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**Use of nuclear power sources in outer space**

# Workshop on the Use of Nuclear Power Sources in Outer Space: the United States approach to nuclear launch accident mitigation

## Paper submitted by the United States of America**

*Summary*

The United States of America subjects its planned launches of nuclear power source applications to an extensive launch radiological contingency planning process to characterize and mitigate any possible effects of a nuclear launch accident. This process is consistent with the relevant guidance recommended in the Safety Framework for Nuclear Power Source Applications in Outer Space, jointly published by the Scientific and Technical Subcommittee and the International Atomic Energy Agency in 2009. For every launch involving nuclear material, the United States creates contingency plans to mitigate accident sequences that could lead to a radiological hazard. A network of remote sensors and monitoring teams are established around the launch area to determine whether a release from an accident has occurred and, if necessary, to characterize the nature of a release. Information from the sensors is collected and interpreted in the Radiological Control Center, which is staffed by national experts in radiological emergencies. These experts may recommend actions to limit the exposure of population groups in potentially affected areas. A joint information centre is established to promptly distribute consistent, accurate and current information to the appropriate Governments, international

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organizations, non-governmental entities and the general public. Numerous exercises are conducted before every launch to practice this response and ensure that the United States is ready to react appropriately and promptly in the unlikely event of a launch accident involving nuclear material.

# I. Introduction

1. The United States has instituted a detailed and thorough approach to launch accident mitigation involving the use of a nuclear power source. This process is consistent with the Safety Framework for Nuclear Power Source Applications in Outer Space (A/AC.105/934) (see also the paper submitted by the United States entitled "Workshop on the Use of Nuclear Power Sources in Outer Space: the United States approach to risk assessment and its role in implementing an effective safety programme for space nuclear power sources applications in outer space).[1] The process includes detailed radiological contingency planning, assessing the situation in the unlikely event of a launch accident involving a nuclear power source and, if necessary, recommending protective actions and communicating this information to Governments and the public.

2. A phased approach of coordinated radiological contingency planning efforts is an integral part of the planning for each nuclear power source space mission using the provisions set forth in the United States National Response Framework (available from www.fema.gov/emergency/nrf/). The Framework is a guide on how the United States responds to incidents involving hazardous materials. The Nuclear/Radiological Incident Annex of the Framework specifically addresses nuclear and radiological releases.

3. The Annex provides a more detailed description of the policies, situations, concepts of operations, authorities and responsibilities of the federal departments and agencies governing the immediate response and short-term recovery activities for incidents involving the release of radioactive materials. The Annex applies to incidents where the nature and scope of the incident requires a federal response to supplement the incident response at the state and local level.

4. The Annex identifies the National Aeronautics and Space Administration (NASA) as the federal coordinating agency in the event of a launch accident involving a nuclear power source on a NASA mission. NASA is responsible for designating a coordinating agency representative to lead this effort, including a planning portion and a response implementation portion on both United States Government property and non-United States Government property. NASA launches all of its nuclear power source missions from the Kennedy Space Center in Cape Canaveral, United States; as such, the Kennedy Space Center also develops a supplemental plan to address these requirements for all missions using a nuclear power source.

# II. Radiological contingency planning

5. The radiological contingency planning efforts for each mission typically begin with formal coordination between NASA and the Department of Energy around three years prior to the scheduled launch. One of the major functions of the radiological contingency planning process is identifying the requirements basis for the contingency response plan and establishing the timelines for the development of effective plans and timely procedures for addressing an accident or incident that

[1] A/AC.105/C.1/L.312.

could result in a radiological release. The mission-specific support plans are requirements driven and normally include, but are not limited to, the following areas: data management plans, out-of-launch area contingency plans, source recovery plans, data assessment plans, logistics support plans and field monitoring. The writing and development of the plans is accomplished through an iterative series of drafts and reviews. Measures are taken to ensure that each plan is fully vetted prior to final staffing and signature.

6. A series of approximately 7-10 major interagency meetings are held during the radiological contingency planning process. Numerous other sub-meetings involving specific topics and personnel also take place, and tailored validation drills and exercises are also held in support of the mission. The meetings are designed to address, outline and implement the radiological contingency planning path for the upcoming mission. Attendees at radiological contingency planning meetings include representatives from NASA, the Department of Energy, the state of Florida, Brevard County (the local jurisdiction where the launch occurs), the Department of Defense, the United States Air Force, the Environmental Protection Agency, the Federal Emergency Management Agency, the National Weather Service of the National Oceanic and Atmospheric Administration, the Department of State and the United States Coast Guard.

