Office of Counterterrorism and Counterproliferation
Nuclear Incident Policy and Cooperation

Radiological and Nuclear Search Concepts

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Objective

This module will provide a basic overview of radiological/nuclear search operations, including the application of radiological detection instrumentation and best practices for operational tactics, techniques, and procedures.

Goals

This module will introduce basic radiological/nuclear search operations and include the following:

- Review the principles of detection
- Understand radiation hazards and alarms
- Examine search instruments and techniques
  - Buildings and stadium complexes
  - Large areas, roadways, and parking areas
  - Pedestrian and vehicle portals
- Practice the process for developing a search Concept of Operations (CONOPS)

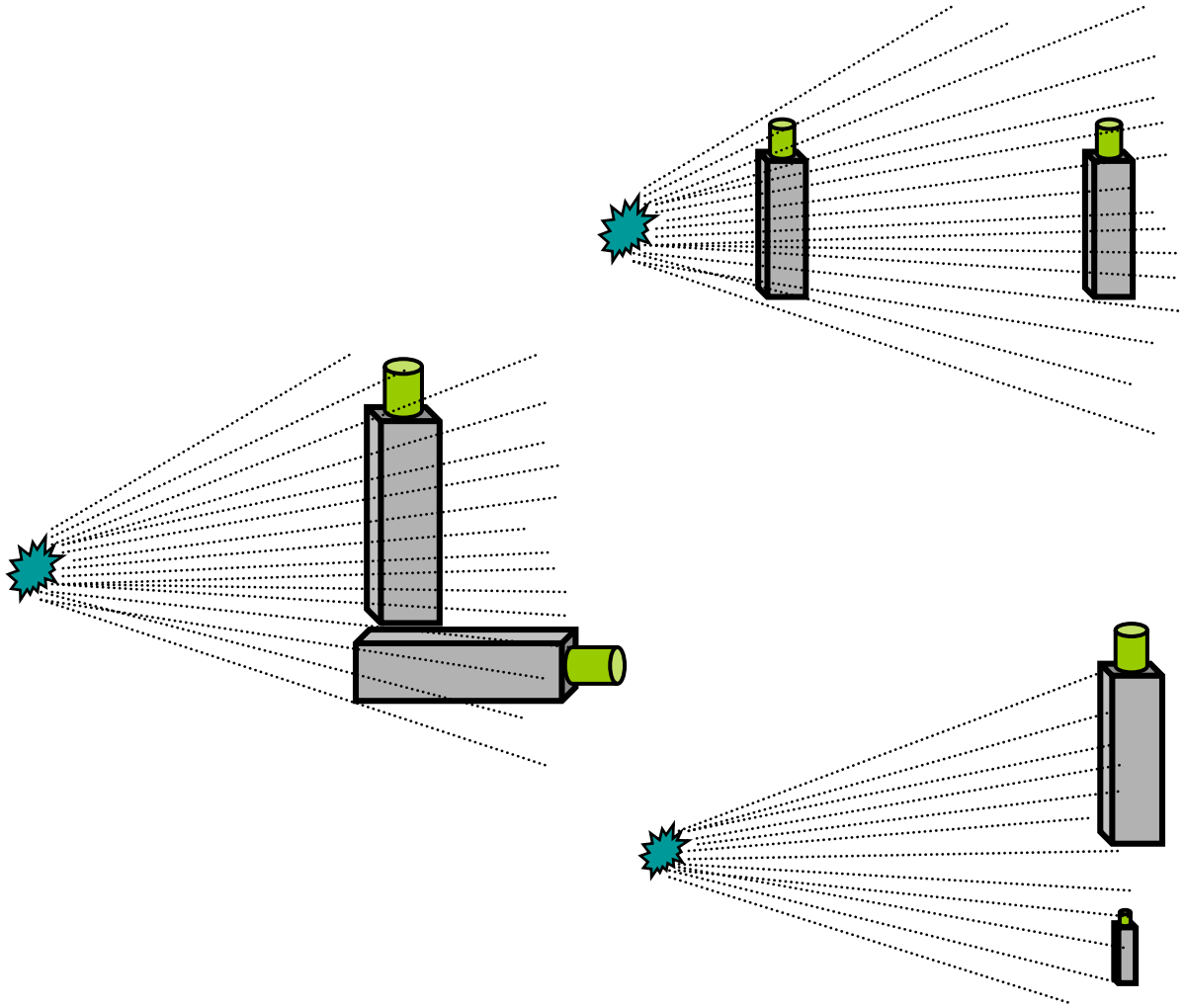
What is Radiological/Nuclear Search?

- Definition: Radiological/Nuclear (RN) search is the process of locating specific materials or devices that could create a radiological exposure health hazard, cause radioactive contamination, or result in a radiological/nuclear incident.
- A radiological/nuclear search may be required to support the following incidents:
  - Lost or stolen source
  - Terrorist threat
  - Intelligence information
  - Law enforcement investigation
  - Environmental concern
  - Material out of regulatory control
  - Nuclear security at a Major Public Event

Principles of Detection

Factors that Affect Detection

- Time
- Distance
- Shielding
- Geometry
- Detector Size



Principle Factor 1 - Time

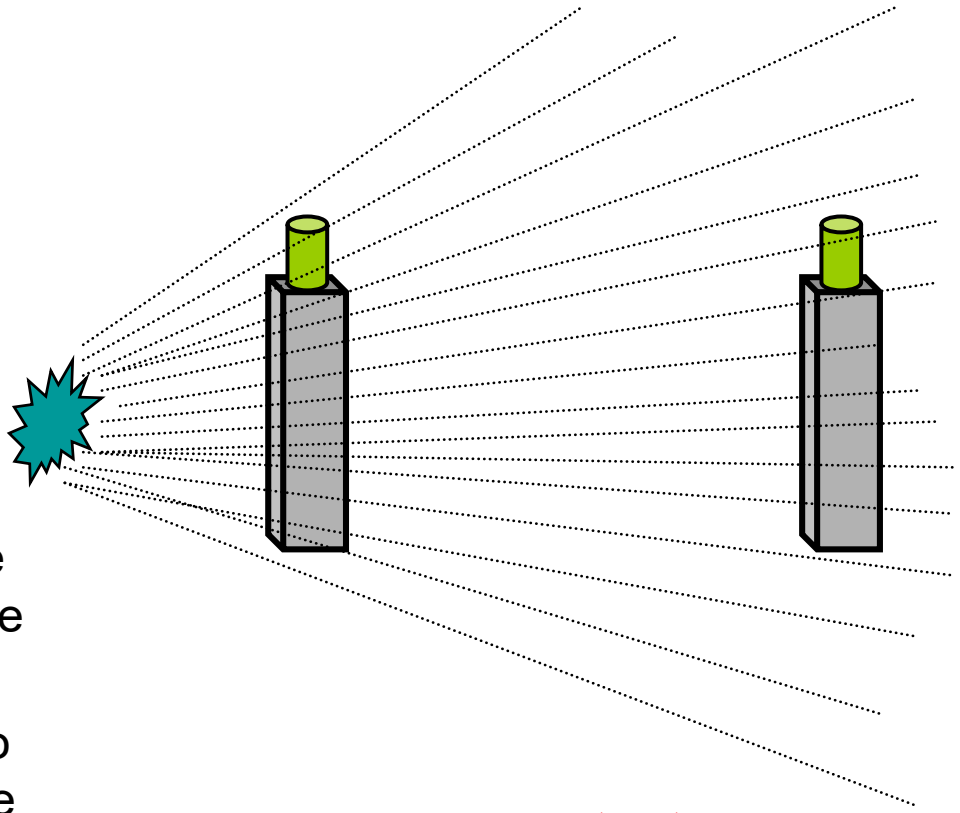
- **Time**
- Distance
- Shielding
- Geometry
- Detector Area

