



# NASA Procedural Requirements

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## Nuclear Flight Safety

**Responsible Office: Office of Safety and Mission Assurance**

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# Preface

## P.1 Purpose

- a. This directive defines the roles and responsibilities for managing and overseeing NASA's nuclear flight safety activities. It provides the requirements to implement NASA's policy to protect the public, NASA workforce, high-value equipment and property, and the environment from potential harm as a result of NASA activities and operations, by factoring safety as an integral feature of programs, projects, technologies, operations, and facilities.
- b. This directive also describes NASA's implementation of Federal requirements under National Security Presidential Memorandum (NSPM)-20, "Presidential Memorandum on Launch of Spacecraft Containing Space Nuclear Systems," dated August 20, 2019, radiological contingency planning (RCP) as a part of broader NASA emergency management activities (see NPD 8710.1 and NPR 8715.2) and other factors, as well as agency-specific activities relating to ensuring safety and mission success for NASA-sponsored payloads containing space nuclear systems (SNS) or other radioactive material (note that these terms are defined in [Appendix A](#)).
- c. This directive establishes a framework where other requirements, guidance, and processes (e.g., Department of Energy (DOE) nuclear safety and security requirements, U.S. Air and Space Force range safety requirements, NASA payload safety processes) relevant to nuclear flight safety can be implemented in to the overall Safety and Mission Assurance (SMA) process.

## P.2 Applicability

- a. This directive is applicable to NASA Headquarters and NASA Centers, including Component Facilities and Technical and Service Support Centers. This directive applies to the Jet Propulsion Laboratory (a Federally-Funded Research and Development Center), other contractors, recipients of grants, cooperative agreements, or other agreements only to the extent specified or referenced in the applicable contracts, grants, or agreements.
- b. This directive is applicable to activities involving flight of SNS or other radioactive material for which NASA is the sponsoring agency or that involve the use of NASA personnel and assets for phases of a flight where the SNS or other radioactive material has the potential to affect Earth's biosphere. In some cases, aspects of the NASA nuclear flight safety program may fall under the auspices of another Federal agency, such as in the case of a Federal Aviation Administration (FAA)-issued license for the launch of NASA-provided radioactive material. If applicability of this directive is not clear, NASA personnel will consult with the Nuclear Flight Safety Officer (NFSO) and the Office of the General Counsel to confirm responsibilities for nuclear flight safety.
- c. This directive considers nuclear safety and radiological risk from both normal and off-normal conditions during all phases of flight for which the SNS or other radioactive material has the potential to affect Earth's biosphere, typically starting with installation of the SNS or other radioactive material into an integrated launch vehicle on Earth. Matters outside of this scope are generally addressed by other NASA disciplines (e.g., planetary protection, crew safety).
- d. This directive does not address procedures, requirements, or licensing details for using, storing,

shipping, or handling radioactive materials in ground processing facilities or activities, nor does it cover these activities as they relate to preparation of the actual radioactive material for space use. For additional information on these matters, see NPR 1800.1, NASA Occupational Health Program Procedures, Center-specific Radiation Protection Program requirements and procedures, and relevant documents from the licensing or authorizing agency.

e. This directive does not serve to meet National Environmental Policy Act (NEPA) compliance, does not serve to govern the level of NEPA analysis required for a mission, and does not serve to govern if there is sufficient safety data to make NEPA determinations. For additional information on NEPA matters, see NPR 8580.1, Implementing the National Environmental Policy Act and Executive Order 12114.

f. In this directive, all mandatory actions (i.e., requirements) are denoted by statements containing the term “shall.” The term “may” denotes a discretionary privilege or permission, “can” denotes statements of possibility or capability, “should” denotes a good practice and is recommended, but not required, “will” denotes expected outcome, and “are/is” denotes descriptive material.

g. Where conflicts exist between provisions of this directive and Federal statutes or regulations (e.g., provisions of the Atomic Energy Act), or higher-level NASA directives, those statutes, regulations, and higher-level NASA directives take precedence.

h. In this directive, all document citations are assumed to be the latest version unless otherwise noted. Use of more recent versions of cited documents may be authorized by the responsible SMA Technical Authority (TA).

i. Some documents listed as an authority document or reference are called out as either a reference or authority in the citations found within the text.

## **P.3 Authority**

a. NPD 1000.3, The NASA Organization. b. NPD 8700.1, NASA Policy for Safety and Mission Success.

## **P.4 Applicable Documents and Forms**

a. National Security Presidential Memorandum on the Launch of Spacecraft Containing Space Nuclear Systems (NSPM-20). b. NPR 7120.5, NASA Space Flight Program and Project Management Requirements. c. NPR 8715.5, NASA Range Flight Safety Program. d. NPR 8715.7, NASA Payload Safety Program. e. NASA-STD-8719.24, NASA Payload Safety Requirements. f. NASA-STD-8719.25, Range Flight Safety Requirements. g. Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans.

## **P.5 Measurement/Verification**

Compliance with the requirements contained in this directive is continuously monitored by the SMA TA. Compliance may also be verified as part of selected life cycle reviews and by assessments, reviews, and audits of the requirements and processes defined within this directive.

## P.6 Cancellation

a. Chapter 6, “Nuclear Safety for Launching of Radioactive Materials” and Appendix D, “Activity and Radioactive Material Limits - Basic A1 /A2 Values” of NPR 8715.3D, NASA General Safety Program Requirements, dated August 01, 2017. b. NPI 8715.93, “Impacts of NSPM-20 on NASA Nuclear Flight Safety Requirements and Practices”, dated June 5, 2020

# Chapter 1. Overview

## 1.1 Introduction

1.1.1 This directive implements Federal requirements under NSPM-20, “Presidential Memorandum on Launch of Spacecraft Containing Space Nuclear Systems,” dated August 20, 2019. NSPM-20 updates the Federal process for the launch of SNS to “ensure a rigorous, risk informed safety analysis and launch authorization process.” This directive also incorporates NASA’s responsibilities under the authorities of other agencies involved in the launch of SNS or radioactive material, the National Response Framework, and the U.S.’s international commitments.

1.1.2 Procedures and levels of review and analysis required for nuclear launch and reentry authorization or concurrence vary with the quantity and form of material planned for use, as well as with the potential radiological risk (e.g., human health exposures, impacts on land use, or impacts on property use). In the context of this document, reentry or planned return to Earth refers to intended portions of the spaceflight and is addressed in the authorization or concurrence process. By contrast, unplanned reentry (referring to an unintended event) is addressed in the safety analysis and RCP processes.

## 1.2 Delegation of Responsibilities

1.2.1 Unless specifically prohibited, responsibilities and requirements may be delegated. The stated role or actor remains accountable for its implementation and outcome.

1.2.2 Where an office or organization is stated as the actor of a requirement, the Official in Charge of that office or organization is responsible and accountable for the action and its outcome.

## 1.3 General Terms

Definitions for general terms, such as “A2 mission multiple” and “space nuclear system” are provided in Appendix A.

## 1.4 Request for Relief

1.4.1 For additional information on the defined process for requesting and granting relief from requirements within this directive and standards incorporated by reference herein, see NPR 8715.3. The Chief, SMA is the Approving Authority for requests for relief to the requirements in this directive.

1.4.2 For NASA missions, non-conformances with Federal nuclear launch authorization direction in NSPM-20 or other applicable regulatory-agency requirements will be elevated to the Administrator. The Administrator, Chief, SMA, and Chief Health and Medical Officer (CHMO) would make such determinations in consideration of applicable National Space Policy and the responsibilities defined in NPD 8700.1 with regards to consent to human safety and property risk on behalf of the general public.

1.4.3 For NASA missions, non-conformances with NSPM-20 requirements will be formally communicated to the Director, Office of Science and Technology Policy (OSTP).

# Chapter 2. Roles and Responsibilities

## 2.1 Administrator

2.1.1 The Administrator is responsible for the radiological risk to the public, NASA workforce, high-value equipment and property, and the environment from launching or reentering NASA space nuclear systems (SNS) and other radioactive material. To this end the Administrator:

- a. Determines the acceptability of the radiological risk associated with launching or conducting a planned return to Earth (reentry or fly-by) of an SNS and other radioactive material.
- b. Ensures NASA fulfills its responsibilities related to the standing Interagency Nuclear Safety Review Board (INSRB) to review NASA and other Federal Government launches, and when requested by the Secretary of Transportation, commercial launches, in accordance with the membership and responsibilities outlined in NSPM-20.
- c. Authorizes launch or requests the President's authorization for launch, in accordance with NSPM-20 and Chapter 4 of this directive, when NASA is the sponsoring agency.

