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Managing the Consequences of a Clandestine Nuclear Attack

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PREFACE

This document reports on work performed by the Institute for Defense Analyses in partial fulfillment of a task entitled "An Integrated Cross-Capability Assessment and Risk Management Framework for Evaluating Major DOD Force Capability Options," sponsored by the Offices of the Under Secretary of Defense (Policy/Resources & Plans), Under Secretary of Defense (AT&L), Director (PA&E), and Deputy Director of the Joint Staff (J-8).

Dr. Victor A. Utgoff reviewed a draft of this report and made numerous helpful comments that were incorporated into this final version.

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CONTENTS

TABLES

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SUMMARY

This report considers how to manage the direct consequences of two clandestine nuclear explosions, presents a concept for the response operation, establishes the capabilities required and tasks to be performed, and estimates the numbers and types of responders needed to conduct the operation. The objective of the response operation is to maximize the number of healthy survivors and minimize the disruptive effects on the economy and society. The purpose of the report is to provide a basis for further work to establish an agreed upon response strategy, refine the personnel estimates, and address policy issues that will determine how the response operations will be conducted. Personnel estimates are derived by applying reasonable planning factors to accomplish anticipated workloads.

The report does not address the indirect consequences of such an event, such as the likely spontaneous evacuation of other—perhaps many—U.S. metropolitan areas.

THE ATTACKS

Two attacks are considered in the analyses. One is a 1.5-kiloton weapon detonated in a mid-sized city. The other is a 10-kiloton weapon detonated in a major metropolitan area. The smaller scenario was developed in 1997 by the Federal Emergency Management Agency. The larger scenario is Scenario #1 for official planning promulgated by the Homeland Security Council. The major assumptions upon which the analysis is based are taken from the Catastrophic Incident Supplement of the National Response Plan (NRP), and are as follows:

- The attack will occur with little or no warning.
- The weapon will be detonated at ground level.
- The attack will initiate an immediate federal response.
- State and local capabilities will be quickly overwhelmed.
- Mutual aid agreements will be null and void.
- Local emergency response management, medical, and public health capabilities will be destroyed or degraded significantly.

It is also assumed that the population in the affected areas will be unprepared, lacking public information, fallout shelters, evacuation procedures, and radiation meters and dosimeters.

SPATIAL ORGANIZATION

Based on the known effects of nuclear explosions, the space around the point of detonation is organized into three zones. The Primary Zone contains the blast, thermal, and prompt radiation effects. The Fallout Zone contains the delayed radiation effects from fallout. The Secondary Zone that surrounds the Primary and Fallout Zones serves as the base of operations within which people can work without exposure to radiation. The layout of the zones is shown in Figure S-1. The exact location of the perimeters will have to be determined by reconnaissance teams measuring radiation intensity.

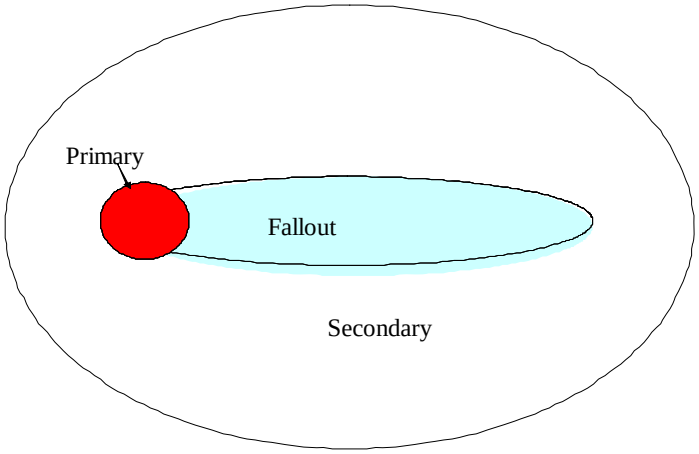

Figure S-1. Spatial Organization for a Nuclear Attack Response Operation

EFFECTS AND WORKLOADS

The major effects of the two explosions and the workloads resulting from those effects are shown in Table S-1.

Table S-1. Major Effects and Workload from the Nuclear Explosions

	1.5-kiloton Explosion	10-kiloton Explosion
Radius of Primary Zone (miles)	1	2
Perimeter of Primary Zone (miles)	6	12.5
Length of Fallout Zone (miles)	20	200
Perimeter of Fallout Zone (miles)	44	430
Dead	32,000	250,000
Injured	17,000	100,000
Radiation Illness	24,000	75,000+
People to be Evacuated & Processed	250,000	1,500,000
Vehicles to be Decontaminated	100,000	400,000
Secondary Zone Population	2,000,000	7,500,000
States Involved	1 - 2	4 – 5

THE STRATEGY

The general strategy is to place primary emphasis on evacuating the people in the Fallout Zone and processing them. Timely response is important. It is assumed that the initial actions will be taken by National Guard troops, who will establish the skeleton of the response organization to be filled in by arriving federal troops.

The Primary Zone will be established and sealed off to prevent inadvertent entry and to control exit by survivors of the immediate effects of the explosion. Controlled patrols by trained and equipped personnel may be sent into the Primary Zone to determine conditions and to perform limited search and rescue operations. As radiation intensity diminishes, the perimeter of the Primary Zone will be moved inward to permit workers to operate in the Primary Zone without excessive exposure to radiation.

The boundary of the Fallout Zone will be established initially based on plume modeling and validated as soon as possible by airborne and ground recon teams with radiation meters. Once this is done, emergency public information will be disseminated to guide the people in the Fallout Zone on how and when to move into the Secondary Zone. As the evacuees emerge from the Fallout Zone, they will pass through checkpoints along the perimeter at which they will be decontaminated, registered, triaged, and forwarded to treatment facilities or reception centers for further processing.

The Secondary Zone will serve as the base of operations for the response operations. The perimeter of the Secondary Zone will be controlled to discourage entry of persons with no official business and assure that evacuees leaving the Secondary Zone can be traced. Within the Secondary Zone, the evacuees will be provided medical treatment, long-term care for radiation victims, housing, and essential supplies and

services. Depending on the capacity of the Secondary Zone to host evacuees, it may be necessary to construct and operate emergency camps to house and care for a significant portion of the evacuees.

Once the evacuation is under control, emphasis will shift to the next phase of the operation, which is to provide long-term stability. As permitted by conditions, essential infrastructure services will be restored, remains will be processed, and the psychological effects of the incident will be addressed.

The response operation will be conducted in an orderly and deliberate manner, rapidly but without haste or disorder. Security, law, and order will be maintained at all times. Collaboration among the multiple agencies involved in the operation will be the key to successful execution.

TASKS TO BE PERFORMED

The concept of operations calls for the following major tasks to be accomplished in the general order listed below:

- Manage the Response
  - Identify the nature, location, and scope of the detonation
  - Activate NRP emergency management structure
- Maintain Situational Awareness
  - Predict the effects of the attack
  - Measure radiation intensity to bound the Primary and Fallout Zones
  - Inform the public, responders, and managers
- Save Lives
  - Establish cordons around the Primary, Fallout, and Secondary Zones
  - Manage the evacuation of the Fallout Zone
  - Decontaminate persons leaving the Primary and Fallout Zones
  - Conduct search & rescue operations in the Primary Zone
- Care for survivors and evacuees
  - Register and process survivors
  - Treat injured and ill persons
  - Provide mass care
  - Provide emergency housing
  - Provide emergency transportation

- Provide emergency logistics
- Provide emergency water supply
- Perform other Emergency Support Functions

- Stabilize the Situation
  - Restore essential services
  - Process the remains of the dead
  - Support agency operations in the Secondary Zone
  - Maintain security, law, and order

PERSONNEL ESTIMATES

The total numbers of personnel estimated to accomplish each of the above tasks were derived by the use of reasonable planning factors. The next step was to determine how many of these personnel could be civilians from federal, state, and local agencies, and how many would have to be military troops—active, National Guard, or State Defense Forces. Military troops would be used because:

- Military troops are required if the task requires armed personnel authorized to enforce the law and police officers are too few to perform the task. (It is assumed that the President will authorize the use of federal troops to enforce the law under the Insurrection Act.)
- DOD has special capabilities and technologies that can be applied to the response operation to perform tasks or augment civilian personnel.
- Only DOD has the capability to marshal and deploy the large numbers of trained, organized, equipped, and disciplined forces needed to conduct the response operation. Local and state personnel will be busy in their respective jurisdictions, and non-DOD federal agencies have few resources that can be freed for a catastrophic incident.

Personnel estimates to manage the consequences of the two nuclear attack scenarios are shown in Tables S-2 and S-3, respectively. Estimates by individual task are explained in the body of the document and summarized in Tables 15 and 16. Tasks that require large numbers of military personnel are measuring radiation intensity, securing the perimeters of the Primary and Fallout Zones, decontaminating evacuees, performing medical triage, constructing emergency camps, and supporting DOD operations.

Table S-2. Personnel Estimate for Responding to a 1.5-Kiloton Explosion

	Total	Civil	Military
Manage the Operation	3,000	2,000	1,000
Maintain Situational Awareness	5,200	3,200	2,000
Save Lives	17,200	6.500	10,700
Care for Evacuees	38,200	25,700	12,500
Stabilize the Situation	26,400	5,600	20,800
TOTAL ESTIMATE	**90,000**	**43,000**	**47,000**

Table S-3. Personnel Estimate for Responding to a 10-Kiloton Explosion

	Total	Civil	Military
Manage the Operation	5,000	3,500	1,500
Maintain Situational Awareness	15,000	10,500	4,500
Save Lives	54,200	21,500	32,700
Care for Evacuees	146,100	83,400	62,700
Stabilize the Situation	79,700	31,100	48,600
TOTAL ESTIMATE	**300,000**	**150,000**	**150,000**

This report presents the results of an initial analysis of how to manage the consequences of a clandestine nuclear attack. It is intended to be a prototype to be refined through discussion, disagreement, and successive improvement until a consensus is achieved. At that point, the resulting methodology can serve as the basis for preparing detailed plans for specific major metropolitan areas and as a basis for preparations and programs. The planning factors and estimates in this document are fair game for clarification and improvement. However, even at this preliminary stage, the personnel estimates in this paper can be used as a basis for addressing the programmatic implications of this kind of incident. Moreover, this general approach—particularly spatial organization—can also be used to address other forms of catastrophic attacks and some lesser attacks as well.

I. INTRODUCTION

> Today, it would be easy for adversaries to introduce and detonate a nuclear explosive clandestinely in the United States. The overarching recommendation of this Task Force is this: *For DOD to carry out both its exclusive and support responsibilities vis-à-vis the clandestine nuclear threat, it must develop substantially expanded and improved military force capabilities specific to this threat.*
>
> Defense Science Board Task Force on Preventing and Defending Against Clandestine Nuclear Attack, June 2004

The purpose of this analysis is to estimate the numbers and types of DOD military forces that will be needed, in addition to local, state, and other federal resources, to deal with the direct consequences of a clandestine nuclear explosion in the United States. Military forces in this context are armed troops in the Active or Reserve components of the military services, the National Guard in either federal or state status, and armed State Defense Forces. The analysis does not address such likely indirect consequences as the spontaneous precautionary evacuation of other U.S. metropolitan areas.

The IDA team used a capability-based approach to estimate the resources—people and equipment—required to respond to a nuclear device detonated by terrorists in the United States. In recent years, some attention has been paid to nuclear accidents and radiological emergencies, but these events are quite different from nuclear explosions. Little attention has been paid to dealing with the consequences of the most serious threat, which is detonation without warning of one or more nuclear weapons.

This analysis is a first rough cut at establishing what it takes to manage the consequences of a clandestine nuclear attack. The concept, capabilities, tasks, and above all the planning factors used to derive the personnel estimates are all subject to criticism and modification. Ideally, it will be possible to use this paper as a starting point to refine the way in which response operations are planned and executed. A nuclear attack is a possibility, and it is necessary to contemplate what to do about one. That said, the estimates derived by this analysis do not translate directly into force structure or other concrete measures. Using these personnel estimates—suitably reviewed and vetted—as a base, it will be possible to devise a planning and resource posture that can respond adequately to the frequent lesser terrorist incidents while providing a surge capability to respond to the infrequent catastrophic incidents. This is a starting point for that process.

II. DESCRIPTION OF THE NUCLEAR ATTACKS

The analysis is based on two scenarios, each of which describes the effects of a nuclear explosion detonated without warning at ground level. In each scenario, the device has avoided detection en route and has been placed at the target clandestinely. One of the scenarios is for a 1.5-kiloton yield device detonated in a state capital, and the other is for a 10-kiloton yield device detonated in a major metropolitan area. The appendix to the present document summarizes the effects of those explosions, with emphasis on radioactive fallout, and provides some information on how to avoid death or illness from ionizing radiation. Table 1 presents the basic characteristics of the two attacks.

Table 1. Basic Characteristics of Two Nuclear Attack Scenarios

Basic Characteristics	State Capital	Major Metropolitan Area
Nuclear yield ((kilotons)	1.5	10
Location	n/a	North 38.90; West 77.0392
Height of burst	4th (top) floor of parking garage	Ground level
Height of cloud top (feet)	12,000	26,607
Mean wind direction	Notional	North East
Wind velocity at cloud top (miles per hour)	Notional	74.5
Time of day	Mid-morning	Working hours
Day of week	Workday	Workday

In the 1.5-kiloton scenario, a terrorist group detonates an improvised nuclear device in a van parked on the fourth floor of a parking garage adjacent to a state capitol building in a mid-sized city in central United States.[1] The explosion results in a fireball about 300 feet in diameter with a mushroom cloud rising to 12,000 feet before dispersing in about 45 minutes. The detonation occurs about noon in the middle of the workweek. The explosion causes the following effects:

- Blast overpressure damages people and structures. The overpressure at the point of detonation is about 200 pounds per square inch (psi), 15 psi at ¼

[1] Federal Emergency Management Agency, An Assessment of Federal Consequence Management Capabilities for Response to Nuclear, Biological, or Chemical (NBC) Terrorism: A Report to the President, February 1997 (FOUO); and Federal Emergency Management Agency, Federal Capability to Respond to the Consequences of an NBC Terrorist Incident, June 1999 (FOUO).

mile, 5 psi at ½ mile, 3 psi at ¾ mile, and 2psi at 1 mile. Destruction is complete near the point of detonation and is minimal outside the 1-mile zone.

