National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, CA 94035-1000

November 29, 2012

Reply to Attn of: MEMORANDUM FOR THE RECORD

National Environmental Policy Act (NEPA) Compliance for Lunar Atmosphere and Dust Environment Explorer (LADEE)

1.0 Introduction

The National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321, et seq.), requires Federal agencies to consider the environmental impacts of a project in their decision making process. To comply with NEPA and associated regulations (the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA [40 CFR Parts 1500-1508] and NASA policy and procedures [14 CFR Part 12 16 Subpart 12 16.3]), NASA prepared the *Environmental Assessment (EA) for the Routine Payloads on Expendable Launch Vehicles (ELVs)*, November 2011. This EA includes ELVs from Cape Canaveral Air Force Station (CCAFS), Florida; Vandenberg Air Force Base (VAFB), California; Ronald Reagan Ballistic Missile Defense Test Site (RTS) at the U.S. Army Kwajalein Atoll in the Republic of the Marshall Islands; NASA Wallops Flight Facility (WFF), Virginia; and Kodiak Launch Complex (KLC), Alaska. The EA assesses the environmental impacts of missions launched from CCAFS, VAFB, RTS, WFF, and KLC with spacecraft that are considered routine payloads. (Ref: Final Environmental Assessment for Launch of NASA Routine Payloads on Expendable Launch Vehicles, November 2011).

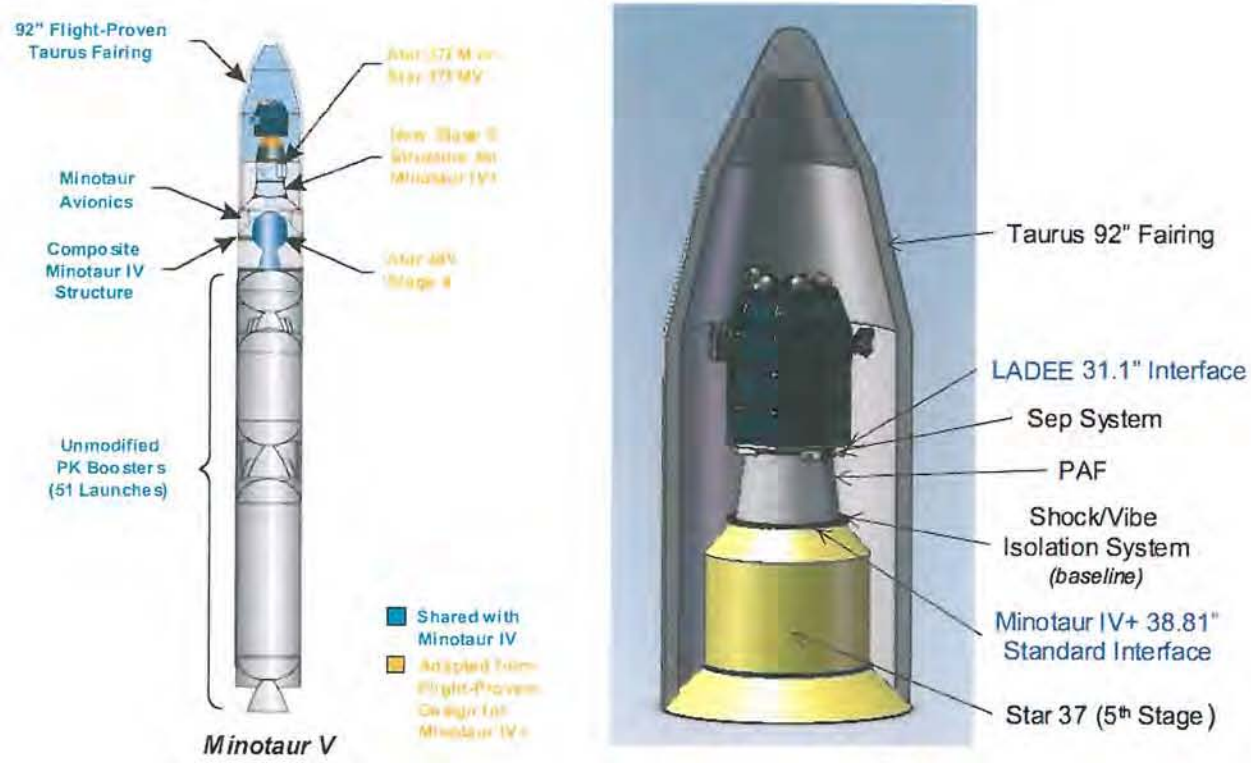
Spacecraft defined as routine payloads utilize materials, quantities of materials, launch vehicles and operational characteristics that are consistent with normal and routine spacecraft preparation and flight activities at VAFB, CCAFS, RTS, WFF, and KLC. The environmental impacts of launching routine payloads from VAFB, CCAFS, RTS, WFF, and KLC fall within the range of routine, ongoing and previously documented impacts that have been determined not to be significant. Spacecraft covered by this EA meet specific criteria ensuring that the spacecraft, its operation and decommissioning, do not present any new or substantial environmental or safety concerns.

To determine the applicability of a routine payload classification for a mission launched from VAFB, CCAFS, RTS, WFF, and KLC and coverage under the NASA routine payload EA, the mission is evaluated against the criteria defined in the EA using the Routine Payload Checklist (RPC).

2.0 Mission Description

The Lunar Quest Program (LQP), located at the Marshall Space Flight Center (MSFC), is a multi-element program consisting of flight missions, instruments for lunar missions of opportunity, and research and analysis efforts. The Lunar Atmosphere and Dust Environment Explorer (LADEE) is a LQP Robotic Lunar Exploration (RLE) mission, planned for launch in Summer or Fall 2013. Its goal is to explore the lunar environment while demonstrating the feasibility of lunar laser communication and use of the Minotaur V space launch vehicle for future NASA missions. The LADEE mission is a cooperative effort between NASA's Ames Research Center (ARC), Moffett Field, CA, and NASA's Goddard Space Flight Center (GSFC), Greenbelt, MD. NASA's MSFC, Huntsville, AL, manages LADEE within the LQP Office.

LADEE is scheduled for launch from WFF on a Minotaur V five-stage rocket consisting of Minotaur IV+ with a Star 37FM or FMV upper stage during a launch window open between July and October 2013.



