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POTENTIAL LAUNCH APPROVAL PROCESS FOR COMMERCIAL SPACE NUCLEAR SYSTEMS

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The current launch approval process for any space nuclear system has only been used for government launches, but there has been increasing interest by commercial entities to use space nuclear systems. To inform the identification of options to develop a launch approval process for commercial entities, we review the existing legal framework and launch approval process for government launches using nuclear systems and commercial launches with non-nuclear systems. We then discuss potential launch approval processes and implications for two different commercial space nuclear launch scenarios. We conclude by presenting the unresolved issues regarding commercial space nuclear launch approval, and recommend Congress establish a comprehensive approval framework.

I. INTRODUCTION

The existing launch approval process for space nuclear systems has only been used for government launches. Space nuclear systems include fission power or propulsion and radioisotope power source (RPS) systems. To date, there have been no commercial space nuclear launches, which we define as a nongovernment entity assuming a major role in the mission, such as taking responsibility as the mission operator or sponsor. The legal and policy documents that govern space nuclear missions do not currently explicitly include commercial launches, and there are significant open questions that must be resolved prior to the first commercial reactor or RPS launching into space.

Addressing this policy gap is timely, as there is interest in commercial space nuclear launches. Nongovernment entities have been contracted to fabricate parts of past launches. For example, United Launch Alliance (ULA) constructed the Atlas V rocket for the 2011 Mars Science Laboratory (MSL) National Aeronautics and Space Administration (NASA) mission. The power source for MSL is a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) with 4.8 kg of plutonium dioxide. But now companies such as BWX Technologies, Atomos, and Ultra Safe Nuclear Company are actively pursuing the development of commercial nuclear fission systems for commercial customers. For radioisotope systems, no commercial entity has announced independent development activities.

Commercial activities currently under consideration by U.S. companies include, but are not limited to, on-orbit or cis-lunar activities (e.g., space tug operations proposed by Ad Astra Rocket Company) and operations on celestial bodies (e.g., lunar activities proposed by Moon Express and Astrobotic). As commercial activities expand to take on the various roles of the nuclear launch process, responsibilities and requirements for launch approval will need to be adjusted to account for nongovernment actors.

This paper focuses on commercial space nuclear launch approval, which is but one of the many review steps in the lifecycle of a space nuclear mission. Other processes that will need to be explored for suitability for commercial providers of space nuclear missions include the approval for fuel manufacturing or procurement, the licensing of terrestrial transport, the approval for payload/system integration, the commercial launch vehicle license, the range safety review, and reentry or decommissioning licensing. Roles and responsibilities will need to be defined for each of these stages, including which Federal agencies will provide oversight.

II. EXISTING LEGAL AUTHORITIES

To determine the existing legal framework for commercial space launches involving nuclear systems, we review laws, regulations, and policy governing distinct activities, including terrestrial nuclear materials use and transport, commercial launches, and space nuclear launches. These categories of activities are examined separately to identify the landscape of which Federal departments and agencies are currently responsible for activities related to commercial space nuclear launch, which will affect subsequent framework development.

II.A. Nuclear Materials Authorities

The Atomic Energy Act provides that a “person” may not own, possess, or use a production facility, a utilization facility, or special nuclear material without either license from the Department of Energy (DOE) or Nuclear Regulatory Commission (NRC). The Act splits authority over nuclear materials between DOE and NRC. NRC has licensing and regulatory authority over the possession, use, transfer, and transport (in conjunction with the Department of Transportation [DOT]) of commercial nuclear facilities and materials (i.e., those not owned by

DOE) under or within the jurisdiction of the United States [1].

II.B. Commercial Launch Authorities

The DOT is directed by Congress to broadly "encourage, facilitate, and promote commercial space launches and reentries by the private sector" (51 U.S.C. § 50903) [2]. To implement this vision and ensure public health and safety, safety of property, and the national security and foreign policy interests of the United States are preserved, Congress authorized the Federal Aviation Administration (FAA) to license the operation of all commercial launch and reentry activities conducted by U.S. entities domestically and abroad [2].

The FAA has jurisdiction over non-Federal launch sites, and has promulgated regulations found in the Code of Federal Regulations Chapter 14 Parts 401, 417, 420 [3]. Federal launch ranges, such as Vandenberg Air Force Base and Wallops Flight Facility, are governed by additional regulations under the purview of the range operator, e.g. Air Force or NASA, as applicable [4].

II.C. Space Nuclear Launch Authorities

All government missions involving space nuclear systems, including fission and RPS systems, require presidential approval. The current launch approval process is governed at a high level by two executive documents – Presidential Directive/National Security Council Memorandum No. 25 (PD/NSC-25, last updated in 1996) [5] and the 2010 National Space Policy [6] – and the National Environmental Protection Act (NEPA) [7].

