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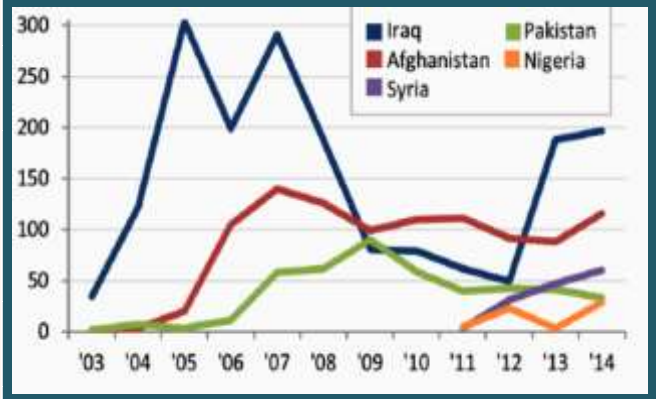
Multi-Modal Fused IED, PBIED & VBIED Detection Technologies



Homeland Security Research Corp.

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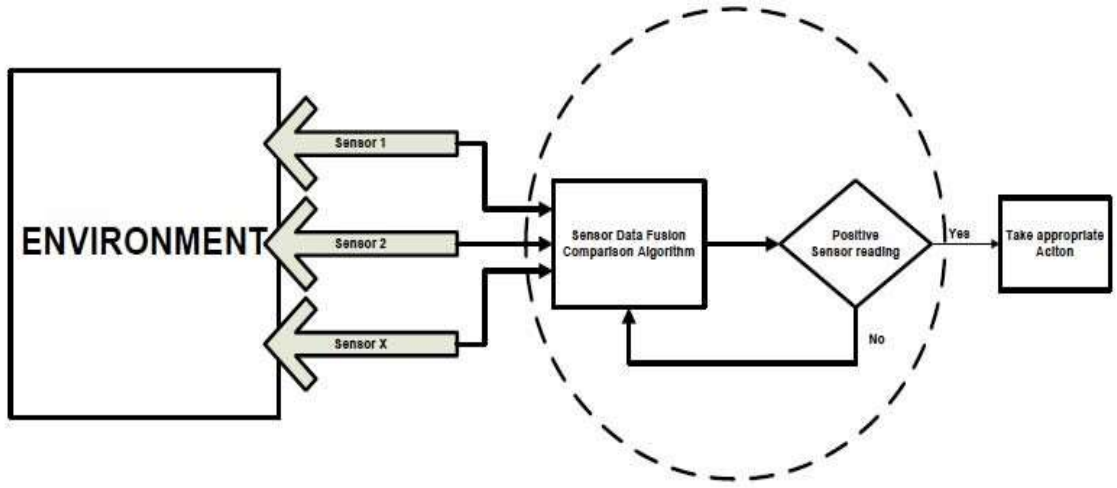
1.1 Technology Review

A Multi-Modal Fused Standoff Explosives Detection methodology is a use of multiple orthogonal and –or semi orthogonal standoff technologies, each with a unique type of detection ROC. The accuracy of each detection system will be determined by the ability of the system to identify a suicide bomber when there is a suicide bomber actually present and in detection range of the sensor(s), and for the system to not identify a suicide bomber when there are no suicide bombers present. The detection system will use the sensors orthogonally. An orthogonal system involves using different independent technologies for detection. Independent sensors will scan the intended environment, either actively or passively, for threat indicators. As the sensors continue to scan and receive indicators of a suicide bomber with an explosive vest and wires, the data from all the sensors will be fused together to determine if there is an actual threat present.

