Explosives have been used biology essay

[Science](), [Biology]()

Explosives have been used for many applications within the military, employed by industry and are more recently involved in acts of terrorism. Explosive based terrorism has grown enormously because explosive-based weapons are simple, easy to deploy and can cause enormous damage. Mumbai(1993, 2006); Oklahoma, USA (1995); Nairobi, Kenya, and Dar es Saalam, Tanzania (1998); Kuta, Indonesia (2002); Madrid, Spain (2004) and more recently Kano, Nigeria (2012) are a constant reminder of the potential of the damage a handful of terrorists can cause using explosives. The psychological effect of a successful explosive attack on the common population as well as on the terrorists group far exceeds the actual physical damage by the device. The number of options available to terrorists is far greater today than ever before, but the most widely used and therefore the most significant threat for security professionals worldwide, is exactly the same as it was decades ago: explosives. Use of explosives, has become the choice of weapon for spread of terror and is likely to remain preferred option till the time terrorists are not able to get their hands on something better viz biological, chemical or nuclear devices. 3. Bombs are the current weapon of choice amongst terrorist groups. The threat compounds and methods of delivery have evolved over time, as have the technology and techniques to detect them. In many respects, it is a high-tech game of cat and mouse. It is estimated that 70 percent of all terrorist attacks worldwide involve explosives, and even when the public safety agencies know of the presence of a device, they have only a 20 percent chance of finding it. The detection of explosives remains a key area of interest within research and development. 4. The challenges of detection is compounded by the variety of different explosives which have an array of chemical structure and the fact that they are used in a plethora of complex environments with dynamic backgrounds and have a range of matrices and containments. Detection of traces of explosive substances in the air, the low vapour pressures of explosives are issues which are exacerbated when these explosives are wrapped or packaged to avoid detection. 5. The detection of explosives and explosive-related compounds has become a heightened priority in recent years for homeland security and counter-terrorism applications. This has led to increased research into explosive detection as well as further developments in to the existing analytical techniques so as to enable faster, more sensitive, less expensive and simpler determinations and identification of explosives. There has been a huge increase in research within this area – through development of new, innovative detection approaches and the improvement of existing techniques. Miniaturization, portability, ruggedisation, improvements in stand-off distances, selectivity and sensitivity are some of the features which have improved.

CHAPTER II: METHODOLOGY

Statement of Problem

6. The continuous terrorist attacks have raised the issue of detection of explosives and have generated a great demand for rapid, sensitive and reliable methods for detecting explosives. Detecting explosives is a very complex and expensive endeavor because of the wide variety of materials that can be used as explosives, the lack of easily detectable signatures, the vast number of avenues by which these weapons can be deployed. This paper seeks to prove that despite the high sensitivity and selectivity

available with the present explosive detection techniques a integrated approach is necessary to tackle the future threats.

Hypothesis

7. Existing methods of explosive detection have proved inadequate thus there is a need to combine trace and bulk detection techniques to meet the present and future challenges in explosive detection.

Justification of Study

8. Explosive devices are the principle tools in the hands of terrorists today because of their ability to disable human beings and destroy property. Thousands of people are killed and properties worth crorers of rupees are damaged every year by terrorist bombs. Protection against the use of explosives involves access control, detection, and protection/ mitigation techniques. With the increasing global concerns regarding terrorist action, enhancements in national security and defense are required to rapidly monitor and detect the presence of explosives in a fast, efficient and economic fashion. A simple, easily operable, quick, selective, economical, easily interpreted and if possible portable detection method is the Silver Bullet sought by everyone to detect explosive. 9. Traditional security measures included the use of metal detectors in conjunction with X-ray machines to identify the metal component in the explosive devices and cannies for detection of explosives. One major problem with the conventional approaches was that the explosive substances are often not easily detectable and to add this many terrorist groups adapted by avoiding the metallic objects. The techniques presently available for explosives detection

can broadly be divided into two major categories based on their operating principles trace and bulk detection. Trace explosives detection focuses on chemical detection of explosives by collecting and analyzing tiny amounts of explosive vapor or particles while the bulk explosives techniques detects macroscopic mass of explosives material, usually based on either imaging or on nuclear (molecular) properties of the explosive. 11. In view of the afore mentioned facts it is essential to understand the challenges with regard to identification and detection of explosives and the various techniques being followed world over for the same. This study has been prompted by the fact that the developments in technology have metamorphosed the existing technology and ushered in new possibilities in the way the problem of explosive detection is tackled.

