ALERT: Awareness and Localization of Explosives-Related Threats

Northeastern University | Boston University | Rensselaer | UMR University of Missouri-Rolla | Texas Tech University | Washington State University | University of Rhode Island

Explosive Detectors And Alternative Threat Sensing Modalities (Thrust F2)

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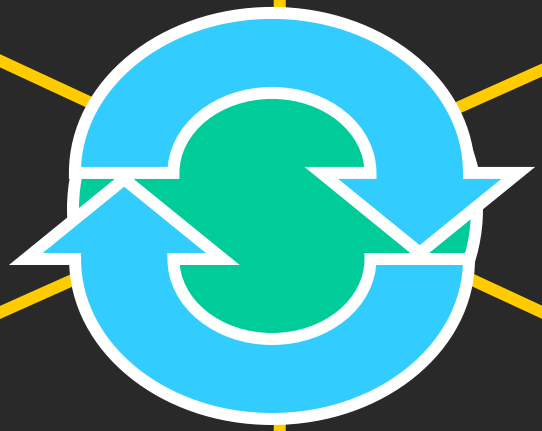
AWARENESS AND LOCALIZATION OF EXPLOSIVES-RELATED THREATS
DETECTION
MITIGATION
RESPONSE
ALERT

The ALERT Fundamental Science Program: A Multidisciplinary and Integrated Approach

Chemical & Physical Characterization Of Explosives (F1)

Advanced Explosive Material & IED Detectors (F2)

Mitigation Science & Technology (F4)

