

Interagency Nuclear Safety Review Board (INSRB)
“Playbook”
Non-binding Guidance for INSRB and Its Counterparts

Revision 2

Approved by INSRB on January 20, 2023

FOR TRIAL USE

INSRB evaluates quality, identifies significant gaps, recommends areas for additional analysis, and advises the head of the sponsoring agency (US Government launches) and the Secretary of Transportation (commercial launches, upon request), all per NSPM-20

Description of Interagency Nuclear Safety Review Board (INSRB) Document Hierarchy

INSRB Charter – The Charter describes INSRB’s intent and functionality at the highest level. It outlines expectations, and in the case of those aspects that flow directly from NSPM-20 requirements, it is compulsory. It generally sets requirements for how INSRB will behave. Its primary function is to create a basic framework for INSRB’s conduct of business.

INSRB Playbook (this document) - This document describes INSRB’s intent and functionality at a more detailed level. It is generally non-binding, but it sets expectations for how the Board and INSRB Review Groups (IRGs) are likely to behave. It also addresses clarifications in governing policies when those are identified. Its primary function is to document expectations and boundaries for how INSRB will conduct business, and how INSRB expects that mission owners and product recipients will interface with the Board and IRGs, to promote openness and effectiveness in its activities.

Terms of Review for Mission XYZ – This document summarizes more detailed planning documents related to the sponsoring agency’s approach to safety, safety analysis activities, mission structure, etc., and the INSRB’s review strategy, team composition, etc., to provide a document suitable for obtaining approval from the applicable Agency Heads (or their designees).

IRG Gaps or Omissions Reports and Safety Evaluation Reports - These documents describe an IRG’s identification of significant gaps and evaluations of safety analysis quality, in the context of specific missions. They are non-binding, and they are directed to the head of the sponsoring agency (USG launches) or the Secretary of Transportation (non-USG launches). Their primary function is to advise those entities relative to their role as potential launch decision authorities.

Key Terminology: In this document...

Board	the standing (permanent) INSRB
INSRB review group	the set of INSRB Members or Alternates appointed to conduct a specific review (one from each agency, unless review group participation has been limited) once the Board’s interactions with a potential mission sponsor have progressed to the point that standing Board interactions are no longer sufficient and there is a need to codify the Terms of Review
INSRB	the collective (both the standing Board and IRGs)
program office	the sponsoring agency’s mission program or project office, or the commercial launch or reentry applicant to the Federal Aviation Administration, who has the responsibility for preparation of the nuclear safety analysis, recognizing that some nuclear and range safety authorities may continue to reside with other Federal departments or agencies
safety analysis team	the typically cross-organizational team spanning the spacecraft, launch vehicle, launch operations, and space nuclear system safety analysis development

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Preamble

Coordinated interagency reviews of the launch of nuclear power sources for space use have been occurring since 1963, with the format of that review being remarkably stable from 1968 to 2019, including the use of working groups with Federal and non-Federal participants over that same period. With the issuance of NSPM-20, the community is taking the opportunity to leverage past experience and include commercial launch and reentry of space nuclear systems while also making thoughtful changes that will improve efficiency.

The relevance of terrestrial precedents has been a key sticking point in refining the nuclear safety analysis and nuclear safety review process over time, and this warrants purposeful attention up front. In 1982, a former NASA coordinator for interagency nuclear safety reviews wrote (in a paper associated with a National Academies' Symposium, and referring to the early interagency reviews of radioisotope power system and reactor launches), "It was also obvious that the same procedures used for ground-based systems could not be followed, because the systems were lightweight and could not be enclosed in big protective containers or heavy shielding and because potential launch failures on or near the pad and reentry following an unsuccessful launch and short orbital lifetimes could result in the system falling to earth in unknown and uncontrolled areas."¹ Some of these aspects of space nuclear system launches will always exist. Conversely, the U.S. now possesses 6 decades of experience in analyzing, reviewing, approving, and launching radioisotope power systems.

The above mentality has, at times, been used to justify a unique approach to space nuclear system analyses and reviews, but a key word in the above is "procedures." The INSRB asserts that it continues to be inappropriate to use terrestrial nuclear power *procedures* for space nuclear system launches. Conversely, the INSRB asserts that it is entirely appropriate to use terrestrial nuclear power *policies*, *approaches*, and *experience* in performing analyses and reviews, so long as it is done thoughtfully, accounts for the differences that exist between the terrestrial and non-terrestrial situations, and maintains consistency with applicable laws, regulations, policies, or agreements that may apply. The reader will see many elements of terrestrial nuclear power approaches in this document, within the unique context of the Federal space nuclear system launch authorization process, and particularly as it relates to anchoring safety analysis in an established standard that promotes effective review. In implementing this guidance, the community must distinguish between higher-level tenets that are translatable versus detailed procedures that are too closely married to their terrestrial contexts.

In addition, INSRB acknowledges the fundamental difference between "high heritage" missions involving the launch and interplanetary flight of radioisotope power systems versus more novel missions involving orbiting spacecraft with a nuclear power system (which the US has not performed in many decades) and fission systems (of which the US has only launched one, in 1965). Meanwhile, fission systems have fundamentally different risk profiles relative to radioisotope power systems in that they will be safed until reaching a suitable orbit or trajectory (and thus pose minimal radiological risk unless a mishap defeats that safing). **This Playbook creates a framework that can be used in all cases, but that can be scaled and tailored based on the details of the mission's unique aspects relative to past reviews, the**

¹ Kerr, T. B., "Procedures for Securing Clearance to Launch Reactors," Proceedings of a Symposium, Advanced Compact Reactor Systems, 15-17 Nov. 1982, National Academy of Sciences, Washington, D.C

degree to which the analysis is founded in accepted and applicable standards, and the nature of the peer review performed upstream of an INSRB review.

Returning to the point that NSPM-20 has created an opportunity to leverage past experience while making thoughtful changes that will improve efficiency, several points warrant highlighting. First, the policy specifically creates quantitative Safety Guidelines, which help the analysts, reviewers, and decisionmakers judge “how safe is safe enough?” relative to past cases where the process lacked such an anchor. Second, the policy risk-informs the level of decisionmaking (assigns this to the agency level for some situations that would have previously required White House approval). Third, the policy explicitly specifies the requirement for a safety analysis (the prior policy was less clear on this point), and specifically describes the ability to leverage an established prior analysis, when appropriate. Fourth, the policy establishes a standing (rather than ad hoc) review entity (the INSRB), and more clearly delineates the intended scope and focus of mission-specific reviews. Finally, the policy adds the Department of State and Department of Transportation to the interagency review body, thus strengthening the ties to domestic and international cooperation, and to commercial activities. Within this context, this Playbook establishes INSRB’s conduct of operations to promote efficient and effective reviews.

Within this context, the INSRB has the following basic intents:

- To provide missions with insightful feedback that promotes good safety practices and culture, while making safety analysis and launch approval activities as effective as possible,
- To provide the community with continuity in safety evaluation that promote stable practices and lessons learned mission-over-mission,
- To provide Agency Heads (et al.) with insightful reviews that foster confidence when making launch decisions and addressing external stakeholder inquiries.

INSRB maintains and utilizes this Playbook to support these intents.

Contents

1. Roles and Responsibilities.....	1
1.1. Sponsoring Agency Heads (including the Secretary of Transportation), or Designees	1
1.2. Heads of Within-agency Organizations Responsible for Supporting INSRB Membership.....	1
1.3. NASA Chief of Safety and Mission Assurance	1
1.4. Agency Board Members.....	1
1.5. Agency Board Alternates	2
1.6. Board Secretariat (a.k.a., Secretary)	2
1.7. INSRB Review Group (IRG) Chair.....	3
1.8. IRG Review Manager.....	3
1.9. INSRB Review Group (IRG) Members.....	3
1.10. Consulted Subject Matter Experts (SMEs)	4
1.11. Program Office Representatives	4
2. INSRB General Conduct of Business	5
2.1. Board Membership	5
2.2. The Role of NASA as the Administering Agency	6
2.3. Quorum, Decisions, and Actions.....	7
2.4. INSRB Review Group (IRG) Empanelment	8
2.5. Board and IRG Interactions.....	9
2.6. Availability of Subject Matter Expertise.....	10
2.7. Defining a USG Launch versus a Commercial Launch under DOT Authority	11
2.8. Information Security and Information Handling Protocols.....	11
2.9. Electronic File Management and Retention Practices.....	13
2.10. Approach to Elevating Concerns and Documenting Formal Dissents.....	14
2.11. Maintaining an Appropriate Degree of Independence.....	15
2.12. Revision Protocols for INSRB Documents	15
3. INSRB Review and Evaluation Scope	17
3.1. Differentiation Between Evaluation and Analysis	17
3.2. Identification of Other Applicable Federal, State, and Local Requirements	18
3.3. Review Boundaries with Respect to Varying Ways to Measure Risk.....	19
3.4. Review Boundaries with Respect to Other Uses of the Nuclear Safety Analysis.....	20

3.5.	Aspects Specifically Excluded from Review	21
4.	INSRB Review and Evaluation Process.....	22
4.1.	Overview of General Approach.....	22
4.2.	Interface Between Major Participating Entities, Including Technical Peer Review.....	28
4.3.	Interface between Safety Analysis and Review and Launch Deviations/Constraints.....	31
4.4.	Relevance of Reviews of Earlier Missions and System-Specific SARs	32
4.5.	Funding, Reimbursement, and Procurement	33
4.6.	Roadmap of Relevant Consensus and Agency-specific Standards and Guidance	34
4.7.	Relevance of Margins and Defense-in-depth	34
4.8.	Acceptance and Exit Criteria	35
5.	INSRB Review and Evaluation Products.....	37
5.1.	Contents of the Mission-specific Review Plan and the Terms of Review	37
5.2.	Expected Contents of Documents Preceding the Mission SAR for Launch Approval	39
5.3.	INSRB Information Requests.....	42
5.4.	INSRB Agency Head Gaps or Omissions Report.....	43
5.5.	Issuance of the Mission SAR for Launch Approval.....	43
5.6.	INSRB Safety Evaluation Report.....	43
5.7.	INSRB Safety Evaluation Presentation to Sponsoring Agency Head or the Secretary of Transportation	45
6.	References.....	46
	Appendix A: Definitions	47
	Appendix B: Acronyms.....	48
	Appendix C: Sample Empanelment Checklist	49
	Appendix D: Subject Matter Expertise Matrix	50
	Appendix E: Defining a US Government Launch versus a Commercial Launch and DOT Authority	52
	Appendix F: Tabulation of NSPM-20 Safety Guideline Results.....	55
	Appendix G: Sample Schedule.....	56
	Appendix H: Sample Outlines of Sponsoring Agency Submittals	57

1. Roles and Responsibilities

1.1. Sponsoring Agency Heads (including the Secretary of Transportation), or Designees

Responsibilities of these individuals include:

- Approving Terms of Review, as the means of formalizing the sponsoring agency's (or the Secretary of Transportation's) INSRB review request, and aligning on the nature of that review, as required by NSPM-20.

1.2. Heads of Within-agency Organizations Responsible for Supporting INSRB Membership

Responsibilities of these individuals include:

- Notifying the Board Secretariat of the appointment or change in appointment of a Board primary member or optional alternate.
- Ensuring that the appointee comes from a part of their agency that houses relevant technical expertise but is not directly involved in space mission planning or execution (i.e., has sufficient checks and balances within their agency's governance structure to ensure impartiality).
- Ensuring that the appointee is technically-qualified, as discussed in Section 2.1.
- Ensuring that the appointee has a clear understanding of the degree of autonomy and authority that is intended by the appointment.
- Addressing concerns elevated by the INSRB or stakeholders of the INSRB process regarding the agency's involvement in INSRB activities.

1.3. NASA Chief of Safety and Mission Assurance

Responsibilities of this individual include:

- Appointing a Board Secretariat (a.k.a., Secretary), typically expected to be the NASA Nuclear Flight Safety Officer or their designee, charged with administering the standing Board.
- Adjudicating any concerns regarding how the Board Secretariat is performing their functions.

1.4. Agency Board Members

Responsibilities of these individuals include:

- Voting on all matters in front of the INSRB.
- Identifying the participant from their agency to serve on an IRG as part of IRG empanelment (from amongst the formally appointed standing Board participants).
- Serving, when designated, on IRGs.
- Ensuring information security and information handling is properly executed, as discussed in Section 2.8.
- Addressing concerns elevated to the Board.
- Ensuring that any involvement by individuals who are not civil service or military officers is consistent with INSRB being an intergovernmental committee under the Federal Advisory

Committee Act², and that these individuals are not being asked to perform inherently-governmental activities³.

- Maintaining situational awareness of relevant launch vehicle, launch operations, and space nuclear system technology, as well as commonly-used safety analysis models and methods.

1.5. Agency Board Alternates

Responsibilities of these individuals include:

- Serving, when needed, in the place of the Agency Board member.
- Serving, when designated, on IRGs.
- Ensuring information security and information handling is properly executed, as discussed in Section 2.8.

1.6. Board Secretariat (a.k.a., Secretary)

This role refers to the individual filling this role for the standing Board. Responsibilities of this individual include:

- Receiving the formal identification or notification of change of the primary member, and alternate if applicable, from each agency, and maintaining an up-to-date INSRB roster.
- Performing general Secretariat-type duties, including those specified in Section III, Section IV, and Section VII of the INSRB Charter, and those described in the present document. Amongst others, these include:
 - Recording actions, dispositions, and any Formal Dissents during Board activities; and
 - Distributing meeting minutes, including actions and decisions, within five business days of the meeting and subsequently archiving the same.
- Consulting on administration of IRGs, in coordination with the IRG Chair and the Review Manager (as applicable).
- Facilitating NASA Administrator agreement to the terms of any IRG review, as specified in NSPM-20, and discussed in Section VI and Section VIII of the INSRB Charter.
- Obtaining permission to distribute copyrighted materials, in cases where multiple parties would otherwise be paying fees for access.
- Managing INSRB (standing Board) electronic file management and archival, as discussed in Section 2.9.

² INSRB is not within scope for FACA because INSRB is an “intergovernmental committee” composed wholly of full-time officers or employees of the Federal Government (see 41 CFR 102-3.40(h) – Types of committees or groups not covered by FACA). Further, INSRB can utilize contractors that are not full-time officers or employees of the Federal Government, however, in such cases it is important that the Board not operate in a way that would make these contractors de facto Board members.

³ Such activities (and related functions) are discussed in the Federal Activities Inventory Reform Act of 1998, FAR SubPart 7.5, and OMB Circular A-76. In general, INSRB doesn’t perform such activities.

1.7. INSRB Review Group (IRG) Chair

This role refers to the Chair of the formally appointed IRG, and responsibilities include:

- Leading the development of the Mission-specific Review Plan, as discussed in Section 2.4, including providing their approval of the plan, and coordinating higher-level approvals.
- Providing review status updates at Quarterly Board meetings
- Administering the IRG, in coordination with the IRG Review Manager.
- Calling IRG meetings, and managing participation, as discussed in Section IV of the INSRB Charter.
- Providing direction to the team in accordance with the approved review plan, and refereeing dialogue between the team and the program office, to ensure a focused review.
- Ensuring that all IRG members are given the opportunity to review and comment on proposed findings issued by the IRG, as discussed in Section V of the INSRB Charter.
- Facilitating agreement to the Terms of Review, as specified in NSPM-20, and discussed in Section VI and Section VIII of the INSRB Charter.
- Coordinating any Agreements needed to support IRG reviews, as discussed in Section IX of the INSRB Charter, to also include any non-disclosure agreements.
- Transmittal of the Terms of Review, the Agency Head Gaps or Omissions Report, and the INSRB Safety Evaluation Report to applicable Agency Heads.

1.8. IRG Review Manager

This role refers to an individual appointed to assist the Chair of the formally appointed IRG. The individual may come from the Chair's own organization, however, other unconflicted personnel from the sponsoring agency can also fill this role under the IRG Chair's direction. The Review Manager's responsibilities include:

- Carrying out the administrative support functions of the IRG, under the direction of the IRG Chair.
- Providing support when requested by an IRG Chair who is coordinating any Agreements needed to support INSRB reviews, as discussed in Section IX of the INSRB Charter, to also include any non-disclosure agreements, and retaining signed copies of these Agreements.

1.9. INSRB Review Group (IRG) Members

This role refers to the civil service or military officer members of the formally appointed IRG, and responsibilities include:

- Contributing to the development of the Mission-specific Review Plan, as discussed in Section 2.4, including providing their approval of the plan.
- Abiding by the Information Security provisions described in this document, including any non-disclosure agreements, and proactively identifying any instances where these provisions conflict with their agency's policies and practices.
- Abiding by the guiderails provided in Section 3.1, regarding types of analysis performed.

- Avoiding instances where IRG review auspices are being inappropriately used to pursue issues related to non-INSRB roles and working with the safety analysis end-user community to retain clear boundaries and interfaces with these non-INSRB roles, as discussed in Section 3.4.
- Performing an effective review that comports with the process outlined in Section 4, and which results in the timely development of the applicable deliverables described in Section 5.

1.10. Consulted Subject Matter Experts (SMEs)

Responsibilities of these individuals include:

- Fulfilling their defined role for providing insights to the IRG and remaining within the specified review scope, as well as the general provisions prescribed in this document (e.g., information security protocols).

1.11. Program Office Representatives

This role refers to the sponsoring agency's lead program or project office for Government missions. For commercially-launched missions, there is no formal program office. Instead, the applicant to the Federal Aviation Administration (FAA) has the primary responsibility for the safe conduct of the launch or reentry, including the preparation of the nuclear safety analysis, recognizing that some nuclear safety authorities and range safety authorities may continue to reside with other Federal departments or agencies. In this case, the FAA assures that its safety regulations are satisfied by evaluating the application. The payload operator could be a government or commercial entity.

For either government or commercial missions, the responsibilities are:

- Supporting the review process described in Section 4 of this document.
- Producing the products, or equivalents established within the Terms of Review, described in Section 5 of this document, in a timely fashion.