Scope

12. This paper concentrates on analysis of the existing explosive detection techniques available for use in areas which have limited or no access control (public areas). In doing so, it first outlines the challenges of explosive detection in a controlled environments, its peculiarities and then it discusses the different types of detection techniques available their advantages and disadvantages. Lastly, it identifies the likely way ahead in the field of explosive detection. Since the military explosive detection requirements and its working environment are unique, it has been excluded from this study.

Data Collection

13. The data for this study has been collected from books and reports on the subject, primarily from the Defence Services Staff College, Library. The

electronic source has been explored extensively to derive the most current events and reports on the issue. Bibliography of sources is appended at Appendix A.

Preview

14. The study will be covered under the following heads :-Chapter I: Introduction. Chapter II : Methodology. Chapter III: Characteristics Of Explosives. Chapter IV: Trace Explosives Detection Technologies. Chapter V: Bulk Explosives Detection Technologies. Chapter VI: Recommendations. Chapter VII: Conclusion.

CHAPTER III: CHARACTERISTICS OF EXPLOSIVES

Types of Explosives

15. Explosives have been around for centuries: the Chinese, for example used them in the form of black powder to make weapons which propelled arrows from bamboo tubes. The evolution of explosives has always been driven by need, technology, and serendipity. The first useful explosive stronger than black powder was nitroglycerin, developed in 1847. As nitroglycerin was unstable, it was replaced by nitrocellulose, smokeless powder, dynamite and gelignite, World War II saw an extensive use of new explosives which in turn, have largely been replaced by modern generation of explosives such as trinitrotoluene and C-4. 16. Explosives are chemical compounds that can be initiated to undergo self-propagating decomposition resulting in the sudden release of heat and pressure. Most common explosives have extremely low vapour pressures at ambient temperature, however the vapour pressures of explosives increase rapidly with

temperature. Explosives are classified as low or high explosives based on their burn rates. Low explosives burn at low rates includes propellants, black powder etc. High explosives detonate at velocities of kilometers per second and are further divided into primary and secondary explosives based on their stability. 17. Military, Commercial And Homemade Explosives. The low and high explosives can further be loosely categorized based on the availability and usage as military, commercial and a third category called homemade explosives (HME) because they can be constructed with unsophisticated techniques from everyday materials. All of the three types of explosives mentioned have the basic properties of explosives however they differ from each other in respect of their sensitivity, power of explosive and stability which in turn effects their stability and effectiveness.(a) Military Explosives. It includes the high explosives such as PETN, RDX and the plastic explosives like C-4 and Semtex. The military uses these materials for a variety of purposes, such as the explosive component of land mines, shells or warheads. RDX was used in the Mumbai passenger rail bombings of July 2006. PETN was used by Richard Reid, the " shoe bomber" in his 2001 attempt to blow up an aircraft over the Atlantic Ocean.(b)Commercial Explosives. These are often used in construction or mining activities and include trinitrotoluene(TNT), ammonium nitrate, dynamite, nitroglycerin, ammonium nitrate and fuel oil. Dynamite was used in the 2004 Madrid train station bombings, ANFO was the explosive used in the Oklahoma bombings in 1995. The common commercial and military explosives contain various forms of nitrogen, the presence of this nitrogen is exploited by detection technologies in determining if a threat object is an explosive.(c)Homemade

Explosives (HME). HMEs can be created using household equipment and ingredients readily available at common stores and do not necessarily contain the familiar components of conventional explosives. HMEs using TATP and concentrated hydrogen peroxide were used in the July 2005 London railway bombing. HMEs are extremely unstable and require special care during handling to avoid detonation.

Figure 1; Vapour pressur of high explosive

21. Scenarios for Explosives Detection . Because the problem of explosives detection encompasses so many different potential environments and situations, an essential requirement is consideration of different scenarios. Complications in explosive detection arise when one considers areas which have virtually uncontrollable entry points to public places and road networks with unpredictable vehicular and pedestrian traffic. Some potential applications for explosives detection include:(a)Routine Screening of Large Numbers of Personnel. This application primarily occurs at the entrances to buildings or facilities, when it is desired to screen all incoming persons to determine whether they have explosive materials in their possession. (b)Screening Of Large Numbers Of Vehicles. Screening vehicles includes by definition the screening of people and packages contained within those vehicles. Occurs primarily at high-security checkpoints and requires rapid processing.(c)Screening of Large Numbers of Hand-Carried Items. This application will normally occur in conjunction with Application (a) and in many cases, different explosives detection systems will be used to screen the people and their hand-carried items.(d)Screening of Mailed and Shipped Items. It involves screening letters, packages and shipping crates arriving at

