Networked Application of Chemical, Biological, Radiological and Nuclear Detectors for Early Detection and Warning of CBRN Events in Transit Environments

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Terrorist Attacks on Transit Systems

- **The Tokyo Subway Attack – March 20, 1995**
- **The Madrid Bombing – March 11, 2004**
- **The London Metro Bombing – July 7, 2005**

What's Next?

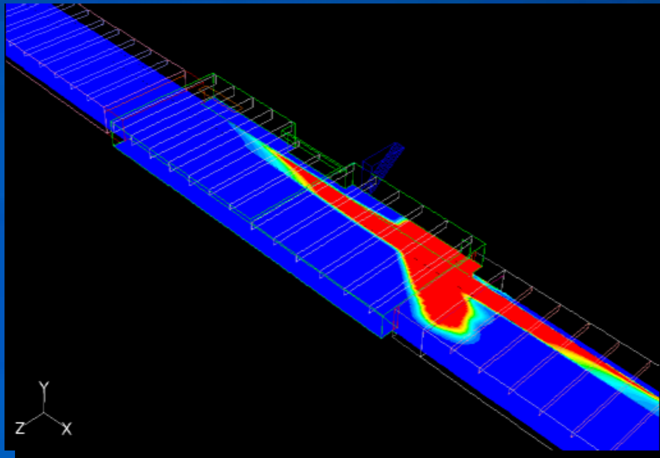
Sample Scenario 1: Radiological Dispersal Device (RDD)

Spent nuclear fuel rods are supplied by Iran and shipped in a cargo container to Colombia then flown to Mexico and loaded on human mules used to smuggle drugs across the border. They are met in Arizona by sleeper cell agents who take the fuel rods by car toward its final destination. Three men get off subway cars at three different locations in downtown New York and head toward the New York Stock Exchange. ……..

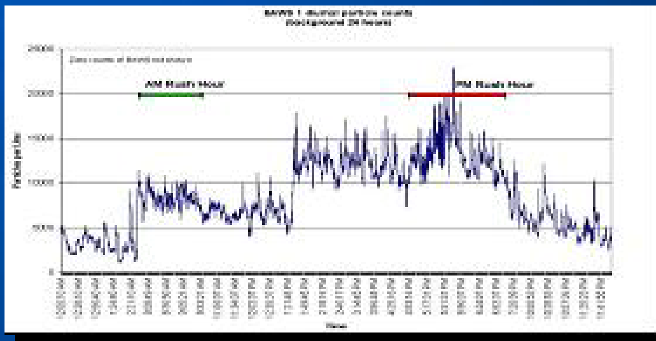
The Unique Challenges of the Transit Environment

- Biological sensing problems
  - High particulate counts
    - Platform counts 100 X outside counts (PPLA)
  - Interferants
    - Diesel trains, vacuum trains mimic ‘Releases’
    - Skin cells, pollen mimic the biological signature
- Chemical sensing problems
  - Interferants
    - Pesticides and rodenticides
    - Cleaning agents, perfumes and deodorants
- Radiological sensing problems
  - Infrastructure provides many heavy steel obstructions conducive to shielding low level sources

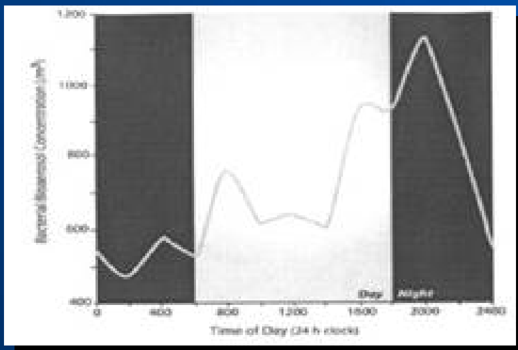
The Unique Challenges of the Transit Environment



- Unusual ambient air currents
- Train operations
  - Piston effects
- Diurnal effects
  - Bimodal distributions due to AM/PM rush hours



- Seasonal effects
  - Pollen/spore count variations[1]
  - Temperature
  - Humidity
- EMI / RFI



Reference 1: "An Introduction to Biological Agent Detection Equipment for Emergency First Responders", National Institute of Justice, NIJ Guide 101-00, December 2001 Page 14.