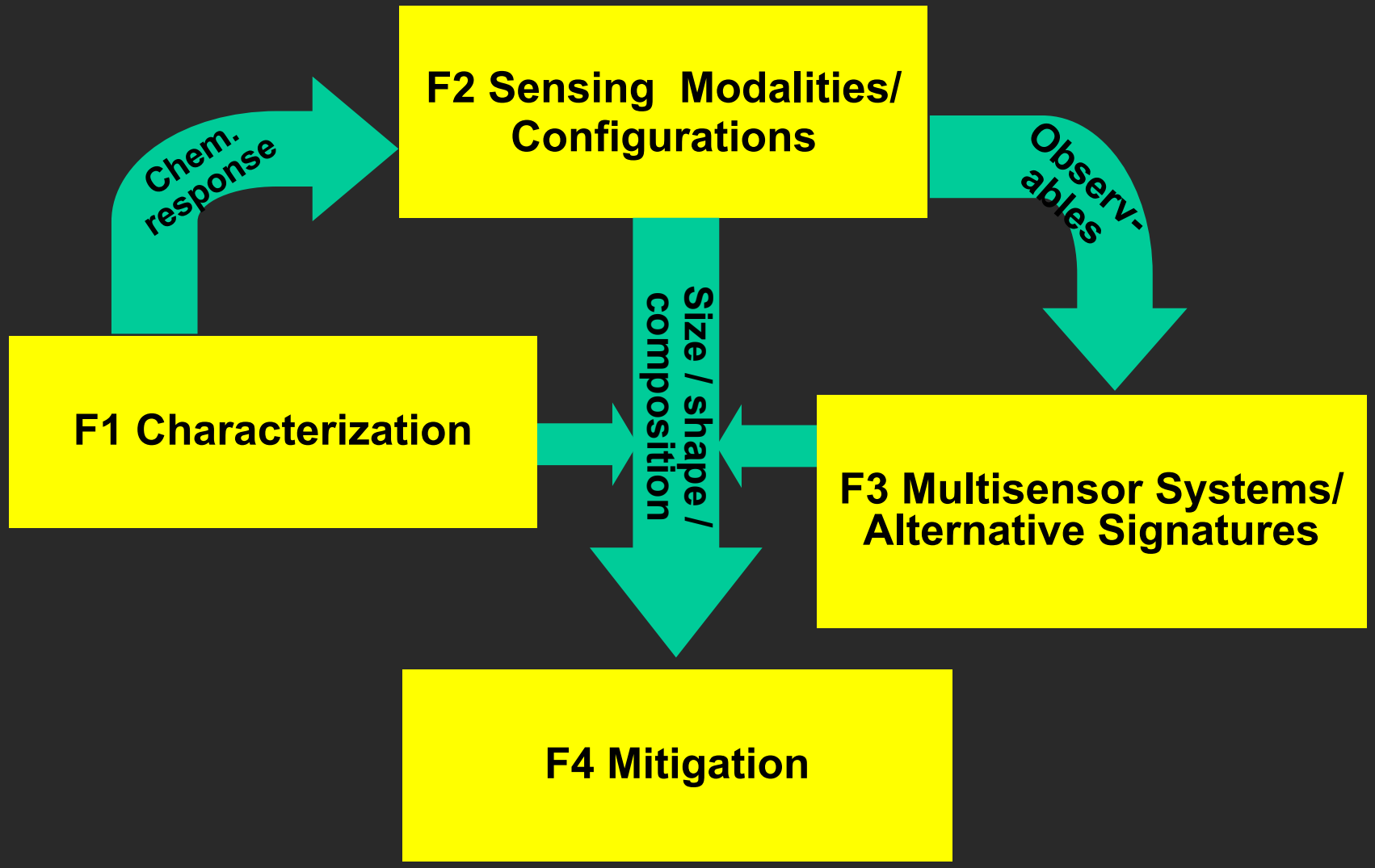


Unconventional Detection Approaches (F2)

Human Factors & Man-Machine Interface (F3)

Multi-Sensor Networks & Fusion (F3)

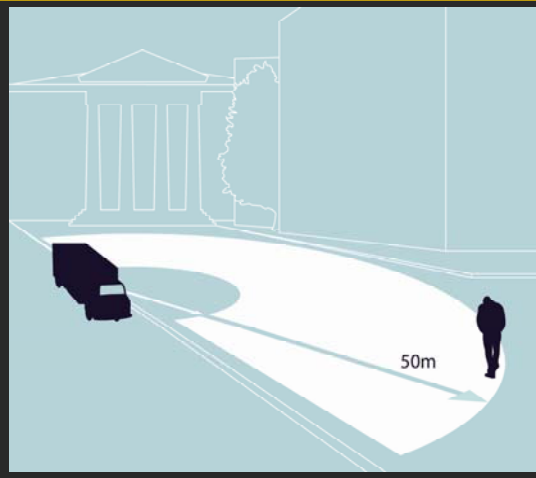
The Thrust F2 Relates to The Others



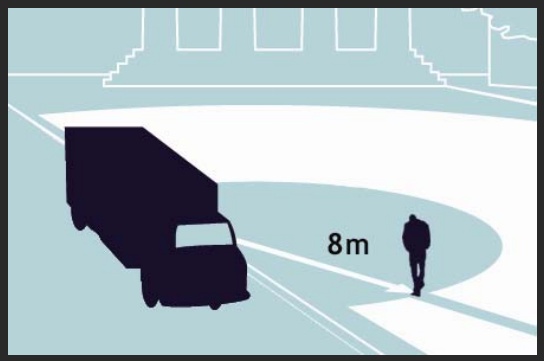
True collaboration both across discipline and among thrusts

Detection Regimes

- Distant targets (10 m to >100 m),
  - Stand-off detection of hazards
  - Far enough away to minimize threat



- Mid-range targets (3 to 10m)
  - Enhanced sensing discrimination
  - Not explicitly surrounding target



- Intimately near targets (< 3 m)
  - Non-invasively examined
  - Mostly portal sensors

Some Explosives Threat Detection Tradeoffs

- Sense within hidden / concealed / shielded / non-stationary environments
- Imaging to detect suspicious shapes (video, X-ray, THz, mm-wave radar, acoustics, NMR)
- Chemical detection to identify suspicious materials (Mass Spec., Gas Chrom., “Artificial Dog Nose”)
- Material frequency response to characterize molecular structure (Hyperspectral, IR, UV, THz, NQR, LIBS)
- Device frequency response to identify wireless electronic triggers (EM emission sensing)
- Nuclear methods to identify elemental composition (neutron / gamma detection)

Some Initial Sensor Modalities to be Investigated and Developed Within ALERT

- *F2-B.* Microwave and mm-wave sensing – Rappaport (NU)
- *F2-A.* Active and passive spectroscopy & hyperspectral detection – McKnight(NU)
- *F2-C.* Terahertz spectroscopy – Zhang (RPI)
- *F2-D:* Ultra compact mass spectrometer – Camilli (WHOI)
- *F2-E:* Detection and neutralization of electronics used with explosives – Beetner (UMR)

Microwave and Mm-Wave Radar

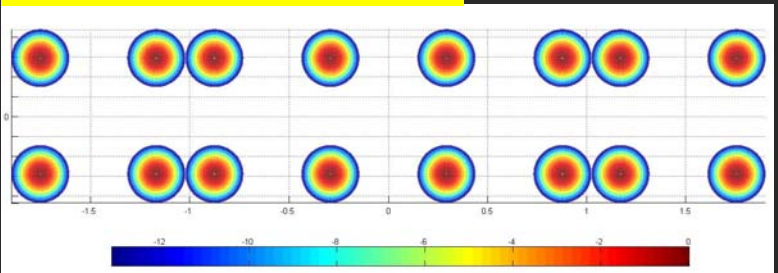
- One of the few sensing modalities that can penetrate clothing or walls & sense threats at standoff DISTANCE
- Conventional radar used for detection and positioning – air or sea craft – does not identify shape or texture

