National Nuclear Security Administration
Defense Nuclear Nonproliferation

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Global Threat Reduction Initiative

Reducing Nuclear and Radiological Threats Worldwide

Protection of Radioactive Sources

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Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Welcome

Purpose

The goal of this training is to provide awareness of radiation safety and security, to discuss radiological incident response, and to promote communication with source licensees to minimize the consequences of this threat.

Introduction

Presentation Outline

- What is radiation?
- What are the effects of radiation on people?
- How do you protect yourself from radiation?
- How do you protect your sources from theft/sabotage?
- How do you respond to a radiological event?
- How do you assess radiation levels/dose rates?
- What tools can I use to assess these levels?

Radiation & Radioactive Material

Terminology

What is the difference between radiation, radioactive material and contamination?

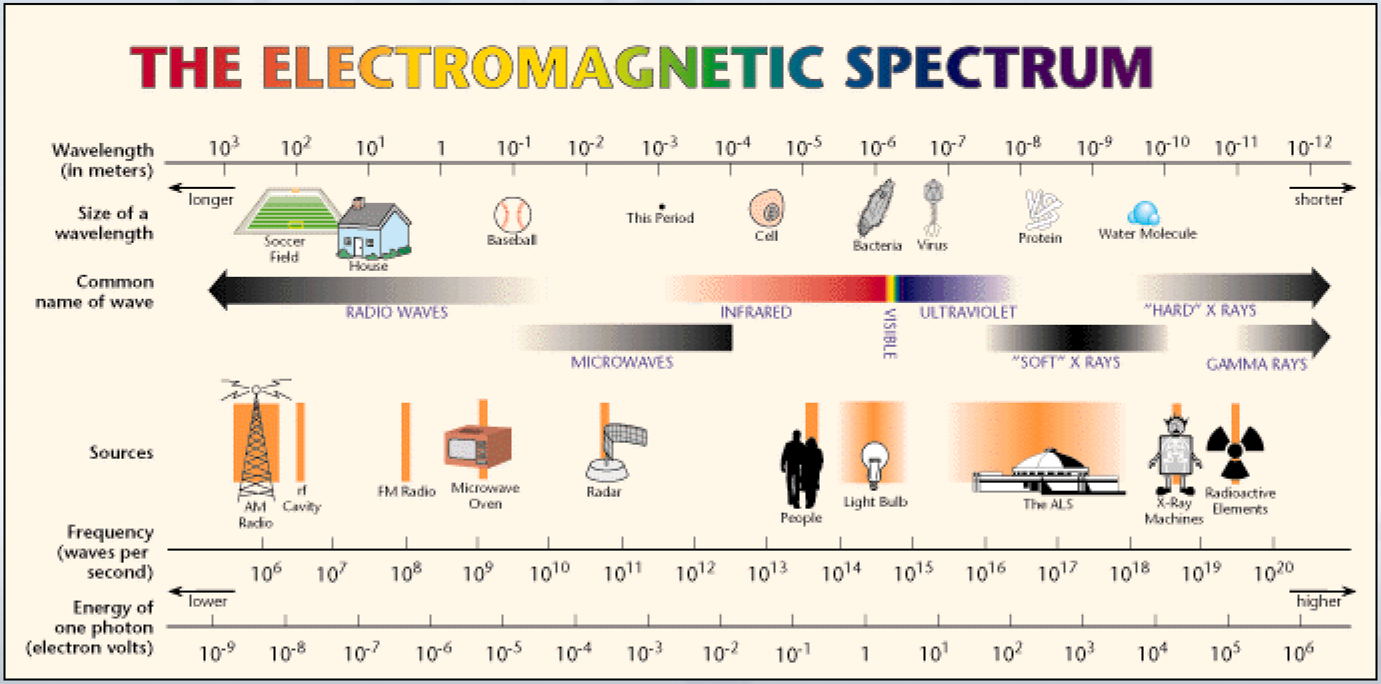
- Radiation is the **energy** given off from an atom that is not stable.
  - Measured by dose/dose rate (Rads, Grays, mRem).
- Radioactive material is a **substance** emitting radiation (naturally occurring or man-made).
  - Measured by activity (Curie, Bequerel, Sievert)
- A Radioactive Source is a type of radioactive material packaged so the radiation can be used safely for industrial, medical, or research purposes.

Why are atoms not stable?

- Atoms are unstable (Radioactive) if there are too many or too few neutrons for a given number of protons

What is Radiation?

- Ionizing
  - Ionizing radiation has enough energy to remove electrons from an atom
- Non-ionizing



Lbl.gov

Why is radiation harmful?

- Removing electrons from atoms (Ionization) can affect the normal function of cells.
  - This can directly rupture membranes that surround cells.
  - This can form free radicals in cells that can form harmful chemicals which can attack DNA or other cellular structures.
- Effects of radiation on cells:
  - There is no damage.
  - Cells repair the damage and operate normally.
  - Cells are damaged and operate abnormally.
  - Cells die.
- Biological effects depend on how much and how fast a dose is received.
  - The faster the dose is delivered, the less time the body has to repair itself.

Why is radiation harmful?

- A chronic dose is a small dose over a lifetime.
  - Cells have time to repair damage.
- An acute dose is an intense dose over a short period of time.
  - Cells have a harder time repairing damage after an acute dose. Replacement of damaged cells with new cells may take a few months.

Types of Ionizing Radiation

Alpha

- Hazardous if inhaled or digested
- Shielded by gloves or clothing

Beta (Sr-90)

- Hazardous if inhaled or digested
- Hazardous to eyes
- Shielded by safety glasses