- The longer a detector can detect a source, the more sensitive and accurate the measurement
- Sensitivity is influenced by:
  - Relative speed of detector and source activity
  - Distance
  - Shielding
  - Geometry
  - Detector Area

Principle Factor 2 - Distance

- Time
- **Distance**
- Shielding
- Geometry
- Detector Area

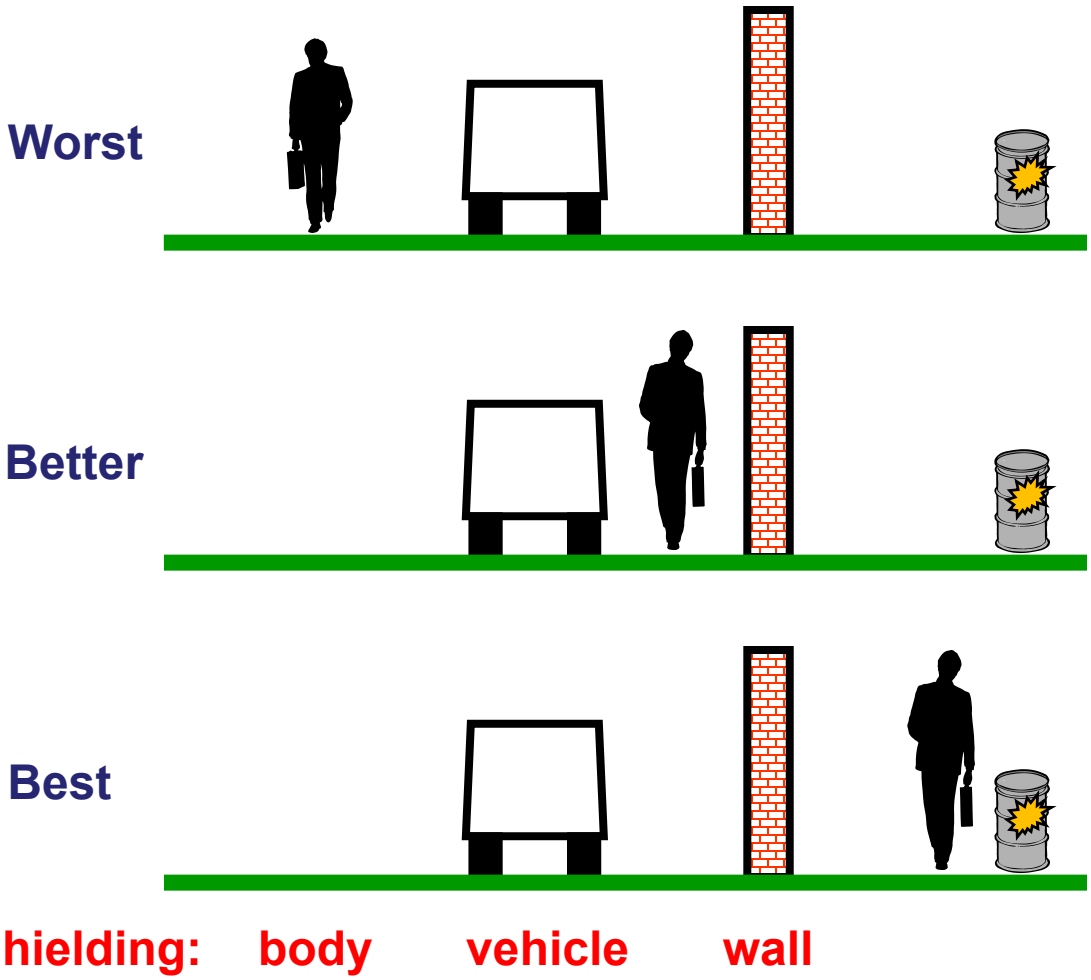
- The closer the detector is to the source, the higher the count rate and sensitivity
- As the distance from detector to source increases, the count rate decreases, lowering sensitivity



Principle Factor 3 - Shielding

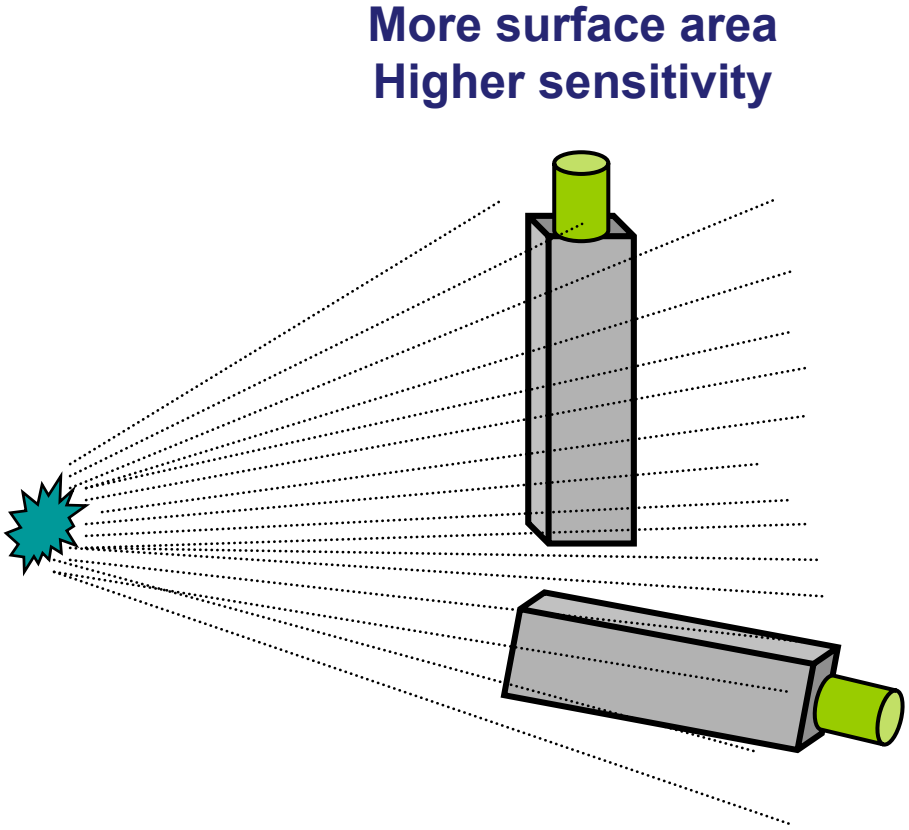
- Time
- Distance
- **Shielding**
- Geometry
- Detector Area

- Minimize shielding between the detector and source for highest sensitivity
- Even shielding by your body can lower sensitivity