Figure 1 - Multi-Modal Fused Standoff Explosives Detection System



- The Multi-Modal Fused Standoff Explosives Detection system works by having one or many sensors scan the environment. The sensors may be placed in the same location or spread out over different locations in order to scan a larger portion of the environment. The system works independently of where the sensors are placed. The data from each sensor is fed into a central processing unit, indicated by the dashed circle in Figure 32. If one sensor has scanned and received data from an

individual but needs amplifying information to accurately determine if a suicide vest and wires are present, then the system will automatically aim another sensor to begin prosecuting the same individual to receive more data. The system will have the ability to automatically aim sensors at a target by using video tracking systems. The tracking system will be controlled in the central processing unit. The central processing unit also includes the comparison algorithms that fuse the data from the multiple sensors. The comparison algorithms are constructed using the sensors in a parallel or series sequence based on sensor detection ranges and location of the sensor in relation to the intended target environment.

- The advantage of using a Multi-Modal Fused Standoff Explosives Detection System is that the sensitivity and specificity is increased for the overall system. The sensitivity is the ability of the system to identify explosive vests if an explosive vest is present. This increases because the use of multiple independent sensors will be able to detect more of the possible indicators of an explosive vest. The specificity is the ability of the system to identify explosive vests only if an explosive vest is present. This is increased because more sensor types are used in an orthogonal system and each sensor independently detects indicators of an explosive vest only when an explosive vest is actually present. The orthogonal detection system will also reduce the probability of false alarms. This happens because the different independent sensor types are less likely to report false positives at the same time.
- Separate from active Radar and Infrared, Millimeter-wave, Terahertz, and X-ray are passive sensors that receive and process data that is qualitative in the form of images. Due to the time constraints while detecting suicide bombers, it is not feasible for users of these sensors to analyze the images, compare the image to images with suicide vest characteristics, and determine if there is a potential threat. Computer image analysis software must be utilized to process the images and determine if there is a threat. The image analysis software must be able to compare the images from the sensor to images and data compiled from simulations and field tests.
- Data from field tests and simulations compose images, images of individuals with and without suicide vests or explosives on their body, taken at various angles, distances, and temperatures. The more exact the sensor image characteristics match the image characteristics in the software, then the stronger the detection of a threat. The low-level and high-level threshold values for each sensor are determined by how accurate an image matches an image in the image analysis software.

Counter-Bomber is a standoff, non-imaging (radar/video), easy-to-use, automatic detection system comprised of a fully mobile, screening and tracking device that automatically interrogates subjects in an operator developed area of interest. The

system rapidly determines if an individual is a threat potentially wearing a suicide bomb device or other hidden weapons such as handguns or machine pistols.

The Counter-Bomber system was developed by the SET Corporation, a wholly owned subsidiary of SAIC that specializes in smart sensing and information solutions.

The Counter-Bomber provides a powerful force protection capability by automatically and accurately detecting concealed threats at standoff distances. Counter-Bomber is a video-steered radar probe that utilizes novel radar signal processing and video tracking techniques to accurately (e.g. high Pd, low Pfa) determine if a subject/person is a potential threat. Counter Bomber has been successfully deployed in Iraq and Afghanistan since 2008 with the USMC, U.S. Army and USAF. While the system has been extensively tested by the U.S. Government for detection of suicide vests, Counter-Bomber has also demonstrated the ability to detect other concealments such as handguns, machine pistols, etc.

1.2 Example: The CounterBomber® System

The CounterBomber® system integrates radar and real time video tracking to screen individuals for features evident in suicide vests and small arms weapon systems.

Deployed by armed forces around the globe, the CounterBomber® system provides a one of a kind capability that automatically detects anomalies associated with human delivered suicide bombs beyond the blast radius.

CounterBomber® is used to protect high-value assets against the threat of suicide bombers. The system is currently deployed to numerous locations in Iraq and Afghanistan.

