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IMPROVING THE NUCLEAR LAUNCH APPROVAL PROCESS; PROGRESS AND PLANS

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Launches involving radioisotope power systems (RPS) or radioisotope heater units (RHU's) must comply with a number of different statutory, regulatory, and administrative requirements. While some of these are well defined, others have been carried out on the basis of past practice rather than a set of formal standards. In addition, some of the requirements reference outdated standards and are in need of updates. The overall process is also time consuming and expensive. This paper describes efforts by NASA, the Department of Energy (DOE) and others to make improvements to the process while maintaining safety and environmental protection.

I. INTRODUCTION

Radioisotope Power Systems (RPS) support missions that need autonomous, long-duration power. RPS have a proven record of operation in the most extreme cold, dusty, dark, and high-radiation environments, both in space and on planetary surfaces.

RPS technologies offer potential to serve a wide range of missions. The NASA RPS Program has an established relationship with the DOE and current agreements and processes are in place to support mission requirements.

Safety is an integral part of any nuclear system, and it encompasses the entire system lifecycle.

The strategy used to meet safety objectives for any U.S. space nuclear heat source or system is to:

Design and build safety into each nuclear heat source and system at the outset, considering its potential applications;

Demonstrate the safety of each nuclear heat source and system through rigorous analysis and testing; and

Separately and quantitatively assess the environmental impact as well as the level of risk for each proposed nuclear system and nuclear-powered space mission for use in decision making and approval processes.

II. REGULATORY REQUIREMENTS

The goal of the nuclear launch approval process is to understand the risks (environment and public) associated with the launch of radioactive materials. The current process evolved from existing federal requirements, which include:

II.A. Presidential Directive/National Security Council – 25 (PD/NSC-25)

Entitled **"**Scientific or Technological Experiments with Possible Large-Scale Adverse Environmental Effects and Launch of Nuclear Systems into Space," this directive was first issued in 1977 under President Jimmy Carter. The directive addresses a range of actions that could have international impacts. One paragraph specifically addresses launches involving nuclear material. It specifies that certain launches require Presidential approval, and requires an Interagency Nuclear Safety Review Panel (INSRP) (including DOD, DOE, NASA, EPA and the NRC) to evaluate the risks associated with missions requiring the President's approval.

II.B. 2010 National Space Policy

The National Space Policy has been updated a number of times. The 2010 version largely deals with the issues associated with commercial space. It has a short section addressing nuclear launches and requires Presidential/designee approval for nuclear-powered spacecraft launches; and directs DOE to conduct a nuclear a nuclear safety analysis and produce a safety analysis to be evaluated by the ad hoc INSRP.

II.C. National Environmental Policy Act (NEPA)

NEPA requires federal agencies to analyze potential environmental impacts during program and project decision making**.** It specifically requires an environmental impact statement (EIS) for "major federal actions significantly impacting the quality of the human environment."[1] The Council on Environmental Quality (CEQ) has regulations which expand upon the requirements in the statute and provide guidance on its implementation. NASA also has issued regulations (14 CFR 1216) for its implementation of NEPA.

II.D. National Response Plan (NRP)

The NRP provides the mechanisms for a comprehensive coordinated response to all Incidents of National Significance. Incidents of National Significance are high-impact events that require an extensive and well-coordinated multiagency response to save lives, minimize damage, and provide the basis for long-term community and economic recovery. As the principal Federal official for domestic incident management, the Secretary of

Homeland Security declares Incidents of National Significance (in consultation with other departments and agencies as appropriate).

In order to prepare the response in the event of an accident associated with a nuclear launch, a radiological contingency plan (RCP) team is established and includes all appropriate federal, state and local agencies that may be involved in the response.

