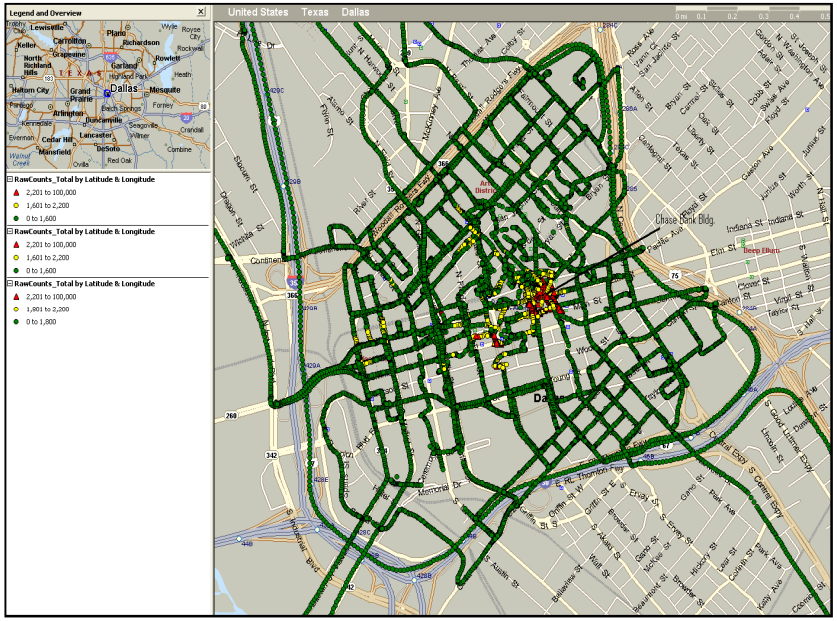
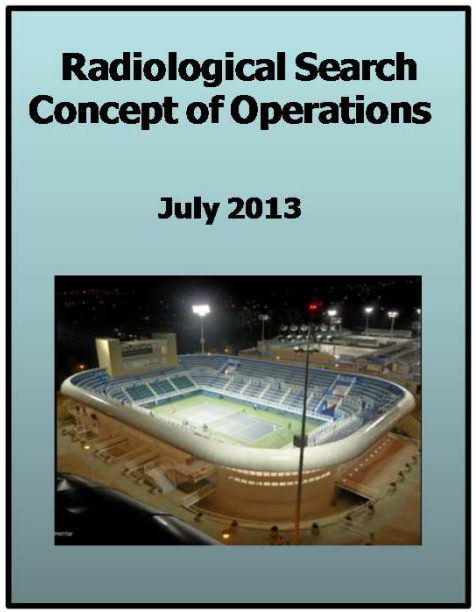
Advanced Radiological Search Concept of Operations



Concept of Operations (CONOPS)

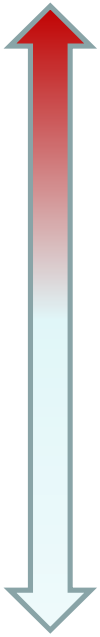
A Radiological Search Concept of Operations (CONOPS) is the operational component which defines the actions taken to prepare for, respond to and resolve a nuclear/radiological incident or accident.



What is the Threat?

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

Most likely



Least likely

Industrial – Cs-137, Co-60, Ir-192, Sr-90, Ra-226	***Medium to high activities***
Medical – Tc-99m, Tl-201, 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***

Industrial Sources

High activity radiation sources are routinely used in industry

Radiography Camera

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

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

Gamma Irradiator

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

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

Teletherapy Unit

Activity exceeding 6000 Ci (220,000 GBq)

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

Search CONOPS Planning Phase

The Radiological Search CONOPS should address the following:

What triggered the search?

What are the safety/security concerns?

What resources are available?

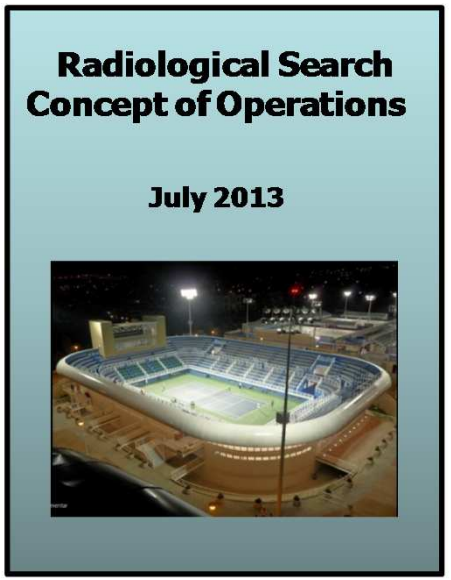
What Personal Protective Equipment (PPE) is required?

What is the source, activity, radiological situation?

What are the time constraints?

What is the search area?

What is the adjudication process?



Search CONOPS Planning Phase

What triggered the search?

Terrorist threat

Intelligence report

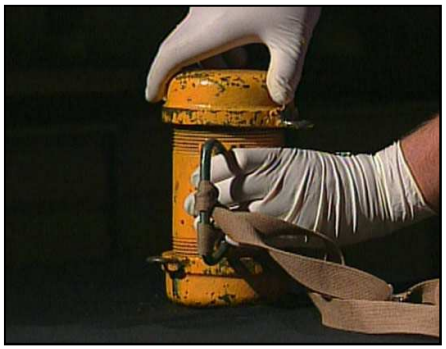
Smuggling concern

Theft

Accident

Lost source

Major Public Event (MPE)



Search CONOPS Planning Phase

What are the safety/security concerns?

Law enforcement escorts required

Low profile or overt operations

Search area secured

Search area physically safe to enter

Explosives/other non-radiation hazards

High dose/contaminated areas

Personal Protective Equipment (PPE)

Search CONOPS Planning Phase

What resources are available?

Trained searchers

Emergency managers

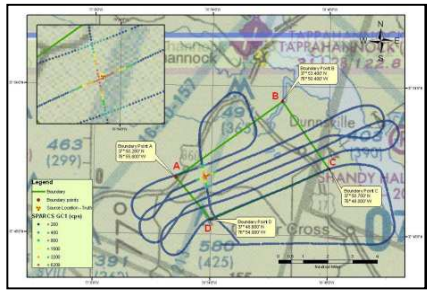
Competent authority experts

Deployable search equipment

Home team and reachback capabilities

Geographic Information Systems (GIS)