PD/NSC-25 states that "[t]he head of the sponsoring agency will request the President's approval for the flight through the Office of Science and Technology Policy [OSTP]" [3]. It is uncertain if and how this could apply to commercial launches. The "sponsoring agency" cannot be the licensing authority, i.e. FAA, for the commercial mission.[1] Therefore PD/NSC-25 could only apply in the commercial context if there is some other government agency willing to act as the "sponsor" of the mission.

Under 14 CFR § 415.115, FAA also has the authority to evaluate the launch of any radionuclides on a launch vehicle or payload on a case-by-case basis, and issue an approval if the FAA determines the launch is consistent with public health and safety.

[1] "Sponsoring" implies the agency is taking financial responsibility for any issues that arise by funding clean up, etc. This is not a role that FAA fills for commercial launches that it licenses. Furthermore, the 2010 NSP requires the head of the sponsoring department or agency to approve exceptions to debris mitigation standard practices and FAA has interpreted this not to apply to the commercial launches it is licensing.

III. CURRENT LAUNCH APPROVAL FOR GOVERNMENT SPACE NUCLEAR SYSTEMS

One existing framework that could be adapted to commercial space nuclear launch approval is the government space nuclear launch approval process.

The launch approval process for nuclear missions involves three separate (somewhat concurrent) reviews – (1) the mission owner (NASA or the Department of Defense (DOD)) prepares an Environmental Impact Statement (EIS) or Environmental Assessment (EA) as mandated by NEPA, (2) the DOE performs the safety analysis and prepares a Safety Analysis Review (SAR), and (3) the Interagency Nuclear Safety Review Panel (INSRP) reviews the SAR and prepares a Safety Evaluation Report (SER). Based on these inputs, either the Director of OSTP or the President renders approval for a launch [8].

Neither the guiding legal documents nor lower level interagency or agency policy documents provide any details regarding the scope or content of analysis required for the SAR or SER. There are no formal standards or guidelines, nor is the level of required analysis based on the relative level of risk of the mission. For recent missions, the process has taken an average of six years and costs over $40 million [8].

IV. COMMERCIAL LAUNCH APPROVAL

The current approval process for non-nuclear commercial launches could also help inform the development of a commercial nuclear launch approval process.

An overview of the process FAA undertakes to review commercial license requests is summarized in Figure 1. The FAA has exclusive jurisdiction over licensing commercial launch vehicle operation and is not permitted to charge user fees (51 U.S.C. § 50920). Launch licenses are authorized for launch-specific activities (e.g., operation of a specific vehicle launched from a determined location) or for launch operators (e.g., range of approved vehicles for launch from or reentry to a determined location).

Responsibility lies with the licensee to demonstrate the requirements have been met for the five categories of review. Thus, while FAA is not technically charging an application fee, there is certainly cost associated with filing an application due to the required analyses. There is also a nuance for the environmental review; the issuance of a launch/reentry site operator license or a launch/reentry license requires an environmental review under NEPA. An applicant is required to provide the FAA with sufficient information to comply with NEPA and other environmental requirements by preparing or using a third-party to prepare an EA or EIS.

Statute indicates that commercial launch license applicants cannot be required to obtain permissions from Federal agencies other than FAA to conduct commercial launch activities ("one-stop shop" model) (51 U.S.C. § 50919). However, the Federal Communications Commission's authority to regulate communications and Commerce's authority to regulate earth observations are not affected. Under its regulations, FAA reaches out to other Federal agencies for interagency consultation. For example, it will contact DOD for national security matters and State if a foreign operator. In addition, applicants must comply with requirements levied by other agencies, such as export control.

FAA is required to issue its launch licensing decision within 180 days of receiving a "complete enough" license application (51 U.S.C. § 50905). However, there is no time limit on the pre-application consultation, and the FAA can toll (pause) the review period if it finds an issue with the application and needs to obtain additional information from the applicant (14 CFR § 413.15).

The FAA may grant waivers to regulatory requirements including the requirement to obtain a license so long as it is in the public interest and will not harm "public health and safety, safety of property, and national security and foreign policy interests of the United States" (51 U.S.C. § 50905). For example, Space X was granted a waiver to use an autonomous system rather than the required human "in the loop"; the autonomous system was actually safer.