II.E. NASA Procedural Requirement (NPR) 8715.3 "General Safety Program Requirements", Chapter 6 "Nuclear Safety for Launching Radioactive Materials"

NASA's Nuclear Launch Safety Approval (NLSA) process is captured in NPR 8715.3 "General Safety Program Requirements", Chapter 6 "Nuclear Safety for Launching Radioactive Materials." The NPR includes NASA procedural requirements for implementation of PD/NSC-25, and is managed by Office of Safety and Mission Assurance (OSMA). It includes requirements to designate a Nuclear Flight Safety Assurance Manager (NFSAM) and an INSRP Coordinator, and calls for the OSMA to provide assistance to the cognizant NASA Mission Directorate and project office(s) in meeting nuclear launch safety analysis/evaluation requirements and review all radiological contingency and emergency planning.

III. PROGRESS ON IMPROVEMENTS

III.A. PD/NSC-25

The PD/NSC-25 was last amended in 1996. It requires Presidential approval for launches of reactors and other devices with a potential for criticality and for radioactive sources containing total quantities greater than 1,000 times the A2 value listed in Table I of the International Atomic Energy Agency's (IAEA's) Safety Series 6, Regulations for the Safe Transport of Radioactive Materials, 1985 Edition (as amended 1990).

In June 2018, the National Science and Technology Council (NSTC) Subcommittee on Space Hazards and Security formed a Nuclear Safety Launch Process (NSLP) Working Group (hereafter, "the WG"). The WG was tasked with reviewing the existing launch approval process and considering potential policy and process adjustments, possibly including revisions to PD/NSC-25.

Areas that the work group felt needed to be addressed included:

- Trigger levels – i.e. the establishment of a revised threshold for triggering the launch approval process.

- Bounding – i.e. an acceptable risk or exposure level that is determined to be sufficiently safe for launch approval, and

- Processes, i.e. the establishment of standards and procedures to guide the INSRP in the conduct of their reviews. For example, a charter or terms of reference could be developed for the INSRP to outline what is and is not expected from the review.

III.B. NEPA

NASA's regulations implementing NEPA list types of actions that "normally require an EIS," including "Development and operation of a space flight project/program which would launch and operate a nuclear reactor or radioisotope power systems and devices using a total quantity of radioactive material greater than … a total quantity of radioactive material for which the A2 Mission Multiple (see definitions in Appendix A to this subpart) is greater than 10))."2

NASA has begun discussions with the Council on Environmental Quality (CEQ), the executive agency which oversees NEPA implementation across the federal government. The initial indications are that CEQ is supportive of making NASA's NEPA regulations less proscriptive and more flexible.

NASA has also kicked off the development of a Programmatic Environmental Assessment (PEA) for missions that would use only RHU's. The PEA would satisfy NASA's obligations under NEPA for missions that fit within its parameters. The PEA would cover spacecraft launched from Kennedy Space Center (KSC) and Cape Canaveral Air Station (CCAFS), Florida. The U.S. Department of Energy (DOE), U.S. Air Force (USAF) and Federal Aviation Agency (FAA) are cooperating agencies on the PEA. The DOE's cooperating agency role stems from its responsibility in producing and controlling the radioisotope material used in RHUs; DOE maintains the ownership of RHUs throughout their life cycle and allows for their use in NASA missions. The USAF is a cooperating agency because it manages the launch facilities at CCAFS and has expertise in launches using RHUs. The FAA is a cooperating agency because it issues launch operator licenses and experimental permits for commercial spacecraft activities at KSC.

A key question in the development of the PEA is how many RHU's should be considered to be within its scope. The current direction is now basing the upper limit of RHUs on the projected need as determined by NASA; we will then perform the impact analysis on alternatives developed based on the potential need and disclose the risk through the NEPA process. This process follows a traditional NEPA approach of agencies determining their proposed action based on their needs and then determining the environmental effect of that need. The current alternatives being considered are as follows: Alternative A) Up to 65 RHUs (or the Curie equivalent) Alternative B) up to 130 RHUs (or the Curie equivalent).

The PEA is scheduled to be completed by mid-2019.

III.C. NATIONAL SPACE POLICY

The National Space Policy states that the Secretary of Energy “shall conduct a nuclear safety analysis” for launches that require Presidential approval. However, it does not say how that analysis should be conducted.