## 2.2 Mission Directorate Associate Administrators

2.2.1 Mission Directorate Associate Administrators (MDAAs) are responsible for:

- a. Providing resources to achieve and assure compliance with applicable Agency nuclear flight safety requirements, including any evaluation by the INSRB.
- b. Designating the personnel responsible for ensuring the implementation of applicable nuclear flight safety requirements (i.e., any delegated responsibilities under this section, as well as those responsibilities of the NASA Program and Project Manager role), and if desired, assigning an individual to provide NASA mission-specific administrative support to the INSRB. In the latter case, this individual must be selected from outside the applicable program or project management chain and be free of any organizational or personal conflict-of-interest.
- c. Designating an individual that is responsible for coordinating with other entities that may be contributing SNS or other radioactive material to the flight (e.g., the Payload Project Manager role in NPR 8715.7), and ensuring that nuclear flight safety requirements are being addressed in a manner that addresses the entire manifest, when their Mission Directorate has responsibility for flight activities (consistent with NPR 8715.5).
- d. Identifying and categorizing all space flight equipment that contains or uses nuclear or radioactive materials (per Chapter 3 of this directive).
- e. Notifying the NFSO and making required reports in accordance with Chapter 4 of this directive, when an SNS or other radioactive material is identified for potential use on NASA spacecraft or in NASA-provided payloads, in order to schedule nuclear launch authorization or concurrence activities.
- f. Arranging for the preparation of the nuclear safety analysis, facilitating the nuclear safety review, and obtaining authorization or concurrence for launch or reentry, in accordance with NSPM-20 and



Chapter 4 of this directive.

g. Conducting contingency, planning as required by the National Response Framework and other requirements, including provisions for emergency response and support for source recovery efforts.

*Note: NPD 8710.1 and NPR 8715.2 address the broader NASA emergency management policy and program requirements.*

h. Consulting with the NFSO to: (i) support research and technology development to close knowledge gaps within the areas of NASA responsibility, and in partnership with other relevant Federal authorities, and (ii) develop nuclear flight safety requirements for future missions that fulfill NASA's responsibilities while remaining compatible with other Federal authorities.

## 2.3 NASA Program and Project Managers

2.3.1 The NASA Program and Project Manager (generally intended here to refer to the Implementing Program and Flight Project Managers) are responsible for:

- a. Incorporating nuclear flight safety considerations starting with program or project formulation through the point at which the SNS no longer has the potential to affect Earth's biosphere.
- b. Providing sufficient resources, access, and engagement for conducting the nuclear safety analysis and review, obtaining authorization or concurrence for launch or reentry, and supporting RCP development, in accordance with NSPM-20 and Chapter 4 of this directive, as applicable.
- c. Ensuring, to the extent of responsibility applicable under defined licensing/permitting documentation or agreements, compliance with all pertinent directives, licenses, agreements, and requirements promulgated by authorizing or regulating agencies relative to the use of nuclear or radioactive materials planned for a launch or planned return to Earth (fly-by or reentry).
- d. Assisting the MDAA (or designee) in requesting launch authorization or concurrence.

## 2.4 Office of International and Interagency Relations

2.4.1 The Office of International and Interagency Relations is responsible for supporting RCP activities and coordinating with the Department of State to ensure fulfillment of the US Government's international (e.g., United Nations Conventions) and NASA's interagency responsibilities.

## 2.5 Office of Protective Services

2.5.1 The Office of Protective Services (OPS) is responsible for:

- a. Supporting RCP activities and coordinating with the Department of Homeland Security's Federal Emergency Management Agency (FEMA) to provide adequate emergency response and recovery planning for applicable missions, as specified in Chapter 4 of this directive, and in consideration of NPD 8710.1 and NPR 8715.2.
- b. Establishing and assuring appropriate staffing of the Emergency Operations Center (EOC) at NASA Headquarters when specified in radiological contingency, radiological emergency, and

recovery plans developed in accordance with Section 4.5.

## 2.6 Center Directors

2.6.1 Center Directors are responsible for:

- a. Providing assistance to the cognizant NASA Mission Directorate(s) and project office(s) in implementing and complying with the nuclear flight safety requirements and processes provided in this directive.
- b. Providing information about facilities and operations necessary to support the nuclear safety analysis, nuclear safety review, and the launch authorization process.

2.6.2 The Center Director affiliated with the range where the launch or reentry is expected to occur, is additionally responsible for:

- a. Applying payload and range safety requirements for the launch or reentry of SNS or radioactive material as required by NPR 8715.7, NASA Payload Safety Program, NASA STD 8719.24, NASA Payload Safety Requirements, NPR 8715.5, NASA Range Flight Safety Program, and NASA-STD-8719.25 Range Flight Safety Requirements.
- b. Developing and implementing site-specific ground operations and radiological contingency plans to address potential ground handling accidents and potential launch or landing accident scenarios and to support source recovery operations, commensurate with the radioactive materials present.
- c. Providing resources, as appropriate, to maintain NASA's institutional capabilities needed to support ground operations and RCP for the launch of SNS (e.g., the Radiological Control Center (RADCC) at Kennedy Space Center).
- d. Coordinating radiological contingency plans and exercises with the CHMO.
- e. Exercising contingency response capabilities as deemed necessary to ensure adequate readiness of participants and adequacy of planning to protect the public, site personnel, and facilities.
- f. Ensuring appropriate and timely coordination with regional Federal, State, territorial, and local emergency management authorities to provide for support to, and coordination with, offsite emergency response elements.
- g. Making provisions for special offsite monitoring and assistance in recovery of radioactive materials that could spread into areas outside the geographical boundaries of the launch site.

## 2.7 Center Radiation Safety Officer

2.7.1 The Center Radiation Safety Officer is responsible for providing the NASA Program or Project Manager with radiation protection expertise and information needed for calculating the A2 mission multiple for missions involving radioactive material that do not include SNS.

## 2.8 Chief, Safety and Mission Assurance

2.8.1 The Chief, SMA, is responsible for advising the Administrator and other senior officials on

matters related to risk, safety, and mission success and serves as the lead SMA TA. To provide independent oversight of programs and projects in support of safety and mission success, the Chief, SMA, is responsible for:

- a. Appointing a technically-qualified NASA representative to the INSRB. Whenever possible, the NFSO should not serve as the INSRB member performing the review or administrative support for a NASA-sponsored mission because the INSRB and the NFSO have different roles and responsibilities, as well as different degrees of access to mission-specific information. If having separate individuals fill these roles isn't possible, the Chief, SMA would ensure appropriate controls and mitigating measures are in place (e.g., through a memorandum of agreement with the mission).
- b. Assisting other authorities in the review and evaluation of radiological risk, including coordinating with the CHMO regarding decisions involving risk acceptance.
- c. Concurring on launch or reentry for missions, as described in Chapter 4 of this directive.

2.8.2 The Chief, SMA designates the NFSO to support these responsibilities and oversee nuclear flight safety and related nuclear and radiological matters in consultation with the MDAAs.

## 2.9 Nuclear Flight Safety Officer

2.9.1 The NFSO (formerly known as the Nuclear Flight Safety Assurance Manager) advises the Chief, SMA on all matters related to nuclear flight safety and related nuclear and radiological matters, and assists the Chief, SMA in providing independent oversight of programs and projects in support of safety and mission success. The NFSO is responsible for:

- a. Engaging TAs, Mission Directorates, and Programs and Projects involving the launch or reentry of SNS or other radioactive materials on compliance with this directive.
- b. Providing administrative support to the INSRB in its standing capacity.
- c. Ensuring NASA meets its reporting responsibilities in NSPM-20.
- d. Concurring on radiological contingency plans for flights requiring RCP.
- e. Concurring on Earth launches or reentries for missions as described by Chapter 4 of this directive, and performing assessments, when applicable, consistent with Chapter 4 of this directive.
- f. Coordinating with organizations that have important interfaces with the nuclear flight safety program, such as Office of the Chief Health and Medical Officer's (OCHMO's) ionizing radiation protection program and the Office of the Chief Engineer's program and project management requirements.

## 2.10 NASA INSRB Representative

2.10.1 The NASA INSRB representative is responsible for:

- a. Participating in all relevant INSRB activities.
- b. Chairing INSRB mission-specific activities, advising the NASA Administrator of gaps or omissions in INSRB-reviewed safety analyses, and ensuring a safety evaluation report (SER) is developed, for NASA-sponsored Tier II and Tier III missions.

- c. Facilitating agreement on behalf of the Administrator on the terms of any INSRB review, including costs, between NASA and the agency requesting INSRB review, per NSPM-20.
- d. Facilitating early INSRB engagement in the safety analysis process (after the conceptual design of the mission is generated) for NASA-sponsored Tier II and Tier III missions, as directed by NSPM-20, in order to identify gaps in time for mission planners to address them without creating unnecessary delays in the launch timeline.

## 2.11 Chief Health and Medical Officer

2.11.1 The CHMO advises the Administrator, the Chief, SMA, and the applicable Mission Directorate(s) of potential health effects related to activities involving flight of nuclear or radioactive material and participates in NASA and Federal RCP and operational activities, including providing subject matter expertise in the case of any clean-up efforts. NASA roles, responsibilities, and procedural requirements for protecting the public and workforce from risks associated with the handling, use, and storage of radioactive material and radiation generating equipment while not in flight are documented in NPR 1800.1.

# Chapter 3. Mission Categorization for the Purposes of Nuclear Flight Safety

## 3.1 Space Nuclear System Tiering

3.1.1 For all missions that include an SNS, the MDAA shall notify the NFSO before System Definition Review (SDR)/Mission Definition Review (MDR) of the forthcoming launch or reentry request to support planning of nuclear safety analysis and review activities, as outlined in Chapter 4.