- Thermal effects cause second-degree burns out to 2 miles. There are numerous secondary fires.
- Prompt radiation from the explosion will expose to a fatal dose all persons in a circle of radius ½ mile and half those in a circle of radius 1 mile. Symptoms will appear from ½ to 6 hours after the explosion. Deaths will occur from 2 to 14 days after the explosion.
- Gamma radiation will extend outward from the point of detonation and also be carried by radioactive fallout particles borne on winds aloft downwind about 12 miles. Persons receiving a less than fatal dose will require immediate treatment of varying intensity, depending on exposure, and long-term health monitoring and treatment for radiation-induced cancer.

In the 10-kiloton scenario, terrorists detonate a 10-kiloton nuclear device in a major metropolitan area.[2] The explosion occurs without warning during working hours on a weekday when the city is full of commuters. The device is detonated on the ground in the center of the city. The explosion results in a fireball and a mushroom cloud rising to 26,000 feet before dispersing.

The explosion causes the following effects:

- Blast overpressure at the point of detonation is several hundred psi. Overpressure is 30 psi at ¼ mile, 8 psi at ½ mile, 4 psi at ¾ mile, and >2 psi at about 1 mile.
- Thermal effects will take effect inside the area affected by the blast effects. Secondary fires are likely to result from the thermal effects.
- Prompt radiation effects will occur inside the area affected by the blast effects.
- Gamma radiation will extend outward from the point of detonation and also be carried by radioactive fallout particles borne on winds aloft downwind about 200 miles.

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2 The Homeland Security Council, *National Planning Scenarios: Created for Use in National, Federal, State and Local Homeland Security Preparedness Activities*, April 2005 (FOUO). This document presents 15 scenarios for use by the entire homeland security community for planning, estimating estimates, and setting priorities. Scenario #1 depicts a 10-kiloton nuclear explosion in a major metropolitan area. The data used in this analysis is for a detonation in Washington, D.C., which is used as the "exemplar" for this scenario.

III. METHODOLOGY AND ASSUMPTIONS

This analysis uses a capabilities based approach based on assumptions flowing from the nature of the incident and availability of resources.

A. Methodology

The general approach taken in this analysis is as follows:

- Establish the objective functions for the response operation. A clear statement of the objectives of the operation provides the basis for formulation of policies, plans, and programs for consequence management.
- Formulate a concept of operations describing how the response operation will start and evolve over time to achieve the objective functions.
- Describe the capabilities required to carry out the concept of operations, and identify the tasks that have to be done to provide those capabilities.[3]
- Translate weapons effects into workload factors that determine the time-phased amount of each capability needed to achieve the objective function.
- Estimate the numbers and skills of personnel and the numbers and types of equipment needed to deal with the workload, considering time and space constraints. This will provide an estimate of the total number and skills of personnel and the total amount and kind of equipment and supplies needed to manage the consequences without regard for source.
- Consider the supply of non-DOD resources based on the assumptions and apply criteria to determine the estimated demand for military troops.

This methodology allows us to make a rough estimate of the total personnel needed to manage the consequences of a clandestine nuclear attack and to estimate the number of federal troops that would be needed as part of the overall response. The following sections detail the concept of operations and the capabilities and personnel required for the response.

[3] Although not considered in this analysis, it would be possible also to define metrics to allow managers to know the extent to which they can accomplish these tasks.

B. Assumptions

The general assumptions upon which we based this analysis are stated below. The assumptions marked with asterisks are found in the Catastrophic Incident Supplement to the National Response Plan, Appendix 1—General Planning Assumptions.[4]

- The attack may occur with little or no warning.*
- The attack will be a ground burst.
- The attack will initiate an immediate federal response.*
- State and local capabilities will be quickly overwhelmed.*
- Mutual aid agreements will be null and void. *
- There will be widespread panic and disorder.
- The population in the affected area will be unprepared, lacking public information, fallout shelters, evacuation procedures, radiation meters, and dosimeters.
- Local emergency response management, medical, and public health capabilities will be destroyed or degraded significantly.*

IV. CONCEPT FOR CONSEQUENCE MANAGEMENT OPERATIONS

The objective functions for managing the consequences of a nuclear explosion are to maximize the number of healthy survivors and minimize the duration and severity of societal and economic disruption. In order to do these things, it is necessary to inform the public of measures to avoid or minimize exposure to ionizing radiation, measure and map radiation intensities, prevent people from unwitting exposure to radiation, process and care for people who have been or may have been exposed to radiation, and promote stability and resumption of normal activity.

The first step in formulating a concept of operations is to organize the space around the point of detonation. As shown in Figure 1, the area affected by the explosion is divided according to the kind of effects into three zones: (1) a Primary Zone that contains the blast, thermal, and prompt radiation effects; (2) a Fallout Zone that contains the delayed radiation effects from fallout; and (3) a Secondary Zone that surrounds the Primary and Fallout Zones to serve as a base of operations in which people can work without exposure to radiation.

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[4] Department of Homeland Security, National Response Plan, Catastrophic Incident Supplement, Appendix 1, General Planning Assumptions, Draft Version Four, June 2004. (FOUO)

The strategy for managing the consequences of a nuclear attack is to seal off the Primary Zone until proper arrangements can be made to enter it and work without endangering the responders; identify and control the boundary of the Fallout Zone while encouraging people to evacuate that area; and establish in the Secondary Zone a base of operations to conduct the response operation and take care of the evacuees. All of these three major activities are carried out at the same time.

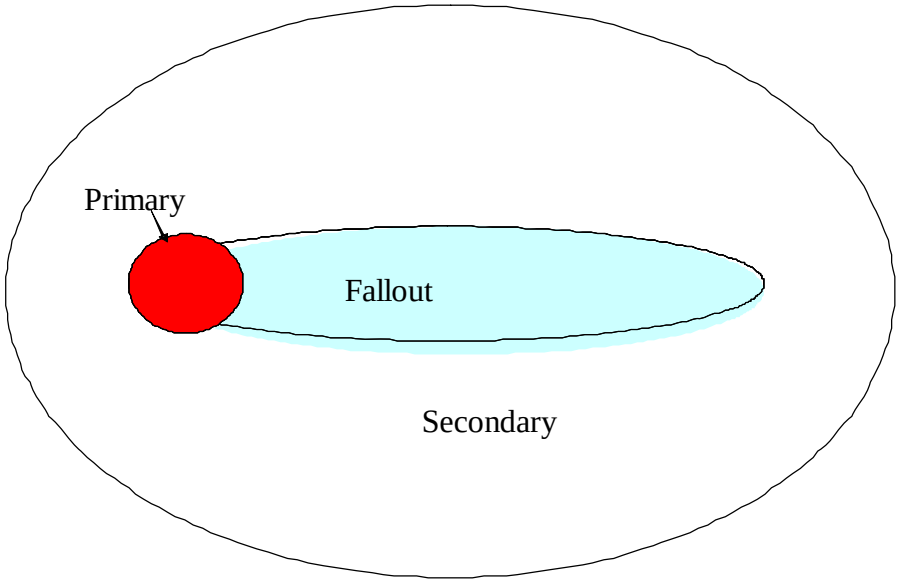

Figure 1. Nuclear Explosion Response Zones

The Primary Zone is an irregular circle whose center is the point of detonation and whose radius is the distance from the center beyond which people can work without protection against radiation. The strategy for the Primary Zone is to establish a tight cordon around the perimeter then move the cordon inward carefully as radiation intensity diminishes, dealing with victims and damage found in the areas newly uncovered as the Primary Zone decreases in size. Consistent with safe limits of radiation exposure, trained, and properly equipped personnel may enter the Primary Zone for short periods of time to assess damage, deploy sensors, and evacuate survivors. Survivors who are able to leave the Primary Zone on their own will be processed as they pass through the cordon. For this analysis, the initial radius of the Primary Zone has been established arbitrarily at the 1 rem per hour radiation contour, although, as will be discussed below, this contour would likely soon be adjusted to limit the need to rotate cordon personnel to ensure their

exposure remains within acceptable limits..[5] This distance will be outside the direct thermal, prompt radiation, and blast effects of the explosion. Entry into the Primary Zone will be controlled to prevent people from unwittingly putting themselves at risk. Exit from the Primary Zone will be controlled to assure that survivors are decontaminated, registered, processed medically, and sent either to medical facilities for treatment or to reception centers for further processing. Since the area of the Primary Zone will diminish as radiation intensity decays, most actions to deal with damage done by the blast and thermal effects will be deferred until they can proceed safely. Properly trained and equipped personnel might do be able to do some very important short-duration work inside the Primary Zone.

The Fallout Zone is an elliptical area stretching downwind from the point of detonation within which there is radiation from the fallout of the explosion. The radioactive plume originates in the Primary Zone and extends downwind as determined by the yield of the explosion, height of burst, and wind velocity. The boundary of the Fallout Zone is likely to be highly irregular due to differences in the flow of air over and downwind from the point of detonation. The strategy for the Fallout Zone is to define it, establish a loose cordon around it, and evacuate people from the zone as rapidly as possible. The goal is to get all of the people out of danger until the intensity of fallout radiation diminishes to safe levels. Once the evacuation is done, there will be no response activity inside the Fallout Zone. Unprotected people will be denied entry into the Fallout Zone. People leaving the Fallout Zone will be decontaminated, registered, processed medically, and sent either to a medical facility for treatment or to reception centers for care and housing. As radiation intensity decays, the Fallout Zone will contract, and evacuated persons will be allowed to reenter safe areas under controlled conditions.

The Secondary Zone is an elongated elliptical area that surrounds the Primary Zone and the Fallout Zone and contains the space, people, and activities affected by the exodus of survivors from the other zones and the influx of emergency management and military personnel to deal with the consequences of the explosion. This is a staging area and base for response operations. The size of the Secondary Zone is determined arbitrarily to be the distance that persons evacuated from the Fallout Zone can travel in 1 day, or about 200 miles. Entry into the Secondary Zone will be controlled to prevent unauthorized persons from entering the zone and increasing the confusion and burden on

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[5] See the appendix for an explanation of radiation and the units used to measure radiation intensity and accumulated dose.

its housing and support capacities. Exit from the Secondary Zone will be controlled to ensure that evacuees are accounted for.

A. Primary Zone Operations

In the Primary Zone, the combined effects of blast, thermal, and direct radiation will kill many people, injure others, and destroy many buildings and the infrastructure sufficiently to disrupt activities and make movement difficult. Radiation measurements will determine when it will be safe for emergency responders to enter the outermost areas of the zone to look for survivors, estimate damage, and start the response and recovery process. Initially, the boundary of the Primary Zone will be established at the 1 rem/hour intensity contour based on estimates of the yield of the nuclear device. The boundary will be adjusted subsequently based on measured radiation intensity levels. The perimeter of the Primary Zone will be secured to prevent inadvertent entry by unauthorized personnel.

In the 1.5-kiloton scenario, the initial Primary Zone radius is about 1 mile, the perimeter is a little over 6 miles long, and the area just over 3 square miles. Of the 130,000 people who lived or worked in that zone at the time of detonation, 32,000 are dead, 4,000 are seriously injured, 3,000 have 2nd or 3rd degree burns, 2,000 have acute radiation sickness from a less than fatal dose, 7,000 have minor injuries, 24,000 have chronic radiation sickness that will result in cancer, and 27,000 are unaffected physically by the detonation. Almost everyone within a half mile of the detonation point is dead, and almost all of the survivors are in the belt from ½ to 1 mile from the point of detonation.

In the 10-kiloton scenario, the initial Primary Zone radius is about 2 miles with a perimeter 12.5 miles long and an area of 12.5 square miles. At this distance from the point of detonation, blast overpressure would be less than 1 psi and not a significant factor. It is estimated that about 57,000 people in the Primary Zone will be killed from all causes. Another 33,000 people will be injured or ill from all causes and will require immediate medical attention.[6]

Operations in the Primary Zone and along its perimeter are complicated by the presence of gamma radiation from the detonation. For the 10-kiloton explosion, the intensity of gamma radiation 2 miles from the point of detonation would be about 1 rem/hour. Personnel responsible for securing the perimeter and processing people

6 The way that the effects are stated in the 10-kiloton scenario makes it very difficult to calculate killed and injured people or to state the damage to structures from the blast overpressure.

leaving the Primary Zone could accumulate a harmful dose of radiation in a relatively short period of time. Either the personnel will have to be rotated often or they will have to have hasty shelters. Alternatively, it might be advisable to increase the initial radius of the Primary Zone to the point where radiation intensity poses no danger to unprotected workers. It is necessary to calculate not only the 1 rem/hour radiation contour but also the radiation contour that signifies insignificant radiation intensity.

Because of the presence of gamma radiation, conducting response operations inside the Primary Zone will be very dangerous for emergency workers. The length of time that personnel can be exposed to radiation will be limited by their accumulated radiation dose, which should not exceed 25 rem per sortie into the zone. This will permit hasty reconnaissance and placement of some radiation sensors but will be inadequate to permit effective search and rescue operations. Some survivors of the prompt effects, including many with minor injuries, will be able to walk out of the Primary Zone. It may be possible, but perhaps not advisable, to conduct limited search and rescue operations inside the Primary Zone. This topic is addressed in Section C.4., below.

In both of these attacks, physical damage does not necessarily lead to widespread or prolonged disruption of essential services. Underground utilities are likely to be relatively unscathed. Even complete destruction of switches, bridges, and power lines in the Primary Zone can be by-passed so that the effects are largely limited to the Primary Zone itself. Doing this rapidly depends on having plans in place for rerouting and using backup circuits. The necessity to wait until radiation intensities have diminished to a safe level will delay response and recovery actions in the Primary Zone.

