investigation
 ** U.S. Department of Agriculture

At Stennis, the majority of explosive materials are owned and stored by the U.S. Navy. Except for one discussion involving safe separation distances, the Stennis ESO had minimal contact with the Navy ESO. The Stennis ESO does not have any communication with commercial tenants that may use and store energetic materials, such as Rolls-Royce, despite the fact that the lease agreement clearly states that the tenant shall grant NASA access to inspect its facilities. The Stennis ESO stated that he had no knowledge of the commercial tenants’ use of energetic materials and the Center had not conducted any oversight inspections.

At Glenn’s Plum Brook Station, the majority of stored energetic materials, including military and small arms ammunition, is owned by tenants. Glenn requires tenants to provide an annual inventory list; however, the ESO had not validated the accuracy of the inventory record. We reviewed the inventory records and found insufficient data to ensure that the energetic materials were properly stored. For example, the FBI provided the ESO an inventory list that appears to indicate that initiating devices are improperly stored with high-order mass detonating explosives. The ESO did not follow up on this potential violation to confirm the accuracy of the information or to mitigate the potentially hazardous situation. Although tenant agreements generally contain a “hold harmless clause” that may protect NASA from financial liability, personnel, property, and the public remain at risk of physical harm.

Lack of Headquarters Oversight. Although, Agency policy states that the overall responsibilities of the Headquarters Office of Safety and Mission Assurance include

verifying the effectiveness of the Center's Explosives Safety Programs to ensure that adequate levels of both programmatic and institutional resources are applied, NASA Headquarters does not conduct inspections, provide guidance, or perform oversight of the Centers' Programs.³¹ The NASA Headquarters Office of Safety and Mission Assurance is staffed by 32 employees, one of whom is the Headquarters Explosives Safety Manager. According to him, the primary role of Headquarters is to develop Agency-wide Explosives Safety Program policies and procedures. He further stated that his office does not:

- have the resources to oversee each Center's Explosive Safety Program;
- provide funding to Centers' Explosives Safety Programs; or
- oversee Program performance.

Instead, Headquarters relies on each Center's Safety and Mission Assurance Directorate to oversee their respective programs.

In addition, the Headquarters Office of Safety and Mission Assurance requires the NASA Safety Center to conduct Institutional/Facility/Operational (IFO) Safety Audits on behalf of NASA Headquarters every 3 years.³² The IFO process provides independent verification that institutions, facilities, and operations at each NASA Center comply with Agency safety requirements, including applicable Federal, state, and local safety and health statutes and regulations. These audits are designed to cover a wide variety of areas, including energetic materials. However, the NASA Safety Center has not conducted an IFO audit of the Centers' Explosives Safety Programs, and Headquarters personnel have not conducted an audit or Explosives Safety Program review at the sites we visited in more than 10 years.

Lack of Dedicated Resources. NASA management does not provide sufficient resources to ensure the Agency's Explosives Safety Programs are conducted in accordance with NASA-STD-8719.12. We found that that the Center ESOs did not have sufficient personnel, budget, or time to carry out their assigned responsibilities.

At each of the Centers and Facilities we visited, ESO duties were considered an ancillary or part-time responsibility. This was especially apparent at Wallops where the Safety Office Chief, who is responsible for all on-site safety programs, was also carrying out the tasks of the ESO. Because his time and effort was devoted to managerial oversight of the safety programs under his purview, he was unable to conduct the requisite hazard analyses, inspections, and inventory of the vast amounts of energetic materials, storage, and test facilities. In our judgment, one staff person does not have adequate time to

³¹ NASA Policy Directive 1000.3D, "The NASA Organization," December 3, 2008.

³² NPR 8705.6B, "Safety and Mission Assurance Audits, Reviews, and Assessments," May 24, 2011

address Wallop's overall safety program requirements and complete the routine tasks of an ESO.

Similarly, the ESO assigned to White Sands is responsible for managing multiple geographically dispersed safety critical programs. In addition to White Sands, he is the ESO at Johnson and Ellington Field in Houston, Yuma Proving Grounds in Arizona, and the NASA Forward Operating Location in El Paso, Texas. Furthermore, this same individual was recently assigned as the Pressure Vessel and Systems Program Manager at Johnson – another critical safety program.³³

At Stennis, in fiscal year 2012 the Safety and Mission Assurance Directorate had a shortfall of three full-time employees. Following the retirement of the previous ESO, the ESO responsibilities were allocated to a safety specialist with no previous explosive safety experience who is also responsible for the Center's construction safety program and is a member of the Center's Source Evaluation Board.³⁴ In spite of the discrepancies we found in the Center's Program, the ESO stated that the level of effort did not justify a full-time employee.

A similar lack of resources has also affected operations at NASA Headquarters. The Headquarters Office of Safety and Mission Assurance staff decreased from 40 in fiscal year 2011 to 32 in 2012. The Headquarters Explosives Safety Manager stated that only 20 percent of his time is allocated to the Explosives Safety Program because his primary responsibilities include oversight of the Government and Industry Data Exchange Program and the Interagency Nuclear Safety Program. In addition, except for \$30,000 set aside for an annual Pyrotechnics Workshop, Headquarters provides no specific budget dedicated to the Agency's Explosives Safety Program. Furthermore, the ESOs from the sites we visited stated that their programs are funded from their Center's Management and Operations budgets and that they do not receive separate line-item funding for their Center Explosives Safety Programs. We believe this lack of dedicated resources has severely hindered the Agency's ability to meet Explosives Safety Program requirements.

Lack of Training and Experience. NASA-STD-8719.12 requires each Center to have a trained and experienced ESO. However, NASA does not specify the type of training required, and as a result we found no consistency in the training received by Agency ESOs. In our judgment, none of the ESOs at the sites we visited had the appropriate combination of experience and training needed to properly carry out their responsibilities. We found that ESO training is insufficient and ESOs are not effectively participating in the evaluation of selected explosive, propellant, and pyrotechnic safety training programs for staff at their Centers.