3.1.2 For missions involving SNS, the MDAA shall determine the mission's tier (with an associated technical basis) and obtain Chief, SMA concurrence to inform the graded approach outlined in Chapter 4 of this directive and to ensure conformance with NSPM-20. Appendix C provides information on NSPM-20 tiers. The NFSO will evaluate each tier determination to inform the Chief, SMA's concurrence.

3.1.3 For the aspects of mission tiering based on the quantity of material-at-risk, the MDAA (to be the MDAA with flight responsibilities if multiple MDAA's are contributing SNS or other radioactive material) should use the highest A2 mission multiple based on the quantity of radioactive materials expected:

- a. During pre-launch activities.
- b. At launch.
- c. Anytime the spacecraft will be in Earth orbit.
- d. During any planned return to Earth (reentry or fly-by).

3.1.4 The MDAA shall make a tier determination at up to 3 stages, as follows (the reasoning for multiple tiering determinations is discussed in Appendix C):

a. Preliminary Tier Determination (PTD) – This determination is made immediately preceding Key Decision Point C, as that life-cycle gate is defined in NPR 7120.5. This tiering determination will be made predominantly on the material-at-risk (A2 mission multiple – see Appendix D) and nuclear fuel-type provisions (for fission reactor systems) contained in NSPM 20. Information related to the potential radiation exposure levels and associated likelihoods from the safety analyses of relevant past missions will also be considered. This determination serves to provide initial alignment and clarity on whether a mission Safety Analysis Report (SAR) is required, whether the INSRB needs to be engaged, and who the likely authorizing official will be. This determination also serves to lock in the International Atomic Energy Agency (IAEA)-issued A2 values applicable to the mission, given that these values are periodically updated. If the PTD concludes that a mission is not likely to meet Tier I, II, or III criteria, this marks the end of the tiering determination process (and all subsequent nuclear flight safety processes described in this directive will be governed solely by the A2 mission multiple).

b. Provisional Final Tier Determination (PFTD) [Only applicable if PTD = Tier I, II, or III] – This determination is made at the approximate mid-point between initial mission SAR release and final

mission SAR delivery, using the postulated accident exposure levels and associated likelihoods available at that time. This determination serves to ensure earlier recognition of situations where the authorizing official may change with the final mission SAR (either a higher or lower level of authorization required), or where the degree of INSRB involvement (or lack thereof) requires adjustment (i.e., Tier I vs. Tier II).

c. Final Tier Determination (FTD) [Only applicable if PTD = Tier I, II, or III] – This determination is made upon issuance of the mission SAR (Tier I), or the SER (Tier II or III). This final tier determination will codify the level of authorization required for the mission and set the stage for seeking that authorization. This determination serves to establish a final and transparent basis for establishment of the authorizing official.

## **3.2 Categorization for Other Missions with Radioactive Material**

3.2.1 For all missions that involve radioactive material, but do not include an SNS, the MDAA, in consultation with the cognizant Center Radiation Safety Officer(s), shall use total mission radioactive material inventory contained on the launch vehicle to calculate the A2 mission multiple value per Appendix D.

3.2.2 For all missions that involve radioactive material but do not include an SNS, and for which the A2 mission multiple is determined to be greater than 1, the MDAA shall notify the NFSO before SDR/MDR of the forthcoming launch or reentry request to support planning of nuclear safety analysis and review activities, which are outlined in Chapter 4.

## **3.3 Other Foreseen Circumstances**

NASA personnel shall consult with the NFSO and the NASA Office of the General Counsel to determine what provisions, if any, of this directive apply when NASA participates in the launch or reentry of a vehicle or spacecraft from other countries or territories, or in connection with commercial entities, if the applicability of the provisions in this directive are not sufficiently clear.



# Chapter 4. Nuclear Flight Safety Requirements

## 4.1 Overview of Requirement Characterization

The level of rigor required for nuclear safety analysis and review, the level of authority required to authorize launch or reentry, the degree of interagency coordination warranted, the degree of RCP needed, and several other relevant characteristics are all a function of the mission categorization described in the previous chapter. This formulation provides a graded and risk-informed approach to supporting the decision-making process. Table 1 provides a mapping of the various required characteristics for each of the differing possible tiers and categories. This chapter provides the actual requirements associated with each unique element. Appendix E provides a notional process flow for nuclear flight safety-related activities.

## 4.2 Nuclear Safety Analysis

4.2.1 The following requirements apply to the development of a nuclear safety analysis via either a mission SAR or a Safety Analysis Summary (SAS), in accordance with Table 1. As discussed in the associated definitions in Appendix A, the distinction between these two documents is the degree of rigor and quantification. Additional contextual information is also provided in Appendix C.

4.2.1.1 The NASA Program or Project Manager shall compile the inputs required by the safety analysis preparer (e.g., information about the launch vehicle and launch operations) in a timely manner to support safety analysis preparation, as well as ensuring any needed revisions are addressed as the mission progresses.

4.2.1.2 The NASA Program or Project Manager shall arrange for the preparation of the nuclear safety analysis (SAS or mission SAR) by the safety analysis preparer.

4.2.1.3 The NASA Program or Project Manager should ensure sufficient coordination between the NFSO, the INSRB (when applicable), the program, the launch vehicle inputs provider, and the safety analysis preparer, including agreement to a schedule (typically to be developed prior to Key Decision Point C or its equivalent) for the delivery of a mission SAR using a phased approach, with the complete final mission SAR being delivered in accordance with the timeline listed in Table 1. Information potentially useful in the generation of this schedule is provided in Appendix C and Appendix E.

**Table 1. Summary of NASA Nuclear Flight Safety Process Characteristics**

Characteristic [Section Cross-Reference]	Space Nuclear Systems (SNS) / NSPM-20			Other Missions with Radioactive Material		
	Tier III	Tier II	Tier I	500 to 1,000×A2	A2 to 500×A2	<A2 <sup>2</sup>
Nuclear Safety Analysis [Section 4.2]	SAR	SAR	SAR	SAS	-	-
SAR/SAS Completion [Section 4.2]	12 mos. PTSLR	12 mos. PTSLR	10 mos. PTSLR	6 mos. PTSLR	-	-

Nuclear Safety Review [Section 4.3]	INSRB/SER	INSRB/SER	NFSO/RSR	NFSO/RSR	NFSO/RSR <sup>1</sup>	-
SER/RSR Complete [Section 4.3]	9 mos. PTSLR	9 mos. PTSLR	8 mos. PTSLR	4 mos. PTSLR	4 mos. PTSLR <sup>1</sup>	-
Public Release of SER/RSR [Section 4.3]	Exec Summary	Exec Summary	Exec Summary	Exec Summary	Exec Summary	n/a
Agency Views Request [Section 4.4]	When applicable	When applicable	No	No	No	No
Launch/Reentry Request [Section 4.4]	7 mos. PTSLR	7 mos. PTSLR	6 mos. PTSLR	4 mos. PTSLR	4 mos. PTSLR <sup>1</sup>	3 mos. PTSLR <sup>1</sup>
NASA Launch/Reentry Authority/Concurrer [Section 4.4]	President or designee	NASA Admin-istrator	NASA Admin-istrator	NASA Chief, SMA	NFSO <sup>1</sup>	NFSO <sup>1</sup>
RCP [Section 4.5]	Yes	Yes	Yes	Yes	No	No
General Counsel consultation [Section 4.5]	Yes	Yes	Yes	Yes	Yes <sup>1</sup>	No
Life-cycle activities after launch authorization [Section 4.6]	Yes	Yes	Yes	No	No	No
Information to NEPA Manager [Section 4.7]	Yes	Yes	Yes	Yes	Yes	Yes
Annual Reports to OSTP [Section 4.7]	Yes	Yes	Yes	No	No	No

<sup>1</sup> Except where an Office of Safety and Mission Assurance (OSMA)-issued categorical relief is being applied.

<sup>2</sup> This value was informed based on interagency discussions. An effort is underway to develop a quantitative technical basis for this threshold, which would be reflected in a future revision of this directive.

PTSLR = Prior to scheduled launch or reentry; RCP = Radiological contingency planning; RSR = Radiological Safety Review; these and other acronyms are provided in Appendix B.



4.2.1.4 In all cases in which a comparative analysis is being utilized (e.g., a system-specific SAR), the NASA Program or Project Manager shall obtain from the safety analysis preparer and any separate entity responsible for launch vehicle inputs, an assessment of the gaps and evaluation findings identified during the prior analyses (and its reviews) relative to improvements in the state-of-knowledge in the intervening time, prior to adopting a comparative analysis approach. Additional information is provided in Appendix C.

## 4.3 Nuclear Safety Review

4.3.1 The following requirements apply to Tier II and Tier III missions, which for NASA-sponsored missions require an INSRB review and SER, in accordance with NSPM-20:

4.3.1.1 The NASA Program or Project Manager shall engage the INSRB early in the safety analysis process, typically to occur prior to Key Decision Point C and after the conceptual design of the mission is generated, in accordance with NSPM-20's requirement for INSRB engagement early in the safety analysis process.

