New Concepts in Radiological Emergency Planning

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Agenda

• National Response Framework
• Shelter-in-Place vs Evacuation
  - Nuclear Power Plant
  - RDD/IND Event
• Responder RDD/IND Protocols
• Summary and Wrap-Up
How the Framework is Organized

Core Document

Doctrine, organization, roles and responsibilities, response actions and planning requirements that guide national response

Emergency Support Function Annexes
Mechanisms to group and provide Federal resources and capabilities to support State and local responders

Support Annexes
Essential supporting aspects of the Federal response common to all incidents

Incident Annexes
Incident-specific applications of the Framework

Partner Guides
Next level of detail in response actions tailored to the actionable entity

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Applying the Framework

• Most incidents wholly managed locally
  - Some require additional support (state, county)
  - Small number require Federal support
  - Catastrophic requires significant Federal support
  - State Governor must request Federal support
    • Stafford Act ("Emergency Declaration")

• Who’s in Charge when the Feds Arrive?
  - State, county or local responders
  - Unless local authorities abdicate the lead responsibility
  - “Incidents of National Significance”
Incident Annexes

- Biological Incident
- Catastrophic Incident
- Cyber Incident
- Food and Agriculture Incident
- Nuclear/Radiological Incident
- Oil and Hazardous Materials Incident
- Terrorism Incident Law Enforcement and Investigation
Nuclear/Radiological Annex

• The concept of operations for a response provides for the designation of one agency as the Coordinating Agency (CA)

• Nineteen (19) Federal Agencies have responsibilities under this Annex

• Seven Agencies can be designated as CA
  • DHS, NRC, DOD, DOE, EPA, NASA, USCG
Coordinating Agency

• The agency with primary responsibility for coordinating the Federal response to a radiological incident serves as the coordinating agency.

• The coordinating agency coordinates the actions of Federal agencies related to the incident utilizing this annex, agency-specific plans, and/or the NRF, as appropriate.
## Who is the CA?

<table>
<thead>
<tr>
<th>Nuclear/Radiological Facilities or Materials Involved in Incident</th>
<th>Coordinating Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nuclear facilities:</strong></td>
<td></td>
</tr>
<tr>
<td>(1) Owned or operated by DOD or DOE</td>
<td>(1) DOD or DOE</td>
</tr>
<tr>
<td>(2) Licensed by NRC or Agreement State</td>
<td>(2) NRC</td>
</tr>
<tr>
<td>(3) Not licensed, owned, or operated by a Federal agency or an Agreement State, or currently or formerly licensed facilities for which the owner/operator is not financially viable or is otherwise unable to respond</td>
<td>(3) EPA</td>
</tr>
<tr>
<td><strong>Radioactive materials being transported:</strong></td>
<td></td>
</tr>
<tr>
<td>(1) Materials shipped by or for DOD or DOE²</td>
<td>(1) DOD or DOE</td>
</tr>
<tr>
<td>(2) Shipment of NRC or Agreement State-licensed materials</td>
<td>(2) NRC</td>
</tr>
<tr>
<td>(3) Shipment of materials in certain areas of the coastal zone that are not licensed or owned by a Federal agency or Agreement State (see DHS/USCG list of responsibilities for further explanation of “certain areas”)</td>
<td>(3) DHS/USCG</td>
</tr>
<tr>
<td>(4) All others</td>
<td>(4) EPA</td>
</tr>
</tbody>
</table>
### Radioactive materials in space vehicles impacting within the United States:

1. Managed by NASA or DOD
2. Not managed by DOD or NASA and impacting certain areas of the coastal zone
3. All others

<table>
<thead>
<tr>
<th>(1) NASA or DOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2) DHS/USCG</td>
</tr>
<tr>
<td>(3) EPA</td>
</tr>
</tbody>
</table>

### Foreign, unknown, or unlicensed material:

1. Incidents involving inadvertent import of radioactive materials
2. Incidents involving foreign or unknown sources of radioactive material in certain areas of the coastal zone
3. All others

<table>
<thead>
<tr>
<th>(1) DHS/CBP</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2) DHS/USCG</td>
</tr>
<tr>
<td>(3) EPA</td>
</tr>
</tbody>
</table>

