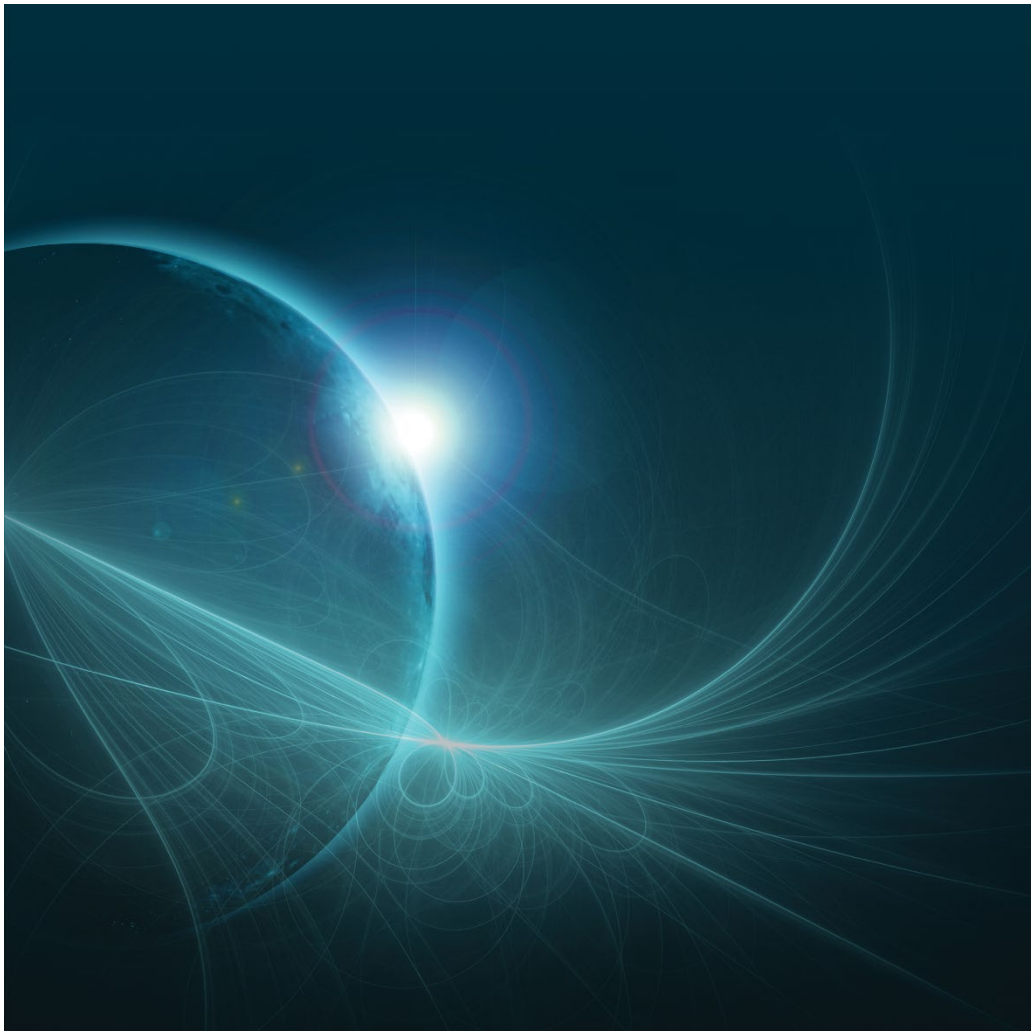
National Aeronautics and Space Administration



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SECTION 1

Introduction

The National Environmental Policy Act (NEPA) requires all federal agencies, including the National Aeronautics and Space Administration (NASA), to consider the environmental impacts of their proposed actions and any reasonable alternatives to those actions. The purpose of this handbook is to provide an overview of NASA's NEPA requirements for nuclear-enabled missions and suggest measures to maximize administrative efficiency in ensuring appropriate NEPA compliance.

This handbook will guide NASA NEPA professionals, launch approval engineers, and mission program managers as they navigate the relatively complex requirement of analyzing NASA's proposed use of nuclear materials during the NEPA process. This handbook is also intended to ensure these individuals make informed and consistent decisions, while appropriately coordinating with one another.

The guidance in this handbook was developed through extensive review of *Code of Federal Regulations* (CFR), Title 40, Part 1500 (Council on Environmental Quality [CEQ] NEPA implementing regulations); 14 CFR Part 1216 (NASA Procedures for Implementing NEPA); NASA Procedural Requirement (NPR) 8580.1A (NASA NEPA Requirements); existing U.S. Department of Energy (DOE) and prior mission NASA nuclear NEPA documents (Appendix A); existing regulations for the use of nuclear materials in space programs (Appendix B); and documents by individuals with special expertise (Gallagher and Outlaw, 2017; Norwood et al., 2018; and NASA/TM-2019-220256).

1.1 NASA Use of Nuclear Materials

NASA uses nuclear material in two primary ways: laboratory research and development, and space nuclear systems that are launched. The amount and types of nuclear material used to implement activities in each area varies.

1.1.1 Facility and Laboratory Use

Nuclear research and development activities include the experimental production and testing of models, devices, equipment, materials, and processes. These activities use mostly small quantities of nuclear material, although specific programs may use larger quantities. An overview of laboratory use of nuclear materials is provided in Section 2, *Facility and Laboratory Use of Nuclear Material*.

1.1.2 Space Nuclear Systems

The main types of space nuclear systems used by NASA are radioisotope systems and fission systems. Radioisotope systems currently consist of radioisotope thermoelectric generators (RTGs), radioisotope heater units (RHUs), and dynamic power systems. Radioisotope systems are managed by the Science Mission Directorate (SMD) Radioisotope Power System (RPS) Program. Fission systems consist of propulsion and power and are currently in early design. Fission systems are managed by the Space Technology Mission Directorate (STMD). A more detailed overview of space nuclear systems is provided in Section 3, *Space Nuclear Systems*.

1.2 NASA Nuclear NEPA Requirements

NEPA requires federal agencies to integrate environmental values into their planning and decision-making processes, analyze the environmental impacts of major actions and reasonable alternatives, and present those impacts to the public before the action is undertaken. This analysis is documented in a categorical exclusion (CatEx), an environmental assessment (EA), or an environmental impact statement (EIS).

As a federal agency, NASA is subject to NEPA for major actions and activities; therefore, a decision to undertake a nuclear-enabled mission should be made only after evaluating the full range of potential environmental impacts associated with the mission and other reasonable alternatives such as solar or battery. It is important that the level of environmental analysis is proportionate to the potential environmental impact (that is, preparation of an EA/Finding of No Significant Impact [FONSI] versus preparation of an EIS). The agency must analyze the potential direct, indirect, and cumulative impacts of the proposed action on affected environmental resource areas, and, when appropriate, use scoping to identify the range of actions, alternatives, and impacts that the public believes should be included in the environmental impact analysis.

This handbook will assist NASA in preparing legally sufficient NEPA documents for nuclear-enabled missions that are proportionate to the expected environmental impact of the proposed action and that conform to applicable regulatory requirements.

SECTION 2

Facility and Laboratory Use of Nuclear Material

Nuclear materials are used at NASA Centers to support laboratory research and development activities, including the experimental production and testing of models, devices, equipment, materials, and processes. In addition, nuclear material is used in the laboratory for instrument detectors and equipment calibration. Laboratories at NASA Centers also support the development of radiation sources and radiation testing.

The use of nuclear materials by NASA Centers is managed through licenses issued by the U.S. Nuclear Regulatory Commission (NRC). These licenses allow NASA facilities to use, receive, acquire, possess, and transfer byproduct, source, and special nuclear materials. Certain facilities, such as NASA's federally funded research and development center (FFRDC), the Jet Propulsion Laboratory (JPL), operate under NRC agreement state-issued licenses. NRC licenses may be specific to each material or cover a broad scope of source materials, such as materials containing either thorium or uranium. Source material facility licenses can be renewed for up to a 10-year period; consequently, licenses are continually updated and obtained across NASA Centers. In addition to an NRC facility license, a contractor may have an individual state-issued nuclear license for the use and handling of nuclear material. In this scenario, NASA remains an owner of the nuclear materials and should also have an NRC license for the facility.

Nuclear materials used at NASA Centers typically include general byproduct material between atomic numbers 3 and 83, Iron-55, Cobalt-60, Selenium-75, Krypton-85, Strontium-90, Cadmium-109, Barium-133, Cesium-137, Promethium-145, Europium-152, Gadolinium-153, Uranium-234, Uranium-235, Uranium-238, Plutonium-238 (Pu-238), Plutonium-239, Americium-241, and Curium-244. This is not a comprehensive list.

2.1 NASA Center Use of Nuclear Material

NRC licenses for NASA Centers are generally a "Type A specific license of broad scope." This type of license sets a limit on the quantity of the material and is considered an "all materials" license. The NRC defines a Type A specific license of broad scope as "*a specific license authorizing receipt, acquisition, ownership, possession, use, and transfer of any chemical or physical form of the byproduct material specified in the license, but not exceeding quantities specified in the license, for purposes authorized by the Act*." (10 CFR Section 33.11)

The broad scope of the license provides NASA Centers with management and operational flexibility regarding the use of nuclear materials. The NRC license requires establishment of a Radiation Safety Committee at each Center that possesses nuclear materials. This Committee rigorously reviews all aspects of the Center's nuclear activities and provides an annual report to the NRC. The Center's Radiation Safety Officer (RSO) is responsible for managing the NRC license and ensuring it covers all aspects of use, quantity, or types of material that apply to the Center's nuclear activities.

2.2 NASA Centers with NRC Licenses

The following is a list (as of March 2022) of Centers with an NRC license(s):

- Ames Research Center: Broad Scope (Type A) material license
- Glenn Research Center (GRC): Broad Scope (Type A) material license
- Goddard Space Flight Center: Two material licenses, including a Broad Scope (Type A) and Irradiator
- Johnson Space Center: Broad Scope (Type A) material license
- Kennedy Space Center (KSC): Broad Scope (Type A) material license
- Langley Research Center: Material license (limited)
- Marshall Space Flight Center: Material license (limited)
- JPL: Operates under the California Institute of Technology's (Caltech's) State of California Material License. California is an NRC agreement state.

NRC licenses are subject to amendment over time; contact the Center RSO to obtain the most up-to-date NRC license information for a specific Center.

SECTION 3

Space Nuclear Systems

The following section provides an introduction to space nuclear systems and considerations relevant to the NEPA practitioner who may not work regularly with these systems. The descriptions provided here represent the current families of systems; however, space nuclear systems continually evolve as the technology matures. This is not meant to be an all-encompassing list of systems; this handbook is meant to be applied to any NASA space nuclear system. Individuals responsible for NEPA compliance should work with the experts detailed in Section 4, *Roles and Responsibilities*, as appropriate to better understand they system may be working with.

When missions have power or thermal control requirements that exceed those available from solar or battery sources, nuclear (i.e., radioisotope or fission) systems are often used. Nuclear systems are especially beneficial in space because of their lower weight-to-energy output ratio compared to solar and battery sources and because they can function independently of sunlight (NASA, 2019). Nuclear systems enable various types of potential missions, such as flybys, orbiters, landers, rovers, boats, submersibles, and balloons. Previous classes of missions that used nuclear systems include the following:

- 21 planetary flybys, including all planets except Mercury
- Examination of numerous planetary moons
- Five deploying surface science missions (Apollo) to Earth's moon
- Mars landers and rovers
- Polar and elliptical observations of the Sun
- Five missions beyond the edge of our solar system

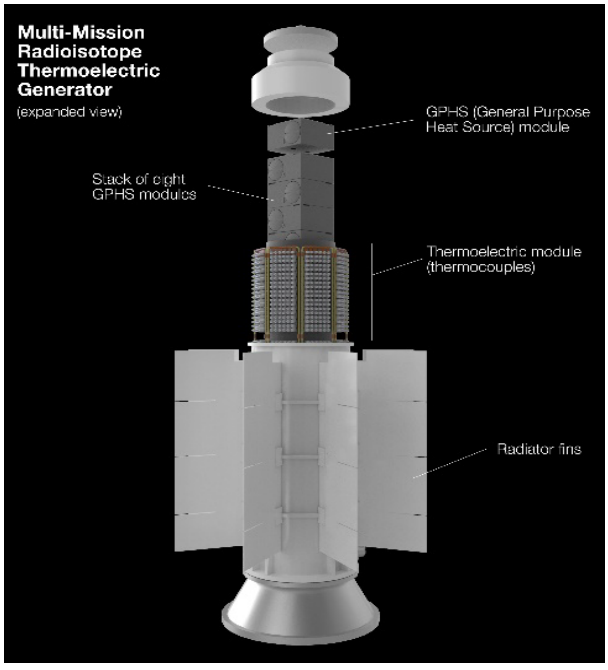
NASA nuclear systems can generally be broken into two primary categories based on the type of nuclear material used: (1) radioisotope-based systems, such as RTGs and RHUs, and (2) fission-based space nuclear power and propulsion systems. The following sections provide an overview of these systems.

3.1 Radioisotope-based Systems

Deep space and lengthy missions on lunar and planetary surfaces often used radioisotope technology for either heat or power. Nuclear systems are advantageous for these missions due to the functional limitations of solar power and the limited life constraints of batteries. Radioisotope-based systems emit energy from the nuclei of unstable atoms to produce heat. The heat is used to produce electricity for power or to warm spacecraft systems and instruments. The multiple layers of protection incorporated into the design of these systems provide significant resistance to radionuclide dispersion during accident scenarios, including launch pad or ascent explosions. The following sections outline the sub-categories of radioisotope-based systems that NASA currently utilizes.

FIGURE 3-1

Multi-mission Radioisotope Thermoelectric Generator



3.1.1 Radioisotope Thermoelectric Generator Power Systems

RTGs, a specific type of RPS, provide electrical power for spacecraft by converting the heat generated by the natural decay of Pu-238 nuclei into electricity using devices called thermoelectric couples. RTGs provide a long-lived solution, compatible with the half-life of the radioisotope. RTGs are a highly reliable power option and can be used in multiple environments during space or planetary exploration missions. The heat energy from an RTG provides a reliable and steady-state source of warmth and electrical power to maintain

proper operating conditions for a spacecraft and its instruments in cold and low solar energy environments. The current RTG model is the multi-mission radioisotope thermoelectric generator (MMRTG) (Figure 3-1).

3.1.2 Dynamic Radioisotope Power Systems

Dynamic power systems are a class of RPS that employs thermal-to-electrical conversion. NASA is working to develop dynamic radioisotope power systems (DRPSs) that use moving parts to generate a power current to enable space missions. The advantage of pursuing a DRPS is the thermal energy conversion efficiency, which is on the order of 3 to 4 times greater than the current state-of-the-art RTG. This increase in efficiency provides more fuel-efficient use of the Pu-238 radioisotope heat source material, which means a mission could potentially have more power with less Pu-238. These options make DRPS a candidate for certain human exploration missions and a viable option for specialized science missions (NASA, 2018).

3.1.3 Radioisotope Heater Units

RHUs are small devices that use the natural decay of Pu-238, to provide thermal energy. They are typically used to heat electronics and propellant system components and therefore, are generally placed close to the equipment needing heat. The current generation of RHUs are referred to as light-weight radioisotope heater units (LWRHUs) (Figure 3-2) and have provided localized heat to deep space missions since the 1980s. A LWRHU contains a fuel pellet, which consists of 2.7 grams of Pu-238. The entire LWRHU is approximately the size of a C-cell battery and outputs about 1 watt of heat. RHU requirements for previous NASA missions ranged from 2 to 120 RHUs.

FIGURE 3-2
Light-weight Radioisotope Heater Unit

3.2 Nuclear Fission

In addition to RPS power technologies, NASA is developing nuclear fission reactors for surface power and deep space propulsion missions. Fission reactors generally include a uranium bearing fuel form incorporated into a reactor, a control system, and a heat rejection system. The only space reactor flown in U.S. history was the SNAP-10A launched in 1965, before NEPA was established. Numerous other fission reactor development programs have progressed since 1965; however, none have resulted in a launch. NASA is currently investigating the development of several new generation fission reactors.

Electric power generation from fission for surface deployment will range from as low as 10 kilowatt-electric (kW_E) systems for small operations, to more than 100 kW_E in support for sustained human presence. Electric power generation systems are also possible for thermal Nuclear Electric Propulsion (NEP) systems; however, this technology will need to provide 3 megawatt-electric (MW_T) to as much as 6 MW_T of thermal power from the fission reactor. Space rated electric power generator systems require the integration of several engineering subsystems, including dynamic power conversion engines that use a working thermal fluid. Space fission power systems typically use heat pipes, pumped gas, or pumped liquid metal to transfer heat from the core to a power conversion subsystem. Fission reactors used to power Nuclear Thermal Propulsion (NTP) systems are relatively simple systems that operate at extreme temperatures ranging as high as 2800 to 2900 C. The NTP propulsion system typically uses hydrogen propellant which passes through and is directly heated by the reactor core to produce thrust.

A nuclear fission reactor does not present a radiological hazard unless it achieves sustained criticality at a significant power level. This is an important difference compared to RPS. A RPS operates on the natural atomic decay of a radioisotope (Pu-238), and the system design needs to ensure containment of the radioisotope core. The envisioned procedure to launching fission nuclear reactors will preclude sustained criticality during assembly and testing, and the reactor will be held in a subcritical state during the payload handling, shipment, integration, and launch stages. Significant power, radiation-producing power operation will not occur until the fission system has achieved a safe orbit. Launch approval requirements set forth in *National Security Presidential Memorandum No. 20* (NSPM-20), Section 3 guide the design all space fission systems. Fission reactor designs will preclude criticality from any likely launch or reentry condition, and procedural requirements will launch of a subcritical reactor with cold uranium fuel.

3.2.1 Fission Surface Power

As NASA begins to establish a presence on the Moon with a look forward to Mars and other locations in the solar system, a reliable and expandable power source will be needed that can provide power during the lunar night, within permanently shadowed regions on the Moon, and during the long dust storms of Mars. The Fission Surface Power (FSP) Project is a near-term technology effort to develop fission nuclear power systems to enable long-duration stays on extra-terrestrial surfaces. The three main subsystems critical to the successful FSP system design and operation are the fission reactor for generating thermal energy, the power conversion system for generating electricity, and lightweight heat rejection radiators. NASA intends to advance the subsystem designs of the reactor, power conversion system, and thermal radiators into an integrated 10-kWE class FSP system and operate that system on the surface of the Moon as part of a capability demonstration mission. The current preliminary reactor designs under study uses low enriched uranium as its fuel source. The lunar surface mission will serve as a pathfinder for additional lunar power systems that have direct extensibility to human Mars missions.

3.2.2 Space Nuclear Propulsion

NASA's Space Nuclear Propulsion (SNP) Project is focused on advancing a deep-space propulsion system that will satisfy a Mars human exploration transportation need. Recent development has chiefly focused on nuclear thermal propulsion systems; however, NASA is currently performing system trade studies between nuclear thermal propulsion (NTP) and nuclear electric propulsion (NEP) for the Mars transportation architecture. Once sufficient technical and programmatic data has been gathered and assessed to support a technical and programmatic comparison for between each propulsion option, NASA will be able to make a final down select decision.

The current conceptual designs for a nuclear thermal propulsion system uses high-assay, low enriched uranium as the fuel source. The thermal energy generated by the fission reactor heats liquid hydrogen propellant, which then expands through a rocket nozzle to provide vehicle thrust. Project activities include advancing high-temperature fission fuels, irradiation tolerant materials and avionics, high-temperature reactor materials, subsystem hardware designs, and system integration.

NEP system design has less fidelity than NTP designs, primarily because NTP technology has active development work during recent years and NEP subsystems are conceptual. For NEP, the heat produced by the fission nuclear reactor is extracted using either a liquid or a gaseous fluid medium coupled into a power conversion system to yield electricity. Generated electric power is supplied to the electric propulsion systems that accelerate an ionized gas stream to extremely high velocity. NEP propulsion systems impart significantly more momentum to a spacecraft as a percentage of propellant mass flow relative to nuclear thermal propulsion. NASA is engaged in technology maturation studies to assess the current state-of-the-art critical subsystem technologies for NEP and evaluating the technology gaps that must be closed to produce a reliable, human-rated capability.

3.3 NEPA and the Nuclear Launch Safety Approval Process

The NEPA process is a separate requirement from the Nuclear Launch Safety Approval Process, as each relies on disparate regulations with differing goals and implementation. Where the ultimate purpose of NEPA is to ensure that potential environmental impacts are disclosed to public officials and citizens before decisions are made and actions are taken, the purpose of the Nuclear Launch Safety Approval Process is to provide NASA with a risk-informed process for launching radioactive material in order to inform launch safety. Launch safety is a paramount consideration before a launch is approved, and per NASA regulation, launches will not occur if they are deemed to be unsafe (NPR 8715.3 NASA General Safety Program Requirements). Launches of spacecraft containing space nuclear systems have an even higher burden; the U.S. government has a separate launch safety review under *National Security Presidential Memorandum No. 20* (NSPM-20) that requires, depending on tier, launch approval from the highest levels of NASA or the Executive Branch. NSPM-20 is provided in Appendix C.

While NSPM-20 requires NEPA to be conducted for nuclear-enabled missions, it does not influence how NEPA is conducted or serve to determine if there are sufficient safety data available to make NEPA determinations. Furthermore, NSPM-20 should not be used to determine the required level of NEPA documentation.

The requirements of the Nuclear Launch Safety Approval Process, which are detailed in Appendix B, inform the NEPA process as a form of mitigation that alleviates the potential for a significant impact. By adhering to the Nuclear Launch Safety Approval Process, including NSPM-20, NASA ensures that an accident resulting in even low-consequence radiation exposure to a general member of the public is unlikely and that potential accidents resulting in higher-consequence exposure are progressively less likely. This concept is explored further in Section 5, *NEPA Documentation*, and Section 6, *Impact Assessment*.

SECTION 4
Roles and Responsibilities

The following section defines the roles and responsibilities regarding NEPA compliance for NASA's nuclear activities. Requirements for NASA's use of nuclear materials are managed through several offices and individuals at NASA Headquarters (HQ), the RPS Program Office (located at GRC), and the launch site. There also are a number of cooperating, consulting, and other outside agencies that play important roles in the NEPA process for nuclear activities. A NASA NEPA team shall be formed for all proposed nuclear-enabled missions where NASA is required to perform an EA or EIS. A typical team construct for a NASA Nuclear mission NEPA effort (either an EA or EISs) includes the following:

Core NEPA Team: Participate in regular status calls to be led by the Environmental Management Division (EMD) and the NEPA Contractor

- NASA NEPA Manager (Team Lead)
- NEPA Contractor Lead
- Program Executive
- OGC NEPA Legal Counsel
- RPS Program Office (RPSPO) NEPA Lead
- DOE (Cooperating Agency Representative)
- U.S. Space Force (USSF) (Cooperating Agency Representative)
- Payload Developer (e.g., Applied Physics Laboratory or Jet Propulsion Laboratory) NEPA Representative

NEPA Contributors: Provide subject matter expert inputs and participate in internal reviews

- KSC NEPA Manager: Endangered Species Act (ESA), National Historic Preservation Act (NHPA) and Coastal Zone Management Act (CZMA) consultations
- SMD Coordination: RPSPO Executive, SMD NEPA Liaison, Public Affairs
- Inter-office Coordination: OLIA, OIIR, Human Exploration and Operations Mission Directorate (HEOMD) NEPA Liaison

Table 4-1 located at the end of this section explains the assignments of roles throughout a mission-driven NEPA document. A process flowchart is provided in Section 5, *NEPA Documentation*.

4.1 National Aeronautics and Space Administration

In this section, the NASA offices involved in NASA's nuclear activities are discussed.