2. INSRB General Conduct of Business

2.1. Board Membership

2.1.1. Identification of Agency Board Representative

Each of the seven agencies identified in NSPM-20 for INSRB membership identifies a primary (civil service or military officer) member to serve on the standing Board⁴. This identification should be made in writing (email is sufficient) to the Board Secretariat, by the head of the organization (i.e., the head of the Office or Center within the agency) from which the Board member originates (hereafter referred to as “the appointer.”) Board members must come from a part of their agency that houses relevant technical expertise but is not directly involved in space mission planning or execution (i.e., has sufficient checks and balances within their agency’s governance structure to ensure impartiality). Board representatives must communicate changes in organizational function or role to INSRB, particularly when they change the organization’s relationship with mission planners and executors.

NSPM-20 requires that these members be technically qualified. No formal qualification program exists (such as the qualification standards discussed in Section 3.2 and 3.3 of DOE-STD-1104-2016), or is being developed, for INSRB membership. Rather, an appointment indicates that the individual possesses the following characteristics:

- Demonstrated subject matter expertise in a sub-set of nuclear policy, nuclear design, nuclear safety, nuclear safeguards, range safety, spaceflight, radiation protection, emergency preparedness, and supporting scientific and engineering disciplines, fitting with their agency’s role, that will help to ensure the INSRB is sufficiently knowledgeable to perform its reviews;
- Demonstrated understanding of Federal policy and the regulations and guidance governing their agency, that will permit effective advisement on matters before the INSRB;
- Established seniority in position and access to agency leaders that will permit representation of their organization, though not necessarily authority to commit resources on behalf of their organization;
- Established trust by the agency that will permit participation in discussions with high-ranking officials (e.g., the National Space Council) on behalf of their organization;
- Demonstrated interpersonal and communication skills that will permit effective contributions to the INSRB’s deliberations, presentations, and reports; and
- Sufficient available time, relative to other workload demands, to fulfill their INSRB duties.

As part of this identification process, the appointer should ensure that the appointee has a clear understanding of the degree of autonomy and authority that is intended by the appointment (e.g., in what situations is the appointee authorized to speak on behalf of the organization, in what

NSPM-20

“The INSRB shall consist of representatives from the Departments of State, Defense, Energy, and Transportation, the Environmental Protection Agency, NASA, and, as appropriate, the Nuclear Regulatory Commission. Each of these agencies shall designate technically qualified personnel to the INSRB.”

⁴ The general approach to INSRB is similar to the “CS2” (Civil Service Consensus Board with Expert Support) model in NASA’s Standing Review Board construct. The CS2 model is characterized in NASA/SP-2016-3706 Rev. B, Section 3.1 and Appendix E.

circumstances should the appointee seek informal or formal concurrence from the agency’s senior leadership prior to acting, what type of back-briefing is expected regarding the INSRB’s activities). The appointer would also be involved in adjudicating any concerns raised regarding the appointee’s performance.

Note that in the text of NSPM-20, the Nuclear Regulatory Commission (NRC) is identified for inclusion “as appropriate.” This language reflects the NRC’s standing as an Independent Agency that cannot be directed by the Administration in the same manner as the other agencies in question. Nevertheless, in practice INSRB expects that the NRC will have the same standing as the other six agencies.

2.1.2. Identification of Agency Board Alternate (Optional)

An alternate Board member may be identified, and the tenets associated with doing so are the same as that for the primary member, including being a civil service employee or military officer and being technically-qualified. If an alternate is identified, past experience has highlighted the relevance of the following additional considerations:

- Since a second participant requires additional agency resources, this individual should be well-suited to serve on an INSRB Review Group (IRG) when the Board is managing multiple concurrent reviews, for efficiency.
- The individual should be someone who can improve continuity, effectiveness, knowledge transfer, and flexibility in coverage, as these relate to providing reliability of information processing and decision-making, in instances where the primary member has limited availability.
- The individual must be able to represent their agency’s interests and views in a manner that is consistent with the primary member, unless a Formal Dissent warrants differing views.

Additional representation (beyond a primary member and an alternate) is not encouraged, except in the following situations:

- Focused turnover in anticipation of the planned departure of a member or alternate;
- Instances where the Board is processing numerous missions concurrently (in which case the individual(s) would still need to be appointed as an alternate prior to being appointed to an IRG, as discussed in Section 2.4).

Observers are not encouraged, but are not prohibited, so long as they are not incurring expense to a mission being reviewed. Later portions of this document discuss meeting attendance, interaction with a program office, and other considerations that would be relevant in the case of an observer.

2.2. The Role of NASA as the Administering Agency

NSPM-20

“...the NASA Administrator shall establish an Interagency Nuclear Safety Review Board (INSRB).”

NSPM-20 designates NASA as the empaneling agency for the INSRB, and this implies some additional responsibilities for NASA in the administration of the INSRB. The INSRB Charter further specifies NASA’s role within the adopted governance structure, including the assignment

of a NASA employee as a Board Secretariat. The INSRB Charter also defines specific roles and responsibilities associated with this unique agency role for NASA, which are further elaborated on in the

present document, and included amongst the Roles and Responsibilities in Sections 1.3 and 1.6. Beyond these unique roles, NASA does not generally assume any additional responsibility relative to other agencies. Most notably, NASA is not responsible for the review costs of a mission sponsored by another agency.

Should there be a concern with how either the Secretariat or the NASA Board member is conducting their INSRB role, this concern should be brought to the attention of the NASA Chief of Safety and Mission Assurance.

2.3. Quorum, Decisions, and Actions

Note: The following passages describe the situation for standing Board activities. A similar approach is intended for IRG activities.

Regarding quorum, this is defined in Section V of the INSRB Charter, and generally requires representation from one-half or more of the relevant agencies. An alternate can represent an agency for quorum purposes, but that alternate must be civil service or a military officer (to support general conformance with INSRB not being subject to the Federal Advisory Committee Act (FACA)).

Regarding decision making, Section V of the INSRB Charter outlines INSRB's approach to consensus, including the handling of Formal Dissents in cases where consensus cannot be reached. Decisions made during INSRB meetings will be recorded in the meeting minutes by the individual administering the meeting (e.g., the Board Secretariat for Board meetings). Interim decisions reached through electronic correspondence between meetings will be specifically re-visited during the next meeting and recorded in the meeting minutes for posterity. Formal decisions must be stated clearly as a motion to approve, seconded, and recorded, and the participating agency representatives must be specifically given the opportunity to abstain or dissent. If dissent is expressed, and consensus is not reached through subsequent dialogue, the dissent will be recorded and the dissenter will be asked to prepare a description of the dissenting view within 5 working days, to be appended to the meeting minutes or other relevant document. If multiple parties dissent for similar reasons, the dissenting view can be consolidated in to a single dissenting view, if they so choose.

Regarding actions, identified actions can be taken without a formal decision, unless there is concern expressed that the action substantively affects matters requiring a formal decision. Actions will be recorded in the meeting minutes and tracked by the Board Secretariat (or IRG Chair and Review Manager depending on the context). Each INSRB meeting will include a brief review of open action items, and the meeting minutes will capture those actions that were closed since the prior meeting.

2.4. INSRB Review Group (IRG) Empanelment

NSPM-20

“For Federal Government launches in Tier II and Tier III, the head of the sponsoring agency shall request of the NASA Administrator that the INSRB review the nuclear safety analysis... When necessary to protect national security, the head of the sponsoring agency, in consultation with the APNSA, may restrict INSRB member participation in any mission review...At the request of the Secretary of Transportation, the INSRB shall review any nuclear safety analysis associated with a potential commercial launch of a space nuclear system under review by the Secretary of Transportation. The terms of any INSRB review, including the costs of such review, shall be agreed upon between the NASA Administrator and the head of the agency requesting INSRB review.”

IRG empanelment occurs when the Board’s interactions with a potential mission sponsor have progressed to the point that standing Board interactions are no longer sufficient and there is a need to codify the Terms of Review⁵. It marks the transition from less formal interaction to a more formal engagement, and it occurs in concert with the Agency Head interactions outlined in NSPM-20. The timing of empanelment is a balance between INSRB’s needs for mature mission information to develop an implementable review plan versus the sponsoring agency’s needs for a stable and focused review. Empanelment would generally occur after the Board has received and reviewed the Initial Federal Launch Authorization Basis Strategy, or an equivalent set of mission-specific information, and before the Mission Safety Analysis Report for Interim Review is received (see Section 4.1 for

the overall process). However, other timings are permissible.

Review team member selection should consider the composition of subject matter expertise needed for the review (see Section 2.6 for more information on subject matter expertise), which will be a part of developing the Mission-specific Review Plan (discussed in Section 5.1). To form a provisional IRG, the Board members from the agencies anticipated to be participating in the review will identify their agency’s proposed representative from amongst the standing Board. The Board members must consider access authorization (i.e., security clearances) when making this identification, in cases where the review will involve classified information. Past experience has demonstrated the importance of reviewers that possess both rich technical expertise as well as sufficient relevant experience to support a holistic view of mission safety and risk management.

The anticipated empanelment sequence of events, and their characteristics, is:

- The Board receives the Federal Launch Authorization Basis Strategy (see Section 5.2.2), or equivalent, from the program office;

⁵ There may come a time when some INSRB reviews become routine enough that an Executive review by the Board itself is most effective. In such cases, it would still be important that the requirements of NSPM-20 are met (e.g., agreement to the Terms of Review by the applicable sponsoring agency head(s), and that a Chair from the sponsoring agency lead the review effort). The following criteria can be used to identify situations where an Executive review may make more sense: (i) only one or two reviews are occurring concurrently, (ii) the mission in question doesn’t involve many novel aspects, (iii) the mission in question is developing the SAR to a known standard and performing a thorough upstream peer review for which INSRB will have sufficient insight, (iv) the mission and INSRB are both operating and coordinating based on a well-established operating procedure, and (v) the mission does not involve classified information or other aspects that limit participation.

- The Board votes to approve formation of a provisional IRG, including identification of its Chair (who hails from the agency sponsoring the mission, or the Department of Transportation, in accordance with Section III of the INSRB Charter), Review Manager (if applicable), and members, and records this approval in meeting minutes (an email vote is permissible)⁶;
- The provisional IRG drafts a Mission-specific Review Plan (discussed in Section 5.1), including estimated costs, if any;
- The provisional IRG provides the Board, and separately the program office (or the FAA applicant for a commercial mission should the Chair from the Department of Transportation deem this to be appropriate), an opportunity to provide feedback on the plan, and dispositions this feedback;
- The provisional IRG members provide their approval of the Mission-specific Review Plan via email concurrence;
- The IRG Chair works with the program office to summarize the most salient aspects of the Launch Authorization Basis Strategy and the Mission-specific Review Plan in a Terms of Review document that will be used to obtain approval by the relevant Agency Heads;
- The sponsoring agency (if other than NASA) and NASA agency-level approvals of the Terms of Review document are obtained by the Chair and the Board Secretariat, by:
 - having the sponsoring agency head (or designee) sign the Terms of Review and transmit that plan (and the associated request for INSRB review) to the NASA Administrator, and
 - having the NASA Administrator (or designee) counter-sign the Terms of Review and provide it to the IRG Chair and the Board Secretariat for retention and implementation.

The latter step (which would be simplified for a NASA mission) serves as the sponsoring agency's formal notification of the need for a review, and NASA's formal agreement of that review, in accordance with the stipulations in NSPM-20. It also serves as the formal empanelment of the review team. In accordance with Section VI of the INSRB Charter, the IRG and the program office will coordinate changes to the IRG or the Mission-specific Review Plan unless disagreement prompts the need to elevate.

Appendix C: Sample Empanelment Checklist provides a more action-oriented example checklist of the empanelment process.

2.5. Board and IRG Interactions

The INSRB organizational structure and functions are defined in Section III of the INSRB Charter. The primary benefits of having IRGs, versus reviews being conducted directly by the entire Board, include:

- It allows for the role of a Chair for the review, whereas the Board itself is a Board of equals;
- It allows for more effective interactions at the review level, by permitting interactions directly between a smaller group of reviewers and the program office, where appropriate;
- It allows for clearer division of responsibilities when multiple mission reviews occur concurrently;
- It allows the Board, in its executive function, to focus on strategic, rather than tactical matters.

⁶ This step will explicitly consider any request to limit participation in the review (due to national security considerations or as deemed appropriate by the Secretary of Transportation), in accordance with Section 5(c) of NSPM-20. Later signature of the Terms of Review by the relevant Agency Heads will be the means of codifying this determination.

The primary detriment of having review teams is the additional burden and bureaucracy it can entail. Avoiding unnecessary burden while ensuring consistent focus is the primary balance of interest in executing this conduct of operation model. For this reason, the IRG is empowered to handle all INSRB-related matters relevant to their review.

To promote coordination and awareness, the IRG Chair should provide a status of the mission-specific review during all Board Quarterlies. For the same reason, those administering the IRG (i.e., the IRG Chair and the Review Manager⁷ (if applicable)) and the Board Secretariat should have routine interactions.

2.6. Availability of Subject Matter Expertise

Access to subject matter expertise in relevant areas will allow the IRG to critically assess quality (as defined in Appendix A: Definitions) and identify significant gaps in an effective manner, by allowing the reviewers to focus their activities and their questioning in the areas that are most impactful to safety and risk management. Ensuring this access has three primary aspects:

1. The Board should periodically re-visit its familiarity with, and its access to, subject matter experts in general terms.
2. As part of empaneling an IRG, the Board should explicitly address which skills are needed for the review, and identify which skills are not resident in the review group membership. (Section 5.1 provides more detail.)
3. In executing the Mission-specific Review Plan, the IRG should engage with subject matter experts, as needed.

To support deliberations related to all 3 aspects, Appendix D: Subject Matter Expertise Matrix provides a starting point for assessing what skill sets are needed, which are readily-available amongst the Board or IRG members, and thus, what skill set availability requires additional attention. It is not necessary to identify available subject matter expertise in all applicable areas at the start of a review because some areas may not require in-depth knowledge if they are not impactful to overall safety and risk. Conversely, INSRB needs to plan appropriately, as accessing expertise can be a long-lead time item depending on the source of the subject matter expertise.

The general order of preference for addressing skill set gaps within a mission review will be situational, but should consider the following general order of priority:

- Can the skill set gap be addressed by requesting additional information from the program office or leveraging other existing independent reviews associated with the mission, such as the Range Safety review or the upstream nuclear safety peer review?
- Can the skill set gap be filled by soliciting involvement from an unconflicted civil service employee or military officer at one of the INSRB-participating agencies, who has the organizational flexibility to support without implementing a reimbursement agreement?

⁷ Such an individual would help administer the review but would not be a review team member in the sense of decision-making and the like. For this reason, the individual could be a Federal contractor, so long as their administrative duties do not result in them performing inherently-Governmental functions or being a de facto Board member. In other words, their standing would be more akin to that of a consulted SME.

- Can the skill set gap be addressed by placing additional burden on the program office to procure an independent reviewer in the relevant area, or otherwise demonstrating that independent review in that area is not necessary?
- Can the skill set gap be filled by soliciting involvement from an unconflicted civil service employee or military officer at any agency, by implementing a reimbursable agreement?
- Can the skill set gap be filled by procuring contract support?
- Can the INSRB Safety Evaluation Report reasonably state that the area went unreviewed?

Again, the actual approach taken will be governed by the circumstances of the situation. The IRG should engage the program office to discuss the skill set gap, and available options, any time that the program office will be impacted by the chosen solution. If the program office refuses support due to having a different view to the skill set gap's importance, and the INSRB does not have other means of addressing what it sees as an important skill set gap, then the matter should be elevated and described in the IRG's review product(s).

2.7. Defining a USG Launch versus a Commercial Launch under DOT Authority

Per NSPM-20, commercial launches and Federal Government launches have different features, though many of the practices and processes in the present document are common to both. In some cases, namely those involving solely commercial participants or solely Government agencies, the distinction on whether a particular launch will be "commercial" versus "non-commercial" will be evident. Although it is increasingly common to have mixed participation of government and commercial partners, the definition of what is a commercial launch, from the DOT/FAA licensing perspective, is whether or not the launch or reentry event is commercially conducted. This topic is discussed at length in Appendix E: Defining a US Government Launch versus a Commercial Launch and DOT Authority.

NSPM-20

"Federal Government missions...are non-commercial missions either conducted or sponsored by an agency. Consistent with chapter 509 of title 51, United States Code, the Secretary of Transportation, or the Secretary's designee, is the licensing authority for commercial launches of spacecraft containing space nuclear systems..."

2.8. Information Security and Information Handling Protocols

Broadly speaking, INSRB will follow the originating agencies' policies and practices for documents produced by other agencies. For INSRB-generated documents, INSRB will generally follow NASA policies and practices for matters involving the standing Board, or the sponsoring agency's policies and practices for matters involving an IRG review.

2.8.1. Non-disclosure Agreements

As part of the Mission-specific Review Plan, the Board Secretariat, the Mission-specific Review Chair, and agency-specific General Counsel(s), will work with the program office to identify whether any non-disclosure agreements (NDAs) or similar arrangements (as discussed in 32 CFR 2002.4(c)) are required in order for the review team to access mission-related materials. If this need exists, it will be specified in the Mission-specific Review Plan but executed outside of that plan. The sponsoring agency may choose any form for Agreements or arrangements to share information with non-executive branch entities, so

long as they include a requirement to comply with Executive Order 13556, Controlled Unclassified Information (November 4, 2010), CUI implementing regulations at 32 CFR Part 2002, and the CUI Registry. Information sharing agreements are required, at a minimum, to include the provisions found in 32 CFR 2002.16(a)(6). These provisions include the stipulation that, when the disseminating agency is not the designating agency, the disseminating agency must notify the designating agency.

If classified information is exchanged, the transmitter of that information must also ensure that the recipient has a need-to-know, the appropriate clearance authorization, and the ability to appropriately safeguard the information.

When writing NDAs, the parties should balance the flexibility to accommodate unforeseen circumstances against not writing them in a way that restricts the flow of information that doesn't warrant that level of protection. The Board Secretariat, or the IRG Chair and Review Manager (as applicable), will retain signed copies of NDAs, as well as a master list of those individuals covered by the NDA.