4.3.1.2 The NASA Program or Project Manager, with concurrence by the INSRB, the Chief, SMA, and the cognizant MDAA, shall document the terms of the INSRB review, including any estimated costs of the review. Given NSPM-20 requires the terms and costs of such a review to be agreed to by the NASA Administrator and the head of the agency requesting the review, for NASA internal missions the terms and any costs of the INSRB review need the concurrence of the Chief, SMA and the applicable MDAA.

4.3.1.3 The NASA INSRB representative may, as the designated interface between the INSRB and the NASA mission, provide recommendations to the NASA Program or Project Manager on areas for additional analysis when gaps are identified, and do so in a timeframe that allows mission planners to address them without creating unnecessary delays in the launch timeline, in accordance with NSPM-20.

4.3.1.4 The NASA INSRB representative shall, as the designated interface between the INSRB and the NASA mission, ensure that any omissions or gaps identified by the INSRB during review of a NASA mission, along with any recommendations for corrective actions, are provided to the NASA Administrator (or their designee) prior to completion of the mission SAR, in accordance with NSPM-20.

4.3.1.5 The NASA INSRB representative shall, in coordination with the INSRB, ensure that the SER is ready in the timeframe identified in Table 1, and that a publicly-available Executive Summary is produced.

4.3.2 The following requirements apply to Tier I missions and other (non-tiered) missions with radioactive material requiring a nuclear safety review as specified in Table 1; in these cases the nuclear safety review takes the form of an RSR (described in Appendix A).

4.3.2.1 The NFSO shall perform a Radiological Safety Review (RSR), to include a publicly-available Executive Summary, in accordance with the timeframe identified in Table 1. Appendix A describes the general form of the RSR.

4.3.2.2 For Tier I missions only, the NASA Program or Project Manager, in coordination with the NFSO, shall ensure that significant gaps in the safety analysis are identified and provided to the safety analysis preparer, prior to mission SAR completion.

## 4.4 Launch and Reentry Authorization or Concurrence

*Note: The requirements below are intended to work in tandem with the nuclear flight-specific payload and range safety requirements for the launch and reentry of SNS or other radioactive materials contained in NPR 8715.5, NPR 8715.7, NASA-STD-8719.24 and NASA STD-8719.25.*

4.4.1 The MDAA should request Agency Views (this is the historically-used term, and is defined in

Appendix A) from the other 6 INSRB-participating agencies for SNS missions in Tiers II or Tier III, if any of the following conditions exist: (i) the SER concludes that the nuclear safety analysis is of insufficient quality to support decision making, (ii) the INSRB has been unable to reach unanimity on the SER contents and a formal dissent by an INSRB member is being attached to the SER, or (iii) an agency represented on the INSRB has specifically requested the opportunity to provide an Agency View. The MDAA can always request Agency Views of their own volition. In all other cases, the mission SAR and SER would be transmitted to the Head of the INSRB agencies (or their designee) as a courtesy, in parallel to proceeding with the launch authorization request.

4.4.2 Launch and reentry authorization or concurrence (as applicable) is obtained in accordance with the authorities and timelines indicated in Table 1, and outlined as follows:

4.4.2.1 For SNS in Tier III, the Administrator shall request and obtain the President's authorization through the Director of the OSTP. Per NSPM 20, 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. To support the Administrator's request, a briefing by the applicable MDAA, the nuclear safety analysis preparer, and the INSRB on the mission SAR, the SER, and the radiological contingency plans will be provided to the Administrator. If a Tier III mission included a planned return to Earth (reentry or fly-by), that would be part of the mission profile addressed by the mission SAR, and thus covered by the launch authorization.

4.4.2.2 For SNS in Tier II, the MDAA shall request and obtain authorization from the NASA Administrator. The authorization request will include a briefing by the applicable MDAA, the nuclear safety analysis preparer, and the INSRB on the mission SAR, the SER, and the radiological contingency plans. If a Tier II mission included a planned return to Earth (reentry or fly-by), that would be part of the mission profile addressed by the mission SAR, and thus covered by the launch authorization.

4.4.2.3 For SNS in Tier I, the MDAA shall request and obtain authorization from the NASA Administrator. The authorization request will include a summary of the major findings from the mission SAR and the RSR, as well as information regarding the radiological contingency plans. If a Tier I mission included a planned return to Earth (reentry or fly-by), that would be part of the mission profile addressed by the mission SAR, and thus covered by the launch authorization.

4.4.2.4 For missions involving radioactive material, but not including an SNS, the MDAA, in consultation with the cognizant Center Radiation Safety Officer(s), shall request concurrence from the NFSO or Chief, SMA (in accordance with Table 1), except where an Office of Safety and Mission Assurance (OSMA)-issued categorical relief memo is being applied (in which case only a notification is required). This concurrence request needs to account for radioactive material integrated into the spacecraft as part of mission design, as well as radioactive material that may be included in the launch or reentry (e.g., cargo). When the mission involves planned return to Earth (reentry or fly-by), this will be included in the launch concurrence request and will be covered by the launch concurrence. Appendix F provides a suggested format for the radioactive material reporting portion of the request.

4.4.2.5 For any planned return to Earth (reentry or fly-by) of radioactive material not covered by a launch concurrence (such as return from an orbiting research platform) the NASA Program or Project Manager shall request reentry concurrence in accordance with the analysis, review, and timelines identified in Table 1, except when an OSMA-issued categorical relief memo is being applied (in which case only a notification is required).

## 4.5 Contingency Planning and Coordination

4.5.1 For missions designated to require RCP in Table 1, the MDAA as the lead programmatic authority and the Center Director affiliated with the applicable range as the lead institutional authority, in coordination with the Chief, SMA and the NFSO, shall negotiate and implement a process to assure the safety of the

public and NASA workforce in the event of a mishap that may create radiological risk, in cooperation with OCHMO, OIIR, OPS, the preparer of the nuclear safety analysis used for launch approval, relevant U.S. government agencies (including explicit Authorities and established Agreements therein, such as ones with the DOE), relevant local and State authorities, and international partners.

4.5.2 In developing the process to assure safety in the event of a mishap that may create radiological risk, the MDAA and Center Director should address:

- a. Definition of an appropriate radiological contingency planning risk posture, comparative or otherwise, to inform decisions regarding radiological safety.
- b. Development, reporting, independent review, and acceptance by relevant authorities of an assurance case tailored to the defined radiological contingency planning risk posture substantiating sufficient radiological material control and mishap preparedness, including the information necessary to make informed and reliable decisions regarding:
  - (1) Invoking contingency plans (with such plans being developed) to control where the radiological material will impact when vehicle or spacecraft control is possible;
  - (2) Monitoring, assessment, analysis, and communications capabilities sufficient to determine whether a release of radioactive material has occurred, characterize the location and nature of the release, and develop protective action recommendations for the safety of personnel and the public;
  - (3) Invoking material recovery plans (with such plans being developed);
  - (4) Disseminating information about the mishap and any recommended protective actions at the local and State levels;
  - (5) Coordinating with the Department of Homeland Security's FEMA to support Federal-level coordination, and meeting the expectations of the National Response Framework and the Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans (including NASA's role as Primary Authority, when applicable);
  - (6) Working in concert with nuclear and other flight safety authorities or licensing entities to ensure additional relevant requirements therein are being met;
  - (7) Preparing, obtaining approval of, and issuing communications to the general public and to international partners, via the appropriate communications channels;
- c. Implementation and exercising of the above process, plans, and capabilities, and integration of the above process within the mission-wide mishap preparedness and contingency planning (MPCP) process, which is developed in accordance with NPR 8621.1.

4.5.3 For missions that fall in to NSPM-20 Tier I, II, or III, and for other missions with an A2 mission multiple greater than 1, the NASA Program or Project Manager should consult with the Office of the General Counsel to determine if any additional actions need to be taken with respect to alignment on relevant nuclear/radiological-specific insurance and indemnification provisions. Missions other than those described above, would generally not warrant this step.

## 4.6 Life-Cycle Activities Relevant After Launch Authorization

### 4.6.1 General (Tier I, II, and III missions only)

4.6.1.1 The NASA Program or Project Manager shall incorporate nuclear flight safety considerations starting with program or project formulation through the point at which the SNS or other radioactive material no longer has the potential to affect Earth's biosphere. Examples of the types of considerations that apply

include: factoring radiological risk in to the launch vehicle selection process, managing radiation exposure to equipment, managing access to the spacecraft and the SNS, managing SNS maintenance, managing SNS control (when applicable), managing criticality safety, managing SNS malfunctions, biasing aimpoints for Earth gravity assist trajectories, and managing operational procedures and training.

4.6.1.2 The NASA Program or Project Manager, in coordination with the CHMO and the Mission Directorate with human rating responsibilities, shall address radiation exposures from the SNS into mission planning and execution for missions involving crews, or for missions where the SNS is anticipated to come into proximity with crew from other missions.

4.6.2 Lead-up-to-Launch and Post-Launch Operation (Tier I, II, and III missions only)

4.6.2.1 The NFSO should ensure that the results of the nuclear safety analysis and nuclear safety review are factored into SMA oversight after launch authorization, including consideration of the safety guidelines in NSPM-20. Appendix C presents two alternative approaches to accomplishing this best practice.