7. The Kennedy Space Center normally hosts radiological contingency planning meetings. Having the meetings at the Space Center allows the use of existing mission facilities, including the Radiological Control Center, which are designed for and dedicated to the facilitation of the radiological contingency planning concept of operations for nuclear power source missions. Additionally, holding the radiological contingency planning meetings at the launch site facilitates coordination efforts with state and local government emergency management representatives at their actual emergency operations centres. These radiological contingency planning coordination efforts with state and local emergency management representatives are an acknowledgement of their key role in the implementation of National Response Framework and Nuclear/Radiological Incident Annex guidance.

8. The development of radiological contingency plans is based on data and results from the detailed safety analyses and risk assessments developed for each mission as part of United States procedure for approving nuclear power source launches. Comprehensive efforts are taken early in the radiological contingency planning process to determine and evaluate all radiological risks that have been identified in studies and/or regulatory safety documents prepared for the mission. Such documents are mission specific and include: the environmental impact statement, the final safety analysis report and the safety evaluation report. The risk assessments are consistent with section 5.3 of the Safety Framework and focus on the radiological materials, the launch vehicle and meteorological and other environmental considerations. The information found in the environmental impact statement provides a starting point for obtaining the data regarding possible environmental impacts that are required for initial radiological contingency planning efforts to identify and characterize any radiological release in the unlikely event that an accident occurs. Eventually, the environmental impact statement data are replaced and updated by the data contained in the final safety analysis report.

9. The radiological source term and risk information contained in the final safety analysis report are used to develop atmospheric modelling approaches to obtain expected dispersal plumes of the radiological materials for each mission, based on local meteorological information. Current and historical meteorological data for the Kennedy Space Center launch site are used to model meteorological conditions for the projected launch window and support the staging and deployment of radiological monitoring and response personnel and equipment. It should be noted that the Kennedy Space Center and its surrounding area is one of the most highly meteorologically monitored and studied areas in the world.

10. The key objective of the radiological contingency planning effort is to ensure that all required assets are in place (on site and off site) prior to any nuclear power source mission launch. These assets are necessary for ensuring a timely response to an accident that could result in a radiological release and providing for a smooth transition of that initial response into a full federal response, should the need arise.

11. As the radiological contingency planning process moves along and the unique requirements for each mission are established, a list of mission plans and procedures are identified for development. These plans, coupled with the information in the safety documents indicated above, provide the basis for the tailoring of personnel and equipment requirements to address staffing, monitoring and response contingencies for that particular mission.

12. The ongoing radiological contingency planning process provides for modifications and changes to the plans and procedures throughout the planning effort and the radiological contingency planning meetings provide an established forum for discussing and modifying documents. Once the plans have been developed, coordinated and approved, they are circulated to all involved agencies for familiarization as part of the preparations for mission planning and for the scheduled pre-launch radiological contingency planning drills and exercises involving radiological contingency planning personnel, equipment and facilities that will be used to support the mission launch.

13. The radiological contingency planning process is designed to respond to accidents that may result in radiological release, along with providing resources for an initial response, including locating and identifying radiological materials. The period of support for deployed radiological contingency planning resources is designed to be short — just a couple of days. Additional federal resources may be deployed upon request. To facilitate this transition and the influx of personnel and equipment and to maintain continued operations of Radiological Control Center activities throughout the transition, the Department of Energy ensures that its Consequence Management Home Team is operational during each nuclear power source mission launch. The Consequence Management Home Team mission is to provide all of the support required to address the radiological issues from any accident while additional trained and equipped personnel are deployed to mitigate the consequences of a radiological mishap.

14. The Federal Radiological Monitoring and Assessment Center is a federal service that can respond to nuclear or radiological incidents, as described in the Nuclear/Radiological Incident Annex of the National Response Framework. Under the National Response Plan, the Department of Energy is responsible for maintaining the operational readiness of the Center. The Center is an interagency

organization with representatives from various federal, state and local radiological response organizations. Its purpose is to assist state, local and tribal governments in their mission to protect the health and well-being of their citizens through verification of radiation measurement and interpretation of radiation distributions based on protective action guidelines from the Environmental Protection Agency, the Food and Drug Administration or local administrations and through the characterization of overall radiological conditions.

15. A radiological contingency response review is conducted by NASA with key personnel from each of the agencies involved with the radiological contingency planning efforts for the upcoming mission approximately 30-60 days before the launch. The purpose of the review is to ensure that all known requirements have been fully addressed and to obtain a "ready to support" response from each agency representative with a support role in the mission.