a particular location such as items addressed to government officials, senior executives.(e)Investigating a Suspicious Item. Involves screening of small numbers of people, vehicles or mailed/shipped items since, the number of people/items to be screened is small, more time can be spent on screening . (f)Bomb Search. Involves the screening of a room, building or any other area when there is reason to believe that a bomb may be present. It places a premium on being able to screen a large area in a short period of time. (g)Special Situations or Events. Includes any significant event, situation, place that may require increased security measures with regard to explosives detection.(h)Protection of Infrastructure. Includes structures such as utility plants, dams or communication facilities that may need explosives protection. 22. Operational Considerations. Once the explosives detection application has been identified, the following operational factors need to be considered to understand the peculiarities in field detection of explosive :- (a)Explosives to be Detected. Although it is obviously desirable to be able to detect all types of explosive, however some explosives are more commonly used by the terrorists and encountered more often than others hence require more focus than others.(b)Novel Explosives. Detectors are generally designed to look for specific characteristics, as a result, novel explosives are unlikely to be detected until identifying characteristics and reference standards have been developed and incorporated into equipment designs.(c) Working Environment. If explosives detection is being performed in an area that already has a high explosives background level, then the sensitivity of detection system needs to be modified. Environmental factors like temperature, humidity, dust and wind also influence the detection capability.

(d) Equipment Location and Use. An important component of a detection strategy is identifying where and how passenger detection equipment will be used. In a given location, portals could be used as a primary screening technology for all passengers, or as a secondary screening technology for selected passengers only.(e) System Costs. Depending on the type of system and the desired degree of sophistication, system costs can range from approximately $20, 000 to more than $1, 000, 000. Cost normally has a bearing on some of the desired parameters though higher cost is certainly no guarantee of a " better" detection system.

Figure 2; System concept showing segregation of detection

(f)Health And Public Safety Issues. For application involving screening of people for explosives, the potential health effects of the screening technique also need to be considered.(g)Privacy Issues. The privacy of an individual who are being screened can become a constitutional/legal issue in personnel screening applications. Equipment that uses a vacuum " wand" or puffs of air for sample collection may offend some passengers' sense of propriety or modesty.(j)Potential for Intentional Disruption. Possibility of screening regimen based on trace detection can be exploited to intentionally disrupt the operation of an airport by dissemination of trace quantities of an explosive material in the airport .(k)Innocuous Detection. Innocuous true positives occur when a passenger has been in contact with explosives, but for legitimate reasons like individuals taking nitroglycerin for medical purposes or individuals in the mining or construction industry.(l)Operator Ease. Detection systems vary dramatically in their complexity and ease of use, from highly technical laboratory systems that will be used primarily by experts to field-portable units that can be used by a police officer or security guard with a few hours of training.(m) Reaction time. Collection and interpretation of data in quick timeframe gives operator time to allow an appropriate response to an impending threat.(n)System Speed (Throughput Rate). In high-volume applications the ability to screen items or people quickly is very important. The need for a high throughput rate can be met by replacing 100 percent screening with screening a random selection of people. 20. System Performance Parameters. Detection of explosive involves collecting a sample, processing the sample and ultimately deciding whether explosives are present or not. The operational considerations mentioned above define the system's performance requirements and varies with each different technology. The following parameters describes a system's overall performance :(a) Sensitivity. Trace detection requires high sensitivity and is essential in order to have an acceptable rate of detection. One way to determine an explosives detection system's sensitivity is to evaluate the probability of detection (Pd) when the system is presented with an explosive. The Pd refers to the likelihood that an explosives detection system will detect a certain amount of explosive material under a given set of conditions.(b)Limit of Detection (LOD). The LOD is the smallest amount of explosive that will cause an explosives detection system to alarm and is important because of the relatively small number of molecules that can be collected as a result of their very low vapour pressures. The LOD is a good way to compare the sensitivity of different explosives detection.(c) False Alarm Rates. The false alarm rate is a critical parameter to examine when comparing the explosives detection system. A desirable detection system should have low false alarm rates. There are two types of false alarms: false negative and false positive. A false negative occurs when an explosive material is present, but the explosives detection system fails to detect it, where as a false positive occurs when an explosive material is not present but the detection system alarms anyway.

Figure 3; Possible false alarms are false negative and false positive

22. In addition to the aspects mentioned above, to facilitate continuous operation the sensor should be readily reversible at room temperature. These sensors should also have fast detection and regeneration times for efficient operation and finally, should have the capability for mass deployment to cover the breadth of terrorist threats.

