Optimizing Decision Making for Late-Phase Recovery from Nuclear or Radiological Terrorism Incidents in the United States

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Abstract. In August 2008, the U.S. Department of Homeland Security (DHS) issued its final Protective Action Guides (PAGs) for Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) incidents. This document provides recommendations for protection of public health in the early, intermediate, and late phases of response to an RDD or IND incident, and it discusses approaches to the implementation of the necessary actions. However, while the DHS guidance provides a general description of the goals of the-late phase recovery, it does not describe the complex optimization approach to decision making during the process of achieving these multifaceted goals. In an effort to more fully define the process and procedures to be used in optimizing the late-phase recovery and site restoration following an RDD or IND incident, DHS has tasked the National Council on Radiation Protection and Measurements (NCRP) to prepare a comprehensive report addressing all aspects of the optimization process. The preparation of the NCRP report is a three-year (2010–2013) project by a scientific committee designated as SC5-1, entitled "Optimizing Decision Making for Late-Phase Recovery from Nuclear or Radiological Terrorism Incidents." Members of SC5-1 represent a broad range of expertise, including homeland security, health physics, risk and decision analysis, economics, environmental remediation and radioactive waste management, and communication. The Committee intends to interact with stakeholders at the local, state, and federal levels during the course of its deliberations.

KEY WORDS: Nuclear or Radiological Incidents; Late-Phase Recovery; Optimizing Decision Making; Environmental Remediation

1. Introduction and Rationale

Subsequent to the tragic events of September 11, 2001, many activities have been undertaken, both in the United States and at the international level, to address the response to, and management of, malicious events. One specific area of concern involves the use of radioactive or nuclear material in such events, in the forms known as a "radiological dispersal device" (RDD) or an "improvised nuclear device" (IND).

While the current effort on emergency preparedness has been focused primarily on triaging the initial response to the event, the society has been slow to address the more complex, long-term issues regarding recovery in the aftermath of the event [1, 2]. For an RDD event specifically, a legitimate concern is the potential for widespread contamination over affected communities, which could cause considerable disruption to the society. Therefore, when developing emergency plans to manage an RDD incident, specific guidance on long-term recovery is required to deal with relevant issues that emerge.

On August 1, 2008, the U.S. Department of Homeland Security (DHS) issued an important final guidance document, entitled "*Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents*" [3]. The guidance provides Protective

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Action Guides (PAGs) to support decisions on actions to be undertaken to protect the general public and emergency workers. The guidance offers explicit protective actions for both early and intermediate phases. The early phase is the period at the beginning of the incident, when immediate decisions for effective use of protective actions are required and actual field measurement data are generally not available. The intermediate phase follows the early phase; it begins after the source and releases have been brought under control, and when protective action decisions can be made, based on measurements of deposition and dose rates. For late-phase response (i.e., long-term recovery and site restoration), the DHS guidance recommends a process for deriving a long-term plan in lieu of a predetermined cleanup level. This approach involves a site-specific "optimization" process, for developing the appropriate cleanup criteria for the contaminated area. The principle of *optimization of protection* has been advocated by the International Commission on Radiological Protection (ICRP) [4] and follows on from the principle of *justification*. The primary objective of late-phase activities is to help restore conditions and return the community to a new normality in the most expedient manner. However, the approach to a full recovery is likely to be multifaceted and involve a high level of complexity. That is, setting a priority for a particular decision will inevitably involve trade-offs among many key factors and also entail complex deliberations with stakeholders in reaching optimization.

In 2010, DHS commissioned the National Council on Radiation Protection and Measurements (NCRP) to prepare a comprehensive report addressing all aspects of the optimization process [5]. The preparation of the NCRP report is a three-year (2010–2013) project by a scientific committee designated as SC5-1, entitled "Optimizing Decision Making for Late-Phase Recovery from Nuclear or Radiological Terrorism Incidents." Members of SC5-1 represent a broad range of expertise, including homeland security, health physics, risk and decision analysis, economics, environmental remediation and radioactive waste management, and communication. This will not be the first report published by NCRP on preparing for and responding to, RDDs and INDs (e.g., [6 - 8]).