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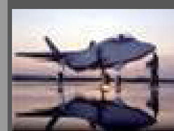
Transit MetroGuard™ System

Mission: Protect Riders & Their Infrastructure

Transit Protection Systems

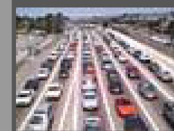
- -Complex Integration
- -Systems of Systems
- -Disciplined Approach
- -Process-Driven

Defense

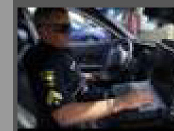


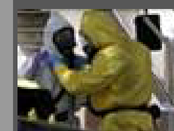
Intelligence

Homeland Security



Public Safety





Bringing Domain Expertise to a New Critical Mission

Detailed Management of Requirements

- High reliability in extremely harsh environment
- Closely tailored to unique transit requirements
- Aggressive leveraging of COTS sensors & communications

Increase

System Reliability

Probability of Detection

Upgradeability

Expandability

Mean Time Between Failures

Calibration Interval

Internal Testing

False Alarms

Airborne Interference

Response Time

Maintenance Cycle & Cost

Acquisition Cost

Mean Time To Repair

Technology Risk

Decrease

Goal: Provide Actionable Intelligence

Turning Data into Knowledge . . . and Knowledge into Action

Acquire: Sensor Suite

Air Particle Counter	
UV-LIF	
Wet Sample Collector	
Chemical	Radiological

Controller
Power / Communications

Driving Detector Requirements

- *Operation in a Harsh Environment*
- *Probability of Detection*
- *Probability of False Alarms*
- *Scheduled Maintenance Interval*
- *Calibration Interval*
- *High MTBF, Low MTTR*

Remote Detector Unit (RDU)

Analyze: The Advantages of a Networked Approach

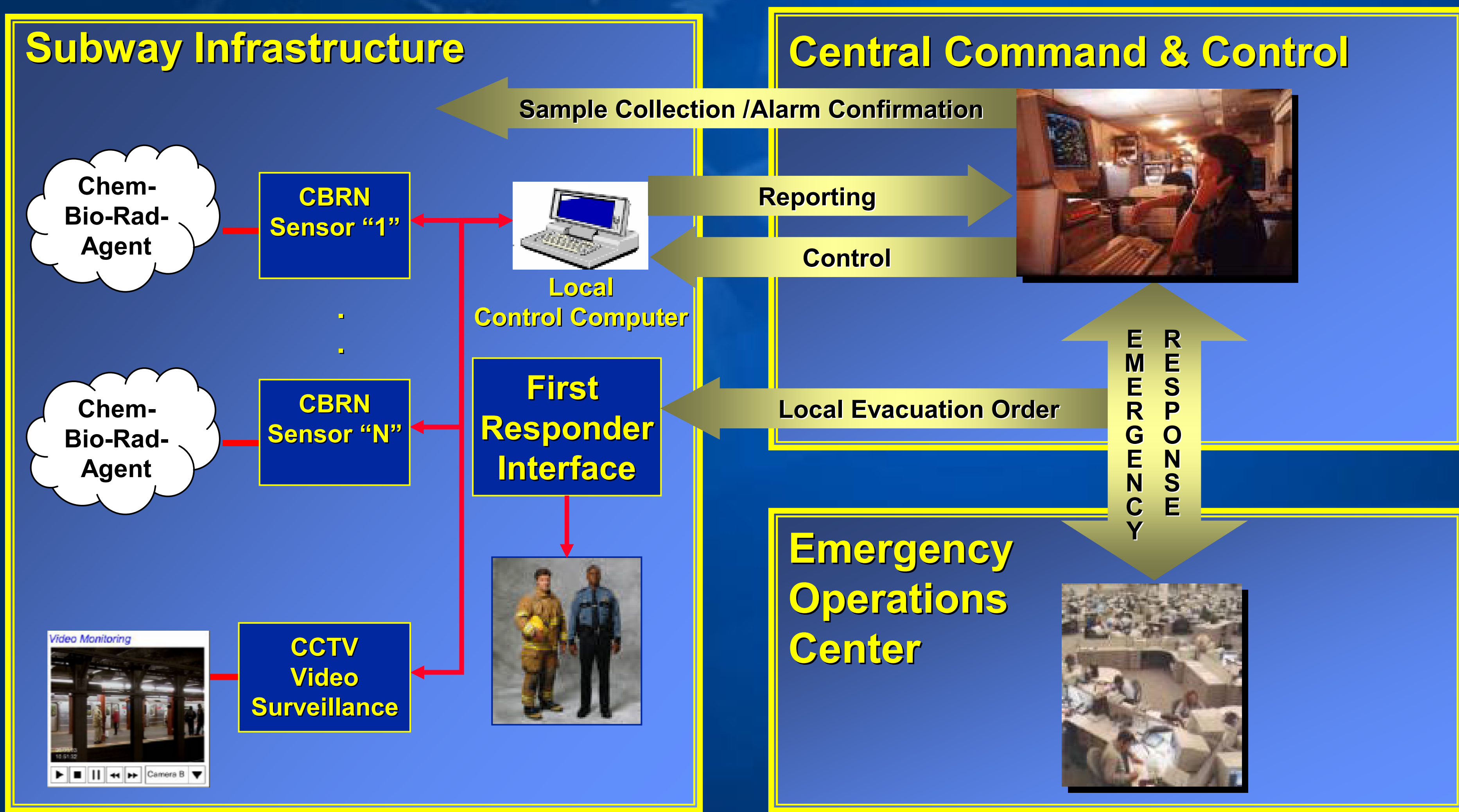
- The basic premise of the networked approach is that a distributed array of detectors can utilize temporal and spatial characteristics of releases to increase the Probability of Detection (PoD) and reduce the Probability of False Alarms (PFA), versus use of single point detectors by
  - Spotting trends
  - Negating single detector failures
  - Requiring fewer detectors to establish coverage