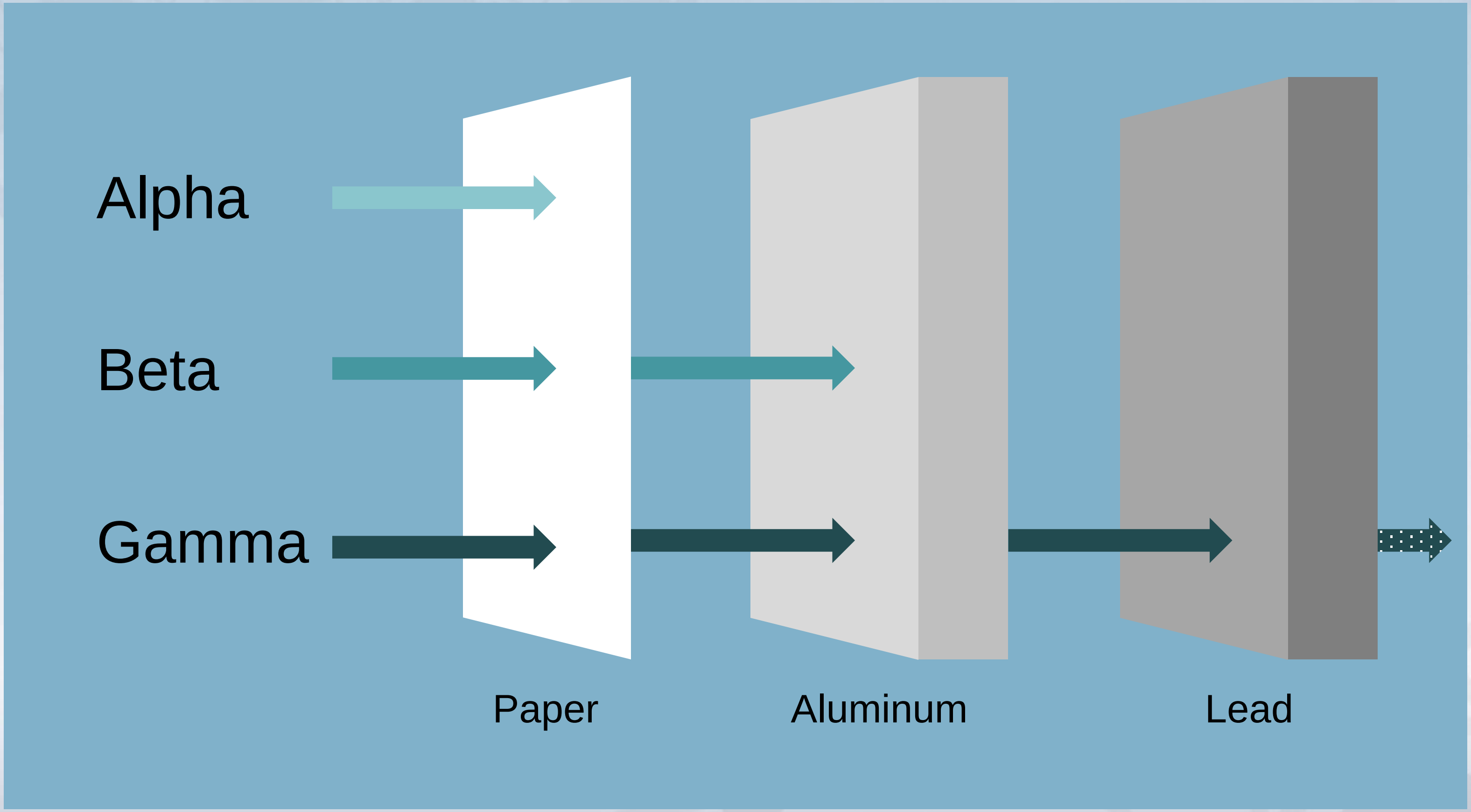
Gamma (Co-60, Cs-137)

- External hazard
- Shielded by high-density materials including concrete, steel, or lead

Neutron

Radiation Penetration

Radioactive particle types have different responses to materials.



Protection from Radiation

- Time
  - Reduce the amount of time spent near exposed sources.
- Distance
  - Increase the distance between you and the source.
- Shielding
  - Utilize shielding to block the radiation coming from the source.

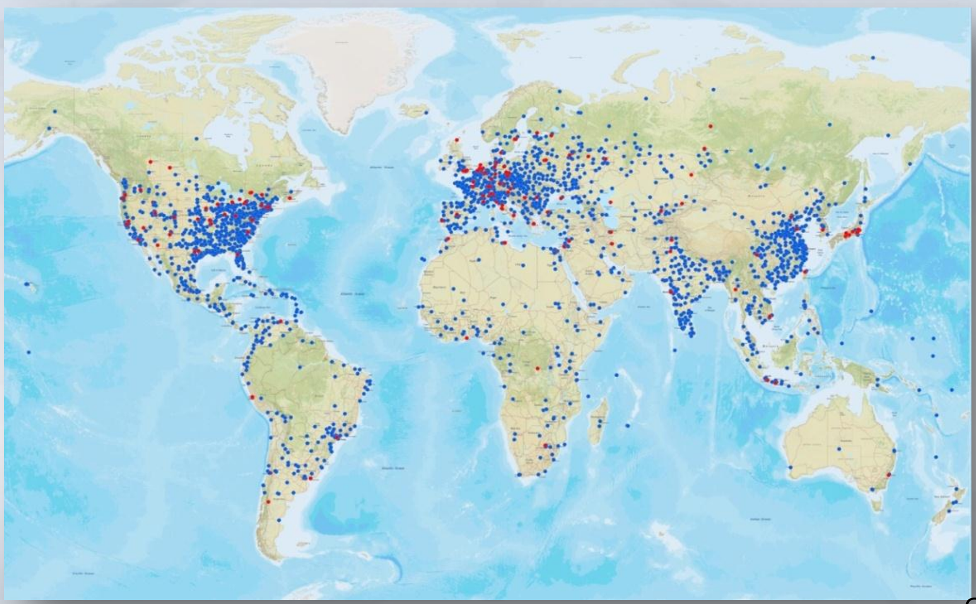
Beneficial Uses of Radioactive Sources

Device or Activity	Radionuclide	Use	Example
Irradiators	Co-60, Cs-137	Used in the sterilization of commercial products, food, medical devices, and blood, in addition to other items. Also used for research applications. Frequently found in commercial operations, medical centers, and universities. Devices are fixed.	 Blood Irradiator
Teletherapy	Co-60, Cs-137	Used in the treatment of cancer. Frequently found in medical centers. Devices are fixed.	 Teletherapy Unit
Industrial Radiography	Ir-192	Used in the testing of the integrity of materials. Frequently found in commercial operations and petrochemical operations. Devices are portable.	 Radiography cameras
Brachytherapy	Ir-192	Used in the treatment of cancer. Frequently found in medical centers. Devices are portable.	 Brachytherapy Unit

Propagation of Radiological Material

Nuclear and radiological materials are located at thousands of civilian sites and are used for legitimate and beneficial commercial, medical, and research purposes

It is estimated that over 5,000 facilities world-wide contain sources of 10 curies or greater.



Graphic from *GTRI Standard Briefing*

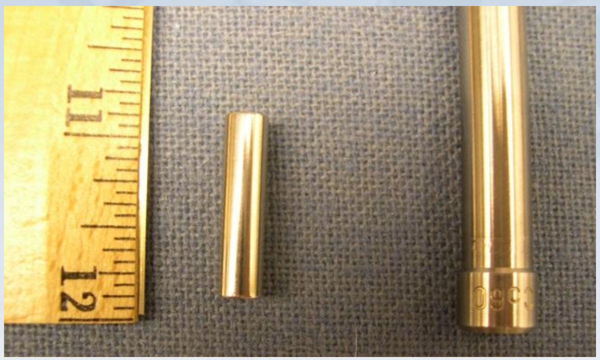
Attractiveness of Sources to Potential Adversaries

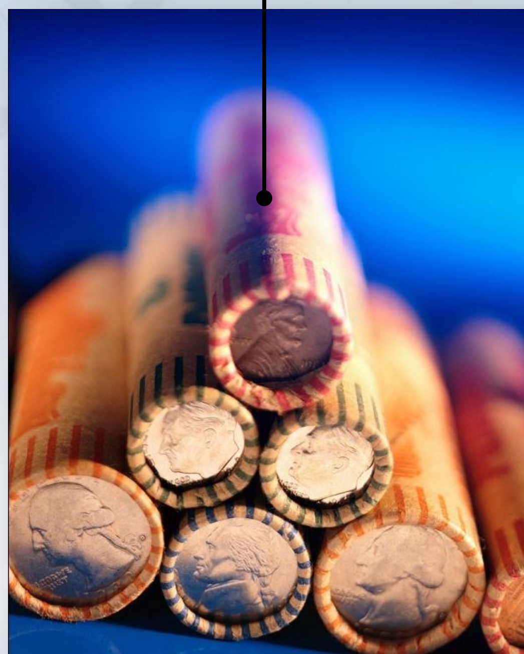
- Readily available material
- Relatively unsophisticated technology
- Minimal security in many instances
- Uncontrolled radiation may cause fear and panic

Materials of Concern

Radiological

1,000 Ci of radioactivity (about the size of a roll of coins) is all that is needed to make a large radiological dirty bomb.