Logistics - transportation, communications



Radiation Detection Equipment

Radiation Search




Radioisotope Identification


Source Recovery



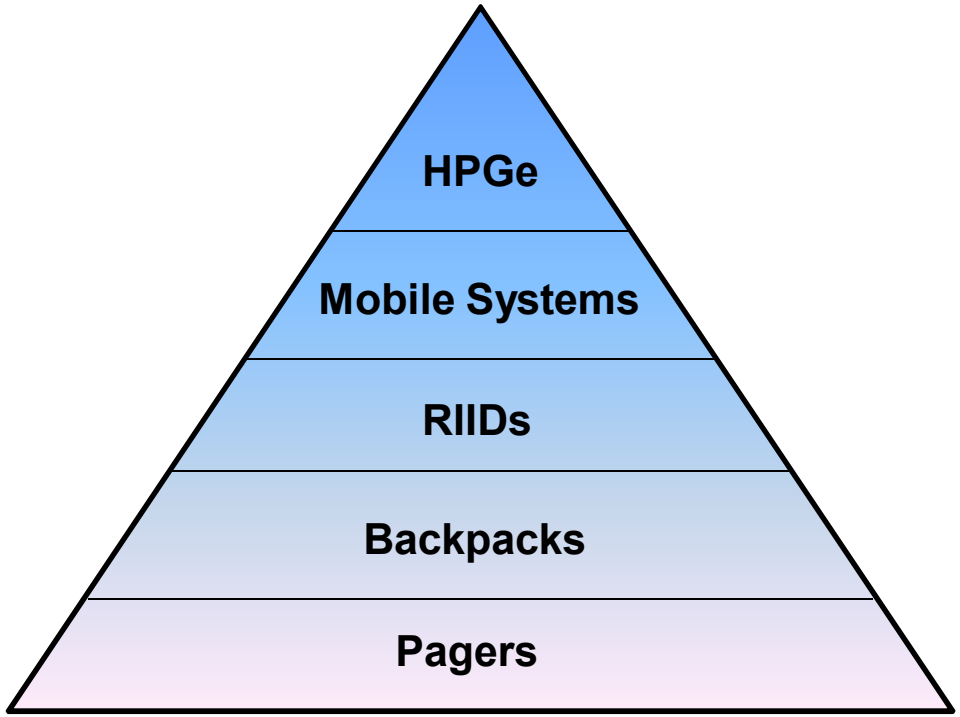
Radiation Detector Pyramid

Employ more low cost, easy-to-use pagers and less high cost, harder-to-use HPGe's

Least

Number of detectors required for field operations

Most



Search CONOPS Planning Phase

What PPE is required?

No PPE required to Level A

Personal dosimetry

Alarming dosimeters with preset alarm levels

Turn back limits and stay times

Protective action guidance

Decontamination procedures

Search CONOPS Planning Phase

What is the source, activity and radiological situation?

Radioisotope

^{137}Cs, ^{60}Co
^{241}Am, ^{90}Sr

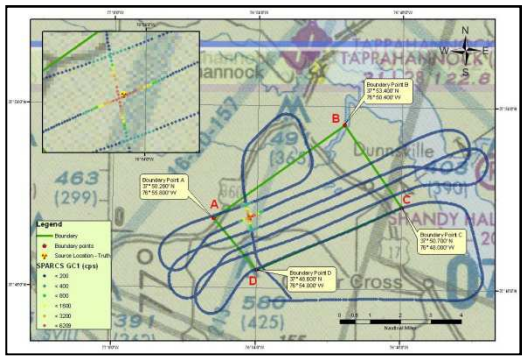
Source type – alpha/beta/gamma/neutron

Sealed point source

Sealed point source with breach

Small area contamination

Large area dispersed source



Low, medium or high activity

Search CONOPS Planning Phase

What are the time constraints?

Immediate search response

Deliberate search response

Planned event search response

Search CONOPS Planning Phase

What is the search area?

Large area – urban/rural area, warehouse/office complex, accident site

Medium area – high-rise building, stadium, conference center, accident site

Small area – storage facility, warehouse, house, truck/container, accident site

Long distance – along a roadway or train tracks

Maritime – harbor/marina, small/medium boat, cargo ship in port or at sea

Vehicle portal – border crossing, roadway choke point, Major Public Event

Pedestrian portal – border crossing, airport/train station, Major Public Event

Search CONOPS Planning Phase

What is the adjudication process?

Law enforcement interdiction

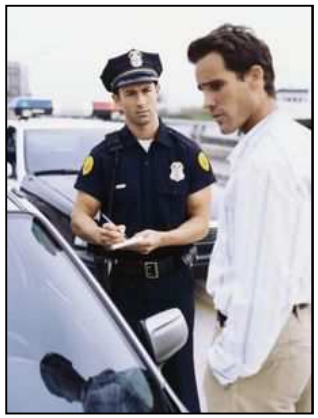
Investigation and interviews

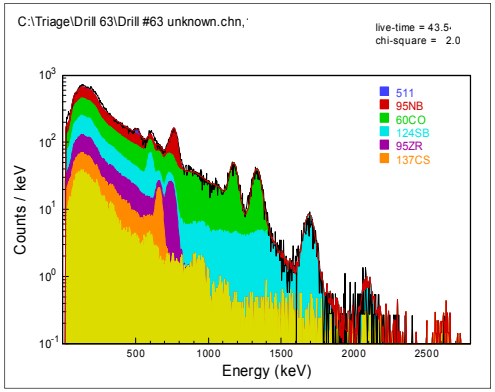
Radioisotope identification

Neutron measurements

Contamination surveys

Site characterization





Three Step Process for Radiological Search

Large Area Search, Small/Medium Area Search and Adjudication

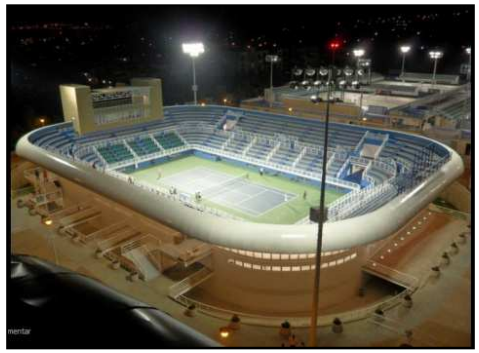
Step 1	Step 2	Step 3
Large Area Search	**Small/Medium Area Search, Localization and Pinpointing**	**Adjudication**
Mobile	Venues	Interdiction
Maritime	Portals	Investigation
Aerial	Shipboard	Identification
		Characterization

What do you expect to find?

