Issues Associated with Decision Making in Long-Term Recovery Following a Nuclear or Radiological Terrorism Incident – 11035

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ABSTRACT

Concern over acts of terrorism has emerged in recent decades and was greatly heightened by the events that took place in New York City on September 11, 2001. Since then, substantial attention has been devoted to addressing the possible scenarios that may arise from the use of various hazardous materials or dangerous devices for terrorist acts. Some of these efforts are associated with radiological hazards, such as radiological dispersal devices (RDDs) and improvised nuclear devices (INDs). By far, however, most preparedness efforts have focused on responding to the early phases of events, including triage to rescue lives or avoidance of initial exposure by evacuating or sheltering the affected populations, rather than the long-term recovery issues that may last for several years. Such lack of preparedness has raised considerable concern, as exemplified by the issues raised in a report by the General Accountability Office in January 2010. The concerns are based on past nuclear events, such as the 1986 Chernobyl accident in the Former Soviet Union; the natural disaster caused by Hurricane Katrina in New Orleans, Louisiana, in 2005; and the Deepwater Horizon oil spill in the Gulf of Mexico in 2010. In all these events, a general lack of preparedness capability for long-term recovery has fully illustrated the need for response that must go far beyond the initial triaging effort. The desired preparedness effort should consider long-term recovery issues that likely will encompass the entire spectrum from public policy, to impact analysis, to technology development, as well as stakeholder involvement in decision making. All these aspects require considerable in-depth development and preparation, much of it far in advance of the events.

INTRODUCTION

The potential use of radioactive or nuclear material in terrorist acts, either as radiological dispersal devices (RDDs) or improvised nuclear devices (INDs), has been a grave concern worldwide. As a result, extensive planning efforts have been conducted by responsible government agencies during the past decade. However, most of the emergency planning activities for managing such incidents have focused primarily on issues associated with responding to the initial triage effort, with much less emphasis on subsequent issues such as cleanup and recovery where extensive radioactive contamination could be an issue. The complexity of addressing lingering long-term contamination and subsequent recovery thus warrants careful deliberation and advance planning.

In general, society as a whole is ill-prepared to cope with the long-term aftermath of a major destructive event due to either natural or man-made causes. The extent of the problem has been manifested in natural disasters such as Hurricane Katrina, which hit the Louisiana area in 2005 [1]. Perhaps the most poignant reminder is the recent Deepwater Horizon incident involving a massive oil spill in the Gulf of Mexico in 2010 [2]. In these events, recovery of the affected society will take many years, if not decades and beyond. For radiological events, concern along these lines was expressed in a recent report issued by the Government Accountability Office (GAO) [3], which discussed areas of deficiency regarding the nation's ability to address potential long-term effects of radiological terrorist incidents. The GAO report concluded by calling for the preparation of a national disaster recovery strategy to address cleanup of areas contaminated with radioactive materials through RDD or IND incidents. Such discussion has been further elaborated by Chen and Tenforde [4] and also others [5-6].

RADIOLOGICAL EVENTS AND IMPACTS

As yet, no terrorist events of any large scale have involved radiological or nuclear materials or devices. Much of the available information, particularly that associated with late-phase implications, is derived largely from experience gained in past events involving nuclear facility operations or management of radioactive sources, including (1) nuclear power-generating facilities, (2) military and defense operations, and (3) radiation sources and transport [7]. To help characterize and communicate the significance of these events, the International Atomic Energy Agency, together with the Organization for Cooperation and Economic Development's Nuclear Energy Agency, have designed the international nuclear and radiological event scale (INES) [8]. INES comprises seven levels of severity (from low to high, Anomaly [Level 1] to Major Accident [Level 7]).The INES levels assigned for nuclear facilities are based on three major attributes: effect on people and the environment, effect on radiological barriers and control, and effect on defense in depth (the latter two applying only to nuclear facilities). Any significant impact would register a severity of at least Level 5 (i.e., releases that would require implementation of planned countermeasures). Such events have been cited by Chen and Tenforde [4] with possible INES levels, as follows:

- Level 5 – Accident at Three Mile Island Unit 2, Dauphin County, Pennsylvania, March 1979 [9]; and the Cesium Source Accident, Goiania, Brazil, September 1987 [10]
- Level 7– The Chernobyl Accident, Pripyat, Ukraine (Former Soviet Union) April 1986 [11]

A few more incidents have also been described in International Radiological Protection Commission (ICRP) Report 111 [12].