2.8.2. Sharing of Copyrighted Materials

In cases where there is a desire to circulate copyrighted materials amongst INSRB participants, access to the material would require multiple parties paying document access fees, and such distribution is not clearly permitted, the Board Secretariat will check with the issuing source and obtain permission to distribute (if allowed).

2.8.3. Marking and Handling

All marking and handling must be done in accordance with the relevant agency-specific requirements (e.g., NASA Interim Directive (NID) 1600.55, NASA Procedural Requirement (NPR) 2190.1), and in accordance with any applicable designation and classification guide (e.g., CG-SNS-1 and other DOE classification guides referenced therein, DoD classification guides). The document owner must ensure that products are reviewed by qualified individuals when they may include classified or sensitive information. In the case of classified information, an individual approved as a derivative classification authority must mark the document using an approved security classification guide, in accordance with agency-specific policies and all other applicable authorities (e.g., Executive Order 13526, 32 CFR 2001). In general, most (if not all) CUI and classified material that INSRB has cause to handle will have been generated by DoD or DOE and will have thus already been marked accordingly prior to transmittal to INSRB. The same may or may not be true for ITAR/EAR information, which at NASA is governed by NASA Procedural Directive (NPD) 2190.1.

Regarding CUI, and to the extent that there are any differences in agency-specific CUI implementation, INSRB will follow individual agency practices with deference to the originating agency's process when flexibility permits (e.g., NID 2810.135 for NASA).

2.8.4. Other Information Security Practices

INSRB will handle other activities related to information security, such as the handling of a sensitive information spill, in accordance with the policies and practices of the involved individual agency or agencies.

2.8.5. Public Availability of INSRB Documents

Most INSRB documents will be deliberative in nature (i.e., pre-decisional), and will frequently contain sensitive material, such as launch vehicle information, mission information, or nuclear device information. INSRB anticipates a few exceptions, as follows:

- Approved versions of the INSRB Charter and this Playbook will be publicly-available;
- The IRG will prepare an Executive Summary for the INSRB Safety Evaluation Report that is free from sensitive information and releasable to the public;
- While copies of final INSRB documents will be maintained by NASA (as the administering agency), copies of these documents will also be possessed by other agencies. To the extent that these documents are records responsive to a particular Freedom of Information Act (FOIA) request, they will be subject to the relevant agency's routine FOIA processes (and thus be potentially releasable).

For these reasons, involved parties need to manage the sharing of documents that have associated confidentiality expectations (such as information provided by an FAA applicant), and routine interagency coordination, appropriately. Other than the cases identified above, INSRB will treat other INSRB-developed products as non-public.

2.9. Electronic File Management and Retention Practices

The overall purpose of this section is to provide practical information. It does not alter, in any way, agency-specific requirements related to National Archives and Records Administration policies or those related to cybersecurity.

2.9.1 Standing Board Activities

The Board Secretariat shall store Board files on a NASA-approved cloud storage system that has been rated for use with Controlled Unclassified Information, taking any additional precautions that may be required (e.g., encrypting files with Personally Identifiable Information or Export Control Information). This can include the NFSAM's personal OneDrive storage, so long as key documents are also stored in locations accessible by the NASA INSRB representative (e.g., the NASA nuclear flight safety Teams site, the NASA nuclear flight safety website, the OSMA Flight Projects repository). File retention should follow the standard National Archives and Records Administration policies. Working documents (and any equivalent documents) shall follow agency standards for those agencies possessing the documents. Such documents need only be provided to the Secretariat if they form an intrinsic basis for an official IRG document (e.g., are specifically referenced in such a parent document). As a general rule, the Board Secretariat will not process classified information on behalf of an IRG.

2.9.2 Mission-specific

For IRGs, the IRG Chair and Review Manager will maintain electronic files (i.e., records) associated with the review, in accordance with that agency's policies. Annually, and at the end of the review, the sponsoring agency personnel will transfer an archive of final review products to the Board Secretariat. The exception to this will be cases where such electronic files are classified, or otherwise have a need-to-know consideration that makes it inappropriate to provide them to the Board Secretariat. In such cases, the annual and end-of-mission-review file archive will include a file listing (or equivalent), but not

provide the actual files. In such cases, the sequestered files shall be retained by the sponsoring agency in accordance with standard National Archives and Records Administration policies.

2.10. Approach to Elevating Concerns and Documenting Formal Dissents

INSRB encourages good nuclear safety culture. The “Safety Framework for Nuclear Power Source Applications in Outer Space,” jointly published by the United Nations Committee on the Peaceful Uses of Outer Space Scientific and Technical Subcommittee and the International Atomic Energy Agency, in 2009, describes such a situation as including:

- Clear lines of authority, responsibility, and communication;
- Active feedback and continuous improvement;
- Individual and collective commitment to safety at all organizational levels;
- Safety accountability of the organization and of individuals at all levels;
- A questioning and learning attitude to discourage complacency with regard to safety.

INSRB encourages the raising of concerns early. Such concerns should be brought to the attention of the individual leading the relevant INSRB activity, and if warranted, to the INSRB as-a-whole. The Board Secretariat can be utilized as a resource for raising a concern, but contacting the Board Secretariat is NOT a requirement, and Board Secretariat involvement should not be allowed to hinder the raising of a concern. Concerns germane to INSRB’s review should be discussed, and elevated as necessary, toward achieving resolution. If a concern is not satisfactorily addressed, it may lead to a Formal Dissent. In NASA terminology (NPD 1000.0C), a Formal Dissent is “a substantive disagreement with a decision or action that an individual judges is not in the best interest of,” in this case, INSRB, “and is of sufficient importance that it warrants a timely review and decision by,” in this case, a higher-level of authority.

Any individual associated with the nuclear safety analysis, nuclear safety review, or other related activity (e.g., radiological contingency planning) has the standing to raise a concern. However, only individuals participating in an INSRB activity (civil service employees, military officers, or contractors⁸) have the standing to raise Formal Dissents (within the INSRB context) to INSRB documents or actions, and only the IRG members and standing Board members have the standing to attach a Formal Dissent to an IRG report (such as the Agency Head Gaps or Omissions Report or the INSRB Safety Evaluation Report).

For INSRB, the Formal Dissent process will be implemented by the following steps, which balance the importance of capturing dissenting views with the reduced degree of infrastructure that INSRB has relative to a US Government agency:

- The individual raising the dissent must specifically request that the dissent be recorded and resolved by the Formal Dissent process. A Formal Dissent must be supportable and based on a clear and sound rationale (not on vague or unyielding opposition).
- The individual raising the dissent must document their position in a timely manner (generally within 5 business days), and this description must be provided to all INSRB members party to the relevant activity.

⁸ Since contractors and civil service or military officer consultants would typically be involved with a topic-specific portion of the review, any Formal Dissent raised should either be rooted in that portion of the review or should otherwise be carried forward by a review team member.

- If the Formal Dissent relates to an IRG review, it should be discussed between the dissenting party, the IRG Chair, and the program office lead. If this discussion does not resolve the issue to the dissenter's satisfaction, then it should be elevated to the Agency Head via attachment to the relevant document or another suitable process.
- For a Formal Dissent associated with a final document and identified and documented prior to the issuance of that document, the Formal Dissent must be attached to the document when it is issued.
- For a Formal Dissent associated with an INSRB voted decision or action, the Formal Dissent must be attached to the Board meeting minutes that record the associated vote.

2.11. Maintaining an Appropriate Degree of Independence

Section 2.1 has already discussed the role of Board membership selection in maintaining an appropriate degree of independence. This section will address other relevant aspects.

NSPM-20 does not mention the word “independent” in describing the INSRB’s evaluation role. Consistent with this, the INSRB must seek to balance the efficiency of knowledge and resource sharing against the known decision traps associated with dependent activity. To accomplish this, INSRB must maintain a sufficient degree of independence in terms of its technical knowledge (i.e., possesses a diverse set of experiences and aptitudes), its programmatic and managerial latitude (i.e., not vested in the Program’s success and not beholden to the Program in setting its review objectives and priorities), and its financial auspices (i.e., cannot have its reviews efforts dictated by the Program during the course of its review by virtue of the Program unilaterally changing its committed support).

To maintain a sufficient degree of technical independence, beyond what has already been discussed in Section 2.1 and Section 2.6, the INSRB must have access to technical expertise that is free from vested interest in the mission planning and execution (meant here to include individuals that are vested in the development of the underlying technology, such as the reactor design), or else be aware of that vested interest so that it can be mitigated in how INSRB uses the collected advice or information. This applies to expertise provided by civil service employees, military officers, contractors, or members of academia, all of which could have roles in supporting a particular mission’s planning and execution. To be clear, this refers to involvement in the mission planning and execution performed on behalf of the program office or their subsidiaries toward furthering the frontline purpose of the mission; it is not referring to entities that provide regulatory support functions such as range safety and contingency planning under the auspices of involved safety organizations. When vested interests are identified, INSRB should acknowledge this potential conflict-of-interest and should ensure that the advice given is not the sole basis for a substantive INSRB decision (e.g., a decision not to pursue further scrutiny of a technical assumption in the nuclear safety analysis).

Finally, to maintain a sufficient degree of financial autonomy, all terms of the review scope and cost shall be negotiated as part of the Mission-specific Review Plan and Terms of Review (see Section 4.2, Section 4.5, and Section 5.1).

2.12. Revision Protocols for INSRB Documents

2.12.1 INSRB Charter

The terms for revision of the INSRB Charter are spelled out in Section X of the INSRB Charter.

2.12.2 INSRB Playbook (this document)

Substantive changes, to mean those that can reasonably affect technical judgments or interagency affairs pertinent to either INSRB's general business or its mission-specific reviews, shall require Board approval (following the consensus framework prescribed in the INSRB Charter). Other changes, to mean non-substantive changes such as reflecting changes in NASA IT policy, records retention policies, etc., can be made unilaterally by the NASA Secretariat, so long as the revised version is distributed to the Board with changes identified. Prior to the issuance of major revisions to the Playbook, stakeholders of the INSRB process (e.g., recent and anticipated program offices, OSTP staff) should be given the opportunity to provide comment.

2.12.3 Other Official INSRB Products (Mission-specific Review Plans, Significant Gap Reports, INSRB Safety Evaluation Reports, Letters)

These products will most typically be developed by a provisional or empaneled IRG, depending on the context. In either case, an individual appointed by the applicable entity can edit and maintain them. Approval and issuance of the product will follow the consensus framework described in the INSRB Charter. For official products, and after consensus has been reached by the Board or IRG, handling protocols are described in Section 2.5. The program office should be provided opportunity to provide comment, as well as confirmation of stated facts, prior to the issuance of major products to sponsoring Agency Heads, OSTP, or the public.

2.12.4 Unofficial INSRB Products (i.e., working documents)

Document owners should use version control marking for unofficial or working INSRB products, and preferably will adopt the practice of placing a versioning number and date-of-last-modification on the cover page. Document owners should also insert markings to designate their pre-decisional status. Otherwise, these documents are not subject to any unique provisions.

3. INSRB Review and Evaluation Scope

3.1. Differentiation Between Evaluation and Analysis

The scope of the INSRB’s review includes evaluating the nuclear safety analyses, identifying gaps in the analyses, and recommending areas for additional analysis where it identifies gaps.

The scope of the INSRB’s review does not include repeating or conducting analysis that would mirror or supplant the safety analysis, as the sponsoring agency has the primary responsibility to prepare the estimates of risk to be used by the decisionmaker. Some degree of analysis is inevitable to support a substantive and efficient review of the sponsoring agency’s safety analysis report, and such analysis is consistent with the intent of NSPM-20, so long as it is not duplicative or resource-intensive. This is discussed more later in this section.

At each stage in the review process (see Section 4.1 of this document for a discussion of the different stages) the INSRB should determine if, in order for it to arrive at its evaluation findings, there is:

- sufficient information in the safety analysis documentation,
- sufficient information in any supporting technical basis documents,
- sufficient access to underlying modeling and simulation activities, and test results, in terms of both data sets and documentation.

Since the INSRB as-a-whole will have varying levels of familiarity with tools used in mission-specific analyses, the Board (in its standing role) should maintain situational awareness of tools commonly used in nuclear safety analysis, periodically hold discussion with safety analysis preparers about tool selection, and generally plan for maintaining or acquiring the necessary expertise to support mission-specific reviews. The use of subject matter expertise is discussed in Section 2.6. While INSRB doesn’t advocate for the use of specific tools, selection of tools commonly used in nuclear safety analysis (as opposed to mission-specific tools) may create some efficiencies in the review.

As mentioned earlier, many effective reviews of complex analyses necessitate some degree of reviewer calculations for the sake of determining the relative priority of analysis items that are being probed by understanding parameter sensitivities, the effects of sources of model uncertainty or methodological assumptions, verifying key translations of computational information, etc. Such calculations help to avoid taking every single question back to the safety analysts for disposition or highlighting gaps that are in fact insignificant.

The nature of such a calculation will be situational, but a few tenets are provided here to help anchor choices:

- INSRB reviewers should not perform complex or resource-intensive (e.g., greater than 20 hours level-of-effort) analysis. If simple checks prove insufficient, the issue should be identified as a potential gap, and the program office should be asked to supply additional evidence, or to otherwise support resolution of the issue.

NSPM-20

“The INSRB may recommend areas for additional analysis where it identifies gaps, but it is not tasked with repeating or conducting its own analysis.”

- Calculations should focus on the particular area being probed; the nuclear safety analysis and expert judgment should be used to assist in placing this focused assessment into the broader significance. Use of expert judgment should be properly documented.
- Safety analysis-provided sensitivity and uncertainty analysis are preferable to the use of INSRB-generated alternative modeling.

Use of applicable consensus standards by the safety analysis preparation team will generally act to minimize the need for these types of calculations.

3.2. Identification of Other Applicable Federal, State, and Local Requirements

NSPM-20

“For any mission that includes a space nuclear system, mission planners and launch authorization authorities should, as appropriate, seek to ensure that... normal operation of the space nuclear system is consistent with applicable Federal, State, and local requirements.”

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

The Board Secretariat will maintain an informal catalogue of other (i.e., in addition to NSPM-20) applicable federal, state, and local requirements that arise during INSRB activities, for general awareness, and potential implications. This listing can be provided to mission planners upon request. However, it remains the responsibility of the mission planners and launch authorization authorities, and not INSRB, to ensure

applicable laws, regulations, policies, or agreements are being met.

3.3. Review Boundaries with Respect to Varying Ways to Measure Risk

This section focuses specifically on what consequence and risk measures INSRB envisions receiving, as part of its charge to evaluate the quality of the safety analysis. It is closely related to, but also distinct from, later discussions of other end-users of the safety analysis (Section 3.4) and aspects specifically excluded from review (Section 3.5).

INSRB has two fundamental expectations in this area. The first is that the safety analysis will report those risk measures described in NSPM-20. The second is that the safety analysis will address accident impacts (if any) not adequately represented by the former, which would reasonably influence the launch decision (as informed by discussions with the launch decision authority if feasible).

Appendix F: Tabulation of NSPM-20 Safety Guideline Results provides discussion on the expected approach to tabulating the NSPM-20 Safety Guideline measures. Beyond the Safety Guidelines comparison, INSRB expects that the safety analysis will contain the other measures specified in NSPM-20, namely the likelihood of an accident resulting in an exposure in excess of 5 rem TED to any member of the public, the number of individuals who might receive such exposure in an accident scenario, and comparisons of potential exposure levels to other meaningful measures such as those examples provided in NSPM-20.

The above measures of consequence and risk focus solely on radiological exposures to humans, and with articulated basis, this may be sufficient for the INSRB's purposes. As discussed in Section 3.4, the INSRB does not intend to delve into other end-uses of the nuclear safety analysis, or other peripherally-related processes, that may necessitate other consequence or risk measures, such as a Range Authorities' concern over Range contamination or the National Environmental Policy Act consideration of ecological habitats. Even so, INSRB's charge is to evaluate the quality of the safety analysis presented, and to the extent that the safety analysis addresses other measures of risk, INSRB may comment on these if they are relevant to the safety analysis quality. Further, in instances where the overall accident impacts are not well-represented by the measures presented (e.g., cases where modeling assumptions about land interdiction or decontamination artificially suppress estimates of human exposures, cases where two contrasting accident scenarios have similar human exposure estimates but drastically different impacts on a high-value asset), INSRB does reserve the right to comment on this. To be clear, INSRB does support the modeling of mitigative actions (e.g., sheltering-in-place), when sufficient basis exists to

NSPM-20

“Nuclear safety analysis and review is a critical step before any launch of a space nuclear system. Safety analysis should include an assessment of potential consequences to a maximally exposed individual member of the public in accident scenarios.”

Sections 3(a)(ii) – 3(a)(iv) contains Safety Guidelines in the form of a piece-wise linear exceedance probability threshold as a function of the corresponding exposure to any member of the public.

“The mission SAR...shall include a concise, high-level summary of key risk information... This summary should include...the number of individuals who might receive such exposure [5 rem TED] in an accident scenario; and comparisons of potential exposure levels to other meaningful measures such as...background radiation, average public exposure from natural and manmade sources, and other relevant public safety standards.”

indicate that this is the more realistic situation. In all applicable cases, the INSRB will document what it has and hasn't reviewed via discussion in its products (e.g., the INSRB Safety Evaluation Report).

3.4. Review Boundaries with Respect to Other Uses of the Nuclear Safety Analysis

In some shape or form, a host of activities are influenced by the nuclear safety analysis, and these include payload safety, range safety, flight safety and launch authorization, ground processing of the space nuclear system at the launch site, radiological mishap preparedness and radiological contingency planning (including radiological material recovery planning), insurance considerations, and national and international coordination and outreach. Section 3.3 discusses this topic specifically in the context of overlapping safety analysis consequence and risk measures.

INSRB will focus on evaluating the quality of the safety analysis for supporting the NSPM-20 launch authorization, and will generally support these other users as needed, but not perform review work on their behalf. This posture is an attempt to balance the efficiencies that could be gained by mixed reviews versus the inefficiencies and confusion that can be caused by INSRB operating outside of its charge. To promote this balance, INSRB may request informational briefings from entities working in these other areas, is likely to peruse documents published by these other activities to aid in mission familiarization, will typically agree to provide briefings upon request from these same entities, and would reach out to these entities if in possession of information that calls in to question matters of safety in these areas. However, these exchanges will focus on cooperation, rather than collaboration. A simple example is the overlap between the dose calculations performed for comparison to the NSPM-20 Safety Guidelines (and reviewed by an INSRB Review Group (IRG)) versus the dose calculations performed as part of the radiological contingency planning.