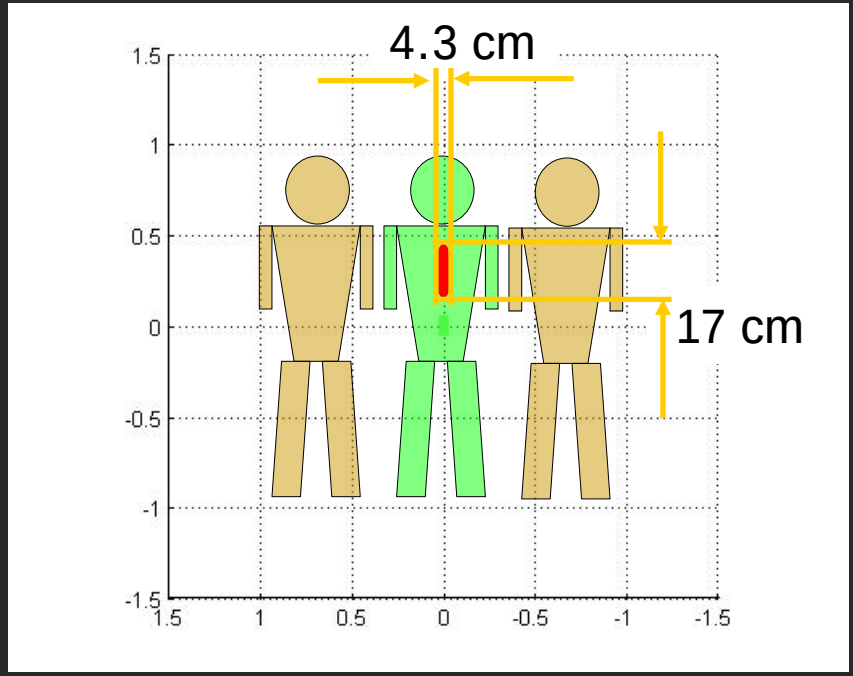
  FAILS AT DETECTING OBJECTS ON SKIN AT DISTANCE
- Imaging radar operates in the millimeter wavelength range (30 – 350 GHz) can ideally resolve small targets
- Wall Penetrating Radar interrogates through exterior walls: determine interior plan and objects
- Radar scanning of bags can eliminate water-based (food) false alarms

Large Array of Reflectors Provides Multiple Views for Surface Texture Discrimination

To discern features, must have tight illuminating spot
= multiple views
= large aspect angle
= wide aperture
→ 4m array for 50 m range

16 elements





Array width: 1000 λ (4 m)