The examples of historical radiological or nuclear incidents serve as a benchmark for gauging the potential severity levels for an RDD or IND incident. Judging from the extent of the potential contamination and impact, one might possibly categorize a full-blown RDD incident at Level 5 (widespread contamination) and an IND incident at Level 6 or 7 (potential for causing major destruction) [4]. Of course, such incidents might cause a considerable range of impacts, depending on the scenarios and circumstances. Nevertheless, the potential threat of widespread contamination is something that a planner must consider as a late-phase recovery issue.

GUIDANCE AND APPROACH FOR LATE-PHASE DECISION MAKING

The document, *Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents,* issued by the Department of Homeland Security (DHS) in 2008 [13] provides guidance for all phases of response to an RDD or IND event and incorporates a framework and approach for implementation. Specific dose criteria are prescribed for both the early and intermediate phases of the event. No criterion, however, is provided for the late-phase (i.e., recovery) actions. Instead, a process called "optimization" was recommended for decision making associated with late-phase actions. The approach is a multifaceted process with extensive stakeholder involvement in reaching a decision.

The principle of optimization has been embedded in protection against ionizing radiation for many decades. In fact, it is the second principle of current radiation protection practice (the first being justification of practice, and the third being application of dose limitations). The latest guidance from the ICRP Report 103 [14] defines *optimization of protection* as follows:

> *The process of determining what level of protection and safety makes exposures, and the probability and magnitude of potential exposures, as low as reasonably achievable, economic and social factors being taken into account.*

The optimization approach is discussed further in ICRP Report 111 [12], which characterizes the late-phase recovery as the existing exposure situation for which a target reference level is designated. The potential reference level ranges from 100 mrem/yr to 2 rem/yr, but a level of about 100 mrem/yr is suggested. Of course, application of the ALARA (i.e., as low as reasonably achievable) principle is also emphasized. Along with the optimization approach, the ICRP specifically emphasizes the need to engage stakeholders in the decision-making process, although it also recognizes that the process should maintain flexibility. The recommended reference level is not meant for *compliance* purposes but rather for *management* purposes – as a guide that should be applied continuously to control the exposure to affected populations.

The optimization process described above would follow a similar approach, elaborated in a separate effort as reported in 1997 by the Presidential Commission on Risk Assessment and Risk Management [15]. The Commission described an iterative process of engaging stakeholders in the following sequence: defining the problem and context, characterizing the risks, identifying viable options, formulating decisions, taking actions, and evaluating the results. In this process, the stakeholders are fully engaged in decision making, until the process reaches completion. The many issues considered include public health, socioeconomics, national security, public welfare, and communications. The Commission's report is intended to serve as a model in developing the approach to making late-phase decisions on recovery following an event that could have significant long-term public health consequences.

CHALLENGES OF THE PLANNING EFFORT

Valuable lessons learned from past radiological events, such as the 1986 Chernobyl nuclear accident in Ukraine [11] and the 1987 Goiania incident in Brazil [10] discussed above, would serve as important bases for formulating effective responses to recovery phase issues. Previous exercises including the TOPOFF exercises [16] conducted by DHS also provide some useful insights. The recent Liberty RadEx exercise [17], conducted in late April of 2010 by the Environmental Protection Agency and collaborating agencies, specifically focused on the late-phase recovery issues from a simulated RDD event in the city of Philadelphia [17]. The exercise offered direct insight into the optimization process discussed above. Lessons learned from natural disasters including Hurricane Katrina in New Orleans in 2005 [1] and the Deepwater Horizon oil spill in the Gulf of Mexico in 2010 [2] also provide important information regarding recovery.

Several important issues regarding preparedness for late-phase recovery after radiological or nuclear events [3-6] are summarized below.

Applicable Policies

One of the most important subjects in developing preparedness for late-phase recovery activities is policy issues; developing policies generally requires time, and the lack of appropriate policies can substantially hinder recovery efforts. Examples of policy issues include radioactive waste management and disposal during a cleanup effort when large amounts of radioactive wastes of various types are generated [4]. Since timely disposal of the wastes in licensed radioactive disposal facilities might not be possible in view of long shipment distances, certain policies should be established to address at least the interim storage and disposal issues bearing on the event site.

Alternatively, further investigation may be needed on the feasibility of developing facilities allowing disposal of certain low-activity wastes to alleviate the burden. The need for such policy has been revealed in the previous nuclear incidents discussed above and was fully acknowledged in the Liberty RadEx event [17].