4.1.1 Environmental Management Division

The Environmental Management Division (EMD) maintains NASA NEPA regulations (14 CFR Part 1216), policy (NRP 8580.1), and guidance documents. The EMD Director serves as NASA's Senior Environmental Official.

NASA NEPA Manager

NASA's NEPA Program is managed by the EMD at NASA HQ. The NASA NEPA Manager oversees the implementation of the NEPA Program across NASA Centers and annex facilities and provides national level policy and procedural guidance applicable to each NASA Center. All nuclear-enabled launches should be elevated to the NASA NEPA Manager. The NASA NEPA Manager serves as the NEPA Project Lead for nuclear-enabled projects managed at HQ and is responsible for developing the scope of work, developing the government estimate, and selecting the NEPA contractor for nuclear-enabled missions. The NASA NEPA Manager coordinates with the SMD and STMD NEPA Liaisons to determine the appropriate level of NEPA documentation.

Center NEPA Managers

Each Center has a resident environmental management office and an assigned NEPA Manager. NEPA Managers located at the Centers perform the day-to-day NEPA work for their respective Center. The NEPA Manager provide NEPA oversight for Center actions, including activities using nuclear materials. The Center NEPA Managers are responsible for ensuring that the NASA NEPA Manager is engaged on EAs and EISs involving nuclear materials. The JPL NASA Management Office (NMO) also has a designated NEPA Manager. The JPL NMO NEPA Manager serves as the liaison between JPL, Caltech, and EMD, see *Section 4.2* for further explanation. The Center NEPA Manager where the nuclear activity is to occur also is responsible for coordinating the necessary consultation(s) and environmental permitting requirement(s). This includes requirements per the ESA, NHPA, and CZMA. Currently, launches of payloads containing RHUs and RTGs are conducted primarily at KSC, and for this reason, the KSC NEPA Manager is responsible for consultations associated with nuclear-enabled missions.

4.1.2 Office of General Counsel

NASA's Office of General Counsel (OGC) provides functional leadership regarding legal services and issues related to all aspects of NASA activities. Specifically, the OGC provides legal advice and reviews NEPA documents for agency consistency, legal sufficiency, and litigation risk.

General Law Attorney

The General Law Attorney ensures NASA activities are conducted in compliance with statutory and regulatory requirements. The General Law Attorney also provides expert advice, oversight, and overflow support to the Centers and provides legal services to all the offices at HQ.

4.1.3 Science Mission Directorate

NASA's SMD is responsible for providing a broad portfolio of mission capabilities, including nuclear-based systems, for NASA to achieve its current and future mission needs. The RPSPO is a component of SMD.

SMD Associate Administrator

The SMD Associate Administrator (AA) serves as the responsible official for all SMD-funded programs and projects, which includes compliance with nuclear launch safety and NEPA requirements.

SMD Mission Program Executive

The SMD Program Executives (PEs) are responsible for ensuring NEPA compliance for their assigned programs and projects.

SMD NEPA Liaison

The SMD NEPA Liaison works with the NASA NEPA Manager and SMD Mission PEs to ensure NEPA is included in SMD mission planning.

RPS Program Manager

Under SMD's Planetary Science Division (PSD), the RPSPO, in collaboration with DOE, manages nuclear radioisotope power technologies that maintain NASA's current space science capabilities and aid in future space exploration missions. The RPSPO Manager, based at GRC, leads negotiations with DOE for the development of nuclear systems in support of NASA missions based on NASA's Memorandum of Understanding (MOU) with DOE. The RPS Program Manager serves as the primary liaison with DOE.

RPS Nuclear Launch Approval Manager

The RPSPO is responsible for the acquisition and development of RPSs and devices such as RTGs and RHUs; therefore, the RPS Nuclear Launch Approval Manager is responsible for the management of the nuclear launch safety approval activities related to RPSs. The RPSPO management has been assigned to the GRC (NASA, 2018). The RPS Nuclear Launch Approval Manager generally serves as the liaison between the NASA NEPA Manager and RPS PD for programmatic NEPA activities.

RPS NEPA Compliance Manager

The RPS NEPA Compliance Manager works with the NASA NEPA Manager, and RPSPO to ensure NEPA is included in RPSPO sponsored activities. The RPS NEPA Compliance Manager engages in all NEPA documents involving the use of systems under the RPS Program.

4.1.4 Space Technology Mission Directorate

The STMD is responsible for technology development and demonstrations in support of nuclear propulsion and fission surface power systems.

STMD Associate Administrator

The STMD AA serves as the responsible official for all STMD-funded programs and projects, which includes compliance with nuclear launch safety and NEPA requirements.

STMD Mission Program Executive

The STMD PEs are primarily responsible for ensuring compliance with policies for their assigned programs and projects.

STMD NEPA Liaison

The STMD NEPA Liaison works with the NASA NEPA Manager and STMD PEs to ensure NEPA is included in mission planning. The position also assists the NASA NEPA Manager in determining the appropriate level of NEPA documentation and developing the mission-specific scope of work. The STMD NEPA Liaison also engages in all programmatic NEPA documents involving the use of nuclear systems under STMD.

4.1.5 Human Exploration and Operations Mission Directorate

Human Exploration and Operations Mission Directorate (HEOMD) provides NASA with leadership and management of NASA space operations related to human exploration.

HEOMD NEPA Liaison

If HEOMD is involved in a nuclear-enabled mission, the HEOMD NEPA Liaison is responsible for informing the NASA NEPA team of relevant launch vehicle and crew information as it applies to the NEPA process and representing HEOMD as a member of the project-specific NEPA team.

Launch Safety Program

The Launch Safety Program (LSP) is responsible for certifying launch vehicles capable of launching nuclear enabled payloads to launch from the U.S. Eastern Range. LSP provides launch vehicle specifics to DOE in order to develop the Databooks used to develop a safety analysis report (SAR) to comply with NSPM-20. LSP is based at KSC.

4.1.6 Office of Safety and Mission Assurance

The Office of Safety and Mission Assurance (OSMA) ensures safety and enhances the success of all NASA activities. OSMA ensures that the risks to the general public and the environment associated with a planned launch of radioactive materials into space have been evaluated and that any required notifications and approvals have been made prior to launch.

Chief of Safety and Mission Assurance

This position is responsible for advising the NASA Administrator and other senior officials on matters related to risk, safety, and mission success for nuclear activities. Primary duties include assuring missions comply with NSPM-20, chartering the Interagency Nuclear Safety Review Board, and coordinating the radiological safety aspects with the Office of the Chief Health and Medical Officer (OCHMO).

NASA Nuclear Flight Safety Assurance Manager

The NASA Nuclear Flight Safety Assurance Manager is responsible for reviewing nuclear launch safety approval requests submitted by programs and projects that plan to launch radioactive material or nuclear-enabled payloads, and helps projects meet the nuclear launch safety analysis requirements. In this role, the

NFSAM also coordinates the Interagency Nuclear Safety Review Board, which evaluates the quality of the safety analysis associated with nuclear missions that meet criteria specified in NSPM-20.

4.1.7 Office of the Chief Health and Medical Officer

The OCHMO is responsible for policy and oversight of all health and medical activities at NASA.

NASA Radiation Protection Officer

The OCHMO Radiation Protection Officer (RPO) is responsible for managing and implementing NASA's Radiation Protection Program for both ionizing and nonionzing sources of radiation across all NASA Centers and facilities, including JPL. The OCHMO RPO has oversight over the individiual NASA licensees to ensure that radiation safety activites are being performed in accordance with licensee-approved procedures and federal, state, and local regulatory requirements, as well as NASA-adopted consensus standards. The OCHMO RPO is also responsible for identifying radiation protection problems; initiating, recommending, or providing corrective actions to the Centers; and verifying implementation of corrective actions. The RPO at all NASA Centers has the authority and responsibility to stop any activities involving sources of ionzing or nonionzing radation in which health and safety may be compromised. The RPO is the designated health and safety expert for NEPA-related activities.

Center Radiation Safety Officers

Center RSOs manage ionizing and nonionizing radiation protection programs at the Center level. The Center RSO approves the procurement and use of byproduct material on a Center's materials license and ensures its safe use in accordance with applicable policies, procedures, and regulatory agency requirements. The Center RSO is the primary point of contact for matters related to its NRC licenses. The RSO at the Center level has the authority to stop any operations involving sources of ionizing or nonionizing radiation in which health and safety may be compromised. The complete role and responsibilities of Center RSOs are defined in NPR 1800.1 (NASA, 2016).

4.1.8 Office of Legislative and Intergovernmental Affairs

The Office of Legislative and Intergovernmental Affairs (OLIA) supports relationships between NASA and the U.S. Congress, as well as state and local governments. Since NEPA requires NASA to inform the public of its decision-making process for major federal actions, government representatives often engage in the NEPA process. The OLIA assists in the development of the public involvement plan, is responsible for approval of the NEPA distribution list, and provides congressional notifications as a part of the NEPA distribution process.

4.1.9 Office of International and Interagency Relations

The Office of International and Interagency Relations (OIIR) provides executive leadership and coordination for all NASA international and interagency activities and partnerships, and for policy interactions between NASA and other U.S. Executive Branch offices and agencies. NASA's NEPA process can require cooperation with international or interagency partners to support mission needs. Therefore, the OIIR is responsible for maintaining DOE relations, per the NASA-DOE MOU. The OIIR also is responsible for official communications with federal agencies, such as the U.S. State Department, and international partners (i.e., European Space Agency, Canadian Space Agency).

4.1.10 NASA Public Affairs

NASA Public Affairs personnel are responsible for managing public relations. The appropriate center and HQ public affairs offices should be notified prior to publication of nuclear-related NEPA documents.

4.2 Non-NASA Institutions

While NEPA only applies to federal agencies, other institutions support NASA as mission managers and as technical experts. These institutions also support the NASA NEPA process.

4.2.1 Payload Developer

The organization or institution awarded a NASA mission is expected to provide planned mission details to support NASA in meeting their NEPA responsibilities. Caltech Jet Propulsion Laboratory, and Johns Hopkins University Applied Physics Laboratory have historically served in this capacity. A designated representative

from the mission institution should actively serve on the NASA NEPA team to assist in developing the NEPA documentation (e.g., mission description, purpose, need and alternatives). Caltech often provides an individual from their Launch Approval Engineering Office to serve as a liaison between the payload developers (mission team) and the NEPA team.

4.3 Cooperating Agencies

For nuclear-enabled activities, the following agencies can be invited to serve as cooperating agencies during NASA's preparation of mission-specific and programmatic NEPA documents.

4.3.1 U.S. Department of Energy

DOE supports NASA in the development of space nuclear systems. DOE, pursuant to its statutory authorities, retains responsibility for nuclear materials and nuclear activities, including protection of human health and safety, security, safe handling, and safe use of nuclear materials. DOE controls all work done by DOE and its contractors at DOE facilities. NASA provides DOE with its requirements as to RPS specifications, scheduling, interface, and management controls to support NASA's space mission needs; and DOE is responsible for the design, development, fabrication, evaluation, testing and delivery of the RPS to meet NASA requirements. DOE's existing NEPA documentation covers RPS research and development activities at DOE facilities. If the research and development of an RPS falls outside the scope of existing DOE NEPA documentation, NASA may serve as a cooperating agency to DOE to supplement DOE's existing NEPA analysis.

4.3.2 U.S. Department of Defense/U.S. Space Force

The two primary launch sites for NASA nuclear-enabled missions are Cape Canaveral Space Force Station (CCSFS), Florida, and KSC, Florida. The USSF serves as a cooperating agency because of its jurisdictional responsibility to approve nuclear-enabled missions launched from CCSFS. USSF has implemented policies and procedures that govern the launch of nuclear-enabled missions from USSF facilities. This special expertise informs NASA during the development of nuclear-enabled mission and programmatic NEPA documents. A USSF representative serves as a designated core NEPA team member for nuclear-related NEPA activities.

4.3.3 Federal Aviation Administration

The Federal Aviation Administration (FAA) has special expertise with respect to environmental issues for space launch and re-entry vehicle operations. It is also a cooperating agency because of the potential for commercial space vehicle operators to apply for a license for launches or re-entries involving radioisotope-based systems. FAA's Office of Commercial Space Transportation regulates the U.S. commercial space transportation industry and is required to analyze the potential environmental impacts of proposed licenses and permitted actions, including the licensing of launch activities and the operation of the launch sites. The FAA provides a representative to serve as a designated team member for nuclear-related NEPA activities, as applicable.

4.4 Consulting Agencies

NASA generally needs to consult with the following agencies per the ESA, NHPA and CZMA.

4.4.1 U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) is responsible for implementation of Section 7 of the ESA. Under Section 7, NASA must consult with the USFWS when a proposed action may affect a listed endangered or threatened species or their critical habitat. See Appendix D for a sample Section 7 letter for a nuclear activity.

4.4.2 U.S. Department of the Interior

Section 106 of the NHPA requires that NASA consult with the Advisory Council on Historic Preservation and the Florida State Historic Preservation Officer if a proposed action may adversely affect a cultural or historic resource. See Appendix E for a sample Section 106 letter for a nuclear activity.

4.4.3 Florida State Clearinghouse

The CZMA establishes a national policy to preserve, protect, develop, restore, and enhance the resources of the nation's coastal zones. Federal agencies are responsible for making consistency determinations within coastal zone areas. For KSC, federal consistency reviews are conducted by the Florida State Clearinghouse. NASA would follow the state of Florida's coastal zone management requirements for activities at KSC. See Appendix F for a sample Florida CZMA letter for nuclear activities.

4.5 Outside Agencies

The U.S. Environmental Protection Agency (EPA) and the Federal Emergency Management Agency (FEMA) have established roles in NASA's use of nuclear material, though they typically do not serve as cooperating agencies in the NEPA process. An explanation of each agency's role is provided in this section.

4.5.1 U.S. Environmental Protection Agency

EPA has the ability and authority to respond to many different types of radiological incidents. According to the Atomic Energy Act and Nuclear/Radiological Incident Annex, EPA is one of the primary authorities for federal response for radiological incidents. EPA is also responsible for coordinating the federal environmental response to incidents involving the release of nuclear and/or radioactive materials that occur in the inland zone and in areas of the coastal zone not addressed by the U.S. Coast Guard.

4.5.2 Federal Emergency Management Agency/Local Response

Federal roles and assigned tasks regarding federal assistance to state and local governments in their radiological emergency planning and preparedness activities are set out in 44 CFR Part 351. FEMA's Radiological Emergency Preparedness Program coordinates the national effort to provide state and local governments with relevant and executable planning, training, and exercise guidance and policies necessary to ensure that adequate capabilities exist to protect against, mitigate the effects of, respond to, and recover from incidents involving nuclear materials.

TABLE 4-1

Roles and Responsibilities for NASA NEPA Actions Involving Launched Nuclear Materials

	Internal Documentation	Public Review	Public Notification	Public Review
Responsible Party	**REC for Launch of Small Sources[1]**	**Programmatic Impact Assessment (EA or EIS)[2]**	**Application of Programmatic Checklist[3]**	**Mission Specific Impact Assessment (EA or EIS)**
NASA NEPA Manager	**Consulted**	**Accountable** - HQ action	**Accountable** - HQ action	**Accountable** - HQ action
Center/NMO NEPA Manager	**Accountable**	**Accountable** - Center action	**Accountable** - center action	**Accountable** - center action
RPS NEPA Compliance Manager	**Consulted**	**Accountable**	**Accountable**	**Accountable**
OGC NEPA Counsel	**Consulted** - legal sufficiency	**Consulted** - legal sufficiency	**Consulted** - legal sufficiency	**Consulted** - legal sufficiency
SMD NEPA Liaison	**Informed** - if SMD action	**Consulted** - if SMD action	**Consulted** - if SMD action	**Consulted** - if SMD action
STMD NEPA Liaison	**Informed** - if STMD action	**Consulted** - if STMD action	**Consulted** - if STMD action	**Consulted** - if STMD action
HEOMD NEPA Liaison	**Informed** - if HEOMD action	**Consulted** - if HEOMD action	**Consulted** - if HEOMD action	**Consulted** - if HEOMD action
KSC Environmental Compliance Manager		**Responsible** - consultation lead		**Responsible** - consultation lead
NEPA Contractor (EA/EIS Author)*		**Responsible** - document production		**Responsible** - document production
Payload Developer (Mission NEPA Representative)*		**Consulted** - mission details		**Consulted** - provides mission details
RPS Program Executive		**Informed**		**Informed**
RPS Program Director		**Responsible** - DOE coordination		**Responsible** - DOE coordination
Mission Program Manager/Executive	**Consulted**		**Consulted**	**Consulted**
DOE NEPA Cooperating Agency POC**		**Responsible** - nuclear analysis		**Responsible** - nuclear analysis
USSF NEPA Cooperating Agency POC**		**Consulted**		**Consulted**
FAA NEPA Cooperating Agency POC**		**Consulted**		**Consulted**
OSMA Nuclear Flight Safety Assurance Manager	**Consulted** - A2 mission calc	**Consulted**		**Consulted**
Center Radiation Safety Officer	**Responsible** - A2 mission calc		**Informed**	**Informed**
OIIR Rep		**Informed**		**Informed**
Public Affairs Representative		**Responsible** - public engagement support		**Responsible** - public engagement support
OLIA Representative		**Responsible** - Congressional notices		**Responsible** - Congressional notices
OSI Assistant Administrator		**Informed**		**Informed**
NASA Federal Register Officer		**Responsible** - post NOA/NOI (EIS only)		**Responsible** - post NOA/NOI (EIS only)
Mission Directorate AA (Responsible Official)		**Accountable** - signature		**Accountable** - signature

[1] Created by completing Routine Payload Environmental Checklist

[2] Applied during preparation of new programmatic EA or EIS

[3] Conducted when applying a Programmatic EA or EIS to a new mission

* NASA Contractor

** Cooperating Agency

Responsible: Individual(s) assigned a task

Accountable: Ultimate ownership or final decision-maker

Consulted: Individual(s) consulted prior to the decision, provides necessary information

Informed: Individual(s) informed after the decision

SECTION 5
NEPA Documentation

NEPA requires the systematic examination of the environmental consequences associated with implementing a proposed federal action. The three levels of NEPA documentation are described as follows:

- **CatEx** – A CatEx is used for actions that individually or cumulatively have no potential for substantial effects on the environment. A record of environmental consideration (REC) is an internal memorandum that confirms the proposed action meets the existing parameters of NASA's list of CatExs or an existing programmatic NEPA document. Refer to Appendix G for examples of applying CatExs.
- **EA** – An EA is prepared for an action that has the potential to adversely impact the environment, which precludes the use of a CatEx. An EA is concluded with a FONSI if any potential significant impacts can be avoided or mitigated. If a FONSI is not applicable, then an EIS, described as follows, must be prepared before undertaking agency action.
- **EIS** – An EIS is an in-depth study of a proposed action that may have significant environmental impacts. Preparation of an EIS is procedurally and technically more comprehensive than preparation of an EA. Furthermore, given the substantial public notice and comment period requirements, an EIS may take significantly longer to prepare than an EA. The EIS is concluded with a record of decision (ROD).

Implementing the appropriate level of NEPA documentation is a critical component of mission success. Each level of NEPA documentation carries distinct schedule, budget, and stakeholder implications. This section provides a discussion of the steps a Center or Program NEPA Manager should employ in coordination with the NASA NEPA Manager to ensure the proper level of documentation.

5.1 Step 1: Identification of an Existing Categorical Exclusion or NEPA Document

In Step 1, a Center NEPA Manager should determine if an existing CatEx or existing NEPA document covers the proposed action. If a proposed action is covered by a CatEx, an existing programmatic NEPA document, or a project-specific NEPA document, then the Center NEPA Manager can generate a REC and no further NEPA action is necessary. Refer to Appendix G for an example of applying a CatEx. The following sections outline some of the nuclear-specific considerations when applying a REC.

5.1.1 Categorical Exclusions

The use of small quantities of radioactive materials is covered under NASA's CatExs for Research and Development Activities. However, the CatEx is currently under review by the CEQ and has not been finalized. The following is the current language intended for the CatEx.

> *3(ii) Use of small quantities of radioactive materials used for instrument detectors, calibration, and other purposes. Materials must be licensed, as required, and properly contained and shielded. Materials may be associated with spacecraft, aircraft (including unmanned aircraft systems), sounding rockets, balloons, laboratories, watercraft, or other outdoor activities.*

Note that this CatEx can be applied to both laboratory and space nuclear activities, assuming the quantity of nuclear material is below any thresholds for harm. To apply this CatEx for launches, Radiation Safety Officer (with a later review by the OSMA Nuclear Launch Safety Assurance Manager) needs to calculate the A2 mission multiple to ensure that it results in a quantity less than 100,000 times the A2 (Tier I per NSPM-20). If the use is within this threshold, a memorandum should be sent to OCHMO, EMD, and SMD RPS Office, outlining the calculations and providing nuclear launch safety approval. If the use is greater than the small quantity threshold, then it is elevated to the Center's NEPA Manager and HQ NEPA Manager for potential further NEPA action. Examples of the memorandum are included in Appendix H.

5.1.2 Programmatic Documents

To maximize administrative efficiency in implementing an agency's NEPA compliance program, agencies are encouraged to employ a programmatic approach to NEPA documentation (40 CFR Section 1500.4(i)). The CEQ issued guidance titled *Effective Use of Programmatic NEPA Documents*, which provides guidelines for

agencies to use when developing programmatic NEPA documents (https://www.govinfo.gov/content/pkg/FR-2014-12-23/pdf/2014-30034.pdf). To align with CEQ's implementing regulations and guidelines, NASA EMD has prepared, and is currently developing, programmatic documents for nuclear-enabled missions. These programmatic documents will allow future missions to incorporate existing analyses by reference or tiering and reduce the burden of repetitive mission-specific nuclear analysis for NEPA compliance.

NASA has conducted the following programmatic documents for nuclear-enabled missions:

- Programmatic Environmental Assessment (PEA) of Launches Involving RHUs (NASA, 2020)
- Mars Exploration Program Programmatic Environmental Impact Statement (PEIS) (NASA, 2005)
- PEIS for Galileo and Ulysses (NASA, 1989)

Once a programmatic NEPA document has been completed and an associated FONSI (for an EA) or ROD (for an EIS) has been signed, a program specific checklist is created, which guides NEPA professionals to ensure a mission is within the scope of the programmatic document. Upon completion of the checklist it is then possible to reference that programmatic NEPA document in mission-specific documents that involve the use of the technology covered by the programmatic document, this includes a REC, EA or EIS. This programmatic process helps NASA comply with the requirement of 40 CFR Section 1500.4(i) by reducing duplicative analyses and finding efficiencies in the NEPA process, without compromising the NEPA principle of informing the public and NASA decision maker.

5.1.3 Existing NEPA Documents

When considering the level of NEPA documentation for a mission, it is important to review existing NEPA documents that may cover the proposed action and determine if the potential impacts are covered in previous analysis. NASA conducts NEPA analyses for each of its primary missions, and existing NEPA documents are located on the NASA Environmental Tracking System (NETS) website. Other agencies such as USSF, DOE, and NRC also conduct NEPA analyses for proposed actions that may encompass a NASA action. If adequate NEPA documentation exists, the Center or NASA NEPA Manager may either incorporate the existing document by reference into another NEPA document (EIS, EA, or REC) or tier another NEPA document (EIS, EA, or REC) from the existing document. The following sections briefly describe how to apply these techniques.

Incorporation by Reference

Incorporating existing NEPA documents by reference is encouraged when the effect will be to cut down on bulk without impeding agency and public review of the action (40 CFR Section 1502.21). Incorporation by reference is recommended for documents in which NASA was not the lead federal agency or a cooperating agency on the original document. The incorporated document should be cited in the NEPA document and its contents briefly described. The document relied on should be reasonably available for inspection by potentially interested persons within the time allowed for comment. Material based on proprietary data that are not available for review and comment should not be incorporated by reference.