4.6.3 Decommissioning and Disposal of SNS (Tier I, II, and III missions only)

4.6.3.1 For SNS-enabled missions designed to operate in low Earth orbit, the NASA Program or Project Manager shall demonstrate by analysis that the mission design enables for disposal of the SNS in a sufficiently high orbit (as defined in Space Policy Directive-6), including the incorporation of a highly reliable operational system to ensure effective and controlled disposition of the reactor.

*Note: Considerations for fission reactor systems are discussed in Section 3(a)(iii) of Space Policy Directive-6, dated December 16, 2020. All activities related to safe storage and orbital decay should involve the Orbital Debris Program Office.*

## 4.7 Internal and External Reporting

4.7.1 The NFSO shall transmit a copy of gap identification documents, the mission SAR or SAS, the SER or RSR, and launch and reentry authorizations or concurrences, as applicable, to the NASA Headquarters National Environmental Policy Act (NEPA) Manager and the CHMO.

4.7.2 On an annual basis, the NFSO shall provide a report to the Chief, SMA for transmittal to the Director of OSTP listing all launches that the agency has sponsored 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 (i.e., the mission multiple calculated in Chapter 3), and listing all such launches planned for the coming calendar year.

4.7.3 The NFSO shall execute an annual briefing by NASA staff (and relevant interagency stakeholders) to OSTP and the National Science and Technology Council on the status of safety analysis for all planned NASA-sponsored Tier II or Tier III missions that will involve the launch of an SNS.

# Appendix A. Definitions

**A2 value.** These values are listed in Table 2 of the [IAEA's Specific Safety Requirements No. SSR-6, Regulations for the Safe Transport of Radioactive Material](#) (Source: <https://nucleus-apps.iaea.org/nss-oui/collections/publishedcollections>); the current version is the 2018 Edition; “A2 will mean the activity value of radioactive material, other than special form radioactive material, that is listed in Table 2 or derived in Section IV and is used to determine the activity limits for the requirements of these Regulations.”

**A2 mission multiple.** A measure of the amount of radioactive “material at-risk,” relative to an IAEA standard used for land, sea, and air transport.

**Agency views.** This refers to a formal process of transmitting the mission SAR and SER to the Head of an INSRB-participating organization and requesting any feedback that the Agency Head wishes to be integrated into the launch authorization decision.

**Categorical relief.** A memorandum co-issued by the Chief, SMA and CHMO, which outlines conditions where OSMA nuclear flight safety concurrence is not required owing to the small degree of radiological risk of the mission relative to the assurance provided through NASA’s routine oversight of the handling of radioactive materials, and separately, of payload and range safety activities. When a launch or reentry meets these prescribed conditions, a waiver is not required for any requirements in this directive that specifically states inapplicability upon the invocation of categorical relief (a.k.a., a blanket concurrence).

**Launch activities.** The launch phase begins when the spacecraft transfers to internal power and ends when the spacecraft achieves an operational configuration after separation from the launch vehicle.

**Member of the public.** This term is defined on an analysis-specific basis as follows: (i) primary consideration should be given to the distinction between public and non-public as it is codified for the applicable range; (ii) barring this, the codified policy of the applicable nuclear safety authority (DOE or Nuclear Regulatory Commission (NRC)) will be used.

**Nuclear safety.** Application of safety policies, principles, and techniques to ensure the control and containment of radioactive material to minimize adverse impacts from accidents that could endanger life or cause property damage. Assessing and managing radiological risk is an important component of nuclear safety; however, nuclear safety also encompasses aspects (e.g., RCP, modeling uncertainty) that may not be explicitly modeled in the radiological risk assessment.

**Pre-launch activities.** Defined to start at the earliest stage of launch vehicle integrated operations where a hazard (e.g., crane failure, fire) would exist for credible accidents to cause the uncontrolled release of radioactivity.

**Radioactive material.** In the context of this document, this refers specifically to radioisotopes contained in a payload that undergo radioactive decay, and in so doing produces alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, or other particles capable of producing ions (i.e., ionizing radiation). The term is used differently than space nuclear systems, to denote material that typically has smaller quantities of radioisotopes and are typically in a form without engineered safety features.

**Radiological Control Center (RADCC).** The RADCC is an onsite operational control center at



Kennedy Space Center staffed by NASA, DOE, Range personnel, and other Federal, State, and local emergency management organizations to manage data collection and assessment (typically called the Data Assessment Center, or DAC), provide management decisions for radiological matters (typically called the Primary Authority Representative Management Group, or PMG) and oversee public information and messaging (typically called the Joint Information Center, or JIC).

**Radiological risk.** In the context of this directive, this term refers to the application of risk concepts (see Risk) to assess the potential impacts of postulated accident scenarios that result in release of radiological material. This assessment typically analyzes some combination of human health exposures (via applicable exposure pathways), impacts on land use, and impacts on property use. These differing impacts are often inter-related (e.g., land interdiction assumptions may balance impacts on land use against the dose received through specific exposure pathways). The scope of impacts considered is typically proportional to the radiological risk.

**Radiological Safety Review (RSR).** A review of a planned launch or return to Earth (fly-by or reentry) of radioactive material (sometimes evaluating a nuclear safety analysis and sometimes serving as a stand-alone nuclear flight safety review) that qualitatively or semi-quantitatively addresses the radiological risk of the mission, by describing the form and quantity of radioactive material being launched or reentered, describing the relevant mission profile, providing an analysis of the probabilities of launch and in-flight accidents which could result in the terrestrial release of radioactive materials (surface and air), providing a realistic and a pessimistically-biased estimate of the health and other effects due to a radioactive material release in the considered accident scenarios, and providing mission-specific information that would be relevant for contingency planning and material recovery. The scope and depth of the RSR would be tailored and scaled to the risk, and would be less intensive than the effort needed to develop a SER.

**Range safety.** Application of safety policies, principles, and techniques to protect the public, NASA workforce, and/or property from hazards associated with range flight operations. Additionally, the term “Range Safety” is informally used to refer to the organization responsible for implementing/enforcing range safety requirements.

**Risk.** The consideration of (a) scenarios leading to undesired outcomes, (b) the likelihood of these scenarios, and (c) the consequences, impact, or severity of the impact that would result if those scenarios were to occur. Within a probabilistic risk assessment framework, a primary representation of risk is the product of the likelihood of occurrence and the associated consequence, aggregated across all modeled scenarios. A separate representation of risk involves the tabulation of the probability of exceeding a given consequence at a specified value (or range of values) using a complementary cumulative distribution function. In both uses, uncertainty is customarily treated.

**Safety Analysis Report (SAR).** The study of credible potential releases of radioactive material into the biosphere, often founded in a probabilistic risk assessment that: (a) uses launch vehicle accident probabilities and accident environment data as inputs to analysis tools that estimate the probabilities and magnitudes of postulated radiological releases, (b) predicts transport through and deposition in the environment, (c) estimates accident impacts, and (d) evaluates the variability and uncertainty of the estimates, including gaps in knowledge (i.e., missing or incomplete information) that could impact the calculated estimates. Such a study may be system-specific (i.e., a system specific SAR) or within the context of a mission (i.e., a mission SAR). As described in NSPM-20, a system-specific SAR establishes a safety basis (a set of conditions under which safety analysis and hazard controls provide assurance of safe operation). To leverage this system-specific SAR, the mission SAR must either (i) demonstrate that the mission is within the safety basis envelope or (ii)

include supplemental safety analysis for any deviations that are outside of the established safety basis envelope.

**Safety Analysis Summary (SAS).** Relative to a SAR, a SAS is typically not a probabilistic risk assessment, but rather a quantitative screening analysis resulting in a conservatively-biased assessment of the radiological risk of launching or reentering smaller sources. The SAS provides a description of the radioactive materials, their physical state/chemical form, quantities involved, mission profile information, the probabilities of potential launch vehicle and spacecraft failures, the resulting accident impacts, and a characterization of the associated radiological risk. The level of detail (including the degree of realism sought through validation of the physical models used) should be commensurate with the anticipated radiological risk based upon relevant past radiological analyses.

**Safety Evaluation Report (SER).** The product of an INSRB review which documents the INSRB's findings to the head of the sponsoring agency or the Secretary of Transportation in order to inform the decision to proceed with launch and, for Tier III missions, inform any decision to request Presidential launch authorization.

**Space Nuclear System (SNS).** This term is used here to include devices using radioactive or fissioning material, typically with engineered safety features relevant to launch and flight. It includes radioisotope power systems (RPSs), such as radioisotope thermoelectric generators (RTGs) and radioisotope heater units (RHUs), and fission reactors used for power and propulsion.

**Tiers.** The terms Tier I, Tier II, and Tier III relate to very specific criteria that are described in NSPM-20 and discussed further in Appendix C here. In the present document, an un-tiered mission is one that does not meet the criteria of Tier I, II, or III and relates to the flight of radioactive material other than a space nuclear system.