Analyze: The Advantages of a Networked Approach

- Increases Probability of Detection
  - Enables multi-sensor temporal and spatial correlation
    - Lower thresholds for Alerts correlated in time to allow detections that would otherwise go unnoticed
    - Lower thresholds for Alerts correlated in space (e.g., Waterfall Alerts)

- Decreases Probability of False Alarms
  - High threshold single detector alarms
    - Increases single detector signal to noise requirement
  - Correlation between independent detectors
    - Reduces single detector failure alarms

Act: Coordinated CONOPs



*Metro*Guard™ Application to Scenario 1: RDD

Spent nuclear fuel rods are supplied by Iran and shipped in a cargo container to Colombia then flown to Mexico and loaded on human mules used to smuggle drugs across the border. They are met in Arizona by sleeper cell agents who take the fuel rods by car toward its final destination. Three men get off subway cars at three different locations in downtown New York and head toward the New York Stock Exchange. ……..

Understanding the Source of the Radiation: Nuclear Fuel Rods

- There are about 557 nuclear power reactors in the world; about 440 are currently in operation
- Most nuclear reactors are powered by fuel rods that contain two types of uranium ^{235}U (2-3%) and ^{238}U (97-98%)
- Fuel that is burned in a nuclear reactor undergoes controlled fission, releasing neutrons, other radioactive elements and plutonium (^{239}Pu)

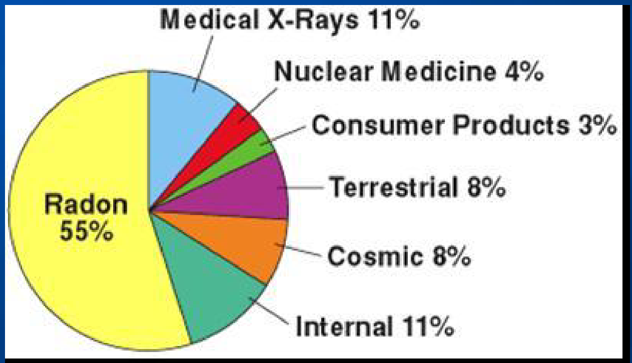
Understanding the Source of the Radiation: Nuclear Fuel Rods

- The Fissioning process results in extremely hot and radioactive spent fuel
- After 3 years in a reactor, 1,000 lbs. of 3.3 percent enriched uranium (967 lbs. ^{238}U and 33 lbs. ^{235}U) contains[1]:
  - 8 lbs. of ^{235}U (alpha, gamma emitter)
  - 8.9 lbs. of plutonium isotopes (alpha, beta, gamma emitter)
  - 943 lbs. of ^{238}U and assorted fission products