When searching for a radiation source, you may also encounter other radioactive materials that are used every day in commerce

People or hand bags

Medical treatments
Radium watches
Pacemaker
Camera lenses
Jewelry/gemstones



Buildings or stadiums

Fertilizer
Water softener
Granite/Brick
Porcelain/ceramics
Smoke detectors

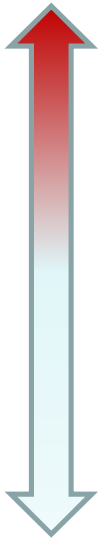
Trucks or cargo

Industrial gauges
Radiography cameras
Food products (bananas)
Laboratory sources
Granite/Brick/Tiles
Porcelain/ceramics

Medical Radiation Sources

The primary source (99%) of radiation alarms in the public is due to individuals with medical radiopharmaceutical treatments

Most likely



Diagnostic – radiation source injected for imaging

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

Least likely

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

Large Area Search Tool

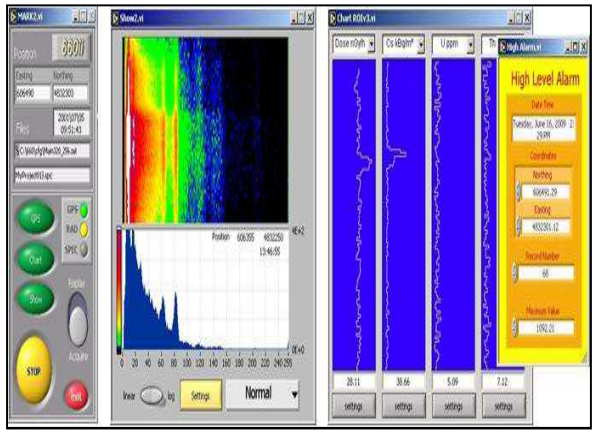
High sensitivity radiation detectors

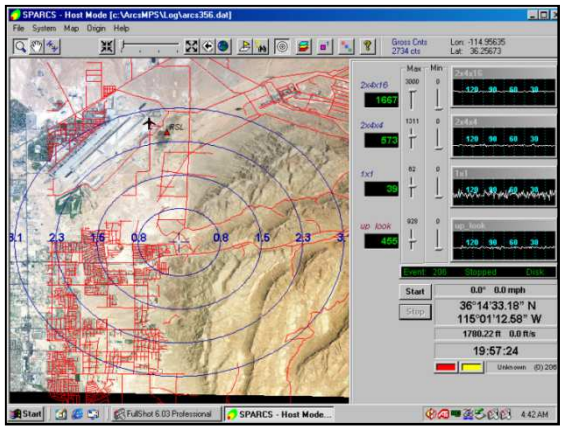
High sensitivity gamma detection systems are used for large area radiological search.

Systems are rugged and readily mounted in vehicles, watercraft or aircraft.

Large Area Search Tool

Examples of high sensitivity radiation detectors

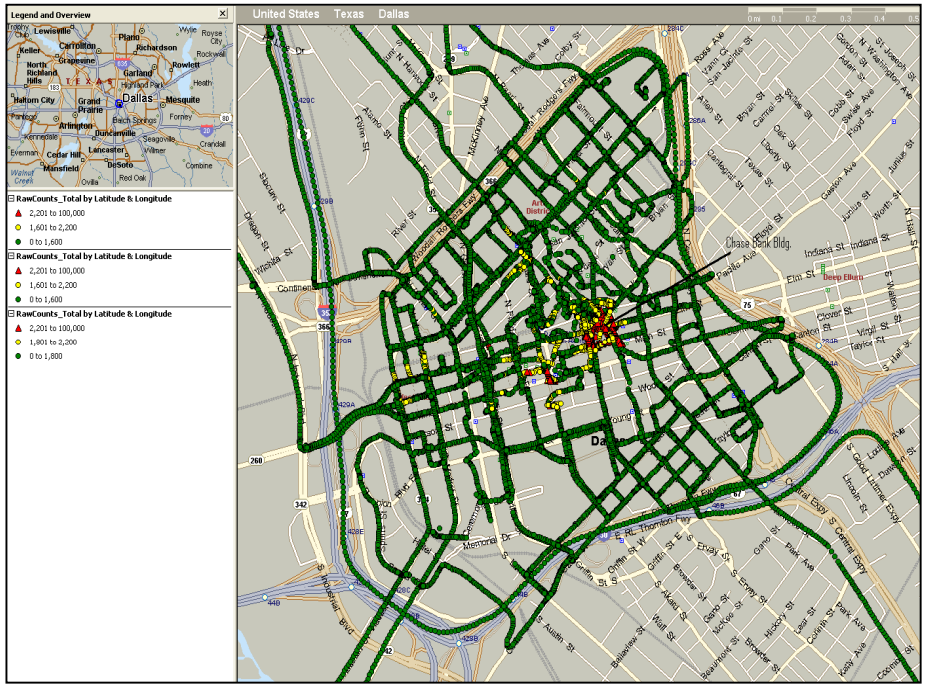




Mobile Search

Large area, high sensitivity search

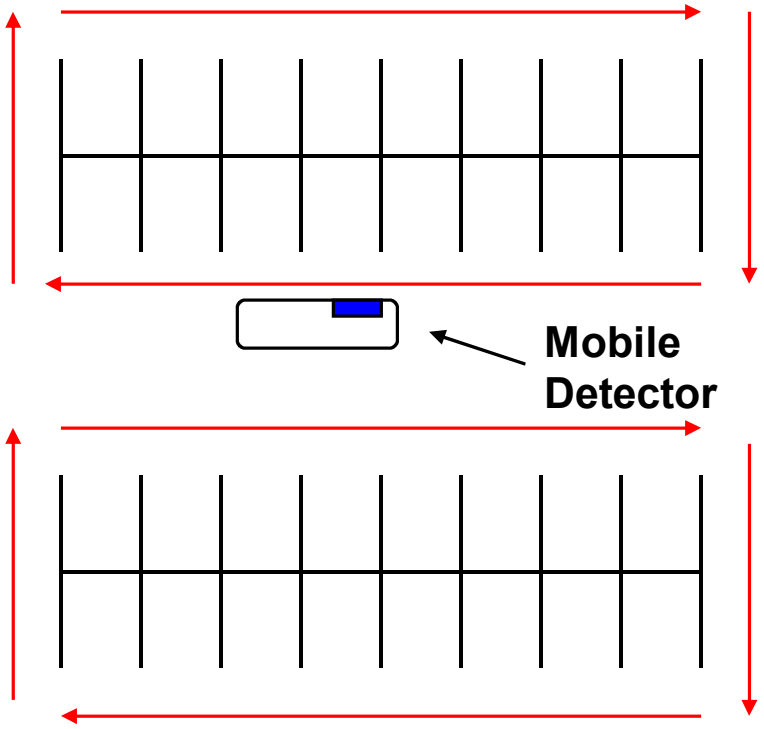
Mobile teams are effective for large areas to search vehicles along the roads, parking lots and garages. Multiple teams can be deployed to cover area. Operations typically conducted with law enforcement.