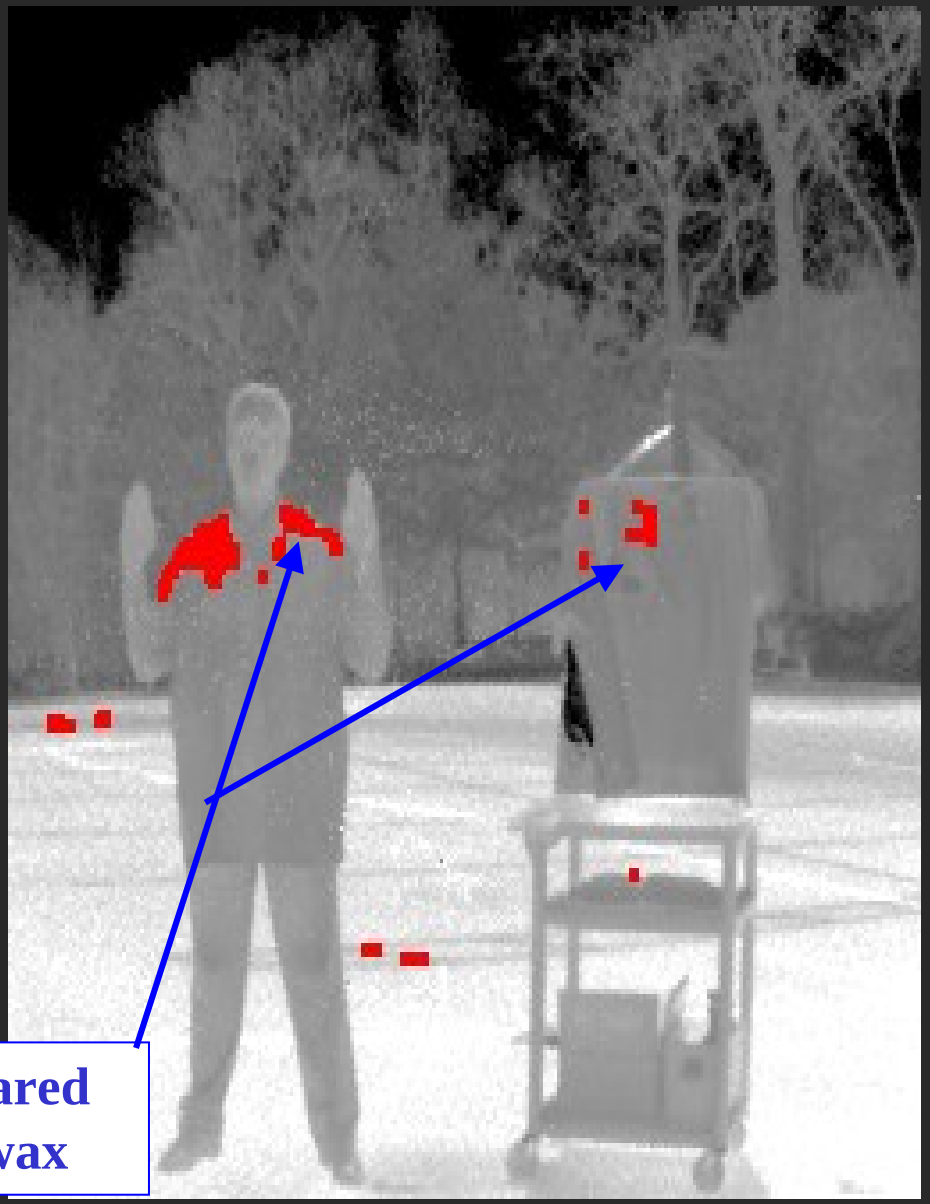
- Scan spot digitally across body
- Arbitrary spatial resolution
- Identify local irregularities on skin

IR Emissive Spectroscopy

- Explosives are sticky waxy compounds with low vapor pressure that persist on the clothing, hands, and face of people working with them.
- Explosives substances have characteristic spectral signatures in the mid- (3-5 μ) and far-IR (8-14 μ) spectral regions.
- Humans are strong sources of IR emission in the mid- and far-IR.
- IR emission contains the same spectral information as absorption of the same body.
- Spectral analysis of the emission from human targets and their clothing can detect explosive residues at safe standoff DISTANCE.