Tiering

Tiering is encouraged in cases where NASA was the lead federal agency or a cooperating agency on the NEPA document. Tiering NEPA documents eliminates repetitive discussions and focuses the current effort on the issues ripe for decision (40 CFR Section 1502.20). When an existing broad NEPA document is followed by a site-specific NEPA action, the more specific NEPA document needs only to summarize the issues discussed in the broader document and incorporate the discussions from the broader document by reference. The more specific document must state where the earlier document can be found.

5.2 Step 2: Is an Environmental Assessment or Environmental Impact Statement Required?

In Step 2, the Center or HQ NEPA Manager should determine if an EA or EIS is warranted. A typical process flowchart for making this decision is provided on Figure 5-1.

The CEQ NEPA regulations encourage federal agencies to conduct an EA to determine the potential for a significant impact and assess whether an EIS is warranted. Although immediate preparation of an EIS is an option, Center NEPA Managers and HQ PEs should be aware that doing so could result in substantial additional project management costs and lengthen project schedules, which may be unnecessary. An EIS

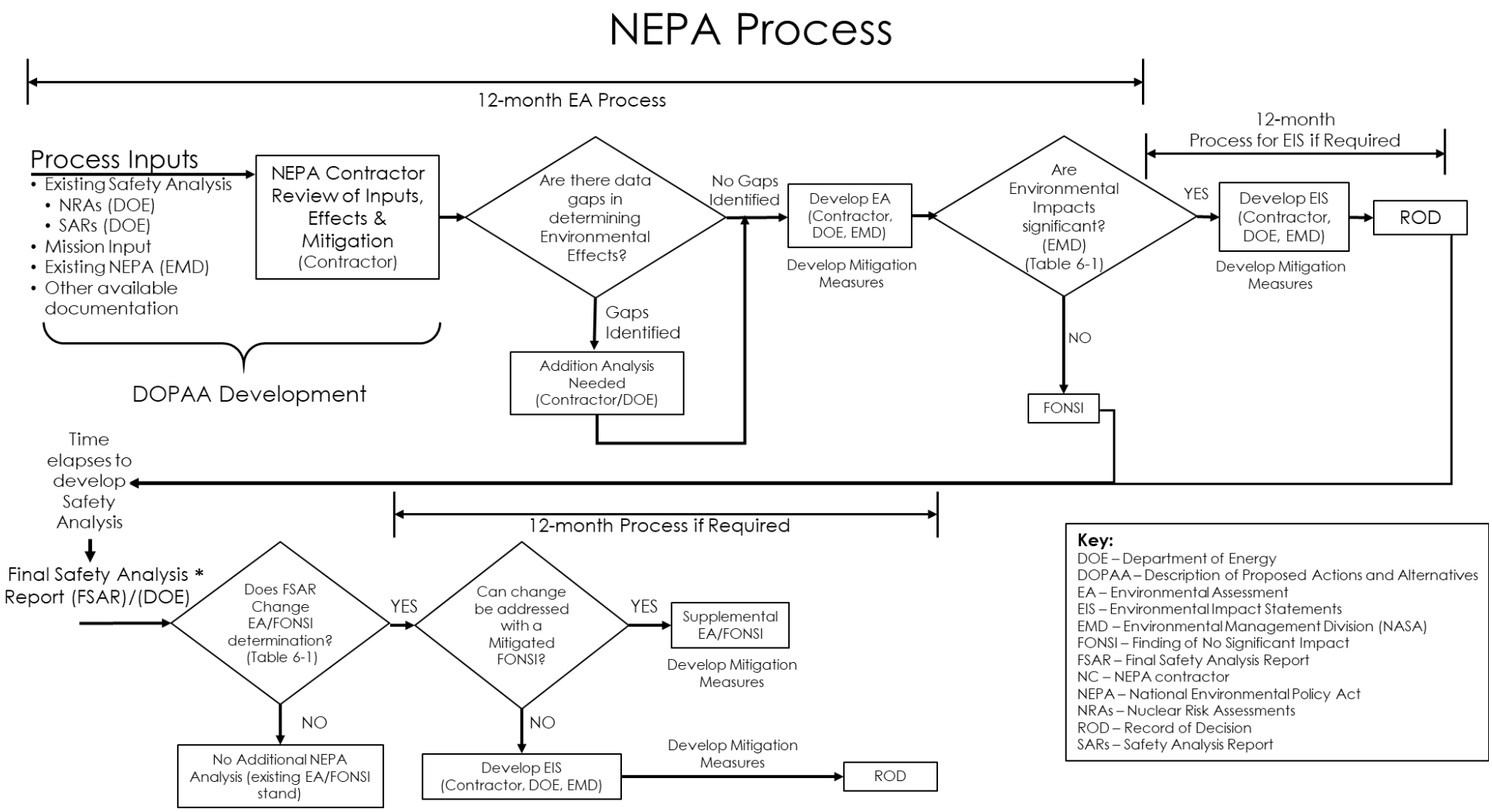
generally requires substantially more time and budget than an EA. Furthermore, the public often perceives an EIS as a “permit” for a significant impact, whereas an EA demonstrates that an agency is committed to keeping impacts to a less than significant threshold. Therefore, by immediately performing an EIS there is a danger of an unnecessary negative public perception.

Mission program managers tasked with a nuclear-enabled mission should consult with NASA HQ staff to discuss the appropriate NEPA strategy prior to committing to a level of NEPA documentation. Appropriate HQ staff include the NASA NEPA Manager, and OGC General Law Attorney. This coordination is important as standardized processes and procedures across NASA is critical.

5.3 Step 3: Conduct the Impact Assessment

In Step 3, an impact assessment is conducted. The CEQ NEPA implementing regulations (40 CFR Part 1500), NASA Procedures for Implementing NEPA (14 CFR Part 1216), and the NASA NEPA Requirements (NPR 8580.1A) provide the requirements for conducting either an EA or an EIS. Those requirements are not restated here; however, the considerations that apply specifically to the NEPA analysis of nuclear actions are provided in Section 6, *Impact Assessment*.

FIGURE 5-1
NEPA Process Flowchart (Mission and Programmatic EAs and EISs)



* An FSAR is only conducted for mission specific actions

SECTION 6

Impact Assessment

A standardized approach is to be applied to all NASA NEPA documents. The following guidance is intended to help NEPA practitioners evaluate, characterize, and communicate potential environmental impacts for both programmatic evaluations and mission-specific actions. Appendix I, Nuclear NEPA Frequently Asked Questions, provides more detail on this approach.

6.1 Evaluating Radiation Exposure in the NEPA Context

In the context of a nuclear-enabled mission, a successful launch should, theoretically, result in no adverse radiological impacts on public health or the environment because there would be no release of radioactive material into the environment during a nominal launch. However, there is some probability that a launch mishap could occur and result in an accident of potentially serious dimensions. This possibility requires an analysis that is somewhat different from that undertaken in many NEPA cases. For example, if a proposed agency action is the construction of a highway or dredging of a harbor, some adverse environmental effects are certain to occur, such as the destruction of wetlands or disturbance of animal or fish habitat. While these types of actions may result in consequences that can be only estimated, the seriousness of the certain consequences normally provides an adequate basis for determining whether the effect on the environment will be sufficiently significant to require an EIS. In the case of a rocket launch carrying a nuclear-enabled payload, it is not the certain consequences of the proposed action (nominal launch) that are significant; instead, it is the accidental releases of radioactive material into the environment that might render the proposed action environmentally significant.

The CEQ's regulations at 40 CFR Section 1502.22 address the process for an agency to follow when reasonably foreseeable significant adverse effects on the environment are identified, but there is incomplete or unavailable information in the record that precludes a definitive conclusion on the matter. The regulations clarify that the term "reasonably foreseeable" includes impacts which have "catastrophic consequences, even if their probability of occurrence is low" (that is, there is an uncertainty that the impact will occur) (40 CFR Section 1502.22(b)(1)). The CEQ regulations do NOT require the agency to conduct a "worst case" accident environmental impact analysis.

When confronted with a situation where there is incomplete or unavailable information, the NEPA practitioner should complete an assessment that examines both the probability of a given harm occurring AND the consequences if that harm occurs. Only if the harm in question is so remote and speculative as to reduce the effective probability of its occurrence to zero may the NEPA evaluation dispense with the consequences portion of the analysis. NASA's NEPA-implementing regulations (14 CFR Section 1216.306) NORMALLY require the preparation of an EIS for actions involving the development and operation of a space flight project or program that would launch and operate a nuclear reactor or RPS. However, the NEPA practitioner is advised that in cases where the probability of a significant harm is extremely small, but not zero, preparation of an EIS is not necessarily required; a balancing of probability against consequences should be conducted. Consultation with the NASA NEPA Manager and OGC is recommended prior to making a final determination.

In its role as a cooperating agency, DOE supports NASA in the development of safety documents for nuclear-enabled mission. DOE, in coordination with its national laboratories, models various launch accident scenarios to evaluate the probability of a mishap that results in the release of radioactive material into the environment. DOE's modeling results may be used to satisfy the CEQ's requirements to provide a "*summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment*" and an "*evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community.*"

Understanding that NASA NEPA documents are not risk assessments, but evaluations of potential impact is an important distinction when preparing an EA or EIS in a manner that satisfies the requirements of NEPA, the Administrative Procedure Act, and judicial scrutiny. To better inform the decision maker, the NEPA analysis should answer the following questions:

1. What entity/entities/environmental resource(s) are affected?

2. How is the entity affected? What attributes, features, or characteristics are expected to change?
3. What is the likelihood (probability) of an effect?
4. What is the direction of an effect (positive, negative, mixed)?
5. What is the magnitude of the effect (negligible, minor, moderate, significant)?
6. How long is the effect expected to last (short-term, long-term)?
7. What is the consequence of the effect? Does the effect matter?
8. What reasoning and evidence supports these conclusions and is there reasoning and evidence that would lead to different conclusions?

The analysis for all nuclear-enabled mission documents should, to the fullest extent practicable, quantify the various factors considered. To the extent there are important qualitative considerations or factors that cannot be quantified, these considerations or factors need to be discussed in qualitative terms. NASA NEPA documents should ensure proper consideration is given to compliance with applicable environmental quality standards, requirements, and guidelines that have been imposed or recommended by federal, state, regional, and local agencies having responsibility for environmental protection.

Matters related to the legal sufficiency of NASA's processes and procedures should be referred to NASA HQ OGC, with copies submitted to the NASA HQ NEPA program manager. The administrative record becomes important if or when a document is litigated, because the administrative record contains the paper trail of documents that formed the basis of the agency's decision.

NEPA documents for programmatic and mission-specific nuclear-enabled missions evaluate programs and missions that are scientifically based and involve complex engineering concepts. The NEPA practitioner must ensure the document is written in manner that is understandable to the general public. A document written in a way that only scientists and engineers can understand would not further NEPA's requirement to inform the public, and the document may be found noncompliant if subject to judicial review. Consequently, it is important to simplify the impact analysis to the degree possible and present the potential impacts, especially the greatest potential harm and its probability of occurrence, in a way that is clearly expressed to the public.

To align with national level policy requirements and DOE's recommended process to evaluate potential nuclear effects of a proposed action, the NASA NEPA practitioner should present the impact of a release of radioactive material into the environment in terms of the effect on the "maximally exposed individual" (MEI). The benefit of focusing the analysis on the effects to the MEI is that the MEI concept accounts for all possible exposure vectors (that is, oral or respiratory ingestion via air, water, food, and soil exposure) by which a person may experience a health effect (refer to Section 6.1.1 for further discussion of the MEI). In addition, the NEPA practitioner should focus the analysis on the launch phases of most concern, that is, those which will occur at the launchpad and impact the surrounding community (Phases 0 and 1). This approach may differ from the Nuclear Launch Safety Approval and SAR processes, but the target audience of those processes is the trained engineer and nuclear physicists, while the target audience of the NEPA document is the general public.

The following five principles should be implemented to effectively evaluate, characterize, and communicate potential environmental impacts in a NEPA document.

6.1.1 Principle 1: Focus on the Maximum Exposed Individual

There are a number of methodologies for determining potential health impacts from radiation exposure. For example, physicists can calculate the collective dose to a population or the maximum dose to an individual. However, NEPA guidelines state that an impact assessment should discuss impacts in proportion to their significance. For less than significant issues, the assessment should provide enough discussion to show why a significant environmental effect is not realized and why more study is not warranted (40 CFR Section 1502.2(b)). Because collective dose generally involves very low doses to very large populations, if the potential impact to the MEI is less than significant, then it is not necessary to examine the impact to a population because it is inherently a lesser impact. If the impact to the MEI is significant, the principles of NEPA are still met because the greatest potential impact would be disclosed.

Finally, analysis of the MEI aligns with the current national level guidelines established in NSPM-20 and is used by DOE in evaluating radiological effects of its proposed actions. The MEI methodology provides a well-

established analytical framework that is defensible because it is generally easier to communicate to the public. Collective dose, on the other hand, is a conceptual framework that relies on more speculative analysis and baseline hypotheses that may not be as easily understood by the public or defended pursuant to a legal sufficiency challenge. For these reasons, it is best to avoid discussions of collective dose and focus on the impacts to the MEI in the environmental consequences section of NEPA documents.

6.1.2 Principle 2: Explain Radiation Exposure in Plain English

Many general members of the public perceive exposure to radiation as inherently dangerous. It is the responsibility of the NEPA practitioner to ensure that potential impacts are presented in a manner that clearly explains the effects of radiation exposure in a manner that aligns with scientifically unbiased source material. The following text is an example of how to explain potential radiation exposure to the general public. This language was created for the NASA RHU PEA and focuses on Pu-238; however, this template can be modified to explain the health impacts associated with other nuclear materials, such as uranium. It is advisable to have a qualified nuclear expert or certified health physicist craft this language to ensure its accuracy.

Provide an explanation of what radiation exposure means in simple terms:

> *Humans are constantly exposed to natural ionizing radiation from various sources, including cosmic radiation (from outer space) and terrestrial radiation (from Earth's rocks and soils). These types of radiation are commonly referred to as background radiation. Manmade sources of radiation also exist; for example, smoke detectors, cigarette smoke, and certain coatings on camera lenses emit small quantities of radiation. Because living cells are constantly exposed to ionizing radiation, they have developed biochemical mechanisms to repair damage from this exposure. However, when a sizable quantity of radiation is delivered to human tissue, ionizing radiation can overwhelm repair mechanisms and cause significant health effects such as cancer. External exposure to alpha radiation is not harmful because the outer dead layer of skin serves as a natural barrier and prevents penetration to more sensitive cells. However, if alpha-emitting radionuclides such as Pu-238 are introduced into the body by inhalation (or breathing), they can deposit in internal organs and deliver a radiation dose to tissues, which can then lead to adverse health effects.* (NASA, 2020)

Provide an explanation of how radiation exposure effects the human body:

> *The International Commission on Radiological Protection (ICRP) has studied the movement of Pu-238 within the human body. The inhalation of small particles, less than 5 microns in diameter, poses the greatest potential health effect. Breathing is approximately 1,000 times more effective than eating for transporting plutonium to the sensitive tissues in the human body. Ingested (or eaten) Pu-238 would quickly pass through the digestive system and be excreted, with only a minute fraction being absorbed into the blood stream. Inhaled Pu-238 could be transported to the deep portions of the lungs, depending on the particle size. Generally, particles larger than 5 microns would be intercepted in the nose or throat, swallowed, and passed through the digestive tract and excreted. Particles smaller than 5 microns could accumulate in the deep lung regions. Most health effects would result from Pu-238 accumulating in the deep lungs and then migrating into the blood stream, which transports it to body tissues. Once Pu-238 has entered the blood stream, it deposits primarily in the liver and skeletal system, creating a potential for cancer if the radiation dose is sufficiently large (ICRP, 1986; NRC, 2006). Therefore, most of the potential radiological health effects associated with mission mishaps are attributed to the potential release of Pu-238 in a vaporized form. Mishap scenarios that do not result in a release Pu-238 or that result in a release of Pu-238 in solid fragments are a relatively minor component of the overall risk spectrum.* (NASA, 2020)

Provide an explanation of how radiation is measured:

> *The unit of biological radiation dose impact is called a Roentgen Equivalent Man (rem). Radiation dose is a measurement of the amount and type of ionizing radiation energy adsorbed per unit mass of body tissue and the relative biological effect of that absorbed radiation. An average person in the U.S. is exposed to approximately 0.62 rem per year from background and manmade sources of radiation. This yearly dose has not been shown to cause harm to humans, including children and other sensitive populations (NRC, 2018).* (NASA, 2020)

Once a clear, plain English explanation of radiation is provided, the necessary conditions for a release and the associated impacts are easier to explain.

6.1.3 Principle 3: Explain the Conditions Necessary for a Release

The probability of an inadvertent release of nuclear material is often dependent on the launch phase. A typical SAR considers a number of mission phases, including prelaunch, launch, ascent, and re-entry. However, when explaining impacts to the general public, it is important to keep the analysis as simple as possible so that it can be readily understood and still adequately present the potential impacts. Therefore, it is recommended that the NEPA analysis for nuclear-enabled missions focus on the mission phase with the greatest potential consequence, instead of providing a sliding scale of potential impacts dependent on launch phase. By focusing on the mission phase with the highest potential impact, the document becomes more succinct, and the public is aware of the most conservative probability. This is not to say that risks from other phases should be ignored. Instead, an explanation should be given to clarify that the worst-case exposure calculations are provided to give a conservative estimate of the potential impacts, then any other potential impacts from later launch phases or to different individuals can be discussed qualitatively.

For radioisotope-based systems, the most credible potential for an adverse health effect from a launch mishap would be from the aerosolization of the radioisotope material. This potential has been analyzed repeatedly during the Nuclear Launch Safety Approval Process for radioisotope-based system missions, and the following scenarios have been found to be the bounding[1] conditions for a release of vaporized radioisotope material:

- **Onsite Release:** A sustained exposure to burning solid fuel or a liquid propellant fire could result in the release of a measurable amount of vaporized radioisotope material during an incident on or near the launch pad during the launch and ascent phase. This scenario is referred to as a "full-stack impact" and represents the upward boundary of a potential release. This occurrence is extremely unlikely[2], as it would require burning fuel to land on, or very close to, the RPS. NASA designs its missions to avoid this potential scenario.
- **Offsite Release:** A suborbital (below low Earth orbit) space vehicle mishap could occur along the vehicle flight path, which could result in the RHU or RTG unintentionally returning to Earth beyond the launch area. RHUs and RTGs are designed to withstand the re-entry environment and would be able to withstand most suborbital accidents. Furthermore, the rocket boosters, which contain the rocket fuel, are jettisoned relatively early in the flight sequence, thereby greatly lowering the potential and quantity of released radioisotope material, as proximity to burning fuel represents the upward bounds of potential release scenarios. Therefore, the potential of a radioisotope material release is extremely unlikely in this scenario.

The release scenarios for a fission reactor are different. A nuclear reactor does not present a significant radiological hazard unless it achieves sustained criticality, which is not possible for a Pu-238-based system because there is no fission chain reaction. United Nations Resolution 47/68 sets out a non-binding principle that nuclear reactors should not be made critical before they have achieved their operating orbit or interplanetary trajectory. This is consistent with NASA working group recommendations for nuclear propulsion, which clarify, "*the reactor should not be operated prior to space deployment, except for low power testing on the ground, for which negligible radioactivity is produced*." Therefore, although the quantity of material may be much greater in a fission reactor, assuming no criticality occurs, the health effects of dispersed radioactive material are small compared to a Pu-238-based system. Nonetheless, inadvertent criticality is a potential scenario and could occur during accidents involving launch and ascent or unintended hot re-entry, including failure to reach orbit. Although this likelihood is very small, it is not zero; therefore, it should be discussed during the NEPA process.

6.1.4 Principle 4: Rely on Existing Information to the Degree Possible

NASA has prepared programmatic and mission-specific NEPA documents to evaluate the probability and consequences of a health effect resulting from the use of nuclear material in payloads for every mission using

[1] In this sense, "bounding" refers to the greatest potential for harm. Other release scenarios are possible; however, both the probability of the event and potential dose would be substantially less.

[2] The term "extremely unlikely" is based on DOE guidelines for risk (DOE Standard 3009) and represents a 1 in 10,000 (100 times per 1,000,000) to a 1 in 1,000,000 chance of occurrence.

nuclear material since 1989. In addition, NASA and DOE have coordinated the preparation of mission-specific SARs and nuclear risk assessments (NRAs) to inform the NEPA analysis concerning the risk of release and the health effects if such a release were to occur. The NRA process was specifically developed to allow NASA to conduct a NEPA review prior to completing a SAR to reduce associated schedule risks. An NRA follows a composite approach that combines data from all potential launch vehicles; conversely, a SAR is conducted once a single launch vehicle has been selected. Although mission-specific NRAs can provide increased fidelity regarding the probability and significance of potential environmental impacts, preparation of an NRA is an exceedingly extensive process and is not a requirement of the NEPA process. Specifically, the CEQ NEPA implementing regulations encourage the use of existing data and clarifies that new scientific studies and technical research is not warranted (40 CFR Section 1502.23).

Alternatives to the NRA include engagement with DOE to conduct modeling, which will inform the decision maker, or to adopt analysis prepared for an action that likely has similar environmental effects. For these reasons, it is possible to forego the NRA process and reference previous work for Pu-238-based system missions without increasing vulnerabilities in the NEPA process. Potential opportunities for more efficiently determining the probability and consequence of nuclear-enabled missions are determined by DOE and could include the following:

- **Consequence Analysis:** Develop scoping calculations based on previous analyses to provide a conservative estimate of radiological dose from a specific system and bound the upper limits of a potential impact. This calculation is typically performed by DOE and was conducted for the NASA RHU PEA.
- **Documented Safety Analysis (DSA):** DOE STD-3009, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*, describes the methodology for preparing a DSA for nonreactor nuclear facilities per 10 CFR Part 830. A DSA includes a hazard analysis, accident analysis, and hazard control considerations. A single generic launch vehicle configuration would be used to develop bounding values for fuel and other variables and the mission phase with the greatest potential for accident and health impact should be considered. The DSA is prepared by DOE.

The Nuclear Launch Safety Approval Process for fissionable material is not as mature as the radioisotope--based system approval process, primarily because no nuclear fission projects have been launched by NASA since the inception of NEPA in 1970, and no nuclear fission program has progressed completely through the process established by the now expired Presidential Directive (PD)/National Security Council (NSC) 25 (replaced by NSPM-20). Therefore, it will be necessary for NASA HQ, in coordination with DOE, to conduct a detailed safety analysis specific to fission reactors prior to the NEPA assessment. However, the safety review effort should be commensurate with the potential consequences and probability of mishap. For example, if a reactor system is not designed to operate in low Earth orbit and does not include a flyby or return to Earth scenario, then the issues associated with post-operation criticality are not applicable and should greatly simplify the safety analysis. For most reactor programs, the only concern will be with inadvertent criticality, and program engineers have a design goal to reduce inadvertent criticality to a very low probability. Nevertheless, inadvertent criticality events could result in high, localized radiation doses; therefore, an effort needs to be made to better understand the probability and potential consequences of inadvertent criticality.

6.1.5 Principle 5: Clearly State the Potential Level of Impact

The measure of significance should depend on whether a potential launch of nuclear material presents an unacceptable potential impact to the public. Therefore, it is important to rely on established regulatory guidelines to defend a significance determination. Table 6-1 provides a comparison of potential probability and consequence scenarios and recommended impact thresholds. These thresholds are based on established guidance by EPA, DOE, and NRC, which are presented in Tables 6-2 and 6-3.