CHAPTER IV: TRACE EXPLOSIVES DETECTION TECHNOLOGIES

23. Detection of explosive is based on technologies that focus on either bulk explosives or traces of explosives. Trace explosives detection involves acquisition and analysis of microscopic residues of the explosive material and detection of explosives by collecting and analyzing tiny/ microscopic amounts of explosive vapour or particles. Sample collection methods and the presence of a background of explosives material at a site profoundly affects the usefulness of trace detection methods. Trace explosives detection can be further divided into vapour and particulate sampling. Canine detection is also considered a subset of trace detection.

Figure 4; Main categories of explosive detection methodologies

(a) Vapour Detection. Gas-phase molecules that are emitted from a solid or liquid explosive are known as vapour. The concentration of explosives in the air is related to the vapour pressure of the explosives material and factors such as the amount of time the material is present in a location, its packaging, air circulation in the location.(b)Particulate Detection. It is the acquisition and analysis of microscopic particles of the solid explosives material that adhere to surfaces. Careful handling of the explosive and the proper use of disposable gloves reduces the spread of particulate contamination; however reducing it to zero is extremely difficult.

Figure 5; Trace detection technologies

Ion Mobility Spectrometry (IMS).

30. Ion mobility spectrometry (IMS) is one of the most widely used detection techniques due to its ability to characterize the sample both qualitatively and quantitatively and the very low detection limits that are attainable. IMS detection can operate in particulate and/or vapour detection modes and is based on how fast ions move and reach the detector. The operator collects a sample either by drawing in air near the object or by swiping a surface to collect particles. The system delivers the sample to the ionization region of the IMS detector, where electrons interact with the incoming explosives molecules to form negative ions. The negative ions next move into the drift region of the IMS. The time required for the ions to travel the length of the drift region is called the drift time and is a complex function of the charge, mass and size of the ion. 31. Advantages.(a)Portability. IMS systems range

from small hand-held systems tolarge dedicated-site portal systems.(b)Ease of Use. Most units can be successfully operated by a person with only a few hours of training. IMS systems operate under ambient conditions and are priced moderately.(c) Dual Use. IMS is one of the most widely used techniques not only for trace detection of explosives but also other contraband materials. 32. Disadvantages(a)Radioactivity. IMS instruments normally contain a small quantity of radioactive material as an ionizing source which leads to extra paperwork and regulatory oversight. (b)Recalibration. The drift time associated with a given ion is dependent on atmospheric pressure and thus changes during inclement weather or when the spectrometer is moved.(c)Peak Resolution. Another drawback of IMS technology is peak resolution in mixtures or " realworld samples".

Chemiluminescence (CL)

33. Chemiluminescence is the production and emission of light that occurs as a product of a chemical reaction (A + B → products + light). These sensors utilise either direct or indirect detection methods. Direct detection techniques utilises any fluorescence which the sample may emit itself or through inducement with a chemical reaction where as Indirect detection involves the implication of explosives being present through their effect on a fluorescent material such as via quenching. The commonly used reaction scheme for explosives detection involves infrared radiation (IR) light emission from excited-state nitrogen compounds. The produced IR light is directly proportional to the amount of the nitrogen-containing explosive material present. 34. Advantages.(a)Portability. The hand-held system weighs less than 7 lb and the portable system weighs over 150lb and are

easy to use .(b) System Setup. Varies between instruments, with hand-held instruments being ready for use in less than one minute.(c) Sample Collection. Vapour and/or particle collection is available on most systems with a throughput rate of approximately three samples per minute. 35. Disadvantages.(a)Specificity. A significant drawback of CL systems is their inability to detect explosives that are not nitro-based.(b)Detectibility. Used alone, CL techniques cannot identify what type of explosive molecule is present and may result in false positives.

Thermo-Redox

36. Thermo-redox technology is an electrochemical technique based on the thermal decomposition of explosive molecules and the subsequent reduction of Nitrogen Dioxide(NO2) groups. A sample is drawn into the system and is passed through a concentrator tube, which selectively traps explosive-like materials. The sample is heated rapidly to release Nitrogen Dioxide(NO2) molecules and these molecules are detected using proprietary technology. 37. Advantages.(a)Portability. Hand-held systems weigh less than 7 lb. (b)Ease of Use. Most units can be successfully operated by a person with only a few hours of training.(c)Throughput Rate. Two to three samples per minute can be tested in field and the system is ready within one minute of power-up. 38. Disadvantages.(a)Interferents. This technology detects only the presence of NO2 groups and identifies the presence of an" explosive-like" material, without identifying a specific explosive.(d)Sample Collection. All systems collect vapour and some can also collect particle samples.