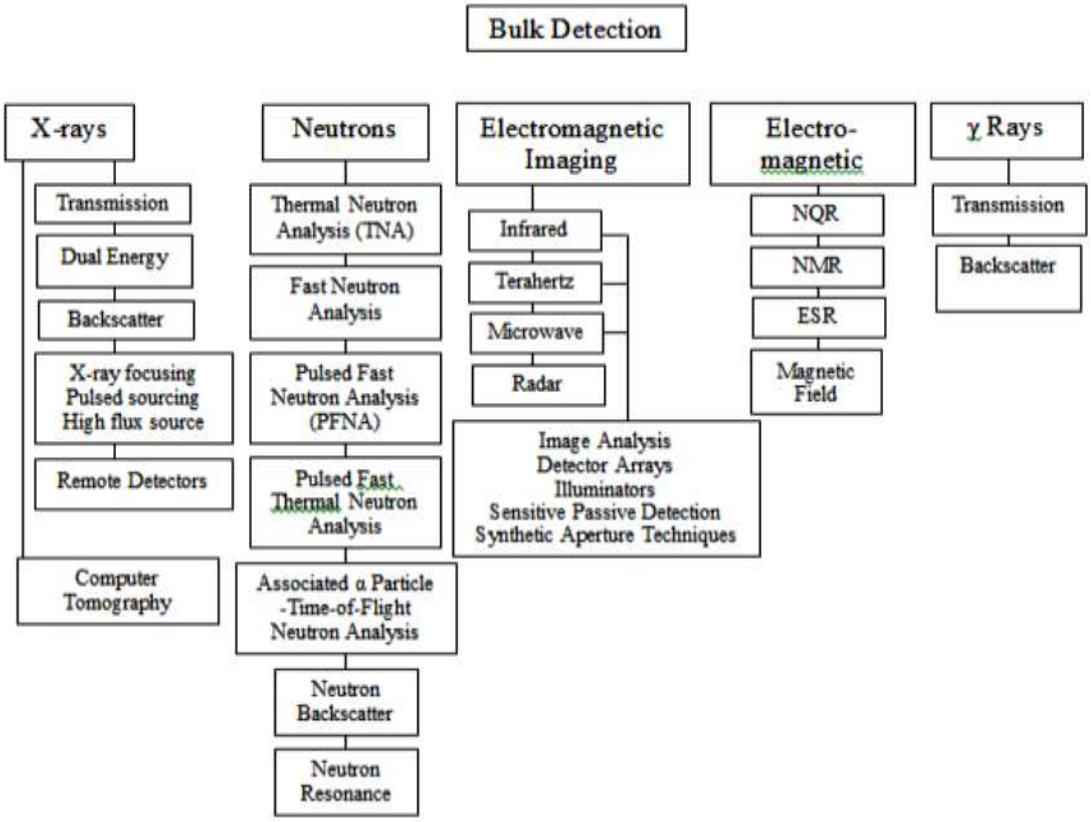
Figure 2 - The CounterBomber® System

1.3 Standoff IED, PBIED & VBIED Detection Technologies

- Improvised Explosive Devices (IEDs), PBIED & VBIED are persistent threats that manifest themselves in almost innumerable forms. Their detection and safe disposal is a formidable challenge.
- Over the past two decades, much progress has been made to address this challenge with the development of technologies with ever increasing levels of sophistication. These range from indirect methods to detect packaging, wiring, or fusing to more direct detection methods.
- Standoff detection methods are focused on detecting chemicals (including explosives and explosive devices) at a remote distance. In the case of substance detection on people or vital assets, this technique reduces the potential for severe damage. In addition, this technique enables detectors to collect signals transmitted over longer distances.
- In some modalities, it is possible to identify small concentrations of the threat chemicals: explosives, breakdown products, and/or precursors (trace detection), while other methodologies are based on the detection of suspicious packages, wires, fragmentation materials, and other physical attributes of IEDs (bulk detection).
- Key challenges in standoff detection include extending the distances at which effective PBIED, VBIED & IED Detection can be conducted, reducing the impact of various interferences and backgrounds (e.g., atmospheric and environmental) to increase sensitivity, effective PBIED, VBIED & IED Detection of multiple mobile potential threats, and increasing the speed at which the detection is made.