### Nuclear weapons

| DOD or DOE (based on custody at time of incident) |

### All deliberate attacks involving nuclear/radiological facilities or materials, including RDDs or INDs

| DHS |
Cooperating agencies provide technical and resource support, as requested by the coordinating agency.
Determination of CA

• Incidents of National Significance: DHS

• Conditions:
  - DHS assistance is requested because state and local capabilities are overwhelmed
  - Multiple federal agencies become “substantially” involved
  - Major disasters/emergencies as defined by the Stafford Act or other catastrophic incidents
  - As directed by the President
Foreseeable Threats

In rank-order of probability:

1. Radiological Dispersal Device (RDD)
   • Conventional explosive used to disperse radioactive sources, high-pressure aerosol “Dirty Bomb”

2. Conventional explosive at “nuclear facility”
   • A dispersal event rather than a criticality, or nuclear fission event, including airplane collision

3. Improvised Nuclear Device (IND)
   • Device capable of criticality, or fission
   • Self-built or stolen
Why Isn’t the Nuclear Facility Ranked First?

• Examples: nuclear power facility, radioactive waste site, or nuclear weapons facility.

• Commercial nuclear facilities are guarded 24 hrs/day, 365 days/yr by heavily armed, well trained personnel (Mall cops need not apply)

• Security systems well coordinated with local, state and federal agencies (Post 911-NPP)
Comparative Size of Targets

WTC
- 208’ wide
- 1,353’ tall

Pentagon
- 1,489’ wide (921’ per side)
- 71’ tall

Containment Building
- 130’ wide
- 160’ tall

Spent Fuel Pool
- 80’ wide
- 40’ tall

Dry Casks
- 10’ wide
- 20’ tall
(12 depicted)
Radiological Emergency Responses

- Nuclear Facility Release
- Transportation Accident
- Lost or Fugitive sources
- Radioactive Dispersal Device (RDD)
- Improvised Nuclear Detonation (IND)
Nuclear Plant

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Emergency Planning Zones (EPZs)

0-10 Mile EPZ:
Plan to evacuate, shelter and/or administer KI

10-50 Mile EPZ:
Plan to control foodstuffs and/or water supplies.
Manual of Protective Action Guides and Protective Actions For Nuclear Incidents

EPA 400-R-92-001
May 1992
The projected *avoided* dose at which a specific protective action is recommended.
PAG vs Accident Phase

• Early:
  - Notification
  - Evacuation
  - Shelter in place
  - KI administration

• Intermediate:
  - Long-term relocation
  - Control of foodstuffs

• Late:
  - Permanent relocation
  - Land use restrictions
Interim Changes to PAGs

• DHS published “Protective Action Guides for Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) for interim use on January 3, 2006 (71 FR 174)

• EPA to release new PAGs (update to EPA 400-R-92-001) sometime this year? (2009).

• New PAGs are definitely needed now!
EVACUATE OR SHELTER?
Evacuation May Not Be Appropriate

New Draft PAGs: 1-5 rem

• For a short duration, high exposure release sheltering may be more protective.

• Sheltering may be preferred for higher risk groups up to 5 rem.

• Sheltering may be preferred for hazardous environmental conditions up to 5 rem (or 10 rem for higher risk groups)
Considerations for Evacuation
Sheltering Dose Reduction
Factors for External Radiation

Source: AFRRI
### Sheltering Dose Reduction Factors for Internal Exposure

<table>
<thead>
<tr>
<th>Ventilation Rate (air changes/h)</th>
<th>Duration of Plume (h)</th>
<th>DRF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>0.5</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>0.54</td>
</tr>
<tr>
<td>1.0</td>
<td>0.5</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>0.83</td>
</tr>
</tbody>
</table>

DRF = Dose Reduction Factor

Source: AFRRI
Radiological Emergency Responses

- Nuclear Facility Release
- Transportation Accident
- Lost or Fugitive sources
- Radioactive Dispersal Device (RDD)
- Improvised Nuclear Detonation (IND)
Why are “Dirty Bombs” Ranked First?