Another demonstrated need for a large-scale event is the development of a self-help program for the affected populations [12], to complement government-initiated cleanup activities with the full participation of the general public. In this regard, appropriate guidance and applicable tool kits would need to be developed well in advance. This specific issue was also raised by stakeholders during the Liberty RadEx event [17].

Research Needs

Understanding the basic physical aspects of radiological or nuclear events and subsequent contamination by the associated radionuclides is key to developing appropriate countermeasures. These physical aspects include atmospheric dispersion of the radioactive cloud, transport of radionuclides in the environment, and the spread of contamination through environmental media along various pathways. Although some of these issues have been well studied and understood, the specifics that pertain to the urban environment (a likely terrorist target) are largely unknown. For example, the bulk of nuclear explosion data were obtained at the Nevada Test Site (a remote location) some decades ago, and their applicability to an urban setting would depend on substantial adaptation and validation for events pertaining to INDs. Additionally, very little information exists to account for patterns of radioactivity deposition in an urban area and to integrate the partitioning of contamination on buildings, streets, parks, and sewage for the urban system. More research is needed in these areas to assess the recovery effort. Such issues have been echoed in the lessons learned from the Deepwater Horizon event where the evolving ecological damages were revealed while the event continued to unfold [2]. Specifically the GAO report also pointed out that current research efforts lack full-scale testing and verification despite the availability of extensive technology that has been developed for those purposes [3].

Uncertainties in Decision Making

The difficulty of developing a sound preparedness effort is often compounded by the highly unpredictable nature of a terrorist event. The lack of past examples could compel analysts to resort to modeling predictions based on either premature or inappropriate assumptions [18], thereby substantially influencing the decision-making process by either overestimating or underestimating the impacts of interest (human health risks, underlying costs, etc.). Emphasis should therefore be placed on identifying key parameters and their sensitivity to the overall outcome rather than striving to include an exhaustive list of parameters that may not carry significant relevancy to the issues. Even more uncertainties are involved in every step of decision making. These include the potentially viable future land use options; waste generation, treatment, and disposal; decontamination technology and efficacy; and the psychological effects on the affected members of the public. Past experiences and lessons learned, from either relevant events or exercises, offer immensely valuable input. Such information should be fully utilized, in conjunction with the new research and development work discussed above, to reduce the uncertainties in planning responses to terrorism events as pertaining to late-phase recovery.

Stakeholder Involvement

The optimization approach emphasizes extensive involvement with stakeholders in decision making. However, it must be recognized that the optimization process for the recovery phase actions would be fundamentally different from the more familiar processes prescribed under the current statutory cleanup processes including the EPA Superfund process. One difference is that decisions related to event situations are far more complex in nature, potentially involving multifaceted and yet interrelated issues, including recovery of the local economy, cleanup of the affected urban area, treatment and disposal of large amounts of radioactive wastes, and making resources (i.e., funds and logistics) available to support the action. In recognition of these concerns, the Federal Emergency Management Agency has recently advocated the “whole of community” concept for preparedness [19] against IND events. The concept requires full participation from all sectors of the community in responding to the event, throughout the entire process. To achieve this participation of stakeholders as partners in decision making, a systematic approach toward optimization will be required to develop a comprehensive framework and instructive processes with a sound scientific basis for stakeholder involvement.

SUMMARY AND SUGESTED PATH FORWARD

Although considerable effort has been expended in developing preparedness against RDDs or INDs, tremendous gaps exist with regard to late-phase recovery. Past experiences have confirmed these deficiencies, and the GAO report [3] and others have properly called attention to the potential consequences. The GAO specifically suggested the development of a national disaster recovery strategy to better cope with the potential long-term effects from acts of terrorism. The optimization process would be an important centerpiece of that process [4]. In fact, efforts along this line are already under way. For example, the National Council on Radiation Protection and Measurements (NCRP) has published several studies [20-23] aimed at addressing the decision processes associated with response to radiological or nuclear incidents. Recently, NCRP has undertaken an important study focusing specifically on the optimization decision-making process as it applies to long-term cleanup and site recovery following an RDD or IND incident. Efforts leading to late-phase preparedness have gradually gained national attention because of the recent natural disasters and topical exercises. This will lead to a more robust national state of readiness in responding to serious events that would be caused by RDDs or INDs.

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