# III. Radiological contingency facilities, personnel and equipment

16. Radiological contingency planning support personnel are identified by specific positions that are either on site at the Kennedy Space Center or off site in selected federal, state or local facilities that have been identified and/or established, as necessary, for each particular launch. Three primary radiological contingency planning mission support elements are: the coordinating agency representative management group, the Radiological Control Center and the joint information centre. All personnel that support radiological contingency efforts have clearly developed position descriptions and associated checklists, which are reviewed and revised, as required, for each mission. The personnel, support plans, equipment and facilities are validated through a series of intensive drills and exercises. Substitutes are trained for each position so that in the event that the primary individual is unable to perform their duties, their duties can still be fulfilled. Substitute personnel are also subject to training, drills and exercises.

17. The coordinating agency representative management group is led by the coordinating agency representative and is composed of federal, state and local government representatives. It provides the focal point for on-site and off-site operations, including the coordination, approval and dissemination of information and recommendations involving the status of the radiological materials on the mission.

18. The Radiological Control Center is staffed by federal, state and local government representatives, as well as engineers, scientists, physicians and other experts from across the United States. The Center staff provide a single tailored and trained hub for the initial management of any mission accident or incident (on and off site) involving a possible release of radiological materials.

19. The joint information centre is located in close proximity to the coordinating agency representative management group and the Radiological Control Center and it includes engineers and public affairs experts from federal, state and local governments. The primary purposes of the joint information centre are to: (a) ensure the timely release of fully coordinated and approved radiological information with a focus on public health and safety and environmental protection; and (b) serve as the

focal point for communication and the exchange of information between the coordinating agency representative management group and the Radiological Control Center and the media and the general public regarding any issues involving the radiological materials on board the mission.

20. Radiological monitoring teams are field units that have direct communication with a dedicated point of contact within the Radiological Control Center. The pre-positioned radiological monitoring teams provide an initial response to an accident to verify whether or not a radiological release has occurred. If applicable, the teams also characterize the release and assist in determining which areas may be contaminated. One of the radiological monitoring teams deployed for each mission is specifically designed, staffed and equipped to identify the nuclear power source and its components and to take initial steps for its safe and secure recovery.

# IV. Characterizing the location and nature of a release of radioactive material

21. The Radiological Control Center collects real-time information on the telemetry, trajectory and tracking data for the mission launch vehicle. If an accident or incident occurs with the launch vehicle during any phase of the launch to orbit, the Center would have access to that information and the predicted impact locations of the spacecraft and associated debris, including the nuclear power source. This information, combined with local meteorological data, can be used to help predict the potential dispersion of any radioactive material and related ground concentrations and radiation doses in the unlikely event of a launch accident.

22. The Lawrence Livermore National Laboratory's National Atmospheric Release Advisory Center has an extensive global network of meteorological information that, if necessary, can be used for modelling atmospheric releases throughout the world. A scientist from the National Atmospheric Release Advisory Center is located in the Radiological Control Center to provide predictive radiological dispersal plots for a potential launch accident. These plots provide the planning basis for the initial deployment and staging of unmanned environmental continuous air monitors and the radiological monitoring teams.

23. If an accident were to result in a radiological release, the National Atmospheric Release Advisory Center would model the plume and deposition of the radiological materials potentially contained in the plume, based on meteorological data, input from the network of detection devices and the ground sampling obtained by the radiological monitoring teams in the field.

24. Environmental continuous air monitors are automated radiation detection devices that continuously sample ambient air to determine if radioisotopes are present. The air samples are collected at a height of 1.5 m, which is approximately mouth and nose level for an adult human. This is important because inhalation is the primary dose pathway for released nuclear power source radiological material (plutonium-238). Environmental continuous air monitors are optimized for outdoor weather conditions, including wind. they can detect alpha and beta radiation, and can be programmed specifically to detect certain radioisotopes, such as plutonium-238. The monitors can report the concentration of radioisotopes in the air and have their own independent power supply. They transmit data via satellite on a

real-time basis to the Radiological Control Center. In the event of a communications failure, the monitors maintain a record of the measurements taken. This information can be read directly from the monitors and sent to the Radiological Control Center via radio, telephone or courier, as necessary.

25. Before a launch, the radiological detection equipment and radiological monitoring team personnel are strategically placed in identified positions around the launch area, both on site (at the Kennedy Space Center and Cape Canaveral Air Force Station) and off site (in surrounding communities), based on the projected meteorological conditions at the launch. Most detection and monitoring equipment is placed in fixed locations so that background levels of radiation can be established in advance of a launch and to aid in radiological contingency planning plans and exercises. Some equipment and personnel are mobile and can be moved hours before launch, as dictated by weather conditions, to best monitor the area.

26. The initial pre-launch positioning of the mobile environmental continuous air monitors and radiological monitoring teams is adjusted based on updated information and a series of National Atmospheric Release Advisory Center plots starting approximately 24 hours prior to the scheduled launch. Final positioning usually takes place two to four hours prior to launch.