Principle Factor 4 - Geometry

- Time
- Distance
- Shielding
- **Geometry**
- Detector Area

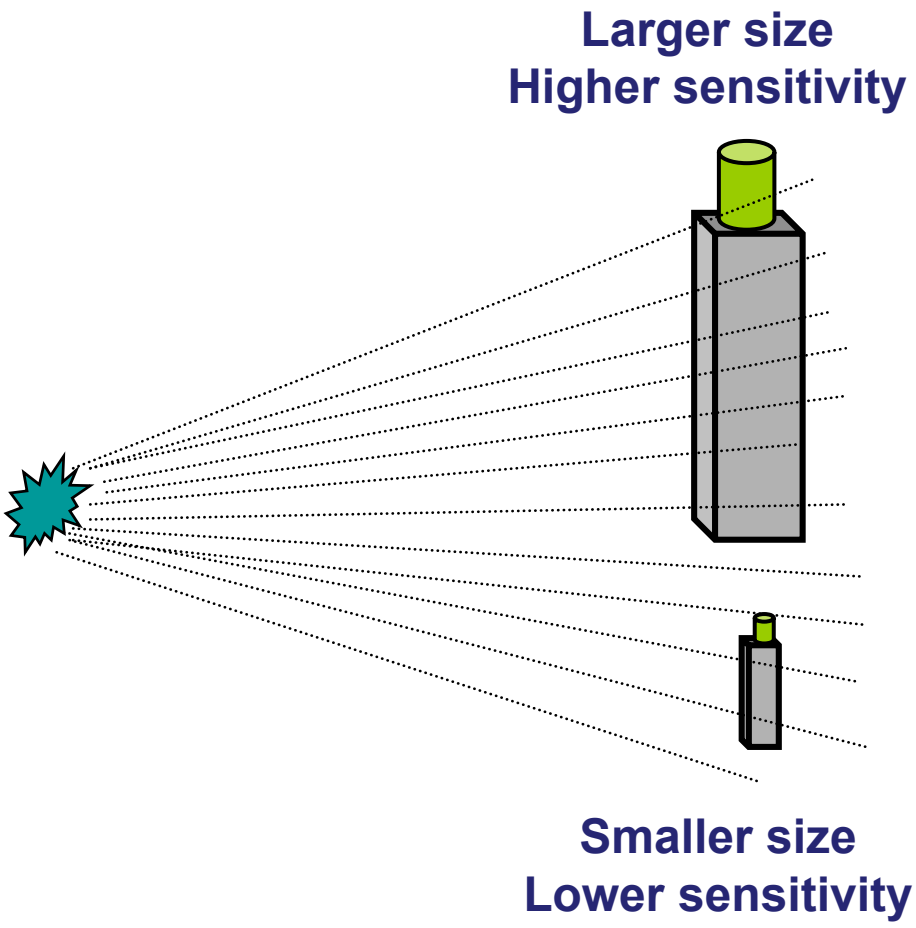


- The more detector area facing the source, the higher the sensitivity
- The detector to source orientation or geometry is very important to sensitivity and detection

Principle Factor 5 – Detector Area

- Time
- Distance
- Shielding
- Geometry
- **Detector Area**

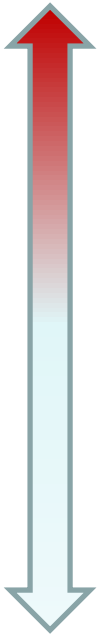
- A large detector (with more surface area facing the source) has more sensitivity
- Important to maximize detector surface area facing the source when detecting from long distances (vehicles and aircraft)



What is the Threat?

A lost or stolen industrial source is the most likely concern for a radiological threat

Most likely



Industrial: Cs-137, Co-60, Ir-192, Sr-90, Ra-226 — ***Medium to high activities***

Medical: Tc-99m, Tl-201, Ga-67, I-123, I-125 I-131, In-111, Cs-137, Co-60, Ir-192 — ***Low activities***

Naturally Occurring Radioactive Materials (NORM): K-40, U-238, Th-232 and decay products — ***Very low activities***

Special Nuclear Materials (SNM): U-235, Pu-239, U-233 — ***Very hard to acquire***

Least likely

Industrial/Medical Sources

High activity Cs-137, Ir-192, and Co-60 radiation sources are routinely used in industry

Radiography Camera

Activity from 750–3700 GBq (20–100 Ci)

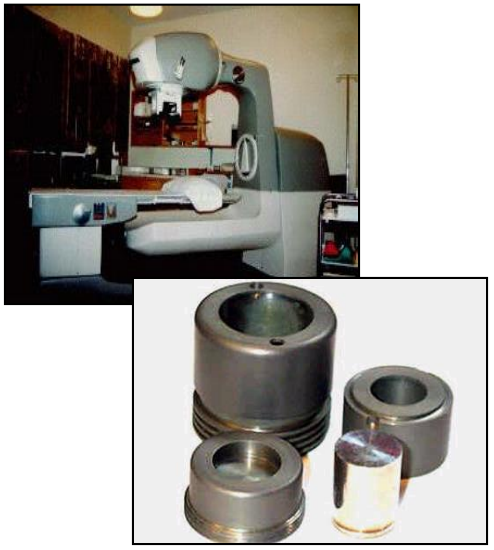
Dangerous - Out of shield > 0.5 Sv/h (50 R/h) at 1 m

Gamma Irradiators

Activity from 3700–37000 GBq (100–1000 Ci)

Dangerous - Out of shield > 1 Sv/h (100 R/h) at 1 m

Tele-therapy Unit



Activity exceeding 220,000 GBq (6000 Ci)

Dangerous - Out of shield > 1 Sv/h (100 R/h) at 1 m

What do you expect to find?

During a search, expect to respond to several alarms caused by "real" radioactive materials

On people or hand bags

- Medical treatments
- Radium watch
- Pacemaker
- Camera lenses
- Jewelry/gem stones

At building complexes

- Chemicals (pallet)
- Water softener (pallet)
- Granite/brick facade
- Porcelain/ceramics
- Smoke detectors

In delivery trucks

- Industrial gauges
- Food products (bananas)
- Laboratory sources
- Porcelain/ceramics

Search Techniques for Buildings and Stadium Complexes

Building Complex Search

A targeted area or building search may be required to assist law enforcement in investigations or Major Public Events

Stadium/Sports Complex

Building/Warehouse Complex

Typical Radiation Hotspots

During searches, all radiation hotspots should be located, indentified, and documented on all floor plans

Examples of non-hazardous or benign radiation hotspots include:

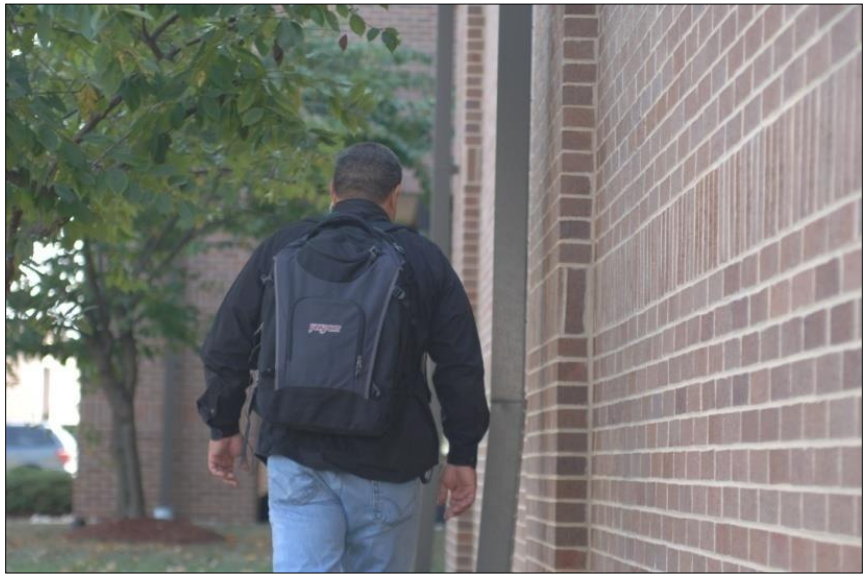
- Building materials – ceramics, tiles, red brick, granite
- Industrial supplies – fertilizer, chemicals, water softeners
- Structures – tunnels, enclosed entrance ways, columns (mass effect)
- Surfaces – interfaces between grass, brick, asphalt