TABLE 6-1
NEPA Impact Thresholds for Radiation Exposure

MEI Exposure (Member of the Public)[c]	Annual Probability of Airborne Release[a, b]			
	Beyond Extremely Unlikely (< 1:1,000,000[d])	Extremely Unlikely (1:10,000 to 1:1,000,000)	Unlikely (1:100 to 1:10,000)	Likely (1:1 to 1:100)
> 25 rem	Negligible	Moderate	Significant	Significant
5 rem to 25 rem	Negligible	Minor	Moderate	Moderate
0.025 rem to 5 rem	Negligible	Minor	Minor	Moderate
< 0.025 rem	Negligible	Negligible	Negligible	Negligible

[a] Probability thresholds are based on definitions provided in DOE-STD-3009-2014.
[b] Activities in the red or "significant" threshold, would generally require an EIS; activities in "negligible," "minor," or "moderate" thresholds would generally require an EA, assuming there are no other significant impacts associated with the mission.
[c] A general member of the public is defined as an individual who is outside the restricted area around a launch site.
[d] 1:1,000,000, or 1E-6, is defined as an acceptable level of risk by EPA (1991), FAA (2000), USAF (2019), and DOE (1994).
MEI = maximum exposed individual
rem = Roentgen Equivalent Man

TABLE 6-2
Established Radiation Dose Guidelines for Background Exposure

Guideline	Dose (rem)	Regulation/Authority
Exposure of the Public to Nuclear Operations	0.1 rem/ year	NRC 10 CFR 20.1301 DOE O458.1
EPA Limit for Routine Public Exposure Near a Nuclear Facility	0.025 rem/year	EPA 40 CFR Part 190
Total Average Background Radiation	0.36 rem/year 25 rem/lifetime	DOE-STD-3009-2014
Total Average Annual Dose	0.62 rem/year 43 rem/lifetime	NRC[a]

[a] NRC, 2017 (https://www.nrc.gov/about-nrc/radiation/around-us/doses-daily-lives.html)
CFR = *Code of Federal Regulations*
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
NRC = U.S. Nuclear Regulatory Commission
rem = Roentgen Equivalent Man

TABLE 6-3
Established Radiation Dose Thresholds for Accident Exposure

Guideline	Dose (rem)	Regulation/Authority
Known Threshold for a Health Impact	10 rem	EPA[a]
Adequate Protection Guideline for a Nuclear Accident (including reactors)	25 rem/incident	DOE-STD-3009-2014
DOE Co-located Worker Evaluation Guideline	100 rem/incident (lowest dose to cause acute radiation sickness)	DOE-STD-3009-2014

[a] EPA, 2019 (https://www.epa.gov/radiation/radiation-health-effects#acuteeffects)
CFR = *Code of Federal Regulations*
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
rem = Roentgen Equivalent Man

When presenting potential consequences of radiation exposure, the focus should be on established regulatory guidelines and known typical exposure rates (Tables 6-2 and 6-3) and comparing those thresholds to dose that result from accidents. Radiation exposure from a launch incident would manifest as a passing

cloud of radiation, which would dissipate over a distance. Consequently, the thresholds for significance of a launch mishap should be greater than annual operational limits. For example, the EPA threshold for annual radiation exposure from drinking water is 0.004 rem (40 CFR Part 141), but this represents a continual exposure rate, not a one-time exposure from a launch incident involving nuclear material. The 25-rem evaluation guideline used by DOE is appropriate for use in determining significance in a NEPA document because it is generally accepted as a value indicative of no significant health effects for a single lifetime exposure (that is, represents a low chance of latent cancer).

The tools identified in Section 6.1.4 (scoping calculations and DSAs) should be used to obtain the probability and consequences of the proposed action and the finding should be compared to Table 6-1. The requirements of NSPM-20 and the creation of a SAR should also be detailed in the NEPA document, as this process serves as a form of mitigation to ensure NASA does not launch a high-risk mission. However, as explained in Section 6.1.4, a SAR is not necessary for NEPA.

6.2 Resources of Concern

The CEQ NEPA regulations require a NEPA document to consider the environmental resources that could be impacted from a proposed action. The following sections provide a discussion of the resources that are common in NEPA documents involving nuclear activities. These sections are intended to help the NEPA practitioner think through the potential effects from a proposed nuclear activity and are not meant to be a comprehensive list.

When detailing potential impacts, remind the reader that under normal operating conditions, there would be no potential effects from radiation exposure to any resources. It is only after a launch mishap or inadvertent criticality that the potential for radiation exposure exists. The following guidance focuses on resource considerations after a release of nuclear material.

6.2.1 Radiation Exposure

The radiation exposure section is meant to serve as the traditional health and safety section of a NEPA document. This section is meant to explain the potential impact to the public and workers from radiation exposure, it is the most critical component of a NEPA document involving nuclear activities. It is important to write about this resource so that it is readily understandable by the general public. The principles provided in Section 6.1, *Evaluating Radiation Exposure in a NEPA Context*, are meant to help craft the affected environment and environmental consequences sections for radiation exposure.

In addition to the health impacts associated with radiation exposure, NEPA documents should also address safety potential impacts associated with the diversion of special nuclear materials or nuclear reactor fuel, including highly enriched uranium. This potential impact can be addressed by explaining the engineered safety features of the payloads and operational commitments that NASA and DOE have implemented for the security and recovery of special nuclear material. If highly enriched uranium is not to be used, the NEPA documents should briefly explain that proliferation is not a concern. It is also important to explain that NASA has established nuclear safety procedures, including trained personnel onsite, and established local, state, and national contingency requirements.

6.2.2 Land Use

Land contamination due to radiation exposure after a launch mishap is another important consideration in a NEPA document involving nuclear activities. Historically, NASA has been conservative in presenting these impacts in EISs by not accounting for mitigation commitments detailed in the Atomic Energy Act. NEPA documents should inform the public of technological advances and resource commitments made in radiological contingency planning and risk communication and take credit for these as mitigation measures under NEPA.

DOE has recommended NASA use the MEI as a de facto impact for land contamination because the MEI accounts for exposure to humans from a land contamination vector. Alternatively, or in addition to MEI, a discussion of the U.S. Department of Agriculture crop contamination Derived Intervention Levels could be included as a relevant impact (7.3 microcuries per square meter).

6.2.3 Biological Resources

Terrestrial and aquatic species receive external and internal doses of radiation from inhalation, ingestion, and immersion, similar to the exposure pathways experienced by humans. Ecological protection programs are based on the premise that radiological protection for humans also provides conditions that adequately protect wildlife (International Atomic Energy Agency, 2014). This is also true for small mammals and invertebrates; given their shorter life spans, the probability of experiencing a health effect from radiation exposure is greatly reduced. Therefore, when describing the potential effect to wildlife, reiterate the potential effects to humans, which should be provided in the radiation exposure section of the NEPA document. To the extent threatened or endangered species and designated critical habitat may be adversely affected or modified, the NEPA practitioner should ensure the effects are documented and informal consultation with the USFWS and National Oceanic and Atmospheric Administration Fisheries (National Marine Fisheries Service) is initiated early in the development of the NEPA document. An example of this consultation is provided in Appendix D.

6.2.4 Water Resources

Most launch complexes in the United States are located near major water bodies; consequently, there could be a potential deposition of contamination to surface water. It is best to focus on the insolubility of the nuclear material and explain the limited probability of inhalation of the material, even by aquatic species.

6.2.5 Cultural Resources

A release of nuclear material could result in the deposition of radioactive material on a cultural resource. This is particularly likely because launch complexes themselves are often listed, or are eligible for listing, on the National Register of Historic Places (NRHP). Unidentified archeological resources could also be encountered during the cleanup of contamination. However, the actual effects of potential contamination on the necessary cleanup measures are not realistically predictable. Therefore, it is important to focus on the low probability of the incident and explain NASA's commitments under Section 106 of the NHPA, which would require consultation with the applicable State Historic Preservation Office if cleanup activities were to affect a cultural site. An example of an NHPA consultation is provided in Appendix E.

6.2.6 Hazardous Materials

Nuclear materials such as plutonium and uranium are inherently hazardous and meet the definition of a hazardous material under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Therefore, nuclear materials should be given consideration in the hazardous material section of a NEPA document. However, given the security infrastructure, safety controls, and response and recovery policies and procedures that are in effect during every launch, the potential impacts from the use of nuclear material should be less than significant. It is the responsibility of the NEPA professional to obtain a list of these requirements and ensure they are being implemented.

6.2.7 Cumulative Impacts

A cumulative impact is defined as an impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes the action. However, another activity would have to coincide with a mishap, resulting in a release of radiation, which would be an extremely unlikely event. Nonetheless, a cumulative impacts analysis should take into account the nuclear activities within the region of the launch site, as this is a common concern for the public. For example, are there nuclear power plants in the vicinity of the Center or are other launches of nuclear materials planned from an adjacent facility? Once the potential cumulative activities are stated, explain that the possibility of the activities affecting the same resources during the same time period (a requirement for a cumulative impact to be realized) is exceedingly remote.

SECTION 7

Acronyms

AA	associate administrator
C	degree Celsius
Caltech	California Institute of Technology
CatEx	categorical exclusion
CCAFS	Cape Canaveral Space Force Station
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CZMA	Coastal Zone Management Act
DOE	U.S. Department of Energy
DRPS	dynamic radioisotope power system
DSA	documented safety analysis
EA	environmental assessment
EIS	environmental impact statement
EMD	Environmental Management Division
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FFRDC	Federally Funded Research and Development Center
FONSI	finding of no significant impact
FSP	fission surface power
GRC	Glenn Research Center
HEOMD	Human Exploration and Operations Mission Directorate
HQ	Headquarters
ICRP	International Commission on Radiological Protection
JPL	Jet Propulsion Laboratory
KSC	Kennedy Space Center
kW_E	kilowatt-electric
LWRHU	light-weight radioisotope heater unit
LSP	launch safety program
MEI	maximum exposed individual
MMRTG	multi-mission radioisotope thermoelectric generator
MOU	memorandum of understanding
MW_T	megawatt-electric
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NEP	nuclear electric propulsion
NETS	NASA Environmental Tracking System
NHPA	National Historic Preservation Act
NPR	NASA Procedural Requirement
NRA	nuclear risk assessment
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NSC	National Security Council
NTP	nuclear thermal propulsion
NSPM-20	*National Security Presidential Memorandum No. 20*
OCHMO	Office of the Chief Health and Medical Officer
OGC	Office of General Counsel
OIIR	Office of International and Interagency Relations
OLIA	Office of Legislative and Intergovernmental Affairs
OSMA	Office of Safety and Mission Assurance
PD	Presidential Directive
PE	program executive

PEA	programmatic environmental assessment
PEIS	programmatic environmental impact statement
Pu-238	Plutonium-238
REC	record of environmental consideration
rem	Roentgen Equivalent Man
RHU	radioisotope heater unit
ROD	record of decision
RPO	radiation protection officer
RPS	radioisotope power system
RSO	radiation safety officer
RTG	radioisotope thermoelectric generator
SAR	safety analysis report
SMD	Science Mission Directorate
SNAP	Systems for Nuclear Auxiliary Power
SNP	space nuclear propulsion
STMD	Space Technology Mission Directorate
U.S.	United States
USAF	U.S. Air Force
USFWS	U.S. Fish and Wildlife Service
USSF	U.S. Space Force

SECTION 8

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Appendix A
Relevant NEPA Documents

APPENDIX A

Relevant NEPA Documents

NEPA Documents – Non-nuclear Spacecraft and Launch Site

The National Aeronautics and Space Administration (NASA), the U.S. Air Force (USAF), the U.S. Space Force (USSF), and the Federal Aviation Administration (FAA) have completed multiple National Environmental Policy Act (NEPA) analyses covering the routine activities of space launches at Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS) and the associated non-nuclear payloads.

- **Environmental Assessment (EA) for Operation and Launch of the Falcon 1 and Falcon 9 Space Vehicles at CCAFS, Florida** – The proposed action was to launch the Falcon 1 and 9 vehicles using Space Launch Complex (LC) 40, construction of a new facility, and recovery of launch vehicles. The EA analyzed potential environmental impacts of the proposed action and action alternatives to land use/visual resources, noise, biological resources, cultural resources, air quality, orbital debris, hazardous waste/hazardous materials, water resources, geology and soil, transportation, utilities, health and safety, socioeconomics, and environmental justice. The EA resulted in a finding of no significant impact (FONSI) (https://apps.dtic.mil/sti/pdfs/ADA611861.pdf).
- **Supplemental EA for Space Florida Launch Site Operator License at LC 46** – The proposed action was for FAA to issue a Launch Site Operator License to Space Florida to operate a launch facility at LC-46 at CCAFS. The potential impacts of the proposed action and action alternatives were analyzed in the EA, including the potential environmental impacts of successful launches on air quality, biological resources, water resources, noise, land use, socioeconomic, hazardous materials, solid waste, and pollution. The EA resulted in a FONSI (https://www.faa.gov/about/office_org/headquarters_offices/ast/media/Sept%202008%20Space%20Florida%20EA%20and%20FONSI.pdf).
- **EA for Launch of NASA Routine Payloads** – The proposed action comprised preparing, launching, and decommissioning missions designated as routine payloads. CCAFS and KSC were included as potential sites. The EA analyzed the potential environmental impacts to resources, including air quality, public health and safety, hazardous materials, geology/soils/land resources, water resources, noise/sonic boom, biological resources, cultural resources, socioeconomic factors, and environmental justice, orbital and re-entry debris, perchlorate deposition, stratospheric ozone depletion, and global warming. The EA resulted in a FONSI (https://netspublic.grc.nasa.gov/main/Routine%20Payload.pdf).
- **EA for Multi-use of Launch Pads 39A and 39B, KSC, Florida** – The proposed action was to allow multiple users, including commercial users, to prepare and launch vehicles from KSC LC-39A and LC-39B. The EA analyzed the following resource areas in detail: land use, facilities and infrastructure, health and safety, water quality, atmospheric environment, noise and vibration, biological resources, geology and soils, historic and cultural resources, hazardous materials and waste management, global environment, socioeconomics and children's environmental health and safety, orbital and re-entry debris, and aesthetics. The EA resulted in a FONSI (https://netspublic.grc.nasa.gov/main/finalMultiuseEA.pdf).
- **EA for Crew Dragon Pad Abort Test at LC-40, CCAFS, Florida** – The proposed action was for FAA to issue a launch license to Space Exploration Technologies (SpaceX) for the Crew Dragon abort test at LC-40 at CCAFS. The EA resulted in a FONSI (https://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/nepa_docs/review/launch/media/Draft_EA_for_SpaceX_In-flight_Dragon_Abort_508.pdf).
- **EA, Blue Origin Orbital Launch Site at CCAFS, Florida** – The proposed action was to construct and operate an Orbital Launch Site at the combined areas of LC-11 and LC-26 at CCAFS. The commercial facility would contain infrastructure to test rocket engines, integrate launch vehicles, and conduct launches of liquid-fueled, heavy-life-class orbital vehicles. Blue Origin would sign a lease directly with USAF for both LC-11 and LC-36. The EA analyzed land use/visual resources, noise, biological resources, cultural resources, air quality, climate, hazardous materials/waste, orbital debris, water resources,

geology and soils, transportation, utilities, health and safety, socioeconomics, environmental justice, and U.S. Department of Transportation Act Section 4(f) properties. The EA resulted in a FONSI.

- **Supplemental EA to the Space Exploration Technologies (SpaceX) Vertical Landing of the Falcon Vehicle and Construction EA at Launch Complex 13, CCAFS, Florida** – The proposed action included the construction of two additional landing pads and a small temporary processing building and operations that support landing of additional vehicles at LC-13 (LZ-1) at KSC. The Supplemental EA analyzed effects to land use, noise, biological resources, cultural resources, air quality, climate, hazardous materials/waste, water resources, geology/soils, transportation, utilities, health and safety, socioeconomics, and 4(f) properties. The supplemental EA resulted in a FONSI (https://www.patrick.af.mil/Portals/14/documents/3-27-2017%20Final%20SpaceX%20LZ-1%20SEA-2.pdf?ver=2017-03-27-150629-603).
- **KSC Center-Wide Operations Final Programmatic Environmental Impact Statement (PEIS)** – The PEIS was prepared to evaluate the potential environmental impacts from proposed center-wide KSC operations, activities, and facilities for planning horizons across a 20-year planning horizon. These operations, activities, and facilities are described in the 2013 Center Master Plan. Implementation of the Center Master Plan will facilitate a transformation from a single, government-user LC to a multi-user spaceport. The PEIS analyzed potential impacts to soils and geology, water resources, hazardous materials and waste, air quality, climate change, acoustic environment (noise), biological resources, cultural resources, land use, transportation, utilities, socioeconomics, recreation, environmental justice and protection of children. Although there were adverse impacts associated with the implementation of the proposed action, none were significantly adverse. Because many of the impacts associated with the proposed action are related to the construction or operations of new projects, these environmental impacts would not accumulate by the increased use of RHUs. NASA issued a Record of Decision (ROD) in March 2017 (https://environmental.ksc.nasa.gov/EnvironmentalPlanning/EnvironmentalImpactStatement).
- **Final and Supplemental Final Environmental Impact Statement (EIS), Evolved Expendable Launch Vehicle Program (EELV), CCAFS and Vandenburg Air Force Base (VAFB)** – As part of the EELV Program, the proposed action was the development, deployment, and operation of EELV systems. EELV would use both medium and heavy lift systems at a lower launch cost than the present expendable launch systems. The proposed launch locations for the program were CCAFS and VAFB. The proposed action of the supplemental EIS was to allow the addition of up to five strap-on solid rocket motors on Atlas V life vehicle and to allow the use of larger solid rocket motors on the Delta IV lift vehicle. Both EISs analyzed potential impacts to the local community, land use and aesthetics, transportation, utilities, hazardous materials and hazardous waste management, health and safety, geology and soils, water resources, air quality, noise, orbital debris, biological resources, cultural resources, and environmental justice. Hazardous material and hazardous waste impacts would result from increased launch rates, due to the addition of commercial launches. Because the increased amount of materials and wastes would be consistent with those currently managed in accordance with applicable regulations, no significant impacts are expected. Health and safety impacts from launch-related failures are minimized to insignificant levels through implementation of applicable safety requirements and procedures at CCAFS. USAF issued a ROD in 2000.
  (https://www.faa.gov/about/office_org/headquarters_offices/ast/licenses_permits/media/eelvSEis.pdf)

NEPA Documents – Nuclear

NASA has studied the potential effects of using nuclear technology, including RHUs, through decades of NEPA documentation for major missions, which include EISs and EA in the following list.

- **Final EA for Mars Pathfinder Mission** – The purpose of the Mars Pathfinder Mission was to research the surface of Mars' northern hemisphere. Under the proposed action, the mission would deliver a small rover vehicle inside a landing craft to the surface of Mars and use three RHUs as a heat source. NASA issued a FONSI on October 24, 1994. The Mars Pathfinder launch occurred at CCAFS on December 4, 1996.
- **Final and Supplemental EIS for the Cassini Mission** – The purpose of the Cassini mission was to conduct research on Saturn, its atmosphere, moons, rings, and magnetosphere. Under the proposed action and action alternatives, the Cassini spacecraft incorporated three radioisotope thermal generators (RTGs) to provide onboard electric power and 117 RHUs to regulate spacecraft temperature. NASA issued a ROD selecting the proposed action on October 20, 1995. While the 1995 Cassini EIS analysis

used the best information available at that time, NASA and the U.S. Department of Energy (DOE) continued to evaluate additional accident scenarios specific to the Cassini spacecraft and its launch vehicle and trajectory. Substantial changes to the safety analysis resulted in NASA determining a need for a Supplemental EIS for the Cassini Mission. The proposed action and action alternative differentiated between primary and secondary launch opportunities and both planned to use three RTGs and up to 129 RHUs. NASA issued a Supplemental ROD selecting the proposed action on August 12, 1997. The Cassini launch occurred at CCAFS on October 15, 1997 (https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19990054126.pdf).

- **Final EIS for the Mars Exploration Rover (MER)** – The purpose of the MER was to conduct surface water observations on Mars. Under the proposed action, the MER-2003 project involved two launches, MER-A and MER-B, of identical spacecraft from CCAFS. Each rover required eight RHUs as a heat source. NASA issued a ROD selecting the proposed action in January 2003. The two MER launches occurred at CCAFS on June 10, 2003, and July 7, 2003 (https://spacescience.nasa.gov/admin/pubs/mereis/index.htm).
- **Final EIS for the Mars Exploration Program** – The purpose of the Mars Exploration Program was to further the program's science goals by continuing the exploration and characterization of the planet Mars. The proposed action (Alternative 1) consisted of a long-term program that would send at least one spacecraft to Mars during each launch opportunity at CCAFS or VAFB extending through the first two decades of the twenty-first century. Alternative 2 consisted of NASA continuing to explore Mars through 2020, but on a less frequent, less comprehensive, mission-by-mission basis from CCAFS or VAFB. Under Alternative 1 and Alternative 2, some spacecraft could use radioisotope power systems (RPS) for continuous electrical power and RHUs for thermal control. NASA issued a ROD selecting Alternative 1 in June 2005 (https://netspublic.grc.nasa.gov/main/MEP_ROD.pdf).
- **Final and Supplemental EIS for the Mars 2020 Mission** – The purpose of the Mars 2020 mission was to continue conducting comprehensive science on the surface of Mars and demonstrate technological advancements in the exploration of Mars. The Action Alternatives would implement different power sources for the Mars Rover, including RPS (Alternative 1, which was NASA's preferred alternative), solar arrays (Alternative 2), and solar arrays and RHUs (Alternative 3) to continually provide heat and electrical power to the rover. NASA issued a ROD selecting Alternative 1 on January 27, 2015. Substantial changes to the safety analysis resulted in NASA determining a need for a Supplemental EIS for the Mars 2020 mission. NASA issued a Supplemental ROD for the Mars 2020 mission on March 5, 2020, and the launch occurred on July 30 2020 (https://netspublic.grc.nasa.gov/main/mars2020_seis_rod.pdf).
- **Programmatic EA of Launches Involving RHUs** – The purpose of the document is to provide programmatic coverage of radioisotope heater units in spacecraft launched from KSC and CCAFS. DOE, USAF, and FAA are cooperating agencies. NASA issued a FONSI on February 13, 2020 (https://netspublic.grc.nasa.gov/main/3.04.001_RHU%20PEA%20FONSI%20signed.pdf).
- **EA for the Dragonfly Mission –** The purpose of the Dragonfly mission is to use a rotorcraft lander that would land on the surface of Saturn's largest moon, Titan, and explore multiple locations on the lunar surface and investigate the surface chemistry, atmospheric and surface properties, subsurface properties, liquid reservoirs, and areas where liquid water and complex organic materials that are key to life may have once existed. The rotorcraft lander would use a single MMRTG and up to 43 RHUs. NASA issued a FONSI on September 26, 2022.

The radioisotopes systems used by NASA are manufactured and assembled at three DOE facilities, including Los Alamos National Laboratory in New Mexico, Oak Ridge National Laboratory in Tennessee, and Idaho National Laboratory in Idaho. DOE is also responsible for the transportation of RHUs to the CCAFS or KSC launch site. The potential environmental impacts of these activities have previously been addressed in the following DOE NEPA documentation:

- **EA for the Import of Russian Plutonium-238 (Pu-238)** – DOE prepared an EA for the import of Pu-238 from Russia. The EA addressed the impacts of importing the Pu-238 from Russia and the processing of the fuel within the United States. The FONSI was signed on June 25, 1993 (http://energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/EA-0841-FONSI-1993.pdf).
- **Final Programmatic EIS for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Missions in the United States, Including the Role of the Fast Flux Test Facility** – Presented an evaluation of the environmental impacts associated with the proposed expansion

of nuclear capabilities for nuclear energy research and development activities and the production of Pu-238 to support future NASA space exploration missions. The ROD was signed on January 26, 2001 (https://www.energy.gov/nepa/downloads/eis-0310-final-programmatic-environmental-impact-statement).