## Appendix B. Acronyms

CHMO	Chief Health and Medical Officer
DOE	The United States Department of Energy, including the National Nuclear Security Administration (NNSA)
EOC	Emergency Operations Center
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FTD	Final Tier Determination
IAEA	International Atomic Energy Agency
INSRB	Interagency Nuclear Safety Review Board
LWRHU	Light-weight radioisotope heater unit
MDAA	Mission Directorate Associate Administrator
MDR	Mission Definition Review
MMRTG	Multi-mission radioisotope thermoelectric generator
NEPA	National Environmental Policy Act
NFSO	Nuclear Flight Safety Officer
NRC	US Nuclear Regulatory Commission
NSPM	National Security Presidential Memorandum
OCHMO	Office of the Chief Health and Medical Officer
OIIR	Office of International and Interagency Relations
OPS	Office of Protective Services
OSMA	Office of Safety and Mission Assurance
OSTP	Office of Science and Technology Policy (OSTP), the Executive Office of the President
PFTD	Provisional Final Tier Determination
PSWG	Payload Safety Working Group
PTD	Preliminary Tier Determination
PTSLR	Prior to scheduled launch or reentry
RADCC	Radiological Control Center
RCP	Radiological contingency planning
RHU	Radioisotope heater unit



RPS	Radioisotope Power System
RSR	Radiological Safety Review
RTG	Radioisotope thermoelectric generator
SAR	Safety Analysis Review
SAS	Safety Analysis Summary
SDR	System Definition Review
SER	Safety Evaluation Report
SMA	Safety and Mission Assurance
SMSR	Safety and Mission Success Review
SNS	space nuclear system
TA	Technical Authority
TED	Total effective dose

# Appendix C. Additional Information Regarding NSPM-20 and Nuclear Flight Safety

C.1 The following additional information is provided pertaining to NSPM-20, relative to the requirements contained in Chapter 3. . This is clarifying information and does not contain any additional requirements.

C.1.1 NSPM-20 sets tier boundaries based on material-at-risk, technology, and radiological risk estimates stemming from the nuclear safety analysis, with the ultimate tier depending on a combination of factors. Therefore, final determinations are made after completion of the nuclear safety analysis. However, the characteristics of safety analysis review depend on the tier, and so earlier evaluation of the likely tiering outcome is also needed. Figure 1 provides an illustration of the NSPM-20 tiering criteria, while Table 2 provides a tabular capturing of the same criteria.

Figure 1: Illustration Showing NSPM-20 Tiering Factors

(LWRHU = Light-weight radioisotope heater unit; MMRTG = Multi-mission radioisotope thermoelectric generator; SAR = Safety Analysis Report; SER = Safety Evaluation Report; SNS = Space nuclear system)

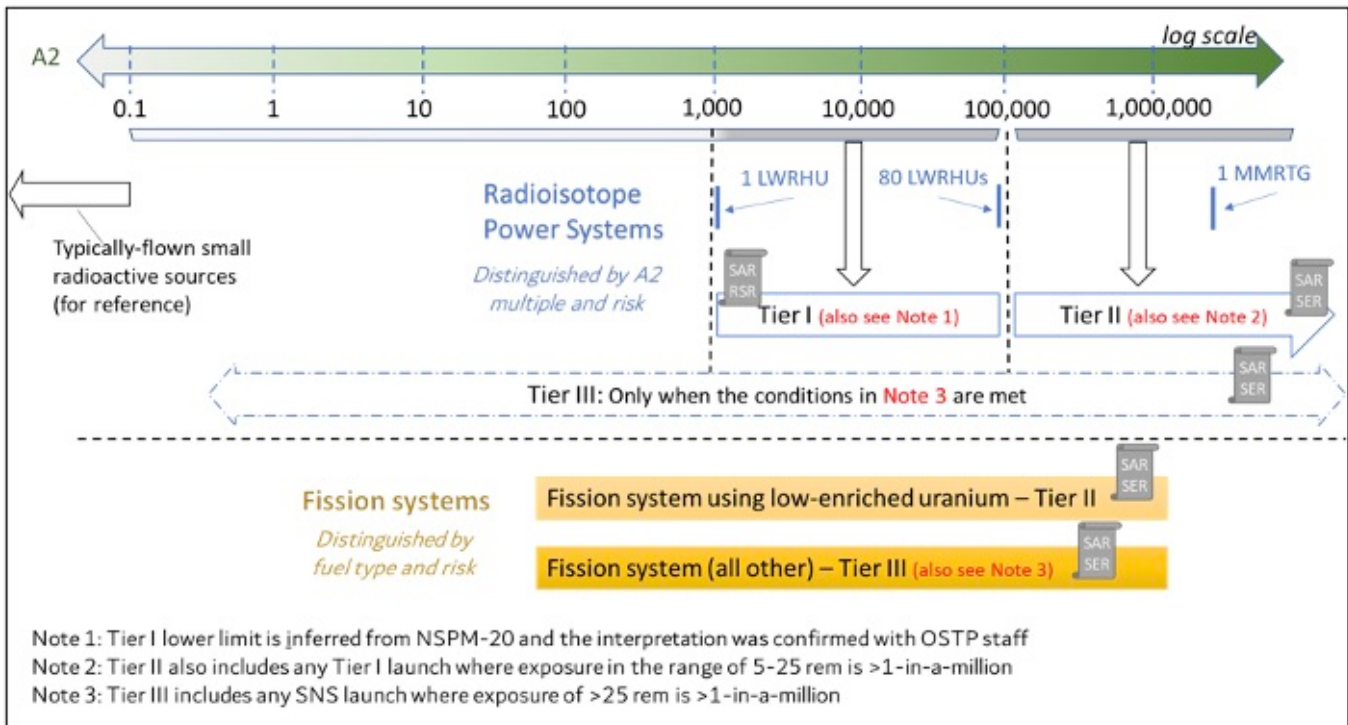


Table 2: NSPM-20 Tiering Criteria

Tier	Criteria for Space Nuclear Systems
Tier I	- Quantity of radioactive material is = 1,000×A2 but = 100,000×A2

Tier II	<ul style="list-style-type: none"> <li>- Quantity of radioactive material is <math>&gt; 100,000 \times A_2</math>, or</li> <li>- 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 total effective dose (TED) to any member of the public is equal to or greater than 1 in 1,000,000, or</li> <li>- Nuclear fission systems and other devise with a potential for criticality using low-enriched uranium.</li> </ul>
Tier III	<ul style="list-style-type: none"> <li>- 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, or</li> <li>- Nuclear fission systems and other devices with a potential for criticality where such systems utilize any nuclear fuel other than low-enriched uranium.</li> </ul>

C.1.2 A few features of NSPM-20 implementation within this directive warrant elaboration.

C.1.2.1 NSPM-20 clearly states in Section 1 that it "updates the process for launches of spacecraft containing space nuclear systems," while later using the terminology "radioactive sources" in the definitions of Tier I and Tier II. In this directive, NSPM-20 is only applied to SNS (with the expectation that no other payload would have an A2 mission multiple greater than 1,000), while the nuclear safety analysis would need to consider any additional radioactive material in the payload (in addition to the SNS). Other requirements in this directive ensure nuclear flight safety for all other missions.

C.1.2.2 While the term spacecraft is used in both NSPM-20 and this directive, any radioactive material on the integrated launch vehicle aside from the spacecraft would need to be considered (acknowledging that this would be atypical for a NASA mission).

C.1.2.3 The lower bound of Tier I is treated to equate to an A2 mission multiple of 1,000. This is effectively the lower end of historical SNS flown and comports with NSPM-20's reporting requirement bounds codified in Section 6 of that document.

C.1.2.4 There is a possibility that an SNS (that is not a fission reactor system) with an A2 mission multiple of less than 1,000 could surpass the NSPM-20 Tier III criterion associated with the probability of an exposure in excess of 25 rem being greater than 1 in 1 million. The tiering approach taken in this directive only addresses this possibility to the extent that it can be reasonably foreseen at the Preliminary Tier Determination stage. Nevertheless, this is not a situation that is anticipated to occur in practice based on contemporary SNS designs, mission profiles, and radiological risk state-of-knowledge.

C.2 The following additional information is provided pertaining to nuclear flight safety, relative to the requirements contained in Chapter 4. . This is clarifying information and does not contain any additional requirements.

C.2.1 The following passages provide contextual information about safety analysis preparation practices.

C.2.1.1 While the details of the SAS or mission SAR schedule will be informed by other guidance, the mutually agreed upon schedule would typically address: the planned analysis schedule; a technical interface document between NASA and the safety analysis preparer; base assumptions, analysis limitations/bounds, and model descriptions associated with the mission SAR or SAS development; and the development of a draft or initial mission SAR well in advance of (e.g., one year prior to) the final mission SAR. This, and related information, can be captured in a Safety Design Strategy, Safety Architecture, Safety Case, or equivalent product.

C.2.1.2 While the details of the SAS or mission SAR will be informed by other guidance, the scope of the

SAS or mission SAR activity would typically include pre-launch and launch activities, as well as all operational phases where the SNS or other radioactive material could result in exposure of a member of the public in the event of an accident. The consideration of accident impacts would typically be sufficiently broad to support the nuclear safety review, the nuclear launch or reentry authorization or concurrence process (comparison to NSPM-20's safety guidelines, the specific items described in Section 5(b) of NSPM-20, and mission tiering), range safety uses, mishap preparedness and contingency planning activities, and public risk communications. The mission SAR or SAS would typically utilize a recognized standard or precedent (NRC or DOE guidance, INSRB guidance, a NASA Technical Standard, a consensus standard) or an appropriate precedent (e.g., the mission SAR from a contemporary mission with a similar payload), adjusted as necessary to address the specifics of the SNS context and the mission at-hand, for baselining the contents of the mission SAR.