DOE management has reviewed the process for producing SAR;s for past missions and has found that:

- Excellent engineering provides significant mitigation of Pu release
- No formal regulations to establish requirements and acceptable level of risk acceptance (exempt from 10 CFR 830)
- The space nuclear safety analysis methodology differs from other current DOE approaches
- The process has remained relatively unchanged for several decades
- There was a lack of prioritization and binning to assess risk importance, as it was easier to accept and make changes versus analyzing the technical merits of risk impacts resulting from these changes

DOE has considered several options for nuclear launches subsequent to Mars 2020. One option is to prepare a documented safety analysis (DSA), centered around the RPS or RHU’s, using DOE published standards as guidelines or references. Once such a DSA is in place, it can be used to bound the conditions for launch in a technology and mission independent fashion. For example, the DSA could show that the RPS or RHU has a very low probability of releasing plutonium-238 under a given set of pressures, temperatures, and shock limits. If future missions do not result in conditions that exceed these established limits, then further analysis of the accident scenario, or any modification to the DSA, would be unnecessary.

A DSA for RHU-only missions has now been kicked off by DOE. When completed, it would function as described above and could significantly streamline the launch approval process for missions within its scope. Assumptions made for this DSA include:

- A single generic launch vehicle / spacecraft configuration will be defined to provide bounding values for fuel, etc.
- The hazard analysis will consider accidents associated only with the launch phase(s) that contributed the majority of risk per the MSL and Mars 2020 FSARs (e.g., pre-launch, early launch)
- A bounding nuclear payload consisting of LWRHUs will be established
- Acceptance criteria (e.g., health effects) other than current DOE Evaluation Guidelines may be needed for evaluation and risk binning of potential hazardous events
- Environmental effects of potential radioactive material releases will be adequately addressed in pertinent NEPA documentation (i.e., the safety analysis methodology does not address environmental impacts)
- DSA may be used to support integration of safety into mission and launch decisions

III.C. FISSION SYSTEMS

In addition to RPS, efforts are also underway to improve the nuclear launch approval process for potential fission systems. Fission systems have been a consideration in the OSTP’s work on the process, and NASA has commissioned a work group to make policy and technical recommendations in this regard. These efforts are described in a separate paper.

IV. GOING FORWARD

A number of potential improvements and new ways of doing business have been identified above. Obviously, these will involve a number of different organizations to carry them out. Those organizations include:

- NASA’s:
    - Science Mission Directorate Mission Program Offices
    - Launch Services Program Office
    - Office of Safety and Mission Assurance (OSMA)
    - Environmental Management Division (EMD)
- Department of Energy
- US Air Force Space Command
- Jet Propulsion Laboratory
- And others

In order to ensure coordination of all these parties, the NASA Radioisotope Power Systems Program Office has established the function of Nuclear Launch Approval Manager (NLAM). The NLAM will conduct both ongoing coordination of the interested parties, and mission-specific coordination, acting as the agent for the mission Program Executive. A number of NASA handbooks and procedural requirements are being rewritten to recognize this function.

The PEA and DSA mentioned above for RHU-only missions could eventually serve as templates for similar documents to be developed for future RPS generators.

V. CONCLUSIONS

The nuclear launch approval process encompasses a number of complimentary safety and environmental reviews, building on an extensive technical basis of information regarding launch vehicles, spacecraft, and RPS/RHU's. This technical basis is the key to maintaining safety and environmental protection. The "how" for the reviews should be updated to ensure they reference current standards, make use of past analysis, and are commensurate in scope to the risks being addressed.

REFERENCES

1. 42 USC §4332
2. 14 CFR §1216.306
3. A. Camp, et al, "RECOMMENDATIONS FOR THE NUCLEAR SAFETY AND LAUNCH APPROVAL PROCESS FOR FISSION REACTORS" Nuclear and Emerging Technologies for Space, American Nuclear Society Topical Meeting, Feb. 25-28, 2019, (2019).