Note: Materials used in these items can contain slightly elevated levels of Naturally Occurring Radioactive Materials (NORM) which is sufficient to cause an alarm in most detection instruments

Backpack Search Detector

Backpack detectors provide a general, all-purpose tool for radiological search operations

- High sensitivity, dual gamma/neutron backpack sensors can be used to search for radiation hotspots in a low profile, but deliberate manner



Internal Search Techniques

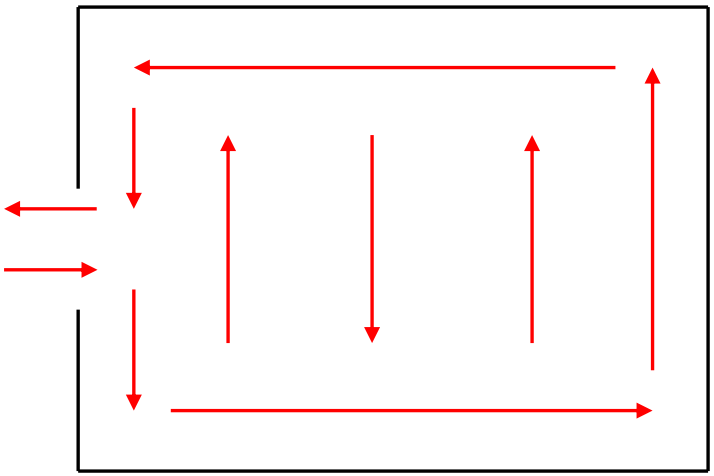
Internal Building

Areas of interest:

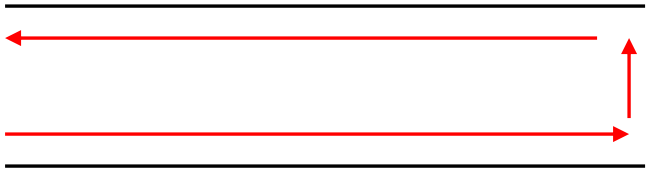
- Common areas
- Auditoriums/Halls
- Offices
- Hallways
- Stairwells
- Mechanical areas
- Storage closets

Technique:

- Walk close to walls, doors, desks, cabinets, etc.



Room Perimeter Search



Hallway Search

External Search Techniques

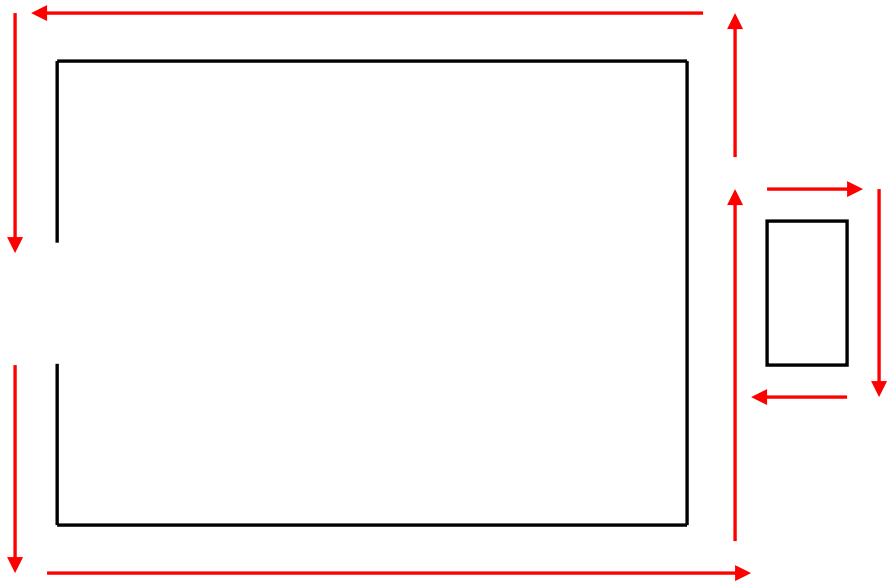
External Building

Areas of interest:

- Storage areas
- Trash cans
- Mail boxes
- Vegetation
- Mechanical areas

Technique:

- Walk close to walls, doors, structures, containers, and vegetation



Building Perimeter Search

Localizing an Alarm Hotspot

Responding to an Alarm

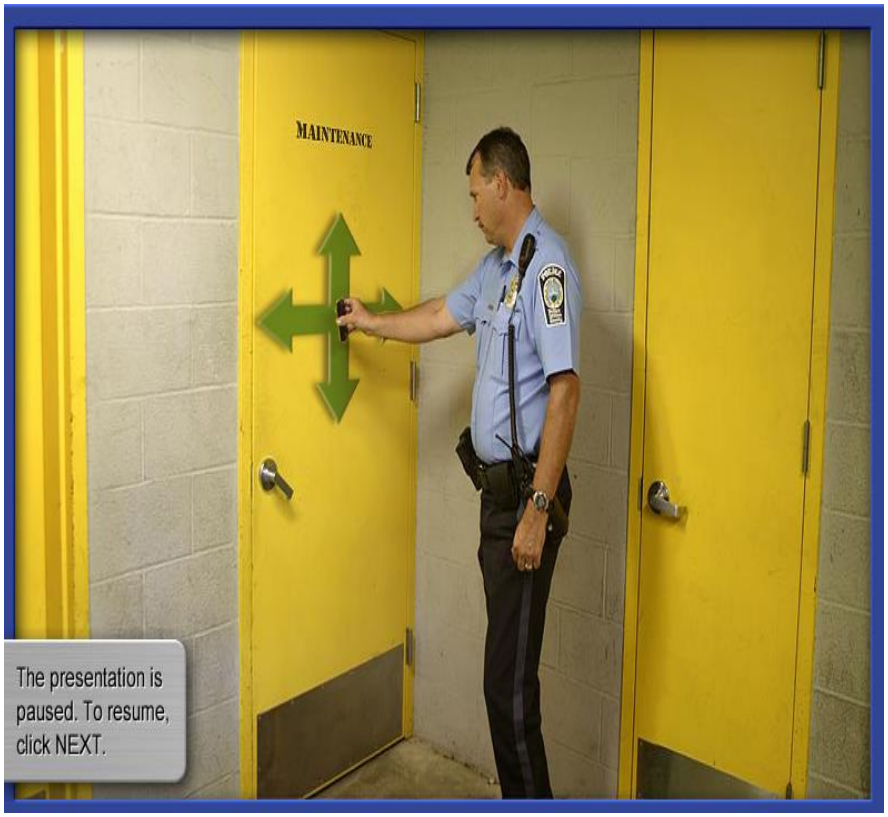
With backpack detector:

- Make multiple passes in both directions
- Verify alarm by repeatability
- Rotate and use body natural shielding

With pager detector:

- Move pager left, right, up, down

Always remember that the source could be in any direction 360 degrees

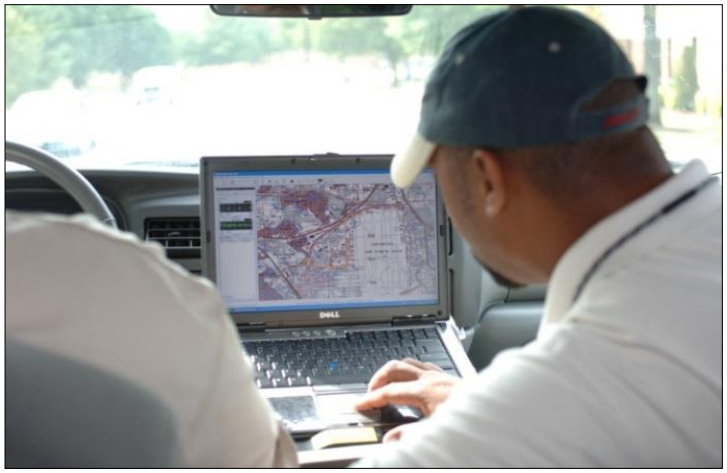


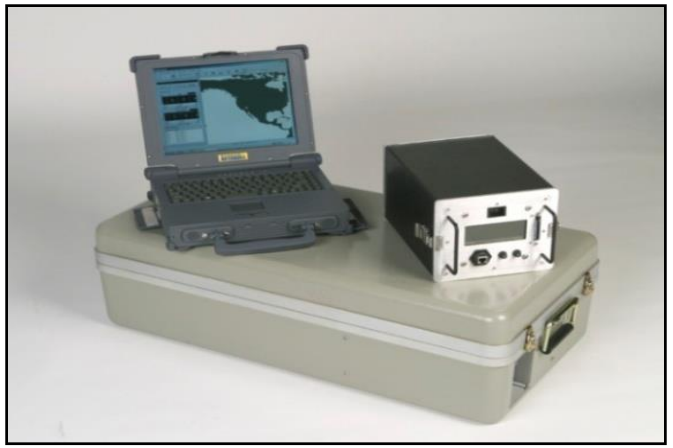
Roadway/Parking Area Search

SPectral Advanced Radiological Computer System (SPARCS)

High sensitivity gamma modular detector system

- Roadways and parking area search
- Real-time tracking via GPS
- Readily mountable in vehicles, watercraft, or aircraft





Parking Lot Search Techniques

Parking Lots and Garages

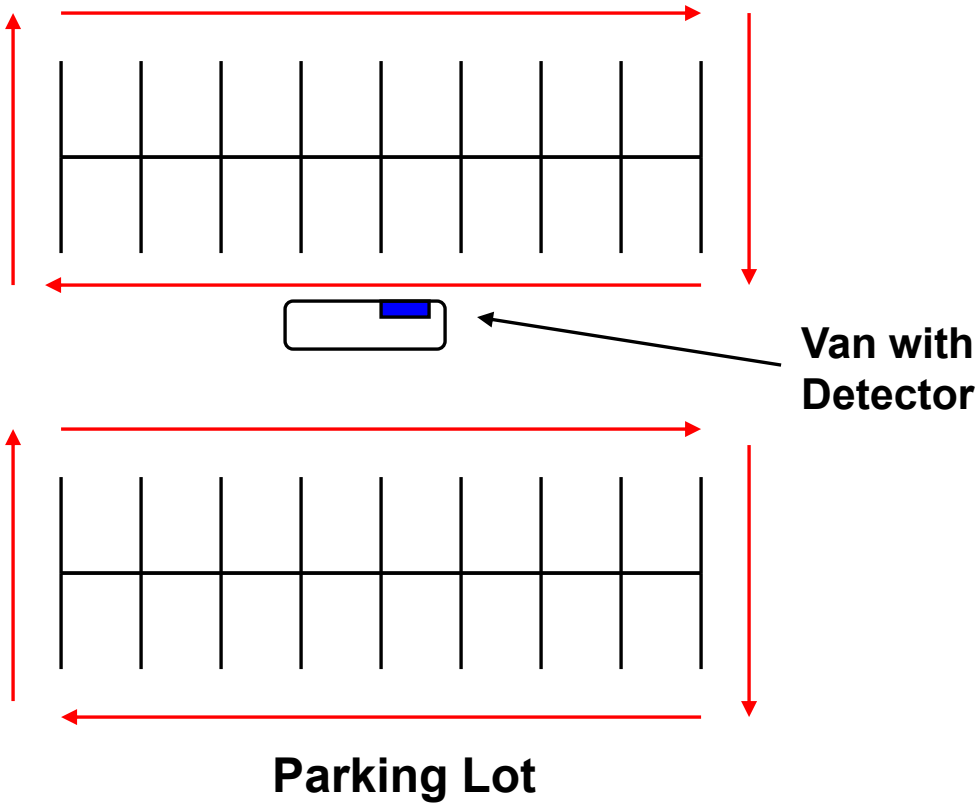
Areas of interest:

- Parking lots and garages
- Vendor parking
- Storage yards

Technique:

- Drive ~ 8 km/h (5 mph)
- Gamma detector on right side of vehicle closest to parked cars

Note: a car engine is an excellent shield for radiation



Street/Urban Search Techniques

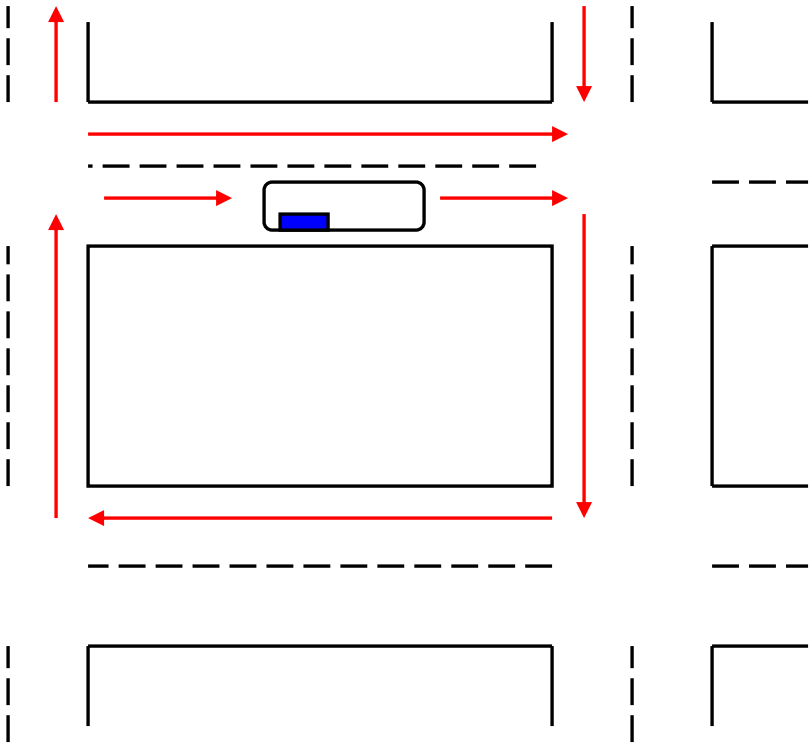
City Streets

Areas of interest:

- Parked cars and trucks
- Storage containers
- Vendor vehicles

Technique:

- Drive 32 km/h (20 mph) or less
- Gamma detector on the right side of vehicle closest to the side of street