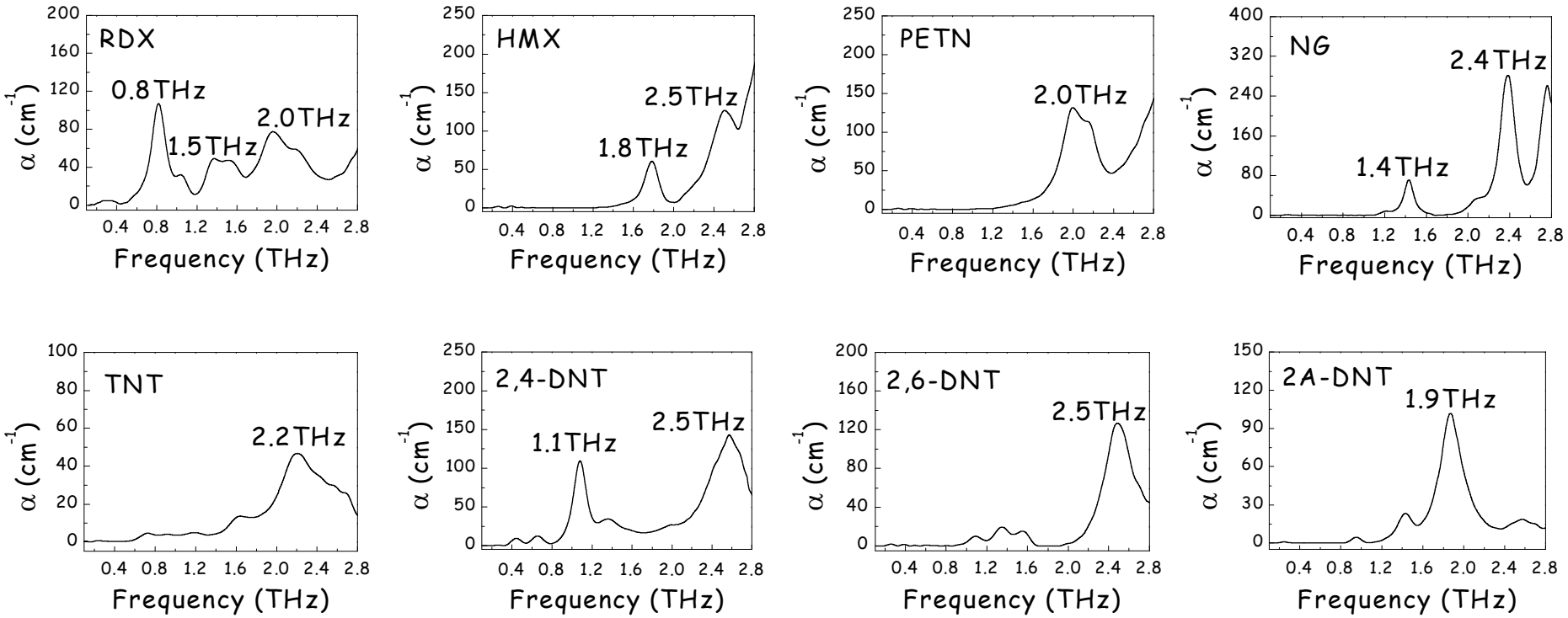
Field Demonstration of IR Detection

AIRIS Spectrometer

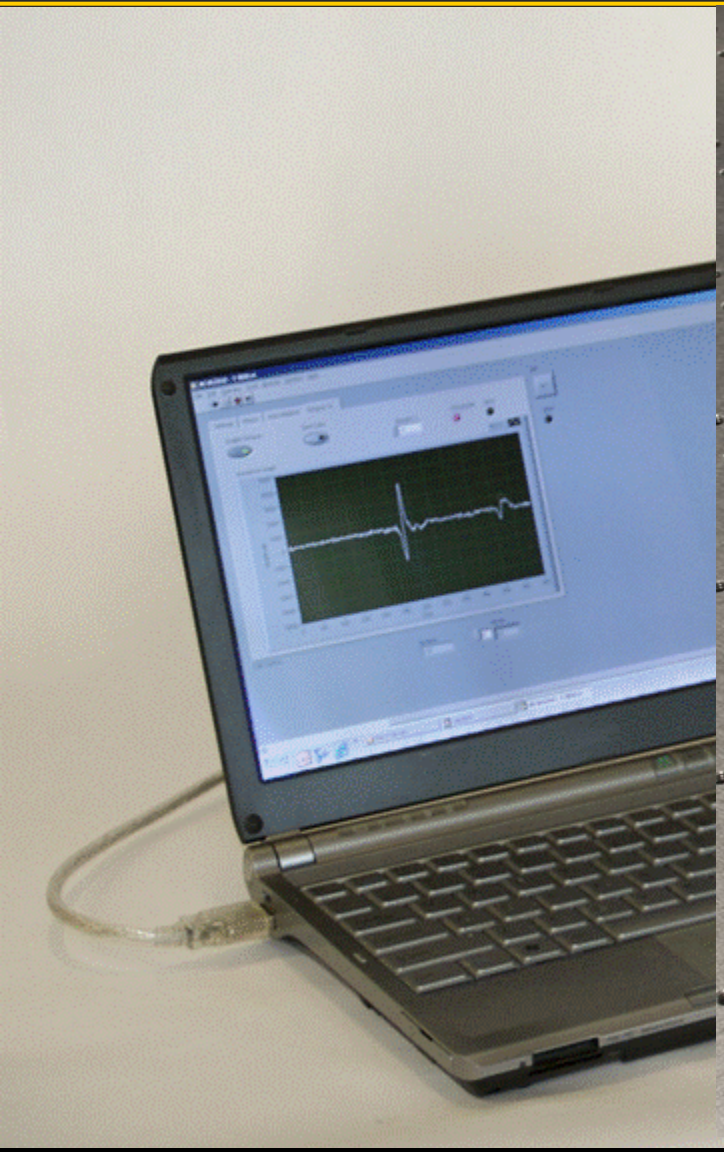


Use of THz Detectors To Identify Explosives & Their Related Compounds

- 22 of 27 explosives and related compounds tested at Rensselaer showed specific signatures in 0.5 - 5 THz frequency range.