A related issue that has arisen in past reviews is the degree of overlap in personnel between the nuclear safety review and these other activities. Some overlap is healthy, and almost unavoidable. To the extent that agencies choose to assign the same personnel to fulfill functions in these differing areas, this will be supported by INSRB, so long as a conflict-of-interest does not arise. In such cases, these individuals should be cognizant of, and clear in communicating about, which function they are performing when interacting with the program office. Conversely, INSRB does not encourage the use of observers for the sake of increasing cross-pollination. Such cases in the past have often proven ineffective, and INSRB will use the afore-described cooperative information exchange to support cross-pollination efforts.

The IRG should acknowledge all of the above issues and should discuss them during the development of the Mission-specific Review Plan, through a cooperative exercise that factors in the program office's schema for safety analysis products. To this end, Section 5 and Appendix H: Sample Outlines of Sponsoring Agency Submittals, have callouts for this consideration in the relevant products.

3.5. Aspects Specifically Excluded from Review

During their review, IRGs will focus on the quality of the safety analysis, which necessarily raises consideration of the safety analysis scope in terms of what the IRG would or would not consider to be a gap in scope. NSPM-20 provides some anchors regarding the scope of the safety analysis, but some additional expectations are offered here, beyond what has been discussed previously related to consequence and risk measures and the interface with other nuclear safety processes.

NSPM-20

“Safety analysis should address launch and any subsequent stages when accidents may result in radiological effects on the public or the environment, for instance, in an unplanned reentry from Earth orbit or during an Earth flyby.”

While recognizing that some natural synergies may exist, INSRB specifically envisions that its review activities will NOT address:

- Other safety management program elements (e.g., fire suppression, quality assurance) except where a specific feature of that program is found to have a direct bearing on a hazard that is within the safety analysis scope;
- Activities associated with manufacture, risk during ground testing, transportation to the launch site, and handling at the launch (or other) facility prior to integration in the launch vehicle, all of which are generally the purview of other safety reviews;
- Radiological hazards that are necessarily addressed through other processes (e.g., nuclear security activities in the case of preventing sabotage, theft and diversion);
- Accident impacts that do not affect Earth’s biosphere (e.g., contamination of other celestial bodies), which is generally the purview of planetary protection reviews;
- Accident impacts that cannot be readily tied to radiological exposure or contamination (e.g., non-radiological hazards that are part of range safety analysis, psychological impacts); and
- Specification of end-of-life disposal, beyond the modeling of accident scenarios that may impact the public or the Earth’s biosphere.

The considerations described in Section 3.4 regarding cooperation with those conducting related activities also applies here.

4. INSRB Review and Evaluation Process

4.1. Overview of General Approach

The INSRB process will be scaled and tailored to meet the circumstances of each mission and it will leverage the upstream and separate mission SAR technical peer review required by NSPM-20. Each mission will have its own approach to establishing system safety foundations prior to the development of a safety analysis, along with its own approach to managing mission activities after launch approval is granted (or for commercial launches, after DOT makes a launch license determination). These approaches will necessarily be driven by sponsoring agency processes, technology drivers, and experience.

This section presents a notional process, to illustrate how activities upstream of INSRB's active involvement can fit in to the mission nuclear safety analysis that INSRB reviews, the general process by which INSRB will perform its review, and how the process by which the reviewed safety analysis (and the broader launch authorization basis) will be maintained after completion of the safety evaluation is established. The presented process is rooted in the context of a government launch. Some aspects may require change to fit the DOT licensing construct. More information about the differences for the commercial launch context will be added after the FAA has published its guidance for licensing of commercial space nuclear system launches and reentries.

This notional process was developed in consideration of DoD's and NASA's approaches to System Safety, DOE's and NRC's Nuclear Safety processes, and the IAEA and United Nations Scientific and Technical Subcommittee's Space Nuclear Power Source Safety Framework. It incorporates features from all of these sources. It does not attempt to specifically reproduce any particular process, given the breadth of missions that INSRB might review.

This notional framework serves as a basis for discussion during mission-specific review planning and provides a general anchor for the general practices and processes described in the remainder of this document. In this notional framework, INSRB progresses through three very broad stages, and each of these stages has assumed elements, including those elements prescribed within NSPM-20. This process as-a-whole is depicted in Figure 1, and described in the following sub-sections.

NSPM-20

“The INSRB shall evaluate the quality of the safety analysis and identify any significant gaps in analysis. The INSRB may recommend areas for additional analysis where it identifies gaps, but it is not tasked with repeating or conducting its own analysis. The INSRB shall engage early in the safety analysis process, after the conceptual design of the mission is generated, in order to identify gaps in time for mission planners to address them without creating unnecessary delays in the launch timeline. Before completion of the mission SAR, the INSRB shall advise the head of the sponsoring agency of any omissions or gaps that the INSRB has identified in analysis that is planned or underway, and may provide recommendations for corrective action.”

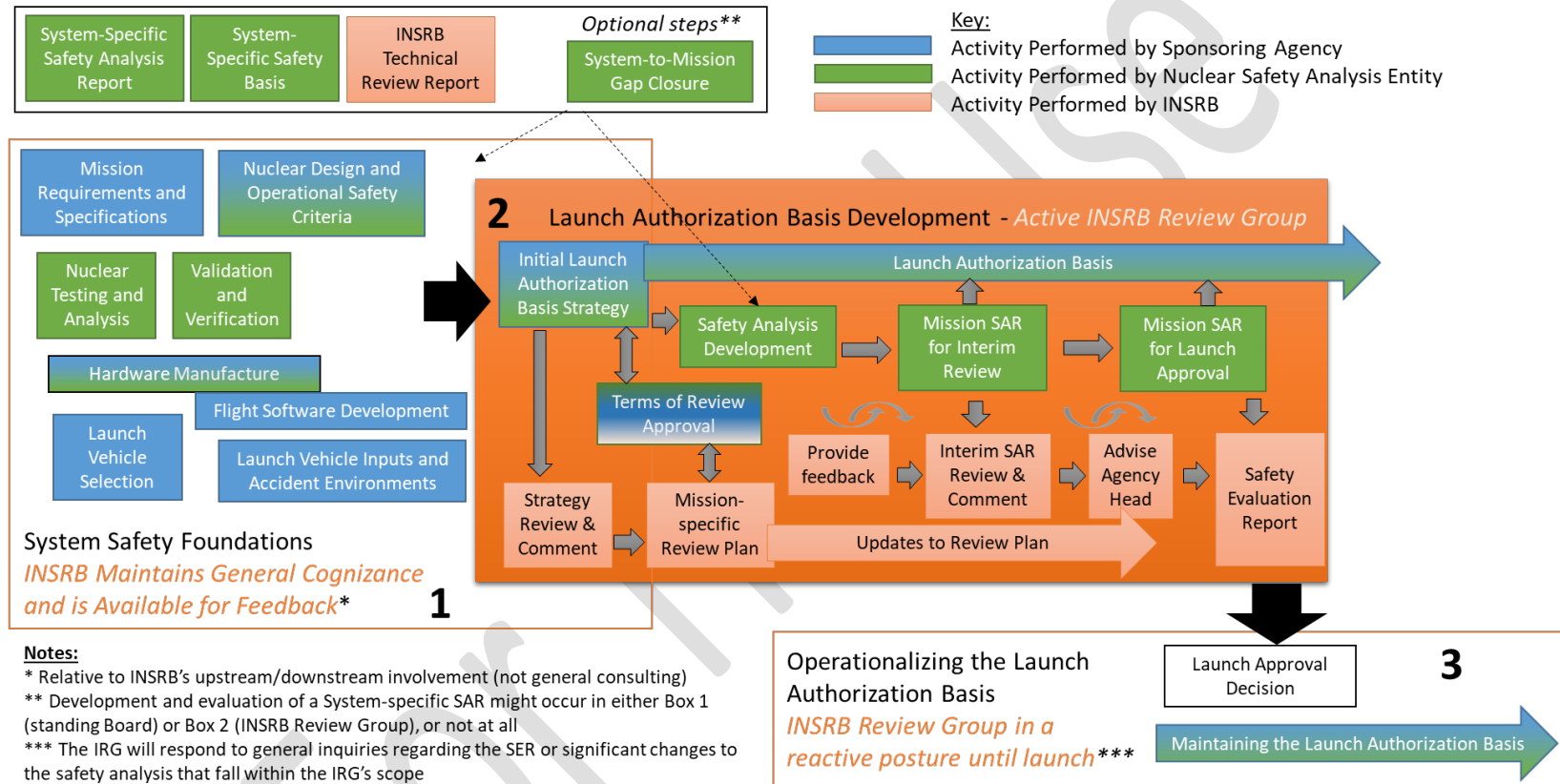


Figure 1 - INSRB Review Process and Broader Notional Backdrop

4.1.1. Anticipated Process Prior to Active INSRB Mission Review

The first of these stages is characterized by active program office work in the area of mission formulation, software and hardware development, safety basis underpinning activities (e.g., safety criteria formulation, testing, validation and verification), launch vehicle selection, etc. Development of a system-specific SAR may also occur during this time frame (or prior), and this aspect is discussed further below. It's anticipated that this effort will leverage past development activities. Use of applicable accepted standards will generally lead to a more streamlined INSRB review later. Section 5.2.1 provides more context regarding the launch vehicle aspects, and how they fit in to the safety analysis preparation, in light of both the direct importance to the nuclear safety analysis, along with the fact that this work has been historically performed (at least in part) by different parties than the nuclear safety analysis.

During this period, the Board will provide consultation on how these mission activities may relate to the future IRG review, consistent with NSPM-20's direction for early engagement. When the program office engages with the Board during this time, the program office should specify whether the interaction (typically a briefing) is for information purposes only, versus when feedback is desired. The Board's consultation during this period will seek to identify potential issues that may challenge the development of an effective safety analysis and affirmative safety review. For example, are there new concepts or novel design features for which there may be deficiencies in applicable supporting data? Early identification of potential issues could give the program office a preview of what gaps may be identified by the IRG at the Mission SAR for Interim Review stage if additional information is not developed. Aside from any review of a system-specific SAR, the Board's primary means of providing feedback during this stage is through issuance of consensus Board Statements.

During this early Board involvement, the program office should communicate whether the mission SAR will rely on a system-specific SAR(s) that establishes a safety basis for the space nuclear system, as allowed by NSPM-20 Section 5(b), and whether early review of that system-specific SAR is desired as a tool for reducing uncertainty and project risk. If this is the case, and in light of this review occurring before the establishment of a mission review, the following streamlined version of the mission SAR approach (which is discussed later) would be taken:

- The head of the sponsoring agency (or their delegate), if not NASA, would request of the NASA Administrator (or their delegate) that an early system-specific SAR review be conducted by the Board;
- The program office would justify that the system-specific SAR has a nexus to a selected upcoming mission to be reviewed by the Board⁹;
- The program office would ensure that the system-specific SAR has received an independent review¹⁰ prior to providing it to the Board;

⁹ The Board should seek clarification if the system-specific SAR has no apparent nexus to a selected upcoming mission to be reviewed by INSRB, in the interest of using limited resources effectively. In addition, the Board should also consider the expected benefit of a review to safety or efficiency, as well as the Board's availability to support the review.

¹⁰ To date, what defines this review, whether a safety evaluation issued by an Atomic Energy Act authority or equivalent is expected, and how this review relates to the peer review required by NSPM-20 for a mission SAR has

- The Board and the program office would hold an up-front discussion about the needs, goals, objectives, and deliverables of the review (to ensure that expectations are aligned from the start);
- In order to ensure the Board review is effective, review stand-up would consider the needed subject matter expertise amongst the available Board members, including identification of areas that the appointed INSRB reviewers can't fulfill¹¹;
- The Board would document its review in a referenceable technical report¹² addressed to the program office, to include any apparent gaps in the system-specific safety analysis that can be leveraged in a later mission SAR review, along with the basis of the review.

Both the review standup process and the resulting review report would need to be caveated to reinforce that this activity is for the mutual benefit of all parties (in order to foster reviewer familiarity and to reduce uncertainty and project risk) and that it does not constrain either the program office or the INSRB in terms of the subsequent mission SAR review. And to be clear, if an early system-specific SAR review is not a useful tool for a program office, stakeholders should not have an expectation of an INSRB review at this earlier stage. Rather, in such a case, INSRB would review any information in a relevant system-specific SAR that is relied on for establishing safety during the mission SAR review.

4.1.2 Anticipated Process during Active INSRB Mission Review

The second stage is characterized by active INSRB and mission interaction, led initially by the standing Board and later by the empaneled IRG. Typically, the transition to this stage will occur when the foundational system safety work and the closely-associated mission development work has progressed to the point of providing a clear view of the strategy that will be utilized to establish a launch authorization basis and seek launch authorization. Earlier transition may occur for novel missions seeking more concentrated INSRB interaction earlier in the development, while later transition may occur for well-proven mission concepts that bear less risk of having significant gaps identified in the INSRB Safety Evaluation Report. The remainder of this section describes a nominal progression, while any particular mission will require flexibility in implementation.

The program office, likely having had interactions with the Board prior to this point, prepares an initial safety case approach document, termed here an Initial Launch Authorization Basis Strategy. INSRB is not in a position to prescribe a certain format or content for this document, though it is discussed to some degree in Section 5.2.2, and is likely to bear resemblance to sponsoring agency or nuclear safety authority equivalents, such as the Safety-in-Design framework in DOE's processes

not been specified. Here, inclusion of a prior review denotes the need that the product has a reasonable pedigree to promote review effectiveness.

¹¹ In this sense, the standup of the review should have elements similar to a mission SAR review, but without the formality of the full empanelment process and the additional rigor of obtaining Agency Head buy-in of the terms of review. It is envisioned that the standing Board would be the owner of the review and the product (as opposed to the mission SAR review that is owned by an empaneled INSRB Review Group), but that it will nevertheless be a subset of Board members and alternates who actually conduct the system-specific SAR review.

¹² This review report should mimic the type of content that would be in an IRG Agency Head Gaps or Omissions Report (that would be associated with the later mission SAR) but need not be tailored to an executive audience. In other words, the system-specific SAR review report might be more technical in nature than the equivalent mission SAR review report, by virtue of being directed to parties who are very familiar with the details of the safety analysis and due to receiving a smaller distribution.

(e.g., DOE-STD-1189-2016). This is a critical document for establishing a clear basis for how the safety analysis will be performed (and thus reviewed), and how that safety analysis fits in to the broader picture. It serves as the primary stepping-off point as a provisional IRG drafts a Mission-specific Review Plan, and therefore, its content should take in to account the type of information that INSRB will be seeking at this stage of the process (see Section 5.1). There should be a specific version of this document issued to the Board, but it will remain a living document thereafter to document the Launch Authorization Basis as it evolves during the safety analysis and safety review process, not to mention changes that will occur in the mission characteristics due to other forcing functions. The Board will provide formal comments on this document.

At this point, the provisional IRG will develop its Mission-specific Review Plan. The activities surrounding this plan development, relating to the establishment of the associated IRG and codification of the plan, are described in Section 2.4. The contents of the plan are described in Section 5.1. The plan will serve to obtain broad stakeholder input and alignment on the IRG's planned review approach. A version of the document will be formally issued (again, discussed in Section 2.4), but it will also remain as a living document thereafter, to reflect changes in the review approach. It will be sunset once it no longer serves a useful purpose, notionally around the time that the Mission SAR for Launch Approval is submitted to the IRG.

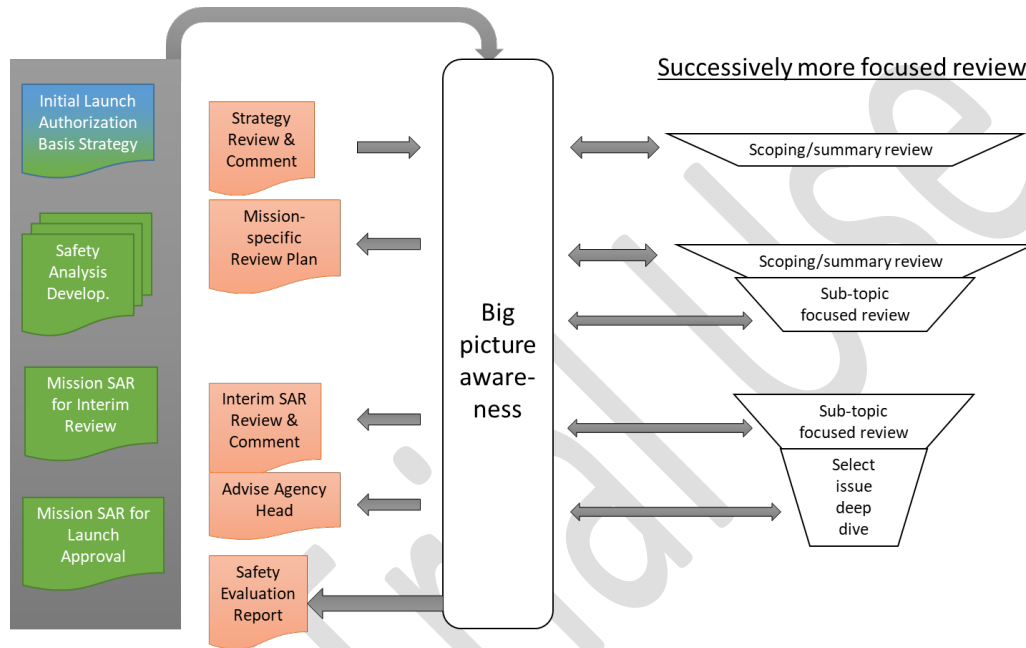
The program office, the safety analysis preparer, and the IRG Chair will work cooperatively to develop an Executive Summary of the Initial Launch Authorization Basis Strategy and the Mission-specific Review Plan, which will be termed the "Terms of Review." This document will be used to obtain Agency Head approval of the review plans, as required by NSPM-20.