- **EA for the Future Location of Heat Source/Radioisotope Power System Assembly and Test Operations Currently Located at the Mound Site** – The FONSI was signed on August 30, 2002 (https://www.energy.gov/sites/prod/files/migrated/nnsa/2017/11/f43/064_DOE%202003%20ISCORS.pdf).
- **Supplemental Analysis Programmatic EIS for Accomplishing Expanded Civilian Nuclear Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility –** Analyzed proposed changes in transportation and storage of Neptunium-237, the starting feed material for production of Pu-238. The proposed change is to move the Neptunium-237 storage location from Oak Ridge National Laboratory in Tennessee to Argonne National Laboratory in Idaho. The ROD was signed on August 5, 2004 (https://www.energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/EIS-0310-SA-01-2004.pdf).
- **Final Sitewide EIS for Continued Operation of Los Alamos National Laboratory** – Analyzed the potential environmental impacts associated with the continued operation of Los Alamos National Laboratory. The primary effects were associated with public risk due to radiation exposure, collective worker risk due to radiation exposure, socioeconomic effects due to employment changes, electrical power and water demand, waste management, and transportation. A classified appendix assesses the potential impacts of terrorist acts. The ROD, as amended, was signed in July 2011 (https://www.energy.gov/nepa/downloads/eis-0380-final-site-wide-environmental-impact-statement).
- **Supplemental Analysis for the Nuclear Infrastructure Programmatic EIS for Pu-238 Production for Radioisotope Power Systems** – Analyzed the potential environmental impacts associated with DOE maintaining the necessary nuclear material and infrastructure to supply Pu-238-fueled RPS to support NASA's missions. DOE determined that there are no significant changes from this Supplemental Analysis and the 2001 ROD from the 2004 Supplemental Analysis was implemented (http://energy.gov/sites/prod/files/2013/09/f2/EIS-0310-SA-02-2013_0.pdf).

Appendix B
Nuclear Launch Safety Approval Process

APPENDIX B

Nuclear Launch Safety Approval Process

The National Aeronautics and Space Administration (NASA) and the U.S. Department of Energy (DOE) follow a rigorous process to quantify the risks associated with launch-related accidents, including Earth atmosphere re-entry and post-re-entry impacts. Mission-specific analyses include launch-related safety analysis reports and safety evaluation reports issued by ad-hoc expert panels established to provide independent review and evaluation of the launch of nuclear material into space. These analyses quantify the risks associated with the use of nuclear material (Idaho National Laboratory, 2019).

The following directives, standards, and regulations apply to NASA's Nuclear Launch Approval Process. The following references are continuously updated, so it is important to work with the appropriate Center subject matter experts to obtain the latest version of a requirement.

International Agreements

- **1992 Principles Relevant to the Use of Nuclear Power Sources in Outer Space** – The United Nations (UN) outlines principles for nuclear power sources, including guidelines and criteria for safe use of nuclear material in space, safety assessment, and notification of re-entry (https://digitallibrary.un.org/record/159141?ln=en).
- **2009 Safety Framework for Nuclear Power Source Applications in Outer Space** – The UN and the International Atomic Energy Agency provide guidance for safety relevant to launch, operation, and end-of-service phases of space nuclear power source applications (https://digitallibrary.un.org/record/656411).
- **Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies** – Represents the basic legal framework of international space law. Among its principles, it bars parties to the treaty from placing weapons of mass destruction in orbit around the Earth, installing them on the Moon or any other celestial body, or otherwise stationing them in outer space. This treaty deals with nuclear weapons instead of radioisotope power systems (RPS). The use of RPS are compliant with this treaty because they are designed to provide only energy and heat to spacecraft; they cannot be used as weapons (https://2009-2017.state.gov/t/isn/5181.htm).

Executive Branch Requirements

- **National Security Presidential Memorandum No. 20 (NSPM-20)** – "Presidential Memorandum on Launch of Spacecraft Containing Space Nuclear Systems" updates the process for launches of spacecraft containing space nuclear systems. Space nuclear systems include radioisotope power systems (RPS), such as radioisotope thermoelectric generators (RTGs) and radioisotope heater units, and fission reactors used for power and propulsion (https://www.whitehouse.gov/presidential-actions/presidential-memorandum-launch-spacecraft-containing-space-nuclear-systems/).

NASA Agency-wide Directives and Requirements

A NASA directive with Agency-wide applicability includes NASA Policy Directives (NPDs) and NASA Procedural Requirements (NPRs). NPDs sets requirements by NASA management to achieve NASA's vision, mission, and external mandates and sets out who is responsible for carrying out those requirements. NPRs implement NASA's policy as delineated in an associated NPD. NPDs and NPRs are established at the NASA Headquarters (HQ) level.

- **NPR 1800.1D, NASA Occupational Health Program Procedures** – Establishes procedures for complying with the requirements of the NASA Occupational Health Program (https://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=1).
- **NPD 1800.2D, NASA Occupational Health Program** – Establishes responsibilities for complying with the requirements of the NASA Occupational Health Program (https://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=1).

- **NPR 7120.5, NASA Space Flight Program and Project Management Requirements** – Establishes a standard uniformity for the process by which NASA formulates and implements space flight programs and projects, including Science Mission Directorate (SMD) RPS Program (https://nodis3.gsfc.nasa.gov/npg_img/N_PR_7120_005E_/N_PR_7120_005E_.pdf).
- **NPR 7120.8, NASA Research and Technology Program and Project Management Requirements** – Establishes the process by which NASA will formulate and implement research and technology, including, but not limited to, scientific research, aeronautics research, and technology developed for space activities. Due to a wide range of activities, this NPR does not standardize their development into a single process; instead, it provides minimum management requirements for research and technology programs and projects that are tailorable to suit their type and complexity (https://nodis3.gsfc.nasa.gov/npg_img/N_PR_7120_008A_/N_PR_7120_008A_.pdf).
- **NPD 8500.1C, NASA Environmental Management** – Establishes responsibilities for complying with all applicable federal, state, and local environmental laws and regulations and NASA's requirements and agreements with other agencies, industry, and organization (https://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=8).
- **NPR 8715.1A, NASA Occupational Safety and Health Programs** – Provides requirements for NASA Occupational Safety and Health Programs for complying with Occupational Safety and Health Administration regulations (https://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=8).
- **NPR 8715.3D, NASA General Safety Program Requirements** – Provides NPRs for characterizing and reporting on potential risks associated with a planned launch of radioactive materials into space on launch vehicles and spacecraft during normal or abnormal flight conditions. Also provides institutional roles and responsibilities related to NASA health and safety programs (https://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=8). This requirement is proposed to be replaced for a standalone NPR for Nuclear Safety.
- **NPR 8715.2B, NASA Emergency Management Program Procedural Requirements** – Sets requirements for developing emergency management programs, plans, and procedures and for effectively working within the protocol of the National Response Framework and National Incident Management System (https://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=8).
- **NPD 8610.7D, Launch Services Risk Mitigation Policy for NASA-Owned and/or NASA-Sponsored Payloads/Missions** – Provides guidance for assigning categories of risk to launch vehicles (high risk, medium risk, and low risk) and required mitigation of the risk through a launch vehicle certification process (https://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=8).
- **NPD 8610.23C, Launch Vehicle Technical Oversight Policy** – Provides approval and insight requirements for the technical oversight of launch services provided by commercial launch service providers. NASA remains accountable for the success of its missions launched with commercially provided launch services, because launch remains an element affecting mission success (https://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=8).
- **NPD 8610.24C, Launch Services Program Pre-launch Readiness Reviews** – Provides NASA management guidelines to assess and certify the flight readiness of launch vehicles, readiness of payload support hardware and software, and readiness of the launch site infrastructure prior to launch through a structured pre-launch review process (https://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=8).
- **NPR 8705.2C, Human-rating Requirements for Space Systems** – Defines and implements the additional processes, procedures, and requirements necessary to produce human-rated space systems that protect the safety of the crew and passengers on NASA space missions (https://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=8).
- **NPR 8705.4, Risk Classification for NASA Payloads** – Establishes baseline criteria that enable a user to define the risk classification level for NASA payloads on human- or nonhuman-rated launch systems or carrier vehicles and the design and test philosophy and the common assurance practices applicable to each level. The establishment of the risk level early in programs and projects provides the basis for program and project managers to develop and implement appropriate mission assurance and risk management strategies and requirements and to effectively communicate the acceptable level of risk (https://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=8).

- **NPR 8705.5A, Technical Probabilistic Risk Assessment (PRA) Procedures for Safety and Mission Success for NASA Programs and Projects** – Provides basic requirements for performing a PRA for NASA programs and projects. It addresses technical, mission success, safety, and health risks. It does not address programmatic risk involving consideration of cost and schedule (https://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=8).
- **NPR 8705.6D, Safety and Mission Assurance (SMA) Audits, Reviews, and Assessments** – Establishes requirements for conducting audits, reviews, and assessments to verify compliance with applicable NASA SMA requirements as required by NPD 1000.3 and NPD 8700.1, in accordance with NPD 1210.2 (https://nodis3.gsfc.nasa.gov/lib_docs.cfm?range=8).

NASA Center-Specific Requirements

NPDs and NPRs are HQ-level documents that take precedence over Center-level documents. Typically, each Center issues Policy Directives or Procedural Requirements that are written to support NASA HQ documents at the local level. Centers may also issue plans or other directions that support the implementation of one of the higher-level documents or cover capabilities that are unique to that Center. Center personnel should verify whether additional Center-level requirements exists. The following entries are examples of Center-level requirements that are applicable to NASA operations at Kennedy Space Center (KSC):

- **KSC-PLN-1903, KSC Radiological Contingency Plan for Major Radiological Source Missions** – Levies requirements primarily on the launch site and launch vehicle.
- **Kennedy NASA Procedural Requirements (KNPR) 8500.1B-1, KSC Environmental Requirements** – Provides direction for implementing environmental requirements in support of KSC operations (https://businessworld.ksc.nasa.gov/BusinessWorld/HomeSubNav/BusinessDocs/KSCDirectives).
- **Kennedy NASA Policy Directive (KNPD) 1860.1B-5, KSC Radiation Protection Program** – Provides direction for implementing the KSC Radiation Protection Program in support of KSC operations (https://businessworld.ksc.nasa.gov/BusinessWorld/HomeSubNav/BusinessDocs/KSCDirectives).
- **KNPR 1860.2B, KSC Nonionizing Radiation Protection Program** – Provides direction for implementing the KSC Nonionizing Radiation Protection Program (https://businessworld.ksc.nasa.gov/BusinessWorld/HomeSubNav/BusinessDocs/KSCDirectives).
- **KNPR 1860.1B-1, KSC Ionizing Radiation Protection Program** – Provides direction for implementing the KSC Ionizing Radiation Protection Program (https://businessworld.ksc.nasa.gov/BusinessWorld/HomeSubNav/BusinessDocs/KSCDirectives).

U.S. Air Force

- **Title 32 *Code of Federal Regulations* (CFR) Part 989, U.S. Air Force (USAF) Environmental Impact Analysis Process** – Implements USAF Environmental Impact Analysis Process and provides procedures for environmental impact analysis both within the United States and abroad (https://www.ecfr.gov/cgi-bin/text-idx?SID=e0df7ed1882cd70db04798f0f2134218&mc=true&tpl=/ecfrbrowse/Title32/32CVIIsubchapT.tpl).
- **Air Force Space Command (AFSPC) Manual 91-710, Range Safety User Requirements Manual, Volume 3, Launch Vehicles, Payloads, and Ground Support Systems Requirements** – Establishes the safety program requirements and minimum design, test, inspection, hazard analyses, and data requirements for hazardous and safety critical launch vehicles, payloads, and ground support equipment, systems, and materials for AFSPC ranges, including the Eastern Range and Western Range (https://static.e-publishing.af.mil/production/1/afspc/publication/afspcman91-710v3/afspcman91-710v3.pdf).
- **Air Force Instruction (AFI) 91-110, Nuclear Safety Review and Launch Approval for Space or Missile Use of Radioactive Material and Nuclear Systems** (*currently being updated*) – Establishes the system safety program requirements and minimum design, test, inspection, hazard analyses, and data requirements for hazardous and safety critical launch vehicles, payloads, and ground support equipment systems, and materials for AFSPC ranges. This includes radioactive sources (USAF, 2015).
- **AFI 91-217, Space Safety and Mishap Prevention Program** – Provides guidance for developing and implementing a comprehensive Space Safety and Mishap Prevention Program for existing and future

space systems. Contains the minimum acceptable risk criteria required for safe space operations and testing (https://static.e-publishing.af.mil/production/1/af_se/publication/afi91-217/afi91-217.pdf).

- **AFI 40-201, (45th Space Wing Supplement) Radioactive Materials (RAM) Management** – Provides personnel guidance on the procedures for the acquisition, receipt, security, use, storage, transfer, transport, distribution, and disposal of all RAM in USAF (https://static.e-publishing.af.mil/production/1/45sw/publication/afi40-201_45swsup/afi40-201_45swsup.pdf).
- **AFI 48-148, Ionizing Radiation Protection** – Defines responsibilities for the protection, monitoring, and medical follow-up of military personnel for the full spectrum of military operations. Applies to uniformed USAF personnel, USAF civilians, and individuals living on USAF installations who might be exposed to radiation (https://static.e-publishing.af.mil/production/1/af_sg/publication/afi48-148/afi48-148.pdf).
- **Department of Defense Instruction 3100.12, Space Support** – Implements policy, assigns responsibilities, and prescribes guidelines and procedures regarding the space support mission area. Space support mission area includes launching and deploying space vehicles, maintaining and sustaining spacecraft on-orbit, and deorbiting and recovering space vehicles, if required (https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/310012p.pdf).

Federal Aviation Administration

- **Commercial Space Launch Act** – Authorizes the U.S. Department of Transportation and, through delegations, the Federal Aviation Administration (FAA) Office of Commercial Space Transportation (AST), to oversee, authorize, and regulate both launches and re-entries of launch and re-entry vehicles, and the operation of launch and re-entry sites when carried out by U.S. citizens or within the United States. (https://uscode.house.gov/view.xhtml?path=/prelim@title51/subtitle5/chapter509&edition=prelim)
- **FAA Order 1050.1F, Environmental Impacts: Policies and Procedures** – Serves as FAA's policy and procedures for compliance with NEPA and implementing regulations issued by the CEQ. The provisions of this order apply to actions directly undertaken by FAA and to actions undertaken by a non-federal entity where FAA has authority to condition a permit, license, or other approval (https://www.faa.gov/documentLibrary/media/Order/FAA_Order_1050_1F.pdf).
- **Title 14 CFR Parts 401, 431, 435, 440 and 460, Human Space Flight Requirements for Crew and Space Flight Participants** – Establishes requirements for human space flight as required by the Commercial Space Launch Amendments Act of 2004, including rules on crew qualifications and training and informed consent for crew and space flight participants. The requirements include an acceptable level of safety to the public and ensure individuals on board are aware of the risks associated with a launch or re-entry (https://www.ecfr.gov/cgi-bin/text-idx?SID=85107591d8a4e3df682b6b8698a28f43&mc=true&tpl=/ecfrbrowse/Title14/14cfrv4_02.tpl#400).
- **Title 14 CFR Parts 413, 414, 415, and 417, License Application Procedures and Safety Approval** – Establishes requirements for FAA launch safety approval and FAA license application procedures. Experimental permit is an authorization issued by FAA to allow an experimental reusable suborbital rocket to launch or reenter. A permit is an alternative to licensing (https://www.ecfr.gov/cgi-bin/text-idx?SID=85107591d8a4e3df682b6b8698a28f43&mc=true&tpl=/ecfrbrowse/Title14/14cfrv4_02.tpl#400).

U.S. Department of Energy

- **Title 10 CFR Part 830, Nuclear Safety Management** – Governs the conduct of DOE contractors, DOE personnel, and other persons conducting activities, including providing items and services, that affect, or may affect, the safety of DOE nuclear facilities and the handling of nuclear material; however, it excludes launches (https://www.ecfr.gov/cgi-bin/text-idx?SID=85107591d8a4e3df682b6b8698a28f43&mc=true&node=pt10.4.830&rgn=div5).
- **DOE Standard Preparation Guide for DOE Nonreactor Nuclear Facility Documented Safety Analysis (DOE-STD-3009-2014)** – Describes a method for preparing a Documented Safety Analysis that is acceptable to DOE for nonreactor nuclear facilities (https://www.standards.doe.gov/standards-documents/3000/3009-astd-2014).
- **DOE Technical Report No. 1, Estimating Radiation Risk from Total Effective Dose Equivalent (DOE/EH-412/0015/0802)** – Guidance from the Interagency Steering Committee on Radiation Standards

on calculating radiation risk estimates from dose (http://ulpeis.anl.gov/documents/dpeis/references/pdfs/DOE_2003.pdf).

- **DOE Order 458.1 Radiation Protection of the Public and the Environment** – Sets requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of the DOE pursuant to the Atomic Energy Act of 1954, as amended (https://www.directives.doe.gov/directives-documents/400-series/0458-1-border-admc3).
- **Title 10 CFR Part 835, Occupational Radiation Protection** – Establishes radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities (https://www.ecfr.gov/cgi-bin/text-idx?SID=e0cf4aadfa488c4434b967cb64f30500&mc=true&node=pt10.4.835&rgn=div5).

Nuclear Regulatory Commission

- **Title 10 CFR Part 20, Standards for Protection Against Radiation** – Establishes standards to protect against ionizing radiation resulting from activities conducted under licenses issued by the U.S. Nuclear Regulatory Commission. These regulations are issued under the Atomic Energy Act and the Energy Reorganization Act. The purpose of the regulation is to control the receipt, possession, use, transfer, and disposal of licensed material by any licensee in a manner so that the total dose to an individual does not exceed the standards for protection against radiation prescribed in this regulation. Part 20.1301, Radiation Dose Limits for Individual Members of the Public, establishes radiation dose limits for the public (https://www.ecfr.gov/cgi-bin/text-idx?SID=8cdd6798fd0d067b6fb48cb52bc11e78&mc=true&node=pt10.1.20&rgn=div5).
- **Atomic Energy Act** – Promotes the utilization of atomic energy for peaceful purposes to the maximum extent consistent with the common defense and security and with the health and safety of the public (https://uscode.house.gov/view.xhtml?path=/prelim@title42/chapter23&edition=prelim).

U.S. Environmental Protection Agency

- **Title 40 CFR Part 141, National Primary Drinking Water Regulations** – Establishes U.S. Environmental Protection Agency (EPA) standards for contaminants in drinking water and related regulations applicable to public water systems (https://www.ecfr.gov/cgi-bin/text-idx?SID=6a70a433b24e144380e3d3b7ce7244b6&mc=true&node=pt40.25.141&rgn=div5).
- **Federal Guidance Report No. 13, Cancer Risk Coefficients for Environmental Exposure to Radionuclides (EPA 402-R-99-001)** – Provides numerical factors for use in estimating the risk of cancer from low-level exposure to radionuclides (https://www.epa.gov/radiation/federal-guidance-report-no-13-cancer-risk-coefficients-environmental-exposure).
- **Protective Action Guides Manual: Protective Action Guides and Planning Guidance for Radiological Incidents (EPA-400/R-16/001)** – Assists officials in planning for emergency response to radiological incidents (https://www.epa.gov/radiation/pag-manuals-and-resources).

Federal Emergency Management Agency

- **National Response Framework** – Guides government response to all types of disasters and emergencies. Sets responsibilities for the Federal Emergency Management Agency (FEMA) (https://www.fema.gov/media-library/assets/documents/117791).

Regional Requirements

Occasionally, other state, regional, and county-level policies may apply to NASA's use of nuclear material in addition to the directives, standards, and regulations previously discussed in this section. Center personnel should verify whether additional regional requirements exist. The following entries are examples of additional considerations for NASA operations in Florida:

- **Chapter 404 Florida Statute, Florida Radiation Protection Act** – Requires the State of Florida to institute and maintain a program to permit the development and utilization of sources of radiation consistent with the health and safety of the public. This statute is compatible with standards and regulatory programs of the federal government for byproducts, source, and special nuclear material

(http://www.leg.state.fl.us/statutes/index.cfm?App_mode=Display_Statute&URL=0400-0499/0404/0404.html).

- **Florida Code of Ordinances, Brevard County Chapter 42 Emergency Services, Article IV Hazardous Materials** – Designates responsibility for removal and remedial action for the release of hazardous material, including RAM (https://library.municode.com/fl/brevard_county/codes/code_of_ordinances?nodeId=PTIICOOR_CH42EMSE_ARTIVHAMA).

Appendix C
NSPM-20

PRESIDENTIAL MEMORANDA

Presidential Memorandum on Launch of Spacecraft Containing Space Nuclear Systems

INFRASTRUCTURE & TECHNOLOGY

Issued on: **August 20, 2019**

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MEMORANDUM FOR THE SECRETARY OF STATE
THE SECRETARY OF DEFENSE
THE SECRETARY OF TRANSPORTATION
THE SECRETARY OF ENERGY
THE ADMINISTRATOR OF THE ENVIRONMENTAL PROTECTION AGENCY
THE ADMINISTRATOR OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
THE CHAIRMAN OF THE NUCLEAR REGULATORY COMMISSION
THE ASSISTANT TO THE PRESIDENT FOR NATIONAL SECURITY AFFAIRS
THE ASSISTANT TO THE PRESIDENT FOR SCIENCE AND TECHNOLOGY AND DIRECTOR OF THE OFFICE OF SCIENCE AND TECHNOLOGY POLICY

SUBJECT: Launch of Spacecraft Containing Space Nuclear Systems

By the authority vested in me as President by the Constitution and the laws of the United States of America, I hereby direct the following:

Section 1. Purpose. This memorandum updates the process for launches of spacecraft containing space nuclear systems. Space nuclear systems include radioisotope power systems (RPSs), such as radioisotope thermoelectric generators (RTGs) and radioisotope heater units (RHUs), and fission reactors used for power and propulsion.

The ability to use space nuclear systems safely and sustainably is vital to maintaining and advancing United States dominance and strategic leadership in space. For United States launches of space nuclear systems, the Federal Government must ensure a rigorous, risk informed safety analysis and launch authorization process. This memorandum establishes processes for Federal Government launches and launches for which the Department of Transportation (DOT) has statutory authority to license as commercial space launch activities (commercial launches). These processes include transparent safety guidelines and are forward-looking and amenable to effective use of space nuclear systems for heating, power, and propulsion.

Sec. 2. Policy. The United States shall develop and use space nuclear systems when such systems safely enable or enhance space exploration or operational capabilities. The Secretary of Energy shall maintain, on a full cost recovery basis, the capability and infrastructure to develop, furnish, and conduct safety analyses for space nuclear systems for use in United States Government space systems. Executive departments and agencies (agencies) shall seek to ensure that safe application of space nuclear systems is a viable option for Federal Government and commercial space activities.

Sec. 3. Safety Guidelines. (a) All United States Government entities involved in the launch of spacecraft containing space nuclear systems (including in the licensing of non-Government launches) shall seek to ensure safe operation. For any mission that includes a space nuclear system, mission planners and launch authorization authorities should, as appropriate, seek to ensure that:

(i) normal operation of the space nuclear system is consistent with applicable Federal, State, and local requirements;

(ii) an accident resulting in exposure in excess of 25 millirem but less than 5 rem total effective dose (TED), as that term is defined in section 835.2 of title 10, Code of Federal Regulations, to any member of the public is unlikely, such that the probability of such an event does not exceed 1 in 100;

(iii) an accident resulting in exposure in the range of 5 rem to 25 rem TED to any member of the public is extremely unlikely, such that the probability of such an event does not exceed 1 in 10,000; and

(iv) the probability of an accident resulting in exposure in excess of 25 rem TED to any member of the public does not exceed 1 in 100,000.