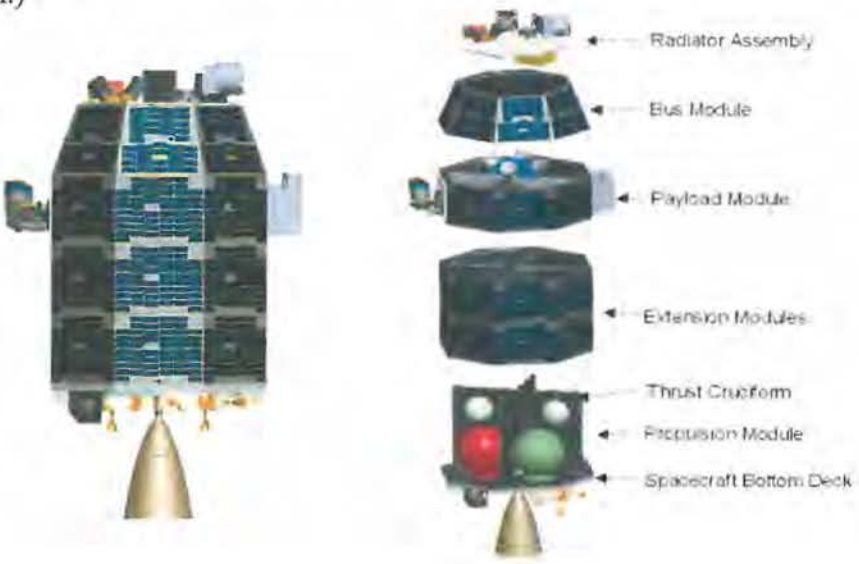
LADEE will gather detailed information about conditions near the surface and environmental influences on lunar dust, which in turn will help researchers predict how future lunar exploration may shape the moon's environment and how the environment may affect future explorers. It will also help scientists understand other planetary bodies with exospheres, or very thin atmospheres, like the moon. The LADEE spacecraft is designed to meet the following primary objectives:

- Determine the composition of the lunar atmosphere and investigate the processes that control its distribution and variability, including sources, sinks, and surface interactions.
- Characterize the lunar exospheric dust environment and measure any spatial and temporal variability and impacts on the lunar atmosphere.
- Demonstrate the Lunar Laser Communication.
- Demonstrate the use of the Minotaur V as launch vehicle for planetary missions.

LADEE will spend about three months reaching nominal lunar orbit and checking out systems before its 100-day science mission starts. The nominal science orbit will be a near-circular 31-mile (50-km) retrograde equatorial orbit with a period of 113 minutes. The periselene will be over the sunrise terminator.

The LADEE mission includes a Laser Communications Technology Demonstration (LLCD) experiment. The LLCD serves as NASA's first space-based laser communication (lasercom) experiment in lunar orbit and is part of the Agency's overall vision to enhance the technological maturity of space-based lasercom. The LLCD system consists of both space and ground systems: the Lunar Laser Communications Demonstration Space Terminal (LLST), Lunar Laser Communications Ground Terminal (LLGT), and Lunar Laser Communication Operations Center (LLOC).

The LLCD will demonstrate the capability of transmitting high rate data to and from Earth at optical wavelengths. The LLCD system will support downlink data rates ranging from approximately 38 Mbps to 622 Mbps, and uplink rates ranging from approximately 10 Mbps to 20 Mbps. The primary objective is to demonstrate duplex optical communication between an earth-based ground terminal and a flight terminal on a spacecraft in lunar orbit. The primary operations phase for LLCD is during the 1-month LADEE Commissioning Phase. The baseline Ground Station (LLGT) is located at the White Sands Complex (WSC). A backup ground station is located at the Jet Propulsion Laboratory (JPL) Optical Communications Telescope Laboratory. Other potential ground stations include Sandia National Labs, Livermore, CA, and Haleakala, Hawaii. (Note: NEPA reviews are currently being done to address modifications needed at the potential sites to accommodate the Demonstration.)

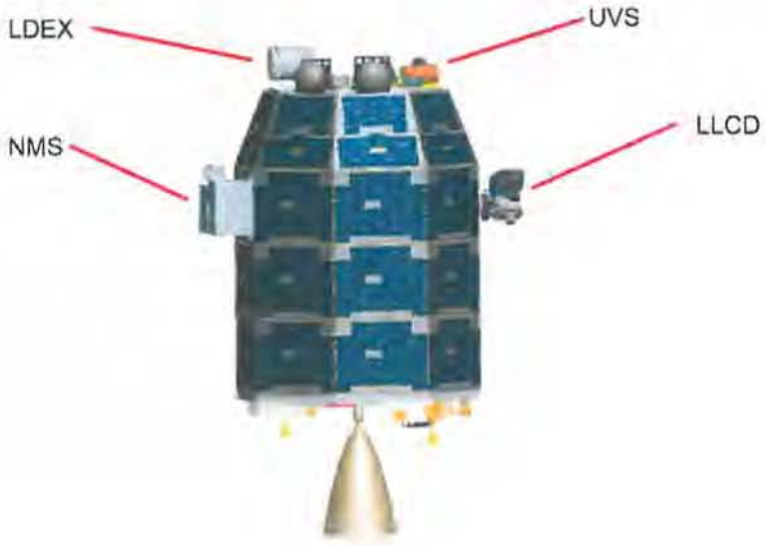


LADEE's spacecraft bus design was derived from the Modular Common Spacecraft Bus (MCSB, a.k.a "Common Bus") architecture developed at NASA ARC. The MCSB is a small, low-cost spacecraft designed to deliver scientifically and technically useful payloads to a variety of locations, including low earth orbit (LEO), lunar orbit and lunar surface, earth-moon lag range points, and near earth objects (NEOs). It consists of a lightweight carbon composite structure designed for ease of manufacturing and assembly. The modular design also allows parallel development, assembly, and test of modules. The spacecraft bus modules consist of: (1) the Radiator Module, which carries the avionics, electrical system, and attitude sensors, (2) the Bus Module, (3) the Payload Module, which carries the two largest instruments, (4) the Extension Modules, which house the propulsion system, and (5) the Propulsion Module.

LADEE will employ three individual instruments to detect and constrain the abundances of chemical elements expected to be prevalent at the 50 kilometer altitude, due to the solar wind and its interactions with the surface, release from regolith, and radiogenic sources.

The three instruments are:

- Neutral Mass Spectrometer (NMS), which is a quadrupole mass spectrometer designed to detect chemical elements up to 150 amu and will monitor the dust composition.
- Ultraviolet/Visible Spectrometer (UV/VS), which will be used for atmosphere studies.
- Lunar Dust Experiment (LDEX), which is a dust detection system that orbits around the moon and is used to detect ions generated in hypervelocity dust impacts and can detect submicron sized dust grains with impact speeds above about 1 km/s.