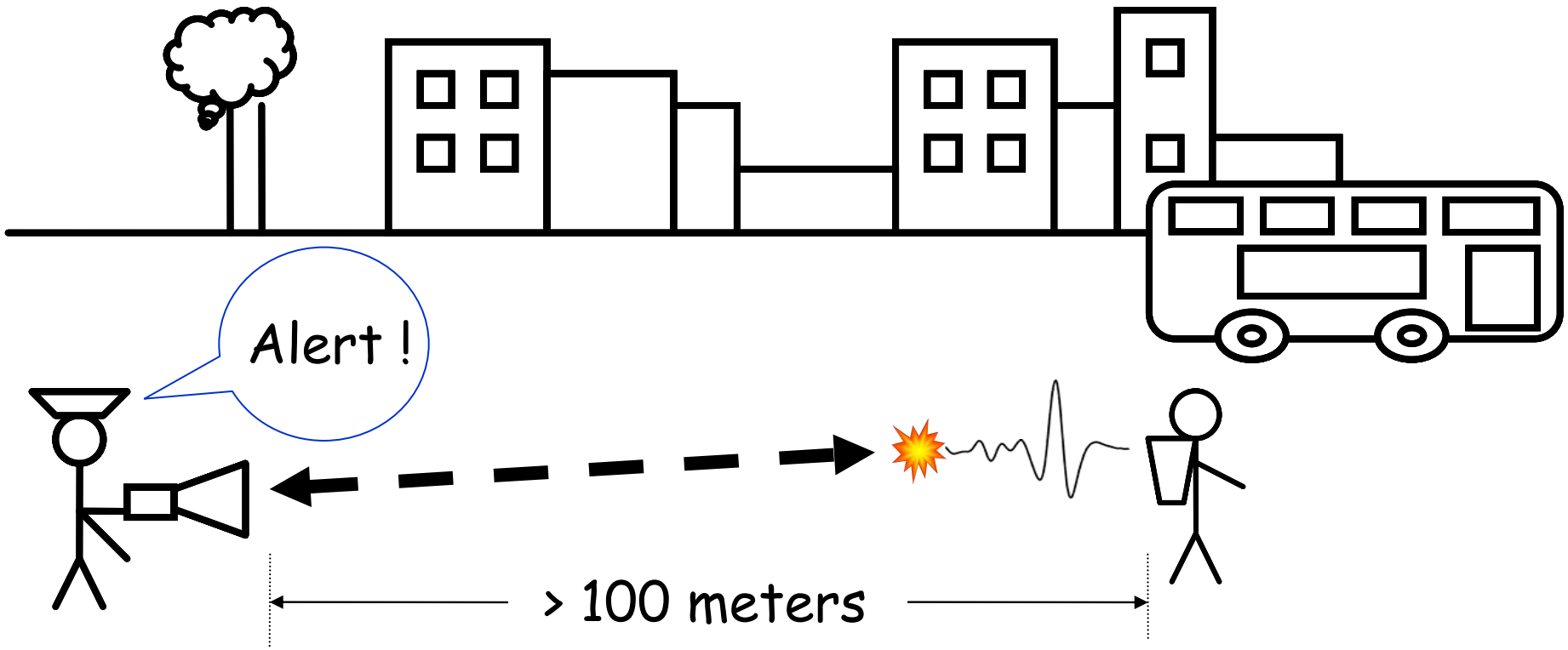


Field Deployable THz Spectrometer



mini-Z won 1st Lemelson-Rensselaer Prize $30,000

Can THz Sensing be Used For Large (>50 m) Standoff Distance Detection?