The IRG review will necessarily be a probing or sampling-type review. A set of core review areas will be defined, organized based on the team's skill composition developed in association with review team empanelment and past review experience (e.g., see Appendix D: Subject Matter Expertise Matrix). Each of these core review areas will, at appropriate points in the review process, receive a scoping review. From this scoping review, a summary view will be developed for each core review area, in terms of which aspects don't warrant continued attention, versus which areas warrant a more focused review. In this way, the review will iteratively move to more-narrowly scoped and more detail-oriented reviews, drilling down on those topics of most risk importance. General entry and success criteria are provided in Section 4.8. This approach will be complimented by a separate aspect of the team's activities that will maintain a "big picture" view of the safety analysis and the mission as-a-whole, to adjust as needed when significant pieces of new information or mission-related changes have important impacts on the safety review, while also serving to maintain a holistic perspective on the safety review. This approach to performing a successively more focused review at the same time as maintaining a holistic perspective is shown pictorially in Figure 2.

The remainder of the IRG review is expected to follow the approach outlined in the Mission-specific Review Plan, with updates to this plan and to the program office's Launch Authorization Basis document serving to guide the process. Only changes relevant to the approved "Terms of Review" document would require re-engaging Agency Heads. As described in Section 5.1, the Mission-specific Review Plan will include fundamental details about the expected conduct of operations, and the means for managing change control. Other parts of this Playbook, such as Section 2.5 for managing interactions between the review team and the standing Board, Chapter 3 for review and evaluation scope, and other parts of this

Chapter (Chapter 4) for review and evaluation process details, will be directly relevant. Meanwhile, details of the products anticipated from the safety analysis, and products to be developed by the IRG, are all discussed in Chapter 5, including discussion in Section 5.3 of how INSRB Information Requests will be drafted.

Figure 2 - Review Process Flow



4.1.3 Anticipated Process Following Active INSRB Mission Review

The third stage is characterized by continued mission involvement, but reduced IRG activity, with the INSRB Safety Evaluation Report having been issued. INSRB and the IRG will use the following approach:

- 1 The IRG will remain empaneled through the time of launch. The IRG Chair will remain the lead for IRG activities and will coordinate with the full IRG whenever circumstances permit. For late-breaking changes (and especially in the couple of weeks leading up to launch) the IRG Chair will have the autonomy to represent the IRG's interests. The IRG will keep the standing Board informed but will not rely on the standing Board for direction.
- 2 Following issuance of the INSRB Safety Evaluation Report, as the program office evaluates changes within the established change control process it will make the IRG Chair aware of all evaluated changes in a timely manner. The IRG will not formally respond to minor changes.
- 3 For significant changes that fall within the IRG's scope (i.e., those that have a potential impact on the quality of the Mission SAR for Launch Approval), the IRG will be ready to receive information on, and support discussions of, these changes and their effects on the launch authorization basis. The IRG will document its conclusions about the effects on the INSRB Safety Evaluation Report in either an INSRB Safety Evaluation Report supplement or a memo to the program office, with the sponsoring agency head on copy in rare and consequential situations.

The IRG is also available to provide consultation on how mission activities and launch authorization activities relate to the completed IRG review, and the conduct of operations during this period is discussed to some additional degree in Section 4.3. This is a period of time where IRG or other Board members are most likely to also be playing separate roles related to activities like radiological contingency planning, range user approval, and flight readiness. The relationship of INSRB involvement to that broader safety analysis end user community is discussed in Section 3.4.

4.2. Interface Between Major Participating Entities, Including Technical Peer Review

NSPM-20

“The Secretary of Energy shall maintain, on a full cost recovery basis, the capability and infrastructure to develop, furnish, and conduct safety analyses for space nuclear systems for use in United States Government space systems.”

“The mission SAR shall demonstrate that safety analysis incorporates technical peer review...”

Clear lines of authority and communication are critical to an efficient and effective review. INSRB reviews are rare relative to the occurrence of launches that do not require this activity, and some entities play unique roles in the context of a space nuclear system launch. Because these interactions are so critical, the safety analysis team and the IRG may want to conduct an initial interaction that will foster trust, perhaps grounded in the nuclear safety culture characteristics in the 2009 IAEA Safety Framework.

On a different note, interactions throughout the review should emphasize the difference between

cooperation (which should be encouraged) and collaboration (which would indicate a loss of independent activity). As an example, INSRB should always strive to characterize matters objectively and to provide the program office an opportunity to comment on formal INSRB products, so that factual errors can be corrected, and misleading or confusing passages can be clarified. Conversely, INSRB should not sanitize or soften its findings in order to placate stakeholders.

The development and maintenance of the Mission-specific Review Plan will be the primary means for specifying and maintaining clear lines of authority and communication between the program office and the interagency reviewers. While the details of that plan are covered later, a baseline approach is established here. This approach will need to be modified to accommodate the organizational situations associated with any particular mission, and especially as it is influenced by contractual considerations on the programmatic side. The primary consideration in this approach is to balance the need for clear lines of authority in the flow of formal information against the need for efficient communication of technical information.

Figure 3 shows this notional model. It assumes formal lines of communication between the various parties, including that the program office and the IRG (led by the Chair from the sponsoring agency) are the two entities interacting directly with the Sponsoring Agency Head (or the Secretary of Transportation), and that the Sponsoring Agency Head (or the Secretary of Transportation) is the interface with the Office of Science and Technology Policy. This general approach will maintain awareness and authorities but will likely be too cumbersome to support routine communications. As such, this figure also assumes that the program office will establish a safety analysis team technical representative (or multiple representatives if it is not practical to have a single individual act in this role across the different parties contributing to the products being reviewed by INSRB). This individual(s) would have the authority to represent the spacecraft, launch vehicle, and nuclear hardware interests on

Legend:

- Formal line of authority/communication
- - - - - Routine communications (when authorized)

Organizational Structure:

- Sponsoring Agency Head or the Secretary of Transportation**
 - Office of Science and Technology Policy
 - Technical Peer Review
 - Program office
 - Spacecraft Provider
 - Spacecraft Inputs & Response
 - Launch Vehicle (LV) Provider
 - LV Accidents and Environments
 - Producer of the Nuclear Hardware
 - Nuclear Safety Analysis
 - INSRB Review Group
 - INSRB (Standing Board)
 - SAT Tech. Rep.
 - Safety Analysis Team (SAT)

Flow of Information:

- Formal line of authority/communication (solid line):
 - Sponsoring Agency Head or the Secretary of Transportation to Office of Science and Technology Policy
 - Sponsoring Agency Head or the Secretary of Transportation to Program office
 - Program office to Spacecraft Provider, Launch Vehicle (LV) Provider, Producer of the Nuclear Hardware, and INSRB Review Group
 - Spacecraft Provider to Spacecraft Inputs & Response
 - Launch Vehicle (LV) Provider to LV Accidents and Environments
 - Producer of the Nuclear Hardware to Nuclear Safety Analysis
 - INSRB Review Group to INSRB (Standing Board)
 - SAT Tech. Rep. to Safety Analysis Team (SAT)
- Routine communications (when authorized) (dashed line):
 - Program office to INSRB Review Group (labeled 1)
 - INSRB Review Group to SAT Tech. Rep. (labeled 1)

Regarding the technical peer review, the specifics of the mission will be critical to determining how that technical peer review relates to other activities. INSRB assumes (for general planning purposes) that the technical peer review will be integrated within the upstream Federal activities and conditional on the organizations involved. In reality, there are a number of different combinations that can exist, but this broader set of possibilities is simplified to three particular paths for the sake of illustration. These illustrations reflect planning-level assumptions, and do not infer any specific established arrangements between or within these agencies. They are as follows:

- For US Government-sponsored missions where NASA is flying DOE-authorized space nuclear systems, the technical peer review would be a component of the DOE Safety Evaluation Report^{13t}, which may include an additional and complimentary, graded, and independent technical review when necessary due to novelty;
- For other US Government-sponsored missions (such as a DoD-sponsored mission involving a fission reactor), the process would be similar to the above except that the technical peer review

29

would be led by the program office, and the agency-specific safety evaluation may not be DOE-led (e.g., may be DoD-led); and

- For commercial launches (i.e., FAA-licensed launches), FAA will leverage the upstream NRC terrestrial licensing process (to the extent relevant) in addition to an applicant-led technical peer review of the nuclear safety analysis; also, in this case, whether an INSRB safety evaluation occurs is at the discretion of the Secretary of Transportation.

Again, these points are illustrative in nature, and the specifics of the process will ultimately receive clarity within the mission-specific Terms of Review. Nevertheless, Table 1 below is an attempt to further distill this information into a digestible form, including how a system SAR review would compare to the mission SAR review in this regard.

Table 1 – General Suggested Analysis and Review Outline

	Nuclear SAR	Technical Peer Review in NSPM-20	Agency Review	Interagency Review	Nuclear Launch Authority
Case 1 (e.g., NASA Pu-238 RPS mission)					
Nuclear system (i.e., system SAR) – see Note 1	DOE (incl. contractors)	Component of the DOE process	DOE SER	INSRB Technical Report (only if requested)	-
Flight (i.e., mission SAR)	DOE/NASA (incl. contractors)	Component of the DOE process	DOE SER	INSRB SER	NASA Administrator or Executive Office of the President (EOP)
Case 2 (e.g., DoD space reactor mission)					
Nuclear system	DoD program office (incl. contractors)	Separate DoD program office contractor	DoD SER	INSRB Technical Report (only if requested)	-
Flight	DoD program office contractor	Separate DoD program office contractor	DoD SER	INSRB SER	Sec. of Defense or EOP
Case 3 (e.g., fully commercial)					
Nuclear system	NRC applicant (for terrestrial safety aspects)	-	NRC terrestrial license	INSRB Technical Report (only if requested)	-
Flight	FAA applicant for launch or reentry (for flight safety aspects)	FAA applicant	FAA launch or reentry license	INSRB SER (if requested by Sec. of Transportation)	Secretary of Transportation

Note 1 - This refers to the establishment of a safety basis envelope for the space nuclear system planned for flight, and may be consolidated with the mission safety analysis report; it is separate from safety analysis report activities related to authorization to possess, fabricate, or transport (terrestrially) the nuclear system

The program office will need to decide how much information to share with the IRG regarding the technical peer review. The more information that is provided, the more the IRG will be able to leverage that information. Some best practices related to framing technical peer reviews and communicating the results of those reviews to the IRG include:

- The approach should be risk-informed regarding what documentation is provided to INSRB, considering novelty, expected risk drivers, etc.
- The elements of the documentation provided to INSRB should include:
 - The scope of the review performed (i.e., the topical areas reviewed and any areas specifically excluded from review);
 - Team composition (i.e., affiliations, resumes; any conflict-of-interest disclosures);
 - Basis/criteria used to determine adequacy of the analysis, including consideration of NSPM-20 Safety Guidelines;
 - Insights gained from the review.
- A case should be made that the technical peer review was sufficiently independent.

The greater the extent to which these details can be agreed to at the Terms of Review stage, the better positions that all parties will be in to effectively leverage the technical peer review during the INSRB evaluation.

Periodic meetings between the SAR team and the IRG are anticipated, will be arranged to occur on mutually agreeable dates and at mutually agreeable locations (if not held using videoconferencing), and will be led by the IRG (including managing the agenda). These meetings will provide a forum for the safety analysis team to present important aspects of their analyses to the IRG and provide a dedicated opportunity for IRG members to ask questions. Experience has shown that consideration should be given to:

- Balancing the benefit of exchanging information amongst the broad audience (i.e., the two teams as a whole) versus allowing breakout discussions where an IRG reviewer focused on a particular area can discuss specifics with the safety analysis team's subject matter expert in that particular area;
- Ensuring that the timing of the meeting allows for read-aheads to be provided in a timely fashion (e.g., 1 week in advance for small or moderately-sized information sets), accounting for any lag in information security reviews/markings, verifying non-disclosure agreements when relevant, and posting the materials; and
- Baselining every major interaction in a reminder of the need to focus on those aspects that are relevant to fulfilling INSRB's charge and avoiding the pursuit of curiosity questions or matters related to other entities' responsibilities, which are more appropriately addressed outside the auspice of an INSRB-led meeting.

Such meetings at each stage of the review should enable a more effective and efficient IRG review. INSRB Information Requests should be transmitted via the appointed representatives.

Beyond the interactions that are focused on analysis and review exchanges, key members of both the safety analysis and review teams should hold routine tag-up meetings to ensure effective management of information flow and early identification of challenges or concerns. The initial plan for such tag-ups is one of the items flagged for inclusion in the Mission-specific Review Plan discussed in Section 5.1.

4.3. Interface between Safety Analysis and Review and Launch Deviations/Constraints

Following issuance of its Safety Evaluation Report, the INSRB does not have an active role. Nevertheless, there is ample operating experience to show that changes to the mission capable of affecting the safety

analysis, and thus the safety evaluation, will continue to occur during the leadup to launch, and thereafter. The sponsoring agency will be managing the process based on many other constraints during this time and will also be coordinating with the safety analysis preparer when those mission changes have the potential to affect nuclear safety. The IRG will need to be responsive to emergent issues that may affect the quality of the nuclear safety analysis (often by virtue of affecting underlying assumptions), and thus the continued applicability of the INSRB Safety Evaluation Report’s findings. Two modes of operation are likely needed, as follows:

- An approach that can support addressing issues when weeks are available to do so, which may involve consultation with the entire IRG; and
- An approach that can support addressing emergent issues when only days (or hours) are available to do so, which may necessarily need to involve only the IRG Chair.

Since these processes are very agency-specific, and even very mission-specific, the Terms of Review will summarize the planned arrangements during this phase.

More broadly, INSRB intends that:

- The INSRB Safety Evaluation Report will be written in a manner such that its use by others downstream is efficient (i.e., it will highlight matters of import, as reflected in the recommended contents in Section 5.6);
- If the INSRB Safety Evaluation Report identifies significant quality issues with the SAR, this would be addressed in the launch authorization process; and
- Other parties involved in launch management (e.g., the Range Safety representatives, Payload Safety representatives, sponsoring agency safety authorities) will have knowledge of significant issues cited in the INSRB Safety Evaluation Report.

Historically, members of the SAR analysis and safety evaluation groups remain involved leading up to launch (i.e., after the launch authorization decision), due to also having roles in areas like range safety, flight safety, or contingency planning activities. Such personnel should be conscious of the distinction between using information that has been documented by the IRG in carrying out these other roles, versus over-extending INSRB’s charge.

4.4. Relevance of Reviews of Earlier Missions and System-Specific SARs

NSPM-20

“To the extent possible, safety analyses and reviews should incorporate previous mission and review experience.”

Section 5(b) of NSPM-20 describes the optional use of a system SAR and associated safety basis envelope, as a basis for reducing the extent of mission-specific safety analysis required.

4.4.1 Leveraging Past Studies

As detailed in NSPM-20, to the extent possible, safety analyses and reviews should incorporate previous mission and review experience. INSRB is committed to conducting its reviews in a manner that leverages prior applicable experience. To this end, INSRB is forming a repository of past review information that can be leveraged by its personnel.

Care must be taken when referring to historic documents, as state of knowledge, technological capability and requirements change with time. Examples include:

- Limited number of launches involving radiological material has led to a limited number of analyses for reference;
- RTG missions conducted over the past 50 years have ultimately been found to have a differing risk profile across important accident phenomena, due to changes in hardware design, mission specification, and state-of-knowledge, for instance -
 - Changes to the geometry of RTGs relative to the spacecraft over past missions have had important effects on real and as-analyzed risk drivers, that would affect the application of review insights to future missions;
- A full grasp of assumptions used in the referenced analysis needs to be understood to ensure the appropriate use of the material, especially in cases where that information is being applied in a deliberately biased manner, for instance -
 - Assuming a higher allocation of probability of failure in the launch area may provide a “conservative” risk assessment to the local population but could lead to an underestimation of risk to downrange populations (if the probability of failure outside the launch area is artificially suppressed to conserve a fixed total mission probability of failure).

When past or current evidence (which should itself have a defensible and documented basis) is used to curtail a portion of a review, this should be documented for traceability and potential leveraging by future mission reviews.

4.4.2. Review of System-Specific SARs

Section 4.1.1 provides a basic discussion of system-specific SAR reviews within the context of early Board engagement with a mission, while Section 4.1.2 describes a mission review process that will also accommodate a system-specific SAR review as part of a mission SAR review. This section is reserved for providing additional detail on the topic of leveraging such reviews once more experience is gained.

4.5. Funding, Reimbursement, and Procurement

As specified in the INSRB Charter, participation in the standing Board itself does not involve reimbursement or procurement, and as such, this section relates entirely to the conduct of IRG reviews. Funding and procurement activities may be necessary to permit the reimbursement of civil service personnel or military officers whose agency fee structure necessitates reimbursement, as well as procurement of subject matter experts (SMEs) from non-civil service or military officer individuals when there is a gap in the skill set of the Board representatives relevant to a particular review. In the latter case, it will be imperative that the IRG procure and utilize such support in a manner that does not impact INSRB’s status of being exempt from the requirements of the Federal Advisory Committee Act (FACA) by adopting the processes and practices described in this section and elsewhere, which ensure INSRB decision-making remains the responsibility of solely civil service employees and military officers.

The source of funding for IRG reimbursement and procurement needs will be provided by the sponsoring agency. The needs will be identified and negotiated as part of the Terms of Review development (see Section 2.4 and Section 5.1), including identification of the specific agreements that need to be put in to place.

So long as review team reviews remain relatively infrequent, each sponsoring agency will be responsible for its own reimbursement and procurement activities. Should the rate of reviews increase significantly, it may make sense for NASA to establish reimbursable agreements and contracts which other sponsoring agencies could leverage via the Economy Act and associated interagency agreements.

4.6. Roadmap of Relevant Consensus and Agency-specific Standards and Guidance

NSPM-20

“Executive departments and agencies (agencies) shall seek to ensure that safe application of space nuclear systems is a viable option for Federal Government and commercial space activities.”