³³ A pressure vessel is any vessel used for the storage or handling of a gas or liquid under positive pressure. A pressure system is an assembly of components under pressure such as vessels, piping, valves, relief devices, pumps, expansion joints, and gauges.

³⁴ A Source Evaluation Board provides analyses of proposals in a procurement solicitation.

We reviewed the training records from each Center and Facility to assess the training received by ESOs and other personnel handling energetic materials and found that two ESOs had not attended formal explosives safety training in the past 14 years; one ESO received training 7 years ago, prior to his arrival at NASA; and the fourth ESO had taken only a basic explosives training course and told us he did not believe he was qualified for the job.

Proper training ensures that personnel responsible for handling explosives have the knowledge and understanding to work safely with energetic materials. NASA policy provides specific criteria for training personnel who are responsible for implementing the Explosives Safety Program and for personnel who handle explosives. Without similar criteria for ESOs' training requirements, NASA has little assurance that Program requirements or personnel training programs are effectively managed.

We also reviewed the condition of training records for ESOs and other personnel handling energetic materials. At the sites we visited, we generally found these records inconsistent, incomplete, out of date, and sometimes illegible. Inconsistencies included variances in the type of information recorded and many training records were missing information such as when the training needed to be refreshed. Incomplete information increases the probability that required training could be missed and decreases the likelihood that persons managing or working with energetic materials have the required knowledge to perform these tasks safely.

Conclusion

Complacency within an Explosives Safety Program can have disastrous consequences for NASA personnel, facilities, and missions. Moreover, absence of a recent mishap does not diminish the urgency of immediately addressing the deficiencies we identified in this review.

Our audit uncovered evidence that NASA's Explosives Safety Programs have been neglected and poorly managed, leaving personnel, property, and the public at risk. Center ESOs are not conducting required safety inspections, keeping complete and accurate inventories, or ensuring tenants' compliance with NASA's policies. Oversight of the Agency's Program by Headquarters personnel is non-existent and ESOs responsible for implementing the Program do not have the experience or adequate training to provide effective oversight. It is imperative that NASA address these deficiencies to prevent the possibility of a catastrophic event.

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

To improve NASA's Explosives Safety Program and better ensure the safety and protection of personnel, property, and the environment, we made the following recommendations to the Chief of Safety and Mission Assurance:

Recommendation 1. Initiate a review of management, storage, and handling procedures of energetic materials at all NASA Centers to identify deficiencies, take corrective actions, and share best practices.

Management's Response. The Chief of Safety and Mission Assurance concurred with our recommendation, stating that he will coordinate with safety personnel and ESOs at the Centers to identify deficiencies, long- and short-term solutions, and update procedures as necessary. The Chief expects to complete this review in 120 days.

Evaluation of Management's Response. Management's comments are responsive; therefore, the recommendation is resolved and will be closed upon verification and completion of the proposed corrective actions.

Recommendation 2. Require that all ESOs inventory energetic materials and initiate investigations of any missing material.

Management's Response. The Chief concurred with our recommendation, stating that he will assign Center safety personnel to work with ESOs to update inventories of energetic materials and report on any planned investigations within 120 days.

Evaluation of Management's Response. Management's comments are responsive; therefore, the recommendation is resolved and will be closed upon verification and completion of the proposed corrective actions.

Recommendation 3. Verify that tenant- and contractor-owned energetic materials on NASA property are stored, handled, and inspected in accordance with NASA procedural requirements and applicable safety standards.

Management's Response. The Chief partially concurred with our recommendation, stating that he will coordinate with the Center safety directors to review the energetic materials stored by tenants and contractors on NASA property and their procedures and processes to ensure the safety of personnel. He also stated that NASA will conduct this review in accordance with the terms of existing agreements.

Evaluation of Management's Response. We agree that it is appropriate for NASA to consider the terms of existing agreements when conducting its review. However, the agreements we reviewed in the course of our audit permit NASA to verify, by inspecting or otherwise observing, that tenants' materials are stored and handled in accordance with Agency requirements. Therefore, we believe that NASA should take such steps to verify

the safety of energetic materials stored by tenants. Accordingly, we are resolving the recommendation but it will remain open until we verify that NASA is taking appropriate corrective action, including verification steps when permitted.

Recommendation 4. Require that an inspection checklist is used and retained for vehicles used to transport energetic materials.

Management's Response. The Chief concurred with our recommendation, stating that within 180 days he will verify with Center safety directors that a current and accurate checklist is being used for vehicles transporting energetic materials.

Evaluation of Management's Response. Management's comments are responsive; therefore, the recommendation is resolved and will be closed upon verification and completion of the proposed corrective actions.

Recommendation 5. Review the responsibilities of Headquarters Explosives Safety Program personnel and assign duties that will provide effective oversight of Center Explosives Safety Programs.

Management's Response. The Chief concurred with our recommendation, stating that within 180 days he will review Headquarters roles and responsibilities and modify them as needed.

Evaluation of Management's Response. Management's comments are responsive; therefore, the recommendation is resolved and will be closed upon verification and completion of the proposed corrective actions.

Recommendation 6. Review personnel and fiscal resource allocations for the Agency's Explosives Safety Program and correct deficiencies.

Management's Response. The Chief concurred with our recommendation, stating that he will coordinate with Center safety directors to review resource allocations within 180 days. The Chief pledged to work with the Centers to address their resource requirements, but noted this was an ongoing process given the limited budget for Explosives Safety Programs and the potential need to request additional funding.

Evaluation of Management's Response. We recognize the challenges associated with addressing the numerous deficiencies identified in a fiscally constrained environment. While we appreciate the Chief's plan to work with the Centers, we encourage NASA to evaluate costs versus risks during that review and allocate appropriate resources. Therefore, the recommendation is resolved but will remain open until verification and completion of the proposed corrective actions.

