Novel Sensor Miniaturization Methods

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HELPING WARFIGHTERS ADAPT

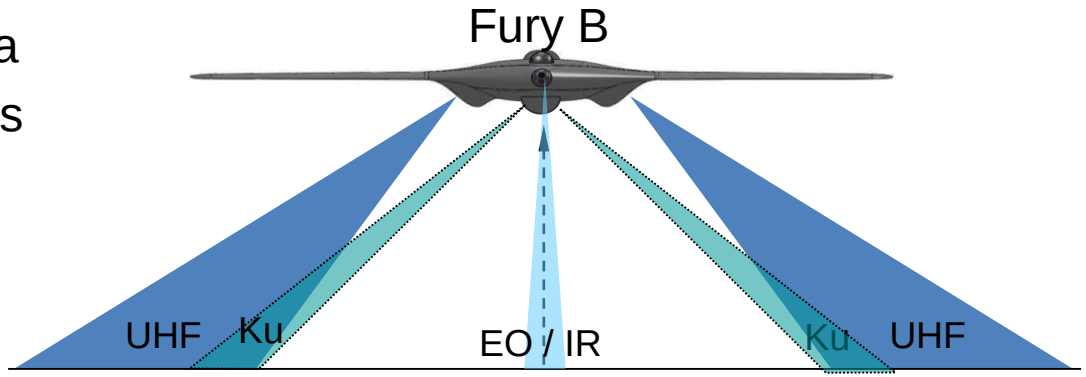
JOINT IMPROVISED-THREAT DEFEAT AGENCY

The overall classification of this briefing is UNCLASSIFIED

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

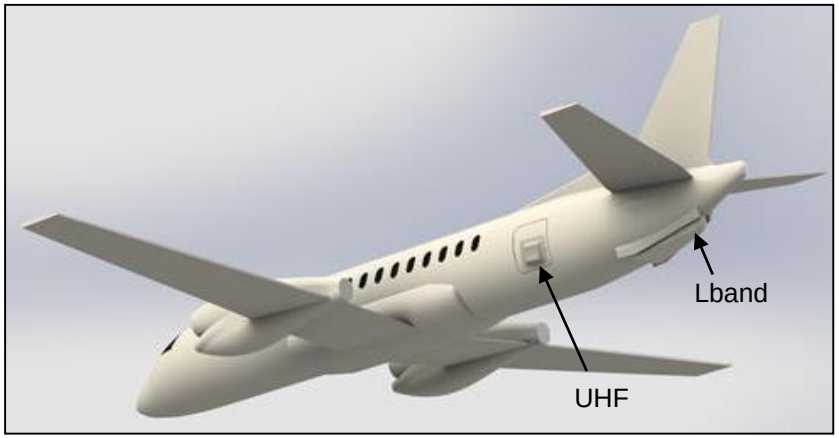
- Multiple Sensors are Possible for Checkpoint Operations
  - Metal Detectors
  - Infrared Imagers
  - Terahertz Imagers
  - mm Wave Sensors (active, passive and polarimetric)
  - Magnetic Field Sensors
  - Non-Linear Junction Detectors
  - Acoustic
  - Nuclear Quadrupole Resonance (NQR)
  - X-Ray

- 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

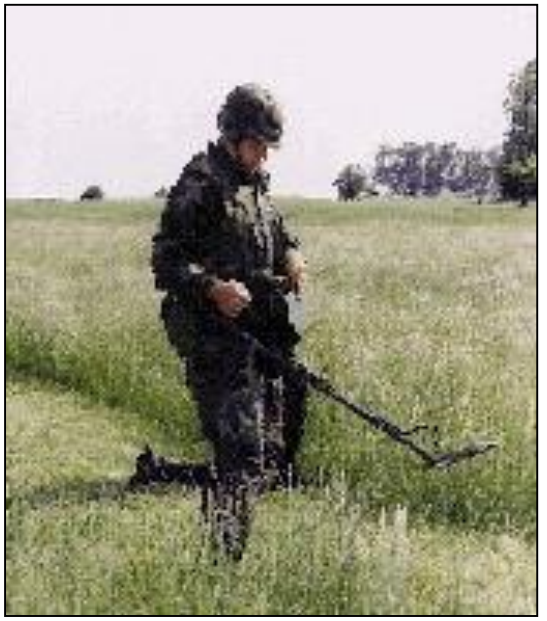
- Various Emplacement Techniques
  - No Single Sensor Adequate
- Robot or Dismount Operated Sensors
- Possibilities
  - Thermal Imager to Find IEDs Emplaced in Surfaces
  - Robot to Activate Pressure Plates
  - Robotic Manipulator to Move Possible Booby-Trapped Objects

DARPA Visi-Building Project



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

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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.