One major problem in both of these scenarios, which are placed in a state capital and Washington, DC, respectively, is that the explosion will kill most government officials and impair the ability of the state government or federal government to respond to the attack. Continuity of operations plans will be activated, but it will take some time before the alternative systems are operational. In the meantime, the response operation must move forward in accordance with existing plans and standard operating procedures.

In both scenarios, the emergency management system within the Primary Zone will have been rendered ineffective by the attack. Many police officers, fire fighters, and health care personnel will have been killed or injured, and most of the survivors will not be in condition or equipped to work in the primary zone. In the 1.5-kiloton attack, state agencies responsible for consequence management have been disrupted. In the 10-kiloton attack, the agencies responsible for consequence management in the major metropolitan

area will have been disrupted. Emergency responders who survive will themselves be trying to leave the Primary Zone, with some of them assisting other survivors.

In the Primary Zone, the primary concern of all involved is personal survival. Once the boundary of this zone has been defined and a tight cordon has been established to control movement in and out, there may be some individuals and groups that attempt to enter the zone to loot or search for family members, particularly in the outer fringes that may appear to be safe.

B. Fallout Zone Operations

The boundary of the Fallout Zone marks the area within which gamma radiation from radioactive fallout poses a health hazard to unprotected people. The size of this area depends on the direction and velocity of the winds aloft that carry the radioactive fallout particles. The anticipated shape is a rough fan that could have an irregular boundary. This boundary is indistinct and hard to define because it depends on measuring the intensity of radioactivity at enough stations to define the boundary perimeter. This line will change as time passes and the intensity of radiation decreases, shrinking the area in which radioactivity remains a danger.

In the 1.5-kiloton scenario, the Fallout Zone extends 13 miles downwind from the point of detonation. The perimeter of the Fallout Zone is about 42 miles, and the area is about 130 square miles.

In the 10-kiloton scenario, the Fallout Zone is divided into two sub-zones. In the Acute Sub-zone, which is inside the 150-rem/day contour, there are 300,000 people, of whom 190,000 receive a fatal dose, 74,000 receive a serious dose that makes them ill, and 36,000 remain healthy. In the Chronic Sub-zone, which marks the area that receives less than 50 rem/day but more than 0.33 rem/day, there are 1,350,000 people, of whom 25,000 will have fatal cancers and another 25,000 non-fatal-cancers some time after the detonation.[7] These casualty estimates are based on the personnel remaining unprotected in the Fallout Zone for 24 hours, neglecting the shielding effects of buildings. There is overlap between the Primary Zone and the Fallout Zone, so some of the people inside the Acute Sub-Zone may be included in casualties from blast and thermal effects.

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7 Radiation intensity in the Acute Sub-zone is stated in terms of rem per 24 hours. Radiation intensity in the Chronic Sub-zone is stated in terms of rem per 96 hours—or 3 days. Thus, 150 rem/day in the Acute Sub-zone is equal to 50 rem/day in the Chronic Sub-zone.

There will be no physical damage from the nuclear explosion in the Fallout Zone. There may be damage from other causes.

The major concern for people within the Fallout Zone will be to survive the harmful effects of ionizing radiation emanating from the fallout. Survival can be achieved either by shielding or by leaving. Leaving the Fallout Zone is the better solution for an unprepared populace. For people with no information and no idea of how to shelter themselves, and no instruments for measuring radiation intensity and accumulated dose, the best thing to do is to get out of the Fallout Zone as fast as they can.

People can minimize their exposure to radiation by taking some relatively simple actions after the explosion, but they have to know what to do and have the means to do it. Those who cannot or will not evacuate can protect themselves and their families by finding or constructing radiation-proof shelters that block gamma radiation. They can wait in their radiation shelters until they can be moved out or until radiation intensity has diminished to a safe level. However, doing these things requires advance planning and preparations, including having the right survival tools. People who shelter in place need to have radiation meters to measure the ambient radiation intensity so they know when it is safe to leave the shelter. Individuals need to have dosimeters to monitor the accumulated radiation they have absorbed; so they can manage their exposure based on their absorption readings. The ability of people to stay in improvised or designated fallout shelters will be limited by the stocks of food and water in those shelters. People without knowledge and survival tools will have to remain in their shelters until they run out of food and water and then take a chance on evacuating without receiving an excessive dose of radiation.

At this time, few preparatory actions have been taken for fallout protection and few people know how to construct shelters, and it is likely that almost all of the residents of the Fallout Zone will seek to leave as soon as they become aware of the radiation hazard. They will move spontaneously, causing traffic congestion and delays. Lacking information about the boundary of the Fallout Zone, they may stop too soon or go too far. Many of those evacuating the Fallout Zone will have already been exposed to radiation without their knowledge. It will be hard to identify these people until symptoms occur within hours or days of the explosion.

Within the Fallout Zone, local governments and operating elements of state agencies will be functional at the outset of the response, depending on the status of utility services and communications. However, like the general populace, they will be ill

prepared to operate in a radioactive environment. They may not have been trained or equipped to manage a massive spontaneous evacuation. In the initial hours before the extent of the Fallout Zone is defined and communicated, there will be great confusion about what to do. Survivors will start to leave the Fallout Zone spontaneously, and local police departments will try to assist their movement away from the danger area. Some emergency response personnel may opt for survival and join the evacuation. When these emergency responders enter the Secondary Zone, they will be relatively ineffective without bases of operations for resupplying and reorganizing. They cannot be counted on for effective support until several days after the explosion.

There may be some civil disorder in the Fallout Zone. The major problem will be in controlling the spontaneous evacuation of the zone. There may be conflict and violence as some people seeking to leave the Fallout Zone ignore instructions and try to get ahead of others or simply out of fear and rage cause trouble when their exit routes are blocked or movement is stalled. During the evacuation and after the Fallout Zone has been emptied of people, criminals may loot and prey on others. Efforts to maintain law and order will focus more on the mass evacuation than on minor criminal acts.

Immediately after the explosion, many people near the explosion will self-evacuate in all directions away from the point of detonation. There will be mass confusion in the area around the point of detonation until the Fallout Zone boundary is determined and announced to the public. Local law enforcement personnel will be busy dealing with a mass, aimless exodus. The movement of these people will impede entry of response personnel and troops and make it hard for people leaving the Fallout Zone. Once the direction and size of the plume is known and the initial perimeter of the Fallout Zone is established, law enforcement personnel and troops will have to prevent evacuees from entering the Fallout Zone and try to manage and curtail outbound movement from safe areas where there is no radiation hazard. As soon as the initial Fallout Zone perimeter is determined, it will be advisable, though difficult, to prescribe a “stay in place” policy for the Secondary Zone. Since this policy will be hard to enforce, it will be necessary as a minimum to keep main routes into the Secondary Zone clear for response personnel, and to stabilize or clear the areas immediately around the Primary Zone and Fallout Zone so that response operations can proceed.

C. Secondary Zone Operations

The Secondary Zone is the support base and staging area for consequence management operations. The Secondary Zone is a band around the other two zones that extends about 200 miles out from the perimeters of the Primary Zone and Fallout Zone. Its outer boundary will be the limit of disruption of normal activities by actions taken in response to the nuclear explosion. For this analysis, the width of the Secondary Zone is established arbitrarily as 200 miles. The Secondary Zone has to be large enough to provide adequate space to house and care for large numbers of evacuees.

The Secondary Zone for the 1.5-kiloton explosion encompasses an area of about 168,000 square miles, has a population of about 2 million, and includes many counties and perhaps parts of two states. In this scenario, about 250,000 people will leave the Fallout Zone and enter the Secondary Zone, increasing its population by 12 percent.

In the 10-kiloton scenario, the area of the Secondary Zone encompasses 164,000 square miles, has a population of 7,500,000, includes parts of several states, and will receive 1.5 million evacuees, a population increase of 20 percent.

The major activity in the Secondary Zone will be to receive, decontaminate, register, examine for medical condition, treat if needed, house, and sustain with essential life support the people evacuated from the Fallout Zone. This activity will require effective command immediately after the detonation. There will be shortages of decontamination equipment and medical facilities at first. In the short term, sufficient mass care resources are available or can be made available to accept a sudden, significant increase in population, but there will be spot shortages and discontent with priorities. In the longer term, there may be shortages of some supplies. Initial enthusiasm by communities in the Secondary Zone may fade as the situation continues without an ending in sight. It will take weeks or even months before the radiation levels in the Fallout Zone allow safe access to that area. During that prolonged period, there may be conflict between the host population and the displaced population, with some animus toward the authorities responsible for maintaining order.

Emergency management organizations in Secondary Zone jurisdictions will be intact and operational, but they will be completely occupied within their own jurisdictions. Local police, fire, and medical personnel will be consumed totally by incidents arising from the evacuation itself—particularly the influx of large numbers of evacuees into their jurisdictions. They will be unable to perform alone the tasks of

securing the perimeters of the Primary, Fallout, and Secondary Zones, managing the spontaneous evacuation of personnel, performing radiation surveys, decontaminating personnel and vehicles, providing medical care, and processing remains. Even after the evacuations are brought under control, there may be violence associated with the movement and reception of thousands of new people into this area, and some people may take advantage of the confusion to loot and rob.

Table 2 shows the relevant features of the areas affected by the two nuclear attacks, including estimates of workload.

Table 2. Relevant Characteristics of Areas Affected by the Nuclear Explosions

Response Zone	State Capital, 1.5-kiloton Explosion	Washington, DC, 10-kiloton Explosion
Primary Zone		
Radius (miles)	1	2
Perimeter (miles)	6	12.5
Area square miles	3	12.5
Pre-attack Population	100,000	300,000
Dead	32,000	57,000
Injured or Burned	17,000	33,000
Radiation Sick	24,000	See Below
Unaffected Survivors	27,000	210,000
Fallout Zone		
Acute Radiation Sub-Zone (> 150 rem)		
Length (miles)		20
Width (miles)		2
Perimeter (miles)		44
Area (square miles)		40
Pre-Attack Population		300,000
Acute Radiation Dead		190,000
Acute Radiation Sick		74,000
Survivors		36,000
Chronic Radiation Sub-Zone (> 1 rem)		
Length (miles)	13	200
Width at End of Fan (miles)	13	30
Perimeter (miles)	42	430
Area (square miles)	130	6,000
Pre-Attack Population	250,000	1,360,000
Fatal Cancers		25,000
Non-Fatal Cancers		25,000
Secondary Zone		
Width of Band (miles)	200	200
Area (square miles)	168,000	246,000
Pre-attack Population	2,000,000	7,500,000
People to be Evacuated	250,000	1,500,000
Vehicles to be decontaminated	100,000	400,000
States involved	1 or 2	MD, DE, PA, NJ

V. CAPABILITIES AND RESOURCES FOR CONSEQUENCE MANAGEMENT

Effective management of the consequences of this kind of attack requires the following major capabilities: managing the response operation, maintaining situational awareness, saving lives, caring for survivors and evacuees, and stabilizing the situation. The effects of the explosion are translated into workloads for each zone, as follows:

- Length of the perimeter of each of the zones
- Number of people killed by the direct and secondary blast and thermal effects of the explosion or who die from injuries or radiation exposure
- Number of people injured by the direct and secondary blast and thermal effects of the explosion or made ill from radiation exposure
- Number of people evacuated into the Secondary Zone

The next step is to consider the capabilities needed to deal with the workload and translate them into personnel estimates. These personnel estimates for each capability are derived initially irrespective of the source. In some cases, time is a factor, for some capabilities are needed early, some may be delayed. Duration is also a factor, for some capabilities are needed only for a short time, and others are needed for an extended period of time.

Personnel to conduct the response operation generated by this methodology can be obtained from a variety of sources. Local government agencies will respond initially. Personnel from state and federal agencies will reinforce these emergency responders. Private-sector companies and local volunteer organizations will also contribute personnel and equipment. Much of the work to be done requires people who are organized, equipped, trained, and disciplined—including fire fighters, health care specialists, public works engineers, and mass care providers. Some of the work requires that personnel also be armed and authorized to enforce the law and use lethal force if necessary.

Since the purpose of this analysis is to estimate the demand for military troops, the personnel estimates are examined to establish the extent to which required personnel should be military troops. Three criteria are applied to make this determination.

1. Military troops are needed if the task requires armed personnel authorized to enforce the law. These tasks are done by police officers as much as possible. Estimates for armed personnel that exceed the capability of law enforcement agencies can be met by state defense force members, National Guard troops, or federal troops. If police and state defense force personnel are not sufficient to do the task, the only other source of armed troops is DOD.

2. DOD, by virtue of its preparations for expeditionary warfare, has capabilities and technologies that can also be applied to domestic operations. If DOD has these capabilities and other agencies lack them entirely or have them in insufficient amounts, DOD can provide the capability entirely or augment civil capabilities as necessary.

3. For a catastrophic incident, DOD is the only organization that can quickly marshal and deploy to the incident site large numbers of trained, organized, equipped, disciplined, and armed personnel to support a response operation. Local emergency responders will be destroyed, disorganized, or busy. State resources alone are inadequate. Other Federal Agencies and the Red Cross will respond with significant numbers of personnel in accordance with the National Response Plan, but their capabilities will be insufficient to meet all of the needs—particularly for crowd control and security. During and after an attack, DHS law enforcement personnel guarding borders, patrolling maritime approaches, and providing internal transportation security will be put on high alert, augmented, and unable to deploy in large numbers to the attack area.

Judicious application of planning factors makes it possible to estimate the total numbers of federal, state, and local, and federal government resources required to achieve the capabilities needed to deal with the workload.[8] Application of the criteria above makes it possible to identify that part of the total personnel estimate that has to be or ought to be filled by military troops. In the following section, capabilities and personnel estimates for the response are discussed in some detail.

A. Manage the Response

Management of the response effort is necessary from the outset to restore order amidst the confusion and to prevent the situation from degenerating into chaos. Doing the right things in the first few hours will save thousands of lives that otherwise would be lost. In this situation, the bottom-up incident command system will be unable to cope with the magnitude of the work to be done. Command posts in the affected zones will be inoperative, and coordination among various jurisdictions will be difficult. It would be very useful if local governments considered carefully what to do for the first few hours after an attack for their metropolitan area and then rehearsed these actions to be taken automatically when an attack occurs. While responders near the incident area will take

[8] In addition to these government personnel, large numbers of personnel from businesses, private organizations, and the public will also be involved in the response operation.

the initial steps, the federal government has to be prepared also to take charge from the top immediately and aggressively.