Chemical Reagent-Based (Colour Change)

39. Reagent-based (colour change) explosives detection of residue is done by observing a colour change after the addition of chemical reagents to an explosive sample. A suspect surface is wiped with the special test paper. The operator sprays the test paper with a specialized spray, noting any colour changes. If there is no reaction, the same paper is sprayed with another reagent. Based on the colour changes, the operator can identify the type or group of explosives. The explosives testing order is critical, and all reagents are to be used in their proper order to perform a complete test on the sample residue. 40. Advantage.(a)Portability. Kits weigh less than a few pounds.(b)Ease of Use. Very simple but the instructions must be followed precisely and the order of sample testing is critical.(c)Low cost. The kit's low cost, coupled with its simplicity and ease of use, make it attractive for the law enforcement community. 41. Disadvantages.(a)Identifying the specific type of explosive present when a positive result occurs is not always possible.(b) Vapour sampling cannot be performed and detection is dependent on sample concentration.

Mass Spectrometry (MS)

42. Mass spectrometry (MS) uses an explosive material's molecular weight and fragmentation patterns for identification. Molecules are ionized and passed through a filter (magnetic, ion trap, time-of-flight), which allows ions to be identified based on their charge-to-mass (m/e) ratio. Most MS systems used for explosives detection are fitted with a front-end GC. The combined GC/MS allows different molecules that are detected with the mass spectrometer to be identified specifically with the additional information of

their unique GC retention times. 44. Advantage. MS has excellent specificity for compound identification. Another advantage of GC/MS detectors is that they do not utilize a radioactive ionizing source. 45. Disadvantages. (a)Portability. Most of the currently available GC/MS systems are laboratory systems, however portable systems are becoming available.(b)Ease of Use. Some technical ability or experience is necessary.(c)Throughput Rate. The sample analysis time can be relatively long approximately 3 samples per hour.

Olfactory Type Sensors

46. Two types of olfactory sensor can be thought to exist, natural and artificial. Dogs have long been used to detect explosives and other species are constantly being investigated. Electronic noses are also being developed but as yet do not have the specificity and reliability for field use. 47. Canine Detection of Explosives. Dogs have long been known to have a highly developed sense of smell and this has been exploited for the detection of explosives since World War II. Explosives detection canines (EDC) are currently used for both random screening of passengers and as a deterrent to criminal/ terrorist activity. Canines have two qualities that trace chemical sensors cannot match at present :-(a)High mobility and ability to rapidly move to various locations throughout a system with minimum impact on passenger flow and operations.(b) The ability to detect explosives they are trained to detect and to follow a scent to its source. 49. The use of sniffer dogs for the detection of volatile explosive vapours is widespread due to their fast, directional and real-time capabilities and the fact that the canines are generally accepted by members of the public. The drawbacks of this

method is that the performance varies widely depending on the individual dog and its training duration and methods. Dogs trained in explosives detection can generally only work for brief periods, have significant upkeep costs and require a human handler when performing their detection role. In addition, direct contact between dogs and airline passengers raises liability concerns. 50. Rats. Rats have a sensitive and discriminating olfactory system and have been shown to correctly discriminate between odours, and alert when explosives are present. They are trained using food rewards to signal the presence of explosives by scratching the ground surface with their feet. The advantage of this method is that rodents are lighter and easy to educate, transport and feed however they can only work under limited weather conditions. 51. Bees. Bees are trained by feeding them on points where the area has been impregnated with explosive chemicals like TNT. They provides greater accuracy and a higher clearance rate however lack of mechanism to transport bees creates employability issues. Insects such as Drosophila melanogaster, have also been investigated due to the capability they have to detect a large range of odours and the simple olfactory system they possess. Acceptability of bees and other insects in a public environment however is a big hindrance. 52. Electronic Noses. Electronic noses usually consist of an array of chemical sensors which interact with a vapour in different ways and to different extent which in turn is combined with a pattern recognition system. The basic principle is that each sensor will give a different response depending on the nature and concentration of vapour present and the pattern recognition process will allow determination of the analyte. The chemical sensing elements in a electronic nose can be electronic, piezoelectric or optical in nature.