The flight avionics packages consists of a commercially available 8-slot 3U cPCI integrated avionics system providing the following functions:

- Command & Data Handling Avionics
- Power Distribution
- Solar Array and Battery Charge Management
- Pyrotechnic Actuation

A separate electronics box in the Propulsion Module handles the valve driver actuation. The power system consists of an array of body-fixed solar panels, connected to batteries through the solar array control card within the avionics chassis. The body-fixed array design minimizes articulation on the spacecraft bus. The propulsion system consists of a main thruster, six attitude control thrusters, two fuel tanks, two oxidizer tanks, two pressurant tanks, an ordnance valve driver box, and associated tubing and cabling. The spacecraft bus communications system consists of a modern architecture and modular design. The radio has separate receiver, transmitter and IHPA modules and produces 5 Watts of RF transmitter power with flexible transmission power modes.

The spacecraft uses an evolved Omni-directional/Medium Gain antenna design, developed at NASA ARC, to achieve omni-directional coverage with a smaller area of medium gain response. The avionics, batteries, attitude sensors, and two of the smaller science instruments are integrated into the Radiator Assembly. This arrangement simplifies integration and testing. The two larger instruments (NMS and LLCD) are mounted on the Payload Module on opposite sides to balance the C.G. The reaction wheels, in a pyramid configuration, are also attached to the Payload Module.

The ground system is composed of the ground-based elements dispersed across the NASA centers and facilities. The LADEE Mission will utilize the Mission Operations Center (MOC) located at NASA Ames Research Center (ARC) in Moffett Field, California. The project will use the Science Operations Center (SOC) located at Goddard Space Flight Center (GSFC) in Greenbelt, MD. The primary ground station will be located at the White Sands Complex (WSC) near Las Cruces, New Mexico. The data from the ground station(s) will be routed to the MOC at ARC for processing, distribution and data storage/archiving. Science and instrument data, along with processed spacecraft health and safety data, will be transmitted to the GSFC SOC. The SOC will perform instrument data processing and scientific analysis of instrument data.

3.0 Evaluation of Specific Environmental Considerations

Earth-Pointing Laser

The GSFC Radiation Protection Office evaluated the flight laser (LLST) portion of the LLCD payload in April 2012, and concluded that its operation would be in compliance with American National Standards Institute (ANSI) standards for safe laser operations. Therefore, laser use will not present a hazard to persons, aircraft, or space systems.

Launch Site Biological Monitoring

WFF is required by its U.S. Fish and Wildlife Service-issued Biological Opinion (BO) to monitor the effects of rocket launches on listed species. Should the LADEE launch occur during times of year when nesting birds or sea turtles would be present on the WFF beach (i.e., summer 2013), site staff will conduct pre- and post-launch monitoring and reporting per the terms and conditions of the most recent BO.

4.0 NASA Payload Determination

The components utilized in the LADEE spacecraft are made of materials normally encountered in the space industry. Use of potentially hazardous materials to provide power, propulsion, and communications to the spacecraft, and to operate LADEE's scientific instruments, will not pose substantial risks to human health or safety. LADEE will use an earth pointing laser, as well as a low-level radiation calibration source during the integration, that will meet all requirements for safe operation. LADEE will not carry any pathogenic organisms. Preparation, launch, and operation of the LADEE spacecraft will not deviate from standard practices across NASA.

The LADEE mission has been evaluated against the NASA routine payload EA for launches from WFF (see enclosed Evaluation Recommendation Package). The evaluation indicates that the mission meets the criteria for a routine payload. The mission does not present any unique or unusual circumstances that could result in new or substantial environmental impacts. Based on this review, it is determined that the LADEE mission qualifies as a routine payload and falls within the scope of the reference routine payload EA. No additional NEPA action or documentation is required.

S. Pete Worden
Director

Enclosure

EVALUATION RECOMMENDATION PACKAGE

Record of Environmental Consideration
Routine Payload EA Checklist
Flight Project Environmental Checklist
Laser Radiation Source Questionnaire

Enclosure

RECORD OF ENVIRONMENTAL CONSIDERATION

Project Name: Lunar Atmosphere and Dust Environment Explorer (LADEE)

1. Sponsoring Entity: P

2. Description and location of proposed action:
   Mission to explore lunar environment and demonstrate laser communication technology
3. Anticipated date and/or duration of proposed action:
   Launch August 2013
4. It has been determined that the above action (CHOOSE ONE):

☐ Is exempt from NEPA requirements under the provisions of **(cite superseding law)**:

☒ Is adequately covered in an existing environmental document **(cite document)**:
Final Environmental Assessment for Launch of NASA Routine Payloads on Expendable Launch Vehicles, November 2011

☐ Fits within a class of actions eligible for categorical exclusion (CatEx), as listed in 14 CFR 1216.304d (CHOOSE ONE):

- ☐ Administrative Activities including:
  - i. Personnel actions, organizational changes, and procurement of routine goods and services.
  - ii. Issuance of procedural rules, manuals, directives, and requirements.
  - iii. Program budget proposals, disbursements, and transfer or reprogramming of funds.
  - iv. Preparation of documents, including design and feasibility studies, analytical supply and demand studies, reports and recommendations, master and strategic plans, and other advisory documents.
  - v. Information-gathering exercises, such as inventories, audits, studies, and field studies, including water sampling, cultural resources surveys, biological surveys, geologic surveys, modeling or simulations, and routine data collection and analysis activities.
  - vi. Preparation and dissemination of information, including document mailings, publications, classroom materials, conferences, speaking engagements, Web sites, and other educational/informational activities.
  - vii. Software development, data analysis, and/or testing, including computer modeling.
  - viii. Interpretations, amendments, and modifications to contracts, grants, or other awards.
- ☐ Operations and Management Activities including:
  - i. Routine maintenance, minor construction or rehabilitation, minor demolition, minor modification, minor repair, and continuing or altered operations at, or of, existing NASA or NASA-funded or -approved facilities and equipment, such as buildings, roads, grounds, utilities, communication systems, and ground support systems, such as space tracking and data systems.

ii. Installation or removal of equipment, including component parts, at existing Government or private facilities.
iii. Contribution of equipment, software, technical advice, exchange of data, and consultation to other agencies and public and private entities, where such assistance does not control a receiving entity's program, project, or activity.
iv. NASA ceremonies, commemorative events, and memorial services.
v. Routine packaging, labeling, storage, and transportation of hazardous materials and wastes, in accordance with applicable Federal, federally recognized Indian tribe, State, and/or local law or requirements.