Protection & Physical Security of Radiological Sources

How are sources protected?

Lithuanian Regulation of Radioactive Material

Provide information from regulator

GTRI Mission and Program Goals

DOE STRATEGIC GOAL 2.2

Prevent the acquisition of nuclear and radiological materials for use in weapons of mass destruction and other acts of terrorism

GTRI MISSION

Reduce and protect vulnerable nuclear and radiological material located at civilian sites worldwide.

GTRI is:

- A part of President Obama's comprehensive strategy to prevent nuclear terrorism;
- Developing an aggressive plan to secure all nuclear weapons materials within four years; and
- The key organization responsible for implementing the U.S. HEU minimization policy.

Convert

Convert research reactors from the use of highly enriched uranium (HEU) to low enriched uranium (LEU)

These efforts result in permanent threat reduction by minimizing and, to the extent possible, eliminating the need for HEU in civilian applications – each reactor converted or shut down eliminates a source of bomb material.

Remove

Remove and dispose of excess nuclear and radiological materials

These efforts result in permanent threat reduction by eliminating bomb material at civilian sites – each kilogram or curie of this dangerous material that is removed reduces the risk of a terrorist bomb.

Protect

Protect high priority nuclear and radiological materials from theft and sabotage

These efforts result in threat reduction by improving security on the bomb material remaining at civilian sites – each vulnerable building that is protected reduces the risk until a permanent threat reduction solution can be implemented

Slide from *GTRI Standard Briefing*

Physical Protection System

A physical protection system (PPS) is the integration of people, procedures, and equipment for the protection of assets or facilities (the target) against theft, sabotage, or other malicious acts.

Physical protection systems are designed according to a graded approach which is based on:

- Level of threat
- Attractiveness of target
- Potential for and degree of consequences

PPS Goals

Deter the Adversary

- Implement a PPS which all adversaries perceive as too difficult to defeat
- Problem: deterrence is impossible to measure

Defeat the adversary with PPS

- PPS functions required: detection, delay, response
- Actions of response force prevent adversary from accomplishing the goal

PPS Functions

To best deter and defeat an adversary, the following three functions must be present in a PPS

- Detection
- Delay
- Response

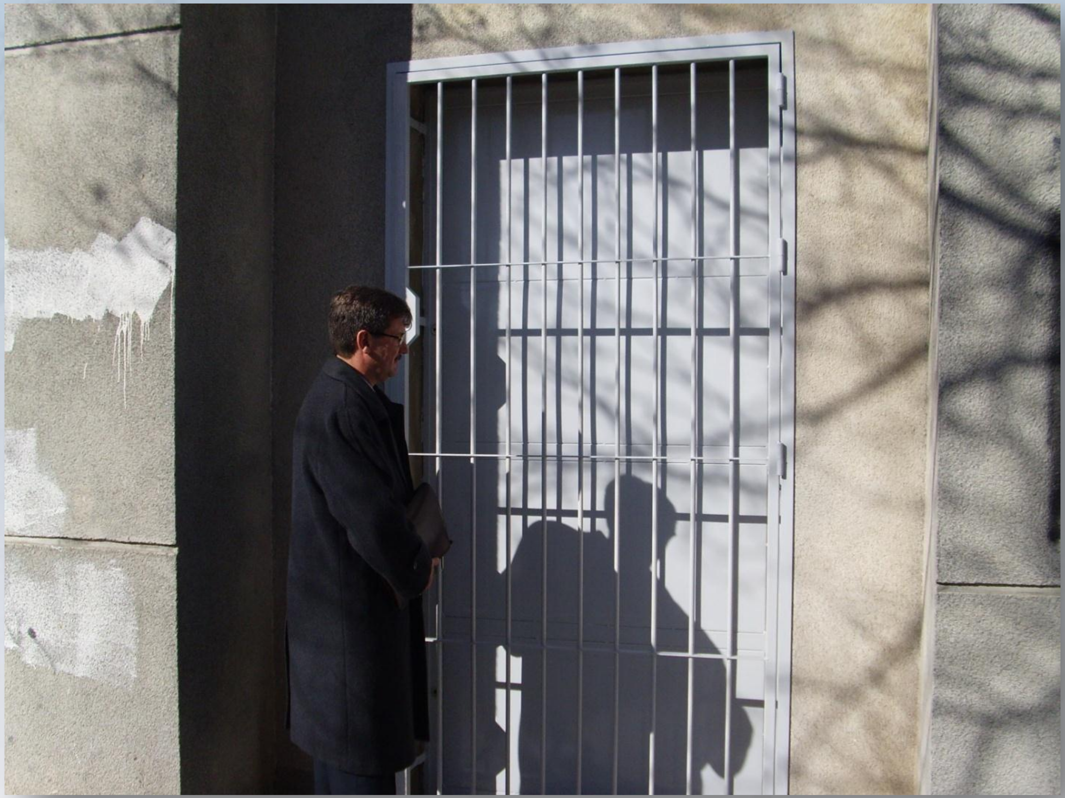
Site Security Upgrades

The goal is to identify gaps in the existing system and correct with security actions.

GTRI Comprehensive and Integrated Security System Elements

Security Function	Description	Sample Security Actions
Deter	Administrative and technical measures that create awareness of the threat, obtain a commitment to address the threat, and provide basic deterrence to prevent an attack.	•Threat awareness briefing •Basic security training •Clear vegetation/debris from building and perimeter vicinity
Control	Technical and administrative measures that provide nuclear and radioactive materials accounting and limit access to those materials.	•Tamper-Indicating Devices •Establish two-person rule •Basic computerized accounting log
Detect	Technical measures that are designed to alert personnel that an unauthorized access has been/is occurring.	•Intrusion detection system •Fiber-optic seal/cable or contact switch at material source •CCTV surveillance with proper area lighting
Delay	Technical measures that increase the time required for an adversary to enter and gain access to the protected material.	•Secure safes and containers for material storage •Basic hardening of material storage room (doors, windows, walls, ventilation ducts)
Respond	Technical and administrative measures following the detection of an unauthorized access to protected material.	•Encourage establishment/enhancement of on-site response •Radio communications system
Sustain	Administrative and technical measures that ensure continuity of system effectiveness	•Minimum three-year warranty for upgrades •Obtain written commitment on host country/site investment

Common Upgrades



Common Upgrades

Responding to a Radiological Event

What is the Threat?