This section is reserved to identify consensus and agency-specific Standards and guidance that prove particularly effective in INSRB activities. INSRB does not require or endorse the use of any particular Standards but may suggest the use of those that prove to result in efficiency.

4.7. Relevance of Margins and Defense-in-depth

The purpose of this section is simply to state INSRB’s viewpoint on the relevance of safety margins and defense-in-depth, toward promoting transparency in INSRB’s reviews. INSRB recognizes that NSPM-20 outlines a process relying largely on risk-oriented Safety Guidelines but that it does not explicitly address the treatment of uncertainty which is generally addressed in a number of ways that include: (i) the use of component-level and system-level factors-of-safety and defense-in-depth as part of system safety and (ii) the assessment of margin to safety thresholds and defense-in-depth within the safety analysis¹⁴.

In performing its reviews INSRB does not expect a particular approach to how factors-of-safety and defense-in-depth are incorporated into the system safety approach used during design and development (which is generally consistent with how agencies operate – e.g., see DOE-STD-1104-2016 Section 4.4), nor does INSRB seek to dictate the specifics of how margin to safety thresholds and defense-in-depth are reflected in the safety analysis and risk management posture. INSRB acknowledges that each agency has its own approaches to incorporating these concepts in to system safety, that a number of differing approaches have been developed and documented by safety organizations for assessing them as part of demonstrating safety and reducing risk (e.g., NRC Regulatory Guide 1.174), and that a number of philosophical outlooks have been generated on this broad subject (e.g., 1999 letter from the Chairman of the Advisory Committee on Reactor Safeguards to the Chairman of the NRC entitled, “The Role of Defense in Depth in a Risk-Informed Regulatory System”).

Rather than forecast a particular approach, INSRB expects that the safety analysis will specifically address margin and defense-in-depth as a part of framing the safety of the activity relative to its estimated risk, and as part of the treatment of uncertainty. Generally speaking, INSRB anticipates that margin will be quantified when practical. Further, and again generally speaking, INSRB anticipates that defense-in-depth will appear in both the fundamental safety criteria applied during design (a.k.a., a structuralist approach), as well as in the addressing of risk trades that utilize the results of the safety analysis (a.k.a., a rationalist approach). As experience is gained in performing safety reviews within the

¹⁴ The term “safety margins” is often used by communities of practice in both system safety in design as well as safety case formulation. In both cases, the general concept is the same, meaning a measure of the degree of cushion between the anticipated response and an unacceptable response. Beyond that general concept, the surrounding context of the term’s usage often diverges between these two communities.

NSPM-20 construct, it should become possible for analysts and reviewers to provide more definition on adequate implementation of safety and defense-in-depth.

4.8. Acceptance and Exit Criteria

Table 2 documents entry and success criteria associated with key INSRB activities. These criteria are currently defined at a very high-level. As INSRB gains more experience in interacting with end-users of the process and performing reviews, it will likely be straight-forward to add more specificity to this list (e.g., akin to the analogous criteria in NASA NPR 7123.1C Appendix G or DOE-STD-1104-2016, Sections 4.3 and 8.6), in order to promote more predictability in the process.

For Trial Use

Table 2: Entry And Success Criteria for Various INSRB Activities

Entry Criteria	Success Criteria
INSRB Review Group Empanelment Process	
<p>For US Government launches:</p> <ol style="list-style-type: none"> 1. The IRG Chair receives the Launch Authorization Basis Strategy, or equivalent, and determines that it contains sufficient information. <p>For commercial launches:</p> <ol style="list-style-type: none"> 1. The DOT INSRB Member notifies INSRB that the DOT requests an INSRB review and provides information about the review comparable to the type of information described in this document for the Launch Authorization Basis Strategy. 	<p>ALL of the following conditions are satisfied:</p> <ol style="list-style-type: none"> 1. INSRB votes to approve formation of a provisional IRG. 2. The provisional IRG drafts a Mission-specific Review Plan and solicits/adjudicates comments on that plan. 3. The Mission-specific Review Plan is used to formulate the Terms of Review document, and the relevant Agency Heads approve those terms of review.
Safety Evaluation – Individual Review Elements	
<p>For interim reviews, BOTH of the following apply:</p> <ol style="list-style-type: none"> 1. The program office provides sufficient information in interim safety analysis documentation and supporting technical basis documents. 2. The program office provides sufficient access to underlying modeling and simulation activities, and applicable test results. <p>For final reviews, the same criteria are satisfied, but involving final products.</p>	<p>ANY of the following conditions is satisfied:</p> <ol style="list-style-type: none"> 1. The safety analysis is found to be of sufficient quality (this term is notionally defined in Appendix A: Definitions). 2. The issue being reviewed has been determined to have insufficient effect on safety and mission risk to warrant further review. 3. The review has determined that the issue is out-of-scope of the INSRB review.
Safety Evaluation - Overall	
<p>BOTH of the following conditions are satisfied:</p> <ol style="list-style-type: none"> 1. The Mission SAR for Launch Approval has been transmitted. 2. The results of the technical peer review required by NSPM-20 have been transmitted. 	<p>ALL of the following conditions are satisfied:</p> <ol style="list-style-type: none"> 1. Each review element identified in the Mission-specific Review Plan has met the element-specific success criteria identified above, including the closure of relevant INSRB Information Requests, and the completion of the review summary to be included in the INSRB Safety Evaluation Report. 2. An Agency Head Gaps or Omissions Report has been issued. 3. The final mission SAR and the technical peer review materials have been reviewed to ensure no emergent issues exist 4. The INSRB Safety Evaluation Report has been written, reviewed, and issued.
Terminating an IRG	
n/a	<p>ANY of the following conditions is satisfied:</p> <ol style="list-style-type: none"> 1. Launch has occurred. 2. The INSRB has been formally notified that the sponsoring agency no longer intends to pursue launch approval for the mission under review. 3. The characteristics of the mission have changed, and it is sufficiently clear that the mission will no longer meet the NSPM-20 Tier II or Tier III criteria (USG mission) or the Secretary of Transportation has rescinded the request for an INSRB review (commercial launches).

5. INSRB Review and Evaluation Products

5.1. Contents of the Mission-specific Review Plan and the Terms of Review

The Mission-specific Review Plan is the key document for articulating how INSRB will conduct its review of the quality of the nuclear safety analysis. It serves to:

- Establish the INSRB Review Group (IRG);
- Establish expectations and boundaries for how that group will conduct its review;
- Articulate expectations for how all parties will perform their work in a mission-specific context (i.e., beyond the more general INSRB conduct of operations covered in this Playbook).

This plan's primary objective is to promote transparency, clarity, effectiveness, and reliability in the review. Following its drafting and buy-in (as described in Section 2.4), all stakeholders should have a common understanding of key elements. As such, it is critical that the plan be developed in a deliberate and thoughtful fashion. Even so, the plan should be adjustable (it will be a living document) and not overly cumbersome to use (a 10-20 page plan is envisioned to be sufficient). Key elements of the mission-specific review plan that are not likely to change, along with key elements from the program office's Initial Launch Authorization Basis Strategy, or equivalent, will be summarized in a Terms of Review document that will be used to obtain Agency Head (or designee) approval.

The contents of the Mission-specific Review Plan include but are not limited to:

- 1) Mission-specific review objectives – to include:
 - a) review strategies to support those objectives, building off of the general review approach outlined in Section 4.1, and
 - b) key figures-of-merit or success criteria (or equivalent) to manage review focus, building off the high-level acceptance criteria in Section 4.8.
- 2) High-level description of the mission under review – to include (potentially by reference):
 - a) the program office's key organizational features and key personnel roles,
 - b) the mission description, and
 - c) the program office's approach to the safety analysis.
- 3) Identification of existing relevant information (e.g., an Environmental Assessment for the same mission, a system-specific SAR, a similar mission's interagency Safety Evaluation Report).
- 4) IRG composition – to include:
 - a) identification of the provisional group members, their relevant areas of expertise, their primary review responsibilities, and their primary writing responsibilities, and
 - b) a skills composition assessment¹⁵ to identify any gaps in expertise, building off the tenets in Section 2.6.
- 5) Communication and operations protocols – to include:
 - a) protocols for use within the IRG, including the expected approach to tracking actions,
 - b) protocols for the group's interactions with all other stakeholders, building off of the tenets in Section 4.2,

¹⁵ Section 3.3 of NASA/SP-2016-3706 provides an example of establishing composition and balance for NASA Standing Review Boards. In particular, the description there of a skill matrix and aspects of the balance assessment described in Section 3.3.1 are applicable here.

- c) the IRG’s understanding of the information to be received from the upstream technical peer review (e.g., the planned scope, team composition information, basis/criteria used to determine adequacy of the analysis, post-review insights, and the basis for sufficient independence) and how it anticipates leveraging this information within its evaluation,
 - d) a preliminary plan for routine tag-ups, topical issue-specific small group discussions, and broader project-level technical interchange meetings, and
 - e) identification of preferred means for transmitting and managing electronic files.
- 6) Identification of any Agreements needed to execute the review – to include:
 - a) Funding agreements, including details about anticipated funding levels, the source of funding, the entity handling procurement, and the support to be procured, building off of the tenets in Section 4.5, and
 - b) Non-disclosure agreements, as discussed in Section 2.8.1.
 - 7) High-level requirements to support an effective review (e.g., access to model documentation; access to source code and model input/output).
 - a) This may also be a suitable place to reflect on the program office’s overall documentation schema and how the IRG will stay focused on its charge, amidst the multiple other end-uses of the nuclear safety analysis – see Section 3.4 for more discussion on this point.
 - 8) Summary of milestone and deliverable schedule, including both the safety analysis and safety review’s key products, and including some degree of acknowledgement of the lags associated with review and comment, document sensitivity review and marking, and distribution or electronic posting.
 - 9) Change negotiation process (i.e., the expected approach to managing the analysis and review approach, scope, and schedule).
 - 10) Assumption log (i.e., assumptions and constraints that are specific to the mission and may or may not be known at the start of the drafting of the Mission-specific Review Plan - this log can be used as a living document during the review to capture and record all assumptions and constraints as they evolve during the mission-specific review.
 - 11) Key stakeholder contact list and stakeholder engagement plan – to include:
 - a) how stakeholders will be engaged in mission review decisions and execution, according to their needs, interest, and impact, and
 - b) means of keeping all stakeholders apprised of review progress.

The authors of the plan should also consult agency-specific guidance and standards (e.g., Section 3.3. of DOE-STD-1104-2016) to identify other useful contents of the plan.

Again, the Terms of Review document would include a summary of the most salient aspects. In addition, the Terms of Review should specifically address how differences of viewpoint between the various analysts and reviewers will be handled, toward the end of ensuring that all effort is made to resolve disagreements, and barring that, to document well-founded differences of viewpoint for decisionmaker consideration. While this point is already discussed in Section 2.10 in the context of the INSRB evaluation, the introduction of multiple sets of reviewers brings more complexity to this issue. A closely related matter is how this interagency differing views process relates to agency-specific processes that may also be in effect, especially in cases where the agency-specific process influences authority-to-proceed or authority-to-indemnify.

At a later date, the INSRB may develop a generic review plan, akin in some ways to the Standard Review Plan concept used by some agencies, to further standardize some aspects of the review. In the meantime, IRG reviews will use such guidance on a more ad hoc basis.

5.2. Expected Contents of Documents Preceding the Mission SAR for Launch Approval

This section describes what may be contained in the documents produced by the program office during active INSRB review, leading up to the Mission SAR for Launch Approval (which is discussed later). These documents correspond to those discussed briefly in the overall process overview discussed in Section 4.1.2, and include:

- Launch Vehicle Inputs and Accident Environments – which would typically precede IRG involvement
- Launch Authorization Basis Strategy – the initial version of which would typically set the stage for IRG empanellment
- Mission SAR for Interim Review – which would typically occur during IRG engagement

The one step not covered here is the “Safety Analysis Model Development” step. At this point no particular form for providing this information is assumed, as it is projected to be very situational.

Broadly speaking, this documentation will allow INSRB to achieve the following:

- Understand the mission concept (including the preliminary indication of what NSPM-20 Tier applies, acknowledging that tiering itself occurs outside of INSRB’s auspices),
- Understand the types of hazards that apply for this particular mission,
- Understand the approach being used by the program office to ensure safety and manage radiological risk,
- Identify and assess any broad gaps in the mission plan, the safety case, or the evaluation and assessment plan,
- Plan and conduct review activities necessary to assess the adequacy of the program office’s safety analyses,
- Plan for ongoing technical exchanges, and
- Establish and maintain a common understanding (with the program office) regarding the process and timeline for the safety evaluation.

Historically, the Program has chosen to accomplish this through a process that involves preparation of preliminary documents which then mature throughout the program office’s safety analysis process until the final versions of these documents become the final set of launch vehicle inputs and accident environments and the Final Safety Analysis Report. This was in part an organizational choice, because the mission owner provided the launch vehicle inputs and accident environments, while the developer of the space nuclear system (who also owned the radioactive material – a different government agency) provided the Safety Analysis Report. The communication of the above information from the program office need not necessarily take the form of one or two large, integrated, finalized documents as described here. In fact, retrospective discussions around the time of the initial writing of this Playbook pointed to an opportunity to re-imagine the form of this documentation. Whatever format is chosen, it should give a clear indication of the totality of the information to be provided and a roadmap of which documents will contain which parts of that totality.

5.2.1. Launch Vehicle Inputs and Accident Environments

In concert with launch vehicle selection, and typically prior to IRG involvement, the program office (in association with applicable partners) typically develop a report, and associated data and tools as warranted, which characterizes the launch vehicle and associated accident environments. This document is an integral input to the nuclear safety analysis and has historically been referred to as a launch vehicle Databook. INSRB doesn't prescribe a specific set of contents, but it must be of sufficient breadth and depth to support the nuclear safety analysis. A sample outline is provided in Appendix H: Sample Outlines of Sponsoring Agency Submittals.

5.2.2. Launch Authorization Basis Strategy

The program office, likely having had interactions with the Board prior to this point, prepares an initial safety approach document, termed here an Initial Launch Authorization Basis Strategy. This is a critical document for establishing a clear basis for how the safety analysis will be performed (and thus reviewed), and how that safety analysis fits in to the broader picture.

A key aspect of this document is to serve as a bridge between the foundational system safety performed upstream, and the development of the safety basis (and associated safety analysis) downstream. While the names of the system safety foundational aspects will vary, the basic anticipated features to be described include:

- Established mission requirements and specifications;
- The launch vehicle inputs and accident environment information – described in Section 5.2.1;
- Any system-specific SAR that is being leveraged, if applicable, including the gap analysis providing the delta between that system-specific analysis and the mission-specific situation;
- Nuclear design and operational safety criteria;
- Nuclear testing and analysis;
- Validation and verification activities; and
- Relevant aspects of hardware manufacture and flight software development.

This document would then describe the methods, models, and software tools that will be used in the nuclear safety analyses, building off of these system safety foundations. Particular emphasis should be placed on novel methods. In so doing, it sets the stage for INSRB's Mission-specific Review Plan development, and the subsequent nuclear safety analysis methods and models discussions.

An example table of contents is provided in Appendix H: Sample Outlines of Sponsoring Agency Submittals. There should be a specific version of this document issued to the INSRB, but it will remain a living document thereafter to document the Launch Authorization Basis as it evolves during the nuclear safety analysis and safety review process, not to mention changes that will occur in the mission characteristics due to other forcing functions.

Because changes in the authorization basis strategy and the actual mission are inevitable, the document would also define the change control process that will be used during launch authorization activities,

prior to and after the launch authorization determination itself¹⁶. By including this change control process in the Initial Launch Authorization Basis strategy, and by summarizing it in the subsequent Terms of Review document, the program office will ensure that the IRG has insight into the process and that the sponsoring agency head agrees to the process.¹⁷ Regarding the basic characteristics of this change control process, it would:

- a. Address the launch authorization basis as-a-whole (e.g., changes to spectator locations or flight safety systems¹⁸ assumed in the nuclear safety analysis and whose change could impact the mission safety analysis report (SAR) results);
- b. Factor in relevant aspects of any change control process associated with the space nuclear system safety basis (i.e., the portion under the jurisdiction of a terrestrial nuclear authority), as part of this broader launch authorization basis (i.e., the overarching nuclear launch authority held by the sponsoring agency head or the Executive Office of the President);
- c. Specify figures-of-merit and uncertainty characterizations that, if produced in the Mission SAR for Launch Approval, would support the distinction between minor and significant changes to the launch authorization basis;
- d. Establish the criteria used to distinguish between minor and significant changes;
- e. Create an agreement between the process owner (the program office) and the authorizing official (sponsoring agency head);
- f. Explicitly account for stakeholders (i.e., other customers) in this process - this would include the INSRB (as the NSPM-20 safety evaluator), the Range Commander (in instances where the Mission SAR for Launch Approval and INSRB Safety Evaluation Report are a part of the Range Commander's launch decision and/or inherent authority responsibilities), the Payload Safety Working Group, the Radiological Contingency Planning team, and the mission SAR preparer itself.

The INSRB will provide formal comments on this document.

5.2.3 Mission SAR for Interim Review

The Mission SAR for Interim Review would, as its name implies, be the first major draft of the mission SAR provided for INSRB review. It would provide preliminary results of nuclear safety analyses. It may also contain all of the up-front material that the mission SAR for launch approval will contain (e.g., the mission and hardware description), or it may simply point to preceding documents that contain this information. The purpose of this document is to inform INSRB on preliminary analysis results roughly a year before the final SAR publication so that INSRB has time to assess the preliminary results and conduct its review, in light of the fact that the timing of nailing down final mission details, issuing the

¹⁶ INSRB sees this change control process as integral to management of the launch authorization basis during the period of interest here, similar to the way in which the Department of Energy's Unreviewed Safety Questions (USQ) or the Nuclear Regulatory Commission's 10 CFR 50.59 processes are integral to managing a terrestrial nuclear facility's safety basis (e.g., see DOE G 424.1-1B). For an overview of the DOE variant of this process, please see this 2016 presentation given by Department of Energy personnel to the NASA Office of Safety and Mission Assurance: <https://sma.nasa.gov/vids/video-item/doe-safety-basis-and-unreviewed-safety-question-processes>.