☐ Research and Development (R&D) Activities including:

i. Research, development, and testing in compliance with all applicable Federal, federally recognized Indian tribe, State, and/or local law or requirements and Executive orders.
ii. Use of small quantities of radioactive materials in a laboratory or in the field. Uses include material for instrument detectors, calibration, and other purposes. Materials must be licensed, as required, and properly contained and shielded.
iii. Use of lasers for research and development, scientific instruments and measurements, and distance and ranging, where such use meets all applicable Federal, federally recognized Indian tribe, State, and/or local law or requirements, and Executive orders. This applies to lasers used in spacecraft, aircraft, laboratories, watercraft, or outdoor activities.

☐ Real and Personal Property Activities including:

i. Acquisition, transfer, or disposal of any personal property, or personal property rights or interests.
ii. Granting or acceptance of easements, leases, licenses, rights-of-entry, and permits to use NASA-controlled property, or any other real property, for activities which, if conducted by NASA, would be categorically excluded in accordance with this section. This assumes that NASA has included any required notices in transfer documentation and any terms and conditions necessary to ensure protection of the environment, as applicable (Record of Environmental Consideration [REC] required).
iii. Transfer or disposal of real property or real property rights or interests if the change in use is one which, if conducted by NASA, would be categorically excluded in accordance with this section (REC required).
iv. Transfer of real property administrative control to another Federal agency, including the return of public domain lands to the Department of the Interior (DoI) or other Federal agencies, and reporting of property as excess and surplus to the General Services Administration (GSA) for disposal, when the agency receiving administrative control (or GSA, following receipt of a report of excess) will complete any necessary NEPA review prior to any change in land use (REC required).
v. Acquisition of real property (including facilities) where the land use will not change substantially (REC required).

☐ Aircraft and Airfield Activities including:

i. Periodic aircraft flight activities, including training and research and development, which are routine and comply with applicable Federal, federally recognized Indian tribe, State, and/or local law or requirements, and Executive orders.

ii. Relocation of similar aircraft not resulting in a substantial increase in total flying hours, number of aircraft operations, operational parameters (e.g., noise), or permanent personnel or logistics support requirements at the receiving installation (REC required).

☐ Does not involve special circumstances that preclude the use of a CatEx, such as:

1) A reasonable likelihood of having (individually or cumulatively) significant impacts on public health, safety, or the environment.
2) A potential to impose uncertain or unique environmental risks.
3) A significantly greater scope or size than is normal for this category of action.
4) A reasonable likelihood of violating Federal, federally recognized Indian tribe, State, and/or local law or requirements imposed for the protection of the environment.
5) A reasonable likelihood of having environmentally controversial impacts on the quality of the environment.
6) A potential to adversely affect environmentally sensitive resources, such as, but not limited to, federally listed threatened or endangered species, their designated critical habitat, wilderness areas, floodplains, wetlands, aquifer recharge areas, coastal zones, wild and scenic rivers, and significant fish or wildlife habitat, unless the impact has been resolved through another environmental review process; the Clean Water Act (CWA), the Coastal Zone Management Act (CZMA).
7) A potential to adversely affect known national natural landmarks, or cultural or historic resources, including, but not limited to, property listed on or eligible for the National Register of Historic Places, unless the impact has been resolved through another environmental review process; e.g., the National Historic Preservation Act (NHPA).

☐ Does not involve an action normally requiring an EA, such as:

1) Specific spacecraft development and space flight projects.
2) Actions altering the ongoing operations at a the Center which could lead directly, indirectly, or cumulatively to substantial natural or physical environmental impacts.
3) Construction or modifications of facilities which are not minor.
4) Proposed actions that are expected to result in significant changes to established land use.
5) A space flight project/program that would return extraterrestrial samples to Earth from solar system bodies (such as asteroids, comets, planets, dwarf planets, and planetary moons), which would likely receive an Unrestricted Earth Return categorization from NASA's Planetary Protection Office (PPO) or the NASA Planetary Protection Subcommittee prior to the return of samples to the Earth.

☐ Does not involve an action normally requiring an EIS, such as:

1) Development and operation of new launch vehicles or space transportation systems.
2) Development and operation of a space flight project/program which would launch and operate a nuclear reactor or radioisotope power systems and devices using a total quantity of radioactive material greater than the quantity for which the NASA

Nuclear Flight Safety Assurance Manager may grant nuclear safety launch approval (i.e., a total quantity of radioactive material for which the A2 Mission Multiple is greater than 10).

3) Development and operation of a space flight project/program which would return samples to Earth from solar system bodies (such as asteroids, comets, planets, dwarf planets, and planetary moons), which would likely receive a Restricted Earth Return categorization from the NASA Planetary Protection Office or the NASA Planetary Protection Subcommittee.
4) Substantial modification of a NASA facility's master plan in a manner expected to result in significant effect(s) on the quality of the human environment.
5) Substantial construction projects expected to result in significant effect(s) on the quality of the human environment, when such construction and its effects are not within the scope of an existing master plan and EIS.

☐ Has not been segmented to meet the definition of a CatEx (e.g. the project is not related to other actions with individually or cumulatively significant impacts).
☐ Does not conflict with the U.S. EPA's June 9, 1989 Record of Decision for the Middlefield-Ellis-Whisman area (the "MEW ROD"), or the modified MEW RODs of September 1990 and April 1996.
☐ Does not conflict with U.S. Navy remediation, monitoring wells, or treatment systems (e.g. landfill caps).

5. Follow-up Actions

☐ Asbestos samples
☐ Lead samples
☐ Air Quality Permit
☐ Industrial Waste Water Permit
☐ Hazardous Waste Generation Permit
☐ Hazardous Materials Storage Permit
☐ Well (Excavation) Permit
☐ Storm Water Permit
☐ Stream Alteration Permit
☐ CWA Section 401/404 Permit
☐ Floodplain (E.O 11988) Coordination
☐ Coastal Zone Management Act Coordination
☐ FESA/ESA Consultation
☐ Section 106 Consultation
☐ Noise Monitoring/Assessment
☐ Tribal Government Consultation (EO 13132)
☐ Environmental Health/Safety Effects on Children (EO 13045) Coordination
☐ Environmental Justice (EO 12898) Coordination
☐ International (EO 12114) Coordination
☐ Sustainability (EO 13514) Coordination
☐ Other:

I have reviewed the information contained herein and have verified that it is accurate and complete.