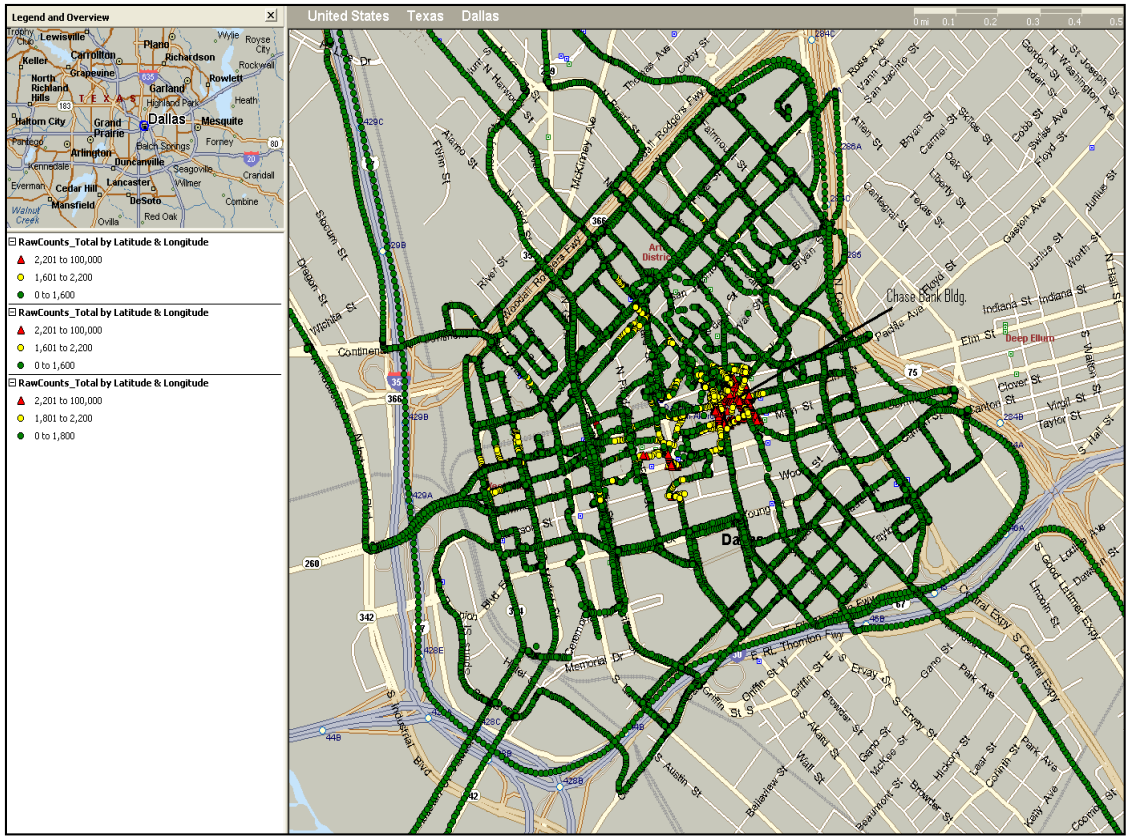
City Streets

Search Techniques for Large Areas

Large Area Search Techniques

Large area or city search

- Situation may dictate that a large section of a city be searched
- Multiple mobile teams can be deployed to accomplish the search mission
- Requires about 8 hours for one mobile team to search a 12 square-kilometer area (5 square-miles)



Maritime Search

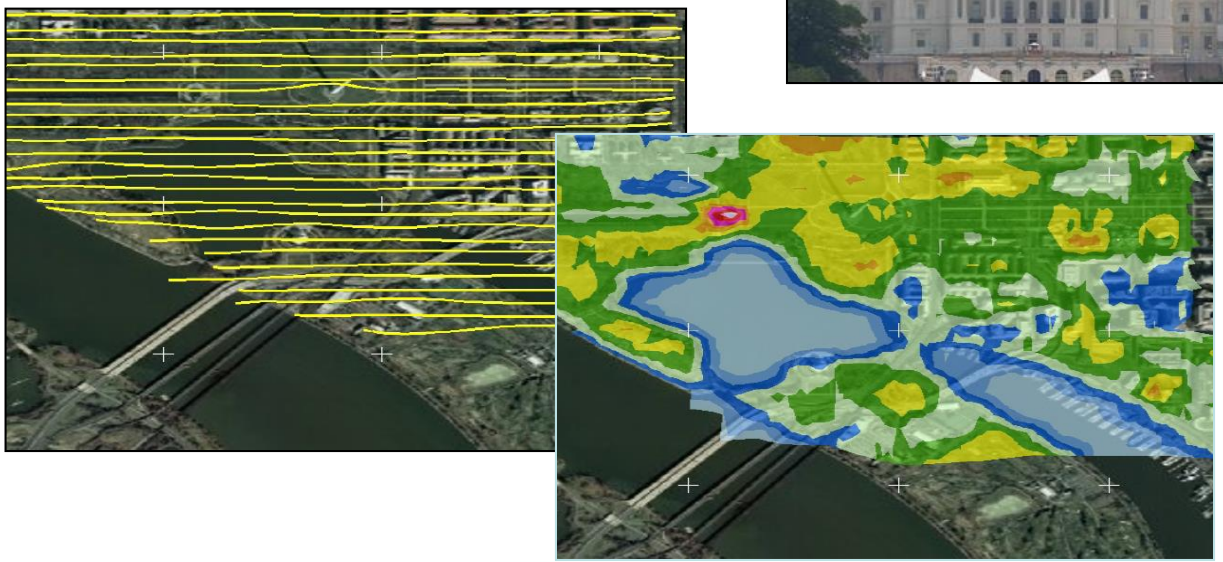
Maritime radiological searches of marinas and ports

Mobile detection systems can be installed in security patrol boats

Aerial Search

Aerial radiological search can be conducted over very large, open areas

- An aerial search of Washington, DC was conducted with a mobile detector system in a helicopter prior to a Major Public Event



Flight profile:

- Altitude 50 m
- Line spacing 100 m
- Speed 100 km/h

Portal Search Techniques

Pedestrian and Vehicle Portal Search

Pedestrian and vehicle portals can be used to target choke point monitoring or to secure a Major Public Event

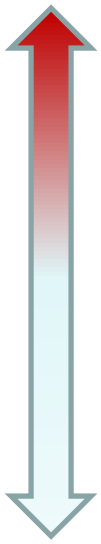
Portal/Choke Point Operations

- A choke point is a location in which people, vehicles, or materials can be channeled
  - Pedestrian Portal/Choke Point
    - Slow pass example - metal detector
    - Quick pass example - turnstile
  - Vehicle Portal/Choke Point
    - Slow pass example - event parking
    - Quick pass example - tunnel entrance
- Establish a primary search/screening station
  - Locate primary station upstream of the choke point
  - Channel pedestrians/vehicles close to detector
- Establish a secondary adjudication station
  - Locate secondary station downstream of the choke point
  - Designate a secure area to conduct investigation and adjudication

Medical Radiation Sources

The primary source (99%) of radiation alarms at MPE's are individuals with medical radiopharmaceutical treatments

Most likely



Least likely

Diagnostic – radiation source injected for imaging

Tc-99m (most common), Tl-201, Ga-67, I-123, I-125, I-131, In-111

- *Short lived radioisotopes (i.e. half lives typically several hours to a day) decay relatively quickly over time. The rule of thumb is that after seven half lives, the radioisotope will have completely decayed to a non-radioactive isotope and therefore, no radioactivity remains.*

- *For example, Technicium-99m (Tc-99m), a radioisotope used to image artery blockage during a heart stress test, has a 6 hour half life. If the initial diagnostic test involved the injection of a saline solution with 740 MBq (20 mCi) Tc-99m, then 370 MBq (10 mCi) remains after 6 hours, 185 MBq (5 mCi) remains after 12 hours, 92 MBq (2.5 mCi) remains after 18 hours, and so on.*