Suicide Vest

Sensors can be placed along streets to detect threats.

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.

Results of a VBIED attack along a street.

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

Detect HBIEDs or Booby Trapped Structures (BTS)

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

Command Wire IED

- 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

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Contractor Scientist

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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

Think outside the box

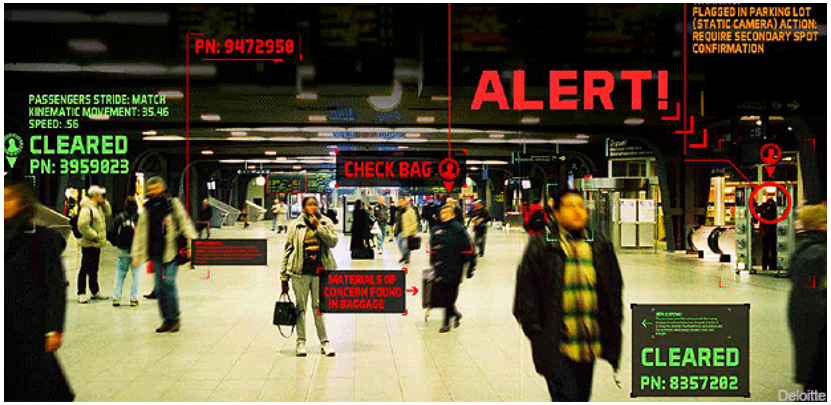
- Bad guys move faster than we can
  - Little to no bureaucracy or "process"
  - Real time laboratory: the battlefield

- "Low hanging fruit" has been picked so…

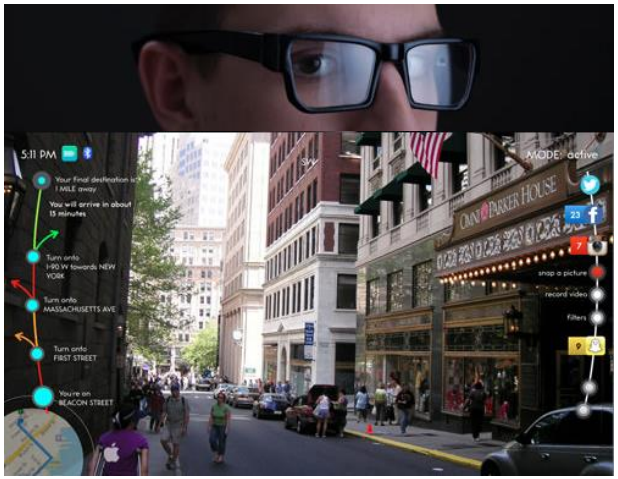
We need novel ways to get after the problem

Augmented Reality and Virtual Reality

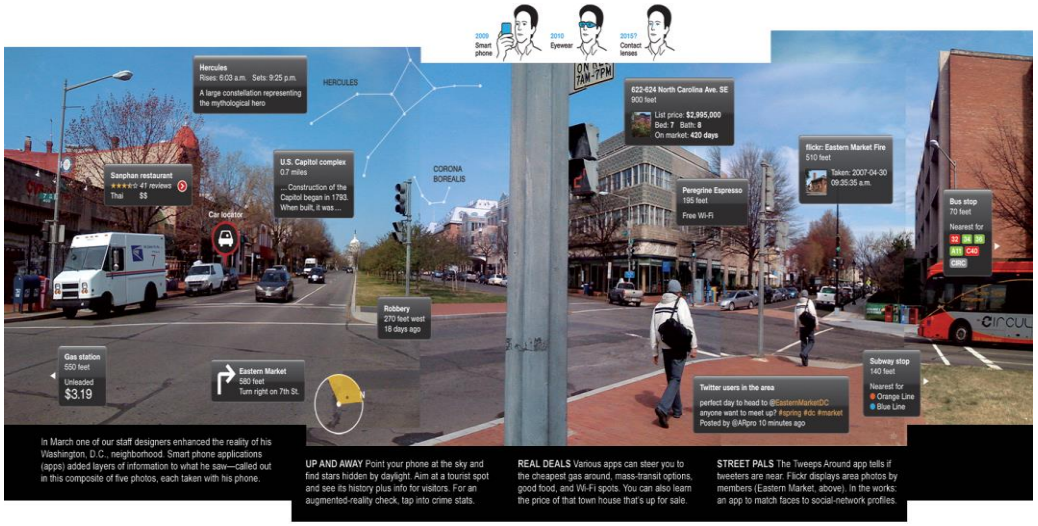
- Enhance/improve situational awareness
  - Indicate previous events and incidents
  - Locations of potential trouble points
- Navigation, scene analysis
  - Overlay & identify features, landmarks
  - Detailed directions



Alerts & information overlaid onto scene.