(b) Additional safety guidelines may be appropriate for the non-terrestrial operation of nuclear fission systems. Within 1 year of the date of this memorandum, the Administrator of the National Aeronautics and Space Administration (NASA), in coordination with the Secretary of Defense and the Secretary of Energy, shall submit to the Director of the Office of Science and Technology Policy (OSTP) and the Assistant to the President for National Security Affairs (APNSA) a report identifying guidelines for safe non-terrestrial operation of nuclear fission reactors, including orbital and planetary surface activities.

Sec. 4. Launch Authorization Processes. Authorization for launches of spacecraft containing space nuclear systems shall follow a three-tiered process based upon the characteristics of the system, the level of potential hazard, and national security considerations. “Federal Government missions,” as the term is used in this section and section 5 of this memorandum, are non-commercial missions either conducted or sponsored by an agency. Consistent with chapter 509 of title 51, United States Code, the Secretary of Transportation, or the Secretary’s designee, is the licensing authority for commercial launches of spacecraft containing space nuclear systems in all three tiers.

Issuance of a launch authorization or license as described in this memorandum shall not relieve the mission sponsor or licensee of its obligations with respect to other applicable laws, regulations, policies, or agreements that may apply to its activities.

(a) Tier I shall apply to launches of spacecraft containing radioactive sources of total quantities up to and including 100,000 times the A2 value listed in Table 2 of the International Atomic Energy Agency's Specific Safety Requirements No. SSR-6 (Rev. 1), Regulations for the Safe Transport of Radioactive Material, 2018 Edition. For Federal Government missions in Tier I, the head of the sponsoring agency shall be the launch authorization authority.

(b) Tier II shall apply to:

(i) launches of spacecraft containing radioactive sources in excess of 100,000 times the A2 value referenced above;

(ii) any Tier I launches where the associated safety analyses determine that the probability of an accident during launch or subsequent operation resulting in an exposure in the range of 5 rem to 25 rem TED to any member of the public is equal to or greater than 1 in 1,000,000; and

(iii) any launches of spacecraft containing nuclear fission systems and other devices with a potential for criticality (defined as the condition in which a nuclear fission chain reaction becomes self-sustaining), when such systems utilize low-enriched uranium (less than 20 percent uranium-235 enrichment). For Federal Government missions in Tier II, the head of the sponsoring agency shall be the launch authorization authority. Tier II missions require additional safety review, as detailed in section 5 of this memorandum, and the launch authorization authority shall consider the resulting analysis and review results when making a launch authorization determination.

(c) Tier III shall apply to launches of any spacecraft containing a space nuclear system for which the associated safety analyses determine that the probability of an accident

during launch or subsequent operation resulting in an exposure in excess of 25 rem TED to any member of the public is equal to or greater than 1 in 1,000,000.

Due to potential national security considerations associated with nuclear nonproliferation, Tier III shall also apply to launches of spacecraft containing nuclear fission systems and other devices with a potential for criticality when such systems utilize any nuclear fuel other than low-enriched uranium.

The President's authorization shall be required for Federal Government launches in Tier III. When the sponsoring agency is the Department of Defense or an element of the Intelligence Community, the head of the sponsoring agency shall request the President's authorization for the launch through the APNSA. In all other proposed Tier III Federal Government launches, the head of the sponsoring agency shall request the President's authorization for the launch through the Director of OSTP. The Director of OSTP may authorize such launches, unless the Director of OSTP considers it advisable to forward the matter to the President for a decision.

Sec. 5. Safety Analysis and Review. Nuclear safety analysis and review is a critical step before any launch of a space nuclear system. Safety analysis should include an assessment of potential consequences to a maximally exposed individual member of the public in accident scenarios. Safety analysis should address launch and any subsequent stages when accidents may result in radiological effects on the public or the environment, for instance, in an unplanned reentry from Earth orbit or during an Earth flyby. To the extent possible, safety analyses and reviews should incorporate previous mission and review experience.

(a) For Federal Government missions in all tiers, the head of the sponsoring agency shall be responsible for ensuring compliance with requirements under the National Environmental Policy Act (NEPA), 42 U.S.C. 4321 et seq. As the licensing authority for commercial space launches, the Secretary of Transportation is responsible for ensuring compliance with NEPA for commercial launches.

(b) For Federal Government missions in all tiers, the head of the sponsoring agency shall ensure that a mission Safety Analysis Report (SAR) be prepared. For commercial launches of spacecraft containing space nuclear systems in all tiers, the Secretary of Transportation shall, if necessary, issue a notice of proposed rulemaking to require that a mission SAR is prepared to inform a launch determination, and to require review of the mission SAR in consultation with other agencies as appropriate. The mission SAR shall demonstrate that safety analysis incorporates technical peer review, and shall include a concise, high-level summary of key risk information. This summary should include: the likelihood of an accident resulting in an exposure in excess of 5 rem TED to any member of the public; the number of individuals who might receive such exposure in an accident scenario; and comparisons of potential exposure levels to other meaningful measures such as nuclear space launch safety guidelines, background radiation, average public exposure from natural and manmade sources, and other relevant public safety standards. When appropriate, a mission SAR may incorporate a system-specific SAR that establishes a safety basis for the space nuclear system. The safety basis provides a set of conditions (a safety basis envelope) under which safety analysis and hazard controls provide assurance of safe operation for the given system. In such cases, the mission SAR must either:

(i) demonstrate that the mission is within the safety basis envelope established in the system-specific SAR, in which case it is not necessary to repeat the analysis supporting the system-specific SAR; or

(ii) include supplemental safety analysis for any deviations that are outside of the established safety basis envelope and for which safety has therefore not yet been demonstrated.

Agencies responsible for system-specific SARs should review them annually and update them as necessary.

(c) Within 180 days of the date of this memorandum, the NASA Administrator shall establish an Interagency Nuclear Safety Review Board (INSRB). The INSRB shall consist

of representatives from the Departments of State, Defense, Energy, and Transportation, the Environmental Protection Agency, NASA, and, as appropriate, the Nuclear Regulatory Commission. Each of these agencies shall designate technically qualified personnel to the INSRB. For Federal Government launches in Tier II and Tier III, the head of the sponsoring agency shall request of the NASA Administrator that the INSRB review the nuclear safety analysis, ultimately including the mission SAR, and report its findings, in the form of a Safety Evaluation Report, to the head of the sponsoring agency in order to inform the decision to proceed with launch and, for Tier III missions, inform any decision to request Presidential launch authorization. When necessary to protect national security, the head of the sponsoring agency, in consultation with the APNSA, may restrict INSRB member participation in any mission review. The INSRB shall evaluate the quality of the safety analysis and identify any significant gaps in analysis. The INSRB may recommend areas for additional analysis where it identifies gaps, but it is not tasked with repeating or conducting its own analysis. The INSRB shall engage early in the safety analysis process, after the conceptual design of the mission is generated, in order to identify gaps in time for mission planners to address them without creating unnecessary delays in the launch timeline. Before completion of the mission SAR, the INSRB shall advise the head of the sponsoring agency of any omissions or gaps that the INSRB has identified in analysis that is planned or underway, and may provide recommendations for corrective action. In licensing non-Federal Government launches in Tier II and Tier III, the Secretary of Transportation shall consult with the heads of any other agencies that the Secretary of Transportation deems appropriate to review the SAR in a similar manner, evaluate the quality of the safety analysis, and identify any significant gaps. At the request of the Secretary of Transportation, the INSRB shall review any nuclear safety analysis associated with a potential commercial launch of a space nuclear system under review by the Secretary of Transportation. The terms of any INSRB review, including the costs of such review, shall be agreed upon between the NASA Administrator and the head of the agency requesting INSRB review.

(d) Within 1 year of the date of this memorandum, the Secretary of Transportation shall issue public guidance for applicants seeking a license for a launch or reentry involving a space nuclear system. This guidance shall describe the process used to evaluate any

such license application, including relevant safety standards, as appropriate and consistent with applicable law.

Sec. 6. Reporting Requirements. (a) On an annual basis, the recipients of this memorandum shall provide a report to the Director of OSTP listing all launches that the agency has sponsored or licensed in the past calendar year of spacecraft using radioactive sources containing total quantities in the range of 1,000 times to 100,000 times the A2 value listed in Table 2 of the International Atomic Energy Agency's Specific Safety Requirements No. SSR-6 (Rev. 1), Regulations for the Safe Transport of Radioactive Material, 2018 Edition, and listing all such launches planned for the coming calendar year.

(b) Any agency planning Tier II or Tier III launches shall provide an annual briefing to OSTP and the National Science and Technology Council on the status of safety analysis for any such planned missions. The Secretary of Transportation shall provide a similar briefing within 120 days of accepting an application for a license pertaining to a commercial mission that will involve the launch or reentry involving a space nuclear system.

Sec. 7. Effect on Prior Memoranda. This memorandum supersedes the section of the June 28, 2010, National Space Policy titled "Space Nuclear Power" and its corresponding section in Presidential Policy Directive–4. The following paragraph replaces the ninth numbered paragraph of National Security Council Presidential Directive-25 (NSC/PD-25) of December 14, 1977 (as modified May 17, 1995, and May 8, 1996):

"9. Launching nuclear systems requires a separate procedure established in National Security Presidential Memorandum-20 of August 20, 2019 (Launch of Spacecraft Containing Space Nuclear Systems)."

Sec. 8. General Provisions. (a) Nothing in this memorandum shall be construed to impair or otherwise affect:

(i) the authority granted by law to an executive department or agency, or the head thereof; or

(ii) the functions of the Director of the Office of Management and Budget relating to budgetary, administrative, or legislative proposals.

(b) This memorandum shall be implemented consistent with applicable law and subject to the availability of appropriations.

(c) This memorandum is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity by any party against the United States, its departments, agencies, or entities, its officers, employees, or agents, or any other person.

DONALD J. TRUMP

Appendix D
Endangered Species Act Consultation Letters

United States Department of the Interior

FISH AND WILDLIFE SERVICE
North Florida Ecological Services
7915 Baymeadows Way, Suite 200
Jacksonville, FL 32256

December 10, 2019

Mr. Donald Dankert
Technical Lead, Environmental Planning
Environmental Management Branch
SI-E3, NASA Kennedy Space Center

Subject: Programmatic Assessment of Radioisotope Heater Units
FWS Log #: 04EF1000-2019-I-1107

Dear Mr. Dankert:

The U.S. Fish and Wildlife Service (Service) has reviewed the informal consultation request and the supporting Environmental Assessment (EA) for the launching of Radioisotope Heater Units (RHUs) from Kennedy Space Center and Cape Canaveral Air Force Station (CCAFS), Brevard County, FL. KSC has prepared an EA in accordance with the National Environmental Policy Act and pursuant to section 7 of the Endangered Species Act of 1973 (Act) (16 U.S.C. 1531 *et seq*.) are requesting our concurrence for the determination " may affect, but is not likely to adversely affect" for all federally listed species at these installations.

RHUs are small devices that use the natural decay of plutonium-238 (Pu-238) to provide thermal energy to heat payloads in space missions. The need for RHUs in space missions is expected to increase as the space program expands; therefore, KSC has programmatically analyzed the use of RHUs for launches at CCAFS and KSC complexes. The proposed action caps the number of RHUs (up to 130 RHUs per launch) and does not include other space nuclear power systems. The proposed action for ESA consultation is the extremely unlikely release scenario outlined in the EA.

Space missions have flown RHUs since the 1960s and there have been no radiological incidents in the history of using RHUs in spacecraft. KSC analyzed the increase utilization and the likelihood of Pu-238 exposure to humans and wildlife if a catastrophic accident occurs. RHU have several safety mechanisms designed to withstand launch mishaps and extreme heat. The units are designed to preclude the release of radioactive materials in the unlikely event there is an unintentional, suborbital return to Earth. KSC reviewed several aerial release scenarios and the highest potential Roentgen Equivalent Man (rem) exposure. Sensitivity analysis, which factors distance from an incident and wind speeds, found that the potential public exposure level rates are expected to be beneath the typical annual background and man-made sources of radiation exposure rates.

Similar to humans, the exposure pathways to wildlife include possibly inhalation, ingestion and immersion. KSC determined that the effects of radiation exposure if multiple safety mechamisms fail will be temporary and minor to wildlife based on the analysis of potential public exposure and background rates and man-made exposure. KSC also analyzed the potential radiological deposition effects to wetlands if Pu-238 is released in the environment under the extreme unlikely release scenario. Responses would be conducted per the National Response Framework and any remediation dredge and fill activities would be coordinated through the U.S. Army Corps of Engineers and state agencies if wetlands or state-regulated waterbodies are affected after an accidental release.

Based on the analysis presented in the EA and the response safeguards in place for the extreme unlikely release scenario, the Service concurs with KSC determination " may affect, but is not likely to adversely affect" all federally listed species for the programmatically covered launch facilities at the CCAFS and KSC installations. If there is an unforeseen, unpredicted, catastrophic failure that results in a higher than predicted value of Pu-238 exposure to humans and wildlife, the Service and KSC have agreed to follow the procedures outlined for emergency consultations, 50 CFR §402.05.

Under the revised regulations 50 CFR §402.16, reinitiating criteria is clarified to include informal consultations (see italics below). Reinitiating of consultation is required and shall be requested by the Federal agency or by the Service, where discretionary Federal involvement or control over the action has been retained or is authorized by law and:

a. If the amount or extent of incidental take is exceeded;
b. If new information reveals that the Action may affect listed species or designated critical habitat in a manner or to an extent not considered;
c. If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion or *written concurrence*; or
d. If a new species is listed or critical habitat designated that the Action that may be affected by the identified actions.

Thank you for the request for consultation for the programmatic radioisotope heater unit. If you have any questions about our concurrence letter please contact Ms. Tera Baird by phone at 904-731-3196 or by email at tera_baird@fws.gov.

Sincerely,

Jay B. Herrington,
Field Supervisor

September 17, 2019

MEMORANDUM FOR: US Fish and Wildlife Service

FROM: NASA Kennedy Space Center
Donald Dankert
NEPA Manager

SUBJECT: Endangered Species Act Section 7 consultation for launches involving Radioisotope Heater Units (RHUs) from Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS).

1. The National Aeronautics and Space Administration (NASA) (lead federal agency) along with the U.S. Air Force (USAF), Department of Energy (DOE) and Federal Aviation Agency (FAA) (cooperating agencies) request your concurrence on a "not likely to adversely affect" determination for federally listed species from the launching of RHUs at KSC and CCAFS.

2. NASA is currently conducting a programmatic environmental assessment (PEA) per the National Environmental Policy Act (NEPA) regulations at 40 *Code of Federal Regulations* (CFR) Section 1500.4(i). As part of this PEA, NASA along with its cooperating agencies, are analyzing the unique environmental effects associated with the launching of radioisotope materials, specifically up to 351 grams of Plutonium-238 (Pu-238) oxide, or the equivalent of 130 RHUs.

3. Through the environmental assessment process NASA has come to the determination that the launching of up to 130 RHUs, would result in only discountable impacts to any federally listed species in the vicinity of KSC or CCAFS. Please see Attachment 1 for a more detailed explanation of RHUs and the associated radiological risk.

4. NASA also reviewed the USFWS "Information for Planning and Consultation" (IPaC) site for listed species in Brevard County, Florida (Attachment 2). While a number of federally protected species may exist in the vicinity of the launch sites, the majority of the impacts would be experienced on or near the launch pad, which is an industrial area. Therefore, there is limited potential for effecting terrestrial organisms. Pu-238 is insoluble in water and there is limited potential for harm through the ingestion (eating) of a Pu-238 oxide in a ceramic form. Any swallowed Pu-238 oxide would quickly pass through the digestive system of an organism before radiation could cause harm. Given the natural limitation of inhalation of the Pu-238 by an aquatic species, there are no realistic expected impacts to aquatic organisms.

5. We appreciate your review of this proposed action. Please contact Mr. Donald Dankert, KSC NEPA Manager, at (321) 861-1196 for additional information regarding the programmatic use of RHUs in launches. Please address any written comments to donald.j.dankert@nasa.gov.

Donald Dankert
KSC NEPA Manager

Attachment-1: RHU Description and Associated Risk
Attachment-2: Brevard County Species List

Attachment 1: RHU Description and Associated Risks

RHU Description

- RHUs are small devices that use the natural decay of plutonium-238 (Pu-238) to provide thermal energy, which is used to heat payloads in space missions.
- RHUs have flown on more than two dozen NASA missions since the 1960s and have been analyzed in approximately eight Environmental Impact Statements since 1988. There have been no radiological incidents in the history of using RHUs in spacecraft.
- The integrity and durability of RHUs have been well documented by the DOE; RHUs are designed to withstand the potential accidents of a wide range of space missions without the release of Pu-238.
- RHUs include five-layers of protection. The first layer of protection is the ceramic material of the fuel pellet. Ceramic materials are naturally resistant to high temperatures and dispersal as a fine powder. Similar to a ceramic coffee cup, the material breaks into pieces when impacted and does not easily disperse as a dust. Dispersal of the radionuclide content of a fuel pellet requires melting the ceramic, which could only happen in the most extreme of launch mishap circumstances.
- For more information on RHUs, please visit: https://rps.nasa.gov/power-and-thermal-systems/thermal-systems/light-weight-radioisotope-heater-unit/

RHU Risks

- There are no inherent environmental effects associated with RHUs operating in a normal environment; consequently, the only potential risks to ESA, MBTA or MMPA protected species relate to the potential inhalation of radioactive material after a launch mishap and the resulting cleanup of any contaminated land. For this to happen there would have to be launch explosion that results in the vaporization of the Pu fuel pellet, which is highly unlikely, given the safety protections built into the RHU.
- The calculated radiation dose after a launch incident that results in release from 130 RHUs is approximately 0.5 rem, which is less than the average annual radiation of 0.62 rem for normal background exposure. Therefore, it is extremely unlikely that the potential radiation exposure after an unlikely event would result in a health effect to a protected species, as the radiation exposure would be within the range of what species are typically subjected to and adapted for.
- The risk of a release of radionuclides in past missions is approximately 1 in 15,000 and the vast majority of any release would remain on the launch pad. Therefore, the potential for a release that contaminates an area occupied by a protected species is extremely unlikely.

Attachment 2: Brevard County ESA Species List

Table 3-3. Federally Threatened and Endangered Species Documented to Occur at CCAFS or KSC

Common Name	Scientific Name	Federal Status
Reptiles and Amphibians		
American Alligator	*Alligator mississippiensis*	T
Atlantic (Kemp's) Ridley Sea Turtle	*Lepidochelys kempi*	E
Atlantic Green Sea Turtle	*Chelonia mydas*	E
Eastern Indigo Snake	*Drymarchon corais couperi*	T
Gopher Tortoise	*Gopherus polyphemus*	C
Hawksbill Sea Turtle	*Eretmochelys imbricata*	E
Leatherback Sea Turtle	*Dermochelys coriacea*	E
Atlantic Loggerhead Sea Turtle	*Caretta caretta*	T
Mammals		
Northern Right Whale	*Eubalaena glacialis*	E
Southeastern Beach Mouse	*Peromyscus polionotus niveiventris*	T
West Indian Manatee	*Trichechus manatus latirostris*	E
Fish		
Smalltooth Sawfish	*Pristis pectinata*	E
Birds		
Eastern Black Rail	*Laterallus jamaicensis ssp. Jamaicensis*	Proposed T
Florida Scrub Jay	*Aphelocoma coerulescens*	T
Piping Plover	*Charadrius melodus*	T
Red Knot	*Calidris canutus rufa*	T
Wood Stork	*Mycteria americana*	E

U.S. Fish and Wildlife Service (USFWS). 2019b. "Information for Planning and Consultation" (IPaC), Version 1.4. Brevard County.

Key:
C = candidate for Federal listing
E = endangered
T = threatened
P = protected under the Bald and Golden Eagle Protection Act.

Appendix E
National Historic Preservation Act Consultation Letters

National Aeronautics and Space Administration
Kennedy Space Center
Kennedy Space Center, FL 32899

September 24, 2019

Reply to Attn of: SI-E3

Florida Division of Historical Resources
and State Historic Preservation Officer
Attn: Jason Aldridge
500 S. Bronough Street
R. A. Gray Building
Tallahassee, Florida 32399-0250

SUBJECT: National Historic Preservation Act Section 106 Consultation for Launches Involving Radioisotope Heater Units (RHUs) from Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS)

The National Aeronautics and Space Administration (NASA) (lead Federal Agency) along with the United States Air Force (USAF), Department of Energy (DOE) and Federal Aviation Agency (FAA) (cooperating agencies) request your concurrence on a "no adverse effect" determination for National Register of Historic Places (NRHP) listed and eligible sites at KSC and CCAFS.

NASA is currently conducting a Programmatic Environmental Assessment (PEA) in accordance with the National Environmental Policy Act (NEPA) regulations at 40 Code of Federal Regulations (CFR) Section 1500.4(i). As part of this PEA, NASA and the cooperating agencies are analyzing the unique environmental effects associated with the launching of radioisotope materials, specifically up to 351 grams of Plutonium-238 (Pu-238) oxide, or the equivalent of 130 RHUs.

Through the environmental assessment process, NASA has come to the determination that the launching of up to 130 RHUs would result in only discountable impacts to NRHP-listed and eligible sites on KSC or CCAFS. There are no inherent environmental effects associated with RHUs operating in a normal environment; consequently, the only potential risks to NRHP listed and eligible sites relate to the potential cleanup activities which would occur after a launch mishap. For this to happen, there would have to be launch explosion that results in the vaporization of the Pu-238 fuel pellet, which is highly unlikely given the safety protections built into the RHU. See Enclosure 1 for a more detailed explanation of RHUs.

Pu-238 is insoluble and will typically remain on the top 2 inches of surface soil after a release. Consequently, the potential of impacting a known or unknown archeological site present in a contaminated area is limited. In the extremely unlikely event decontamination activities require the excavation of soil on or near a NRHP-listed or eligible archeological resource, the Florida State Historic Preservation Officer (SHPO) will be notified prior to any response activities at the site, and appropriate mitigation measures will be developed in accordance with the NHPA. If a new archeological site is identified during decontamination activities, the respective KSC or CCAFS Historic Preservation Officer (HPO) will be notified immediately. The HPO will determine if the site is eligible for listing on the NRHP; if it is deemed eligible, the SHPO will be notified before any other response activities are conducted at that site to determine appropriate mitigation measures.

Numerous NRHP-listed and eligible historic sites, as well as National Historic Landmarks, are located on KSC and CCAFS. These significant historic resources include the launch complexes where missions containing RHUs could be launched. RHU-specific impacts would involve potential decontamination activities, primarily on the exterior of structures. If a historic structure were identified as part of a response activity, the Florida SHPO would be notified beforehand and appropriate mitigations measures would be developed in accordance with the NHPA.

We appreciate your review of this proposed action. Please contact Mr. Donald Dankert, KSC NEPA Manager, at (321) 861-1196 for additional information regarding the programmatic use of RHUs in launches. Please address any written comments via e-mail to <donald.j.dankert@nasa.gov>.