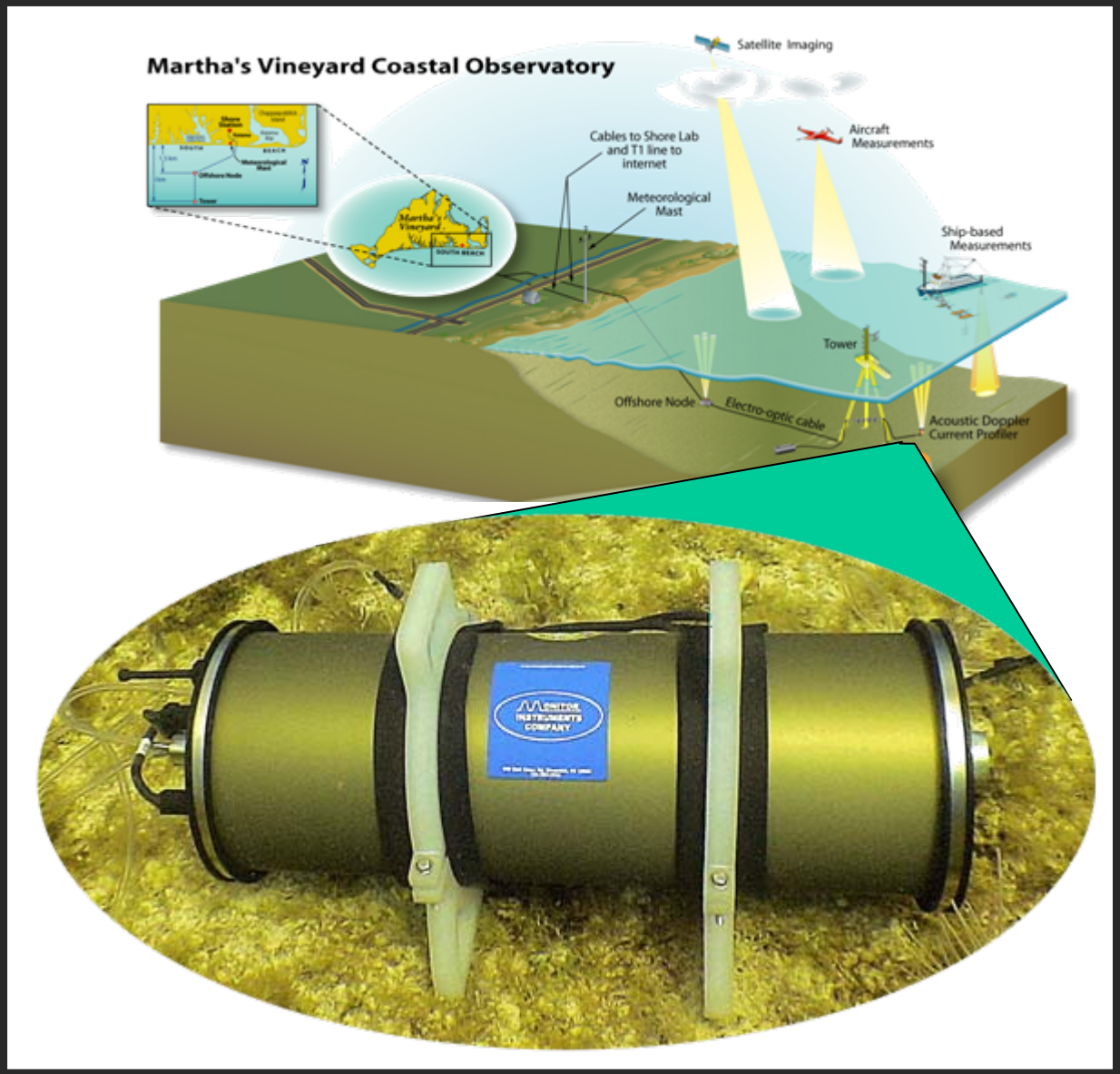
Using **air** to generate and detect an intense THz wave close to the target with ultra-short laser pulses.

TETHYS: an operational portable marine mass spec.: Can it be used for Explosives?

TETHYS

TETHered Yearlong Spectrometer

Mass range	1-200amu
Mass resolution	<0.1amu
Power	~25 W @ 24V
Maximum depth	>5,000m
Endurance	~1 yr
Response time	5 sec
Sensitivity (LOD)	~1 ppb
Weight	13 kg
Displacement	<14 L
Moving parts	none

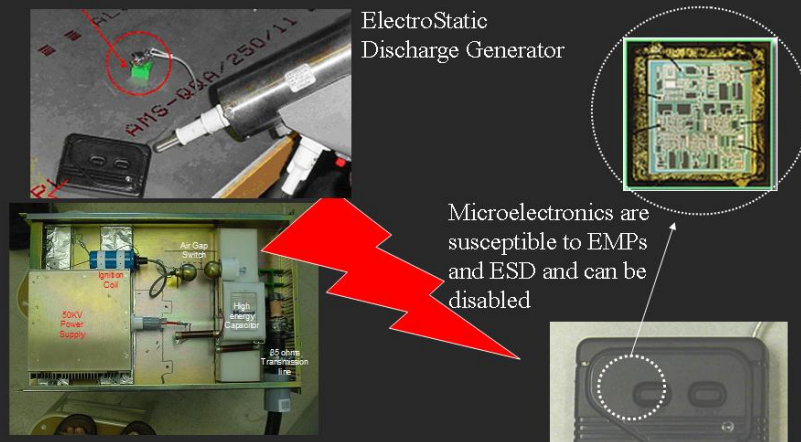


Proposed Research Plan

- **Optimize Kemotron for detection of explosives** agents (including precursors and breakdown products) Yrs 1 to 4
- Adapt **software identification library** to autonomously characterize explosive agents Yrs 1 to 2
- Develop an **embedded localization capability** to assimilate MS data via probabilistic plume dispersion models to generate estimates of likely source locations Yrs 1 to 2
- Develop **bidirectional interface for Kemotron communication** with ALERT network systems Yrs 2 to 3
- Laboratory testing to **establish ROC curves, MLOD** Yrs 3 to 4
- **Finalize Kemotron modifications** for operation onboard mobile robot or a as self-contained handheld system Yr 4
- **Field demonstrations Yr 4**

