Novel Sensor Miniaturization Methods

Dr. George Pappas
Airborne IED Detection

**Sensors**
- Ku-Band Radar - Coherent Change Detection
- UHF-Band Radar – Command Wire Detection
- Ultra Wide Band UHF Radar - Buried Objects & Command Wire Detection
- Hyperspectral Imager - Disturbed Earth
- EO/IR – Change Detection

**Requirement**
- Increase Pd and Reduce Pfa
- Decrease Cost of Operations

**Approach**
- Deploy Orthogonal Sensors
- Deploy Sensors on UAVs

**Miniaturization**
- Ku, UHF, Ultra Wide Band UHF have been miniaturized
- Need Miniaturized Hyperspectral and EO/IR Sensors
Miniaturization of Sensors

Hyperspectral Sensor Issues:

– Full Spectrum Requirement
  ▪ Visible, Near IR, Short Wave IR, & Long Wave IR

– Long Wave Infrared
  ▪ Cooling Requirements – Temperature Reduction Required to Sense in Range Required

– Resolution

EO/IR Sensor Issues:

– Resolution

4 Band Long Wave Sensor

Weight 7.5 lbs
Gimbal Diameter 7”
Spectral Band 7.5-11.5 um
PBIED, VBIED Detection

- Multiple Sensors are Possible for Checkpoint Operations
  - Metal Detectors
  - Infrared Imagers
  - Terahertz Imagers
  - mm Wave Sensors (active, passive and polarimetric)
  - Magnetic Field Sensors
  - Non-Linear Junction Detectors
  - Acoustic
  - Nuclear Quadrupole Resonance (NQR)
  - X-Ray

- Insurgents Generally Avoid Checkpoints

- Small Sensors are Required for Covert Sensor Emplacement and Detection by Dismounted Personnel, e.g.,
  - Small, Body Worn Thermal Imager for PBIED Detection
  - NQR Sensors for VBIED
Booby-Trapped Structures

• Various Emplacement Techniques
  – No Single Sensor Adequate

• Robot or Dismount Operated Sensors

• Possibilities
  – Thermal Imager to Find IEDs Emplaced in Surfaces
  – Robot to Activate Pressure Plates
  – Robotic Manipulator to Move Possible Booby-Trapped Objects
Hand Held Buried IED Detection

• Current Systems
  – Ground Penetrating Radar
  – Metal Detectors
  – Command Wire Detectors

• Possible Systems
  – Non-Linear Junction Detection
  – Short Wire Detection
  – Hyper/Multi Spectral Imaging

• Goal – Combine as Many Functions as Possible in a Light-weight System
Standoff Detection

Dr. Penny Polak-Dingels
Contractor Scientist

The overall classification of this briefing is UNCLASSIFIED
IEDs continue to be a threat.

- Consider three different scenarios where IEDs could be deployed.
- Need to develop sensors to protect against these threats from a standoff distance (distance at which the threat can be identified without any danger to the operator).
Detect PBIEDs in different situations

There is a need to screen persons at public events.

Sensors can be placed along streets to detect threats.

Suicide Vest

IED hidden in backpack
Various sensors can be used for detection.

- mm Wave imaging
- Metal detectors
- Infrared Detectors
- Chemical detectors (trace and bulk)
- X-ray scanners
- Biometric sensors
Detect VBIEDs at a Standoff Distance

Need to identify VBIEDs in city traffic.

• Chemical detectors
• NQR
• X-ray backscatter systems
• Identification of possible threat vehicles
• Biometric sensors

Results of a VBIED attack along a street.
Detect HBIEDs or Booby Trapped Structures (BTS)

IEDs can be hidden inside buildings set to trigger upon entry.

- Radar systems
- Robots that survey building interior with sensors for IED detection
- Remote controlled cameras
- Identify IED components in surrounding area
New Methods/Sensors for Standoff IED Detection.

• There is no current sensor or system of sensors that is 100% effective.
• JIDA will consider new sensors or combination of sensors that improve the capability to detect IEDs.
Novel CIED Techniques: A Short Story

Dr. Hatcher Tynes
Contractor Scientist
Duh...

• IEDs aren’t going away any time soon
  – Easy and cheap to build and employ
  – Hard to detect and defeat
  – They’re effective
  – They’re IMPROVISED

• Bad guys move faster than we can
  – Little to no bureaucracy or “process”
  – Real time laboratory: the battlefield

• “Low hanging fruit” has been picked so…

We need novel ways to get after the problem
Augmented Reality and Virtual Reality

• Enhance/improve situational awareness
  – Indicate previous events and incidents
  – Locations of potential trouble points

• Navigation, scene analysis
  – Overlay & identify features, landmarks
  – Detailed directions

See the world with “info-colored” glasses.