The Catastrophic Incident Supplement (CIS) of the National Response Plan (NRP) tells how the federal government will establish a management capability to achieve unity of effort. This plan calls for designating a Principal Federal Official (PFO) who will represent the Secretary of Homeland Security and deploy to the scene to manage the overall response. Until the PFO arrives, the cognizant Regional Director from the Federal Emergency Management Agency will coordinate the federal response. In addition, a Federal Coordinating Officer (FCO) with staff support will move to a state or other emergency operations center and coordinate provision of federal support through the states to the local authorities, using the incident command structure. Other federal departments and agencies each plan to bring an emergency response team to manage the activities of their own agencies.[9] The general approach will be in accordance with the National Incident Management System.

DOD will maintain unity of command over all DOD elements involved in the response operation. A Defense Coordinating Officer (DCO) will maintain liaison with the Principal Federal Official to facilitate DOD's participation in the overall effort. A Joint Task Force (JTF) will command all of DOD elements involved in consequence management operations. The JTF commander will be or will support the DCO. Elements of the JTF headquarters should be on scene within a few hours of the detonation ready to receive and assign tasks to other military forces at or moving to the scene, assume emergency command of DOD bases and support elements in the Fallout Zone and Secondary Zone, work with the Federal Coordinating Officer from DHS, and establish liaison with local and state authorities as necessary. The JTF headquarters would be augmented with detachments that provide specialized capabilities, such as public affairs, civil affairs, psychological operations, and communications.

The number of people required to provide effective management around the clock depends on the number of people involved in the overall effort and the number of local and state jurisdictions and federal agencies involved. Additional personnel will be required to provide communications support to the headquarters, particularly if there have been electromagnetic pulse (EMP) effects from the explosion. Table 3 shows

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9 Department of Homeland Security, "NRP – Catastrophic Incident Supplement, Draft, June 2004 (FOUO), pp. 5, 6.

estimates of the federal personnel required for the management task for DOD and civil agencies.

Table 3. Personnel Estimates for Management of the Response Operation

	1.5-kiloton Explosion			10-kiloton Explosion		
	Total	**Civil**	**DOD**	**Total**	**Civil**	**DOD**
Headquarters	1,500	1,000	500	2,500	2,000	500
Communications Support	1,500	1,000	500	2,500	1,500	1,000
Total	3,000	2,000	1,000	5,000	3,500	1,500

B. Maintain Situational Awareness

In order to control the response operation and avoid unnecessary deaths and illness, all participants and the general public need to be made aware and kept aware of the situation in sufficient detail to enable good decisions. Having this capability depends in part on being able to predict the effects of the detonation, measure the intensity and accumulated dose of ionizing radiation, and inform the managers, participants, and public of what is happening and what to do.

1. Predict the Effects of the Explosion

It is important to establish the yield and height of burst of the weapon and current weather patterns immediately after the explosion so that the extent and shape of the Primary Zone and Fallout Zone can be predicted. Many subsequent response actions are based on this initial information. The Department of Energy (DOE) is responsible for detecting and assessing the yield of a nuclear detonation and maintains a capability to do that. DOE will detect the detonation, estimate the yield, predict the effect, and model the direction and nature of the fallout. DOE will issue an immediate report to be followed by frequent updates to be disseminated to the response management headquarters. The number of people required is independent of the yield. It is estimated that around 1,000 people will be needed for this task. This number provides personnel to staff the DOE activity and to disseminate the information from the plume models. DOD is not assigned a role in this task, but it is possible that DOD's capabilities for effects prediction and plume modeling can be used to support DOE.

2. Measure Radiation Intensity

It is essential to be able to measure the intensity of ionizing radiation caused by the explosion. Measurements of radiation intensity allow the boundaries of the Primary

Zone and Fallout Zone to be defined, so that the cordons can be established along their perimeters. In addition to measuring the intensity of radiation, it is necessary also to measure the accumulated radiation dose that responders and the public receive. The accumulated dose governs the duration and frequency that individuals can remain in a radiation environment before having to take shelter or leave.

All personnel whose duties might oblige them to enter or approach a suspected radiation hazard should be equipped with a dosimeter to measure the accumulated dose of radiation to which they have been exposed. This information is needed so that personnel and managers can limit the exposure of responders working in the zones. It would be very helpful if individuals and heads of families in the Fallout Zone were provided dosimeters so they can take appropriate survival actions, either sheltering or evacuating. Dosimeters are in common use in the health care delivery system by people whose duties involve X-rays and similar radiation. They are not available in quantity to the general public or the emergency management community. Obtaining dosimeters in large quantities and distributing them to at-risk people after a clandestine nuclear attack will be a major problem. The issue of who is to purchase, stockpile, and distribute dosimeters needs to be addressed and will not be considered in this analysis. DOD would have to provide these instruments for military personnel that are going to be used or might be used as part of a response to a nuclear detonation.

Radiation intensity is measured using a radiac, Geiger counter, or similar device. Trained responders, vehicles, or aircraft can deploy radiation meters. They can be used by reconnaissance teams or placed for unattended operation by having readings transmitted to central stations. There are at present no vehicles or protective clothing that shield people from the effects of gamma radiation well enough to allow them to work for prolonged periods of time in a radiation environment. Without adequate shielding, reconnaissance teams can work only on the margins of the radiation zones, making sure they do not exceed allowable accumulated doses of radiation**.** It might also be possible and useful to employ remote radiation sensors to provide some of this information.

DOD can provide an extensive capability to reconnoiter and report radiation intensities along the perimeters of the Primary and Fallout Zones. Reconnaissance operations will continue during the weeks or months it takes for radiation to diminish to safe levels. DOE will be in charge of this task, and its Nuclear Emergency Search Team (NEST) units will be available, but the DOE capability is oriented toward detecting and

disarming a nuclear weapon before it is detonated, and DOE has insufficient capacity to deal with a radiation problem of this magnitude. Only DOD has or can develop an adequate capability to perform this task in these demanding circumstances.

For the Primary Zone, the task is to allow the tight cordon (see Section C.2, below) to move inward to the extent permitted by radiation intensity. This means that the sensors need to be deployed in high density. The planning factor for this task is to have 20 sensors per mile of perimeter and 6 people per sensor for continuous monitoring. Using these planning factors, it will take 120 sensors and 720 people for the 1.5-kiloton explosion and 260 sensors and 1,560 personnel for the 10-kiloton explosion. These are rounded off to 800 and 1,600 personnel, respectively. This entire task is assigned to DOD because DOD will be in charge of the cordon, and local responders will be unable to function. The measurement task will be integrated with the perimeter security task.

For the Fallout Zone, the task is to determine the boundaries and the internal conditions to provide a basis for instructing the public on how to survive. The planning factor for this task is to provide 2 sensors per mile of perimeter plus additional sensors for interior measurements, with six people per sensor. It is assumed that DOE aircraft will provide measurements of the Fallout Zone, and local responders along the perimeter (not within) will be capable of doing some of this work, particularly for the part of the Fallout Zone that is away from the point of detonation. This approach calls for 42 perimeter sensors for the 1.5-kiloton explosion and 450 sensors for the 10-kiloton explosion. The total personnel estimated for this task are estimated to be 1,400 and 5,400, respectively. The DOD share of this work is estimated to be 1,000 and 3,000 personnel, respectively, allowing for manning of perimeter sensors and some DOD aircraft to supplement the DOE capability. Table 4 shows the estimated numbers of personnel to measure radiation intensity and define the perimeters of the Primary Zone and Fallout Zone.

Table 4. Personnel Estimates for Measuring Radiation Intensity

Response Zone	1.5-kiloton Explosion			10-kiloton Explosion		
	Total	Civil	DOD	Total	Civil	DOD
Primary Zone	800	0	800	1,600	0	1,600
Fallout Zone	1,400	400	1,000	5,400	3,000	2,400
Total	2,200	400	1,800	7,000	3,000	4,000

DOD has significant capabilities that could be used for this task.

- National Guard Weapons of Mass Destruction Civil Support Teams (CSTs) are optimized to deal with chemical and biological weapons response but also have some radiation meters. There are presently 32 of these teams, and 22 more are programmed to enter the force. These teams can go into action immediately under state control.
- DOD aircraft could provide aerial surveillance of the Fallout Zone. Although gamma radiation is invisible to the eye, the radioactive particles are visible in the form of a dark cloud that can be tracked as it moves downwind. Aerial reconnaissance would provide a valuable service immediately after the attack by photographing the Primary Zone and thereafter mapping the movement of the fallout. This would provide real-time situational awareness to commanders on the ground responsible for sealing off the hot zones.
- Army chemical reconnaissance (recon) platoons can measure and report radiation intensities along the boundaries of the Primary and Secondary Zones. These units are designed primarily to detect chemical weapons and airborne biological weapons on the battlefield but also have a capability for detection and measurement of radiation. A recon platoon has six mobile recon teams, each of which has an AN/VDR-2 Radiac Set to measure gamma radiation intensity. Some recon platoons are equipped with the Fox reconnaissance vehicle.
- The Army has about 90 Fox vehicles that protect against chemical and biological agents and will keep fallout particles out of the vehicle, but they do not shield against gamma radiation. These vehicles could work along the perimeters of the Primary and Fallout Zones.

3. Inform the People

The success of the response operation depends on the ability of the governments involved to communicate with their citizens and provide survival instructions and useful information. This will help to avoid panic and disorder. Planning and preparing for this action is the responsibility of DHS. Putting this part of the plan into effect will be the responsibility of the Principal Federal Official and the Joint Information Center but could benefit from support by DOD. The task is broken down into three sub-tasks according to the intended audience for the information. There are three audiences: the management team, the responders, and the public. The work to be done includes receiving, analyzing, and synthesizing information; writing reports and releases; and disseminating the products by means of radio, television, telephone, print media, or other means. The workload for this task is the number of people in each audience. For this analysis, the

planning factors are 1 worker for every 350 managers, 200 emergency workers, or 2,000 members of the general public. Application of these factors provides the personnel estimates in Table 5.

Table 5. Personnel Estimates for Informing the Public

Audience	1.5-kiloton Explosion			10-kiloton Explosion		
	Total	Civil	DOD	Total	Civil	DOD
Managers	250	250	0	500	500	0
Responders	750	750	0	2,000	2,000	0
Public	1,000	800	200	4,500	4,000	500
Total	2,000	1,800	200	7,000	6,500	500

Civil agencies and private sector companies will do most of this work. The DOD role would be primarily to use special aircraft to broadcast messages intended for people in the Fallout and Secondary Zones. DOD public affairs and psychological operations units might also be deployed to assist in informing the evacuees and hosts in the Secondary Zone on the situation and what to do.[10]

C. Save Lives

Saving lives is the primary objective of the response operation. The following capabilities are needed to establish cordons around the hot zones, decontaminate survivors, manage the evacuation of people from the Fallout Zone, and possibly conduct search, rescue, and repair operations in the primary zone

1. Establish Cordons around the Primary, Fallout, and Secondary Zones

It is necessary to maintain positive control over the movement of people to and from the Primary Zone, Fallout Zone, and Secondary Zone. Movement into these zones needs to be discouraged for several reasons, including the increase in medical and life support workloads when people ignore warning and put themselves at risk. Movement out of these zones is encouraged but needs to be controlled to ensure that people are not "lost" in the confusion.

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[10] Psychological Operations units have a capability to produce and disseminate emergency public information by means of loudspeakers and radio to supplement civil capabilities. They will not be used in a psychological operations mode *per se*.

The degree of control will vary, with the tightest control at the boundary of the Primary Zone and minimal control at the boundary of the Secondary Zone. The principal control measures are cordons established on the perimeters of each zone.

A tight cordon will be established around the Primary Zone as soon as possible after the detonation. A tight cordon provides the ability to halt all movement into the zone and to detect and canalize all movement out of the zone. This requires constant intervisibility between adjacent checkpoints, which would be spaced about 50 yards apart. Each checkpoint will be staffed for a three-shift operation 7 days a week. In addition, there will be patrols and reaction forces to respond to movements into or out of the zone and supervisors and support personnel. For the 1.5-kiloton attack, the net perimeter of the Primary Zone to be secured (less the part that opens onto the Fallout Zone) is about 4.5 miles, or about 8,000 yards. For the 10-kiloton attack, the net perimeter to be secured is about 10 miles, or about 18,000 yards. The assumed planning factor for this task is one person on the line per two yards of perimeter to provide continuous intervisibility. For the 1.5-kiloton explosion this works out to 4,000 people on line plus 2,000 in support, or a total of 6,000 personnel. For the 10-kiloton explosion, there would be 9,000 personnel on line and 2,000 in support for a total of 11,000 personnel. This task needs to be carried out by military troops, including National Guard troops and state defense forces under state control, because local and state police near the point of detonation will have been devastated by the attack or busy with other tasks.

A loose cordon will be established along the perimeter of the Fallout Zone as soon as the boundaries of the zone are determined by radiation intensity measurements. A loose cordon requires the ability to detect and warn all people who might be entering the Fallout Zone. Most of these people will be unaware of the danger and will respond positively to warnings. A few people might be entering the zone deliberately to take advantage of the situation for personal gain. The loose cordon provides a way to collect persons leaving the Fallout Zone and direct them to processing stations so they can be decontaminated, registered, and examined. This part of the task may be more difficult as some evacuees will resist the processing and seek to move out of danger no matter what. The criterion for a loose cordon is to have checkpoints at each road intersection along the perimeter with patrols between them. Some of these check points will be co-located with processing stations staffed by decontamination, registration, and medical triage teams. The planning factor for this task is to have 40 police or military personnel per mile in addition to the other personnel at the processing stations. This provides for continuous

support of the processing stations, patrols between them, and reaction forces. Using this planning factor, it takes 2,000 personnel to form the loose cordon for the 1.5-kiloton explosion and 18,000 personnel for the 10-kiloton explosion. For the 1.5-kiloton explosion, this entire task is assigned to DOD because local police departments will not be available to perform this work. For the 10-kiloton explosion, this task is divided between DOD and police departments at the far end of the Fallout Zone that will still be operational. Of the total of 18,000 required for the 10-kiloton explosion, it is estimated that 4,000 will be local or state police and 14,000 will be from DOD.