PART V - BULK EXPLOSIVES DETECTION TECHNOLOGIES

54. Bulk explosives detection involves the detection of a macroscopic mass of explosives material usually based on either imaging or nuclear (molecular) properties of the explosive. Bulk detection seeks the actual explosive material while Trace detection looks for residue or contamination from handling or being in proximity to explosives materials. Bulk detection methods are less dependent than trace detection methods on sampling techniques and are not affected by the presence of explosive background. However, equipment costs associated with bulk detection are often higher and some techniques especially those based on imaging have a lower degree of specificity than trace detection methods. 55. In bulk detection, a visible amount of explosives material is detected and characteristics of the materials in question are measured. Analysis of these parameters can result in findings of mass, density and atomic number of the material in question. While none of these characteristics are unique to explosives, they can indicate a high probability of the presence of explosives. As such systems detect only bulk quantities of explosives, they would not raise " nuisance alarms" on passengers who have recently handled explosives for innocuous reasons.

Figure 6; Bulk detection technologies

Imaging Technologies

57. Gamma rays and X rays, like microwaves and visible light are part of the electromagnetic spectrum. X rays are high-energy radiation and are slightly lower in energy than gamma rays. When X rays and Gamma rays encounter matter, three outcomes are possible, they may :-(a)pass through the material (transmission),(b)be absorbed (absorption), or(c)be deflected off of its original course (scattered or backscattered). All three of these outcomes occur in distinct proportions determined by the initial X-ray energy and the bulk characteristics (density, absorption coefficient, backscatter coefficient and Z number) of the encountered material.

Single-Energy X-ray Technique.

60. In single-energy x-ray techniques, an x-ray beam of one energy is used and the image indicates the degree of absorption of the X rays. Single-energy x-ray systems are useful for bomb detection (looking for wiring, fusing and metal parts) and not as useful for the detection of the explosives material itself. Typically single-energy techniques do not provide enough information for explosives materials detection. Cargo vehicle and shipping containers screening is one important application of single-energy X rays.

Dual-Energy X-ray Techniques.

61. The basic types of dual-energy systems utilize either a single broad x-ray beam and a dual detector arrangement or a combination of low and high-energy X rays to image materials. The two independent images are computer processed to compare low and high-energy x-ray absorption. The

displayed results characterize and identify the various materials by their shape. Artificial colours assigned to different materials to ease of identification by the operator. The system uses colour to separate items in the image into organic (low Z number) and inorganic materials (high Z number). The resulting image is displayed on a monitor for visual identification62. Advantages.(a)Material discrimination based on shape.(b)The ability to detect metals and other high Z number materials in addition to explosives.(c)Low cost. 63. Disadvantages.(a)It can be difficult to separate objects from one another in an image, especially when the object does not strongly interact with X rays.(b)The dual-energy technique does not determine a material's thickness; therefore, it cannot unambiguously determine the Z number of a material.

Computed Tomography (CT) Technique.

64. Computed tomography (CT) is an X-ray technique that produces two dimensional images of cross-sectional " slices" through an object at many angles and then combines these slices to obtain a three-dimensional image. Some instruments operate by taking images in slices throughout an object. The source and detector both move and rotate around a scan circle in which the object is centered. The X-ray beam penetrates the object and is detected on the opposite side. A set of projection data is obtained at a particular angle, the source and detector are then rotated and a new projection is obtained. These CT images have improved density resolution compared to conventional x-ray images. 65. Advantages.(a)CT produces a true cross-sectional slice and objects that are hidden, obscured are identified.(b) Detects explosives-like materials and discriminates them from most other

innocuous, low Z number materials because CT can accurately determine the material density. 66. Disadvantages.(a) High cost because of the automation of the operation of the detector and the source.(b) Higher radiation dose per object and throughput is lower.

Backscatter X-ray Techniques.

67. The input X-ray radiation herein interacts with the material in question and results in the scattering of the input radiation. The amount of x-ray scattering exhibited by a material is a characteristic of the material. The backscatter x-ray systems provide both a standard transmission X-ray image and a backscatter X-ray image of the material. The standard X-ray image provides the identification of high density materials, which are typically metal objects while the backscatter X-ray image highlights organic materials such as plastic explosives. Comparing the two images provides a detailed information about the material’s composition. 68. Advantages.(a) Additional information obtained from the standard x-ray image and thebackscatter image.(b) Moderate cost. 69. Disadvantage.(a)Excessively dense materials can hide other objects. Low Z-number objects could remain hidden behind dense materials.(b) A double-beam backscatter model avoids the dense material problem but at a higher cost.(c)Since the back scatter photons are emitted in all possible directions form the target, capturing of sufficient number of photons to produce high resolution image remains a problem.

Low-Dose X-Ray Backscatter Personnel Screening.