Threat – an adversary with the motivation, intention, and capability to commit a malicious act

Outsider threat

- Terrorists
- Criminals
- Protestors

Insider threat

- Anyone with authorized, unescorted access who could:
  - Act alone or in collusion with an external threat
  - May be passive or active
  - May be violent or nonviolent

Malicious Uses of Radiological Sources

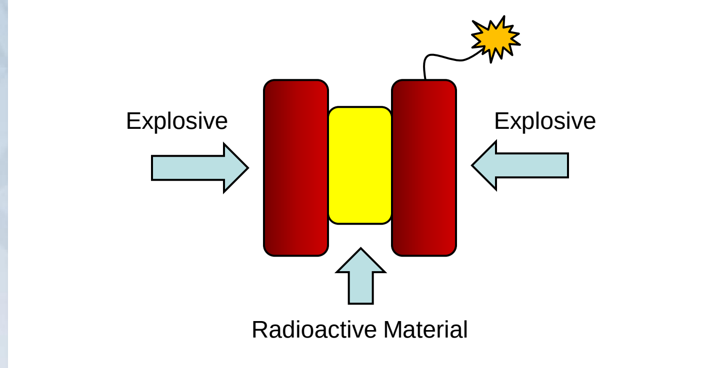
Whether by theft or sabotage, radiological sources can be used for malicious purposes

- Deliberately exposing people and the environment to radiation exposure via
  - dispersal of radioactive material in a Radiological Dispersion Device (RDD or dirty bomb), or
  - external radiation exposure in a Radiological Exposure Device (RED)

Radiological sources are also desirable for the purpose of resale

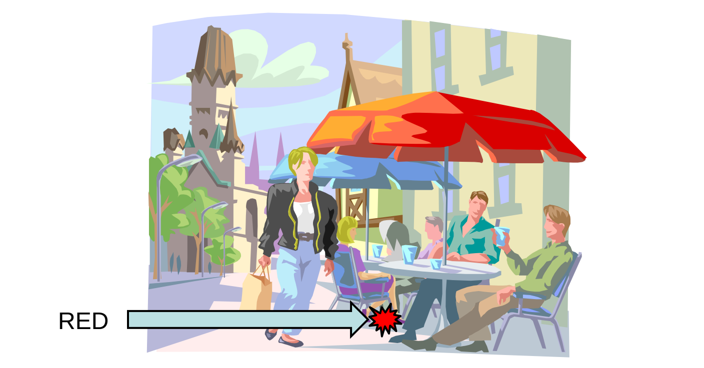
Dangers of Radiological Sources

Radiological Dispersal Device (RDD) aka "Dirty Bomb"



Simple explosive RDD design example

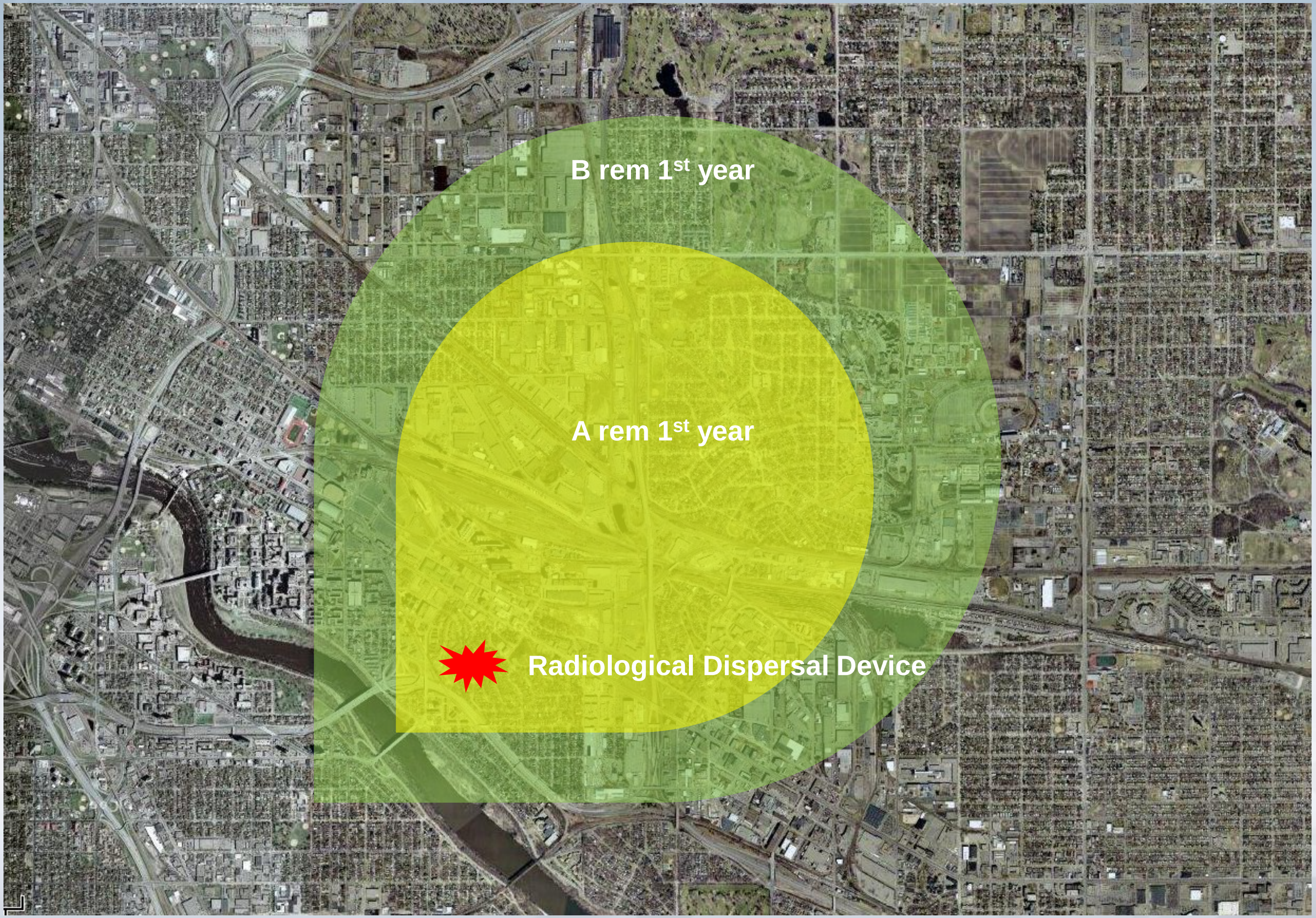
Radiological Exposure Device (RED)



Hidden radioactive sources placed in high population areas

- Weapon of mass disruption
- More likely to be encountered than an improvised nuclear device
- Detonation/exposure would cause radiation contamination, mass evacuation/area denial, widespread public fear/panic
- Economic disruption – billions of dollars in lost wages and cleanup