The Secondary Zone perimeter will be secured to minimize entry of unsolicited volunteers, sightseers and opportunists and to regulate exit of people. People who do not have a good reason to enter the Secondary Zone will be discouraged and in some cases forbidden to enter. While people will be free to leave the Secondary Zone, it will be useful to keep track of them. The intent of this control measure is to limit to the extent possible the instability caused by the response operations themselves so that areas outside of the Secondary Zone will be able to continue with a degree of normalcy. Control over the perimeter of the Secondary Zone will be accomplished by checkpoints at major routes entering the zone. Local and state police personnel can carry out this task. Persons seeking to enter the zone by vehicle will be required to justify their entry on the basis of need, and persons leaving the zone by vehicle will be required to register and provide forwarding addresses. Similar measures will be taken by DHS (the Transportation Security Administration) at airport and by local police at operational rail and bus terminals. Personnel with no legitimate business in the Secondary Zone may be denied entry. It is estimated that this task will require 3,000 personnel for the l.5kt-explosion and 6,000 for the 10-kiloton explosion.

Table 6 summarizes the personnel estimates to establish and maintain the cordons.

Table 6. Personnel Estimates for Maintaining Cordons

Response Zone	1.5-kiloton Explosion			10-kiloton Explosion		
	Total	Civil	DOD	Total	Civil	DOD
Primary Zone	6,000	0	6,000	11,000	0	11,000
Fallout Zone	2,000	0	2,000	18,000	4,000	14,000
Secondary Zone	3,000	3,000	0	6,000	6,000	0
Total	11,000	3,000	8,000	35,000	10,000	25,000

Army or Marine Corps line units can be used for this task. The immediate headquarters in charge of the cordon must have some personnel who are trained in this task and can serve as advisors to subordinate units assigned to the task force. Units assigned to or contemplated for this duty should receive some training beforehand.

2. Manage the Evacuation of the Fallout Zone

Evacuation of the Fallout Zone will be a major management challenge. The evacuation needs to be conducted in such a way as to ensure that the largest number of people can escape the danger of radioactivity and random movements do not lead to frustration and disorder. People will move spontaneously away from the observed point of detonation and the visible fallout plume. This process can be made easier by having pre-planned evacuation routes and emergency public information messages to guide the people out of danger.

The primary focus of the response effort will be to help the people in the Fallout Zone survive. The main mechanism for survival will be to leave the zone. Immediately after the explosion, people will either take refuge in their homes and places of work or get in their vehicles and try to move away from danger. The management challenge is to provide information to these people so they move in the right direction. Those not in the predicted Fallout Zone will be encouraged to stay in place, while those who are or may be in the Fallout Zone will be encouraged to leave in an orderly manner. The evacuation will start spontaneously, and the response managers need to try to bring it under control so that the greatest numbers of people can survive unharmed by radiation.

The responsibility for this task rests with the DHS on the federal level, but most of the work in guiding the evacuation will rest with local and state police departments. Some of these governments may be experienced in conducting evacuations for natural disasters, but the conditions in a nuclear explosion will be more difficult. One reason is that people will be leaving for an indefinite period of time and may want to take a lot of belongings that will hamper decontamination at the perimeter of the zone.

Local police immediately outside the Fallout Zone will have the responsibility for directing the movement of vehicles and pedestrians. This will be a one-way movement for the first several days, for no one will be allowed to enter the Fallout Zone unless they

are on official business. The evacuation needs to be conducted in an orderly and deliberate manner so that the greatest number of people can proceed unimpeded to the Secondary Zone.

The rate of evacuation will be limited both by the necessity to decontaminate and process evacuees at the perimeter cordon and also by the dispersal of vehicles and evacuees into the Secondary Zone. Vehicles need to be directed to continue traveling into the Secondary Zone to predesignated collection points for further instructions, or the traffic will back up into the Fallout Zone.

The general evacuation strategy will be for the local police to direct vehicles to main highways, and for state police to establish and operate traffic control points to direct and maintain the traffic flow in one direction along these arteries. Military and civilian wreckers will be used to clear the highways of broken-down vehicles. State police supported by military police will focus on interstate, national, and state highways leading out of the Fallout Zone. The areas of the Secondary Zones are 168,000 square miles for the 1.5-kiloton explosion and 240,000 square miles for the 10-kiloton explosion. There will be several thousand miles of highways to be patrolled. The number of people that could be evacuated from the Fallout Zone is 250,000 for the 1.5-kiloton explosion and 1,300,000 for the 10-kiloton explosion. This is a short-term task. The peak workload will occur in the first 24 hours after the explosion. There may be additional persons evacuating after that, but they will number far fewer than initially. It is estimated that the number of personnel devoted to this task will be about 2,000 for the 1.5-kiloton explosion and 10,000 for the 10-kiloton explosion. DOD would provide military police units and wreckers to support the state police efforts on major highways. The estimated extent of this DOD support would be 500 for the 1.5-kiloton explosion and 3,000 for the 10-kiloton explosion. Traffic control points would continue to be needed after the evacuation is completed to help control and stabilize conditions in the Secondary Zone. Table 7 summarizes these personnel estimates.

Table 7. Personnel Estimates for Managing the Fallout Zone Evacuation

1.5-kiloton Explosion			10-kiloton Explosion		
Total	**Civil**	**DOD**	**Total**	**Civil**	**DOD**
2,000	1,500	500	10,000	7,000	3,000

3. Decontaminate Persons Leaving the Primary Zone and Fallout Zone

All persons leaving the Primary Zone and the Fallout Zone need to be decontaminated before they are permitted to enter the Secondary Zone. Any vehicles or other items being taken out of these zones also need to be decontaminated. The purpose of decontamination is to prevent the intrusion of radioactive fallout particles into safe areas. The decontamination process is relatively simple. The only thing that needs be done is to wash the people and the items with water. A person being decontaminated will have to undress, take a shower, and put on fresh clothing. As with other "simple" processes, the logistics are difficult. The major problem is the storage and disposition of the water used for showering that has become contaminated. Additional problems are storage of discarded clothing and other items and providing clothing for the evacuees. The practical effect of decontamination is that people leaving these areas will have few possessions or items that they can bring with them.

Decontamination stations will be established as an integral part of the processing points along the perimeters of the Primary Zone and Fallout Zone. When people approach the station, they first will be decontaminated, then registered, and then examined for medical condition. The number of people needed to perform the decontamination is a function of the rate of processing and the time limit within which processing of all or most of the evacuees ought to be done. It is assumed that the evacuees from the Fallout Zone will walk or drive out over a period of 2 days. Other survivors in the Primary Zone will be discovered and evacuated as the perimeter moves inward.

For the Primary Zone, the number of decontamination stations and the personnel to operate them are not a direct function of the number of survivors expected. The design rates of military decontamination sets exceed the demand in this situation. In order to provide effective control, it is assumed that four stations per mile of perimeter would be enough to allow survivors to be collected conveniently and processed. Discounting the part of the Primary Zone perimeter that is inside the Fallout Zone, this planning factor would require about 16 stations for the 1.5-kiloton explosion and 45 for the 10-kiloton explosion. Assuming that it takes 25 people to operate and support a decontamination unit continuously, it would take 400 personnel for the 1.5-kiloton explosion and 1,200 for the 10-kiloton explosion. This task will be assigned to DOD. Decontamination of vehicles and structures uncovered as the perimeter moves inward will have to be done later by civil authorities or private sector companies.

For the Fallout Zone, a heavy workload will occur immediately as people inside the zone try to evade the fallout. About 200,000 people and 50,000 vehicles (assuming about one vehicle per four people) will have to be processed for the 1.5-kiloton explosion. About 1,500,000 people and 400,000 vehicles will have to be processed for the 10-kiloton explosion. Each Army chemical decontamination platoon has four modular decontamination sets, enabling the platoon to process 400 vehicles and 3,200 personnel per hour.[11] The vehicular workload is the major factor in determining the estimate. At full capacity, it would take 125 platoon-hours to do this work for the 1.5-kiloton explosion, and 800 platoon-hours for the 10-kiloton explosion. Doing this work in 24 hours requires 5 platoons (about 200 people) for the 1.5-kiloton and 32 platoons (about 1,300 people) for the 10-kiloton explosion.

Another way to estimate the personnel needed for decontamination is to determine the number of processing points that would be needed and provide a decontamination set or platoon for each. Assuming that processing stations would be located about a mile apart, there would be 40 stations for the 1.5-kiloton explosion and 200 for the 10-kiloton explosion. If one platoon provides sets for four processing points, this would require 4 platoons for the 1.5-kiloton explosion and 11 platoons for the 10-kiloton explosion. Allowing for dispersion and continuous operation, it will take 40 platoons (1,600 personnel) to perform this task for the 1.5-kiloton explosion and 300 platoons (6,000 personnel) for the 10-kiloton explosion.

For the 1.5-kiloton explosion, DOD units will do all of the decontamination work for the primary zone and the close-in portion of the Fallout Zone. Local responders can perform some of the decontamination for those leaving the Fallout Zone. For this analysis, the division of labor is assumed that 800 military personnel and 2,000 civilian responders will be needed.

For the 10-kiloton explosion, local responders can do some of the decontamination of people leaving the Fallout Zone. For this analysis, the division of labor is assumed to be 4,500 civilians and 1,500 military personnel.

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[11] These estimates are for what the Army calls “operational decontamination.” The rate for “thorough decontamination” for vehicles is much lower—on the order of 16 vehicles per hour per platoon.

Table 8 shows the estimated numbers of personnel required for the decontamination task.

Table 8. Personnel Estimates for Decontaminating Evacuees

Response Zone	1.5-kiloton Explosion			10-kiloton Explosion		
	Total	Civil	DOD	Total	Civil	DOD
Primary Zone	400	0	400	1,200	0	1,200
Fallout Zone	2,800	2,000	800	6,000	4,500	1,500
Total	3,200	2,000	1,200	7,200	4,500	2,700

4. Conduct Search and Rescue Operations in the Primary Zone

It may be useful to conduct some limited operations inside the hot zone to explore the situation, search for survivors, perform some rescues, and repair selected vital infrastructure nodes. Working in a radioactive environment is dangerous and should be conducted only by trained personnel who are properly equipped. Emergency responders and troops entering the Primary Zone must have protection against ingestion of radioactive particles and direct reading dosimeters that permit self-monitoring so they can leave the hot areas as they approach their dosage limits. It is possible that robots or personnel in shielded vehicles can perform some critically important tasks.

There is a ring inside the Primary Zone within which responders could operate for limited periods of time. The intensity of gamma radiation around the point of detonation diminishes rapidly according to the distance from the point of detonation. For the 10-kiloton explosion, the intensity is roughly 1000 rem/hour at a distance of 0.1 miles, 300 rem/hour at a distance of 0.67 miles, 3 rem/hour at a distance of about 1.0 mile, and 1 rem/hour at a distance of about 2 miles. Responders working in the area between 2 miles and 1 mile from the point of detonation could work for 2-3 hours before accumulating the maximum permissible dose of 25 rem. This would be enough time for surveys of damage, searches and rescues of some survivors, and some repairs of essential infrastructure links and nodes. As the overall radiation intensity diminishes with time, the ring would also move inward, permitting reconnaissance to allow responders to prepare for specific tasks when they can work unprotected for prolonged periods of time in the uncovered areas.

For this analysis, it is estimated that these missions inside the Primary Zone would require 1,000 personnel for the 1.5-kiloton explosion and 2,000 for the 10-kiloton explosion. There is no workload basis for this estimate, but these figures look to be reasonable, for missions inside the Primary Zone will occur only for exceptional reasons.

Local authorities and private sector companies will do the search and rescue and restoration work in areas uncovered as the radiation intensity diminishes to safe levels. This task is assigned in its entirety to primarily to provide unity of command for the entire operation around and within the Primary Zone.

DOD has at present a limited capability to perform this task in a radiation environment. Army chemical recon units are the best equipped and trained. Engineer units with mobile construction equipment could be used if properly protected. Should DOD accept this mission, it would be useful to create specialized units to perform this task. Table 9 shows the personnel required for primary zone search and rescue operations.

Table 9. Personnel Estimates for Search & Rescue Operations in the Primary Zone

1.5 Kiloton Explosion			10-Kiloton Explosion		
Total	**Civil**	**DOD**	**Total**	**Civil**	**DOD**
1,000	0	1,000	2,000	0	2,000

D. Care for Survivors and Evacuees

Persons who leave the Primary or Secondary Zones will need to be taken care of until they can fend for themselves. Survivors who have managed to get out of the Primary Zone and Fallout Zone will require assistance for prolonged periods. The tasks to be done are to register the survivors and provide medical care, essential supplies and services, housing, transportation, and other support.

1. Register and Process Survivors

Persons leaving the Primary Zone or Fallout Zone will be registered at the perimeter processing stations where they have been decontaminated. Registration is needed to ensure accountability of people so that relatives can be notified and the evacuees are eligible for federal assistance. Once registered, the evacuees will be directed to reception centers where they will receive additional assistance and be provided temporary housing. DHS is the lead agency for registration and processing. Civil agency personnel augmented by civilian volunteers will do all of this work. The workload timing will be determined by the rate at which the people can leave the respective zones and will peak immediately after the explosion and decline thereafter. For this analysis it is assumed that the peak workload occurs in the initial 48 hours after the explosion. It is

also assumed that one processor can register three evacuees per hour. The operation is on a two-shift basis for the initial 48 hours and a three-shift basis thereafter. Table 10 shows the estimated number of processors to do this work.