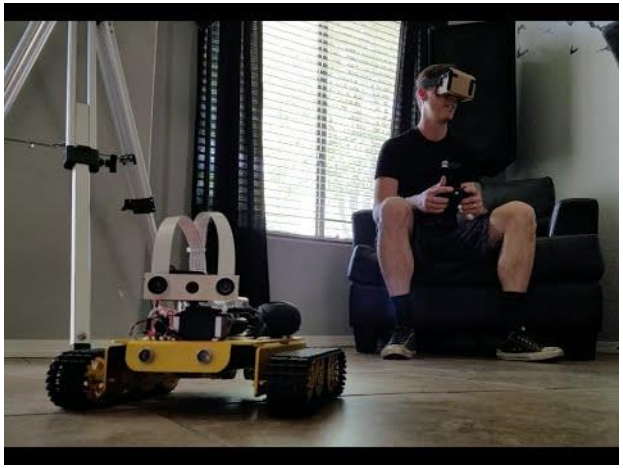
See the world with “info-colored” glasses.



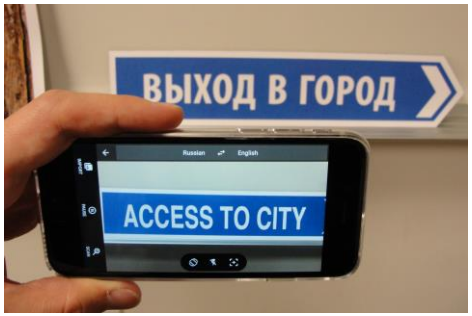
Amplify scene with info on objects, places.

Key enabler

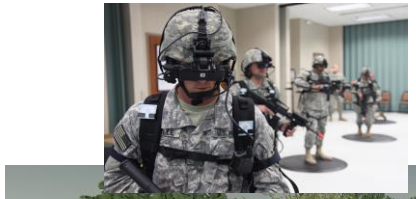
Observe, inspect, analyze remote objects and scenes virtually



Immersive remote robot control

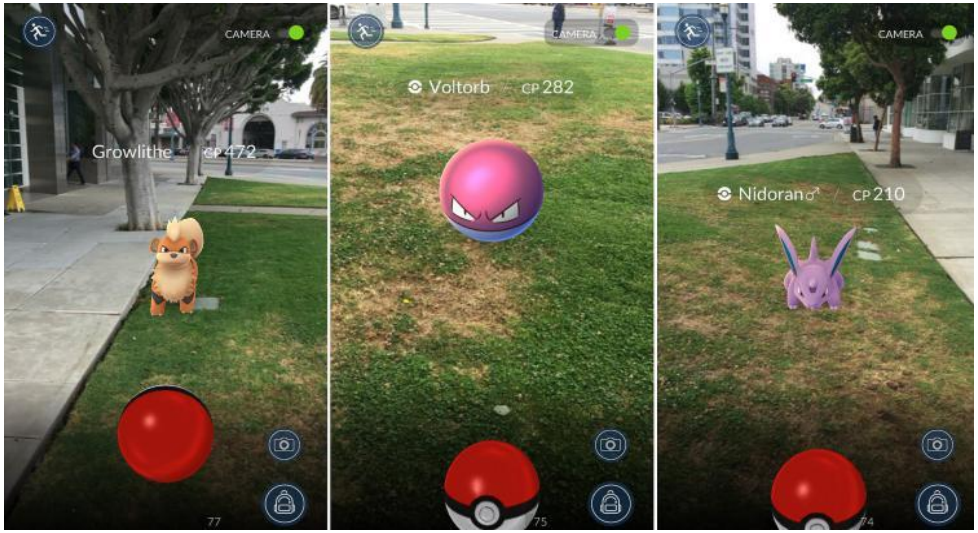


On-the-spot translator



Training & mission simulation; review prior missions

Target identification and engagement



Tag & ID items & places virtually

- 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?