Donald Dankert
KSC NEPA Manager

Enclosures:
Programmatic Environmental Assessment of Launches Involving Radioisotope Heater Units (RHUs)

cc:
HQS FPO/R. Klein
KSC/AD/S. Gilmore
KSC/CC/A. Vinson
KSC/SI-C2/R. Griffin
FWS/L. Hamilton
NPS/J. Grass
NPS/K. Kneifl

FLORIDA DEPARTMENT of STATE

RON DESANTIS
Governor

LAUREL M. LEE
Secretary of State

Donald Dankert
KSC NEPA Manager
Kennedy Space Center
Kennedy Space Center, Florida 32899

October 25, 2019

RE: DHR Project File No.: 2019-6436, Received by DHR: September 24, 2019
National Historic Preservation Act Section 106 Consultation for Launches Involving Radioisotope Heater Units (RHUs) from Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS)

Dear Mr. Dankert:

The Florida State Historic Preservation Officer reviewed the referenced project for possible effects on historic properties listed, or eligible for listing, in the *National Register of Historic Places.* The review was conducted in accordance with Section 106 of the *National Historic Preservation Act of 1966*, as amended, and its implementing regulations in *36 CFR Part 800: Protection of Historic Properties.*

Based on the information provided, our office concurs with NASA's determination that the use of radioisotope heater units (RHUs) for some launches at Kennedy Space Center and Cape Canaveral Air Force Station will have no adverse effect to historic properties listed, or eligible for listing, in the National Register of Historic Places. In the unlikely event that launch mishap occurs, the emergency provisions of the Programmatic Agreement should be sufficient to address the immediate need for emergency response and cleanup, although our office should be notified in that event to address any potential long-term effects to historic properties.

If you have any questions, please contact me by email at *Jason.Aldridge@dos.myflorida.com*, or by telephone at 850.245.6344.

Sincerely,

Jason Aldridge
Compliance and Review Supervisor
Deputy State Historic Preservation Officer

Appendix F
Coastal Zone Management Act Consistency Determination

Rau, Michelle/TPA

Subject: FW: NASA Radioisotope Heater Unit Programmatic EA

Expires: Tuesday, May 19, 2020 12:00 AM

Begin Forwarded Message:

From: "State_Clearinghouse" <State.Clearinghouse@dep.state.fl.us>
Subject: [EXTERNAL] RE: NASA Radioisotope Heater Unit Programmatic EA
Date: 18 September 2019 15:20
To: "Dankert, Donald J. (KSC-SIE30)" <donald.j.dankert@nasa.gov>, "State_Clearinghouse" <State.Clearinghouse@dep.state.fl.us>

Although it is covered by EO 12372, the Florida State Clearinghouse does not select the project for review. You may proceed with your project.

Please continue to send future electronic requests separately and directly to the State Clearinghouse email address, State.Clearinghouse@dep.state.fl.us

Good Luck.

Chris Stahl

Chris Stahl, Coordinator
Florida State Clearinghouse
Florida Department of Environmental Protection
3800 Commonwealth Blvd., M.S. 47
Tallahassee, FL 32399-2400
ph. (850) 717-9076
State.Clearinghouse@floridadep.gov

From: Dankert, Donald J. (KSC-SIE30) <donald.j.dankert@nasa.gov>
Sent: Tuesday, September 17, 2019 3:07 PM
To: State_Clearinghouse <State.Clearinghouse@dep.state.fl.us>
Subject: NASA Radioisotope Heater Unit Programmatic EA

Dear Mr. Stahl:

This letter provides the State of Florida with the National Aeronautics and Space Administration's (NASA's) Negative Determination under Section 307 of the CZMA, 16 United States Code Section 1456, and Title 15 *Code of Federal Regulations* (CFR) Section 930.35. The information in this Negative Determination is also provided pursuant to 15 CFR Section 930.35.

This Negative Determination addresses the Proposed Action for the launch of radioisotope heater units (RHUs) at Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS) in Brevard County, Florida.

Proposed Action

NASA is proposing to programmatically address the use of RHUs in spacecraft launched from KSC or CCAFS. To meet our mission and the mandates of the National Aeronautics and Space Act, NASA must be able to launch spacecraft into the deepest reaches of the solar system and explore distant planets. One of the most significant technical challenges in deep space exploration is efficiently keeping spacecraft warm in deep space environments where the use of solar heating is ineffective. For this reason, an alternative heat source is needed for spacecraft operating under these conditions. The heat from the natural decay of radionuclides is established technology that has been refined based on decades of experience and demonstrated success; recent nuclear-enabled space missions include the 2006 launch of the New Horizons spacecraft, and the 2011 launch of Mars Science Laboratory. RHUs can produce heat for decades under the harsh conditions of deep space without refueling or needing sunlight. Consequently, NASA needs to be able to use RHUs in its deep space and planetary exploration missions.

NASA is the lead federal agency for this action. The U.S. Department of Energy, the U.S. Air Force (USAF), and the Federal Aviation Administration are cooperating agencies on this Programmatic Environmental Assessment.

Federal Review

After review of the Florida Coastal Management Program and its enforceable policies, NASA has made a determination that this activity would not have an effect on the state of Florida coastal zone or its resources.

Thank you for your attention to this matter. Our contractor for the environmental components of this project is Jacobs Engineering, which will serve as our designated representative on this matter. Michelle Rau, project manager, can be reached by telephone at 719-331-5699 or via e-mail at michelle.rau@jacobs.com. Please feel free to contact either Michelle Rau or me (contact information above), if you have any questions or concerns.

Florida Coastal Management Program Consistency Review

Statute	Consistency	Scope
Chapter 161 *Beach and Shore Preservation*	The Proposed Action would not affect beach or shore management in Florida. All land activities would occur on existing federal facilities.	Authorizes the Bureau of Beaches and Coastal Systems within DEP to regulate construction on, or seaward of, the state's beaches.
Chapter 163, Part II *Growth Policy; County and Municipal Planning; Land Development Regulation*	The Proposed Action would not affect local government comprehensive plans.	Requires local governments to prepare, adopt, and implement comprehensive plans that encourage the most appropriate use of land and natural resources in a manner consistent with the public interest.
Chapter 186 *State and Regional Planning*	The Proposed Action would not affect Florida's plans for water use, land development, or transportation.	Details state-level planning efforts. Requires the development of special statewide plans governing water use, land development, and transportation.
Chapter 252 *Emergency Management*	The Proposed Action would not affect Florida's vulnerability to natural disasters. The Proposed Action would not affect emergency response or evacuation procedures.	Provides for planning and implementation of the state's response to, efforts to recover from, and the mitigation of natural and man-made disasters.
Chapter 253 *State Lands*	All activities would occur on federal property; therefore, the Proposed Action would not affect state public lands.	Addresses the state's administration of public lands and property of this state, and provides direction regarding the acquisition, disposal, and management of all state lands.
Chapter 258 *State Parks and Preserves*	The Proposed Action would not affect state parks, recreational areas, and aquatic preserves.	Addresses administration and management of state parks and preserves.
Chapter 259 *Land Acquisition for Conservation or Recreation*	The Proposed Action is not likely to affect tourism and/or outdoor recreation. If on the remote chance a recreational resource is affected by the Proposed Action, NASA and/or the USAF would coordinate with the U.S. Fish and Wildlife Service and National Park Service.	Authorizes acquisition of environmentally endangered lands and outdoor recreation lands.
Chapter 260 *Recreational Trails System*	The Proposed Action would not include the acquisition of land and would not affect the Greenways and Trails Program.	Authorizes acquisition of land to create a recreational trails system and to facilitate management of the system.
Chapter 267 *Historical Resources*	The Proposed Action is not likely to affect cultural resources of Florida. If on the remote chance a historic resource is affected by the Proposed Action, NASA and/or the USAF would coordinate with the Florida State Historic Preservation Office, per the National Historic Preservation Act.	Addresses management and preservation of the state's archaeological and historical resources.
Chapter 288 *Commercial Development and Capital Improvements*	The Proposed Action would not affect future business opportunities on state lands, or the promotion of tourism in the region.	Provides the framework for promoting and developing the general business, trade, and tourism components of the state economy.
Chapter 334 *Transportation Administration*	The Proposed Action would not affect transportation.	Addresses the state's policy concerning transportation administration.
Chapter 339 *Transportation Finance and Planning*	The Proposed Action would not affect the finance and planning needs of the state's transportation system.	Addresses the finance and planning needs of the state's transportation system.

Florida Coastal Management Program Consistency Review

Statute	Consistency	Scope
Chapter 373 *Water Resources*	The Proposed Action does not include construction and would not affect Florida's water resources.	Addresses the state's policy concerning water resources.
Chapter 375 Multipurpose Outdoor *Recreation; Land Acquisition, Management and Conservation*	The Proposed Action is not likely to affect tourism and/or outdoor recreation. If on the remote chance a recreational resource is affected by the Proposed Action, NASA and/or the USAF would coordinate with the U.S. Fish and Wildlife Service and National Park Service.	Develops comprehensive multipurpose outdoor recreation plan to document recreational supply and demand, describe current recreational opportunities, estimate the need for additional recreational opportunities, and propose means to meet the identified needs.
Chapter 376 *Pollutant Discharge Prevention and Removal*	The Proposed Action would be consistent with Florida's statutes and regulations regarding the transfer, storage, or transportation of pollutants.	Regulates transfer, storage, and transportation of pollutants and cleanup of pollutant discharges.
Chapter 377 *Energy Resources*	The Proposed Action would not affect energy resource production, including oil and gas, and/or the transportation of oil and gas.	Addresses regulation, planning, and development of oil and gas resources of the state.
Chapter 379 *Fish and Wildlife Conservation*	The Proposed Action is not likely to affect wildlife. The Proposed Action should not affect marine fisheries. NASA and the USAF will work with the U.S. Fish and Wildlife Service if there is any potential to affect threatened or endangered species. NASA and the USAF will work with the U.S. National Marine Fisheries Service if there is any potential to affect fisheries.	Establishes public policy concerning marine fisheries resources and the hunting, fishing, and taking of game.
Chapter 380 *Land and Water Management*	The Proposed Action would not result in growth-inducing effects.	Establishes land and water management policies to guide and coordinate local decisions relating to growth and development.
Chapter 381 *Public Health, General Provisions*	The Proposed Action would not affect Florida's policy concerning the public health system.	Establishes public policy concerning the state's public health system.
Chapter 388 *Mosquito Control*	The Proposed Action would not affect mosquito control efforts.	Addresses mosquito control effort in the state.
Chapter 403 *Environmental Control*	The Proposed Action would not affect water quality, air quality, pollution control, solid waste management, or other environmental control efforts in Florida.	Establishes public policy concerning environmental control in the state.
Chapter 553 *Building Construction Standards*	The Proposed Action would not involve constructing new buildings.	Establishes policy concerning building and construction in coastal zone areas.
Chapter 582 *Soil and Water Conservation*	The Proposed Action does not involve any construction in Florida. Therefore, the Proposed Action would not affect State of Florida soil and water conservation efforts.	Provides for the control and prevention of soil erosion.
Chapter 597 *Aquaculture*	The Proposed Action would not affect aquaculture production efforts.	Provides for the coordination, prioritization, and conservation of aquaculture production efforts.

Please see the attached EA for additional information. Don’t hesitate to contact me if you have any questions or need any additional information.

V/r,
Don

Donald Dankert
Technical Lead, Environmental Planning
Environmental Management Branch
SI-E3, NASA Kennedy Space Center
(o)321.861.1196 (c)321.222.8825

Appendix G
Categorical Exclusion Examples

#2 Modified per HQ request

NASA Glenn Research Center
Record of Environmental Consideration (REC)

5/8/14

1. Title, description and location of proposed action:

Nuclear Systems Kilopower Project

The Nuclear Systems Kilopower Project consists of the development and testing of a ¼ power full scale ground technology demonstration of a small fission power system based on an 800 We space science power requirement. The components of the demonstration include the reactor core, heat pipes to transfer the heat from the core to the power conversion system, the power conversion system, and the radiators to reject power conversion waste heat. NASA Glenn Research Center (GRC) and Marshall Space Flight Center (MSFC) will design, build, and demonstrate the balance of plant heat transfer, power conversion, and heat rejection portions of the Kilopower Prototype. A non-nuclear electrically-heated demonstration of sodium heat pipe heat transfer, Stirling engine power conversion, and heat rejection will be assembled and tested at NASA GRC. MSFC is responsible for the Non-nuclear core simulator development and the Reactor reflector design. Once the balance of plant has been tested and the reactor core has been fabricated, the balance of plant system will be reconfigured for a nuclear ground test, and the prototype will be assembled and tested at the Device Assembly Facility at the Nevada Nuclear Test Site.

2. Name of project initiator, organizational code, and phone number:

Don Palac, MT, 216-977-7094

3. Anticipated date and/or duration of proposed action:

10/01/14 until late 2017

4. It has been determined that the proposed action:

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

☐ Is adequately covered in the ERD or an existing EA or EIS, entitled:

☒ Qualifies for Categorical Exclusion (CatEx) and has no special circumstances which would suggest a need for an Environmental Assessment per 14 CFR 1216.305(d):

The following CatExs are those that require a REC to be completed. Choose those that apply:

☐ **2-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.

☒ **3-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.

☒ **3-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.

☐ **3-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.

☐ **4-i** : Acquisition, transfer, or disposal of any personal property, or personal property rights or interests.

☐ **4-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 NASA has included any terms and conditions necessary to ensure protection of the environment and any required notices in the transfer documentation, as applicable.

☐ **4-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.

☐ **4-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.

☐ **4-v** : Acquisition of real property (including facilities) where the land use will not change substantially.

☐ **5-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.

☐ **5-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.

☐ Will require preparation of one of the following:

- ☐ Environmental Assessment
- ☐ Environmental Impact Statement

Comments/Mitigation/Monitoring Requirements:

1. This project falls under CATEX 3.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) since it is routine design, fabrication and testing of materials at GRC. In addition, this activity also fall under CATEX 3.ii. (Use of small quantities of radioactive materials in a laboratory or in the field) since a component of depleted uranium will be used under the auspices of the Radiation Safety Officer.
2. This project also involves fabrication and testing at MSFC. In consultation with the MSFC NEPA Manager, the actions at MSFC fall under the CATEX 3.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). See attached e-mail.
3. This project involves nuclear testing at the Defense Assembly Facility (DAF) located at the Department of Energy's Nevada National Security Site and is covered under the DOE Environmenbtal Impact Statement. – 0426 which can be found online at http://energy.gov/nepa/downloads/eis-0426-final-environmental-impact-statement. In addition an environmental checklist for this specific testing will be completed prior to testing which is scheduled for 2017.
4. Specific actions at GRC have been conducted under Safety Permit Reviews for testing (Permits 301-13-0011, 301-14-0014 and 301-15-0002). These permits were evaluated under separate NEPA reviews. Additional Safety Permit reviews are expected. See project file in EEMO for additional documentation.

Signature of Reviewer: Robert F Lallier Jr

Print Name and Title of Reviewer: Robert F. Lallier, Jr., GRC NEPA Manager

Date Signed: 05/08/2015

Distribution: MT/D. Palac
FE/R.F Lallier
HQ OSI/K.Kumor
HQ OSI/T.Norwood
MSFC/M. Reynolds

Attachments: GRC 150
E-mail from Patrick McClure (DOE) dtd April 27, 2015
E-mail from Michael Reynolds (MSFC) dtd April 30, 2015

NASA Glenn Research Center (GRC)
Energy and Environmental Management Office (EEMO)
Environmental Checklist

SECTION I - PROPOSED PROGRAM OR PROJECT DETAILS

Proposed program or project name

Nuclear Systems Kilopower Project

Description and purpose *(Be specific with the size and scope of the action (i.e., including multiple phases). Provide drawings and/or site maps with the GRC 150 submittal).*

The Nuclear Systems Kilopower Project consists of the development and testing of a ¼ power full scale ground technology demonstration of a small fission power system based on an 800 We space science power requirement. The components of the demonstration include the reactor core, heat pipes to transfer the heat from the core to the power conversion system, the power conversion system, and the radiators to reject power conversion waste heat. NASA Glenn Research Center (GRC) and Marshall Space Flight Center (MSFC) will design, build, and demonstrate the balance of plant heat transfer, power conversion, and heat rejection portions of the Kilopower Prototype. A non-nuclear electrically-heated demonstration of sodium heat pipe heat transfer, Stirling engine power conversion, and heat rejection will be assembled and tested at NASA GRC. Once the balance of plant has been tested and the reactor core has been fabricated, the balance of plant system will be reconfigured for a nuclear ground test, and the prototype will be assembled and tested at the Device Assembly Facility at the Nevada Nuclear Test Site.

Location/Facility of proposed program or project

NASA GRC Buiding 301, MSFC Early Flight Fission Test Facility, Department of Energy Nevada Nuclear Security Site

Name of program or project lead	Organizational code	Telephone number
Donald T. Palac	MT	3-7094
Other contact information	Approximate start date(s)	Approximate duration
	October 1, 2014	3 years

Program or project lead or designee signature

DONALD PALAC

Digitally signed by DONALD PALAC
DN: cn=US, o=US Government, ou=NASA, ou=People, cn=DONALD PALAC, 0.9.2342.19200300.100.1.1=dpalac
Date: 2014.10.23 14:15:41 -04'00'

Date signed

SECTION II - INITIAL NEPA EVALUATION

1. Has this action undergone a prior NEPA analysis or Environmental Evaluation?
   If yes, state the date and name of action if different than this one.

☐ Yes ☒ No ☐ Uncertain

2. Is this action part of a larger or broader program or procurement?
   If yes, state the name of other program or procurement.

☒ Yes ☐ No ☐ Uncertain

Space Technology Mission Directorate/Game Changing Technology Development Program

3. Could this action individually or cumulatively result in any of the following:
   a) Have significant environmental impacts; b) Result in a high degree of public controversy, or;
   c) Cause NASA to be at risk of violating any Federal, State, or local laws?
   If yes, please explain.

☐ Yes ☒ No ☐ Uncertain

4. What alternatives, including not implementing t his program or project *(or no action), have been considered and evaluated?*
   Please explain the other alternatives and why they were not further considered. (e.g., other locations for building, locations where testing will occur, materials to be used.)

Select one from drop down list

No action.

NASA Glenn Research Center (GRC)
Energy and Environmental Management Office (EEMO)
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SECTION III - HISTORIC AND CULTURAL RESOURCE CONSIDERATIONS

1. Will this action alter or modify the exterior of a facility?	☐ Yes	☒ No	☐ Uncertain
2. Will this action alter or modify the interior of a facility?	☐ Yes	☒ No	☐ Uncertain
3. Will this action change the existing use of a facility?	☐ Yes	☒ No	☐ Uncertain
4. Will this action remove or replace equipment or machinery?	☐ Yes	☒ No	☐ Uncertain
5. Will this action require ground and soil disturbances deeper than 6 inches?	☐ Yes	☒ No	☐ Uncertain
6. Will this action require alteration of the existing land use?	☐ Yes	☒ No	☐ Uncertain
7. Will this action install something that could be seen from a 1/4 mile or more beyond NASA property boundaries?	☐ Yes	☒ No	☐ Uncertain

For all questions answered "yes," please provide further explanation including potential mitigation measures as necessary.

GRC HISTORIC PRESERVATION OFFICER (HPO) - CONCURRENCE *(Filled out by GRC HPO only.)*

1. Will this action have the potential to impact areas of historic or cultural significance? *(i.e., view-shed, archaeological, architectural, part of Historic District)*	☐ Yes	☒ No	☐ Uncertain
2. Consultations with the Ohio Historic Preservation Office required?	☐ Yes	☒ No	☐ Uncertain
3. Is consultation with the public required *(i.e., public announcement, scoping)*?	☐ Yes	☒ No	☐ Uncertain
4. Will mitigation measures be required to ensure the protection of any significant resources near the location of proposed action?	☐ Yes	☒ No	☐ Uncertain

If yes, explain the mitigation measures as necessary.

GRC HPO Signature	Date review and signed
LESLIE MAIN Digitally signed by LESLIE MAIN DN: c=US, o=U.S. Government, ou=NASA, ou=PIV, cn=LESLIE MAIN, 0.9.2342.19200300.100.1.1=xxxx Date: 2015.04.28 09:26:26 -04'00'	

NASA Glenn Research Center (GRC)
Energy and Environmental Management Office (EEMO)
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SECTION IV - ENVIRONMENTAL CONSIDERATIONS

AIR EMISSIONS/WATER DISCHARGES

1. Will this action release temporary or ongoing air emissions?	☐ Yes	☒ No	☐ Uncertain
2. Will this action use, generate, or emit greenhouse gases *(i.e., CO2, CH4, CFCs)*?	☐ Yes	☒ No	☐ Uncertain
3. Will this action have the potential to create objectionable odors and/or smoke?	☐ Yes	☒ No	☐ Uncertain
4. Will this action require the use of fume hoods or facility exhaust fans?	☐ Yes	☒ No	☐ Uncertain
5. Will this action utilize an interior sink or floor drain?	☐ Yes	☒ No	☐ Uncertain
6. Will this action require the installation or modification of the sanitary and/or storm sewer system?	☐ Yes	☒ No	☐ Uncertain
7. Will this action discharge water into a catch basin, ditch, or swale *(e.g., line flushing)*?	☐ Yes	☒ No	☐ Uncertain
8. Will this action require efforts along a stream bank and/or in a waterway?	☐ Yes	☒ No	☐ Uncertain
9. Does this action have the potential to create polluted run-off or require the storage of material and/or equipment outside, thus exposed to rain or snow?	☐ Yes	☒ No	☐ Uncertain
10. Will this action require the addition or removal of soil by digging, grading, or trenching?	☐ Yes	☒ No	☐ Uncertain
11. Will this action increase the footprint of a facility by 5,000 square feet or more *(i.e., roads, building additions, parking)*?	☐ Yes	☒ No	☐ Uncertain
12. Will this action disturb more than 1 acre of soil *(include staging areas)*?	☐ Yes	☒ No	☐ Uncertain
13. Will this action require the use of pesticides, herbicides, or fertilizers?	☐ Yes	☒ No	☐ Uncertain

For questions answered "yes," please provide details on the contents of the emissions/discharges, approximate amounts (where feasible, conditions that may trigger a large release than expected, and controls measures to prevent a release into the environment.

CHEMICAL AND WASTE MANAGEMENT

14. Will this action involve the use, transportation, storage, or generation of hazardous, toxic, biological or radiological wastes?	☒ Yes	☐ No	☐ Uncertain
15. Will this action require the handling, removal, or storage of contaminated soils, wastewater, or demolition debris?	☐ Yes	☒ No	☐ Uncertain
16. Will this action require the use or installation of an Oil Water Separator?	☐ Yes	☒ No	☐ Uncertain
17. Will this action use any chemical, including but not limited to oils, lubricants, organic solvents, metals, corrosives, and fuels?	☒ Yes	☐ No	☐ Uncertain

For questions answered "yes," please provide details on the source of the waste, approximate amounts, purpose, and control measures.

14. Liquid Sodium will be used as a medium for the heat pipes and will be disposed in a procedure approved by the Waste Management Team.

17. Liquid Sodium will be handled in accordance with the approved procedures outlined in the Safety Permit.

NASA Glenn Research Center (GRC)
Energy and Environmental Management Office (EEMO)
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OCCUPATIONAL AND EQUIPMENT MANAGEMENT

18. Will this action require the use of ionizing or non-ionizing radiation?	☐ Yes	☒ No	☐ Uncertain
19. Will this action require the use of lasers?	☐ Yes	☒ No	☐ Uncertain
20. Will this action require any amount or type of radioactive material?	☒ Yes	☐ No	☐ Uncertain
21. Will this action generate high noise at levels above 80 dBA *(i.e., gas lawn mower)*?	☐ Yes	☒ No	☐ Uncertain
22. Will equipment require the use of water or glycol for cooling purposes?	☐ Yes	☒ No	☐ Uncertain
23. Will this action utilize fuels *(i.e., jet fuel, gasoline, diesel, other)* from underground storage tanks, above ground storage tanks, or 55 gallon drums?	☐ Yes	☒ No	☐ Uncertain
24. Will the action required the use of mobile fuel tanks or tankers?	☐ Yes	☒ No	☐ Uncertain
25. Will the action requires the use of a back-up generator(s)?	☐ Yes	☒ No	☐ Uncertain
26. Will the action require the use of equipment with oil reservoirs with capacities of 55 gallons or more?	☐ Yes	☒ No	☐ Uncertain

For questions answered "yes," please provide details on the following: Amounts and types, purpose, and control measures.