Table 10. Personnel Estimates for Processing Evacuees

	1.5-kiloton Explosion	10-kiloton Explosion
Maximum number of evacuees to be processed	318,000	1,500,000
Processor-hours at 3 evacuees per hour	106,000	500,000
Processors to do work in 48 hours	2,200	10,600
Total Processing Personnel for first 48 hours	6,600	31,800
Residual Processors after first 48 hours	1,800	9,000

2. Treat Injured and Ill Persons

Many if not most of the survivors who leave the Primary Zone and Fallout Zone and enter the Secondary Zone will require medical treatment or psychological counseling. The immediate task is to perform triage screening at the processing stations on the perimeters to determine the condition of each person as he or she enters the Secondary Zone. Some of the survivors will have been exposed to ionizing radiation and may show symptoms only after a few hours or days, while others may develop cancer and other symptoms only after months or years. The obviously injured can be taken directly to medical facilities. Others may develop symptoms later, and there will be a problem with people reporting sick who are suffering from traumatic stress induced by the circumstances. All this will be additional workload beyond the normal patient load of the Secondary Zone, which will itself be increased by the stress of the circumstances.

The Department of Health and Human Services is the lead federal agency to coordinate federal support for medical care. The resources required will be significant and will exceed the capability of the existing health care structure in the Secondary Zone. There are four distinct subtasks to the medical care task: triage persons leaving the Primary Zone and Secondary Zone, treat persons with injuries from the blast or other causes, assess and treat persons with radiation sickness and subsequent cancer, and provide health care for the evacuees who are housed in the Secondary Zone either among the general population or in temporary camps.

Triage processing of persons evacuating the Primary Zone and Fallout Zone will separate them into those who are well, those who are to receive treatment, and those who

are beyond treatment. Table 11 shows the estimated number of medical personnel required for the triage task.

Table 11. Medical Personnel Estimates for Triage Processing

Personnel Estimate	1.5-kiloton Explosion	10-kiloton Explosion
Processing Stations	40	200
Maximum Processing Workload	318,000	1,500,000
Triage team-hours at 4 per hour	80,000	375,000
Triage teams for first 48 hours	1,667	7,812
Triage personnel at 3 per team	5,000	24,000
Triage personnel for first 48 hours	10,000	48,000
Residual triage personnel	2,000	10,000

Triage will require teams of health care providers working continuously for the first several days at the perimeter processing stations. After the initial workload, the number of people to be processed will diminish, and the medical resources used for this task can be reassigned to other tasks. The number of people for this task is a function of the number of processing stations to be staffed continuously. There will be 40 such stations for the 1.5-kiloton explosion and 200 for the 10-kiloton explosion.

A significant part of the medical support task will be to treat persons injured by blast and thermal effects in the Primary Zone and by accidents and violence in the Fallout Zone and Secondary Zone. In the 1.5-kiloton scenario, there will be 40,000 injured or ill personnel needing immediate treatment. In the 10-kiloton attack, there will be over 100,000 injured and ill people needing immediate treatment. Many of these people will need hospitalization, particularly for burns. Those with minor injuries can be treated in clinics, Additional minor injuries will occur during the evacuation, and infectious disease may occur as sanitation declines and routine care is disrupted for both the evacuees and the population of the Secondary Zone. Performing this task will require a full set of medical capabilities, including hospital beds, surgical suites, and specialized capabilities to treat burns. Based on a ratio of 4 patients for every medical person (including technicians and support), the estimated number of personnel required for this task is 10,000 for the 1.5-kiloton explosion and 25,000 for the 10-kiloton explosion.

As the injury workload diminishes, there will be an increase in persons needing treatment for radiation sickness. Large numbers of people who leave the Fallout Zone will receive less-than-fatal doses of radiation and will have symptoms of radiation

sickness and need palliative care. Routine medical care will be needed during the period of prolonged resettlement. Some of the medical personnel that were used initially to treat injuries can provide much of this care. However, it will also be necessary to assemble significant numbers of medical personnel qualified to treat radiation poisoning and cancers.

Additional medical personnel will be needed to provide medical care for the evacuees in emergency housing, including the emergency camps. The medical personnel estimate for this task is 3,000 and 18,000 medical personnel, respectively. Based on the foregoing discussion, the aggregate medical personnel estimate is 20,000 for the 1.5-kiloton explosion and 70,000 for the 10-kiloton explosion. Table 12 shows the aggregate medical personnel estimate by phases. Phase One is the first 48 hours; phase two is thereafter.

Table 12. Medical Personnel Estimates by Phase

Personnel Estimate	1.5-kiloton		10-kiloton	
Medical Task	**Phase One**	**Phase Two**	**Phase One**	**Phase Two**
Triage	10,000	2,000	48,000	10,000
Care for Injured	6,000	10,000	10,000	25,000
Care for Radiation Patients	2,000	5,000	4,000	17,000
Medical Care for Evacuees	2,000	3,000	8,000	18,000
Total	20,000	20,000	70,000	70,000

The medical personnel estimate does not include other medical personnel needed to take care of the pre-attack population who live in the Secondary Zone. It is likely that demand for medical care among that population will increase because of anxiety and because of increased operational activity in the zone. Medical resources in the Secondary Zone can meet many of these needs, but many additional medical personnel will have to be marshaled and moved into the Secondary Zone as well.

DOD medical personnel will focus initially on the medical triage task and then will focus on providing medical care for the emergency camps constructed and managed by DOD. DOD will also provide special medical expertise, such as treatment of burns and radiation sickness, to the other medical elements. The DOD medical personnel estimate is 4,800 for the 1.5-kiloton explosion and 20,000 for the 10-kiloton explosion. Table 13 shows the medical personnel estimate for this task.

Table 13. Medical Personnel Estimates for All Medical Tasks

1.5-kiloton Explosion			10-kiloton Explosion		
Total	**Civil**	**DOD**	**Total**	**Civil**	**DOD**
20,000	15,200	4,800	70,000	50,000	20,000

3. Provide Mass Care

Survivors will need the basics to support life: food, clothing (to replace that discarded during decontamination), and other essentials. The lead agency to manage the procurement and distribution of these goods and services is the American Red Cross, which will deploy employees and volunteers to perform this function, assisted by contractors. For the 1.5-kiloton explosion, the number of survivors to be cared for is about 300,000, and it will take an estimated 400 personnel to manage this task. For the 10-kiloton explosion, the number of people to be cared for is 1.3 million and it will take 5,000 workers to manage that task. While other federal agencies will assist in this task, DOD does not need to play a role except perhaps to provide for persons housed in the DOD-constructed camps.

4. Provide Emergency Housing

This is a crucial task in which DOD may be heavily involved. The workload for this task consists of the people who leave the Primary and Fallout Zones and go into the Secondary Zone. For the 1.5-kiloton explosion, there will be as many as 150,000 people to be provided emergency housing. For the 10-kiloton explosion, there will be as many as 1.5 million people to be provided emergency housing. In each case, some of these people will have been exposed to harmful doses of radiation

One way to deal with this workload would be to provide a housing voucher to the evacuees as they process into the Secondary Zone and allow them to travel as far as they want to find housing anywhere in the United States. However, doing this would make it hard to keep track of the evacuees and would spread the burden and panic over the entire Nation. Even if this were done, some evacuees would not have the means to travel and would have to be housed in the Secondary Zone. Also, some of the evacuees are likely to have radiation poisoning that will appear later, and allowing them to disperse randomly would make it hard to provide treatment when symptoms occur. For this analysis, it is assumed that the policy is to retain all evacuees within the Secondary Zone.

There are several ways to house evacuees in the Secondary Zone. Some of them can be placed in hotels, vacant houses and apartments, and shelters. Others can be housed temporarily in private homes and apartments. When the existing vacant housing stock is filled, it will be necessary to build and operate camps. Evacuees from the Primary Zone will be unable to return to their homes, which will have been destroyed by the explosion. Many of the evacuees from the Fallout Zone will not be able to return to their homes for several weeks or even months. The challenge is to provide semi-permanent housing for a period of up to a year while other provisions for permanent housing are being made.

One of the tasks that has to be done is to find housing for the evacuees that have been registered and processed. This will involve locating available space and matching evacuees to the housing or shelters. It will take about 1,000 people to perform this task for the 1.5-kiloton explosion and 3,600 for the 10-kiloton explosion.

It is assumed that it will be necessary to construct and operate camps to house, feed, and take care of some of the homeless evacuees. The number of people to be in the camps would be the difference between the number of homeless people and those who can be accommodated by existing housing or shelters. The demand for housing can be determined only by examining housing conditions in a specific metropolitan area and comparing them with the numbers of evacuees that could be made homeless by a catastrophic attack.

For this analysis, it is estimated that camps will have to be made available for 40 percent of the total number of evacuees. For the 1.5-kiloton explosion, there will be 100,000 people to be housed in 4 camps each with a capacity of 25,000 people. For the 10-kiloton explosion, there will be 600,000 people to be housed in 24 such camps. The task of housing homeless evacuees in camps breaks down into 4 subtasks: constructing the camps, operating the camps, securing the camps, and providing medical care for the people in the camps. DOD troops will be used to construct the camps, manage them, and provide security and medical care for the occupants.

DOD engineer units will construct the camps at sites designated by civil authorities in the Secondary Zone using materials stockpiled by DHS or DOD. Troops will be used for this task because of the urgency of making these facilities available rapidly. (Contractors will be used to assist civil authorities to house the remaining 60% in existing public spaces.) The estimate is based on using one reinforced engineer battalion per camp plus support for the movement of materials. When the camps are completed and occupied, DOD personnel involved can be reallocated to other work in the Secondary

Zone or released from the response operation entirely. The total number of personnel assigned to camp construction is 1,000 per camp.

Once the camps are built and occupied, DOD will administer them with the assistance of personnel from the civil agencies. Contractors and volunteers will be used to meet the needs of the occupants. Many of the volunteers will be recruited from the camp occupants. In addition to a small headquarters, DOD will station a utilities detachment at each camp to perform and oversee continuing maintenance of the camps. This is essentially a management job, requiring a few people to organize the camp occupants to support and govern themselves. A DOD headquarters of about 50 military personnel and 75 non-DOD personnel will administer each camp. DOD will also provide for each camp an engineer utilities detachment of 25 personnel.

It will be necessary to secure the camps once they are in operation to prevent intrusion by outsiders and disorder within. This is a task for DOD because local police forces will be unable to provide that security in addition to their own tasks elsewhere in the Secondary Zone. DOD can provide military police or line units to perform this task, or it could reassign some of the construction units to this task. The planning factor is to provide a military police battalion of 600 personnel to each camp.

A hospital or equivalent will be assigned to each camp to provide routine medical care for the inhabitants. The planning factor is to provide one medical person for every 80 occupants, or 100 civilian and 200 DOD medical personnel for each camp.

Table 14 shows the estimated allocation of personnel for these four tasks. Medical personnel for the camps have already been included in the total medical personnel estimate discussed above and are listed below as a non-add entry.

Table 14. Personnel Estimates for Emergency Camps

Task	4 camps for 1.5-kiloton explosion			24 camps for 10-kiloton explosion		
	Total	Civil	DOD	Total	Civil	DOD
Construct	4,000	0	4,000	24,000	0	24,000
Operate	600	300	300	3,600	1,800	1,800
Secure	2,400	0	2,400	14,400	0	14,400
Total	7,000	300	6,700	42,000	1,800	40,200
Medical	1,200	400	800	7,200	2,400	4,800

5. Provide Emergency Transportation

It will be necessary to marshal additional transportation assets to take care of the workload involved in response operations and support of the evacuees, to include transporting some of them to emergency housing. The Department of Transportation (DOT) is the lead agency for this function. DOT personnel will focus on managing civil resources made available under contract. It is estimated it will take 3,000 people to do this for the 1.5-kiloton and also for the 10-kiloton. DOD could be called on to provide airlift for critical items and senior officials and members of Congress, military movement control teams, and traffic management capabilities. In addition, DOD transportation capabilities will be needed to support DOD operations in the Secondary Zone.

6. Provide Emergency Logistics

Government personnel will be needed to manage the overall logistical support for the emergency responders, the evacuees, and the population of the Secondary Zone. This is the responsibility of DHS. Most of this work will entail contracting for and coordinating the use of private-sector resources to perform the emergency work in addition to the normal workload in the Secondary Zone. It is estimated that it will require 1,000 federal personnel to perform this task for the 1.5-kiloton explosion and 5,000 for the 10-kiloton explosion. DOD will not be involved directly in this task but will be responsible for supporting its own forces and facilities in the Secondary Zone. DOD may be asked to provide specialized logistical support, including expertise in supply chain management.

7. Provide Emergency Water Supply

The Army Corps of Engineers is the lead agency in the National Response Plan for water supply and will apply many of its civilian personnel to this task in the Secondary Zone. It is also possible that military water supply units will be needed to ensure that enough potable water will be available to all persons in the Secondary Zone, particularly those evacuees housed in the temporary camps. For the 1.5-kiloton explosion, it is estimated that DOD will require 1,000 personnel for this task, and for the 10-kiloton explosion, it would require 2,500 personnel. These estimates include the use of water supply companies in the Secondary Zone and to support decontamination teams at checkpoints around the Fallout Zone and Primary Zone.

8. Perform other Emergency Support Functions

In addition to the foregoing functional areas, other emergency support functions will be needed for the response operations. These include marshaling private-sector resources, ensuring an adequate supply of food and essential services, providing public information and communications, restoring essential infrastructure services, and initiating recovery operations. Generally, DOD will not be involved in these other functions. It is estimated that for the 1.5-kiloton explosion, these tasks will require 3,000 personnel, and for the 10-kiloton explosion, 6,000 personnel.

E. Stabilize the Situation

Throughout the response operations, it is necessary to be able to stabilize the situation to minimize panic and prevent disorder. Stability in the Secondary Zone is needed to permit orderly conduct of evacuation, search and rescue, and life support operations. Stability will be improved by accomplishing the following tasks.