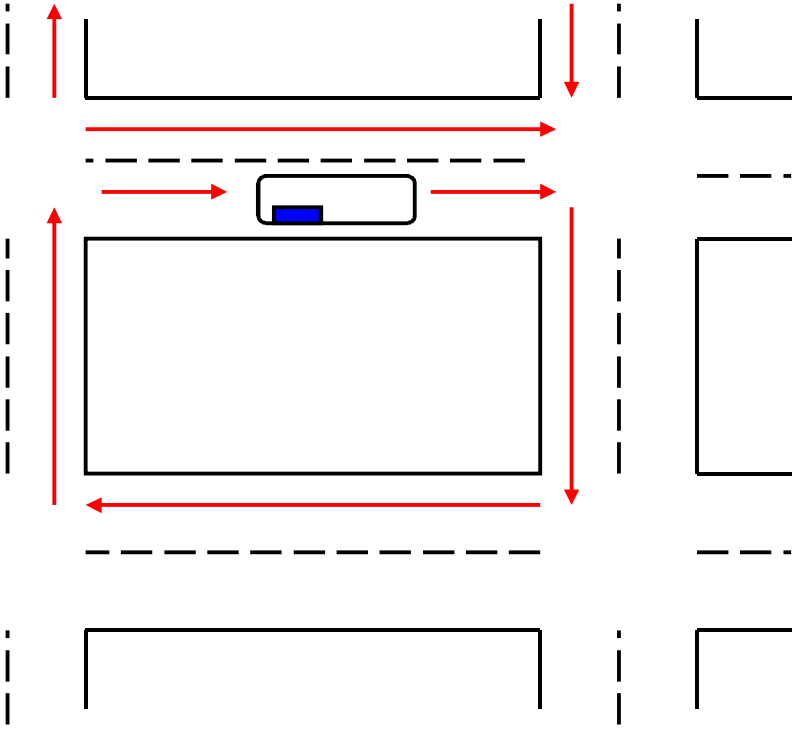
Requires about 8 hours for one mobile team to search a 5 square-mile area (12 square-kilometer)

Mobile Search

Driving techniques for searching parking lots, parking garages and city streets



Parking Lot



City Streets

Maritime Search

Large area, high sensitivity search

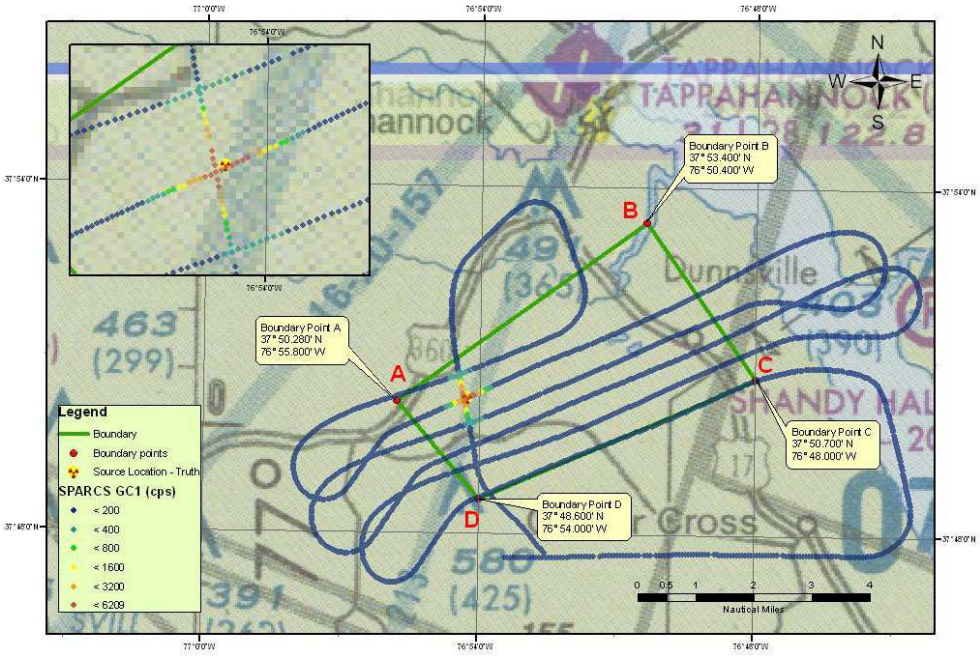
Mobile detection systems can be installed in small security patrol boats to conduct radiological search in the maritime environment to include marinas, ports, bridges and coastal areas. Typically conducted with Coast Guard or maritime security.

Small patrol boats can easily fit into marinas and get close to watercraft or storage areas on or near the water.

Aerial Search

Large area, high sensitivity search

Aerial radiological search is effective when the area is large and relatively open. It can provide negative data as to where the source is not, such as schools, parks, etc. Flight operations coordinated with aviation authorities.



Typical search altitudes for a helicopter are 50 to 100 meters (150 to 300 feet).

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		Characterization

Small/Medium Area Search Tool

Backpack radiation detectors

High sensitivity gamma detection system for small to medium sized areas for radiological search.

Search tools are typically mounted in backpacks for low profile operations.

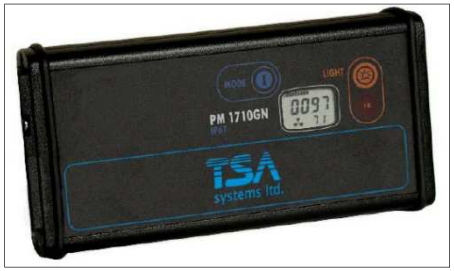
Small/Medium Area Search Tool

Examples of backpack radiation detectors

Localization/Pinpointing Search Tool

Pager radiation detectors

Small compact detectors can be used for scanning suspicious packages or localizing and pinpointing a radiation hotspot



Venue Search

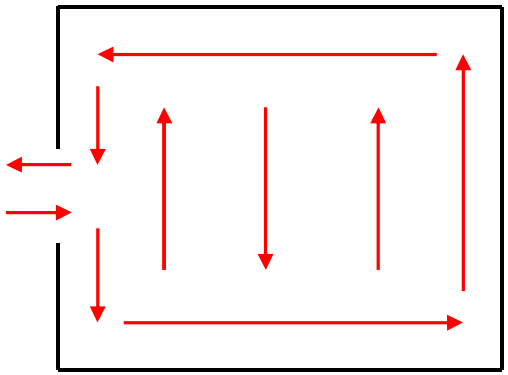
Pre-event planned search for Major Public Events

Venue searches include stadiums, office buildings, airports and warehouses. Requires cadre of foot teams to walk 100% of venue with high sensitivity detection systems. Operations require coordination with site security.

For Major Public Events, search teams work with law enforcement in a low profile manner prior to event to search for radiation sources.