¹⁷ This discussion focuses primarily on US government-sponsored launches. For commercial launches, the Federal Aviation Administration's process may pre-empt portions of these recommendations

¹⁸ Flight safety systems are defined in NASA NPR 8715.5 as "A system (including any subsystem) whose performance is factored into the Range Safety Analysis and relied upon during flight to mitigate hazards."

mission SAR for launch authorization, and issuing the INSRB Safety Evaluation Report are typically and necessarily tight. This document would be functionally similar to the Draft SAR used in many prior space nuclear system reviews.

A sample set of contents for a mission SAR is provided in Appendix H: Sample Outlines of Sponsoring Agency Submittals. Other sources of terrestrial safety analysis document contents could be adapted for this purpose, such as DOE Standards for the content of Documented Safety Analyses, NRC guidance on the content of Safety Analysis Reports, or NEI-21-07 (NEI, 2021).

5.2.4 Interim SAR Results Updates (as needed)

This document highlights any changes between the analyses results provided in the Mission SAR for Interim Review and those expected in the Mission SAR for Launch Approval. It would follow the structure of the Mission SAR for Interim Review, providing the information that has changed. Any new updates to the system descriptions or model assumptions would also be described.

The purpose of this document is to inform the IRG about 3-6 months before the Mission SAR for Launch Approval is published of any expected differences in results so that the IRG can make adjustments to any of its ongoing reviews. Whether or not this is a useful interim document to produce will be highly situational.

5.3. INSRB Information Requests

Note: This section is written generally to encompass both Board and IRG activities, but it would most frequently be relevant in the IRG context.

INSRB Information Requests are the mechanism for seeking and tracking needed clarifications or additional information from the program office but are not intended to prevent direct communication amongst technical experts when such communications are appropriately coordinated and more effective. INSRB Information Requests share similarities with other related processes, such as the Request for Action (RFA) process in the NASA Standing Review Board construct or the Request for Additional Information (RAI) process in the NRC regulatory submittal review process, but should not be mistaken for these other processes.

To the extent possible, INSRB members will rely on the internal expertise of the INSRB, so as not to unnecessarily burden the program office. When a request is needed, an INSRB Information Request with a unique identifier is generated. While a format is not prescribed here, INSRB Information Requests should clearly articulate:

- The request,
- The context for why the request is being made, and
- The specific portion of the safety review/evaluation that requires a response for successful progress or closure.

A list of active and closed INSRB Information Requests should be maintained and managed by an appointed participant in the review process, and the status of INSRB Information Requests should be a standing agenda topic at periodic meetings. INSRB Information Requests cannot be closed until the submitter agrees that they have been dispositioned. In all cases, these requests will be coordinated through the IRG Chair, who may request re-writes when items are unclear, or may suggest bundling

related questions or pursuing alternate means of acquiring the same information. Requests not routed through the IRG Chair are not acceptable, as mission personnel may construe unfiltered reviewer requests as technical direction or as a pre-requisite for receiving a favorable evaluation, which is not the point.

5.4. INSRB Agency Head Gaps or Omissions Report

As highlighted in Section 4.1, NSPM-20 identifies two different forums in which INSRB identifies gaps. The first, “The INSRB shall evaluate the quality of the safety analysis and identify any significant gaps in analysis...” refers to a routine analyst/reviewer interaction that will occur throughout the nuclear safety review process, and is embedded in the processes and products discussed elsewhere in this document. The latter, “Before completion of the mission SAR, the INSRB shall advise the head of the sponsoring agency of any omissions or gaps that the INSRB has identified in analysis that is planned or underway, and may provide recommendations for corrective action” is the subject of this section.

The IRG will develop this report as a formal product, roughly halfway between the issuance of the Mission SAR for Interim Review and the planned issuance of the Mission SAR for Launch Approval. The report would be written by the IRG and transmittal to the sponsoring Agency Head (or the Secretary of Transportation), in accordance with the governance structure described in Section 2.5. The program office should be given an opportunity to review the report for factual accuracy. All told, the process for drafting the report, achieving concurrence by the IRG, providing an opportunity for factual accuracy review, and transmitting the report could easily take a few months, and adequate planning should be undertaken.

The report, which is only expected to be on the order of 1 to 10 pages, should provide a high-level summary of gaps or omissions, any recommended corrective actions, and sufficient supporting discussion to inform the sponsoring Agency Head or the Secretary of Transportation.

5.5. Issuance of the Mission SAR for Launch Approval

The SAR should be formally transmitted to the IRG from the program office, and per NSPM-20, should have received technical peer review prior to transmittal. The more complete and rigorous the upstream peer review is, and the more information that is provided about that peer review, the more that INSRB will be in a position to leverage it. Recommended contents of the Mission SAR are provided in Appendix H: Sample Outlines of Sponsoring Agency Submittals.

As discussed previously in this document, INSRB plans to remain focused on its charge from NSPM-20, relative to others’ uses of the nuclear safety analysis. This will be an easier task to accomplish if the SAR is provided with a clear roadmap of how it addresses various end uses, and how it relates to other products that support other end uses. Transmittal of the SAR to the sponsoring Agency Head (or the Secretary of Transportation), once the INSRB Safety Evaluation Report is finalized, will be governed by sponsoring agency processes.

5.6. INSRB Safety Evaluation Report

The INSRB Safety Evaluation Report documents INSRB’s evaluation of the quality of the safety analysis and builds from the INSRB products discussed earlier. The INSRB Safety Evaluation Report should contain an evaluation of the quality of the SAR’s hazard identification and mitigation approach and

results, its risk estimates, its treatment of uncertainty, and its identification of essential safety features and assumptions. It will necessarily provide reviewer perspective at a topical-specific and holistic level.

The INSRB Safety Evaluation Report development and finalization follows a similar process as the Agency Head Gaps or Omissions Report, in that it is drafted and concurred on by the IRG, and is provided to the program office for a factual accuracy review. In the case of the INSRB Safety Evaluation Report, it is provided to the sponsoring Agency Head in concert with the SAR, or to the Secretary of Transportation. The recommended outline for the INSRB Safety Evaluation Report is as follows:

0. Executive Summary – to include the overall findings of the review, to clearly state what aspects were out-of-scope for the review, and to be written in a stand-alone fashion such that it can be made publicly available without the remainder of the INSRB Safety Evaluation Report
1. INSRB and Nuclear Safety Launch Authorization Process Background – overview of NSPM-20, and INSRB's role in the overall Federal launch authorization process [expected to be fairly standard language used mission-over-mission]
2. Mission Overview – a high-level overview of those aspects of the mission, space nuclear system, spacecraft, launch vehicle, launch complex, etc. that are pertinent to understanding the results
3. Safety Analysis Review – to include a high-level discussion of the review approach used, the activities performed, and an identification of those areas that were either not reviewed or which do not warrant further comment in the INSRB Safety Evaluation Report
4. Commentary on Topical-Specific Issues – to include a short description of each topical area reviewed, from the perspective of affirmative statements of high-quality aspects and any identified omissions, gaps, and recommended actions
5. High-level Conclusion of the Safety Review – to include a more holistic perspective on the quality of the safety analysis, how any identified omissions or gaps may affect the launch authorization decision, and those key aspects (e.g., gaps, omissions, assumptions, uncertainties) that are critical to the findings of the safety evaluation in terms of the effect of potential later deviations or constraints and associated management of mission risk
6. Appendices, as needed – for instance, an appendix capturing lessons learned in conducting the review could be valuable for future analysts and reviewers, as well as revisions to INSRB guidance

If the IRG is unable to reach alignment on the INSRB Safety Evaluation Report content within the group, the Formal Dissent process in Section 2.10 should be followed. Separately, the IRG and the program office may disagree on assertions made in the INSRB Safety Evaluation Report that do not relate to matters of fact. In such cases, the parties should interact to make sure that each has a thorough understanding of the other's perspective. If it is determined that there are indeed fundamental differences of viewpoint, the parties should not further delay transmittal of the SAR and SER. Rather, they should co-develop briefing material that synthesizes the diverse viewpoints and their bases, to accompany the SAR and the SER.

INSRB anticipates that a typical INSRB Safety Evaluation Report would be between 10 to 50 pages depending on the novelty and assessed risk of a mission. If there are further details that are not captured elsewhere, and that the review team feels are important to capture for posterity, these should be documented in a separate technical report.

5.7. INSRB Safety Evaluation Presentation to Sponsoring Agency Head or the Secretary of Transportation

This section serves as a place to document best practices from prior briefings. In the meantime, IRG briefings to sponsoring Agency Heads or the Secretary of Transportation will focus on:

- the contents of the INSRB Safety Evaluation Report;
- a clear statement of what was out-of-scope of the IRG's review; and
- how the INSRB Safety Evaluation Report findings relate to the pending launch authorization decision.

For Trial Use

6. References

CG-SNS-1, “Joint DOE/DoD/NASA Classification and Unclassified Controlled Nuclear Information Guide for Space Nuclear Systems,” August 2018.

DOE-STD-1104-2016, “Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents,” 2016.

DOE-STD-1189-2016, “Integration of Safety into the Design Process,” 2016.

IAEA, “Safety Framework for Nuclear Power Source Applications in Outer Space,” jointly published by the United Nations Committee on the Peaceful Uses of Outer Space Scientific and Technical Subcommittee and the International Atomic Energy Agency, 2009.

INSRB Charter, “Charter of the Interagency Nuclear Safety Review Board,” Version 1, November 16, 2020.

Letter from the Chairman of the Advisory Committee on Reactor Safeguards to the Chairman of the NRC entitled, “The Role of Defense in Depth in a Risk-Informed Regulatory System,” May 19, 1999.

NASA Interim Directive (NID) 1600.55, “Sensitive but Unclassified Controlled Information,” October 16, 2007.

NASA Interim Directive (NID) 2810.135, “Controlled Unclassified Information,” February 2, 2021.

NASA NPD 1000.0C, “NASA Governance and Strategic Management Handbook,” 2020.

NASA NPD 2190.1B, “NASA Export Control Program,” 2012.

NASA NPR 2190.1C, “NASA Export Control Program,” 2017.

NASA/SP-2016-3706 Rev. B, “NASA Standing Review Board Handbook,” 2016.

NEI, NEI-21-07, “Technology Inclusive Guidance for Non-Light Water Reactors,” August 2021.

NRC Regulatory Guide 1.174, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis,” Revision 3, 2018.

NSPM-20, “Presidential Memorandum on Launch of Spacecraft Containing Space Nuclear Systems,” August 20, 2019.

SPD-6, “Memorandum on the National Strategy for Space Nuclear Power and Propulsion (Space Policy Directive-6),” December 16, 2020.

Appendix A: Definitions

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 (the Department of Energy DOE) or Nuclear Regulatory Commission (NRC)) will be used.

Note: Each agency uses somewhat differing definitions and context, but as an example, for a commercial launch the FAA uses the following from 14 CFR § 401.7 Definitions.: “Public means, for a particular licensed or permitted launch or reentry, people that are not involved in supporting the launch or reentry and includes those people who may be located within the launch or reentry site, such as visitors, individuals providing goods or services not related to launch or reentry processing or flight, and any other operator and its personnel.” In invoking the term in 14 CFR § 450.101 Safety Criteria, the FAA distinguishes whether neighboring operations personnel are or are not included for each given metric.

Quality – [the definition used here is intended to be notional in nature and is not intended to replace other codified definitions when used in their applicable contexts] – in the context of NSPM-20, quality refers to the safety analysis being of sufficient pedigree to support a full and well-informed launch authorization decision; such pedigree typically comes from a combination of performing activities under a quality assurance program, founding approaches and assumptions in applicable and accepted standards, validating and verifying key assumptions and information sources, and ensuring consistency with the current state-of-knowledge

rem (Roentgen equivalent man) – standard unit used to measure the dose equivalent (or effective dose), which combines the amount of energy (from any type of ionizing radiation that is deposited in human tissue), along with the medical effects of the given type of radiation.

Safety basis envelope – per NSPM-20, “...a set of conditions...under which safety analysis and hazard controls provide assurance of safe operation for the given system”

Space nuclear system – See NSPM-20, Section I

System SAR – per NSPM-20, a system-specific SAR that establishes a safety basis envelope for that system, for potential leveraging by a mission SAR

Tier I – See NSPM-20, Section 4(a)

Tier II – See NSPM-20, Section 4(b)

Tier III – See NSPM-20, Section 4(c)

Total Effective Dose – See 10 CFR 835.2

Appendix B: Acronyms

APNSA	Assistant to the President for National Security Affairs
BOX	Not an acronym
CUI	Controlled unclassified information
DoD	Department of Defense
DOE	Department of Energy
EAR	Export Administration regulations
FAA	Federal Aviation Administration
FACA	Federal Advisory Committee Act
FOIA	Freedom of Information Act
FTS	Flight termination system
IAEA	International Atomic Energy Agency
INSRB	Interagency Nuclear Safety Review Board
IRG	INSRB Review Group
IT	Information Technology
ITAR	International Traffic in Arms Regulations
LFT	Large file transfer
LV	Launch vehicle
NDA	Non-disclosure agreement
NID	NASA interim directive
NNSA	National Nuclear Security Administration
NRC	Nuclear Regulatory Commission
NSPM	National Security Presidential Memorandum
RFA	Request for Action
SAR	Safety analysis report
SBU	Sensitive but unclassified
SER	Safety evaluation report

Appendix C: Sample Empanelment Checklist

INSRB Example Empanelment Process Checklist

The program office: (i.e., the sponsoring agency mission program/project office)

- ☐ Transmit the Launch Authorization Basis Strategy (LABS), or equivalent (for suggested contents, see Section 5.2.2 and Appendix H)
- ☐ The program office reviews the Review Plan and provides any concerns
- ☐ The program office lead works with the IRG Chair to distill the LABS and Review Plan into an Executive-level “Terms of Review”
- ☐ The Sponsoring Agency Head (or their designee) signs the Terms of Review, and sends the document (along with a request for INSRB review) to NASA

The INSRB and the INSRB Review Group (IRG)

- ☐ Ensure the LABS has sufficient information; iterate if necessary
- ☐ Select the Chair (Board Member or Alternate from the sponsoring agency) and identify a rep. from the sponsoring agency to serve as the “Review Manager”
- ☐ Each agency nominates a rep for the IRG, ensuring they have the necessary security clearance (when applicable)
- ☐ The IRG Chair and Review Manager prepare a SME Matrix (see Appendix D) - any proposed IRG swap-outs are addressed
- ☐ The INSRB votes to approve the Provisional IRG membership
- ☐ The IRG drafts the Mission-specific Review Plan (see Section 5.1)
- ☐ The Board reviews the Review Plan and provides any concerns
- ☐ Concerns with the Review Plan are adjudicated and the IRG members vote to approve the Review Plan
- ☐ The IRG Chair works with the program office lead to distill the LABS and Review Plan into an Executive-level “Terms of Review”
- ☐ A NASA official at the level of the incoming signatory (e.g., the NASA Associate Administrator, the NASA Chief of Safety and Mission Assurance) notifies the NASA Administrator of the activity and signs the Terms of Review

Appendix D: Subject Matter Expertise Matrix

Table 3 provides a template for identifying which areas of expertise are applicable to a particular review, and which reviewers will provide that subject matter expertise. Since assessing subject matter expertise can be subjective, Table 4 offers sample criteria to assist in making this assessment more consistent.

Table 3 – Matrix for Identifying Available, Needed, and Inapplicable Subject Matter Expertise

Topical Area	Sub-topic	Source of Subject Matter Expertise or Inapplicability
Safety systems – general	Nuclear criticality control	
	Flight safety systems (including flight termination systems)	
	Systems integration	
Validation and Verification	Software V&V	
	Hardware V&V	
Nuclear devices	Isotopics (decay chains, assay, etc.)	
	Nuclear fuels – materials science	
	Criticality, reactor kinetics (including thermal feedback), reactivity control systems	
	Radioisotope-specific chemistry	
	Radioisotope power system design	
	Non-proliferation	
Launch vehicle design and operations	Vehicle integration	
	Heavy lifts	
	Propellants	
	Launch complex	
	Launch abort	
	Launch operations	
Launch accidents	Rain of debris	
	Blast and over-pressure (including reactivity excursion-induced damage when applicable)	
	Impact / solid mechanics	
	Fire and thermal	
	Orbital mechanics and reentry heating	
	Vehicle breakup during reentry	
	Hardware response to adverse environments	
Atmospheric Transport and Dispersion	Near-field atmospheric transport	
	Meteorology, including launch site-specific	
	Far-field atmospheric transport and deposition	
	Particle re-suspension	
Biomedical and Environmental Effects	Radiation shielding and particle interactions, and population/receptor modeling	
	Exposure pathways and uptake modeling	
	Epidemiology and radioisotope-specific toxicity	
	Dose response modeling – internal exposures	
	Dose response modeling – external exposures	
	Land and asset contamination	
	Radiological incident response	

	Framing health risks from radiation exposure	
Reliability, Risk Assessment, and Risk Integration	Failure modes and effects analysis	
	Reliability modeling and statistics	
	Human reliability analysis	
	Accident sequence analysis and integration	
	Treatment of uncertainty	
	Communicating about nuclear risks	

Note: For commercial launches and reentries, the FAA does not certify vehicle design and instead licenses the launch or reentry operation.

Table 4 – Sample Criteria for Assessing Primary and Secondary Aptitudes

	Formal training (education or focused professional training)	# of years of applied experience of managing, performing, and/or reviewing activities in the direct area of knowledge	At a level equivalent to
Primary aptitude	Yes	>5	GG-14 or higher
Secondary aptitude	Yes	>5	Any level
	Not required	>5	GG-14 or higher
	Not required	>8	Any level

Appendix E: Defining a US Government Launch versus a Commercial Launch and DOT Authority

Per NSPM-20, commercial launches and Federal Government launches have different features, though many of the practices and processes in the present document are common to both. In some cases, namely those involving solely commercial participants or solely Government agencies, the distinction on whether a particular launch will be “commercial” versus “non-commercial” will be evident, although it is increasingly common to have mixed participation of government and commercial partners. The definition of what constitutes a commercial launch from the DOT/FAA licensing perspective is whether or not the launch or reentry event is commercially conducted.