1. Restore Essential Services

It is necessary to be able to work around the damage from the attack and maintain essential services in the Secondary Zone. The impact of a nuclear explosion on infrastructure systems increases with yield. In the 1.5-kiloton attack, the damage to the infrastructure is severe but limited in scope and disruptive effect because infrastructure systems are operational outside the Primary Zone. The situation is much more serious in the 10-kiloton attack because some critical nodes of infrastructure systems located in the city will be destroyed, making it more difficult to restore services. Within the Fallout Zone, nodes and links may be operational even though the people to operate them are absent. Some measures need to be taken to ensure that these services will be in operation to the extent they support the surrounding Secondary Zone. In the Secondary Zone, services will be overloaded because of the influx of evacuees. Priorities and curtailment of services may be needed to get through the initial response period. Private-sector companies will do most of this work, but it will take some government personnel to manage the restoration process. It is estimated that it will take 1,000 personnel for the 1.5-kiloton explosion and 4,500 for the 10-kiloton explosion. DOD prime power units will assist in rapid restoration of electrical power. DOD participation would be 200 personnel for the 1.5-kiloton explosion and 1,000 for the 10-kiloton explosion.

2. Process the Remains of the Dead

At some point, it will be necessary to process and inter the remains of those who are killed by the effects of the explosion or who die for other reasons during the response. In the 1.5-kiloton attack, the immediate effects of the explosion will result in about 32,000 remains. For the 10-kiloton attack, there will be as many as 250,000 remains. Almost all of these remains will be radioactive and will require special handling to protect the mortuary services personnel and bystanders. The capability to process large numbers of radioactive remains does not exist. It will be necessary to focus initially on dealing with remains outside the Primary Zone and to defer processing of remains inside the Primary Zone until the levels of radiation diminish. DOD capability to support this task is very limited. The personnel devoted to this task would include 200 from DOD for both explosions. The civil sector would have to provide an additional 400 personnel for the 1.5-kiloton explosion and 3,400 for the 10-kiloton explosion.

3. Support DOD Operations in the Secondary Zone

DOD will be responsible for providing support to its own forces engaged in the response operation. DOD installations and activities in the Secondary Zone will be used as bases from which DOD units can operate. Supply, transportation, and maintenance units will provide this support under functional or area command headquarters. For the 1.5-kiloton attack, it is estimated that this task will require about 15,000 troops; for the 10-kiloton attack, 30,000 troops.

4. Maintain Security, Law, and Order

The success of the entire operation depends on maintaining law and order to protect the people in general and the emergency workers in particular from lawless elements that will take advantage of the situation to loot and pursue personal or ideological agendas. This is the responsibility of local and state governments, but their law enforcement agencies will be overwhelmed at the outset and incapable of doing this if widespread disorders occur. In this case, federal military troops will be needed to restore order and protect the people. The presence of large numbers of military troops will tend to deter civil disorders, but there may be instances of disorder and refusal to obey instructions. Military troops will be needed to provide security for DOD bases and evacuee camps in the Secondary Zone. DOD may be directed also to provide security for other federal property or key targets. This will be necessary both during the evacuation and the prolonged period of resettlement in the Secondary Zone.

The security force will be organized on an area basis at the emergency camps and military logistical support areas. They can also be used to reinforce troops engaged in other tasks and deal with additional attacks. If civil disorder occurs, these military troops may be used to assist local and state law enforcement officers in maintaining law and order. The presence of numerous military personnel in the Secondary Zone will tend to deter civil disorder, but there may be violent episodes that exceed the capability of local and state police to manage. In that case, military forces provided for security also can be used for riot control or law enforcement. Security units for the evacuee camps operated by DOD have been included in that task. In addition, some troops would be needed to augment local police to provide presence and respond in the event of civil disorders. It is estimated that this task will require 9,800 personnel for this task for the 1.5-kiloton explosion, including 4,600 troops. For the 10-kiloton explosion, it is estimated that 41,600 personnel, including 17,400 military personnel, would be required.

F. Summary of Personnel Estimates

Estimates of personnel needed to respond to the nuclear attack addressed by this analysis are summarized in Tables 15 and 16.

Table 15. Summary of Personnel Estimates for Responding to a 1.5 Kiloton Explosion

Task and Sub-task	Total	Civil	DOD
Manage the Response			
Headquarters	1,500	1,000	500
Communications	1,500	1,000	500
Maintain Situational Awareness			
Predict the Effects	1,000	1,000	0
Measure Radiation Intensity	2,200	400	1,800
Inform the Public	2,000	1,800	200
Save Lives			
Establish Cordons	11,000	3,000	8,000
Manage Evacuation	2,000	1,500	500
Decontaminate Evacuees	3,200	2,000	1,200
Search and Rescue in Primary Zone	1,000	0	1,000
Care for Evacuees			
Register Evacuees	1,800	1,800	0
Medical Support	20,000	15,200	4,800
Mass Care	400	400	0
Locate Housing	1,000	1,000	0
Emergency Camps	7,000	300	6,700
Transportation	3,000	3,000	0
Logistics	1,000	1,000	0
Water Supply	1,000	0	1,000
Other Functions	3,000	3,000	0
Stabilize the Situation			
Restore Services	1,000	800	200
Process Remains	600	200	400
Support DOD Forces	15,000	0	15,000
Maintain Law and Order	9,800	4,600	5,200
Total	90,000	43,000	47,000

Table 16. Summary of Personnel Estimates for Responding to a 10 Kiloton Explosion

Task and Sub-task	Total	Civil	DOD
Manage the Response			
Headquarters	2,500	2,000	500
Communications	2,500	1,500	1,000
Maintain Situational Awareness			
Predict the Effects	1,000	1,000	0
Measure Radiation Intensity	7,000	3,000	4,000
Inform the Public	7,000	6,500	500
Save Lives			
Establish Cordons	35,000	10,000	25,000
Manage Evacuation	10,000	7,000	3,000
Decontaminate Evacuees	7,200	4,500	2,700
Search and Rescue in Primary Zone	2,000	0	2,000
Care for Evacuees			
Register Evacuees	9,000	9,000	0
Medical Support	70,000	50,000	20,000
Mass Care	5,000	5,000	0
Locate Housing	3,600	3,600	0
Emergency Camps	42,000	1,800	40,200
Transportation	3,000	3,000	0
Logistics	5,000	5,000	0
Water Supply	2,500	0	2,500
Other Functions	6,000	6,000	0
Stabilize the Situation			
Restore Services	4,500	3,500	1,000
Process Remains	3,600	3,400	200
Support DOD Forces	30,000	0	30,000
Maintain Law and Order	41,600	24,200	17,400
Total	300,000	150,000	150,000

VI. OBSERVATIONS AND ISSUES

This final section of the paper provides some observations on the unique characteristics of a nuclear attack and highlights some issues that need to be addressed and resolved in order for the Nation to have the capability to deal effectively with the consequences of a single nuclear attack.

A. NUCLEAR ATTACK CHARACTERISTICS

A nuclear attack is by far the most serious kind of terrorist attack. Yet, it appears to have been given the least attention in planning and preparing for consequence management. There are few nuclear attack scenarios, and those that exist are incomplete and inconsistent. Research and development of technologies for standoff measurement of gamma radiation intensity and shielding against gamma radiation is inadequate. Planning for nuclear power plant accidents and radiological attacks has been done, but these events are quite dissimilar to a nuclear explosion both in kind and quantity of radiation. It is necessary to consider what to do in the event of a single nuclear explosion.

Response actions indicated for a nuclear explosion differ substantially from those indicated for other emergencies. It is unsound to consider consequence management for an artificial category, such as Weapons of Mass Destruction or Chemical, Biological, Radiological, Nuclear, and High-Yield Explosives. Each kind of attack needs to be addressed individually in order to estimate overall resources and identify specialists that need to be organized and trained for consequence management. Some capabilities are common to all attacks, but the most important capabilities needed to deal with nuclear explosions are unique to that particular kind of attack.

One important characteristic of a consequence management operation to mitigate the effects of a nuclear attack is that the response needs to be deliberate, orderly, and controlled at all times. Rash entry into the Primary or Fallout Zones by untrained and unqualified personnel will make things worse. Control of all elements of the total response force, both civil and military, is necessary. Undirected efforts by enthusiastic volunteers from jurisdictions outside the Secondary Zone have to be discouraged. The persons in charge of the operation have to have total and continuous situational awareness of their own forces, the victims, the evacuees, and the people in the Secondary Zone.

Some of the characteristics of important characteristics of consequence management for a nuclear attack are as follows:

- The attack will occur without warning and there will be no time to reorganize or prepare for it in the immediate aftermath.
- The public and the emergency management community will be unprepared to deal with this kind of attack and the magnitude of its consequences.
- Local police and emergency management agencies will be overwhelmed at the outset of the attack.
- Many local personnel will not be available to respond in the immediate post-attack period. Some will be killed, some will be at risk of radiation exposure, and the rest will have their hands full in their own jurisdictions. State resources are limited, particularly if half of their National Guard troops are deployed on federal active duty.
- Large numbers of radiation meters and dosimeters are needed to enable people to deal effectively with the most dangerous consequence—gamma radiation from fallout debris.
- Personal protective clothing and/or shielded vehicles are needed to allow normal response activities to be conducted in the vicinity of the detonation or downwind from it.
- Large numbers of people will move either spontaneously or by direction into areas away from the point of detonation.
- People and vehicles evacuating the Primary Zone and Fallout Zone will have to be decontaminated to prevent the spread of radioactive fallout particles.
- People who evacuate the high radiation zones will have to remain away from their homes for extended periods of time—weeks and perhaps months.
- The immediate vicinity of the nuclear explosion will be subjected to severe damage and will be unsafe for ordinary rescuer and response actions for a long time.

B. ISSUES TO BE ADDRESSED

1. Utility of Nuclear Attack Scenarios

The two scenarios used in this analysis to describe nuclear attacks are very difficult to use as a basis for planning or preparing for a response operation. Effects are described differently and in a complicated manner. The scenarios do not adequately identify anticipated workloads, such as casualties, extent and nature of physical damage,

and disruption of services. It would be helpful to standardize the descriptions of nuclear explosions and to transform the raw effects into workloads. Doing this would allow members of the emergency management community to think in the same way about nuclear attacks.

2. Measuring the Intensity of Radiation

It is impossible to manage the consequences of a nuclear attack unless the responders know the boundaries of the areas in which radiation intensity is too high for human safety. Too little has been done to enable emergency responders to measure radiation intensity after a nuclear explosion in a comprehensive way. Some data are available on how to deal with nuclear power plant accidents and radiological attacks, but nothing was available to provide guidance on how to deal with the detonation of a clandestine nuclear device.

3. Protection against Gamma Radiation

There is no satisfactory way to provide radiation shielding to permit individuals or vehicles to operate for an extended period of time inside the Primary and Fallout Zones. Although there is a lot of work on protection against chemical and biological threats, little is being done about protection against gamma radiation. Admittedly, this is a difficult problem, but there are some indications that it might be possible to develop vehicles that will provide adequate shielding using new composite materials.

4. Sheltering versus Evacuation

For people in the Fallout Zone when the attack occurs, the choice is between sheltering-in-place or evacuating. For an unprepared Nation, the only available option is to evacuate. Programs for fallout sheltering-in-place depend on having in place plans and preparations either for moving to home or community radiation shelters or constructing hasty shelters after the attack. These sheltering measures depend on having emergency managers and a public that is informed about nuclear weapons effects and what to do to protect themselves and the community. Neither condition pertains in the United States today, nor is it clear that there is any enthusiasm to address this kind of preparedness. Lacking a capability for sheltering, the only way to provide a chance of avoiding radiation exposure is to leave the Fallout Zone.

5. Decontamination of Personnel and Vehicles

The task of decontaminating all personnel and vehicles leaving the Primary Zone and the Fallout Zone needs to be addressed. Decontamination is needed to prevent the spread of radioactive fallout, but there is little information on how to do it or how fast it can be done. There are major issues to be resolved. If a car is washed in the decontamination process, can it be assumed that its occupants and other contents are free of fallout? Do the occupants of car have to get out and be decontaminated separately, or may they ride through in the car? How scrupulous does the decontamination process have to be at stations remote from the point of detonation? It is likely that the answers to these questions will degrade the rate at which the decontamination teams can process the people and cars. Decontamination also raises the issue of how to handle radioactive wastewater and other radioactive items discarded in the process. If these issues are not resolved, decontamination will be a major bottleneck in processing evacuees from the Fallout Zone.

6. Housing for Evacuees

In the analysis, it was assumed that the DOD would provide housing and routine medical care for 40 percent of the people evacuated from the Fallout Zone. This is an arbitrary figure that needs to be checked. It might be possible simply to instruct evacuees to keep going until they find a hotel room, perhaps issuing them federal vouchers for commercial accommodations. It would be useful to test the feasibility of this approach by comparing availability of private homes, public shelters, and commercial housing with the demand to get an idea of the shortfall. Comparisons with evacuations to avoid danger from hurricanes are not valid because people escaping a hurricane have to stay away from their homes for only a few days. For nuclear attacks, people will have to remain away from their homes for weeks or months.

7. Availability and Capability of Local and State Responders

Serious thought needs to be given to the availability and capability of local emergency management resources in the aftermath of a nuclear attack. It is commonly assumed that local emergency responders will deal with the immediate effects of an attack and will be augmented only after their efforts prove to be inadequate to the need. Many responders will be killed outright in a nuclear attack, and many of the rest will be disorganized for a time. The idea that responders from other jurisdictions can provide

immediate augmentation is valid only for small events and is unworkable for a catastrophic attack or disaster that affects many jurisdictions simultaneously.

8. Planning Factors

The planning factors used in this analysis admittedly are rough and subject to dispute, but they can be used to provide rough estimates of the personnel and military troops needed to respond to these attacks. Better rules should be developed *de novo* from a series of inter-agency games that address directly how do deal with the consequences of nuclear attacks and how many and what kind of resources are needed. For example, the number of police officers or military troops to establish a tight cordon or a loose cordon (if such terms are defined clearly) can be established by rigorous and detailed examination of specific cases. By considering a wide range of situations, satisfactory planning factors can be established to serve as a guide for initial planning.