Area Radiation Contamination Concept



Malicious Use – A Matter of When, Not If

- **Stolen Cs-137 (North Carolina, 1998)** - 19 vials of Cesium-137 were stolen from a locked safe at a Greensboro, NC hospital during the NCAA basketball tournament hosted in Greensboro. The vials were never recovered and insider involvement was likely.
- **Coworker Attack with Ir-192 Injures 75 People (China, 2003)** - Chinese nuclear medicine expert, was given a suspended death sentence after being convicted of placing radioactive Ir-192 pellets in a colleague's office. Perpetrator worked at a Chinese hospital in Guangzhou and used forged official papers to buy the Ir-192.
- **Unauthorized Access to GammaKnife Room (Pittsburgh, 2006)** - Egyptian national, on a student visa and possessing a large industrial screwdriver, was found after hours in a hospital room housing a large gamma knife machine containing hundreds of Co-60 sources. Scratch marks were left on the back of the machine.
- **Dhiren Barot (UK, 2006)** - Arrested in the U.K. and admitted to performing reconnaissance of American targets for Al-Qaeda. Plotted to blow up the NY Stock Exchange with a "dirty bomb".
- **Cs-137 Source Stolen for Extortion Purposes (Argentina, 2009)** - Two armed men entered the Baker Atlas drilling equipment storage facility in Neuquen, Argentina. They handcuffed the guard and took the keys to a radiological source storage bunker containing Cs-137 sources used for oil well logging. The company began receiving extortion calls, demanding $500,000 and threatening "to make this city glow" if the thieves were not paid.

"Al-Qaeda is interested in radiological dispersal devices (RDDs) or "dirty bombs." Construction of an RDD is well within its capabilities as radiological materials are relatively easy to acquire from industrial or medical sources. Osama Bin Laden's operatives may try to launch conventional attacks against the nuclear industrial infrastructure of the United States in a bid to cause contamination, disruption, and terror."

Synopsis of CIA briefing given to National Association of Chiefs of Police,
"CIA Briefs Law Enforcement on Possible WMD Attacks," Examiner.com, December 14, 2009.

Slide from *GTRI Standard Briefing*

Possible Consequences

- Acute radiation sickness or fatality
- Radiation dose to the public and emergency workers with subsequent increase in latent cancer likelihood
- Contamination
- Loss of function of an area including city, residential or facilities
- Economic disruption
- Social disruption
- Psychological effects

Detection

Discovery of an attempted or actual intrusion.

1. Sensor Activated
2. Alarm Signal Sent
3. Alarm Assessed
4. Communicated to Response

Detection should:

- Also include assessment
- Identify unauthorized activities, while disregarding authorized activities
- Be in-depth with multiple detection points requiring the adversary to use different skills, better planning, and a variety of tools to defeat

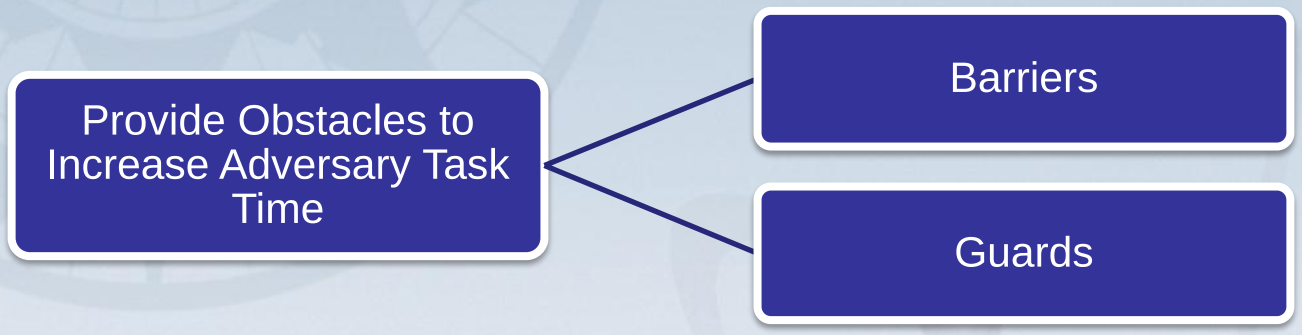
Detection Technology & Design

Examples of detection technology

- Sensors
  - Motion detectors
  - Balanced Magnetic switches
  - People
    - People are considered poor sensors and are not cost effective
- Entry control
  - PIN reader
  - Badge/card reader
  - Iris scanner
  - Finger print scanner
- Assessment technology
  - Cameras
  - People

Delay

Impedes adversary's progress toward task completion to allow time for response.



Delay should:

- Follow detection
- Be maximized at the target for cost effectiveness
- Be in-depth with multiple barriers requiring the adversary to use different skills, better planning, and a variety of tools to defeat

Delay Technology & Design

Delay elements can be very simple in design to very complex

Examples of delay elements:

- Doors
- Locks
- Walls and fences
- Bollards
- People

Defeating Delay

Adversaries may bring a variety of tools to defeat delay elements. The sophistication of tools available to the adversary is taken into consideration when determining the amount of delay to include in a PPS.

Examples of adversary tools:

- Hand tools
- Electric tools
- Explosives
- Vehicles

Response

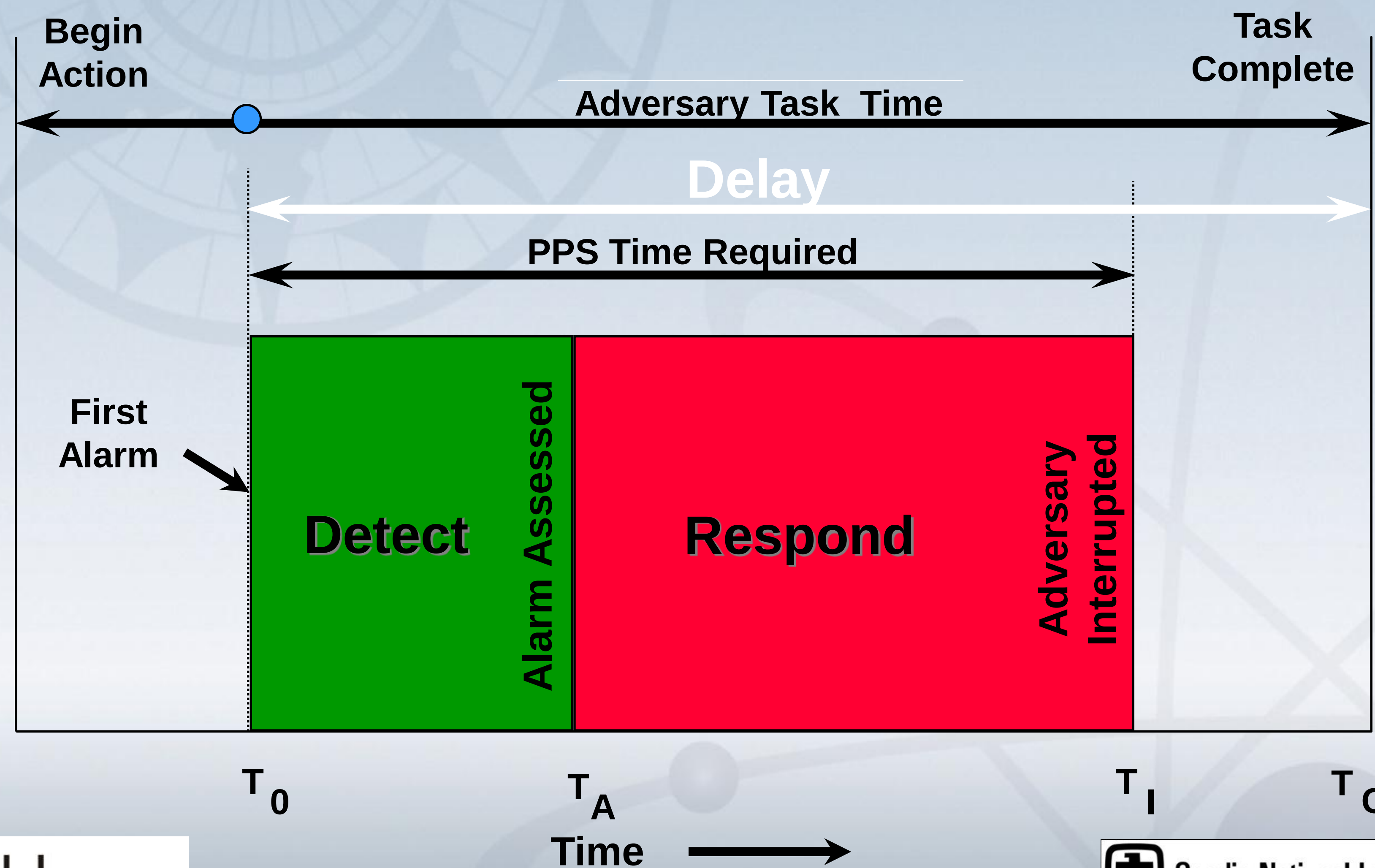
Encompasses the actions taken, following detection, to prevent adversaries from succeeding in completion of their task

Communicate to Response Force → Deploy Response Force → Interrupt Adversary → Defeat Adversary

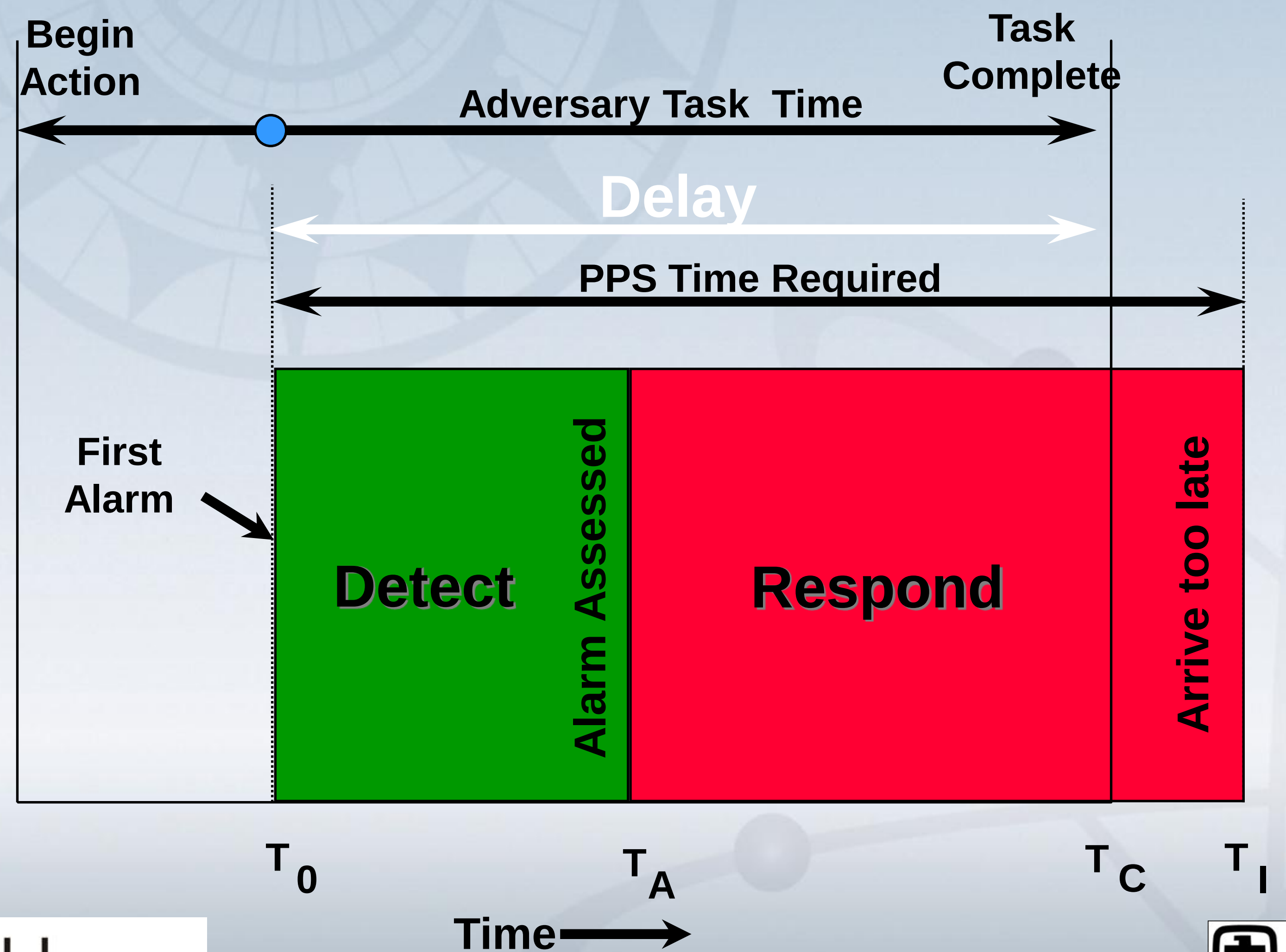
Response should:

- Include multiple levels of response teams which are deployed according to the level of threat
- Have capabilities and resources superior to that of potential adversaries