NEPA Program Manager:

Signature:
Donald McCluck

Date:
11/30/2012

NASA Routine Payload Checklist (1 of 2)

PROJECT NAME: Lunar Atmosphere and Dust Environment Explorer (LADEE) DATE OF LAUNCH: August 2013
PROJECT CONTACT: Butler Hine PHONE NUMBER: 4-4449 MAILSTOP: 240-5
PROJECT START DATE: January 2010 PROJECT LOCATION: ARC
PROJECT DESCRIPTION: Lunar environment exploration and laser demonstration

	YES	NO
A. SAMPLE RETURN:		
1. Would the candidate mission return a sample from an extraterrestrial body?	☐	☑
B. RADIOACTIVE MATERIALS:	YES	NO
1. Would the candidate spacecraft carry radioactive materials in quantities that produce an A2 mission multiple value of 10 or more?	☐	☑
Provide a copy of the Radioactive Materials On Board Report as per NPR 8715.3 with the ERP submittal		
C. LAUNCH AND LAUNCH VEHICLES:	YES	NO
1. Would the candidate spacecraft be launched on a vehicle and launch site combination other than those listed in Table C–1 below?	☐	☑
2. Would launch of the proposed mission exceed the approved or permitted annual launch rate for the particular launch vehicle or launch site?	☐	☑
Comments:		
D. FACILITIES:	YES	NO
1. Would the candidate mission require the construction of any new facilities or substantial modification of existing facilities?	☐	☑
Provide a brief description of the construction or modification required, including whether ground disturbance and/or excavation would occur:		
E. HEALTH AND SAFETY:	YES	NO
1. Would the candidate spacecraft utilize batteries, ordnance, hazardous propellant, radiofrequency transmitter power, or other subsystem components in quantities or levels exceeding the EPCs in Table C–2 below?	☐	☑
2. Would the expected risk of human casualty from spacecraft planned orbital reentry exceed the criteria specified by NASA Standard 8719.14?	☐	☑
3. Would the candidate spacecraft utilize any potentially hazardous material as part of a flight system whose type or amount precludes acquisition of the necessary permits prior to its use or is not included within the definition of the Envelope Payload Characteristics?	☐	☑
4. Would the candidate mission, under nominal conditions, release material other than propulsion system exhaust or inert gases into the Earth's atmosphere or space?	☑	☐
5. Are there changes in the preparation, launch or operation of the candidate spacecraft from the standard practices described in Chapter 3 of this EA?	☐	☑
6. Would the candidate spacecraft utilize an Earth-pointing laser system that does not meet the requirements for safe operation (ANSI Z136.1-2007 and ANSI Z136.6-2005)?	☐	☑
7. Would the candidate spacecraft contain, by design (e.g., a scientific payload) pathogenic microorganisms (including bacteria, protozoa, and viruses) which can produce disease or toxins hazardous to human health or the environment beyond Biosafety Level 1 (BSL 1)[1]?	☐	☑
Comments: E-4: A small instrument cover plate will be released in space on the way to the moon. The item will not stay in earth orbit or return to earth. The orbital debris assessment report, prepared for the LADEE mission, will determine the expected trajectory of the released material.		

Continued on next page

[1] The use of biological agents on payloads is limited to materials with a safety rating of "Biosafety Level 1." This classification includes defined and characterized strains of viable microorganisms not known to consistently cause disease in healthy human adults. Personnel working with Biosafety Level 1 agents follow standard microbiological practices including the use of mechanical pipetting devices, no eating drinking, or smoking in the laboratory, and required hand-washing after working with agents or leaving a lab where agents are stored. Personal protective equipment such as gloves and eye protection is also recommended when working with biological agents.

NASA Routine Payload Checklist (2 of 2)

PROJECT NAME: Lunar Atmosphere and Dust Environment Explorer (LADEE) DATE OF LAUNCH: August 2013
PROJECT CONTACT: Butler Hine PHONE NUMBER: 4-4449 MAILSTOP: 240-5
PROJECT START DATE: January 2010 PROJECT LOCATION: ARC
PROJECT DESCRIPTION: Lunar environment exploration and laser demonstration

F. OTHER ENVIRONMENTAL ISSUES:	YES	NO
1. Would the candidate spacecraft have the potential for substantial effects on the environment outside the United States?	☐	☑
2. Would launch and operation of the candidate spacecraft have the potential to create substantial public controversy related to environmental issues?	☐	☑
3. Would any aspect of the candidate spacecraft that is not addressed by the EPCs have the potential for substantial effects on the environment (i.e., previously unused materials, configurations or material not included in the checklist)?	☐	☑
Comments:		

Table C–1. Launch Vehicles and Launch Sites

Launch Vehicle and Launch Vehicle Family	Space Launch Complexes and Pads				
	Eastern Range (CCAFS)	Western Range (VAFB)	USAKA/RTS	WFF	KLC
Athena I, IIc, III[a]	LC-46	CA Spaceport (SLC-8)	N/A	Pad 0	LP-1[a]
Atlas V Family	LC-41	SLC-3	N/A	N/A	N/A
Delta II Family	LC-17	SLC-2	N/A	N/A	N/A
Delta IV Family	LC-37	SLC-6	N/A	N/A	N/A
Falcon 1/1e	LC-36	SLC-4W	Omelek Island	Pad 0	LP-3[b]
Falcon 9	LC-40	SLC-4E	Omelek	Pad 0	LP-3[b]
Minotaur I	LC-20 and/or LC-46	SLC-8	N/A	Pad 0	LP-1
Minotaur II-III	LC-20 and/or LC-46	SLC-8	N/A	Pad 0	LP-1
Minotaur IV	LC-20 and/or LC-46	SLC-8	N/A	Pad 0	LP-1
Minotaur V	LC-20 and/or LC-46	SLC-8	N/A	Pad 0	LP-1
Pegasus XL	CCAFS skidstrip KSC SLF	VAFB Airfield	Kwajalein Island	WFF Airfield	N/A
Taurus	LC-46 and/or LC-20	SLC-576E	N/A	Pad 0	LP-1
Taurus II	NA	NA	N/A	Pad 0	LP-3[b]
Any other launch vehicle/launch site combination for which NASA has completed or cooperated on the NEPA compliance					

a. Athena III and LP-3 are currently under design.

b While not explicitly listed in this table, the Minotaur IV includes all configurations of this launch vehicle, including the Minotaur IV+, which is a Minotaur IV with a Star 48V 4th stage.