Some of the key issues being considered and discussed by the SC5-1 Committee are discussed below.

2. Optimization Approach and Process

Late-Phase Recovery Considerations

Regardless of the scenario, one common long-term concern is the potential for widespread radioactive contamination of critical infrastructures, as well as public and private properties (including those in highly populated metropolitan areas), that would require an extensive cleanup program. Several important factors would likely weigh heavily in the decision-making process, including access to extensive resources and substantial funding commitments, as well as acceptability of the cleanup options and goals to stakeholders. The challenge for the SC5-1 Committee is to develop suitable guidance, including a process for managing late-phase recovery efforts that takes into account the complexity of the situation and optimizes the overall strategy.

Optimization Principle, Approach, and Implementation

The concept of optimization in radiological protection has been advocated by international and national regulatory and advisory bodies and is also commonly practised by all levels of government in decision-making processes. Of particular relevance is the fact that ICRP has advocated use of the principle of optimization of protection, which maintains that the likelihood of exposure, the number of people exposed, and the magnitude of individual doses "should all be kept as low as reasonably achievable, taking into account economic and societal factors." This objective, commonly referred to as the ALARA (**a**s **l**ow **a**s is **r**easonably **a**chievable) Principle, has been affirmed by the National Council on Radiation Protection and Measurements [9]. The ALARA Principle has thus been a requirement in existing regulations for control of radiation exposures, including the statutes on cleanup of nuclear facilities. It is also considered as a "graded" approach in scope that takes into consideration the magnitude of the potential impact [10]. Implementation of the cleanup decision requires input from all relevant stakeholders, taking into account a broad set of long-term objectives. The protection guidance for living in an *existing exposure situation* is elaborated by ICRP Report 111 [11].Accordingly, the cleanup criteria for late-phase recovery should be developed on the basis of a reference level ranging from 1 mSy/y to 20 mSv/y (residual dose), together with the application of the ALARA Principle.

One key reason that no specific level has been recommended for late-phase recovery in the United States is that the potential impacts of RDD or IND incidents vary widely, from minor to severe, and an array of considerations must be factored into the decision-making process. For example, a small-scale incident may receive an expedited cleanup effort, while an incident causing extensive contamination (e.g., affecting many city blocks in a major urban area) may warrant considerable effort (e.g., in terms of costs and time), thus influencing the decision on the final cleanup criteria. Therefore, it will not be practical to use predetermined criteria for cleanup and site restoration. Any criteria that are chosen will include consideration of existing federal statutory requirements on environmental cleanup (such as the U.S. Environmental Protection Agency's [EPA's] Superfund Program and the U.S. Nuclear Regulatory Commission's [NRC's] rule on license termination), along with other national and international recommendations. A range of other relevant criteria will also be considered, such as the extent and type of contamination, technical feasibility of clean up strategies, their impact on human health and the environment. Furthermore, it must also be kept in mind that the optimization principle will have to encompass factors beyond the long-term health effects to include other priority issues facing the event-disrupted society. These factors may include local economy, health care services, critical infrastructures, transportation systems, public security protection, employment opportunities, etc. Thus, the goal of optimization is meant to favor the overall well-being of the society, rather than simply focusing on limited issues for cleanup purposes. The process of deliberation on cleanup goals and criteria will be developed under the existing emergency management structure by incorporating appropriate technical entities and stakeholders in the decision-making process.

3. Lessons Identified from Historic Events and Exercises

Though the late-phase guidance developed by DHS offers a logical framework for the optimization process, it still lacks specificity and technical substance on how to reach cleanup decisions. In particular, given that the complexity of a cleanup is highly dependent on site-specific factors, several issues especially critical to the decision-making process require more in-depth consideration. Because past terrorist events involving nuclear or radiological sources are rare, we must rely heavily on the information and lessons identified from events that were accidental in nature. Furthermore, much of the concern associated with long-term recovery issues would share some common attributes, whether those issues originated from malicious acts or not. Therefore, one important aspect of the work of the SC5-1 Committee is to evaluate past events for their relevance to the optimization issues discussed above and use them to provide valuable input to developing guidance for any future events.