The FAA’s Office of Commercial Space Transportation (a part of the Department of Transportation) regulates US commercial space transportation. Under 51 USC 50904, a license is required *“(1) for a person to launch a launch vehicle or to operate a launch site or reentry site, or to reenter a reentry vehicle, in the United States. (2) for a citizen of the United States (as defined in section 50902(1)(A) or (B) of this title) to launch a launch vehicle or to operate a launch site or reentry site, or to reenter a reentry vehicle, outside the United States.”*

FAA’s main focus is on public safety. Through compliance with FAA regulations, the licensee is responsible for ensuring public safety and safety of property during the conduct of a licensed launch or reentry. This combination of who is operating the launch or reentry event and who therefore is responsible for public safety are key criteria for FAA in determining who needs a license. Overall, FAA is authorized to regulate only to the extent necessary to protect the public health and safety, safety of property, and national security and foreign policy interests of the United States. In addition, the FAA is to encourage, facilitate, and promote commercial space launches and reentries by the private sector.

It is important to note the following:

- 51 USC does not apply to a launch or space activity “the Government carries out for the Government.”
- FAA does not certify launch and reentry vehicles. Instead, DOT/FAA licenses the launch and reentry operation. As a result, DOT/FAA does not provide assurance for mission success.
- FAA cannot charge user fees for a launch license.

The Government can choose to establish a commercial launch services contract whereby the commercial launch operator oversees its own launch activity. The satellite or payload can also be part of a similar services contract. In general, under a commercial launch, the Government has more of a role of insight than oversight.

A legal clarification for what makes a launch DOT/FAA-licensed or not was provided in a 1990 Department of Justice decision regarding the launch of a joint NASA-Air Force mission called the Combined Radiation and Release Effects Satellite (CRRES). Prior to the July 1990 CRRES launch on an Atlas rocket, General Dynamics applied for and received a DOT commercial launch license to carry out the launch because General Dynamics was performing all of the public safety launch reviews and testing without NASA. However, NASA insisted that it had the final launch approval because the CRRES satellite was owned by the government. In a November 1990 memorandum, the Department of Justice concluded that “DOT’s licensing authority under the CSLA [Commercial Space Launch Act] does not

extend to launches where the Government is so substantially involved that it is effectively directing or controlling the launch.”

An effective way for the US Government to signal its decision on whether a space mission is a government or commercial launch is to identify it in writing as part of the procurement process. Agencies can write a specific requirement in a contract for services that commercial operators must obtain a DOT/FAA launch license. For example, in the Venture Class Launch Services (VCLS) program, NASA’s Launch Services Program awarded contracts that contain the following requirements:

“2.11 LICENSES, PERMITS, AND INSURANCE FOR A LAUNCH SERVICE OPERATOR

(a) The Contractor shall obtain and maintain the necessary licenses, permits and clearances that may be required by the Department of Transportation, Department of Commerce, Department of Defense, NASA, or other Governmental agencies in order to provide launch services under this contract. A Federal Aviation Administration commercial launch license is required under this contract. All costs and fees associated with obtaining licenses, permits and clearances shall be included in the standard launch service price. Approvals required by the payload are the responsibility of NASA.”

Similarly, the VCLS Statement of Work says:

- *“The Contractor shall be responsible for initiating and ultimately obtaining the necessary approval/licensing (i.e., Federal Aviation Administration) to successfully deliver the procured launch service.*
- *Make provision for insurance to cover liability for possible damage to Government property and third parties in accordance with necessary approval/licensing (i.e., Federal Aviation Administration).”*

There are of course tradeoffs for the US Government to consider in choosing to go the commercial launch route, such as mission success and certification, indemnification and insurance, profile and value of the mission to the government, cost savings, enabling new markets and innovation, and reliability of the launch provider(s).

Since 1989, and as of the publication of this Playbook, DOT/FAA has licensed over 60 commercial launches with primary payloads owned by the US Government. All previous NASA space nuclear system launches have not been commercial (i.e., FAA-licensed) launches.

As to payloads, FAA does consider the implications of a payload on launch and reentry safety. As part of FAA licensing there is a Payload Review. However, there are several notable exceptions (§415.53):

- Payloads owned or operated by the US Government;
- Payloads subject to regulation by the Federal Communications Commission;
- Payloads subject to regulation by the National Oceanic and Atmospheric Administration.

In October 2020, FAA issued the final rule for Part 450 on streamlined launch and reentry regulations that go into effect in March 2021. Launch and reentry applicants have up to five years to transition to the new 450 Rule.

The new 450 Rule has slightly adjusted text compared to the legacy regulations but maintains the above exceptions on payloads. §450.43, Payload review and determination, states that:

- “(a) General. If applicable, the FAA issues a favorable payload determination for a launch or reentry to a license applicant or payload owner or operator if—*
- (1) The applicant, payload owner, or payload operator has obtained all required licenses, authorizations, and permits; and*
 - (2) Its launch or reentry would not jeopardize public health and safety, safety of property, U.S. national security or foreign policy interests, or international obligations of the United States.*
- (b) Relationship to other executive agencies. The FAA does not make a determination under paragraph (a)(2) of this section for—*
- (1) Those aspects of payloads that are subject to regulation by the Federal Communications Commission or the Department of Commerce; or*
 - (2) Payloads owned or operated by the U.S. Government.*
- (c) Classes of payloads. The FAA may review and issue findings regarding a proposed class of payload, including communications, remote sensing, or navigation. However, prior to a launch or reentry, each payload is subject to verification by the FAA that its launch or reentry would not jeopardize public health and safety, safety of property, U.S. national security or foreign policy interests, or international obligations of the United States.”*

There is also additional DOT/FAA authority related to payloads under 51 USC, §50904 (c), Preventing Launches and Reentries, which states that: *“The Secretary of Transportation shall establish whether all required licenses, authorizations, and permits required for a payload have been obtained. If no license, authorization, or permit is required, the Secretary may prevent the launch or reentry if the Secretary decides the launch or reentry would jeopardize the public health and safety, safety of property, or national security or foreign policy interest of the United States.”*

As part of NSPM-20 implementation, DOT/FAA is developing guidance for industry.

Since there may be discussions during the development phase of a nuclear mission over whether a launch will be by the government or by a commercial operator, the INSRB should engage with mission owners when it appears that the mission may be classified as a Federal Government mission, and encourage such mission owners to also engage with FAA (who will also be represented on the INSRB). If it is determined that a particular mission is properly categorized as a commercial mission (typically through FAA pre-application discussions, if not already abundantly clear), then INSRB should cease its mission-related activities and await further direction from the Secretary of Transportation or the Secretary’s designee, as facilitated by the INSRB’s FAA representative.

Appendix F: Tabulation of NSPM-20 Safety Guideline Results

NSPM-20 defines Safety Guidelines that use the terminology “...an accident resulting in exposure...to any member of the public is unlikely, such that the probability of such an event does not exceed...” In the relevant excerpt of NSPM-20, the policy points to 10 Code of Federal Regulations (CFR) 835.2 for the definition of “total effective dose,” (TED) but provides no citation for defining “member of the public.” 10 CFR 835.2 provides a definition for “member of the public,” and it is rooted in DOE personnel, contractor, and subcontractor affiliations, and DOE facilities. Meanwhile, DoD, NASA, and FAA all have different definitions and contexts for this term for use in Flight Safety Analysis. Also of relevance, the primary contributor to the risk for an individual from recent space nuclear system launch analyses has been associated with an accident during the early launch phase, typically in the proximity of the launch site, and so difference in definition can be important. INSRB anticipates that the safety analysis will take account of both the Range Authority and Nuclear Authority’s definition.

Regarding how the exceedance probabilities in the Safety Guidelines are formulated, they should estimate the probability that any member of the public exceeds the specified value. Put differently, the tabulation of these exceedance probabilities involves the summation of the probabilities of all modeled accident sequences, across all modeled phases (consistent with accident sequences being mutually exclusive), which result in a TED to any member of the public in excess of the specified value, along with a basis for why the modeled accident sequences and associated consequences reasonably include the vast majority of estimable risks to the public. INSRB is not seeking to constrain how the nuclear safety analysis is performed, or how the results are generated in terms of the use of analytical methodologies, and there are approaches to demonstrate conformance with the NSPM-20 Safety Guidelines that are both more and less complex than the types of probabilistic risk assessments used in past missions. So long as the analysis produces a measure of exceedance risk comparable to the measure described in NSPM-20, and it has sufficient quality, the method itself is not dictated.

Finally, INSRB generally expects that best-estimate values will be used in comparisons to the Safety Guidelines, but that uncertainty results (including sensitivity analysis) will be included. In a probabilistic risk assessment framework, best-estimate results usually refer to mean or median results, and uncertainty can be represented in percentiles (e.g., 5th to 95th percentile results) and sensitivity analysis outcomes. In other analytical frameworks, best-estimate and presentation of uncertainty can take on other forms, and their selection should be defined and justified in the safety analysis, preferably leveraging existing standards such as NASA-STD-7009a.

Appendix G: Sample Schedule

Table 5 provides an example of review activities, and notionally represents the case of a radioisotope power system being carried on a US Government-sponsored mission with a mission profile having some significant differences relative to past launches. Actual mission reviews will invariably differ from this schedule and may take shorter or longer.

Table 5 – Illustrative Schedule of INSRB Mission Review Activities

Item	Target Date
Board and program office begin periodic interactions	e.g., t-48 months
Initial Launch Authorization Basis Strategy issued to INSRB	t-36 months
INSRB comments on the Initial Launch Authorization Basis Strategy	t-35 months
Program office provides responses to all INSRB comments	t-34 months
Provisional review team appointed	t-33 months
Mission-specific Review Plan issued	t-30 months
Mission SAR for Interim Review issued to INSRB	t-24 months
Review team comments on the Mission SAR for Interim Review	t-22 months
Program office provides responses to all INSRB comments	t-20 months
Agency Head Gaps or Omissions Report finalization: <ul style="list-style-type: none"> - interim final completed by review team - interim final provided to Board for deliberation/alignment - interim final provided to program office (for factual review), technical editor, and information security reviewer (in parallel) - issued to head of sponsoring agency 	t-19 months to t-17 months
Mission SAR for Launch Approval issued to INSRB	t-12 months
SER finalization: <ul style="list-style-type: none"> - interim final completed by review team - interim final provided to Board for deliberation/alignment - interim final provided to program office (for factual review), technical editor, and information security reviewer (in parallel) - issued to head of sponsoring agency 	t-11 months to t-9 months
Briefing of head of sponsoring agency	t-8.5 months
SER Executive Summary made publicly available	t-8 months
Opening of launch window	t-0

Appendix H: Sample Outlines of Sponsoring Agency Submittals

The following examples are provided to promote two-way communication regarding anticipated program office submittals, to facilitate alignment. They are not intended as requirements, and its fully anticipated that many missions will elect to provide equivalent information in a format that more closely follows sponsoring agency or nuclear safety authority norms, until a time at which a consensus approach has been fully developed.

Launch Vehicle Inputs and Accident Environments

0. Executive Summary
1. Mission Overview, to include event timelines, mission phases, trajectory information, etc.
2. Description of the space nuclear system as it pertains to the launch vehicle and launch operations, e.g., payload processing fundamentals, payload characteristics, history of use on the selected launch vehicle, etc.
3. Description of the Launch Vehicle (LV), including propellant types and amounts, relevant structural limits for aero-breakup, LV breakup characteristics (e.g. debris catalog(s) for flight termination system (FTS), aero-breakup, and aero-thermal reentry), material information, etc.
4. Description of the launch site, including identification of additional hazards (e.g. propellant storage, structure location)
5. Description of the LV Flight Safety System (type of system and resulting action, etc.)
6. Assessment of LV Reliability (launch history, similar LV(s) relative to assessing probability of failure and allocation, etc.)
7. Assessment of launch environments, including fire/thermal, explosive/overpressure, debris/ground impact, and reentry
8. Identification and characterization of accident scenarios relevant to the mission, launch vehicle, launch operations and space nuclear system
9. Treatment of uncertainty, and key assumptions
10. Appendices, as needed (e.g., legacy assumptions that have been incorporated into the analysis, expert elicitation summaries)

Launch Authorization Basis Strategy

0. Executive Summary
1. High-level description of the mission, including mission requirements and specifications
2. High-level description of the program office's organization and partners, as it pertains to:
 - a. Communication and operation protocols, or relevance to interfacing with INSRB during the review
 - b. Preferences for communication paths and any established focal points of contact
 - c. Mission information requiring special handling (e.g., non-disclosure agreements, etc.)
 - d. Mission and safety analysis schedule
 - e. Plans to communicate information from the upstream technical peer review (e.g., the planned scope, team composition information, basis/criteria to be used to determine adequacy of the analysis, post-review insights, and the basis for sufficient independence),

- f. The program office’s approach to managing information as it pertains to maintaining clear boundaries between the INSRB’s review and other end-users’ activities (e.g., a product development schema identifying which portions of products are relevant to which end-users) – see Section 3.4 for more information on the myriad of potential end-uses
- 3. System Safety Foundation
 - a. Space nuclear system, spacecraft, LV, launch operations and mission characterization
 - b. Nuclear design and operational safety criteria
 - c. Software and hardware quality assurance programs
 - d. Testing, validation & verification
 - e. Assessment of spacecraft, LV, and launch operations-specific reliability and accident environments
- 4. Safety Case development
 - a. Hazards identification and mitigation approach
 - b. Risk assessment, risk management, and NSPM-20 Safety Guidelines conformance plan
 - c. Plan for assessing key uncertainties and evaluating defense-in-depth
 - d. Approach to identification of essential Safety Case features and assumptions
- 5. Plans for operationalization of the Safety Basis
 - a. Approach to managing essential Safety Basis features and assumptions (a.k.a., limiting conditions for operation or technical safety requirements)
 - b. Process for identifying and authorizing changes to the Safety Basis via a formal change control process (a.k.a., unreviewed safety question determination process)

Safety Analysis

- 0. Executive Summary - a high-level summary of key information from the analyses, including:
 - a. The “concise, high-level summary of key risk information” required by NSPM-20
 - b. Comparison of mission risk to the NSPM-20 Safety Guidelines
 - c. Other information relevant to mission tier determination and launch authorization
- 1. Introduction – provides an overview of the mission, and describes the overall approach to safety and risk management (including any existing Standards or regulatory guidance which have been used as roadmaps)
- 2. Mission Overview
 - a. Space nuclear system description – describes the space nuclear system that will be launched, such as design and construction basics (including known deviations), pre-existing radioactivity and nuclear assay (including chemical and physical form), fissionable system parameters, relevant radioactive decay chains and/or fission product yields, personnel radiation exposure characteristics during pre-launch activities, NRC license or DOE authorization information, and a discussion of why normal operation of the space nuclear system is consistent with applicable Federal, State, and local requirements, etc..
 - b. Spacecraft description – a detailed description of the spacecraft and the integration between it and the launch vehicle
 - c. LV description – describes the LV that will carry the spacecraft into space, including any other payloads

- d. Mission profile – describes the proposed launch window, trajectory and flight characteristics, orbital parameters, and end of life disposal plans
 - e. Launch complex – describes the launch complex, buildings, locations and quantities of hazardous materials, vehicle processing facility, etc. (excluding critical assets that the Range is not at liberty to divulge)
 - f. Ground handling considerations during pre-launch, and during disposal (as applicable)
- 3. Overview of System Safety Foundations – draws upon the activities established in the safety strategy, which serve as the basic structure for ensuring adequate safety and providing a stable base for risk management, and describes elements like specific test data used to validate models, hardware and software quality assurance, etc.
- 4. Hazard Identification and Mitigation
 - a. Launch accident descriptions (a.k.a., potential mishap scenarios) – describes accident scenarios and environments - i.e., the “what can go wrong” portion of the risk triplet
 - b. Space nuclear system response to accident environments – describes the methods and tools used to analyze blast and impact, nuclear material entrainment and vaporization, response to propellant thermal environments, etc.
 - c. Launch accident analysis – describes representative accident scenarios and how they each are modeled, describes the tools that are used to model accident scenarios, and describes any risk and reliability evaluations used to develop the probability of occurrence, etc. - i.e., the “how likely is it to occur” portion of the risk triplet
 - d. Reentry accident analysis – similar to the above, for the phases of the mission where reentry is relevant
 - e. Consequence analysis – Describes the methods and tools used to analyze plume rise, meteorological data use, atmospheric dispersion of nuclear material, and the statistical methods used to assess radiological risk and health effects – i.e., the “and what are the consequences” portion of the risk triplet
 - f. Summary of key results – sufficient breakdown and illustration of the results to understand key behaviors (e.g., cases where an averaged value really reflects bi-modal behavior rather than a common tendency) and the effect of key modeling features (e.g., results for landward versus seaward launch meteorology conditions)
 - g. Identification and analysis of employed or discounted mitigations
- 5. Risk assessment, risk management, and NSPM-20 Safety Guidelines Conformance
 - a. Extension of the deterministic and probabilistic analysis into risk results
 - b. Identification of risk management elements (e.g., design features, mitigations) that are employed or discounted
 - c. Comparison to NSPM-20 Safety Guidelines for the total mission, and for individual mission phases
- 6. Assessment of key uncertainties - describes the consideration of parameter and modeling uncertainties through propagation and/or sensitivity analysis in the foregoing analysis, addresses un-modeled sources of uncertainty, and addresses the role of margin (to safety thresholds) and defense-in-depth design or operational features in managing these uncertainties
- 7. Identification of essential Safety Basis features and assumptions
- 8. Operationalizing the Safety Basis

- a. Approach to managing essential Safety Basis features and assumptions - describes those manageable parameters or characteristics integral to maintaining the assessed level of safety
- b. Process for identifying and authorizing changes to the Safety Basis
- 9. Appendices, as needed – To cover topics such as:
 - a. Nuclear fuel, clad, and moderator properties and characteristics (as applicable)
 - b. Material properties and characterization of other components relevant to safety
 - c. Listing and availabilities of supporting analysis results and test results
 - d. Legacy assumptions that have been incorporated into the analysis
 - e. Expert elicitation summaries