Key: CA=California; CCAFS=Cape Canaveral Air Force Station; KSC=Kennedy Space Center; LC=Launch Complex; LP=Launch Pad; MARS=Mid-Atlantic Regional Spaceport; SLC=Space Launch Complex; SLF=Shuttle Landing Facility; USAKA/RTS=United States Army Kwajalein Atoll/Reagan Test Site; VAFB=Vandenberg Air Force Base; WFF=Wallops Flight Facility.

Table C–2. Summary of Envelope Payload Characteristics by Spacecraft Subsystems

Structure	• Unlimited: aluminum, beryllium, carbon resin composites, magnesium, titanium, and other materials unless specified as limited.
Propulsion[a]	• Liquid propellant(s); 3,200 kg (7,055 lb) combined hydrazine, monomethyhydrazine and/or nitrogen tetroxide. • Solid Rocket Motor (SRM) propellant; 3,000 kg (6,614 lb) Ammonium Perchlorate (AP)-based solid propellant (examples of SRM propellant that might be on a spacecraft are a Star-48 kick stage, descent engines, an extra-terrestrial ascent vehicle, etc.)
Communications	• Various 10-100 Watt (RF) transmitters
Power	• Unlimited Solar cells; 5 kilowatt-Hour (kW-hr) Nickel-Hydrogen (NiH_2) or Lithium ion (Li-ion) battery, 300 Ampere-hour (A-hr) Lithium-Thionyl Chloride (LiSOCl), or 150 A-hr Hydrogen, Nickel-Cadmium (NiCd), or Nickel-hydrogen ($Ni-H_2$) battery.
Science Instruments	• 10 kilowatt radar • American National Standards Institute safe lasers (see Section 4.1.2.1)
Other	• U. S. Department of Transportation (DoT) Class 1.4 Electro-Explosive Devices (EEDs) for mechanical systems deployment • Radioactive materials in quantities that produce an A2 mission multiple value of less than 10 • Propulsion system exhaust and inert gas venting • Sample returns are considered outside of the scope of this environmental assessment

a. Propellant limits are subject to range safety requirements.

Key: kg=kilograms; lb=pounds.

NASA Ames Research Center
FLIGHT PROJECT ENVIRONMENTAL CHECKLIST

1. PROJECT/PROGRAM	Date:
Lunar Atmosphere and Dust Environment Explorer (LADEE)	11/30/2011

2. SCHEDULE

PDR/CDR:	Launch Date:
PDR 7/23/2010; CDR 5/20/2011	May 2013 (target)

3. CURRENT STATUS

LADEE is towards the end of Phase C Development. Some flight hardware components have been received, but some are still expected. Spacecraft integration activities are expected to begin in January 2013.

4. PROJECT DESCRIPTION

a. Purpose:

The LADEE Mission will seek new information about the tenuous lunar atmosphere and dust environment before that environment is altered by extended human activity on the Moon. LADEE will determine the composition of the lunar atmosphere and investigate the processes that control its distribution and variability, including sources, sinks, and surface interactions.

b. Spacecraft:

The LADEE spacecraft bus is a small modular bus design intended for a variety of Lunar and other near-Earth missions beyond LEO.

c. Instruments Including Secondary Payload:

LADEE will carry a science instrument payload including a neutral mass spectrometer, ultraviolet spectrometer, and dust sensor. In addition to the science payloads, LADEE will fly a laser communications system technology demonstration experiment.

d. Launch Vehicle:

Minotaur V

e. Launch Site:

NASA Wallops Flight Facility (WFF)
Wallops Island, VA

f. NASAs Involvement/Responsibility:

LADEE is a NASA In-House Mission, meaning that the project is managed by NASA and the spacecraft is developed and integrated by NASA staff using flight hardware components procured through vendor contracts.

g. Participants/Locations:

NASA ARC - Project Management, Spacecraft Development
NASA GSFC - Payload Management
NASA WFF - Launch Vehicle Management, Range

h. End-of-Mission Plan: Planned Re-entry (controlled/uncontrolled?)

The LADEE science orbit is low retrograde equatorial (50Km altitude). When the primary science mission is completed and remaining fuel exhausted, the orbit will quickly decay and impact the Lunar surface. The location and time of impact can be roughly controlled.

5. Is there anything controversial or unique about the mission, spacecraft or instruments? If yes, Explain. Yes ☐ No ☑

6. Is the mission compliant with NASA requirements for limiting orbital debris (NPR 8715.6, and NASA Standard 8719.14? Explain non-compliances. Yes ☑ No ☐

A small instrument cover plate will be released in space on the way to the moon. The item will not stay in earth orbit or return to earth. The orbital debris assessment report, prepared for the LADEE mission, will determine the expected trajectory of the released material.

7. During any phase, does the mission/project include or involve: Check yes for all that apply. If uncertain, check the corresponding box. For all that apply, provide an explanation. Use the additional space below if needed.	Yes	No	Uncertain
A. Fuels	☑	☐	☐
B. Ionizing Radiation Devices/Sources	☑	☐	☐
C. Explosives	☑	☐	☐
D. Hazardous Materials/Substances/Chemicals	☑	☐	☐
E. Lasers (Class, Earth Pointing)	☑	☐	☐
F. Disease Producing Pathogenic Microorganisms/Biological Agents	☐	☑	☐
G. Discharges/Venting of any Substances into Air, Water, or Soil	☐	☑	☐
H. Hazardous Waste Generation	☐	☑	☐
I. High Noise Levels	☑	☐	☐
J. Sample Return to Earth	☐	☑	☐
K. Radio Frequency Communications	☑	☐	☐
L. Construction/Modification/Demolition of a Facility/Lab (onsite - offsite)	☑	☐	☐
M. Land Disturbance, Tree Clearing, Removal of Vegetation	☐	☑	☐
N. Impact on Threatened or Endangered Species	☐	☑	☐
O. Impact/Destruction of Sensitive Wildlife Habitat	☐	☑	☐
P. Impact on/near Areas of Cultural Significance	☐	☑	☐
Q. Impact on Local Social or Economic Conditions (Increase in Traffic, Employment, etc.)	☐	☑	☐
R. Impact on Minority or Low Income Populations	☐	☑	☐
S. New or Foreign Launch Vehicle	☑	☐	☐
T. Other Issues of Potential Environmental Impact	☐	☑	☐
U. Environmental Permits	☐	☑	☐

Additional Information

A-E and K. Use of potentially hazardous materials to provide power, propulsion, and communications to the spacecraft, and to operate LADEE's scientific instruments, will not pose substantial risks to human health or safety. Operation of the LLST portion of the LLCD payload will be in compliance with American National Standards Institute (ANSI) standards for safe laser operations.
I. Personnel that are exposed to excessive noise (above 85 decibels) must use hearing protection.
L. There will be minor modifications to launch pad D-1: Pad 0B to accommodate the LADEE launch. Additionally, modifications will be required to accommodate the LLCD at the baseline ground station at WSC, backup ground station at JPL, and potential ground stations at Sandia National Labs, Livermore, CA, and Haleakala, Hawaii. NEPA reviews are currently being done to address these modifications.