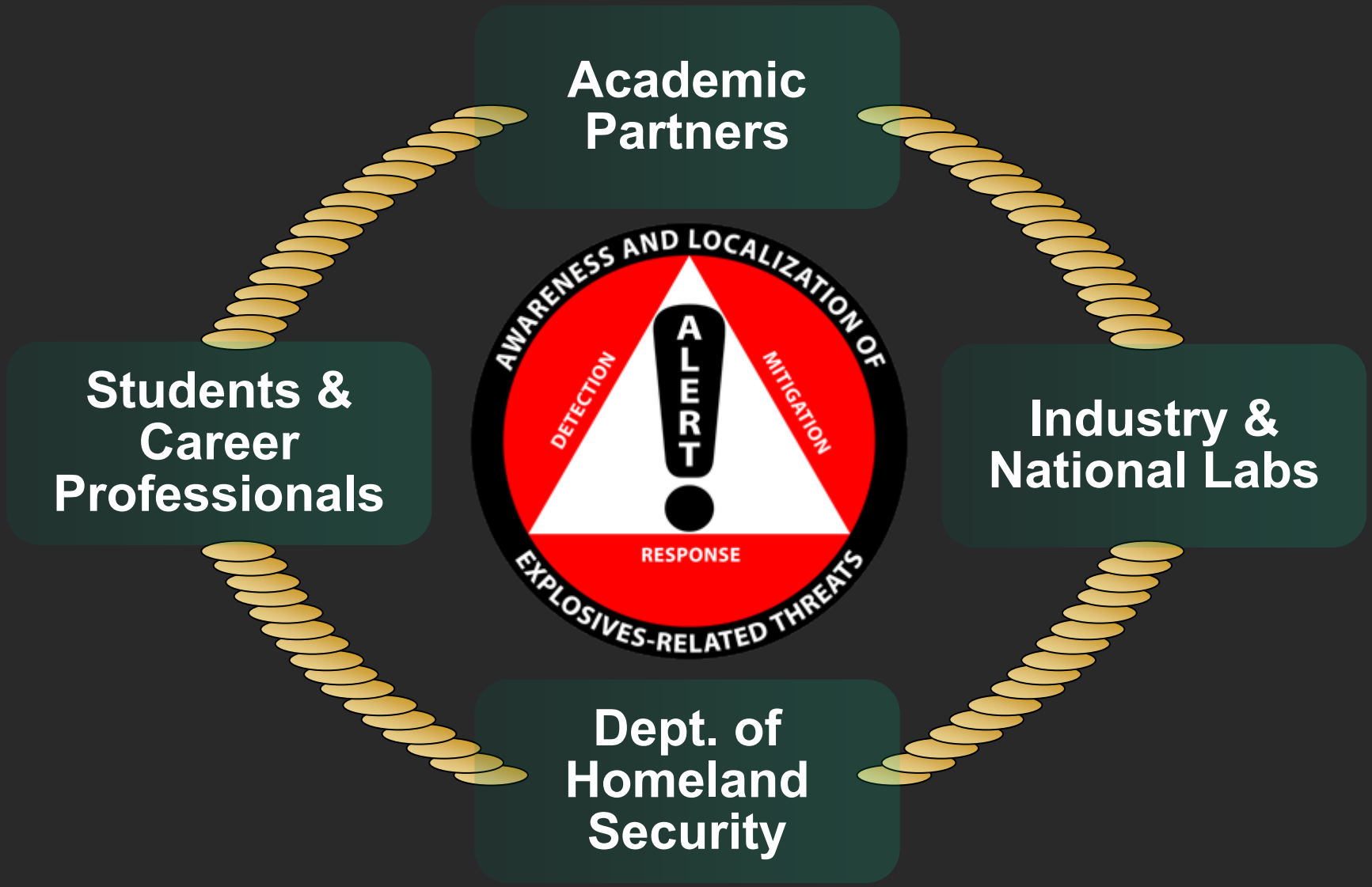
Automatic Detection/Identification of Electronically Initiated Explosives

Neutralization with High-Power EMP



- We are automatically detecting receivers ~50 meters away in very noisy environments using readily available equipment with no analog filters or amplifiers
- Significantly improved algorithms and more sophisticated instrumentation promises a substantial increase in standoff distance

Advantages of Our Approach

- IED can potentially be detected and located in milliseconds from hundreds of meters away
- Technique is not easily defeated
- Does not depend on known background RF environment
- Detection instrument can be highly configurable and adaptable to new threats
- May use small or existing antennas
- Instrumentation can fit in a very small (backpack size) package
- Can be easily combined with other detection techniques, such as chemical sniffing, radar, THZ, or IR or neutralization techniques, such as jamming

ALERT: A Major DHS Resource In the War Against Terrorism