Recommendation 7. Review training requirements, qualifications, and records of all ESOs and energetic material handlers and correct deficiencies. Specifically, establish criteria for

ESO training and ensure that ESOs and energetic material handlers have appropriate experience and up-to-date training to carry out their responsibilities safely.

Management's Response. The Chief concurred with our recommendation, stating that he will coordinate with Center safety directors to review ESO and energetic materials handlers training and qualifications and identify deficiencies within 90 days. He also stated that training criteria and short- and long-term solutions will be identified within one year.

Evaluation of Management's Response. Management's comments are responsive; therefore, the recommendation is resolved and will be closed upon verification and completion of the proposed corrective actions.

Scope and Methodology

We performed this audit from April 2012 through March 2013 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 the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

We reviewed explosive material safety requirements contained in the following NASA policies, as well as Center-specific policies that corresponded with NASA guidance:

- NPR 8715.3C, “NASA General Safety Program Requirements (w/Change 7)” March 12, 2008
- NASA Policy Directive 1000.3D, “The NASA Organization w/Change 37 (May 25, 2012),” December 03, 2008.
- NPR 8705.6B, “Safety and Mission Assurance (SMA) Audits, Reviews, and Assessments,” May 24, 2011.
- NASA Standard 8719.12, “Safety Standard for Explosives, Propellants, and Pyrotechnics with Change 2,” December 12, 2011.
- Draft GLM–QSA–1700.1, “Glenn Research Center, Glenn Safety Manual, Chapter 18—Explosives, Propellants, and Pyrotechnics.”
- Stennis Space Center SPR 1600.1, “John C. Stennis Space Center Security Requirements Handbook, Rev B,” June 30, 2011.
- Stennis Space Center SSP-8715-0001, “John C. Stennis Space Center Safety and Health Handbook, Rev C,” January 31, 2012.
- Wallops Flight Facility Procedures and Guidelines 800-PG-8715.0.2C, “Training and Certification Procedures for Ordnance Handlers at GSFC/WFF,” March 19, 2010.
- White Sands Test Facility Standard Instruction 25-SW-0014.E, “Ordnance Operations,” March 5, 2004.
- White Sands Test Facility Standard Procedure 25-0007.E, “WSTF Explosives, Propellants and Pyrotechnics (EP&P) Safety Program,” September 20, 2011.

To determine whether NASA had adequate internal controls for transportation, storage, and handling of energetic materials, we conducted fieldwork at Glenn, Stennis, Wallops, and White Sands. We interviewed NASA and contractor employees to gain an understanding of the Centers' Explosives Safety Program and operations.

To determine whether NASA had adequate controls in place to account for energetic materials, we selected and reviewed accounting records and performed a physical inventory to identify any explosive material not recorded in the site inventory process (receipt/acceptance, storage, usage, transfer, and disposition) and any lost or stolen materials.

To determine whether NASA applied adequate procedures for safe storage and handling of energetic materials, we inspected magazine sites for compliance with applicable safety requirements, such as magazines no longer safe for storing explosive materials; magazines located in areas encroached by civilian population; incompatible explosive materials stored in the same magazine; and explosive materials stored in a magazine that does not meet design requirements.

To determine whether NASA Headquarters and Centers provided adequate oversight to ensure that the applicable requirements of NASA-STD-8719.12 were implemented and supportive of Center, program, and project missions, we interviewed personnel about their oversight roles and responsibilities. We also assessed the Center, facilities, and Headquarters Office of Safety and Mission Assurance oversight procedures to determine whether oversight reviews were conducted as required. We also reviewed tenant agreements related to the storage of explosive materials to determine whether the NASA requirements and oversight were implemented for the tenant storage and operations.

To assess whether NASA implemented requirements that ensure the safe transportation of energetic materials, we inspected vehicle and transportation records to determine whether any violations or improper operations had occurred.

Use of Computer-Processed Data. We did not use computer-processed data to perform this audit.

Review of Internal Controls

We performed an assessment of the internal controls associated with NASA's transportation, storage, and handling of energetic materials. Throughout the audit we reviewed controls associated with the audit objectives and determined that NASA's internal controls and program oversight were inadequate to ensure the safety and protection of its personnel and facilities from the potentially devastating effects of energetic materials. Specifically, at the four sites we visited, we identified 155 individual discrepancies regarding the storage and handling of energetic materials and the accuracy and completeness of explosives inventories. Headquarters and Center officials were receptive to the individual findings and have swiftly addressed the issues that presented

an immediate threat to personnel and facilities. However, the systemic issues we identified will take significantly greater attention from senior management to correct.

Prior Coverage

During the past 5 years, the NASA Office of Inspector General (OIG) and the Government Accountability Office (GAO) have not issued any reports of particular relevance to the subject of this report

SUMMARY OF DISCREPANCIES

The following table summarizes the discrepancies noted at each site we visited. We based our risk assessment on the severity of an event resulting from the discrepancy and its probability for occurrence.

Discrepancies by Site Visited					
Discrepancy Area	Total Found at Center/Facility	Risk Severity of Discrepancies			Total
		High	Medium	Low	
Storage and Handling					
<i>Storage and Compatibility</i>					23
Glenn	1			1	
Stennis	9	4	3	2	
Wallops	8	4	4		
White Sands	5	2	2	1	
<i>Concurrent Operations</i>					
Stennis	1	1			2
Wallops	1	1			
<i>Labels and Placards</i>					
Stennis	3		3		11
Wallops	4		1	3	
White Sands	4		1	3	
<i>Electrostatic Sensitive Discharge</i>					
Stennis	2		1	1	9
Wallops	3		2	1	
White Sands	4		3	1	
<i>Storage Facility Site Plan and Site License</i>					
Stennis	4	3	1		10
Wallops	3		2	1	
White Sands	3		3		
<i>Hazard Assessment</i>					
Glenn	1		1		4
Stennis	1		1		
Wallops	1		1		
White Sands	1		1		