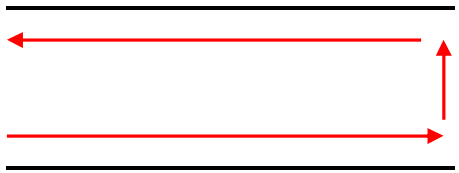
Venue Search

Walking techniques for searching interior and exterior of buildings



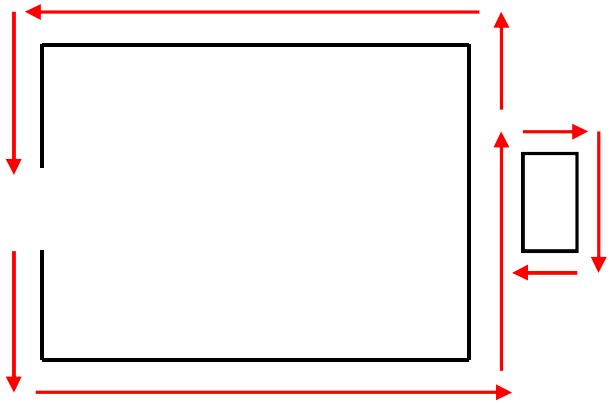
Interior Search

Common areas
Auditoriums
Offices
Mechanical areas
Storage closets
Basements



Hallway Search

If access to rooms is denied, then walking both sides of hallway or corridor provides highest sensitivity for room search

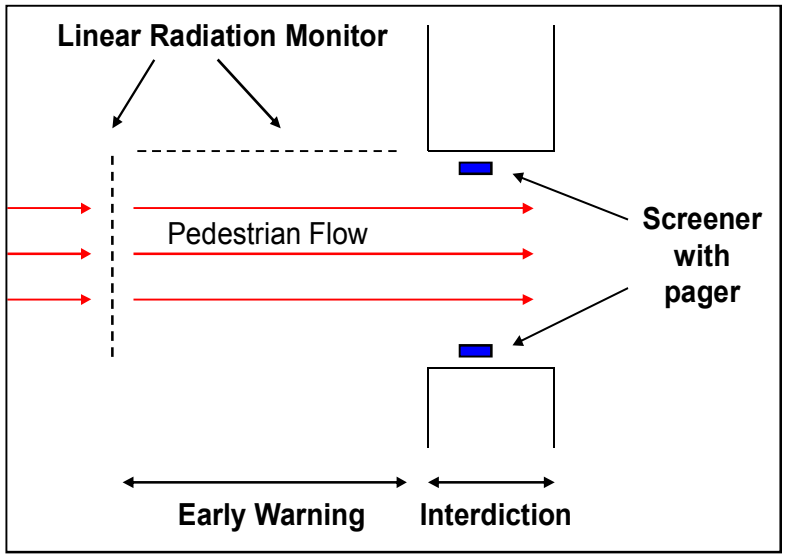


Exterior Search

Storage areas
Trash cans
Mail boxes
Vegetation
Mechanical areas
Delivery bays

Pedestrian Portal Search

Security screeners at portals can be trained in 1 hour to search for radiation with basic detection equipment



Large pedestrian entrances require more complex portal setup, experienced searchers and interface with security

Radiation Pager Wallet Card

As part of the pre-event training, provide security screeners with a wallet card containing response protocols

If this Pager alarms please follow these steps:

- ***Look*** around to try to determine who or what in the immediate area may have set off the radiation pager,
- ***Stop*** pedestrian traffic and locate source of alarm,
- ***Detain*** individual and conduct interview (could be a medical treatment such as a stress test),
- ***Call*** for Rapid Response Team for additional support

Main EOC: 202-555-XXXX

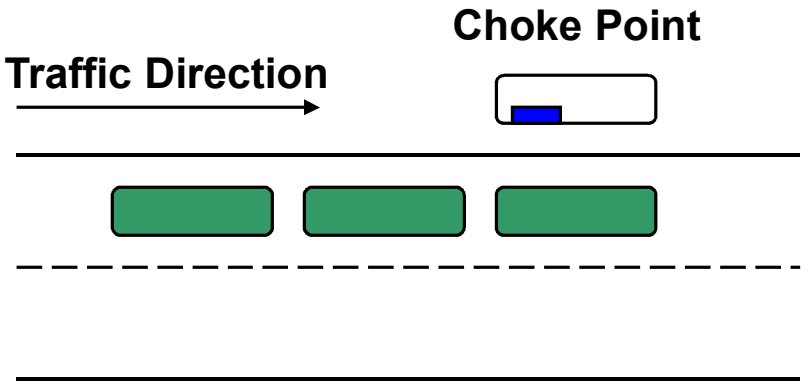
An interview would consist of:

1) ***Security officer conducts interview with alarm adjudication questionnaire***
2) ***Radiation expert determines dose rate and radioisotope using a RIID***
3) ***Security officer and radiation expert review results and detain or release***

Vehicle Portal Search

Effective vehicle portals require proper detector positioning and law enforcement coordination

A portal or chokepoint may be required at a border crossing or Major Public Event to search for radiation. The detection system should be as close as possible to the vehicles being scan, preferably where they are stopped for inspection.



Close coordination with security is required to establish protocols for alarm notification and moving vehicles to a secondary inspection area.

Venue Security Assessment

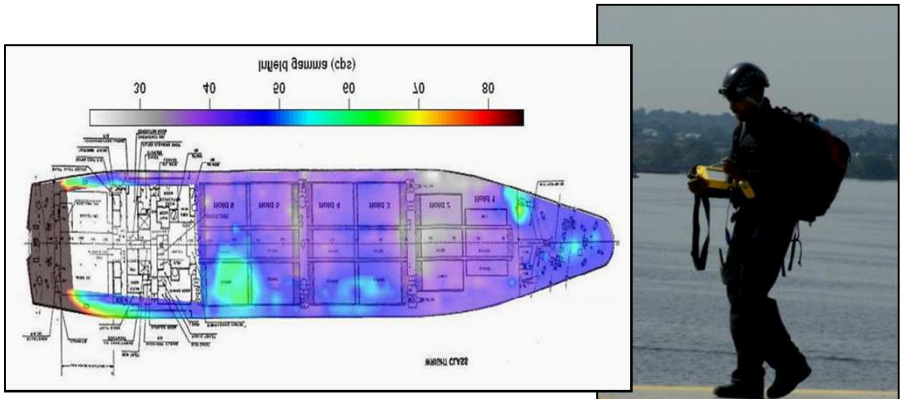
Typical equipment and staffing for a large size stadium with four pedestrian portal entrances

Position	Equipment	Staffing
Team Leader		1
Pedestrian Portals (4)		
Pager detector	8 (2/portal)	8
Identifier (RIID)	4 (1/portal)	2-4
Vehicle Portal (1)		
Mobile detector	1	1
Identifier (RIID)	1	1
Roving Response Team		2-3
Backpack detector	2	
Health physics kit	1	
ID system	1	
Total	**18**	**15-18**