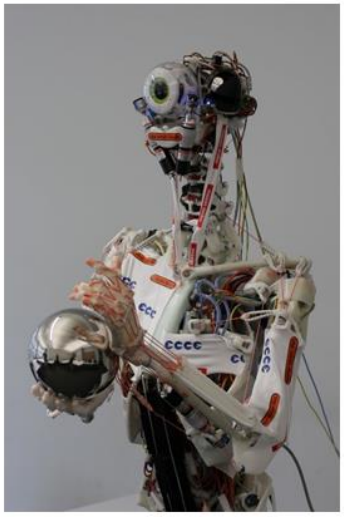
- Training & mission simulation
  - Learn to identify targets
  - Practice mission execution, new TTP & CONOPs

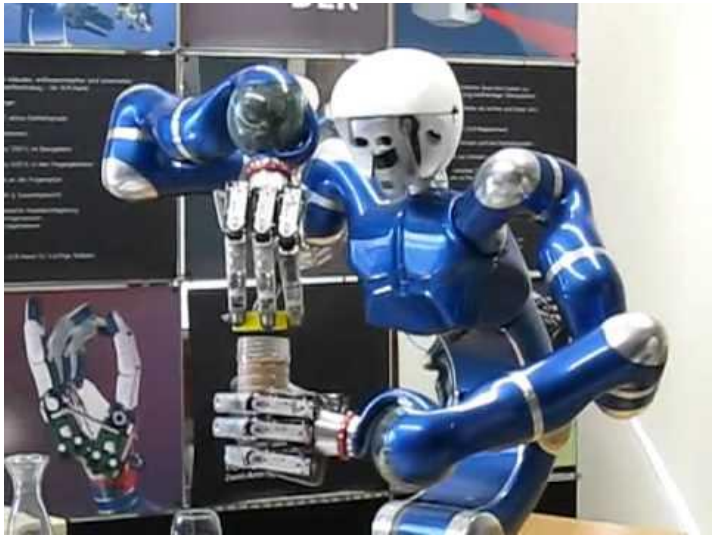
- Review prior missions
  - Area of interest; event types
  - Lessons learned