Discrepancies by Site Visited (continued)					
Discrepancy Area	Total Found at Center/Facility	Severity of Discrepancies - Risk			Total
		High	Medium	Low	
Storage and Handling (continued)					
<i>Grounding and Lightning Protection</i>					21
Glenn	4		2	2	
Stennis	8		6	2	
Wallops	7	2	3	2	
White Sands	2		1	1	
<i>Storage Facility Maintenance</i>					
Glenn	1			1	
Stennis	1			1	
Wallops	1			1	
White Sands	1			1	
<i>Other</i>					
Stennis	10	4	2	4	
White Sands	5			5	
Accountability					
Glenn	1			1	
Stennis	1			1	
Wallops	2		2		
White Sands	4	2	1	1	
Transportation and Inspection					
Glenn	1			1	
Stennis	1			1	
Wallops	1			1	
White Sands	1			1	
Center Oversight					
Glenn	1			1	
Stennis	4			4	
Wallops	3			3	
White Sands	4		1	3	
Headquarters	4		4		
Tenant Oversight					
Glenn	2		2		
Stennis	2		2		

Discrepancies by Site Visited (continued)					
Discrepancy Area	Total Found at Center/Facility	Severity of Discrepancies - Risk			Total
		High	Medium	Low	
Resources					8
Glenn	1		1		
Stennis	1		1		
Wallops	3	1	2		
White Sands	2		1	1	
Headquarters	1		1		
Training					16
Glenn	4			4	
Stennis	4	1		3	
Wallops	4			4	
White Sands	4			4	

EXPLOSIVES, PROPELLANTS, AND PYROTECHNICS HAZARD CLASSIFICATION SYSTEM

1. To ease identification of hazard characteristics and promote safe storage and transport of explosives, NASA uses the DOT hazard classification system, which is an implementation of the international system of classification devised by the United Nations Organization for transport of dangerous goods.
2. The United Nations classification system consists of nine hazard classes. Thirteen compatibility groups are included for segregating explosives on the basis of similarity of characteristics, properties, and accident effects potential.
3. Most explosives are included in the United Nations Class 1. Class 1 is divided into six divisions that indicate the character and predominance of associated hazards.
 - **Hazard Division 1.1, Mass explosion.** Items in this division are primarily a blast hazard and may be expected to mass detonate when a small portion is initiated by any means. Items in Hazard Division 1.1 include bulk explosives, some propellants, demolition charges, some missile components, and some rockets.
 - **Hazard Division 1.2, Non-mass explosion, fragment producing.** These items do not mass detonate when configured for storage or transportation if a single item or package is initiated. When these items function, the results are burning and exploding progressively with no more than a few reacting at a time. Blast effects are generally limited to the immediate vicinity and are not the primary hazard.
 - **Hazard Division 1.3, Mass fire.** These items burn vigorously, and the fires are difficult to put out. Explosions are usually pressure ruptures of containers, which may produce fragments (especially missile motors), but do not produce propagating shock waves or damaging blast overpressure beyond intermagazine distances.
 - **Hazard Division 1.4, Moderate fire - no blast.** Items in this division present a fire hazard with no blast hazard and virtually no fragmentation and/or toxic hazard beyond the fire hazard clearance ordinarily specified for high-risk materials. This division includes items such as small arms ammunition without explosive projectiles, fuse lighters and squibs, colored smoke grenades, and explosive valves or switches.
 - **Hazard Division 1.5, Very insensitive explosives.** This division comprises substances that have a mass explosion hazard but are so insensitive that there is very little probability of initiation or of transition from burning to detonation under normal conditions of transport or storage.

- **Hazard Division 1.6, Extremely insensitive explosives.** This division comprises articles that contain only extremely insensitive detonating substances and that demonstrate a negligible probability of accidental ignition or propagation.

The table below summarizes the fire divisions that are synonymous with the Hazard Divisions 1.1 through 1.4 for explosives. The hazard decreases with ascending fire division numbers.

Fire Division			
Fire Division	Hazard Division	Description	Hazard
1	1.1	Explosives that have a mass explosion hazard. A mass explosion is one which affects almost the entire load instantaneously.	Mass Explosion
2	1.2	Explosives that have a projection hazard but not a mass explosion hazard.	Explosion with Fragment Hazard
3	1.3	Explosives that have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard.	Mass Fire
4	1.4	Explosives that present a minor explosion hazard and moderate fire hazard. The explosive effects are largely confined to the package and no projection of fragments of appreciable size or range is to be expected.	Moderate Fire

(Source: NASA-STD-8719.12 Section 5)

EXPLOSIVES STORAGE REQUIREMENTS

Explosive Storage Principles

1. The highest degree of safety in explosives storage could be assured if each item or division were stored separately. However, such ideal storage generally is not feasible. A proper balance of safety and other factors frequently requires mixing of several types of explosives in storage.
2. Explosives shall not be stored together with dissimilar materials or items that present positive hazards to the explosives. Examples are mixed storage of explosives with flammable or combustible materials, acids, or corrosives.
3. Different types, by item and division, of explosives may be mixed in storage provided they are compatible. Explosives are assigned to a compatibility group when they can be stored together without increasing significantly either the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident.

Storage and Compatibility Groups

Explosives are assigned to one of 13 compatibility groups (A through H, J, K, L, N, and S).

- Group A. Bulk initiating explosives that have the necessary sensitivity to heat, friction, or percussion to make them suitable for use as initiating elements in an explosive train. Examples are wet lead azide, wet lead styphnate, wet mercury fulminate, wet tetracene, dry cyclonite, and dry pentaerythritol tetranitrate.
- Group B. Detonators and similar initiating devices not containing two or more independent safety features. These items are designed to initiate or continue the functioning of an explosive train. Examples are detonators, blasting caps, small arms primers, and fuses.
- Group C. Bulk propellants, propelling charges, and devices containing propellant with or without their means of ignition. These items will deflagrate, explode, or detonate. Examples are single-, double-, triple-base, and composite propellants and rocket motors (solid propellant).
- Group D. Black powder, high explosives, and devices containing high explosives without their own means of initiation and without propelling charge, or a device

containing an initiating explosive and containing two or more independent safety features. These explosives can be expected to explode or detonate when any given item or component is initiated, except for devices containing initiating explosives with independent safety features. Examples are bulk trinitrotoluene, Composition B, black powder, wet cyclonite, or pentaerythritol tetranitrate.