Shipboard Search

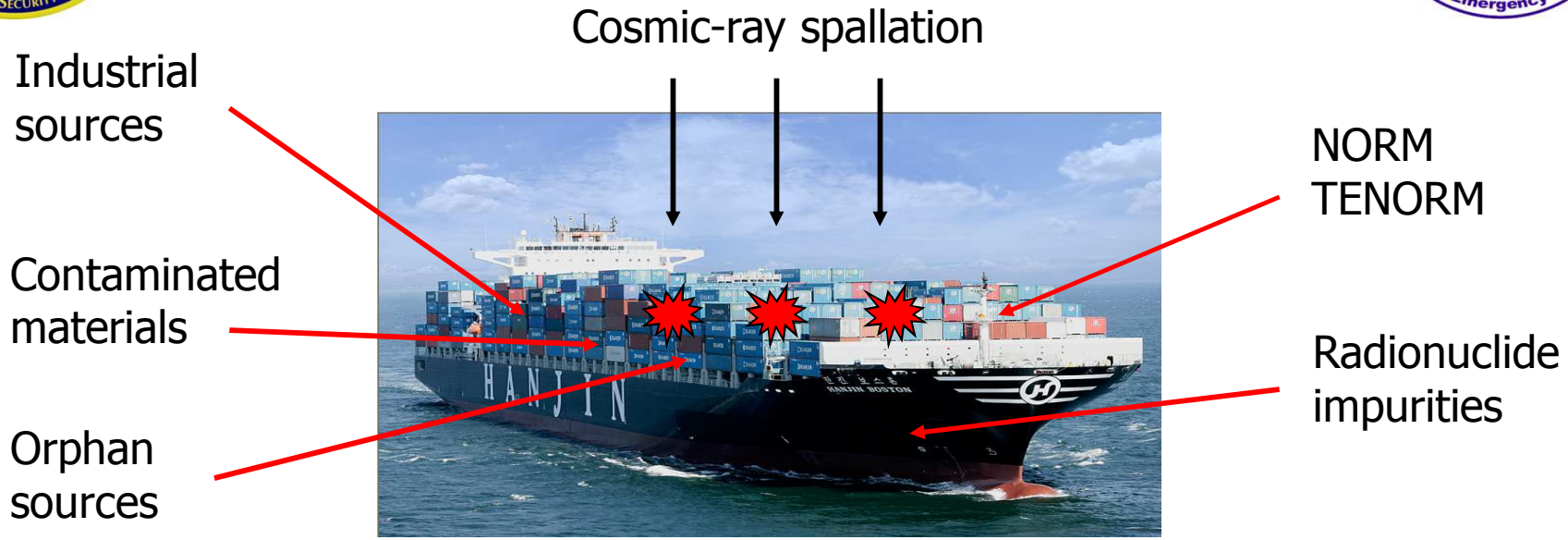
Large cargo container ships are challenging search environments

In port or at sea shipboard radiological search requires specialized teams and detection equipment. The shipboard environment is one of the most difficult areas to conduct search operations. Missions include targeted containers to full ship search.



A targeted container or container hold search may require 6-8 hours whereas a full ship search could easily require 24 hours.

What do you expect to find?



Sources of radiation on a cargo container ship

Cosmic-ray spallation in the ship's steel and dense cargo
NORM (Naturally Occurring Radioactive Materials)
TENORM (Technologically-Enhanced NORM)
Radionuclide impurities in ship and container steel
Industrial radiation sources in commerce
Contaminated metals and bulk materials
Discarded orphan sources in scrap metals

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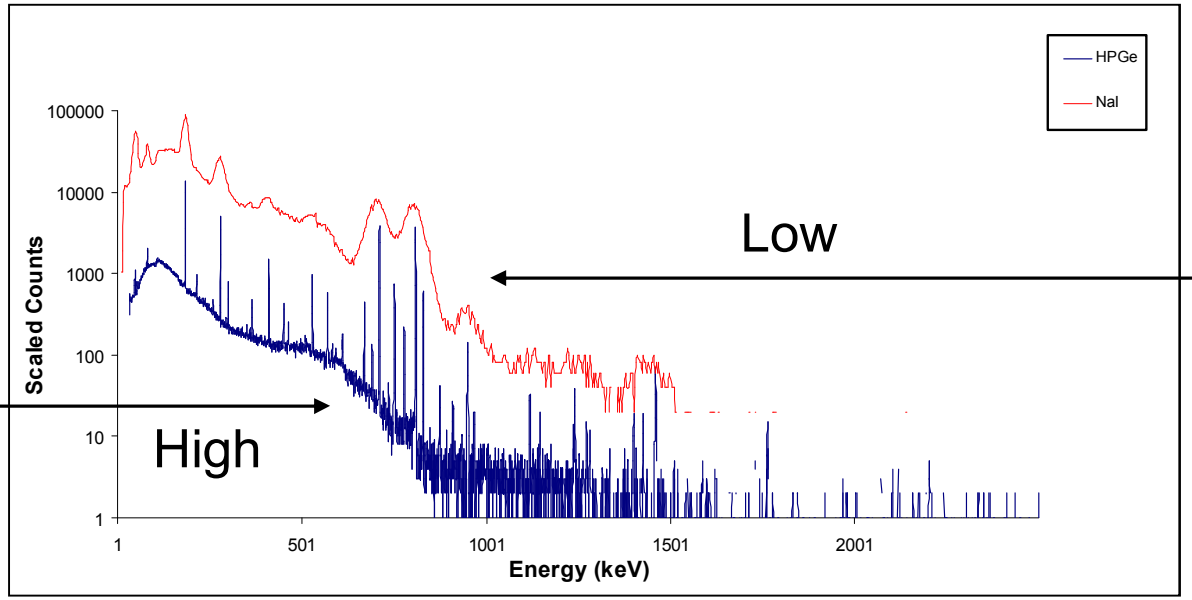
Maritime	Venues	Investigation
Aerial	Portals	***Identification***
	Shipboard	Characterization

Radioactive Material Identification

High Resolution versus Low Resolution Gamma Spectroscopy

"ability to resolve adjacent gamma peaks"

HPGe



NaI

Comparison of a sodium iodide (NaI) spectrum (low resolution) to a High Purity Germanium (HGPE) spectrum (high resolution)

Interdiction/Investigation

Law enforcement + radiation detection

Radiological search teams working closely with law enforcement can resolve most radiological alarms using a series of measurements.

For cases of individuals triggering alarms, investigative techniques and radiation measurements can resolve the alarms which are typically caused by medical treatments.

Interview Questionnaire Example

This questionnaire can be used to investigate and adjudicate alarms

We believe you may have triggered an alarm on our radiation pager and would like to ask you a few questions.

1. What is your name?
2. Have you had any medical treatments lately which involved a radioactive isotope; for example a stress test or iodine treatment? Patient may have a medical certificate from doctor.
3. We would like to take a quick measurement with our sensor to verify the reading.

Perform a one minute ID at close range; if dead time is high (> 5%); move back until less than 5%

Review results of ID for the following:

Medical – Tc-99m, Tl-201, Ga-67, I-123, I-125, I-131, In-111, Ir-192, other
Industrial - Cs-137, Ir-192, Co-60, Ra-226, Am-241, U-238, Th-232, other
Special Nuclear Materials - Pu-239, U-235, U-233, Np-237

If ID confirms Medical and story is corroborated, then notify individual:

Our reading confirms the medical isotope. Appreciate your cooperation. Release and complete Alarm Log.