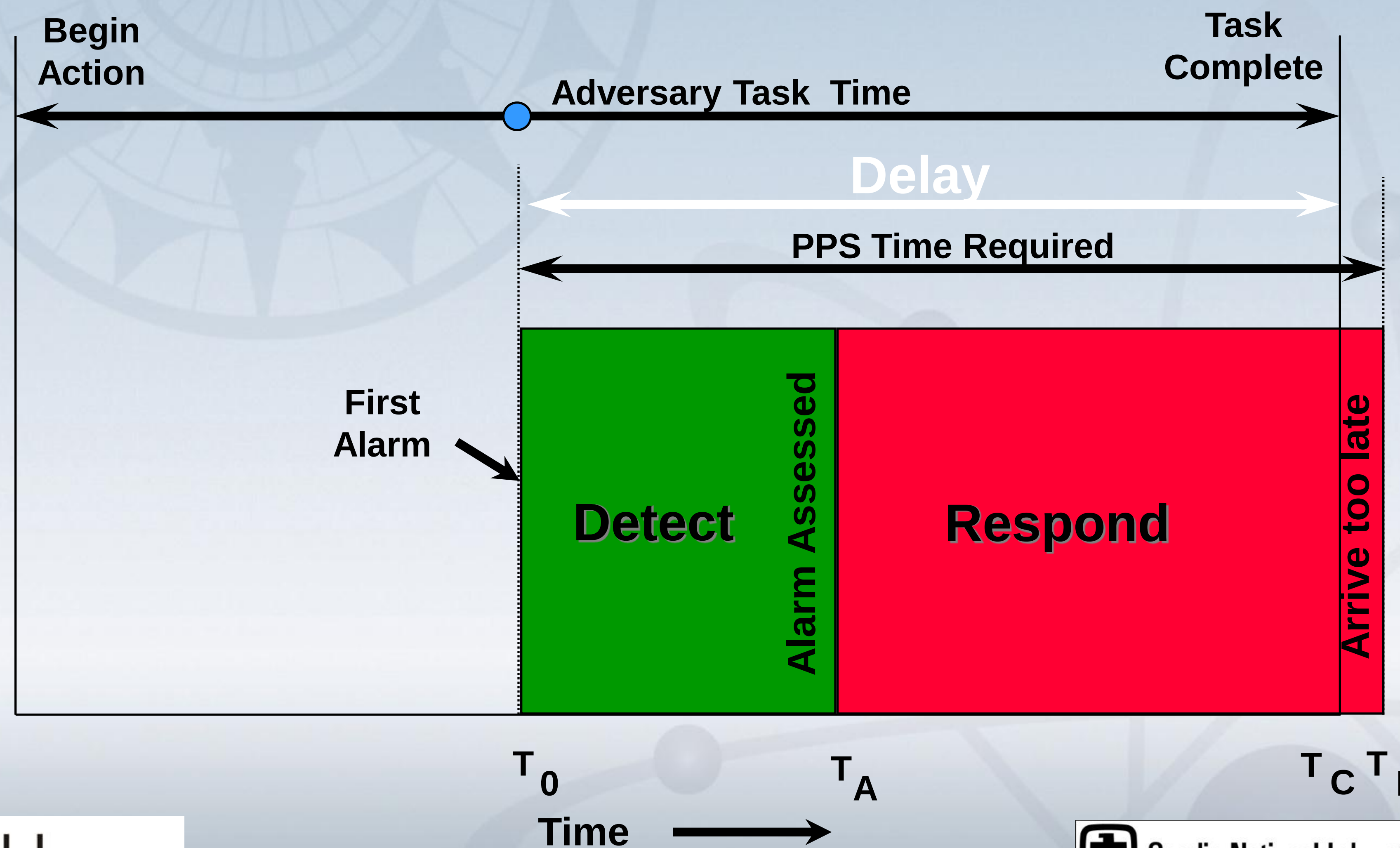
Adversary Task Time vs. PPS Time Required



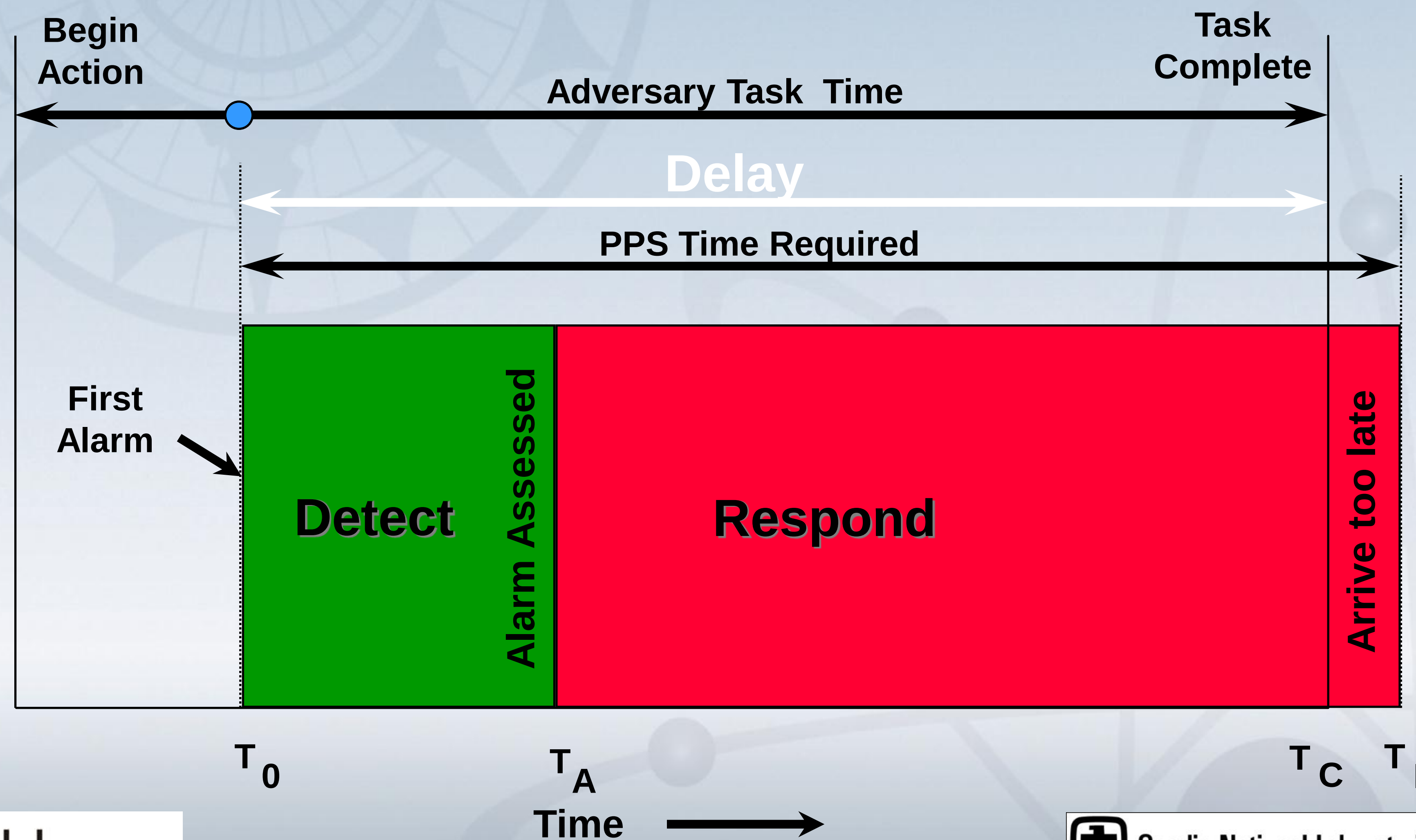
Less Delay


Begin Action
Task Complete
Adversary Task Time
Delay
PPS Time Required
First Alarm
Detect
Alarm Assessed
Respond
Arrive too late
T 0
T A
T C
T I
Time

Late Detection



Slow Response



Radiological Incidents

Radiological Incidents

Police assistance may be required in the event of a radiological incident.