8. What Safety hazards are associated with the mission?

Normal industrial safety hazards
Hazards associated with launch vehicles
Hazards associated with bi-prop propulsion systems

9. Summary of Subsystem Components

Propulsion (Include fuel type, amount, tank size, materials, dimensions	Bi-Prop Spacecraft Propulsion System, MMH Hydrazine Fuel, MON-3 Oxidizer. 134 Kg of propellants stored in 4 spherical Ti tanks 31 Liters each, 39 cm in diameter.
Communications	S-band radio frequency communications system Transmitter Power 7 Watts at 2248.5 Mhz
Structural Materials	Honeycomb Composite with Aluminum and Titanium fittings
Power	115W spacecraft power provided by body-mounted solar arrays
Science Instruments	Neutral Mass Spectrometer (NMS),Ultraviolet Spectrometer (UVS), and dust sensor (LDEX). In addition, a Laser Communications Experiment (LLCD).
Hazardous Components (radioactive materials, lasers, chemicals, etc.)	Laser Communications Experiment
Other (include dimensions and weight of s/c)	Spacecraft maximum mass is 383Kg fueled.

NASA Ames Research Center

FLIGHT PROJECT ENVIRONMENTAL CHECKLIST

Project Manager Printed Name:	Project Manager Signature:		
Butler Hine	Butler Hine 11/30/12		
Project Name:	**Date:**	**Phone Number:**	**Org. Code:**
Lunar Atmosphere and Dust Environment Explorer (LADEE)	11/30/2011	650-604-4449	Code PK

Comments:

SUPPLEMENT TO THE FLIGHT PROJECT ENVIRONMENTAL CHECKLIST

Following are the full responses to items 4a, 4g, and 7 (Additional Information), which are only partially visible on the checklist due to space limitations.

4. Project Description

a. Purpose

The LADEE Mission will seek new information about the tenuous lunar atmosphere and dust environment before that environment is altered by extended human activity on the Moon. LADEE will determine the composition of the lunar atmosphere and investigate the processes that control its distribution and variability, including sources, sinks, and surface interactions.

g. Participants/Locations:

NASA ARC - Project Management, Spacecraft Development

NASA GSFC - Payload Management

NASA WFF - Launch Vehicle Management, Range

7. During any phase, does the mission/project include or involve: Check yes for all that apply. If uncertain, check the corresponding box. For all that apply, provide an explanation. Use the additional space below if needed.

Additional Information

A-E and K. Use of potentially hazardous materials to provide power, propulsion, and communications to the spacecraft, and to operate LADEE's scientific instruments, will not pose substantial risks to human health or safety. Operation of the LLST portion of the LLCD payload will be in compliance with American National Standards Institute (ANSI) standards for safe laser operations.

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L. There will be minor modifications to launch pad D-1: Pad 0B to accommodate the LADEE launch. Additionally, modifications will be required to accommodate the LLCD at the baseline ground station at WSC, backup ground station at JPL, and potential ground stations at Sandia National Labs, Livermore, CA, and Haleakala, Hawaii. NEPA reviews are currently being done to address these modifications.

S. The Minotaur V is a new launch configuration, but is considered in family with the Minotaur IV launch vehicles.

GODDARD SPACE FLIGHT CENTER
REQUEST FOR RADIATION SAFETY COMMITTEE ACTION –
LASER RADIATION SOURCE QUESTIONNAIRE

1. Lafon, Robert, E.	554	781-981-0574	6/1/2011	**Docket #**
Originator's Name: Last, First, MI	Code	Phone	Date	**12-069** (RPO Use Only)

2. Laser Device Description:

a. Application: Lunar Laser Communication Demonstration space terminal

b. Manufacturer Lincoln Lab

Address: 244 wood street, Lexington Ma, 02421

c. Model Number: Custom built for GSFC d. Laser Medium: Diode-pumped erbium fiber

e. Continuous Wave ☐ Single Pulsed ☐ Multiple Pulsed ☒ *(Check one*)*

f. Interlocks: None ☐ Fallible ☒ Fail-Safe ☐ *(Check one*)*

g. Wavelength (nm) 1550.12 For each wavelength complete a GSFC Form 23-28L

h. Beam Shape: Circular ☒ Elliptical ☐ Rectangular ☐ *(Check one*)*

Other: Beam Diameter (mm) 100mm ($1/e^2$) Beam Divergence (mrad): .015

Diameter at Waist (mm) 100mm Aperture to Waist Distance (cm) 0

Major Axis Dimension (mm) ____ Major Divergence (mrad)

Minor Axis Dimension (mm) ____ Minor Divergence (mrad) ____

i. Pulse Width (sec) 0.2 - 3.2 ns j. PRF (Hz) 19.44MHz-311MHz k. Energy (Joules)

l. Gaussian Criteria: e-2 ☒ m. Avg Power (Watts) <=1W

n. Single mode fiber diameter 8 micron o. Multi mode fiber numerical aperture (NA) ____

** to check a box, click on the box*

Add any special notes here. If the fiber is left uncoupled or if the fiber breaks the NOHD would be ~ 1.5 inches.

RADIATION PROTECTION OFFICE (RPO) USE ONLY

3. Date Received 4/13/12 4. GSFC ECN# ____ 5. ANSI Class 1

6. Serial Number Custom built by MITLL 7. Carcinogenic Dye Used? Yes ☐ No ☒

8. Special Ventilation Requirements? Yes ☐ No ☒

9. Industrial Hygiene Office Notified? Yes ☐ No ☒

RPO Certification Ted Simmons (Printed Name) 4/13/2012 (Date)

(Signature)

Notes: See the attached information regarding this fiber coupled laser and potential hazards for I&T as well as free space radiation. There are no restrictions on the use of this laser.