Bulk Detection Methodologies. Bulk explosive detection involves the detection of a macroscopic mass of explosive material (a visible amount of explosives), usually based on either imaging or on the molecular properties of the explosive. Techniques such as thermal infrared, x-ray, and millimeter-wave imaging are often used to detect the physical properties of suspicious objects (e.g., density, temperature). Equipment costs associated with bulk detection are often much higher, and some bulk detection techniques – especially those based on imaging, such as x-ray imaging – may have a lower degree of specificity than trace detection methods.

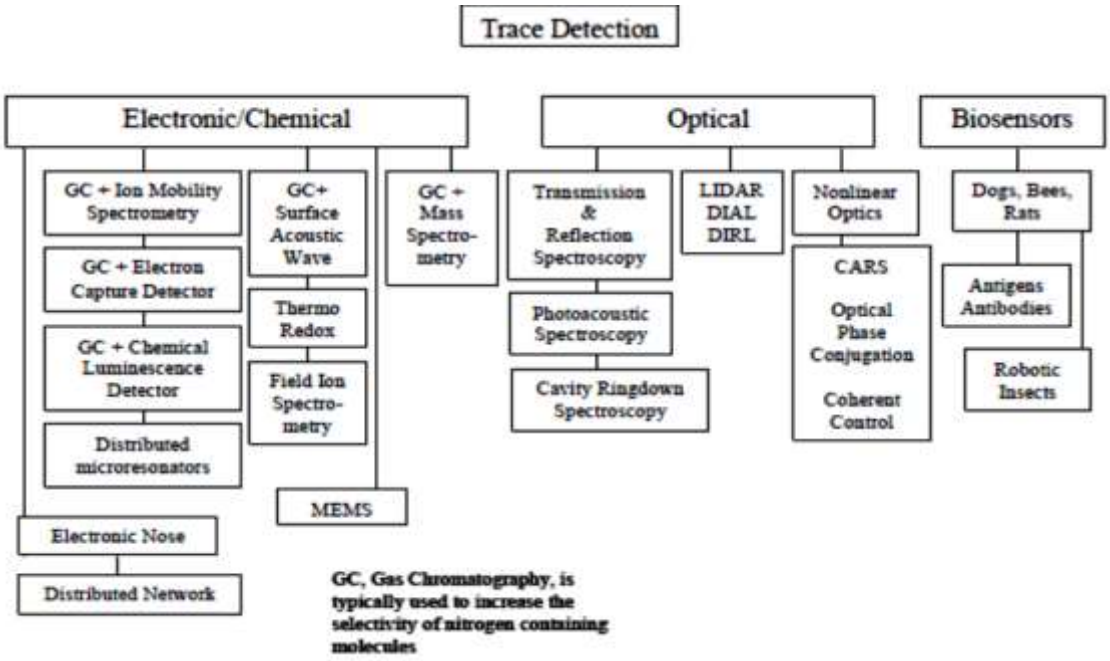
Figure 3 - Standoff & Non-Standoff IED Bulk Detection Technologies



(Source: S. A. Heider**)**

Trace Detection Methodologies. Trace detection techniques essentially detect the presence of a small amount of certain chemicals or explosives existing within an area or in a sample under investigation. Several different methodologies exist that perform trace detection using chemical sensors, and many are based upon optical techniques. In most cases, the detection process entails cross-referencing the wavelengths or wavenumbers measured to a spectroscopic database.

Figure 4 - Standoff IED Trace Detection Technologies



(Source: S. A. Heider**)**

- Standoff IED detection is a form of trace detection performed at a further distance from the sample or target. Standoff detection requires a certain level of energy per wavelength to exist in the backscattered light emitted from the sample and captured by the detector in order to interpret the received information.
- In techniques such as Laser Induced Breakdown Spectroscopy (LIBS), a spectrometer (device consisting of a diffraction grating and photo-detector) is often used to acquire the related information. The numerical aperture of spectrometers is often limited so only a certain amount of the backscattered light is actually captured for detection, which limits the obtained information. Since the spectrometer sends the light through a diffraction grating, acquiring a full spectrum of the sample light usually takes time and requires calibration to compensate for the loss of energy.
- The table below offers a side-by-side comparison of the present and pipeline Standoff IED, PBIED & VBIED Detection technologies.