Reference 1: http://www.chemcases.com/2003version/nuclear/nc-13.htm

Determining a Reasonable Radiation Threshold

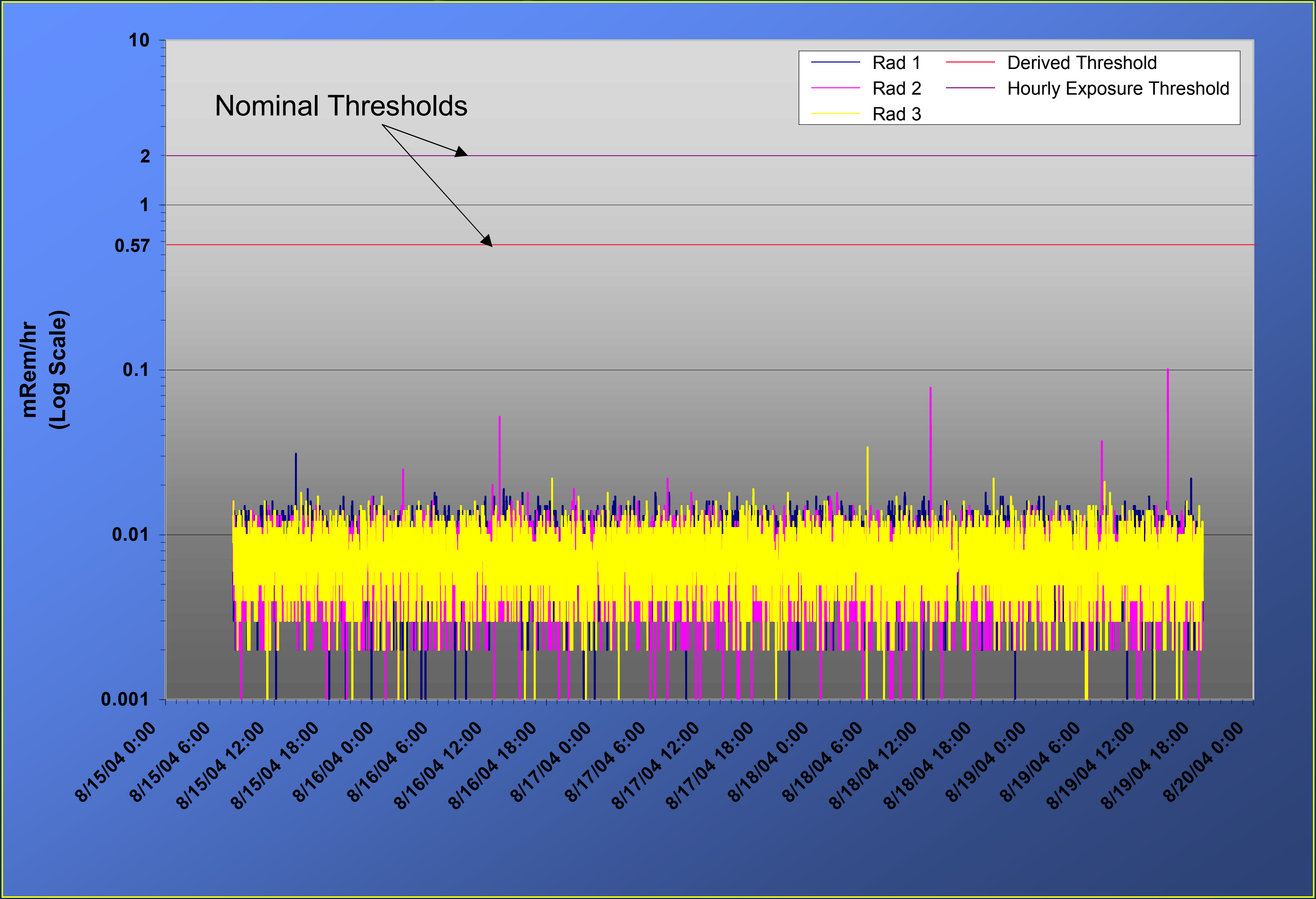
- **OSHA standard of 5000 mRem/year for whole body radiation[1] exposure yields 0.57 mRem/hr**
- **Subpart D- Radiation dose limits for individual members of the public[2]**
  - **"The dose in any unrestricted area from external sources, exclusive of the dose contributions from patients administered radioactive material and released in accordance with (35.75), does not exceed 0.002 rem in any one hour"**