70. This technique screens personnel using low-dose x-ray backscatter which are used to screen people and find materials hidden on their bodies. The

system can image explosives and other contraband hidden under the clothing of persons being scanned. The backscatter x-ray personnel system exposes the subject to a radiation dose that is very low and considered safe . Present scanners can scan only one side at a time. A person would have to be scanned two times, front and back, to ensure that no explosives were located on the person. 71. Advantages.(a)Hands-free screening of people, replaces pat-down and strip searches.(b)The resulting image displays size, shape and location of the object. 72. Disadvantages.(a)Invasion of Privacy. This factor is important because the human body is imaged and the operator visually inspects the image. Efforts are currently underway to develop algorithms to automate the detection of threat objects .(b)Though the radiation doses are low however the public's dread of any radiation is a major hindrance in implementation of this technology.

Dielectrometry.

73. Dielectrometry, uses a low-energy microwave field to irradiate objects. The phase and magnitude of microwave field lines change depending on the dielectric properties of the object in the field. The human body has a unique dielectric response (signature) and is different from any explosives signature. The system irradiate objects and compares the dielectric of the object in the microwave field to known values and can distinguish anomalous areas where the dielectric properties are different. The dielectric sensor is an anomaly detector that can detect anything of sufficient volume that is different from the human body or other material in question. 74. Advantages.(a) Privacy of Screened Individual. The display shows a generic wire-frame human model to display locations of any identified anomalies.(b)Radiation

safety. Dielectrometry uses low-level microwave energy, a non-ionizing radiation. 75. Disadvantages.(a)Non-specific detector. It detects anomalies, not explosives.(b)Moving equipment. Concerns about the imaging array equipment moving around a person, especially a child. 76. Nuclear-Based Technologies. Nuclear-based technologies interrogate the nucleus of the material under inspection. Some nuclear-based techniques utilize high-energy neutrons as the probing radiation to interact with the material's nuclei which in turn emit characteristic radiation which in turn is used to predict the presence of an explosive or explosive-like material with high probability. Another nuclear-based technique probes the nuclei of the material in question with radio frequency pulses and detects quadrupole nuclei. Nuclear-based technologies are much more material-specific for explosives than are imaging technologies and are less subject to operator interpretation of data.

Nuclear Quadrupole Resonance (NQR).

77. It is an explosives detection method based on Nitrogen quadrupole detection. When quadrupole nuclei are exposed to a pulsed RF field, they move to a higher energy state, upon removal of the RF field, the nuclei return to their original lower energy state and the excess energy is released. The released energy is of a characteristic energy, which is dependent upon atom type and crystal structure. 78. Advantages.(a)No ionizing radiation source is used.(b)Highly specific for the identification of explosive compounds. .(c)Very low false alarm rate. 79. Disadvantages. (a)Susceptibility to shielding , metal shielding can make an explosive

invisible to NQR;(b)Not all types of explosives can be detected.(c)Requires proximity of the object to the RF field source.

Neutron-Based Techniques

80. Thermal Neutron Activation. Thermal neutron activation is based on the characteristic emission of gamma rays from the object of concern. The thermal neutron interacts with the nucleus of matter under inspection, gets absorbed and results in the emission of a high-energy gamma ray. Detection of any emitted 10. 8 MeV gamma rays indicates that the material contains nitrogen. Many explosives are nitrogen-containing compounds; therefore, this technique can be used to identify materials that contain nitrogen, which also have a high probability of being explosives. The neutrons used in a thermal neutron activation system are provided by either a radioactive isotope or by an electronic neutron generator. 81. Advantages.(a)Wide Variety of Applications. The penetrating nature of both the neutrons and the emitted gamma rays, allows it to be used in a wide variety of explosives detection applications.(b)High accuracy and low false alarm rate. 82. Disadvantages.(a)Personnel Screening. Exposure to neutrons can have unacceptable health consequences hence is not used for personnel screnning.(b)Not suitable for inspection of large cargo containers due to the use of low-energy neutrons.(c)High cost and false positives .

Pulsed Fast Neutron Activation

84. Pulsed fast neutron activation is a technique where fast neutrons are pulsed at the nuclei of interest and the characteristic gamma ray emission yields information on several elements including carbon, hydrogen, nitrogen,

and oxygen. Using very short fast neutron pulses the location of the detected material can be determined. Pulsed fast neutron activation is a highly specific technology for the identification of various substances. 85. Advantages.(a) This technique has good neutron penetration and can be used on large cargo containers.(b)Three-dimensional location information can be determined in the object of concern. 86. Disadvantages.(a)System complexity.(b)High cost.(c)Radiation and shielding concerns.