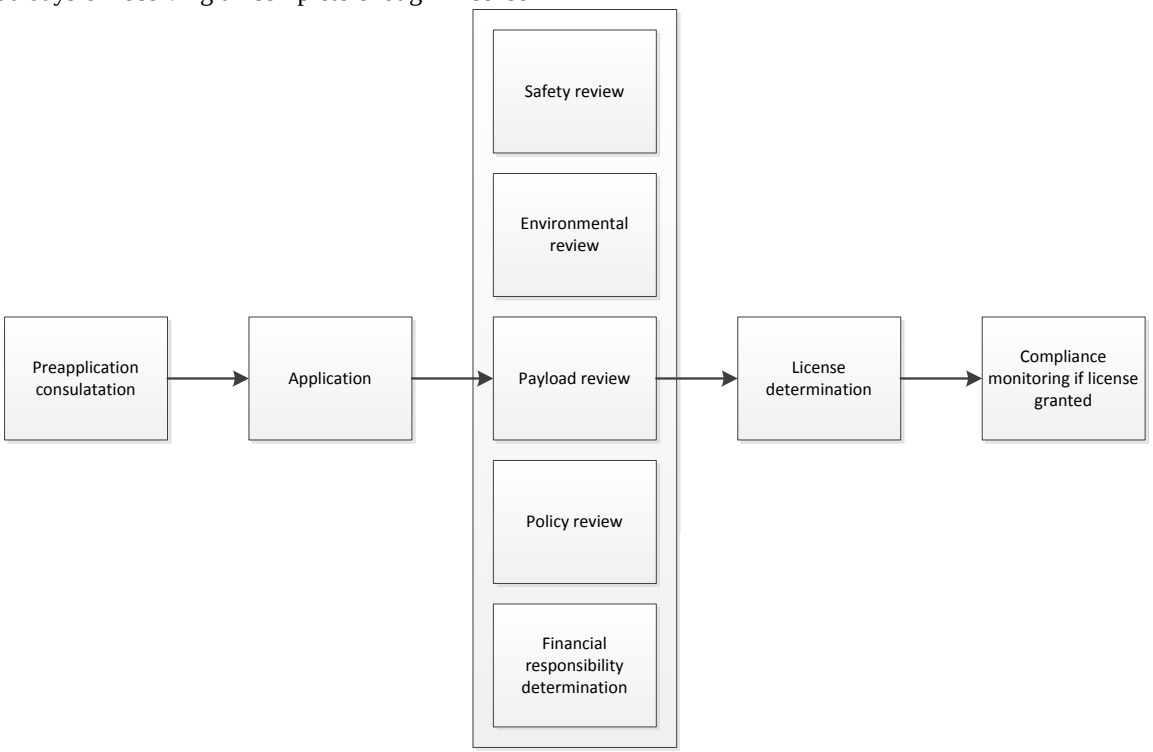

Fig. 1. FAA Process for Licensing Launches [9]

V. POTENTIAL APPROVAL FRAMEWORK

V.A. Critical Components of Commercial Launch Approval Process

In order for the nuclear commercial launch approval process to enable such launches, the cost and length of the process must not be so burdensome as to overwhelm the business case for commercial space nuclear applications. The process must therefore operate within reasonable bounds regarding cost and time. It must also provide a measure of certainty regarding the types of analyses required, relative length and cost of the approval process, and clear guideposts for companies to prove that their systems meet sufficient safety standards. Companies will need some advanced warning regarding how those standards relate to the outcome of a launch license determination.

Even if the current government launch approval process could be adopted wholesale for commercial launch, it is unbounded by anything other than budget and the launch window. In practice, this has meant significant variations in the complexity of analyses completed and the length of time it has taken. Therefore, applying the

government launch approval framework to commercial space nuclear launch approval would require modification beyond substituting the responsible actors. Without including guidelines to inform the safety analysis requirements and timelines associated with launch approval, this will be of limited utility for the commercial space nuclear market.

An effective commercial space nuclear launch approval process would also have to be functional for both RPS and fission. The current process has been proven with RPS systems. Including fission systems is of paramount concern for the commercial industry given that fuel sources that are commonly used for RPS systems, such as Pu-238, will likely remain under government control. While a commercial entity could own a nuclear fuel source if licensed by the NRC, in the case of Pu-238, the only current producer/provider of Pu-238 is DOE.

V.B. Scenarios

There are a number of different scenarios for commercial space nuclear launches when one considers variations in 1) fuel, 2) fuel provider, 3) nuclear device developer, 4) launch operator, 5) launch site operator, 6) mission owner, and 7) intended location. This paper reviews two potential scenarios in order to demonstrate the potential approval framework for commercial space nuclear missions. Scenario A involves a radioisotope heater unit (RHU) developed by DOE to be launched and used by a commercial operator for planetary surface operations. Scenario B involves a commercially developed low enriched uranium (LEU) reactor to be launched and used by a commercial operator in orbit.