- Group E. Ammunition containing high explosive without its own means of initiation and containing or with propelling charge (other than one containing a flammable or hypergolic liquid). Examples are rockets or guided missiles.
- Group F. Ammunition containing high explosive with its own means of initiation and with propelling charge (other than one containing a flammable or hypergolic liquid) or without a propelling charge.
- Group G. Fireworks, illuminating, incendiary, and smoke, including hexachlorethane or tear-producing devices other than those that are water activated or which contain white phosphorus or flammable liquid or gel. These devices result in an incendiary, illumination, lachrymatory, smoke, or sound effect. Examples are flares, signals, incendiary or illuminating, and other smoke or tear-producing devices.
- Group H. Devices containing both explosives and white phosphorus or other pyrophoric material. Examples are white phosphorus, plasticized white phosphorus, or other devices containing pyrophoric material.
- Group J. Devices containing both explosives and flammable liquids or gels, other than those that are spontaneously flammable when exposed to water or the atmosphere. Examples are liquid- or gel-filled incendiary devices, fuel-air explosive devices, and flammable liquid-fueled missiles.
- Group K. Devices containing both explosives and toxic chemical agents. This group contains chemicals specifically designed for incapacitating effects more severe than tearing of the eyes.
- Group L. Explosives not included in other compatibility groups. Devices having characteristics that do not permit storage with other types or kinds of explosives, or dissimilar explosives of this group. Examples are water-activated devices, prepackaged hypergolic liquid-fueled rocket engines, damaged or suspect items of any group, and explosives in substandard or damaged packaging in a suspect condition or with characteristics that increase the risk in storage.
- Group N. Hazard Division 1.6 devices containing only extremely insensitive detonating substance.
- Group S. Explosives presenting no significant hazard. Explosives so packaged or designed that any hazardous effects arising from accidental functioning are confined

within the package. Examples are thermal batteries, explosive switches or valves, and other items packaged to meet the criteria of this group.

The table below illustrates the compatibility of the materials in each group. The marking "X" at an intersection indicates that these groups may be combined in storage. Otherwise, mixing is either prohibited or restricted. The marking "Z" at an intersection indicates that when warranted by operational considerations or magazine nonavailability, and when safety is not sacrificed, logically mixed storage of limited quantities of some items of different groups may be approved

Storage Compatibility Mixing Chart

Groups	A	B	C	D	E	F	G	H	J	K	L	N	S
A	X	Z											
B	Z	X	Z	Z	Z	Z	Z					X	X
C		Z	X	X	X	Z	Z					X	X
D		Z	X	X	X	Z	Z					X	X
E		Z	X	X	X	Z	Z					X	X
F		Z	Z	Z	Z	X	Z					Z	X
G		Z	Z	Z	Z	Z	X					Z	X
H								X					X
J									X				X
K										Z			X
L													
N		X	X	X	X	Z	Z					X	X
S		X	X	X	X	X	X	X	X			X	X

(Source: NASA-STD-8719.12, Section 5)

VEHICLE INSPECTION CHECKLIST

MOTOR VEHICLE INSPECTION (TRANSPORTING HAZARDOUS MATERIALS)									
<i>(Read Instructions before completing this form.)</i>									
This form applies to all vehicles which must be marked or placarded in accordance with Title 49 CFR.					1. BILL OF LADING/TRANSPORTATION CONTROL NUMBER				
SECTION I - DOCUMENTATION					ORIGIN a.		DESTINATION b.		
2. CARRIER/GOVERNMENT ORGANIZATION									
3. DATE/TIME OF INSPECTION									
4. LOCATION OF INSPECTION									
5. OPERATOR(S) NAME(S)									
6. OPERATOR(S) LICENSE NUMBER(S)									
7. MEDICAL EXAMINER'S CERTIFICATE*									
8. <i>(X if satisfactory at origin)</i>					9. CVSA DECAL DISPLAYED ON COMMERCIAL EQUIPMENT*				
a. HAZMAT ENDORSEMENT		d. ERG OR EQUIVALENT COMMERCIAL:		YES	NO	a. TRUCK/TRACTOR		YES	NO
b. VALID LEASE*		e. DRIVER'S VEHICLE INSPECTION REPORT*				b. TRAILER			
c. ROUTE PLAN		f. COPY OF 49 CFR PART 397							
SECTION II - MECHANICAL INSPECTION									
<i>All items shall be checked on empty equipment prior to loading. Items with an asterisk shall be checked on all incoming loaded equipment.</i>									
10. TYPE OF VEHICLE(S)					11. VEHICLE NUMBER(S)				
12. PART INSPECTED <i>(X as applicable)</i>									
		ORIGIN (1)		DESTINATION (2)				COMMENTS (3)	
		SAT	UNSAT	SAT	UNSAT	SAT	UNSAT	SAT	UNSAT
a. SPARE ELECTRICAL FUSES						k. EXHAUST SYSTEM			
b. HORN OPERATIVE						l. BRAKE SYSTEM*			
c. STEERING SYSTEM						m. SUSPENSION			
d. WINDSHIELD/WIPERS						n. COUPLING DEVICES			
e. MIRRORS						o. CARGO SPACE			
f. WARNING EQUIPMENT						p. LANDING GEAR*			
g. FIRE EXTINGUISHER*						q. TIRES, WHEELS, RIMS			
h. ELECTRICAL WIRING						r. TAILGATE/DOORS*			
i. LIGHTS AND REFLECTORS						s. TARPULIN*			
j. FUEL SYSTEM*						t. OTHER <i>(Specify)</i>			
13. INSPECTION RESULTS <i>(X one)</i> ACCEPTED <input type="checkbox"/> REJECTED <input type="checkbox"/>									
<i>(If rejected give reason under "Remarks". Equipment will be approved if deficiencies are corrected prior to loading.)</i>									
14. SATELLITE MOTOR SURVEILLANCE SYSTEM: <i>(X one)</i> ACCEPTED <input type="checkbox"/> REJECTED <input type="checkbox"/>									
15. REMARKS									
16. INSPECTOR SIGNATURE <i>(Origin)</i>					17. INSPECTOR SIGNATURE <i>(Destination)</i>				
SECTION III - POST LOADING INSPECTION									
<i>This section applies to Commercial and Government/Military vehicles. All items will be checked prior to release of loaded equipment and shall be checked on all incoming loaded equipment.</i>									
		ORIGIN (1)		DESTINATION (2)				COMMENTS (3)	
		SAT	UNSAT	SAT	UNSAT	SAT	UNSAT	SAT	UNSAT
18. LOADED IAW APPLICABLE SEGREGATION/COMPATIBILITY TABLE OF 49 CFR									
19. LOAD PROPERLY SECURED TO PREVENT MOVEMENT									
20. SEALS APPLIED TO CLOSED VEHICLE; TARPULIN APPLIED ON OPEN EQUIPMENT									
21. PROPER PLACARDS APPLIED									
22. SHIPPING PAPERS/DD FORM 2890 FOR GOVERNMENT VEHICLE SHIPMENTS									
23. COPY OF DD FORM 626 FOR DRIVER									
24. SHIPPED UNDER DOT SPECIAL PERMIT 868									
25. INSPECTOR SIGNATURE <i>(Origin)</i>					26. DRIVER(S) SIGNATURE <i>(Origin)</i>				
27. INSPECTOR SIGNATURE <i>(Destination)</i>					28. DRIVER(S) SIGNATURE <i>(Destination)</i>				