Therapeutic – radiation source inserted for treatment

Cs-137, Co-60, Ir-192 (inserted sources removed after treatment)

Rule of Thumb – 1 in 10,000 individuals will give a radiation alarm

Radiation Pager

- A Personal Radiation Detector (PRD) is used primarily for routine monitoring, detection, localization, and pinpointing radioactive materials

Pedestrian Portal Search

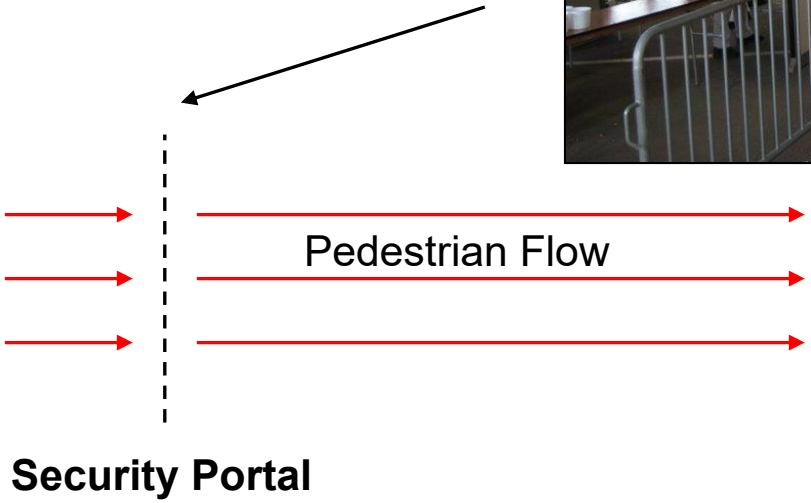
Basic approach is to provide security screeners at portals with individual radiation pagers and training

Areas of interest

- Pedestrians
- Hand bags

Technique:

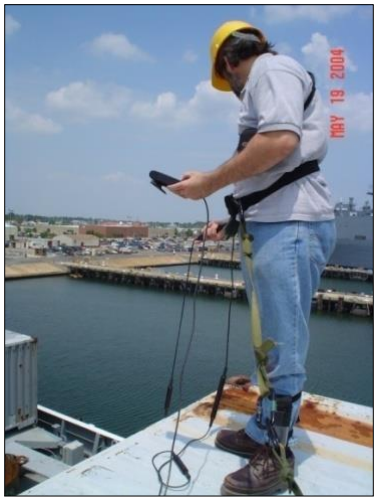
Incorporate radiation monitoring into routine individual and bag screening process



High Volume Pedestrian Entrance

Linear Radiation Monitor (LRM)

- 24 meter (80 foot) cable with gamma sensors for portal monitoring or bundled for a high sensitivity backpack search tool



Pedestrian Portal Search

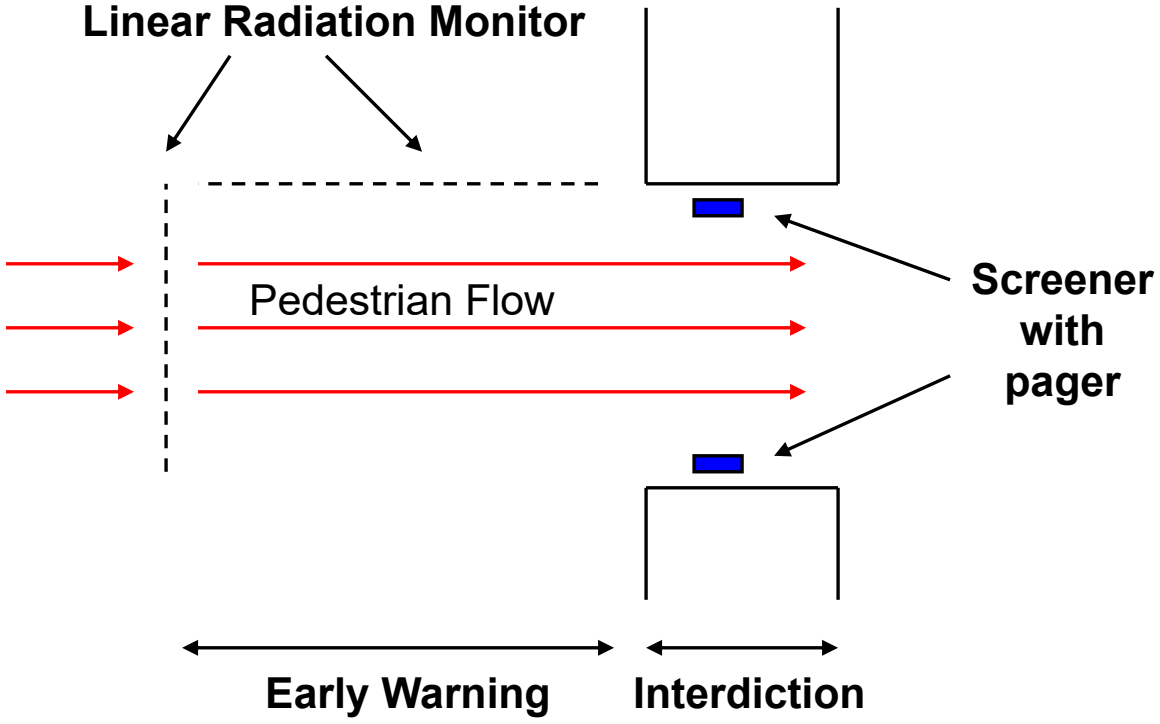
With more equipment, more effective and efficient radiation monitoring can be provided

Areas of interest

- Pedestrians
- Hand bags

Technique:

- Early warning detectors either across an entrance checkpoint or along a walkway from the checkpoint to the entrance



High Volume Pedestrian Entrance

Vehicle Portal Search

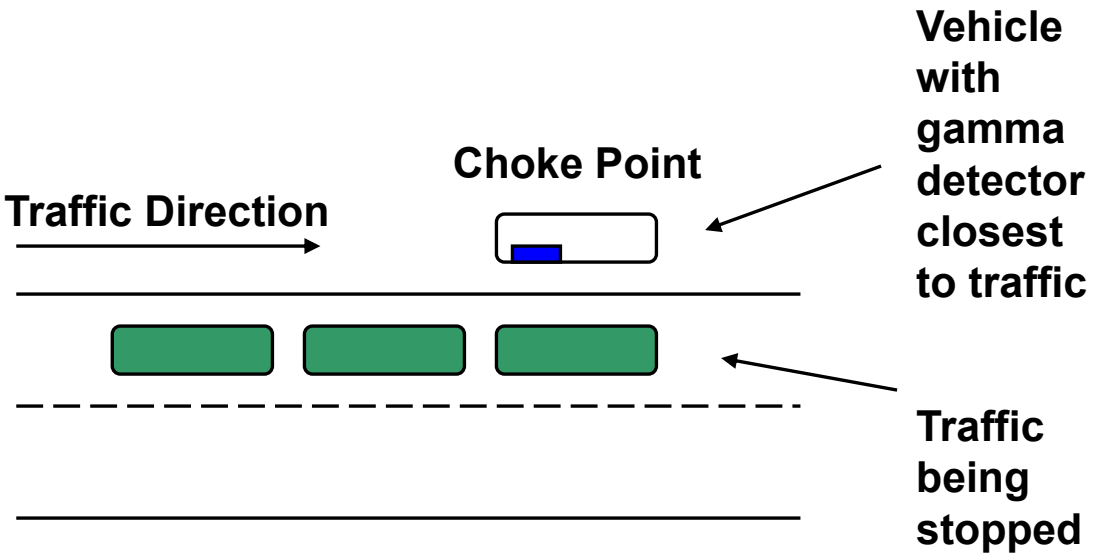
Roadway Choke Point Monitoring

Areas of interest

- Vehicle traffic
- Parking entrance
- Border crossing

Technique:

- Park mobile system vehicle at a choke point close to traffic lane with slowing vehicles; place gamma detector on side closest to lane



Vehicle Portal Monitors

Roadway Choke Point Monitoring

- Silver van with radiation detector closest to road is set up as vehicle portal on a single lane road; security officer nearby to support if alarms
- As vehicle approaches, alarm sounds and security officer approaches vehicle for questioning, radioisotope identification is conducted from inside silver van
- Security officer and radiation monitor confer to determine release or detain

Vehicle Portal Search

In order to resolve an alarm, it may be necessary to detain vehicle(s) in a secondary screening area and investigate further

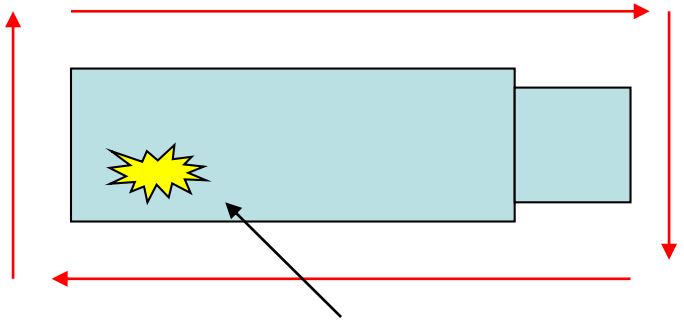
Areas of interest

- Vehicle with alarm

Technique:

- Security separates driver and passengers from vehicle, radiation officer scans passengers, then conducts a walk-around survey of vehicle

Vehicle with Cargo



Radiation Source

If survey finds radiation source in vehicle, request expert assistance

Search
Concept of Operations

Define the Search Problem

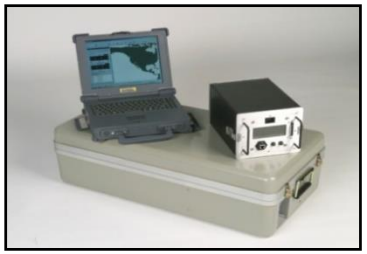
Initial Questions:

- **Who is requesting the support?**
  - Law enforcement, Federal, State, Local
- **What is the reason for the support?**
  - Lost or stolen source, illegal activity, terrorism
- **What is the urgency?**
  - Immediate and/or deliberate
- **What is the operational environment?**
  - Low profile, permissive, or non-permissive
- **What is known about the radiation source?**
  - Radioisotope, activity, packaging, damage
- **Where is the search area?**
  - Local, across country, international
- **What is the size of the search area?**
  - Single building, building complex, roadway

Build a Concept of Operations (CONOP)

Technical Questions:

- **What type of search is required?**
  - Aerial, land, maritime
- **What is the detection distance?**
  - Calculations based on source information
- **What resources are required?**
  - Experts, logistics, equipment, vehicles, aircraft
- **How long will it take to complete?**
  - Estimate from maps or floor plans
- **What equipment/configuration required?**
  - Pager, backpack, mobile, aerial, RIID, HPGe
  - Define alarm thresholds
- **What are the communications protocols?**
  - Alarm reporting and operational security
- **What are the radiation safety issues?**
  - Alarming dosimetry, turn back limits, guidance
- **Is a cover story required?**
  - Low profile, dress requirements, media guidance



Conduct Search Operations

Field Operations:

- **Emergency Operations Center (EOC)**
  - Competent Authority Official (point of contact)
  - Maintain situational awareness/common operating picture
  - Provide situational reports
- **Technical Operations Center (TOC)**
  - TOC Team Leader (point of contact)
  - Command and control
  - Deploy, track, and redeploy teams
  - Distribute and maintain equipment
  - Monitor and assess alarm data
- **Deployed Search Teams**
  - Technical Team Leader (point of contact)
  - Coordinate search operations
  - Investigate alarms with law enforcement
  - Provide situational awareness and reporting
  - Monitor safety and security

Alarm Interdiction and Adjudication

Phased Approach:

Phase I – Primary Search/Screening

- Detect, verify, localize

Phase II – Secondary Search/Screening

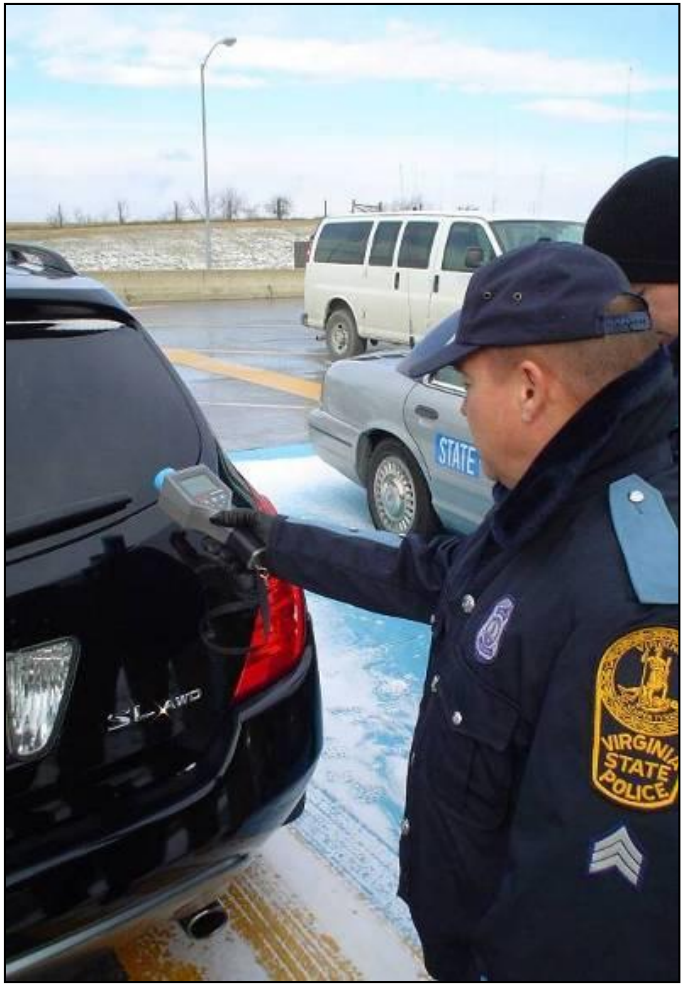
- Detain individual or vehicle, secure area
- Conduct investigation with security
- Assess radiation threat, identify material

Phase III – Expert Technical Assistance

- If not resolved, then request expert assistance
- Mitigate the hazard

Phase IV – Resolution of Incident

- Law enforcement prosecution
- Document incident and report data



Summary

- Radiological/nuclear search operations are complex emergency response missions that often require specialized skills and detection instruments
- Each search mission or area can present its own challenges requiring planning, coordination, and execution
- Search Concept of Operations (CONOP) incorporates all known information about the radiation source and available resources required to implement best practices to maximize the mission success
- Search CONOPS should be documented, resourced, and be trained as much as possible for increased operational readiness

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Questions/Discussion