9. Size of the Primary and Secondary Zones

The number of troops needed to deal with a nuclear explosion depends to a substantial extent on the length of the perimeters of the Primary Zone and Secondary Zones and the number of people evacuated from the Fallout Zone. The values of these parameters depend on the radius of the Primary Zone and the desired width of the Secondary Zone. (The size and shape of the Fallout Zone depends on the size and shape of the fallout plume.) In this analysis, the radius of the Primary Zone was set arbitrarily at the 1 rem/hour radiation contour. Similarly, in this analysis, the width of the Secondary Zone was set arbitrarily at 200 miles. Both of these assumptions need to be addressed and acceptable rules established for these dimensions.

10. Innovation to Meet the Need

Almost all of the capabilities available to manage the consequences of a nuclear attack are designed for other purposes and may not be entirely suitable for dealing with the consequences of a nuclear attack. This situation can be remedied in two ways: by using existing resources in new ways, and by applying the latest technology to the problem. Establishing the size and shape of the Fallout Zone could be done in part without exposing emergency responders to risk by using remote-controlled vehicles with sensors to map radiation intensities.[12] Mapping the limits of gamma radiation could be done in part by using unattended ground sensors. Vehicles shielded against radiation

[12] There are reports that Ford Explorer vans can be equipped for remote operation.

would allow responders to conduct search and rescue operations in the Primary Zone.[13] TACAMO Aircraft could be used to help control the evacuation of the Fallout Zone.[14] Commando Solo aircraft could be used to disseminate emergency public information.[15] Radiation shielding might be improved by using newly developed composite materials. There may be other innovations that can make it easier to deal with this kind of catastrophic incident.

11. Estimated Demand for Military Troops

The estimated total military strength to provide an effective response for the 1.5-kiloton attack is 47,000; for the 10-kiloton attack, it is 150,000. These estimates of troops needed for a nuclear explosion are much larger than DOD plans presently to use for support of consequence management operations. Some of these military troops will have to be on the ground starting within minutes after the surprise attack with preplanned reinforcements arriving rapidly to perform preassigned respective tasks. Military troops include active, Guard, and Reserve units and personnel. National Guard troops are likely to be the first to arrive. DOD plans and policies for defense support to civil authority should be reexamined and revised appropriately. If two or more attacks occur nearly simultaneously, troop estimates are increased accordingly.

Finally, the most significant finding that emerges from this brief analysis is that the United States is unprepared to mitigate the consequences of a nuclear attack. We were unable to find any group or office with a coherent approach to this very important aspect of homeland security. Some attention has been paid to securing fissile material and detecting nuclear weapons in the hope of preventing such attacks, but very little effort has been expended on what to do if prevention fails. The National Response Plan does not address this kind of attack adequately. Bits of knowledge about how to deal with nuclear attacks exist in various places in the U.S. Government, but there is no evidence of an integrated body of knowledge or a workable plan. This is a bad situation. The threat of a nuclear attack is real, and action is needed now to learn how to deal with it and prepare for it.

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13 See "Bad Boy Trucks," www.theautochannel. 7 January 2005. The vehicles are very heavy and quite expensive and may not be completely shielded, but this is a start.

14 The TACAMO Aircraft is an E6-B (Boeing 707) aircraft outfitted with communications to provide an airborne command post.

15 The Commando Solo Aircraft is outfitted to provide broadcast messages and loudspeaker messages to people in the ground.

Appendix
DEALING WITH GAMMA RADIATION FROM RADIOACTIVE FALLOUT

Mitigating the effects of a nuclear explosion requires dealing with the harmful effects of gamma radiation emitted by radioactive fallout particles produced by the explosion. This appendix describes these effects and posits some issues that have to be explored in order to deal with the radiation during response operations to a nuclear explosion.

NUCLEAR WEAPONS EFFECTS

The three basic effects of a nuclear explosion are blast, thermal, and radiation. Blast and thermal effects are prompt, occurring in the first few minutes after the explosion. There are two categories of radiation effects: prompt and delayed.

Blast, thermal, and prompt radiation effects are located in the near vicinity of the point of detonation. They act in a short period of time but leave behind dead and injured persons, property damage, and disruption of services in a relatively small area around the point of detonation. Thermal effects may result in secondary fires. Prompt radiation contaminates areas, making response efforts difficult.

Another effect of a nuclear explosion may be electromagnetic pulse (EMP), which acts to disrupt electronic and electrical devices and systems in the vicinity of the point of detonation. The pulse occurs in a short time, but the effects act instantly, leaving behind problems in maintaining communications and other essential systems.

Delayed radiation is in the form of gamma radiation that emanates from particles of detritus from the explosion that fall out of the atmosphere and pose a health risk to humans and animals.

This appendix will focus on the radioactive fallout problem. The prompt effects, secondary fires, and EMP are important but not, perhaps, as important as fallout radiation when contemplating how to mitigate the consequences of a nuclear explosion.

GAMMA RADIATION

Gamma radiation is a form of electromagnetic ionizing radiation, which can be described as a stream of photons. It is similar to x-rays but with slightly higher frequency. Unlike x-rays, which are a mix of several frequencies, gamma radiation is produced in discrete wavelengths by each radioactive isotope. Three measures of gamma radiation are: the Roentgen (r), the Roentgen Absorbed Dose (rad), and the Roentgen Equivalent Man (rem).[16]

- A Roentgen describes the amount of energy that when absorbed in a cubic centimeter of dry atmospheric air at a pressure equivalent to 760 mg of mercury produces one electrostatic unit of electricity.[17]
- A rad describes the amount of energy transferred to a mass of material. This unit of radiation takes into account that different materials do not absorb the same amount of energy. One r of gamma radiation is about 1 rad of absorbed dose.
- A rem describes the biological effect of a dose in humans. For humans, 1 rad of exposure results in 1 rem of dose. When dealing with radiation protection for humans, the r, rad, and rem may be considered to be equivalent.[18]

Gamma radiation is harmful to humans and animals because the energy interacts with tissue and cells and damages them. The gross measure of damage is the accumulated dose, but there is also duration factor because the intensity of the radiation decays over time. An accumulated dose of radiation that is absorbed over a short period of time does more damage than the same dose absorbed over a long period of time. The intensity of radiation (from a health physics viewpoint) is expressed in terms of amount per unit of time—in this case rem per hour. The accumulated dose is the product of the (average) intensity and the duration of the exposure—in this case rem per day, week, month, or year.

When forecasting the effects of gamma radiation on humans, it is necessary to state both the intensity and the duration of exposure. Intensity is stated in rem per units of time, and duration is stated in units of time. Thus, it would be appropriate to state that a

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16 Steve Quayle's Radiation Measurement Conversion Tables, SI Radiation Measurement Units: Conversion Factors, www.stevequayle.com, 13 December 2004.

17 Encyclopedia Britannica, Macropedia, Volume 15, p. 460.

18 Quayle, op. cit.

human being might receive X rem/hour for 10 days, for an accumulated dose of 240X rem. However, because gamma radiation decays over time, this simple multiplication would be overstated, unless the intensity was an average over the time period.

In the official scenario describing a 10-kiloton nuclear explosion n an urban area, the fallout radiation is described in two categories. An acute category covers intense radiation received over a period of 24 hours and results in death or severe illness for those in that category. A chronic category covers less intense radiation over a period of 96 hours and results in illness for many so exposed.

The decay factor for fallout gamma radiation is stated in a planning factor that says that the dose rate decreases by a factor of 10 for every sevenfold increase in time from the detonation. At the end of the first week (7 days), the intensity will be 10 percent of its value on the day of the detonation. Seven weeks after that, the intensity will be only 1 percent of the original value.[19]

SURVIVING FALLOUT RADIATION

The primary danger from a fission or fusion weapon is radioactive fallout that consists of particles of solid material that are borne on winds aloft and then deposited on the earth downwind from the point of detonation. The particles are themselves radioactive and emit gamma radiation. Human beings are a risk if they are in proximity to radioactive fallout particles or ingest them.

Fallout is visible in the form of a dark cloud of debris and visible particles on the ground and other services. However, the gamma radiation itself is not detectable by human senses, and can be detected and measured in intensity only by special meters—radiacs.

There are two ways to survive exposure to fallout radiation. Either get away from the source of radiation (evacuation) or place a shield between you and the source of radiation (shielding). There is time to take these measures if one recognizes the situation and knows what to do. Radioactive fallout from the explosion takes time to arrive at ground level after the explosion. It takes time for radiation exposure to accumulate to

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19 K..E. Holbert, "Gamma Radiation Shielding," www.asu.edu/holbert/eee460, 19 January 2005. The linear attenuation function is exponential and depends to a small extent on the substance emitting the radiation.

amounts that are lethal or harmful. The optimum survival tactic will be some combination of these two actions.[20]

Using an "infinite dose" as a measure, it is possible to compare the effectiveness of some combinations of shelter and evacuation. An infinite dose is the cumulative dose a person would receive it he or she remained in the fallout zone without taking any survival action. The amount of the infinite dose depends on the distance of the individual from the point of detonation. The closer the human, the higher the infinite dose.

When a nuclear weapon detonates, it creates a fireball and a mushroom cloud of debris. The cloud contains radioactive particles. Depending on the yield and atmospheric conditions, some of the small particles are propelled to an altitude high enough to be caught by high atmospheric winds and borne for long distances aloft. These particles are dispersed around the planet and pose no immediate threat, although they may contaminate food supplies when they eventually fall to the ground. The larger particles are carried downstream by winds and settle to the ground, with the larger particles falling out first followed by the smaller. Generally, the larger particles are more radioactive than the smaller ones. Some time elapses between the detonation and the settlement of the fallout particles on the ground. Once they settle on the ground, they emanate gamma radiation. Generally, the intensity of this radiation is greatest nearer the point of detonation and becomes smaller as the distance from the point of detonation increases.

Humans can reduce the dose of gamma radiation they absorb by taking some relatively simple measures. The highest dose is received by unprotected people standing in the open. There are two kinds of protective measures. One kind is to keep clean from the fallout particles themselves. The other is to shield against the gamma radiation. In order to avoid the fallout particles, people should put on over clothing and avoid exposing bare skin to radioactive particles. Collars and cuffs should be closed. Approved protective clothing should be donned if available. Masks should be donned to prevent ingestion of fallout particles. Once in a sheltered structure, people should doff and discard their clothing, shower, and put on uncontaminated clothing. Washing vehicles and other articles will divest them of the radioactive particles. However, all of these

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20 Walmer E. (Jerry) Strope, "Nuclear Emergency Operations 101," American Strategic Defense Organization, www.strategicdefense.org, 4 January 2005.

actions minimize exposure but do not stop the radiation. The particles continue to emanate gamma radiation in accordance with the decay function.

Shielding from gamma radiation can be done by placing sufficient amount of certain materials between the people and the sources of the radiation. Materials that can block or degrade gamma radiation include compacted soil, concrete, steel, lead, and other dense substances. The relative effectiveness of some of these materials is indicated in Table A-1, which lists the half-thicknesses of material required to degrade the radiation intensity by a factor of two.[21] If one has a shield of 9.2 inches of concrete, it would degrade the initial radiation by 75percent (½ plus ½ of ½).

Table A-1. Gamma Radiation Shielding Effectiveness

Material	Half-Thickness (inches)
Concrete	4.7
Iron	1.3
Lead	0.7

Informed people can do some relatively simple things to minimize exposure while seeking effective shelter or waiting to evacuate. People in tall buildings can minimize exposure by going to the middle level floors—avoiding both the bottom floors and the top floors. People in houses and low buildings should go the basement and seek shelter away from windows. These actions do not protect absolutely, but they reduce exposure so that people can survive without absorbing a lethal dose while preparing to take more effective survival measures.

The timing and order of evacuation is a complex matter. Some time elapses between the detonation and the arrival of fallout on the ground. In this interval, people can move without exposing themselves to gamma radiation. The amount of time depends on the proximity to the point of detonation and the yield of the nuclear weapon. Generally, the time for arrival of fallout on the ground varies inversely with the distance from the point of detonation. This is highly dependent on the weather conditions at the time.

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21 Audeen W. Fentiman, Jeffery A. Henkel, and Ronadl J. Veley, "How Are People Protected from Ionizing Radiation?," Ohio State University, Extension Research, www.ag.ohio-state.edu, 19 January 2005.

Because of these things, simple spontaneous evacuation tends to be more dangerous for people than an orderly evacuation designed to minimize exposure to radiation. When people start to move after detecting the nuclear detonation, they need to know in advance when to start the move, the direction they are going, and how long they have to travel to get out of the Fallout Zone. Lacking this information, they are just as likely to increase their exposure as reduce it.

The objective function of the consequence management operation is to maximize the number of survivors with no long-term radiation effects, so it will be necessary to provide emergency public information so that people will do the right thing. However, the content of this emergency public information depends on being able to make correct assessments of the instantaneous direction, distance, duration, and dimensions of the fallout plume as well as the timing of the safe movement interval and local intensity of radiation along the perimeter and inside the Fallout Zone. If the authorities have from the outset sufficient information to make informed decisions on the safest routes out of the Fallout Zone, they can provide instructions to the people in that zone to move away from danger into the Secondary Zone.

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14. ABSTRACT

This document addresses the actions that should be taken in order to manage the consequences of a clandestine nuclear attack in the United States. The two scenarios used as the basis for this analysis are a 10-kiloton explosion in a major metropolitan area. (This is the official Planning Scenario #1) and a 1.5-kiloton explosion in a medium-sized city. Workloads from these explosions are estimated based on their effects. A concept of the consequence management operation is put forth, and the capabilities needed to deal with the workloads are defined. The tasks that have to be done to create these capabilities are stated, and the numbers of trained personnel needed to perform these tasks are estimated using planning factors. This provides an estimate of the overall numbers of responders needed to deal with the explosions. Based on criteria that call for the use of military troops, the numbers of military personnel to participate in these response operations are determined. This is an initial effort to demonstrate the magnitude of this response operation and obtain some idea of the numbers and kinds of personnel that would be used to maximize the number of healthy survivors and minimize the duration and damage from the disruption caused by the attacks.

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