If the alarm is not from the individual, then continue questioning:

1. Are you transporting any radioactive materials?
2. If the answer is yes, review the driver's manifest and inspect the cargo and labeling.

Perform a one minute ID at close range; if dead time is high (> 5%); move back until less than 5%.

Review results of ID and notify the individual:

1. Our measurement confirms the sensor reading and the cargo manifest. We appreciate your cooperation. (Access either approved or denied).
2. If situation is not resolved, detain and request additional expert support.

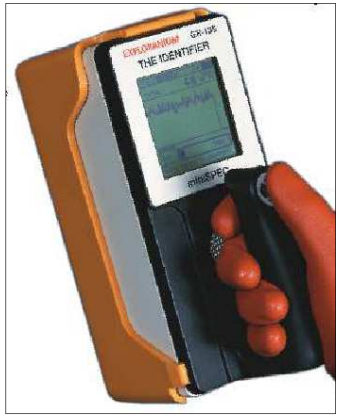
Identification Tools

RadioIsotope IDentifier (RIID)

Low resolution sodium iodide gamma detector can be used for initial ***screening*** of radioactive materials. Spectral data is analyzed by comparing it to a stored radioisotope library. Typically contains a small neutron detector.

Identification Tools

Examples of RIIDs



Identification Tools

High Resolution RIID – The Gold Standard

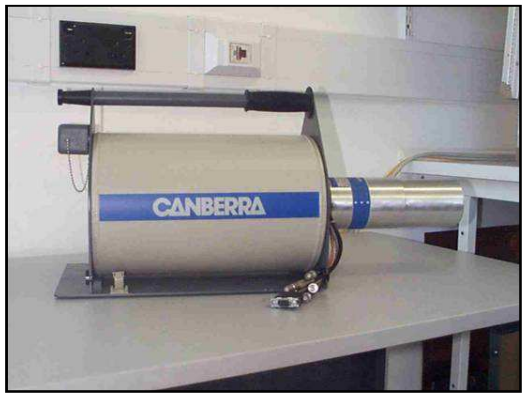
High Purity Germanium (HPGe) detectors are used ***for laboratory quality gamma spectroscopy in the field*** and provide accurate radioactive material identification. Detector requires cooling to very low temperature for operation.

Identification Tools

Examples of High Resolution RIIDs

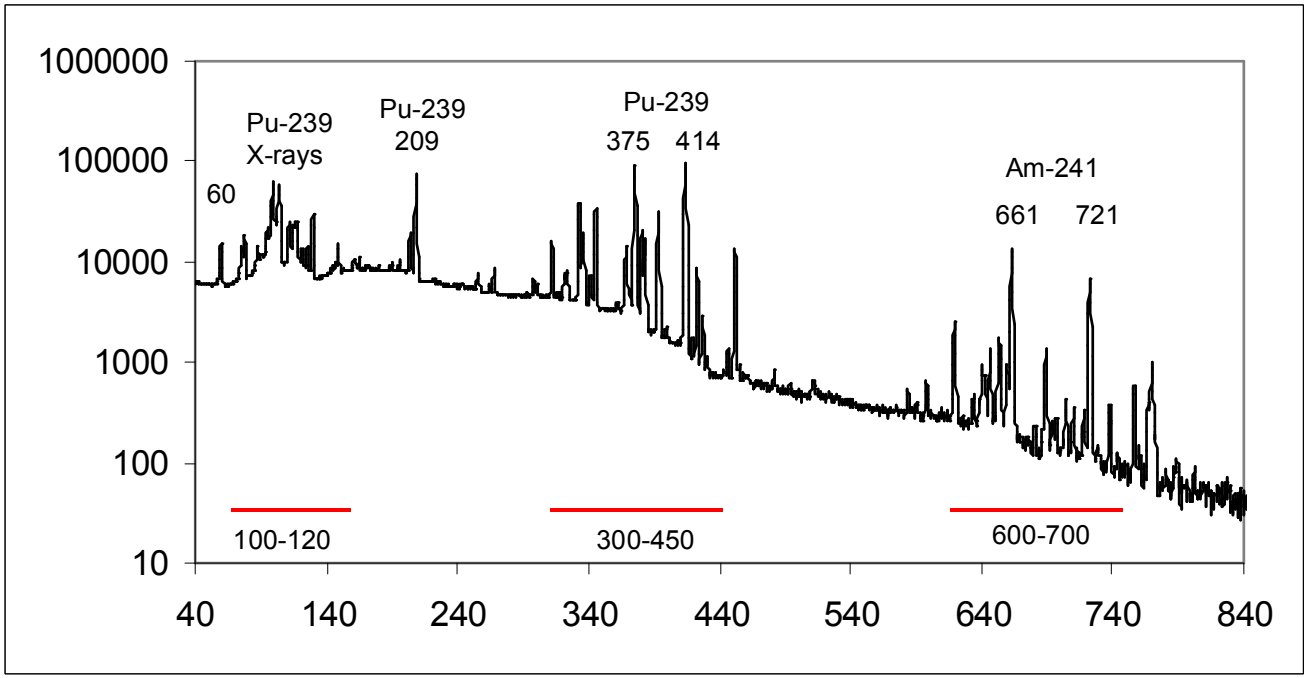
Mechanically cooled →

Liquid nitrogen cooled →



Radioisotope Identification

High Resolution Pu-239 Spectrum

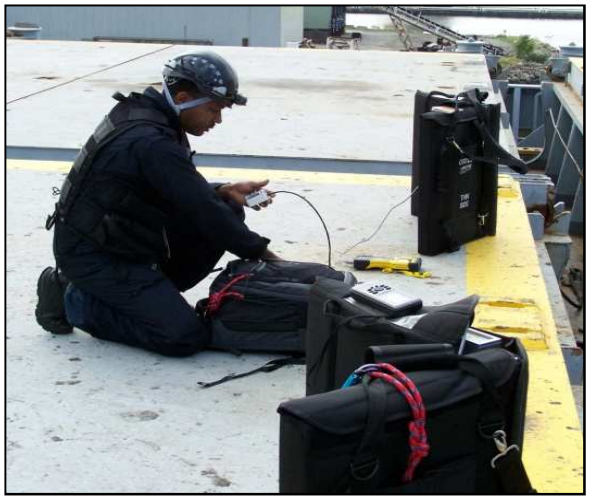


Gamma spectroscopy can be used to extract critical information about the radiation source to include radioisotope identification, enrichment, shielding thickness, surrounding materials and activity.