Re-create & explore a scene virtually

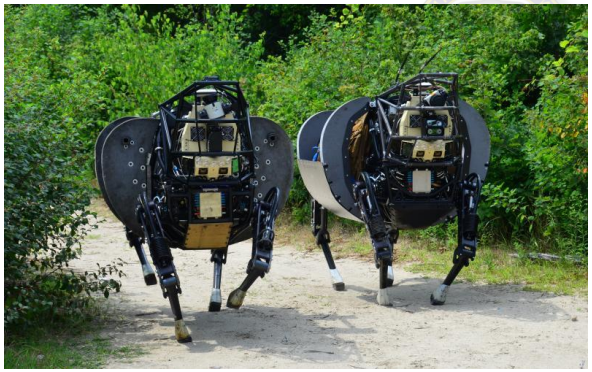
Novel Robotic Solutions

- 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



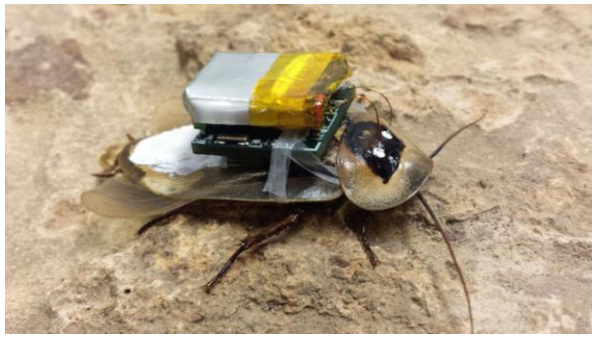


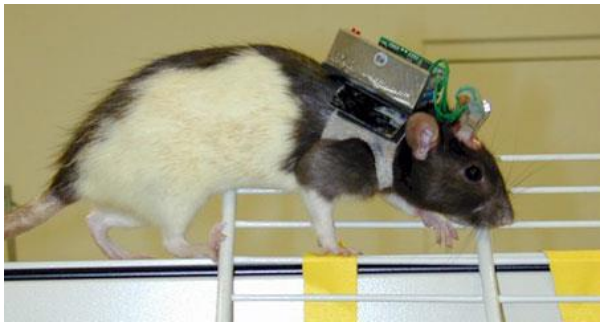
Novel Robotic Solutions



- 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



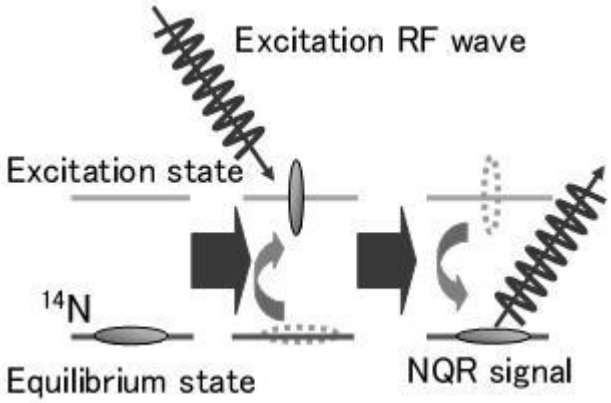


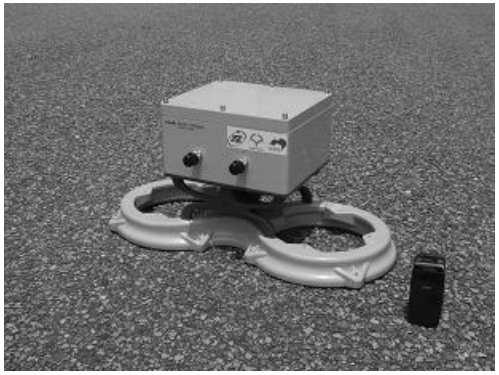
A Prime candidate to transform the problem space

- 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

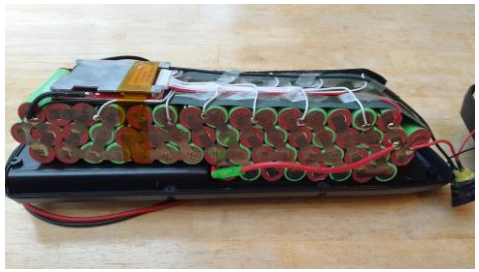




Battery Defeat

- 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

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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

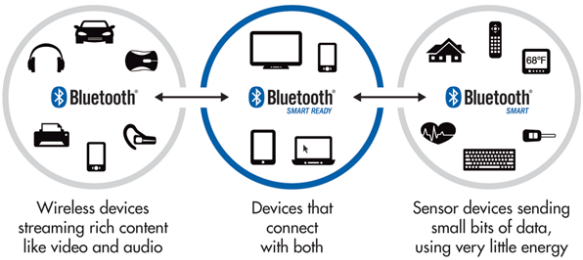
- To get stand-off requires projecting something
  - Types of energy
- What you don't know can kill you
  - Devices are IMPROVISED; don't know what's in the box
  - Have you "duded" it? Does this make things worse?
  - Typically little to no characterization data
    - What's in the box?
    - How does 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

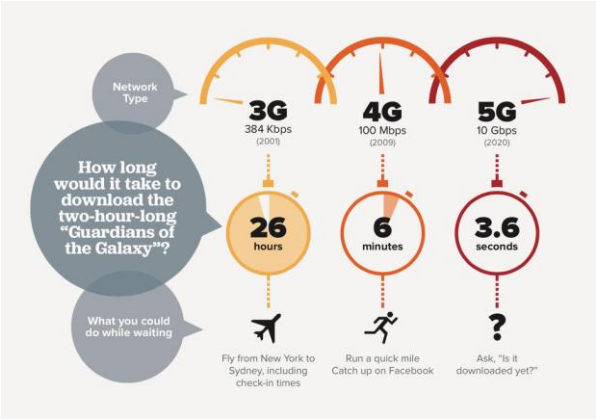
COTS Technologies

"Gotenna"

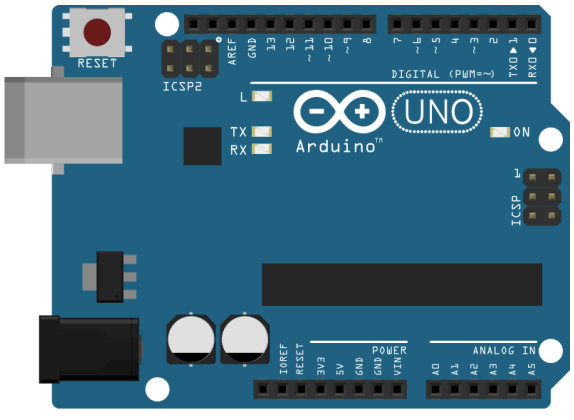


Bluetooth Low Energy

Wifi



3G/4G/5G



DIY Electronics

UAS Systems

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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