Alerts & information overlaid onto scene.

Amplify scene with info on objects, places.
Key enabler

Observe, inspect, analyze remote objects and scenes virtually

Immersive remote robot control

On-the-spot translator

Training & mission simulation; review prior missions
Target identification and engagement

- Show information, tags left by other “friendlies”
  - Device types found & most likely TO BE found
  - Setup, emplacement, location
  - Previous enemy TTP
  - What to do about it?

- Training & mission simulation
  - Learn to identify targets
  - Practice mission execution, new TTP & CONOPs

- Review prior missions
  - Area of interest; event types
  - Lessons learned

Tag & ID items & places virtually

Re-create & explore a scene virtually
Novel Robotic Solutions

• Humanoid robots with capabilities similar to humans
  – Manipulating, handling devices & materials
  – Better access to areas, places that current robots can’t get to
  – Extracting, defeating emplaced devices
  – Options for lab exploitation, examination
  – Reduce risk to humans
  – Coupled with AR/VR
Novel Robotic Solutions

- Fully robotic “critters” with capabilities similar to animals
  - Access areas that existing robots can’t
  - Remotely inspect target areas and devices

- Robotically augmented & controlled “critters”
  - Take advantage of some of nature’s best sensors
  - Natural-born movers with capacity to learn
  - Adaptable
A Prime candidate to transform the problem space

• Who wouldn’t want a robot that turns into a vehicle?
Nuclear Quadrupole Resonance (NQR) for detection

- Enables sensing through non-metallics
- Technique is specific to chemistry of explosive
  - Not all explosives have an NQR signature
- Signal can be small & difficult to detect
  - Susceptible to interference from other sources
- Not much in the way of stand-off
  - Must be practically right on top of target
Battery Defeat

• IEDs need power to work
  – Most use some type of battery

• Drain, disable or destroy battery
  – Regardless of size, design or type
  – Without knowing location

• How do you do it?
  – Early discharge
  – Heating
  – ???

• How do you know you’ve succeeded?
Questions?
Standoff Neutralization

Dr. Ben Clough
Problem Space

- Detecting IEDs has proven extremely difficult
- We’d like to neutralize them reliably
  - Without having to detect them
  - From as far away as possible
  - Regardless of configuration, construction, concealment

- Scenarios include
  - Dismount protection
  - Deliberate clearance
  - Incoming vehicle-borne devices

How we define neutralization: Preventing an IED from functioning as intended
What’s the problem then?

Physics kicks you in the backside

• To get stand-off requires projecting something
  – Types of energy

• What you don’t know can kill you
  – Devices are IMPROVISED; don’t know what’s in the box
  – Have you “duded” it? Does this make things worse?
  – Typically little to no characterization data
    ▪ What’s in the box?
    ▪ How does it all work?
    ▪ Where’d they put it?
What do we know?

• IEDs all have the same basic components
  – Main charge
  – Container/casing
  – Trigger
  – Initiator
  – Power source

• May have additional components
  – Radio control mechanisms
  – Sensors measuring different effects (light, pressure, time, etc.)
  – Timing circuits or other electronics
  – DIY Electronics or other electronics leveraging rapidly maturing COTS technologies
How do we keep ahead of rapid advancements in COTS technology?
What don’t we know?

• What’s out there in the environment
• How it’s built and what’s in it
• Where it is
• How big it is
• How it works
• What it takes to make it “go”
• What it takes to “break” it
Prominent Capability Gaps

- How do we neutralize a device effectively from a standoff distance?

- Can we do it with what we have?

- How do we get energy into a device or key component?

- How can we Neutralize from a dismounted position?

- How can we keep up with the pace of COTS technology evolution?

*There are numerous opportunities for improved material solutions*
Ideas for Improved Neutralization Capability

• Improved & rapid understanding of surrounding spectral environment

• Visualization of rapidly maturing electronic technologies on the market (ECM, DIY Electronics, next generation wireless communications)

• Improved counter-electronic warfare system capabilities (modularity and software-defined updates)

• Improving management of the “power budget”

• Reduced size, weight, & power (SWAP)

*Improving Standoff Neutralization Requires Creative Solutions*