27. The use of strategically placed environmental continuous air monitors and radiological monitoring teams provides a fast, real-time determination of release or confirmation of no release of material, in the unlikely event of a launch accident involving a nuclear power source. The data collected by the monitors and radiological monitoring teams is interpreted by expert scientists and engineers in the Radiological Control Center. The information would be used to help understand the potential population exposure and land contamination in affected areas, should an accident with a radiological release occur.

# V. Recommending protective actions

28. The primary focus of the radiological contingency planning process is protection of public health and safety and the environment following any release of the radiological materials. Specific radiological contingency planning meetings are held and working groups, which include state and local government representatives, federal representatives from NASA, the Department of Energy, the Environmental Protection Agency and other agencies, are established to assist state and local governments to develop protective action guidelines to fit their particular needs. Mission-specific protective action guidelines are coordinated, developed and documented for both on- and off-site locations.

29. One protective action is called “sheltering in place”. To protect launch area personnel, visitors and local residents from any potential hazards involved in an early launch accident, they may be advised to go indoors, close all doors and windows, turn off their heating and air-conditioning systems and wait for the passage of a potential radiological or toxic (chemical) plume. This protective action is also recommended for launch accidents not involving an nuclear power source as a means of protecting people from possible toxic plumes (e.g. from rocket propellants and/or by-products) generated during a launch accident.

30. In addition to the protective action guidelines and recommendations, the Department of Energy works with local government representatives to provide specific medical training to staff from hospitals and medical centres in the launch area. The training focuses on the effects of radiological materials and on the handling and treatment of contaminated patients. The training is coordinated with each medical facility identified by local government representatives and is provided approximately six to eight weeks in advance of every nuclear power source mission launch. Instructors for the training are provided by the Radiation Emergency Assistance Center/Training Site programme of the Department of Energy and are medical doctors, health physicists and occupational health professionals that are experts in the area of the health effects of radiation and the handling and treatment of patients exposed to radiation.

# VI. Dissemination of information to the public

31. In accordance with section 5.4 (f) of the Safety Framework, the United States sets up a joint information centre to provide a single, unified source of information to relevant Governments, the media and the public about the federal radiological response to a launch accident. The timely, effective and efficient flow of information between NASA, the media and the public is integral to a successful response to a launch incident. Similar to the Radiological Control Center, the joint information centre is a group of representatives from federal, state and local agencies.

32. Prior to a launch, joint information centre personnel develop, recommend and execute public information products, plans and strategies that should be set in motion in the event of a launch accident. Given that there are many Governmental agencies involved in the launch of a nuclear power source, mechanisms are established for interagency coordination of public information releases in the unlikely event of a launch accident. Presentations are given to the media (print and television), decision makers and interested public organizations to help inform the public of the risks and benefits of a mission. The joint information centre creates pre-scripted accident-specific announcements to facilitate the timely, accurate and consistent release of public information in the event of a launch accident. Pre-scripted announcements are drafted for all credible outcomes of a launch, including accidents occurring during pre-launch, early ascent and the sub-orbital and orbital phases of a launch. Specific information related to an accident would be added if an accident occurred. These pre-scripted messages include recommended protective actions the public can take in the event of a launch accident.

33. Should an accident occur, the joint information centre will obtain information from the Radiological Control Center to produce and distribute timely information about the launch accident to the media and other groups. The joint information centre reviews any public information developed in response to the accident by partner agencies. The joint information centre also monitors message delivery, media content and public perception of the launch accident and can issue press releases to ensure that correct and appropriate messages on protective actions reach the public. All messages generated by the joint information centre must be approved by the coordinating agency representative before being publicly released.

34. The joint information centre is also responsible for drafting diplomatic cables that are sent to relevant Governments and international organizations. Prior to launch, diplomatic cables are prepared by the joint information centre describing the mission, nuclear power source and risks of the launch. The Department of State sends the cables to embassies and missions worldwide. The joint information centre writes pre-scripted diplomatic cables, similar to the pre-scripted messages described above, so that accurate information can be released to relevant Governments as quickly as possible should the need arise. The Department of State activates its Operations Center during every nuclear power source launch to ensure that, in the unlikely event of a launch accident, the diplomatic cables will be released to relevant Governments as quickly as possible. All of these international messages are approved by the coordinating agency representative before being released.

# VII. Conclusion

35. The United States has set up a thorough and detailed approach to monitoring and mitigating a launch accident involving the use of a nuclear power source. The United States develops a range of plans to deal with potential launch accident scenarios; dedicated facilities, teams and equipment are in place for every launch involving a nuclear power system to determine if a release has occurred. Expert scientists and engineers interpret the data to characterize the release and risk and then make recommendations to policymakers and the public. The joint information centre prepares accurate and timely information to other Governments and the public.