INSTRUCTIONS

SECTION I - DOCUMENTATION

General Instructions.

All items (2 through 9) will be checked at origin prior to loading. Items with an asterisk (*) apply to commercial operators or equipment only. Only Items 2 through 7 are required to be checked at destination.

Items 1 through 5. Self explanatory.

Item 6. Enter operator's Commercial Driver's License (CDL) number or Military OF-346 License Number. CDL and OF-346 must have the HAZMAT and other appropriate endorsements IAW 49 CFR 383.

Item 7. *Enter the expiration date listed on the Medical Examiner's Certificate.

Item 8.a. Hazardous Materials Certification. In accordance with applicable service regulations, ensure operator has been certified to transport hazardous materials. Check the expiration date on driver's HAZMAT Certification.

b. *Valid Lease. Shipper will ensure a copy of the appropriate contract or lease is carried in all leased vehicles and is available for inspection. (49 CFR 376.12 and 376.11(c)(2)).

c. Route Plan. Prior to loading any Hazard Class/Division 1.1, 1.2, or 1.3 (Explosives) for shipment, ensure that the operator possesses a written route plan in accordance with 49 CFR Part 397. Route Plan requirements for Hazard Class 7 (Radioactive) materials are found in 49 CFR 397.101.

d. Emergency Response Guidebook (ERG) or Equivalent. Commercial operators must be in possession of an ERG or equivalent document. Shipper will provide applicable ERG page(s) to military operators.

e. *Driver's Vehicle Inspection Report. Review the operator's Vehicle Inspection Report. Ensure that there are no defects listed on the report that would affect the safe operation of the vehicle.

f. Copy of 49 CFR Part 397. Operators are required by regulation to have in their possession a copy of 49 CFR Part 397 (Transportation of Hazardous Materials Driving and Parking Rules). If military operators do not possess this document, shipper will provide a copy to operator.

Item 9. *Commercial Vehicle Safety Alliance (CVSA) Decal. Check to see if equipment has a current CVSA decal and mark applicable box. Vehicles without CVSA, check documentation of the last vehicle periodic inspection and perform DD Form 626 inspection.

SECTION II - MECHANICAL INSPECTION

General Instructions.

All items (12.a. through 12.t.) will be checked on all incoming empty equipment prior to loading. All UNSATISFACTORY conditions must be corrected prior to loading. Items with an asterisk (*) shall be checked on all incoming loaded equipment. Unsatisfactory conditions that would affect the safe off-loading of the equipment must be corrected prior to unloading.

SECTION II (Continued)

Item 12.a. Spare Electrical Fuses. Check to ensure that at least one spare fuse for each type of installed fuse is carried on the vehicle as a spare or vehicle is equipped with an overload protection device (circuit breaker). (49 CFR 393.95)

b. Horn Operative. Ensure that horn is securely mounted and of sufficient volume to serve purpose. (49 CFR 393.81)

c. Steering System. The steering wheel shall be secure and must not have any spokes cracked through or missing. The steering column must be securely fastened. Universal joints shall not be worn, faulty or repaired by welding. The steering gear box shall not have loose or missing mounting bolts or cracks in the gear box mounting brackets. The pitman arm on the steering gear output shaft shall not be loose. Steering wheel shall turn freely through the limit of travel in both directions. All components of a power steering system must be in operating condition. No parts shall be loose or broken. Belts shall not be frayed, cracked or slipping. The power steering system shall not be leaking. (49 CFR 396 Appendix G)

d. Windshield/Wipers. Inspect to ensure that windshield is free from breaks, cracks or defects that would make operation of the vehicle unsafe; that the view of the driver is not obscured and that the windshield wipers are operational and wiper blades are in serviceable condition. Defroster must be operative when conditions require. (49 CFR 393.60, 393.78 and 393.79)

e. Mirrors. Every vehicle must be equipped with two rear vision mirrors located so as to reflect to the driver a view of the highway to the rear along both sides of the vehicle. Mirrors shall not be cracked or dirty. (49 CFR 393.80)