• Conventional explosives are easy to obtain
• Although not as readily available, potential radioactive sources might be:
  – Examples: gauges, testing sources, waste materials
  – Non-domestic sources (FSU abandoned sources)
  – Radionuclide type and quantity almost unimportant
• Of 26 terror acts in US in past 22 years, 17 have involved explosives (www.cdi.org)
<table>
<thead>
<tr>
<th>Hazard Category</th>
<th>Nuclides of Interest $^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primarily External $^b$</td>
<td>Co-60, Cs-137, Ir-192 $^c$</td>
</tr>
<tr>
<td>Primarily Internal $^d$</td>
<td>Sr/Y-90, Am, Po, Pu, Cm, Ra, Cf</td>
</tr>
<tr>
<td>External and Internal $^e$</td>
<td>Co-60, Cs-137, Ir-192, Cf-252 $^f$</td>
</tr>
</tbody>
</table>
### RDD/IND Exposure Pathways

<table>
<thead>
<tr>
<th>Exposure Pathway</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External Exposure</strong></td>
<td>After NCRP 138, Table 8.1</td>
</tr>
<tr>
<td>Detonation of a WMD</td>
<td></td>
</tr>
<tr>
<td>Plume (during release)</td>
<td></td>
</tr>
<tr>
<td>Surface contamination and activation products</td>
<td></td>
</tr>
<tr>
<td>Personal contamination (skin and clothing)</td>
<td></td>
</tr>
<tr>
<td><strong>Internal Exposure</strong></td>
<td></td>
</tr>
<tr>
<td>Plume inhalation</td>
<td></td>
</tr>
<tr>
<td>Inhalation of resuspended contamination</td>
<td></td>
</tr>
<tr>
<td>Inhalation or ingestion of personal contamination</td>
<td></td>
</tr>
<tr>
<td>Ingestion of contaminated foodstuffs</td>
<td></td>
</tr>
<tr>
<td>Absorption through the skin, or injection (as through a wound) of contaminated material</td>
<td></td>
</tr>
</tbody>
</table>
Initial Findings: RDD

- Primary concern is external exposure from the material deposited on the ground (a.k.a. groundshine).

- Inhalation dose is a very minor concern except to those outdoors and near the explosion. Responders will usually arrive after most the radiotoxic smoke has dissipated.
Smoke and Dust from an explosive RDD may be contaminated. Immediately after a suspicious event, effort should be made to avoid breathing smoke and dust by seeking shelter and through respiratory protection, even ad-hoc protection.

- Sheltering is effective:
  - Respirable aerosol penetrates single residence buildings easily, even so...
  - Inhalation dose to those inside is a small fraction of outside dose
  - Larger buildings have more aerosol removal mechanisms than smaller buildings

- Effectiveness of turning off HVAC of modern high rise building needs further evaluation, buildings at risk should develop individualized emergency shelter in place (SIP) protocols.

- Ad-hoc Respirator: A dry cloth over the nose and mouth can reduce internal dose by 90%
Inhalation not a significant hazard after 10-30 minutes
Radiological Emergency Responses

- Nuclear Facility Release
- Transportation Accident
- Lost or Fugitive sources
- Radioactive Dispersal Device (RDD)
- Improvised Nuclear Detonation (IND)
Improvised Nuclear Device

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Radiological WMD

• Improvised Nuclear Device (IND):
  - A device capable of producing nuclear yield, employed for terrorist or criminal purposes.

  - It may be a modified stockpile warhead, a state-designed nuclear explosive, or a device fabricated by a terrorist/criminal organization.
**National Planning Scenario**

(Low Yield Nuclear Detonation)

- Most Prompt Casualties are from blast and thermal injuries

**PROMPT EFFECTS**
- Blast overpressure
- Severe shockwave damage

**FALLOUT EFFECTS**
- Lethal prompt (initial) radiation
- Severe thermal damage
- General radioactive fallout pattern
- Ionizing radiation

- Most Prompt Casualties are from blast and thermal injuries

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Prompt Effects Summary

• Most prompt casualties (injuries + fatalities) are from blast and thermal energy (not radiation)