Table 1 - Standoff IED, PBIED & VDIED Detection Technologies

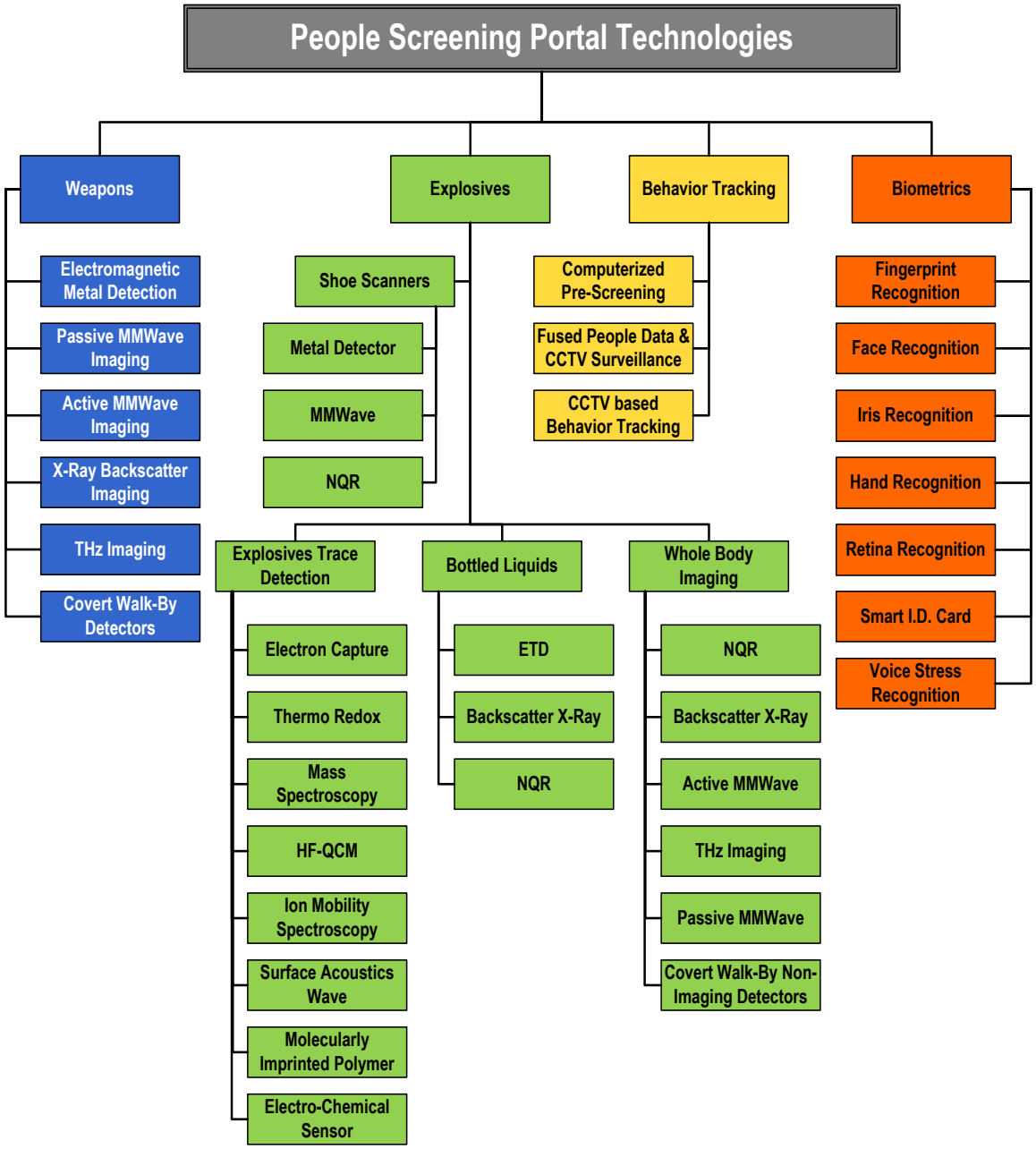
Technology Type	Technology Description	Tactical Purpose	Technology Decision Process
Passive MMW Imaging	Uses natural MMWave illumination emitted and reflected from a person and the surrounding environment	Detects the presence of concealed objects on a person's body	Not automated. Properly trained operators scan crowd looking for image anomalies indicative of concealed weapons (cannot identify a person from a MMW image)
Passive Terahertz imaging	Uses natural Terahertz illumination emitted and reflected from a person and the surrounding environment	Detects the presence of concealed objects on a person's body	Not automated. Properly trained operators scan crowd looking for image anomalies indicative of concealed weapons (cannot identify a person from a Terahertz image)
Passive and Active MMWave Sensors	A signal (no image) from the device can detect the presence of an anomaly in a person's MMWave signature	Detects the presence of concealed objects on a person's body	Can be automated or operated manually. Output is a temporal chart showing signals over the course of time the person is in a device's range
Infra-red Thermography (Passive)	Uses the IR energy naturally emitted and reflected by the human body	Concealed objects are observed with IR imaging systems	Not automated. Operators scan crowd looking for IR image anomalies indicative of concealed weapons
Intelligent Video Systems	Multiple fixes cover CCTV cameras coupled with image processing software compares images over time and identifies anomalies based on user -defined rules	Used to detect, locate and track leave-behind objects and individuals to identify anomalous behavior	Can be automated or operated manually. Software will process images and uses algorithms to detect anomalies
Standard CCTV Surveillance Camera	Commercial-off-the-shelf still and video surveillance systems	Used as an expanded view of the screening zone	Operated manually and uses data to compare other technology output for accuracy research