f. Warning Equipment. Equipment must include three bidirectional emergency reflective triangles that conform to the requirements of FMVSS No. 125. FLAME PRODUCING DEVICES ARE PROHIBITED. (49 CFR 393.95)

g. Fire Extinguisher. Military vehicles must be equipped with one serviceable fire extinguisher with an Underwriters Laboratories rating of 10 BC or more. (Commercial motor vehicles must be equipped with one serviceable 10 BC Fire Extinguisher). Fire extinguisher must be located so that it is readily accessible for use and securely mounted on the vehicle. The fire extinguisher must be designed, constructed and maintained to permit visual determination of whether it is fully charged. (49 CFR 393.95)

h. Electrical Wiring: Electrical wiring must be clean and properly secured. Insulation must not be frayed, cracked or otherwise in poor condition. There shall be no uninsulated wires, improper splices or connections. Wires and electrical fixtures inside the cargo area must be protected from the lading. (49 CFR 393.28)

INSTRUCTIONS

SECTION II (Continued)

i. Lights/Reflectors. (Head, tail, turn signal, brake, clearance, marker and identification lights, Emergency Flashers). Inspect to see that all lighting devices and reflectors required are operable, of proper color and properly mounted. Ensure that lights and reflectors are not obscured by dirt or grease or have broken lenses. High/Low beam switch must be operative. Emergency Flashers must be operative on both the front and rear of vehicle. (49 CFR 393.24, 25, and 26)

j. Fuel System. Inspect fuel tank and lines to ensure that they are in serviceable condition, free from leaks, or evidence of leakage and securely mounted. Ensure that fuel tank filler cap is not missing. Examine cap for defective gasket or plugged vent. Inspect filler necks to see that they are in completely serviceable condition and not leaking at joints. (49 CFR 393.83)

k. Exhaust System. Exhaust system shall discharge to the atmosphere at a location to the rear of the cab or if the exhaust projects above the cab, at a location near the rear of the cab. Exhaust system shall not be leaking at a point forward of or directly below the driver compartment. No part of the exhaust system shall be located where it will burn, char or damage electrical wiring, fuel system or any other part of the vehicle. No part of the exhaust system shall be temporarily repaired with wrap or patches. (49 CFR 393.83)

l. Brake System (to include hand brakes, parking brakes and Low Air Warning devices). Check to ensure that brakes are operational and properly adjusted. Check for audible air leaks around air brake components and air lines. Check for fluid leaks, cracked or damaged lines in hydraulic brake systems. Ensure that parking brake is operational and properly adjusted. Low Air Warning devices must be operative. (49 CFR 393.40, 41, 42, 43, 44, 45, 47, 48, 49, 50, 51, 52, 53, and 55)

m. Suspension. Inspect for indications of misaligned, shifted or cracked springs, loosened shackles, missing bolts, spring hangers unsecured at frame and cracked or loose U-bolts. Inspect for any unsecured axle positioning parts, and sign of axle misalignment, broken torsion bar springs (if so equipped). (49 CFR 393.207)

n. Coupling Devices (Inspect without uncoupling). Fifth Wheels: Inspect for unsecured mounting to frame or any missing or damaged parts. Inspect for any visible space between upper and lower fifth wheel plates. Ensure that the locking jaws are around the shank and not the head of the kingpin. Ensure that the release lever is seated properly and safety latch is engaged. Pintle Hook, Drawbar, Towbar Eye and Tongue and Safety Devices: Inspect for unsecured mounting, cracks, missing or ineffective fasteners (welded repairs to pintle hook is prohibited). Ensure safety devices (chains, hooks, cables) are in serviceable condition and properly attached. (49 CFR 393.70 and 71)

o. Cargo Space. Inspect to ensure that cargo space is clean and free from exposed bolts, nuts, screws, nails or inwardly projecting parts that could damage the lading. Check floor to ensure it is tight and free from holes. Floor shall not be permeated with oil or other substances. (49 CFR 393.84)

p. Landing Gear. Inspect to ensure that landing gear and assembly are in serviceable condition, correctly assembled, adequately lubricated and properly mounted.

SECTION II (Continued)

q. Tires, Wheels and Rims: Inspect to ensure that tires are properly inflated. Flat or leaking tires are unacceptable. Inspect tires for cuts, bruises, breaks and blisters. Tires with cuts that extend into the cord body are unacceptable. Thread depth shall not be less than: 4/32 inches for tires on a steering axle of a power unit, and 2/32 inches for all other tires. Mixing bias and radial on the steering axle is prohibited. Inspect wheels and rims for cracks, unseated locking rings, broken, loose, damaged or missing lug nuts or elongated stud holes. (49 CFR 393.75)

r. Tailgate/Doors. Inspect to see that all hinges are tight in body. Check for broken latches and safety chains. Doors must close securely. (49 CFR 177.835(h))

s. Tarpaulin. If shipment is made on open equipment, ensure that lading is properly covered with fire and water resistant tarpaulin. (49 CFR 177.835(h))

t. Other Unsatisfactory Condition. Note any other condition which would prohibit the vehicle from being loaded with hazardous materials.

Item 14. For AA&E and other shipments requiring satellite surveillance, ensure that the Satellite Motor Surveillance System is operable. The DTTS Message Display Unit, when operative, will display the signal "DTTS ON". The munitions carrier driver, when practical, will position the DTTS message display unit in a manner that allows the shipping inspector or other designated shipping personnel to observe the "DTTS ON" message without climbing aboard the cab of the motor vehicle.

SECTION III - POST LOADING INSPECTION**General Instructions.**

All placarded quantities items will be checked prior to the release of loaded equipment. Shipment will not be released until deficiencies are corrected. All items will be checked on incoming loaded equipment. Deficiencies will be reported in accordance with applicable service regulations.