Radiological incidents can be dangerous because the threat is invisible.

Exposure to radiation can be minimized by:

- Decreasing time: the length of exposure
- Increasing distance: the length of space from the source
- Increasing shielding: the material blocking the source

Exposure to radiation is not always life threatening.

Preparing for Radiological Incidents

The best method to protect against the unknown is to be prepared.

Law Enforcement Agencies have a responsibility develop detailed, robust response plans.

Plans should include: Clearly defined leadership roles and responsibilities.

- Key decisions that need to be made and who will make them
- When decisions will be made

Preparing for Radiological Incidents

It is important that responders have an understanding any threats when responding to incidents.

It is recommended that the police have a relationship with the facilities containing radiological sources. Facilities should provide resources such as maps and locations of sources, a point of contact and technical support in the event of an incident, etc.

Responding to Radiological Incidents

Once an incident occurs, priorities shift from preparation to execution.

Response activities typically include:

- Gaining and maintaining situational awareness
- Activating and deploying resources and capabilities
- Coordinating response actions
- Demobilizing

Responding to Radiological Incidents

If a radiological event is suspected, a perimeter should be established around the target area.

Step 1: Isolate the immediate area of any civilians and have those not in the immediate area shelter indoors

Step 2: Establish a control boundary and cordon off the area

- Request knowledgeable facility representative to identify does rate boundaries
- If radiation levels are unable to be monitored, establish the cordon at the facility's borders

Step 3: Control cordoned-off area ingress and egress

Step 4: Record names and addresses of all persons involved or who were located within perimeter

- Suspected contamination: Keep people in a segregated area until they can be monitored

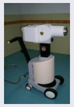
CAUTION: Do not take any equipment out of the area without you and the equipment being checked for possible contamination

Adapted from "GTRI Alarm Response Training"

Hazardous Radiation Exposure Zones

(for unsealed sources only)

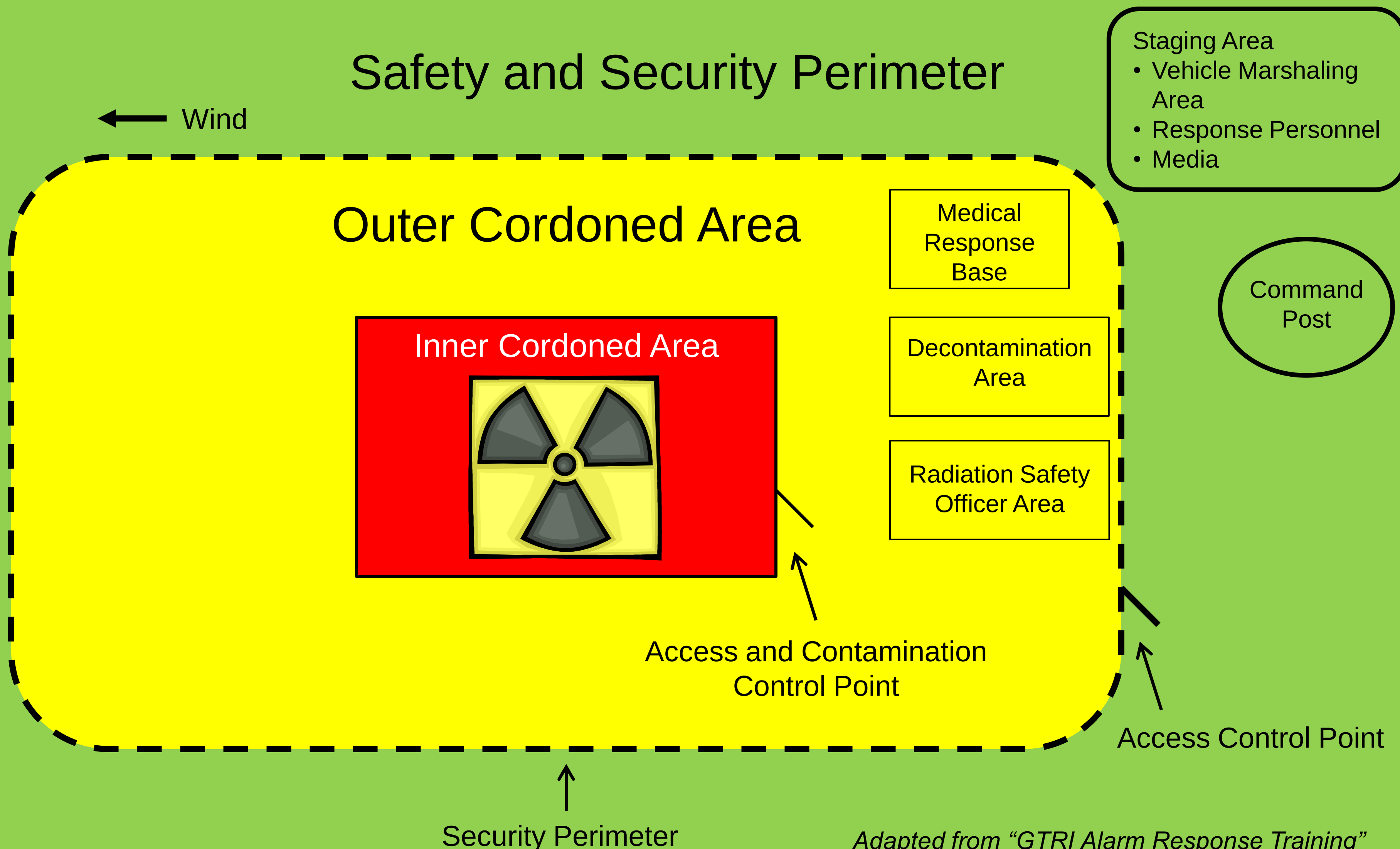
Hazard Zone Codes
Dangerous Zone Establish turn-around point
Restricted Zone Control access for rescue and mitigation efforts only
Safe Zone Establish access control point

Radionuclide	Hazard Zones
Ir-192	**Distance (meter)**
Industrial Radiography/ Brachytherapy  	Distance < 1m
	1m < Distance < 43m
	Distance > 43m

Radionuclide	Hazard Zones
Cs-137	**Distance (meter)**
Blood Irradiator 	Distance < 9m
	9m < Distance < 180m
	Distance > 180m
Teletherapy 	Distance < 12m
	12m < Distance < 220m
	Distance > 220m

Radionuclide	Hazard Zones
Co-60	**Distance (meter)**
Blood Irradiator 	Distance < 17m
	17m < Distance < 275m
	Distance > 275m
Teletherapy 	Distance < 24m
	24m < Distance < 350m
	Distance > 350m

Responding to Radiological Incidents



Adapted from "GTRI Alarm Response Training"

Question and Answers

Global Partners

Slide from *GTRI Standard Briefing*

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