Standoff Biometric identification	CCTV-based standoff imaging applied to facial and/or iris biometric identification	Identify people on watch lists and identity theft	Automated
Standoff Laser based explosives detection	Adapted LIDAR-like chemical warfare technologies to detect airborne explosives traces	Detect explosives carried by a suicide bomber at safe distance	Automated
Active Standoff Terahertz Detection	Passive and active Terahertz radiation used to image and or spectroscopy identification of	Detect explosives carried by suicide bomber at safe distance Detect concealed	Both automated alarm and operator image and data interpretation

Technology Type	Technology Description	Tactical Purpose	Technology Decision Process
	weapons and explosives	weapons and explosive	
Standoff Behavioral Tracking	Off the shelf CCTV–based, behavioral tracking	Track and alarm for persons who demonstrate unusual behavior	Both automated alarm and operator image and data interpretation
Standoff Video Content Analysis	The use of feature detection algorithms to identify shapes of known threats		Semi-Automated
Stimuli Triggered Behavioral Surveillance	Covert Exposure of subjects to terror-related stimuli and tracking their response	Identify people with terrorist intentions	Automated

Note:

- Most standoff systems have an integrated CCTV camera which provides an auxiliary image of the people screened and the environment.
- Passive imaging technology uses only available atmospheric background "illumination" to create the image, while active imaging technology illuminates the subject to create the image.
- Technology image output is not identifiable; however, the device has a standard, on-board camera that will provide a still image alongside the unidentifiable image to identify which person to perform further screening on.

Figure 5 - People Screening Portals - Threats and Associated Detection Technologies



Note: This figure includes portal technologies that relate to people screening and are discussed in the people screening portals report.

More information can be found at:

Standoff IED, Person-Borne & Vehicle-Borne Explosives & Weapon Detection: Technologies & Global Market – 2015-2020