References:

1. http://www.nih.gov/od/ors/ds/rsb/exposure.html
2. 56 FR 23398 May 21, 1991 20.1301: http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/part020-1301.html

Radiation Data in a Transit Environment



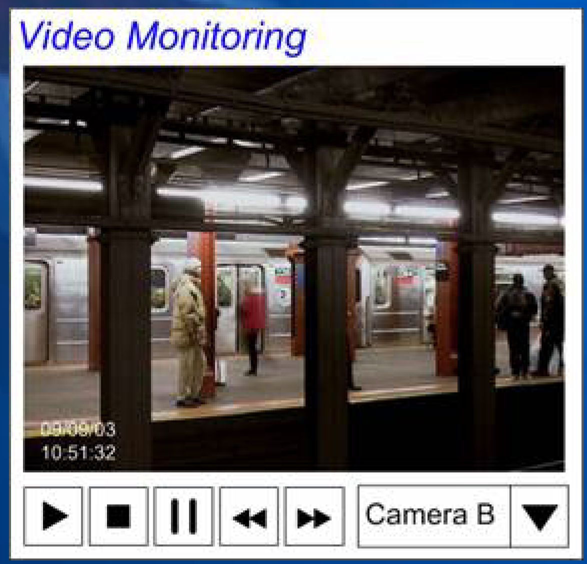
Radiation Data in a Transit Environment

- The station operational cycles are not evident in the bulk of the data
- The handful of outliers (0.08 and 0.1 mem/hr) occurred during normal station busy periods
  - No direct cause identified for any outlier
- 108 hrs of data
- Background radiological readings typically below 0.02 mRem/hr.
- Possible causes of outliers due to:
  - Presence of passengers treated medically with radioactive injections or implants
  - Granite emissions

Sensor Alarm to Video Association

Threat Detection

Video Monitoring / Association



Surveillance / Identification

Sensor Alarm to Video Association

Wall Street

RDU NO.	Time	Gamma Level	Video Frame	No.	FBI DB: Suspect ID
RDU 3	T1	Background		T1	
	T2	Background		T2	
	T3	Alert			
	T4	Background			
	T5	Background			
	T6	Background			
	T7	Background			
RDU 4	T1	Background			
	T2	Background			
	T3	Background			
	T4	Alert			
	T5	Background			
	T6	Background			
	T7	Background			
RDU 5	T1	Background			
	T2	Background			
	T3	Background			
	T4	Background			
	T5	Alert			
	T6	Background			
	T7	Background			

Penn Station

RDU NO.	Time	Gamma Level	Video Frame	No.	FBI DB: Suspect ID
RDU 6	T11	Background		T11	
	T12	Background		T12	
				T13	GODWIN, T. 
				T14	
				T15	
				T16	
				T17	
				T11	
				T12	
				T13	
				T14	GODWIN, T. 
				T15	
				T16	
				T17	
				T11	
				T12	
				T13	
				T14	
				T15	GODWIN, T. 
				T16	
				T17	

Grand Central Station

RDU NO.	Time	Gamma Level	Video Frame	No.	FBI DB: Suspect ID
RDU 11	T24	Background		T24	
	T25	Background		T25	
	T26	Alert		T26	LADIN, B 
	T28	Background		T27	
	T29	Background		T28	
	T30	Background		T29	
				T30	
RDU 12	T24	Background		T24	
	T25	Background		T25	
	T26	Background		T26	
	T27	Alert		T27	LADIN, B. 
	T28	Background		T28	
	T29	Background		T29	
	T30	Background		T30	
RDU 13	T24	Background		T24	
	T25	Background		T25	
	T26	Background		T26	
	T27	Background		T27	
	T28	Alert		T28	LADIN, B. 
	T29	Background		T29	
	T30	Background		T30	

	T28	Alert		T28	LADIN, B. 
	T29	Background		T29	
	T30	Background		T30	

Summary

- Transit environments challenge detector system performance
- Networked application of CBRN detectors can provide early detection and warning
- Networked corroboration increases probability of detection and reduces probability of false alarms
- Analysis of the specific background, the expected propagation of agent material, and interferants is critical to system performance

Thank You