Item 18. Check to ensure shipment is loaded in accordance with 49 CFR Part 177.848 and the applicable Segregation or Compatibility Table of 49 CFR 177.848.

Item 19. Check to ensure the load is secured from movement in accordance with applicable service outload drawings.

Item 20. Check to ensure seal(s) have been applied to closed equipment; fire and water resistant tarpaulin applied on open equipment.

Item 21. Check to ensure each transport vehicle has been properly placarded in accordance with 49 CFR 172.504.

Item 22. Check to ensure operator has been provided shipping papers that comply with 49 CFR 172.201 and 202. For shipments transported by Government vehicle, shipping paper will be DD Form 2890.

Item 23. Ensure operator(s) sign DD Form 626, are given a copy and understand the hazards associated with the shipment.

Item 24. Applies to Commercial Shipments Only. If shipment is made under DOT Special Permit 868, ensure that shipping papers are properly annotated and copy of Special Permit 868 is with shipping papers.

Item 26. Ensure driver/operator signs DD Form 626 at origin.

Item 28. Ensure driver/operator signs DD Form 626 at destination.

MANAGEMENT COMMENTS

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



MAR 21 2013

Reply to Attn of: Office of Safety and Mission Assurance

TO: Assistant Inspector General for Audits
FROM: Chief, Safety and Mission Assurance
SUBJECT: Response to OIG Draft Audit Report, "Review of NASA's Explosives Safety Program" (Assignment No. A-12-017-00)

The Office of Safety and Mission Assurance (OSMA) appreciates the opportunity to review and comment on the subject draft report entitled "Review of NASA's Explosives Safety Program" (Assignment No. A-12-017-00).

In the draft report, the Office of Inspector General (OIG) articulates opportunities to improve NASA's Explosive Safety Program and makes seven recommendations to that end. NASA Headquarters OSMA is responsible for energetic materials policy as articulated in NPR 8715.3 "General Safety Program Requirements" and NASA-STD-8719.12 "Safety Standard for Explosives, Propellants, and Pyrotechnics," while the NASA Centers have responsibility for implementation. NASA's responses to the OIG's recommendations, including planned corrective actions, are as follows:

Recommendation 1: Initiate a review of management, storage, and handling procedures of energetic materials at all NASA Centers to identify deficiencies, take corrective actions, and share best practices.

Management's Response: NASA concurs. Chief, Safety and Mission Assurance (SMA), will coordinate with all SMA Directors to work with Explosive Safety Officers (ESOs) to review current management, storage, and handling procedures of energetic materials to identify deficiencies at their Center/Installations and report back to Chief, SMA, within 120 days. SMA Directors will identify short and long term solutions and update procedures as necessary to be used at their respective Centers. Collaboration between the Centers will be utilized to the fullest extent possible.

Recommendation 2: Require that all ESOs inventory energetic materials and initiate investigations of any missing material.

Management's Response: NASA concurs. Chief, SMA, will assign all SMA Directors to work with ESOs to provide a current, verified inventory of energetic materials, and any

missing materials, to include plans on investigation, at their Centers/Installations and report back to the Chief, SMA, within 120 days.

Recommendation 3: Verify that tenant- and contractor-owned energetic materials on NASA property are stored, handled, and inspected in accordance with NASA procedural requirements and applicable safety standards.

Management's Response: NASA partially concurs. Chief, SMA, will coordinate with all Center SMA Directors to review tenant/contractor types of energetic materials, and their processes and procedures, to ensure the safety of personnel for whom NASA has responsibility at their respective Center/Installations. Center SMA Directors are to conduct this task within existing government agreements and legal confines of contracts.

Recommendation 4: Require that an inspection checklist is used and retained for vehicles used to transport energetic materials.

Management's Response: NASA concurs. Within 180 days the Chief, SMA, will coordinate with Center SMA Directors to verify a current and accurate checklist exists for vehicles used to transport energetic materials.

Recommendation 5: Review the responsibilities of Headquarters Explosives Safety Program personnel and assign duties that will provide effective oversight of Center Explosives Safety Programs.

Management's Response: NASA concurs. Chief, SMA, will conduct a review of Headquarters oversight roles and responsibilities relative to the explosives safety policy across NASA within 180 days and modify as needed.

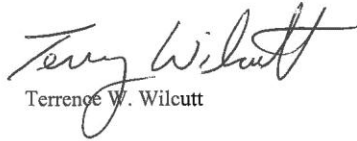
Recommendation 6: Review personnel and fiscal resource allocations for the Agency's explosives safety program and correct deficiencies.

Management's Response: NASA concurs. Chief, SMA, will coordinate with the Center SMA Directors to conduct a review of explosives safety program resources across NASA within 180 days. Upon completion of the review the Chief, SMA, will work with the Centers within the limited budget to address the needs and as appropriate seek additional funding to address requirements. This is an ongoing process.

Recommendation 7: Review training requirements, qualifications, and records of all ESOs and energetic material handlers and correct deficiencies. Specifically, establish criteria for ESO training and ensure that ESOs and energetic material handlers have appropriate experience and up-to-date training to carry out their responsibilities safely.

Management's Response: NASA concurs. Chief, SMA, in coordination with the Center SMA Directors, will review qualifications and records of all ESOs and energetic material handlers and identify any critical shortfalls within 90 days. Chief, SMA, will determine training criteria and identify short and long term solutions within one year.

Again, thank you for the opportunity to review and comment on the subject draft report. If you have any questions or require additional information regarding this response, please contact Kelly Kabiri, OSMA Audit Liaison at (202) 358-0590.



Terrence W. Wilcutt

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To report fraud, waste, abuse, or mismanagement, contact the NASA OIG Hotline at 800-424-9183 or 800-535-8134 (TDD). You may also write to the NASA Inspector General, P.O. Box 23089, L'Enfant Plaza Station, Washington, DC 20026, or use <http://oig.nasa.gov/hotline.html#form>. The identity of each writer and caller can be kept confidential, upon request, to the extent permitted by law.