Review of Historic Events

Issues that have been recognized and addressed in past events of similar nature, with varying degrees of relevance, can be systematically captured in the form of lessons identified. Four categories of events are being evaluated by the SC5-1 Committee: (1) events involving terrorist acts (e.g., poisoning of Alexander Litvinenko in London with Polonium-210, (2) incidents involving nuclear facilities or sites (e.g., Chernobyl Nuclear Power Plant in Ukraine and Fukushima Dai-ichi Nuclear Power Station in Japan, (3) events associated with atomic testing or atomic weapons activities (e.g., Marshall Islands in the Pacific and the Windscale Fire in the United Kingdom), and (4) recent planning exercises in the United States involving nuclear or radiological terrorism (e.g., TOPOFFs [12]and Liberty RadEx [13]). Depending on the availability of information or relevance, cases will be described as examples that may carry some important attributes that pertain to long-term, late-phase recovery. For events that are not directly linked to terrorist acts, the focus tends to be on the widespread contamination of the areas involved in the release of radioactive material. These include some major or significant nuclear/radiological accidents in recent history [14]. The most recent accident, in March 2011 at the Fukushima Dai-ichi Nuclear Power Station [15], deserves special mention because the contaminated area that potentially requires remediation has been estimated to be 13,000 km^2 (roughly the size of the state of Connecticut in the U.S.), based on the cleanup criterion of 1 mSv/yr, or 100 mrem/yr. Such remediation could generate as much as 29 million cubic meters (29×10^6 m^3) of contaminated waste, with decontamination costs on the order of $15.6 billion [16]. The recovery effort in Japan has only just started and will serve as a prime example for practicing the site-specific optimization approach advocated by such international organizations as ICRP and the International Atomic Energy Agency (IAEA).

4. Status of the NCRP Report

The NCRP report, which is due for publication in 2013, will take forward the current DHS guidance by clarifying and elaborating the processes required for both the development and implementation of procedures for optimizing decision making for late-phase recovery that will enable the setting of cleanup goals on a site-specific basis. The report is currently structured to contain a series of topics to address important issues relevant to the long-term recovery from nuclear or radiological events. These include the following:

- Characterization of late-phase conditions and contamination situations
- A decision framework for addressing late-phase recovery issues
- Identification of the affected basic and critical infrastructures and key factors needed for decision making
- A description of the optimization principles and implementation process
- Evaluation of lessons learned from historic events
- Description of sample scenarios to illustrate the optimization process
- Description of long-term monitoring and management of contaminated products
- Consolidated recommendations for late-phase recovery

Special topics that are relevant to supporting the optimization of the decision-making process will include cost-benefit analysis, radioactive waste management, risk communication, stakeholder interaction, risk assessment, and decontamination approach and techniques. In the process, any emerging issues related to the Fukushima nuclear accident will also be evaluated for incorporation.

To ensure that the report and NCRP recommendations are current and relevant with respect to the effective implementation of federal guidance, the SC5-1 Committee will actively coordinate with the agencies of interest and other relevant stakeholders throughout the project duration, thereby ensuring proper and timely incorporation of all relevant information that is available for the development of applicable and effective recommendations. The resulting report will be an important resource providing guidance for those involved in late-phase recovery efforts following a nuclear incident, whether accidental or resulting from an act of terrorism. Timely development of guidance on the late-phase optimization process as espoused by DHS is very much needed by society, preferably well before any RDD or IND terrorism incident occurs.

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Disclaimer

The views presented in this paper are those of the authors in consultation with other members of NCRP SC5-1 Committee. These views do not necessarily reflect the views of the organizations from which the members are drawn.

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