V.C. Potential Process

V.C.1. Potential Process for Scenario A

Scenario A presents a more straightforward hypothetical since much of the government launch approval process could apply to a commercial operator. The commercial operator will enter into a contract with DOE to procure a RHU and DOE will impose conditions on the procurement that replicate the existing safety review process, including the completion of a SAR (by DOE or the commercial entity), a SER by INSRP, and Presidential nuclear launch approval. In the pre-application consultation, once the commercial operator presents FAA with a sufficiently detailed design and specific launch window, the "sponsoring agency" will empanel the INSRP. Since FAA cannot act as the "sponsoring agency", it is possible DOE could take on this role as the provider of the nuclear device.

The SAR and SER will be forwarded to the White House for approval, and the Director of OSTP (or the President) will give approval. At that point, the applicant will present the completed launch license application to FAA and the typical process for commercial launches would follow. The nuclear launch approval determination, along with supporting documentation, shall be included in that package to support the payload safety review. The FAA would work with the appropriate agencies to meet the NEPA requirements for the licensing action and any connected activities.

In order for this process to be viable, FAA must conduct a rulemaking with the support of DOE to make nuclear safety requirements transparent. FAA will be unable to tell an applicant their application is incomplete if it has no standards to weigh the application against. In addition, who bears the financial burden of INSRP will need to be determined.

V.C.2. Potential Process for Scenario B

Under Scenario B, NRC would have licensing authority over use-related activities (including ground transport in conjunction with DOT) up to the launch site (after which FAA authority would apply). But DOE is not providing the nuclear system or the fuel, so there is no contractual hook to require the SAR, SER, and Presidential approval. Instead, it will have to flow through FAA as the licensing authority. To accomplish this, FAA could use its regulatory authority to govern hazardous launches [2] to add a sixth review, "nuclear safety review." The FAA has the legal authority to address the safety of commercial nuclear system in so far as it affects the safety of launch and purposeful reentry. The SAR, SER by INSRP, and possibly the Presidential approval requirement could be built into the nuclear safety review. There is a question as to whether the FAA will be able to use its regulatory authority to designate the President as the approval authority, unless directed by Congress to do so. Another question remains as to who could act as the sponsoring agency in this case if FAA is not permitted. As part of its interagency consultation, FAA could reach out to DOE or NRC, as is appropriate, to review the nuclear safety analysis.

V.D. Unresolved Issues

The potential processes for both scenarios hinge on there being sufficiently concrete standards, guidelines, or criteria, by which a commercial operator could demonstrate that their proposed nuclear launch was safe enough to launch. It is likely that standards will need to be established for government space nuclear launches first so that they may be applied to commercial launches.

Under its legal authorities, DOE has the authority to authorize the use and otherwise distribute special nuclear material. The only other agency that could license commercial nuclear materials or facilities is the NRC. NRC does not currently have licensing standards pertaining to the commercial use of nuclear space systems. NRC authority does not extend to space launches. The NRC does not have authority for day-to-

day operational oversight of commercial spacecraft using nuclear power or propulsion systems in orbit or on the surface of celestial bodies, and has no equivalent oversight or licensing regime to that existing for terrestrial nuclear applications. DOE authorizes and indemnifies its own nuclear devices.

No U.S. Federal agency currently holds regulatory authority for activities on-orbit or on celestial bodies. FAA is authorized to license and regulate launch and purposeful reentry, the Federal Communications Commission regulates communications, and the Department of Commerce through National Oceanic and Atmospheric Administration oversees remote sensing. In current government space nuclear missions, DOE retains title to the RPS provided to NASA. DOE considers on-orbit operations in its safety assessments in support of launch approval and has the authority to monitor on-orbit operations of systems it owns.

Another important point is that FAA's licensing authority does not cover "a launch, reentry, operation of a launch vehicle or reentry vehicle, operation of a launch site or reentry site, or other space activity the Government carries out for the Government" (51 U.S.C. § 50919(g)). Since there have been no nongovernment launches using nuclear systems, FAA has no experience licensing launches with nuclear systems.

The 1992 United Nations Resolution 47/68 "Principles Relevant to the Use of Nuclear Power Sources in Outer Space", specified that "[n]uclear reactors shall use only highly enriched uranium 235 as fuel" [10]. However, we would not expect the government to approve any commercial launches using highly enriched uranium (HEU) due to the inherent security risk. But there remain many open questions regarding what parameters should be set regarding safe altitude and the likelihood of hot reentry, and planetary operations.

Another significant issue is that the current guiding policy document, PD/NSC-25, is marked For Official Use Only (FOUO). It is illogical for the commercial launch approval process be guided by a document that the public is not permitted to view.

VI. CONCLUSION

Given all the unresolved issues with using the existing legal framework to review and approve commercial space nuclear missions, the best-case scenario would be a new comprehensive approval framework mandated by legislation. This framework could fill in the gaps in agency regulatory authority and outline the criteria for review and approval with sufficient specificity to enable the growth of a commercial space nuclear industry.

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