• Literature and models predict:
  – 100,000s casualties can occur from the prompt effects in the first few minutes within a few miles of ground zero,
  – Overall number of casualties likely to be reduced by protection from the urban landscape and being within heavy buildings, however;
  – Tertiary effects (building collapse, glass and debris missiles) may increase number of casualties

• Those outdoors may be temporarily blinded (<1 mile)

• Dust and debris will cloud the air (fallout)
Radiation and Thermal Effects
Unprotected Population (Clear Day)

3° Burns LD-50
1.5km ~360,000 people

300cGy LD-50
1.4km 300,000 people

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FALLOUT

• The nuclear detonation creates a large cloud of radioactive dust & water vapor which fall back to earth contaminating horizontal surfaces

• Dangerous levels of fallout creates visible dust and debris, These particles give off penetrating radiation that can injure people (even indoors)

• Fallout decays rapidly away with time, and is most dangerous in the first few hours after the detonation.
<table>
<thead>
<tr>
<th>Dose Rate</th>
<th>Fallout Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 cGy/hr</td>
<td>Injury in 1 hour</td>
</tr>
<tr>
<td>10 cGy/hr</td>
<td>Injury in 10 hour</td>
</tr>
<tr>
<td>1 cGy/hr</td>
<td>Injury in 4 days</td>
</tr>
<tr>
<td>0.1 cGy/hr</td>
<td></td>
</tr>
<tr>
<td>1,500 cGy/hr</td>
<td>Injury in 3 minutes, LD-50 in 10 minutes</td>
</tr>
</tbody>
</table>
Downwind Dose Rate @ 2 hours

Fallout Effects

<table>
<thead>
<tr>
<th>Dose Rate</th>
<th>Injury Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 cGy/hr</td>
<td>Injury in 1 hour</td>
</tr>
<tr>
<td>10 cGy/hr</td>
<td>Injury in 10 hours</td>
</tr>
<tr>
<td>1 cGy/hr</td>
<td>Injury in 4 days</td>
</tr>
<tr>
<td>.1 cGy/hr</td>
<td></td>
</tr>
</tbody>
</table>

180 cGy/hr
Injury in 30 minutes, LD-50 in 2 hours
RESPONDER RDD/IND PROTOCOLS
Emergency Worker Limits

- 5 rem (OSHA radiation worker dose)
- 10 rem protection of valuable property*
- 25 rem life saving or protection of large populations*
- >25 rem life saving or protection of large populations*

*When lower values not practical. Voluntary basis, fully informed
Considerations for RDD Events

• Area of highest concern limited to 500 m radius from detonation site (worse case)

• Within 500 m, Primary inhalation hazard is gone within 10 minutes (prior to arrival of responders)

• Primary concerns of the early first responder are:
  – Protection from groundshine,
  – Provide guidance on handling contamination, &
  – Assess inhalation concern (resuspension)

• Although inhalation exposure not the main concern, respiratory protection still advised

From Harper and Musolino
Who's Got the Right PPE?

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First Responder PPE

a) Uniform
b) Goggles
c) Half-face APR
d) Gloves

Level A and B protection are ineffective against a primary dose concern: groundshine radiation. Using level A or B may actually increase a responders dose as it limits functionality and communication which will increases their working time in the radiation field.
• Every community should balance the “risk vs. benefit” equation differently to their own specific needs.

• Most important to have a response plan with a scaleable approach.

• Planning is often more important than the plan itself. (Plans are static; Planning is not)

• A sound scientific basis is important
Welcome to the Health Physics Society Homeland Security Committee

Nuclear and radiological weapons may be used in terrorist attacks on the United States or other countries. The intent of the Homeland Security Committee is to provide assistance to professionals and to member of the public in order to reduce the potential for the occurrence or to mitigate the effect of such an attack.
QUESTIONS??

IF THIS WERE AN ACTUAL NUCLEAR POWER PLANT ACCIDENT...

WE WOULD LET YOU SLEEP

THIS IS A TEST...
THIS IS ONLY A TEST

THIS IS A TEST OF THE NUCLEAR REGULATORY COMMISSION EVACUATION PLAN