The space terminal laser is a semiconductor laser followed by an erbium-doped fiber amplifier capable of producing ~1 W of power at 1550.12nm; this power is transported in fiber to the fully enclosed optical head, which will be mounted to the exterior of the LADEE spacecraft. The optical head takes the light from the fiber and turns it into a collimated beam that is transmitted in a collimated 10cm diameter beam out the space terminal's solar window. Prior to launch this solar window will be enclosed by a protective cover. At no time during spacecraft integration will the beam leave the space terminal to propagate free space. This wavelength does NOT present a retinal hazard.

The American National Standard for the Safe Use of Lasers, ANSI Z136.1-2007 establishes the criteria for determining the MPE for a laser system. In the wavelength range 1.5 to 1.8 μm, the MPE is the same for ocular and skin exposure:

Exposure duration from 1 nsec to 10 sec: MPE = 1 J/cm^2
Exposure duration from 10 sec to 3x10^4 sec: MPE = 0.1 W/cm^2.

At the solar window the maximum power density for the 1W, 10cm diameter beam will be ~0.022W/cm^2, well below the MPE for long term exposure. In the **extremely** unlikely event that the solar window should be uncovered and the laser run at maximum power, the resulting beam would not pose a hazard at ANY distance.

A 'worst case' exposure scenario would be the breaking of the fiber that carries the laser power to the optical head. Such a failure is **highly unlikely**. In such a case the unterminated fiber end would have to be directed into the eye from a distance closer than 26cm in order to be over the MPE for *long term* (10-30,000 seconds) exposure. In short, it is difficult to imagine a scenario where personnel could be unintentionally exposed to greater than the MPE while working with the space terminal.

During some tests a small portion (%2) of the Space Terminal laser light hitting the protective cover is coupled into a fiber- the power in this fiber will be at most 20 mW. The fiber transports the light to the various detectors in the test set to verify the laser is operating as designed. In the unlikely event that this fiber was to break, the hazard distance from the fiber end would be ~3.8cm or ~1.5 inches.

Laser Report
AFRL 711HPW/RHDO 2.5.3.64
LHAZ Plugin 5.2.3.2
LTMC Version 3.2.2.7 / Adapter 3.1.0.19
Friday, April 13, 2012

Laser Name: **#12-069 LLST**

Laser Parameters:

Wavelength:	1550.1 nm
Output Mode:	MultiPulse
Average Power (Pulsed):	1 W
Energy Per Pulse:	0.0032154 uJ
Pulse Duration:	0.2 ns
PRF:	311 MHz
Beam Profile:	Circular
Beam Distribution:	Gaussian
Beam Divergence:	0.015 mrad
Beam Waist Diameter:	70.9 mm
Beam Waist Range:	0

MPE Computations:

Exposure Duration:	10 s
Exposure Range:	10 cm
MPE (Eye):	3.215e-010 J/cm²
Limiting Aperture (Eye):	0.35 cm
Class 1 AEL (Eye):	3.094e-011 J
Limiting Aperture (Skin):	0.35 cm
MPE (Skin):	3.215e-010 J/cm²

Classification: Class 1

Description:
Lunar Laser Communication Demonstration space terminal

Hazard Distances and OD Requirements:

Ocular (10 cm, Unaided Viewing, Existing OD = 0)

Exposure Duration:	10 s
NOHD:	0 m
At Viewing Distance:	10 cm
Maximum OD:	2.1
At Range OD:	0.0

Skin (10 cm, Existing OD = 0)

Exposure Duration:	10 s
NSHD:	0 m

At Exposure Distance:	10 cm
Maximum OD:	2.1
At Range OD:	0.0

Diffuse Reflection Hazard Analysis:

Laser to Target Range:	1 m
Target Reflectance:	100.00 %
Viewing Angle: 0 deg	

Ocular Hazards	
Exposure Duration:	10 s
NHZ:	0.0 m
At Viewing Distance:	1 m
OD Required:	0.0
Skin	
Exposure Duration:	10 s
NHZ (Skin):	0.0 m
At Exposure Distance:	1 m
OD Required:	0.0

Viewing Conditions:

Atm. Attenuation Coeff:	0 cm-1 (1/cm)
Aided Viewing Used:	False
Optics Transmittance:	N/A
Optics Objective Diam:	N/A
Optics Exit Diam:	N/A

Laser Report
AFRL 711HPW/RHDO 2.5.3.64
LHAZ Plugin 5.2.3.2
LTMC Version 3.2.2.7 / Adapter 3.1.0.19
Monday, April 16, 2012

Laser Name: **#12-069 LLST**

Laser Parameters:

Wavelength:	1550.1 nm
Output Mode:	MultiPulse
Average Power (Pulsed):	1 W
Energy Per Pulse:	3.2154e-09 J
Pulse Duration:	0.2 ns
PRF:	311 MHz
Beam Profile:	Circular
Beam Distribution:	Gaussian
Beam Divergence:	0.015 mrad
Beam Waist Diameter:	70.9 mm
Beam Waist Range:	0

MPE Computations:

Exposure Duration:	10 s
Exposure Range:	200 cm
MPE (Eye):	3.215e-010 J/cm²
Limiting Aperture (Eye):	0.35 cm
Class 1 AEL (Eye):	3.094e-011 J
Limiting Aperture (Skin):	0.35 cm
MPE (Skin):	3.215e-010 J/cm²

Classification: Class 1

Description:
Lunar Laser Communication Demonstration - aided viewing

Hazard Distances and OD Requirements:

Ocular (200 cm, Aided Viewing, Existing OD = 0)

Exposure Duration:	10 s
NOHD:	37159 ft
At Viewing Distance:	200 cm
Maximum OD:	1.9
At Range OD:	1.0

Skin (10 cm, Existing OD = 0)

Exposure Duration:	10 s
NSHD:	0 ft

At Exposure Distance:	10 cm
Maximum OD:	2.1
At Range OD:	0.0

Diffuse Reflection Hazard Analysis:

Laser to Target Range:	1 m
Target Reflectance:	100.00 %
Viewing Angle: 0 deg	

Ocular Hazards

Exposure Duration:	10 s
NHZ:	0.0 m
At Viewing Distance:	1 m
OD Required:	0.0

Skin

Exposure Duration:	10 s
NHZ (Skin):	0.0 m
At Exposure Distance:	1 m
OD Required:	0.0

Viewing Conditions:

Atm. Attenuation Coeff:	2.5077e-07 cm-1 (1/cm)
Aided Viewing Used:	True
Optics Transmittance:	70.00 %
Optics Objective Diam:	50 mm
Optics Exit Diam:	7 mm