C.2.1.3 The level of detail and content of the mission SAR or SAS will be commensurate with the mission radiological risk. Per NSPM-20, "a mission SAR may incorporate a system-specific SAR that establishes a safety basis for the space nuclear system," and NSPM-20 goes on to describe this relationship. In cases where launch vehicles, configurations, mission characteristics, and SNS are similar and it is determined by the safety analysis and review stakeholders that a comparative analysis will appropriately estimate the radiological risk of the mission, a comparative analysis can be utilized. Radioisotope heater unit (RHU) and radioisotope thermoelectric generator (RTG) risk assessments have demonstrated over time that a fairly mature understanding of mission phase radiological risk contributions exists for these devices, while also demonstrating shifts in the relative importance of phenomena associated with both changes to state-of-knowledge (e.g., breach modeling, dispersion modeling) and mission characteristics (e.g., clad temperature, launch window climatological conditions).

C.2.1.4 Where nuclear or radioactive materials are being provided from multiple sources, MDAAAs may provide a single or multiple safety analysis document(s) to best meet this requirement (e.g., in a case where an SNS relies heavily on an existing system-specific SAR while other radioactive material requires a completely new SAS). Depending on the specifics of the circumstances, it may be necessary to justify why the radiological risks can be treated in an additive fashion when using multiple mission SARs. Some consequence metrics do not scale linearly with the activity of released material.

C.2.2 Regarding insurance and indemnification in the context of radiological incidents, in general, Federal funding is made available for resulting damages and response costs in accordance with Federal law through one or more of the Price-Anderson Act, the Space Act, and the Stafford Act. The final determination of which of these, or other authorities, would be used to provide Federal funding in the event of a launch or reentry accident can only be made after-the-fact, based on the specific facts of the actual incident and the claims in question.

C.2.3 Regarding SMA oversight following launch authorization, two approaches are suggested below for accomplishing this best practice.

C.2.3.1 Alternative #1 - The NFSO, in coordination with the NASA Program or Project Manager, the Payload Safety Working Group (PSWG) Chair, the Project-Level SMA TA, and the INSRB (when applicable) can use the results of the nuclear safety analysis and nuclear safety review to construct a nuclear-specific and mission-specific critical analysis assumptions list that would be formally issued to the PSWG Chair and relevant SMA TAs, for use within the routine launch services and mission execution processes. This list would, in effect, serve as an amendment to the NPR 8719.24 compliance matrix and would serve to facilitate the monitoring of anticipatable issues, if any are identified, that would cause the mission to likely exceed (or further exceed by a significant amount) NSPM-20's safety guidelines, or that would cause a significant degradation of defense-in-depth (e.g., fission product barriers). In this way, the list serves as a tool to codify nuclear flight safety-specific factors into these stages of NASA's routine risk management processes.

C.2.3.2 Alternative #2 - Barring adoption of the above, the NFSO could periodically monitor available

information streams and/or consult with the applicable SMA interface for that phase of the mission in order to identify events and conditions that significantly deviate from the assumptions of the SAR during periods leading up to launch and subsequent operation (that are within scope of the SAR) for Tier I, II, and III missions, and which are also prior to the spacecraft entering inter-planetary flight with no plan for return or Earth gravity assist. In cases where identified events could reasonably be expected to cause the mission execution to exceed (or further exceed by a significant additional quantity) NSPM-20's safety guidelines or requirements (e.g., Department of the Air Force risk constraint), the NFSO would perform a simple, scoping-level qualitative or semi-quantitative assessment of the impact of the event or condition, and document this assessment in a note to file. In cases where a specific event or condition is found to indeed exceed (or further exceed by a significant additional quantity) the safety guidelines or a quantitative requirement, this would be captured in a memo and discussed with the relevant SMA interface, such that it can be factored in to safety and mission success activities (e.g., a PSWG Safety Review, the Safety and Mission Success Review (SMSR)).

C.2.3.2.1 Regarding Alternative #2, depending on the circumstances, the appropriate interface might be the Project-level SMA TA, a Program-affiliated SMA TA, the SMA Launch Services Division Mission Safety Engineer, the Payload Safety Program Executive, the Range Safety Program Executive, or the PSWG Chair. In some cases, the monitoring of information sources (e.g., the Launch Services Portal where the PSWG posts spacecraft non-compliances after the Payload Safety Compliance has been signed) may be a suitable replacement to contacting the interface.

C.2.3.2.2 Also regarding Alternative #2, the appropriate periodicity of monitoring the mission will vary greatly depending on the phase of the mission execution (e.g., more frequently during the period following SNS integration into the integrated launch vehicle and prior to launch versus less frequently during spaceflight). Examples of events and conditions that would be relevant are: (a) a two-fold increase in the time window in which the SNS is being cooled by ground support equipment relative to that assumed in the SAR, (b) a significant deficiency identified in the performance of a safety-relief valve that cannot be mitigated and effectively results in an increase in launch vehicle unreliability, and (c) a spacecraft malfunction while in Earth orbit that significantly increases the likelihood of not being in a sufficiently high orbit when the mission reaches end-of-life.

# Appendix D. Calculation of the A2 Mission Multiple

## D.1 Determination of A2 Mission Multiple

D.1.1 The instructions below relate to the use of IAEA guidance as it pertains to nuclear flight safety, consistent with the use of this same guidance in NSPM-20 and preceding Presidential direction. This guidance is used as a matter of convenience, understanding that the guidance was not developed specifically for use in launch or reentry. Its invocation here may differ from other NASA uses of this guidance, as they pertain to transportation of radioactive material by land, sea, or air under the authorization or licensing by other Federal agencies.

D.1.2 The latest available version of IAEA SSR-6 should be used. Note: IAEA SSR-6 provides values in terabecquerels (TBq), while NASA sources are often catalogued in curies (Ci), so care should be taken when calculating the mission multiple (1 TBq = approx. 27 Ci).

D.1.3 While the table provided in IAEA SSR-6 (Table 2 in the case of the 2018 Update) is typically sufficient for obtaining the necessary A2 multiples, the user should be aware of the caveats and explanation that appears before and after that table (e.g., Sections 402-407 in the case of the 2018 Update), which are applicable to special circumstances.

D.1.4 The A2 mission multiple will be determined using the equation below, where n represents each source of radioactive material on the launch vehicle and spacecraft. A simple example is provided in Table 3.

$$A2 \text{ Mission Multiple} = \sum_n \frac{(Radioactive \text{ Source}_n \text{ Activity})}{Source_n \text{ Isotopic A2 Value}}$$

**Table 3: Sample Multi-source A2 Mission Multiple Illustration**

Radioisotope	Activity (Ci)	A2 value1 (Ci)	A2 mission multiple
Ni-63	0.005	800	6·10 <sup>-6</sup>
Co-60	0.005	10	5·10 <sup>-4</sup>
Cm-244	0.0005	0.05	0.01
Total A2 mission multiple =			~0.01 (1.05·10 <sup>-2</sup> )



# Appendix E. Notional Process Flow of Nuclear Flight Safety-related Activities for SNS Missions

E.1 A general outline of where nuclear flight safety activities reside within the typical NASA mission life-cycle is shown in Table 4, for missions involving space nuclear systems (SNS).

**Table 4: Notional Process Flow of Nuclear Flight Safety-related Activities for SNS Missions**

Pre-Phase A: Concept Studies	Phase A: Concept & Technology Development	Phase B: Preliminary Design & Technology Completion	Phase C: Final Design & Fabrication	Phase D: System Assembly Integration & Test, Launch & Checkout	Phase E: Operation & Sustainment	Phase F: Closeout
<i>Note: This is a notional (simplified) representation. Not all activities are relevant for all missions, and timings will vary.</i>						
Conducting design/risk trade studies <sup>1</sup>	Sizing of SNS requirements <sup>1</sup>  Defining system safety requirements <sup>1</sup>  Nuclear-related testing and analysis <sup>1</sup>  Mission design decisions affecting radiological risk <sup>1</sup>  Notifying NFSO before SDR/MDR to schedule activities	Databook general input development  Deliver Safety Design Strategy (SDS) or equivalent  Preliminary tier determination	Launch vehicle selection <sup>1</sup>  Databook delivered  Mission SAR development  Provisional final tier determination  RCP planning  Security planning  Consultation with Office of General Counsel	Final mission SAR delivered  Final tier determination  Launch auth. request  Mishap preparedness and RCP  Emergency planning  Security execution <sup>1</sup>  Agency views (if applicable)	Mission response to anomalies  SMA monitoring of mission events or conditions relevant to nuclear flight safety	Decommissioning and disposal
INSRB Standing Board Activities <sup>1</sup>	Familiarization and nuclear design discussions for novel missions <sup>1</sup>	SDS review and gaps / recommendations identification  Mission-specific Review Plan/Team <sup>1</sup>	Mission SAR interactions  Advise agency head of gaps and omissions	Final SER delivered		

SNS development, improvement, and sustainment activities.<sup>1</sup>  
 Maintaining the necessary technical competencies and procedures to promote nuclear flight safety under all reasonably foreseeable conditions.<sup>1</sup>  
 Developing, maintaining, and implementing training and procedures to promote nuclear safety and safety culture.<sup>1</sup>  
 Using risk analysis to assess the effectiveness of design features and controls and to provide feedback to the design process.<sup>1</sup>  
 Standing coordination interface between NEPA and nuclear flight safety activities.  
 Reporting and briefing requirements to OSTP, per NSPM-20.