Neutron Assessment Tool

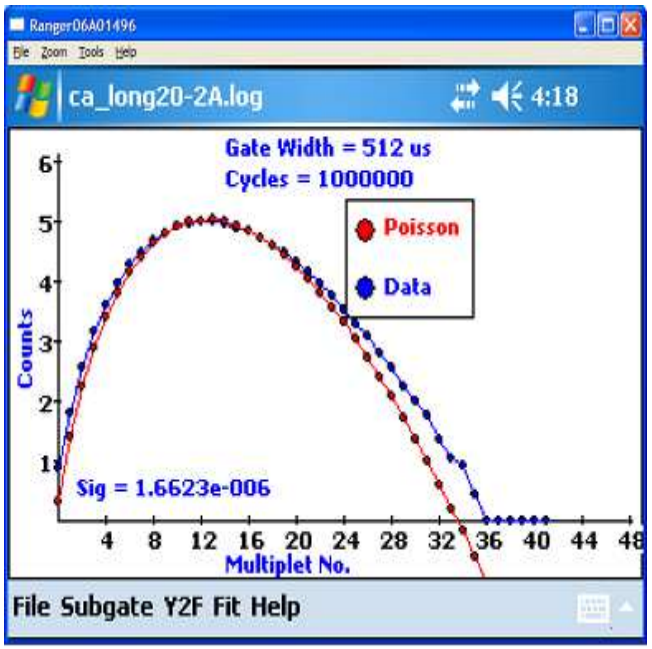
Specialized neutron detection instrument

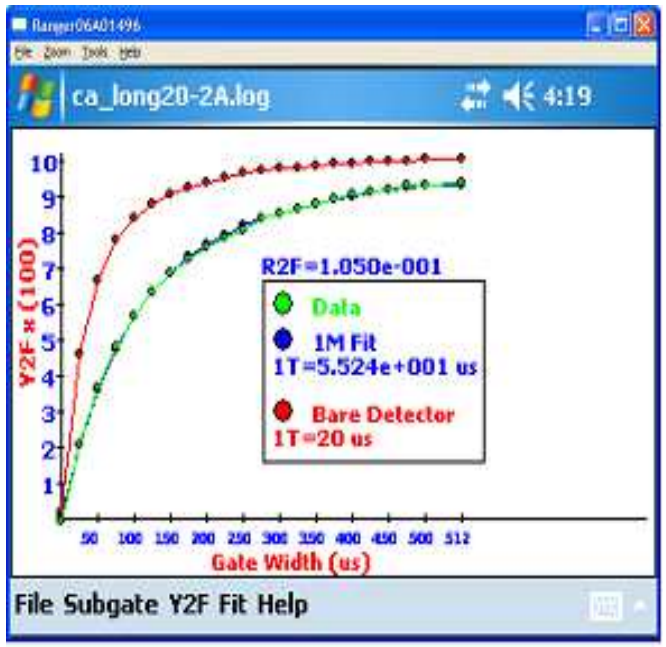
The ***Fission Meter*** is a high sensitivity detector for analysis of neutron sources. It can be used to determine if a neutron source is an industrial source or special nuclear material. Used shipboard to assess cosmic-ray neutrons.



Neutron Assessment Tool

Fission Meter Data – neutron multiplication and lifetime data





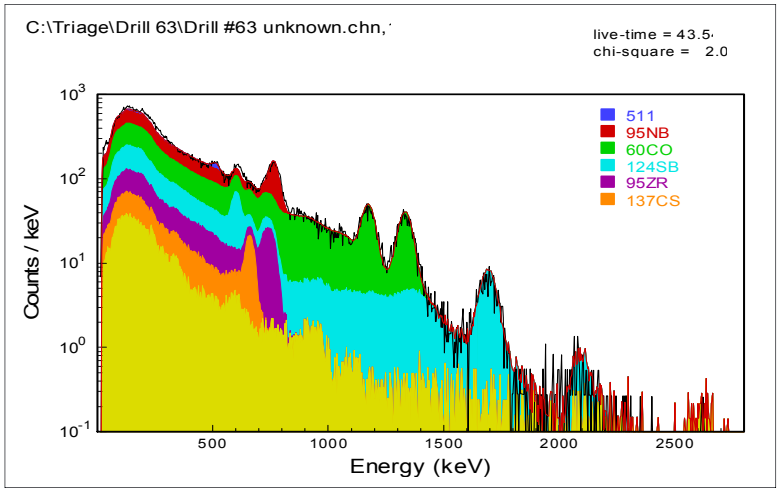
Neutron data provides information neutron multiplication, mass of material and shielding thickness. Fission meter data, when combined with HPGe spectral data, provide critical diagnostic information about the radiation source.

Radiological TRIAGE

Expert advice for radiological data

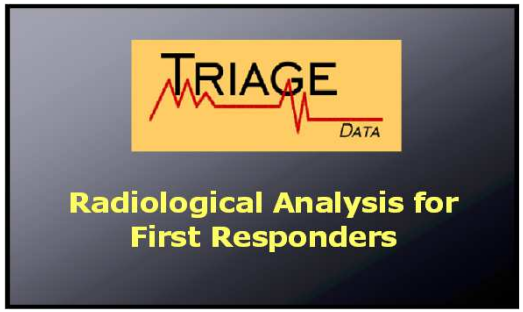
Many first responders are trained to acquire spectral data but often it takes an expert in gamma-ray spectroscopy for proper analysis.

Radiological TRIAGE helps prevent an unnecessary full-scale response when there is no threat, or can ***"pull the fire alarm"*** if the threat appears to be serious.



International Reach Back

- **The Radiological TRIAGE System is available 24/7 to provide:**
  - Radionuclide identification using advanced spectral analysis tools
  - Review for presence of Special Nuclear Materials
  - Conduct isotopic analysis of nuclear materials
  - Estimate quantity of radioactive material
  - Assess potential risk



To access TRIAGE

1. Call the DOE EOC at +1-202-586-8100 and ask for TRIAGE support.

2. The TRIAGE system will be activated. Provide the name and phone number of a contact person.

3. Results in 1 hour via call back.

TRIAGE is a registered reachback capability with the IAEA

Radiological Search

Radiation Search

Large Area Search

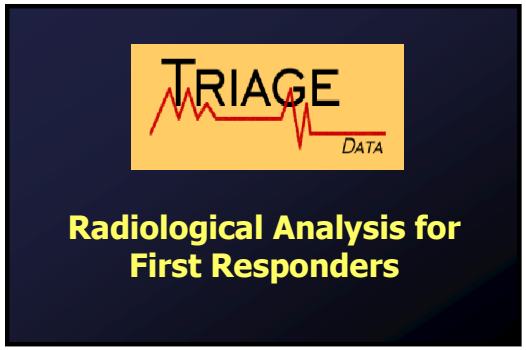
Small/Medium Area Search

Localization/Pinpointing

Radioisotope Identification

Screening

Identification



Data Analysis

Advanced Radiological Search Concept of Operations

Questions?