20. Depleted Uranium will be used under the auspices of the GRC Radiation Safety Officer (RSO) to simulate the dimensions of the final testing to be conducted at the Nevada National Security Site.

SUSTAINABILITY - SOCIOECONOMICS - ENVIRONMENTAL JUSTICE

27. Will this action install or utilize renewable sources of energy *(e.g., wind turbine)*?	☐ Yes	☒ No	☐ Uncertain
28. Will this action consume more than 15,000 KCUFT of natural gas per year?	☐ Yes	☒ No	☐ Uncertain
29. Will this action require more than 3,500 MWH of electricity per year?	☐ Yes	☒ No	☐ Uncertain
30. Will this action require the use of water for process loads?	☐ Yes	☒ No	☐ Uncertain
31. Will this action require the removal of trees?	☐ Yes	☒ No	☐ Uncertain
32. Will recycle content or bio-based products be viable for use with this action?	☐ Yes	☒ No	☐ Uncertain
33. Will this action result in an increase or decrease in personnel at Lewis Field or Plum Brook Station or have other local fiscal impacts?	☐ Yes	☒ No	☐ Uncertain
34. Does this action have the potential to disproportionately affect low-income or minority populations in the surrounding areas?	☐ Yes	☒ No	☐ Uncertain

For questions answered "yes," please provide details on the source of the waste, approximate amounts, purpose, and control measures.

You have completed your section of the form requirements, email to Robert F. Lallier at (robert.f.lallier@nasa.gov)

NASA Glenn Research Center (GRC)
Energy and Environmental Management Office (EEMO)
Environmental Checklist

SECTION V - ENERGY AND ENVIRONMENTAL MANAGEMENT OFFICE (EEMO) CONCURRENCE

1 Will this action be located in a floodplain or wetland?	☐ Yes	☒ No	☐ Uncertain
2 Will this action affect threatened or endangered species of flora or fauna?	☐ Yes	☒ No	☐ Uncertain
3 Will ground water be impacted by this action?	☐ Yes	☒ No	☐ Uncertain
4 Will this action require the submittal of a GRC Facility Change Request (FCR)?	☐ Yes	☒ No	☐ Uncertain
5 Will this action require an air permit or inclusion into the Title V permit?	☐ Yes	☒ No	☐ Uncertain
6 Will this action require a NPDES permit?	☐ Yes	☒ No	☐ Uncertain
7 Will this action require a BUSTR permit?	☐ Yes	☒ No	☐ Uncertain
8 Will this action require a Permit to Install (PTI)?	☐ Yes	☒ No	☐ Uncertain
9 Will this action require the further coordination with other regulatory agencies?	☒ Yes	☐ No	☐ Uncertain
10 Will this action affect a prior CERLCA site or known site of contamination?	☐ Yes	☒ No	☐ Uncertain
11 Will this site require additional soil sampling?	☐ Yes	☒ No	☐ Uncertain
12 Will this project require documentation gathered of the recycled content or bio-based products it will install or utilize?	☐ Yes	☒ No	☐ Uncertain
13 Are there training requirements the action initiator should be aware of?	☐ Yes	☒ No	☐ Uncertain
14 Will this action require usage constraints or additional metering of the natural gas, electricity or water use?	☐ Yes	☒ No	☐ Uncertain

Other requirements/comments

9. Additional fabrication and testing will be done at Marshall Space Flight Center. This review has been identified as CATEX 3.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). In addition, nuclear testing will be done at the Dept of Energy Nevada National Security Site. The particular facility that will be used is the Defense Assembly Facility (DAF) and is covered under the DOE EIS-0426 located at http://energy.gov/nepa/downloads/eis-0426-final-environmental-impact-statement.

15 Should NASA HQ - Environmental Management Division (EMD) be notified?	☐ Yes	☒ No	☐ Uncertain

16 If this action qualified for a Categorical exclusion, select one from the following drop-down list NPR 8580.1A, Appendix C

3. Research and Development 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.

EEMO Evaluator Printed Name	EEMO Evaluator Title
Robert F. Lallier, Jr.	GRC NEPA Manager

EEMO Evaluator Signature	Date signed
ROBERT LALLIER	4/29/2015

Lallier, Robert F. (GRC-FE00)

From: Mcclure, Patrick Ray <pmcclure@lanl.gov>
Sent: Monday, April 27, 2015 11:59 AM
To: Lallier, Robert F. (GRC-FE00)
Subject: NEPA stuff
Attachments: 10CFR830.pdf

Go to this web site: http://energy.gov/nepa/downloads/eis-0426-final-environmental-impact-statement to get the NEPA documents for the Test Site.

We will do the testing in a facility called DAF (Device Assembly Facility)

The work is part of the NCERC (National Criticality Experiments Research Center). It is covered as part of the 500 critical experiments per year that is postulated for the DAF (although the reality is far less than 100). Critical experiments are a class of reactor in the DOE orders and the CFRs (see 10CFR830 which is attached.)

Patrick

4/28/15

Follow up phonecon with Patrick:

Additional reviews are completed prior to testing but since that is not scheduled until 2017, this review is not complete at this time. Documentation will be forwarded to the GRC NEPA Manager when complete.

RFL

Appendix H
A2 Calculation Memorandum Example

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, MD 20771

Reply to Attn of: 360

November 30, 2017

TO: NASA Headquarters
Attn: Nuclear Flight Safety Assurance Manager (NFSAM)/
Ms. Suzanne Aleman

FROM: 360/GSFC Radiation Safety Officer

SUBJECT: Request for Nuclear Launch Safety Approval for the 36.329 UH Galeazzi/University of Miami mission

In accordance with NPR 8715.3D, Chapter 6, a request for approval is hereby submitted for the launch of radioactive material to be launched at the Poker Flat Research Range (PFRR) as part of the NASA Sounding Rocket Program.

The University of Miami is furnishing the radioactive sources that will be launched on a Terrier-Black Brant/36.329 UH sounding rocket. This mission includes two instruments: (1) DXL = Diffuse X-Rays from the Local Galaxy; and (2) UXT = Ultrasoft X-Ray Telescope. Each instrument is a radiation detector designed to study the diffuse X-Ray emission from outer space in the soft X-Ray band (50-2,000 eV). DXL and UXT will carry onboard radioactive sources for gain calibration and each instrument has two proportional counters and each counter requiring independent calibration. DXL uses two (2) Iron-55 X-Ray sealed sources and UXT uses two (2) Curium-244 alpha sealed sources used for exciting a Manganese target. A third source Curium-244 will be transported to the launch site as a spare, but will not be launched.

Radioactive sources are currently at the Wallops Flight Facility were they have been integrated and the detectors tested; projected to remove the sources from the detectors at the end of December and the sources packaged for shipment to the PFRR where they will again be re-integrated prior to the launch. The launch of the sounding rockets with four (4) sources onboard is currently scheduled to take place between January 15-31, 2018 from PFRR.

The radioactive sources report is enclosed as required by NPR 8715.3D, Chapter 6, paragraph 6.3.4. If you have any questions please contact me at (301) 286-0280 or email at daniel.s.simpson@nasa.gov.

Daniel Simpson
GSFC Radiation Safety Officer

Enclosure

MINOR RADIOACTIVE SOURCES BEING LAUNCHED ON GSFC SPONSORED PROJECTS

Vehicle/ Spacecraft	Planned Launch Date (Mo/Yr)	Launch Site	Number of Sources	Isotope	Total Activity (Curies)	A_2 Limit for Isotope (Ci)	A_2 Multiple for Isotope	Remarks/Disposition
Terrier-Black Brant / 36.329 UH	1/2018	Poker Flat Research Range (PFRR)	2	Iron-55 (Fe-55)	4.11E-05	1.00E+03	4.11E-08	These University of Miami sources are internal to two detectors that will be integrated onto the vehicle payload and will serve as calibration sources during flight to monitor the gain of the detectors. The detectors (which contains the sources) will be recovered with the payload and transported back to the University of Miami.
			2	Curium-244 (Cm-244)	6.40E-04	1.00E-02	6.40E-02	
						Mission Multiple →	6.40E-02	

Nuclear Launch Safety Approval Summary (Table 6.1, NPR 8715.3C, Chapter 6)					
A2 Mission Multiple	**Launch Reported to NFSAM**	**Launch Concurrence/ Approval by**	**Launch Reported to OSTP**	**Required Level of Review and Reports**	**Approval/ Concurrence**
Equal to 0.001 but Less than 10	Yes	Nuclear Flight Safety Assurance Manager (NFSAM)	Yes	Paragraph 6.3.4 Report	Concurrence letter from NFSAM

National Aeronautics and Space Administration

Headquarters
Washington, DC 20546-0001

December 19, 2017

Reply to Attn of: Safety and Assurance Requirements Division

TO: Goddard Space Flight Center
Attn: 360/Radiation Safety Officer

FROM: Nuclear Flight Safety Assurance Manager

SUBJECT: Launch Approval Requirements for Radioactive Materials Contained Aboard the Galeazzi/University of Miami Mission on the 36.329 UH Sounding Rocket in January 2018

Thank you for your notification of the intended launch of a two (2) Curium-244 alpha sealed sources and two (2) Iron-55 X-ray sealed sources integral to the Diffuse X-rays from the Local Galaxy (DXL) and Ultrasoft X-ray Telescope instruments aboard the Galeazzi/University of Miami experiment on NASA's Terrier-Black/Brant/36.329 UH sounding rocket, in January 2018, from the Poker Flats Research Range.

Based on the information you have provided, and our review for conformance with Chapter 6 of NPR 8715.3, NASA General Safety Program Requirements, this office does not object to the launch of these materials. Please inform me if there are any changes in materials or quantities prior to launch. Additionally, please ensure that any facilities that will process or house these materials are notified prior to arrival of the materials onsite per local regulations.

Because the radioactive sources aboard this launch contain quantities greater than 0.1 percent of the A2 value in Table I of the International Atomic Energy Agency's Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials, 1985 Edition (as amended 1990), I will report the radioactive material aboard this launch to the Office of Science and Technology Policy, as required by Presidential Directive/ National Security Council Memorandum Number 25 (PD/NSC-25) "*Scientific or Technological Experiments with Possible Large-Scale Environmental Effects and Launch of Nuclear Systems into Space*" (12/14/77, as amended in 1996).

Since this material is planned for recovery back to the University of Miami after the flight, please provide me with confirmation that the material was returned and is fully accounted for.

If you have any questions concerning nuclear launch approval, I can be reached at (202) 358-1745 or by e-mail at suzanne.m.aleman@nasa.gov.

Suzanne M. Aleman

cc:
Office of Safety and Mission Assurance/Dr. Frank Groen
/Ms. Deirdre Healey
/Ms. Sandra Hudson
/Mr. Gerry Schumann

Office of Mission Support Directorate/Ms. Tina Norwood
Office of International and Interagency Relations/Ms. Margaret Kieffer
/Mr. Kevin Conole
Office of Chief Health and Medical Officer/Angel Plaza

Goddard Space Flight Center/360 Mr. Dan Simpson
/250 Ms. Beth Montgomery

Wallops Flight Facility/803 Mr. Gordon Marsh
/803 Mr. Jeff Shelton

University of Miami/Dr. Massimiliano Galeazzi
/Mr. Edward C. Pombier

Appendix I
Nuclear NEPA Frequently Asked Questions

Nuclear NEPA FAQ

1. Why is it appropriate to start the NEPA process with an Environmental Assessment (EA) instead of an Environmental Impact Statement (EIS) for nuclear-enabled missions?

NASA's current National Environmental Policy Act (NEPA) implementing regulations (14 Code of Federal Regulations [CFR] 1216.306(b)(2)) list development and operation of a space flight project/program that would launch and operate a radioisotope power system (RPS) as an action that would normally require an EIS. However, the use of the word *normally* in the caption to 1216.306 is instructive and makes clear that NASA has the discretion to determine the most appropriate level of NEPA analysis when commencing the environmental impact review of a Proposed Action. This discretion is supported by the Council on Environmental Quality's (CEQ's) regulations, which allow agencies to "prepare an environmental assessment on any action at any time in order to assist agency planning and decision making" (40 CFR 1501.3(b)). An EA is typically considered the first step to determine the significance of environmental effects for a proposed action when a Categorical Exclusion (CatEx) is not applicable.

With the goal of reducing unnecessary and repetitive analysis and promoting administrative efficiency, NASA considers the data contained in previously prepared NEPA documents for RPS-enabled missions spanning the past three decades. None of these documents identified a significant environmental impact related to the use of a RPS in a payload. For the most recent RPS enabled mission, Dragonfly, the potential consequence resulting from a mishap could be considered reasonably foreseeable; however, the low probability of the event at the level of exposure to a member of the public allowed for the finding of less than significant (refer to the footnote in Table 3.1-2 of the *Environmental Assessment for the Dragonfly Mission* [NASA, 2022]). EISs are typically reserved for projects expected to have significant impact on the environment; thus, NASA concluded that preparation of an EA for the Dragonfly mission was sufficient.

As with all missions and activities, if NASA becomes aware of significant new circumstances or information relevant to environmental concerns and bearing on the Proposed Action or its impacts, NASA will consider whether the new information triggers the need for additional environmental analysis (such as preparation of an EIS).

2. Why is a mission-specific Nuclear Risk Assessment (NRA) unnecessary for NEPA?

For the past 30+ years, mission-specific safety analysis reports (SARs) and NRAs have been developed to determine the probability and consequences of a health effect resulting from the use of RPS on NASA missions. While the SAR process was a direct requirement from National Security Council/Presidential Directive-25 (NSC/PD-25)[1], the NRA process was developed to allow NASA to complete a NEPA review prior to deciding on a mission-specific launch vehicle, and prior to the mission's preliminary design review (PDR). An NRA follows a composite approach that combines data from multiple potential launch vehicles.

A SAR is conducted after the mission launch vehicle has been selected. The SAR process is still required after completing the NRA because the NRA's composite approach does not provide the most credible

[1] NSC/PD-25 was replaced by National Security Presidential Memorandum (NSPM)- 20 on August 20, 2019

and technically accurate exposure data, which was required for NSC/PD-25 and is currently required under National Security Presidential Memorandum (NSPM)-20.

While mission-specific NRAs can provide increased accuracy regarding potential impacts, it is unlikely to move the NEPA significance threshold beyond what could have been garnered from a non-launch vehicle specific, U.S. Department of Energy (DOE)-developed, alternative approach. Consequently, as long as NASA verifies its NEPA determination against the SAR findings, an NRA is not necessary. If a SAR shows a potential impact that results in an increased significance threshold level (Table 1, *NEPA Impact Thresholds for Radiation Exposure*) above what was expected using an alternate analysis approach, NASA may provide a supplemental NEPA document explaining this deviation to the public when needed. The current NRA process and the DOE non-launch vehicle specific alternative approach provide the same risk protection to NASA; however, the NRA process is a significant expense, in comparison. This was demonstrated during the planning process for the Mars 2020 mission, where a supplemental EIS was required due to a substantial deviation between the NRA and SAR.

3. How does one determine the environmental consequence of a nuclear mission?

The measure of NEPA significance depends on whether a potential launch of nuclear material presents an unacceptable risk to the public or the natural environment. Both the NRA and DOE approaches analyze the specific probabilities and exposure to a member of the public. In the past, both the NRA and DOE analyses were shown in the NEPA document using the specific results, and not in a threshold format.

However, instead of showing specific results, a better approach is for NEPA documents is to use significance criteria, which categorize acceptable risk levels and follow the principles of NEPA regarding impact disclosure. Table 1 below breaks out acceptable risk profiles based on the potential probability (Y-axis) and the various consequence scenarios (X-axis). These thresholds are based on guidance from the U.S. Environmental Protection Agency (EPA), DOE, and Nuclear Regulatory Commission (NRC), which are presented in Table 2, *Established Radiation Dose Thresholds for Background Exposure* and rely on the MEI (maximally exposed individual).

TABLE 1
NEPA Impact Thresholds for Radiation Exposure

	Probability of Airborne Release[a, b]			
MEI Exposure (Member of the Public)[c]	**Beyond Extremely Unlikely (< 1:1,000,000[d])**	**Extremely Unlikely (> 1:10,000 to 1:1,000,000)**	**Unlikely (> 1:100 to 1:10,000)**	**Likely (1:1 to 1:100)**
> 25 rem	Negligible	Moderate	Significant	Significant
5 rem to 25 rem	Negligible	Minor	Moderate	Moderate
0.025 rem to 5 rem	Negligible	Minor	Minor	Moderate
< 0.025 rem	Negligible	Negligible	Negligible	Negligible

[a] Probability thresholds are based on definitions provided in DOE-STD-3009-2014.
[b] Activities in the red or "significant" threshold, would generally require an EIS; activities in "negligible," "minor," or "moderate" thresholds would generally require an EA.
[c] A member of the public is defined as an individual who is outside the restricted area around a launch site.
[d] 1:1,000,000, or 1E-6, is defined as an acceptable level of risk by EPA (1991), Federal Aviation Administration (2000), U.S. Air Force (2019), and DOE (1994).
MEI = maximally exposed individual
rem = Roentgen Equivalent Man

TABLE 2
Established Radiation Dose Thresholds for Background Exposure

Threshold	Dose (rem)	Regulation/Authority
EPA Limit for Routine Public Exposure Near a Nuclear Facility	0.025 rem/year	EPA 40 CFR Part 190
Total Average Background Radiation	0.36 rem/year 25 rem/lifetime	DOE-STD-3009-2014
Total Average Annual Dose	0.62 rem/year 43 rem/lifetime	NRC[a]

[a] NRC, 2017 (https://www.nrc.gov/about-nrc/radiation/around-us/doses-daily-lives.html)
CFR = *Code of Federal Regulations*
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
NRC = U.S. Nuclear Regulatory Commission
rem = Roentgen Equivalent Man

4. Why use the maximally exposed individual (MEI) analysis to determine the level of NEPA impact?

The MEI is a hypothetical individual who–because of realistically assumed proximity, activities, and living habitats–would receive the highest radiation dose, considering all pathways, from a given event, process, or facility (DOE Order 458.1). MEI analysis is a standard method for calculating doses to members of the general public and can be compared to U.S. standards and regulations for exposure. Furthermore, NSPM-20 emphasizes the effect to "any member of the public" and directs an assessment of potential effects to the MEI member of the public. By focusing on the MEI as opposed to other methods, it allows NASA for a concise document, which focuses on the greatest potential effect to a member of the public. This aligns with NEPA regulations and case law, which guides agencies to focus on potential "reasonably foreseeable" impacts and "significant concerns," and discourages "encyclopedic" documents.

5. Why is a deterministic approach more appropriate than a probabilistic approach?

When analyzing consequences associated with potential radiation exposure, there are two primary approaches: probabilistic and deterministic.

A probabilistic approach incorporates the (low) probability of a mishap into the determination of the impact. A probabilistic approach requires a detailed understanding of the probability of a mishap, which is dependent on the launch vehicle and the payload configuration.

A deterministic approach is based on the rem exposure to the MEI under an accident scenario. The deterministic approach is independent of the launch vehicle and the payload configuration.

A deterministic analysis is more conservative than a probabilistic analysis because a probabilistic determination takes into account a probability factor (which is always less than 1). The deterministic approach allows NASA to move away from the NRA, while maintaining a legally and technically defensible NEPA document.

6. How can NASA justify a Finding of No Significant Impact (FONSI), when there is a potential for high consequence events?

While high consequence-low probability effects warrant discussion in the NEPA process, the probability of the impact influences the significance, and therefore, low probability events can be deemed less than significant in the NEPA context. This principle is supported by the following NEPA case law:

- "[A]n agency conducting an EA generally **must examine both the probability of a given harm occurring and the consequences of that harm** if it does occur." *New York v. Nuclear Regulatory Comm'n*, 681 F.3d 471, 482 (D.C. Cir. 2012).
- "[T]he finding that the probability of a given harm is nonzero does not, by itself, mandate an EIS: **after the agency examines the consequences of the harm in proportion to the likelihood of its occurrence, the overall expected harm could still be insignificant and thus could support a FONSI**." Id.; see also *Gov't of the Province of Manitoba v. Salazar*, 691 F. Supp. 2d 37, 50 (D.D.C. 2010)

7. What is the basis for the land contamination determination?

The U.S. Food and Drug Administration (FDA) has established derived intervention levels (DIL) to identify recommended levels of contamination above which individuals consuming contaminated foodstuffs would receive an unacceptable dose (FDA, 1998). The DIL varies depending upon the individual, primarily based on age. For plutonium-238 (Pu-238), the limiting DIL, which is the highest allowable concentration, is defined by FDA as 7.3 microcuries per square meter ($\mu Ci/m^2$). This DIL was selected by DOE for use in the Mars 2020 EIS (SNL, 2019), the RHU Programmatic EA, and the Dragonfly EA. For nuclear systems that rely on materials other than Pu-238 similar industry recognized thresholds should be identified to assess potential effects from land contamination.

U.S. Food and Drug Administration (FDA). 1998. *Accidental Radioactive Contamination for Human Food and Animal Feeds: Recommendations for State and Local Agencies. U.S. Department of Health and Human Services, Food and Drug Administration, Rockville, Maryland*. Retrieved June 2019, from U.S. Department of Health and Human Services, Food and Drug Administration: https://www.fda.gov/regulatory-information/search-fda-guidance-documents/accidental-radioactive-contamination-human-food-and-animal-feeds

Sandia National Laboratories (SNL). 2019. *Nuclear Risk Assessment Update for the Mars 2020 Mission Environmental Impact Statement*. Albuquerque, New Mexico and Livermore, California: U.S. Department of Energy, Sandia National Laboratories.

8. What is the level of public interest associated with nuclear-enabled missions?

Nuclear-enabled missions garnered considerable public interest in the 1990's and there was NEPA litigation on the Cassini (1997), Ulysses (1990) and Galileo (1989) missions; however, all these cases were settled in NASA's favor and launches were able to proceed as scheduled. Recently, the level of public controversy has declined and NASA NEPA documents for nuclear-enabled missions have not received significant public input. The input received during recent public comment periods generally has been provided by scientific experts already engaged in NASA's nuclear activities and is highly technical in nature. The following list provides a brief overview of the comments received on the Mars 2020 EIS, RHU Programmatic EA, and Dragonfly EA.

- Mars 2020 Supplemental EIS – NASA received three sets of comments on the Draft Supplemental EIS. The Environmental Defense Institute submitted a comment objecting to the mission in general because of the use of radioactive material. A general public individual commented that the cumulative impact analysis of land use impacts in the event of a release of radioactive materials was inadequate. Finally, EPA indicated that it had no concerns with the Proposed Action. Based on these comments, no changes to the Final Supplemental EIS were necessary.
- RHU Programmatic EA – NASA received one set of comments on the Draft EA. The Brevard County Emergency Management Office in Brevard County, Florida, submitted comments questioning the technical analysis regarding impacts on the regional area's economy in an accident scenario. Minor revisions were made to the Final EA based on the non-technical comments.
- Dragonfly EA – NASA received one set of public comments on the Draft EA. An individual with technical expertise in the field questioned NASA's use of an EA instead of an EIS; use of the deterministic approach; and the radioisotope thermoelectric generator (RTG) design. Minor revisions were made to the Final EA, but none of the changes were technical in nature.