<sup>1</sup> While important, these are not aspects covered in this directive. They are covered by other NASA requirements and processes, DOE or NRC authorities and requirements, INSRB guidance, and in some cases, they would be addressed in future NASA nuclear flight safety guidance.

E.2 A notional schedule of launch authorization-related activities is provided in Figure 2 (for Tier I missions) and Figure 3 (for Tier II and III missions).

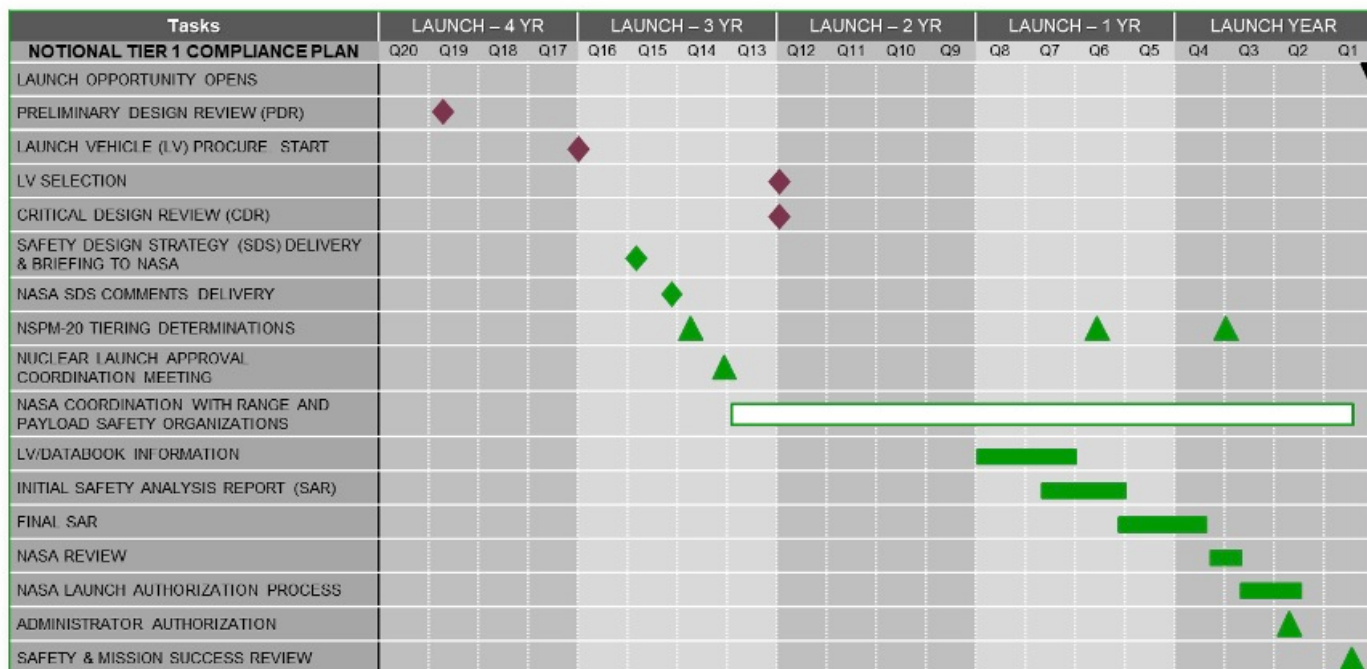


Figure 2: Notional Schedule for Tier I Missions



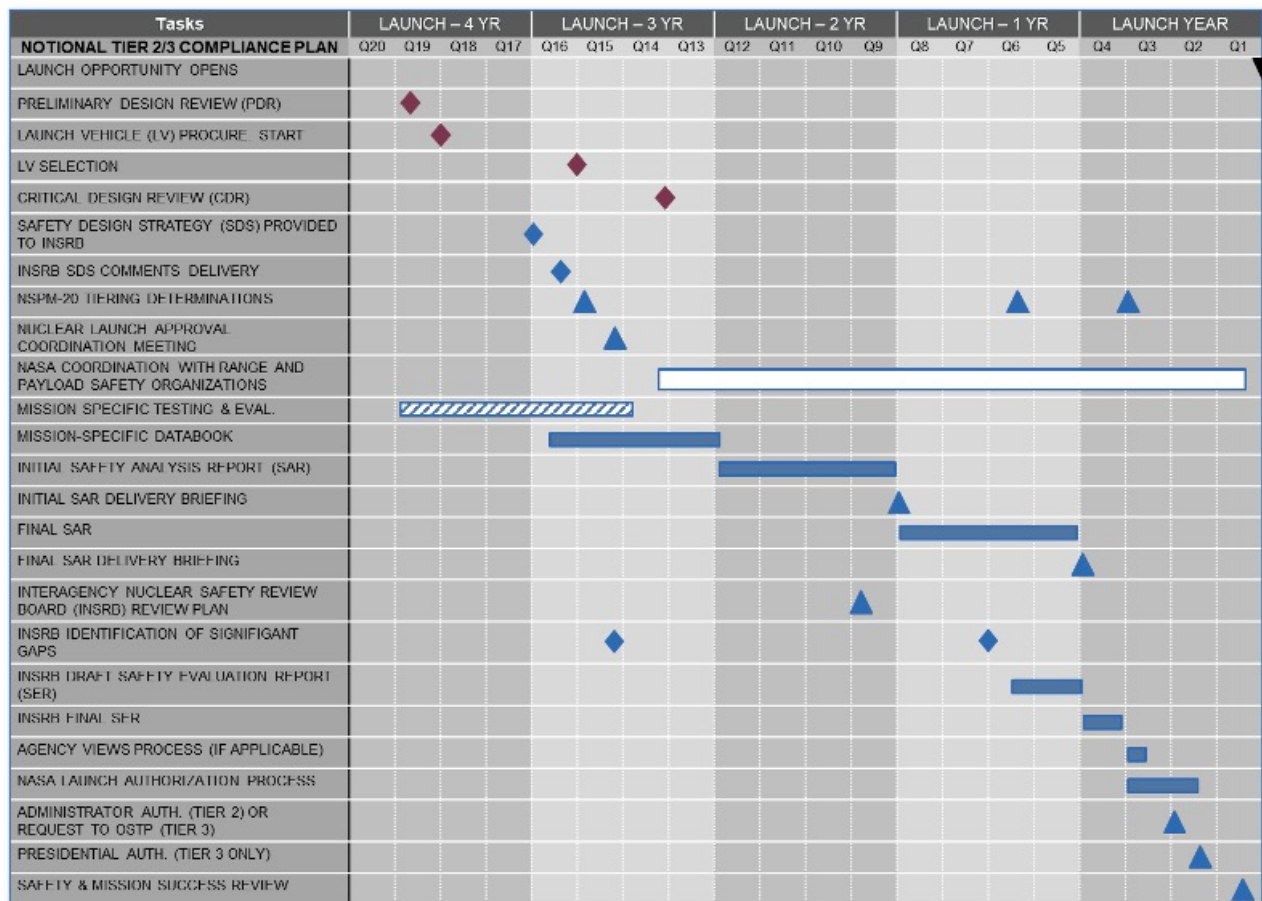


Figure 3: Notional Schedule for Tier II and Tier III Missions

# Appendix F. Radioactive Materials On-Board Report

F.1 The Radioactive Materials On-Board Report template is provided in Table 5.

**Table 5: Radioactive Materials On-Board Report**

Launch Site	Scheduled Launch Date	Isotope	# of Sources	Isotope half-life	Est. activity at spacecraft integration (Ci)	A2 limit for isotope (Ci)	Resulting A2 multiple for each isotope source	Remarks
<i>Sum of A2 multiples for each isotope source =</i>								

# Appendix G. References

G.1 NPD 8710.1, Emergency Management Program.

G.2 NPR 1800.1, NASA Occupational Health Program Procedures.

G.3 NPR 8580.1, Implementing the National Environmental Policy Act and Executive Order 12114.

G.4 NPR 8621.1, NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping.

G.5 NPR 8715.2, NASA Emergency Management Program Procedural Requirements.

G.6 [IAEA, Specific Safety Requirements No. 6 \(SSR-6\), Regulations for the Safe Transport of Radioactive Material](#) (Source: <https://nucleus-apps.iaea.org/nss-oui/collections/publishedcollections>).

G.7 Space Policy Directive-6, Memorandum on the National Strategy for Space Nuclear Power and Propulsion.

G.8 United Nations Convention on Early Notification of a Nuclear Accident (1986).

G.9 United Nations Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1986).