PART VI - RECOMMENDTIONS

89. What predictions can be made today with respect to explosives threats and technologies of the future? There will certainly be new types of explosives, both developed and improvised, which will be delivered in even more novel and ever-evolving ways. For every system and device we implement, the bad guys will find a way to deflect and evade detection and the game of cat and mouse will escalate as they try to keep one step ahead by changing the type of explosives they use and the method in which they are delivered. The illicit use of explosives will, remain a weapon of choice for terrorist organizations and insurgents, for they can take different forms and be delivered to their targets in a variety of ways which makes these devices difficult to detect and defeat. Advances in technology for the detection of explosives, explosive devices or components of such devices can improve our ability to counter their use and resulting impacts. Development of solutions that can be effectively deployed and used in a variety of real-world settings is the need of the hour.

Emerging Trends

90. The trace and bulk explosives detection techniques discussed earlier are expected to remain the principal techniques for use in law enforcement and other applications for at least the next several years. The expected trend for new equipment is toward more portable and miniaturized units rather than improvements in sensitivity as the sensitivity of current instruments is already adequate for most applications. Development that can potentially address many of the issues required for reproducible detection of explosives is that of sensors which can be more specific and miniaturized because it will reduce the cost of the equipment and simultaneously provide cost effective coverage of vast areas. Some of the latest development in the field of explosive detection techniques are as given below :-(a)Enhanced Trace Detection. Trace detection is a proven method and is widely used as an explosives detection solution in aviation security systems. Among the significant developments in trace detection are increased selectivity and sensitivity. The large installed base of trace detection systems provides strong incentives for implementation of these changes on the existing systems rather than going in for much larger investments in replacement of systems.(b)Sampling and Preconcentration. Better sampling and pre concentration techniques provide improved sensitivity and selectivity for detection of explosives, without significantly impacting analysis time or cost. They complement and extend the capabilities of the existing detection systems. The potential benefits include obtaining larger samples of low vapour pressure explosives and " sticky" explosives particles, while at the same time decreasing background interferences and false alarms.(c)Stand-

off Detection. Standoff detection enables detection to take place further away from people and vital assets and reduces the potential for severe damage. These methods focus on both chemical identification as well as detection of suspicious packages, wire, fragmentation materials and other physical attributes of IEDs. It allows for extending distances at which effective screening can be conducted, reducing the impacts of various interferences and backgrounds (atmospheric and environmental) and effective screening of more than one potential threat at a time while in motion.

Figure 7; Dependence of system on the characterized and mapped threat

(e)Portability. One of the most improved aspects of detection technologies is that of portability and much development has been undertaken into the miniaturisation of existing technologies. Techniques which were largely stationary have now become field deployable. More sensitive and specific technologies which were restricted to laboratory application till now are now becoming available for field use.(g)Application based response. Consequent to greater understanding of the way terrorists use explosive the application of detection techniques have also evolved and the utilization of the technologies is getting focused for specific applications. Applications that require not only high sensitivity but also an immediate response, such as airport security, the most promising systems appear to those based on either mass spectroscopy while for detection of explosive devices in other environments (roadside bombs etc) the most important factor is probably the ability to detect at a safe distance, rather than having to approach the device.(h) Nanotechnology. Nanotechnology has become a rapidly expanding area of research over recent years as techniques and knowledge have developed. Materials possess unique characteristics when in a nanoscale form as compared to bulk materials. The incorporation of nanotechnology into existing techniques is an active area of research to enhance sensitivity and selectivity. However the tech is still in experimental stage and would require few more years before it can be applied in field effectively.

Way Ahead

91. Use of explosives by terrorists will continue to remain a problem that the security agencies will have to battle against. Innovative and novel use of explosive will require that research is done in not only the field of explosives detection but also the likely way these explosives are/will be used. Explosives detection research crosses boundaries of physics, chemistry, materials and electronics. Science-based computational and sociological capabilities along with a strong, multi-disciplinary staff and infrastructure is required for providing tangible solutions through the application of a range of techniques. Technology experts are taking an accelerated approach to address shortcomings in discovering and identifying the array of explosives in a variety of forms across a range of venues and environments. Few approaches which can give a possible solution to this complex problem are :- (a)Orthogonality. Two or more explosive detection technologies are completely orthogonal if the detection methods are mutually independent, that is they detect independent characteristics of the explosive device. Example of two orthogonal techniques would be a combination of olfactory analysis and imaging technology in which the imaging technology detects

the shape, mass or density of the explosive which are independent of the chemical composition. The potential advantage of a orthogonal approach over a system dependent on a single technology are firstly that it has a higher probality of detecting the presence of an explosive device over a range of potential threats with fewer false positives and thus be more effective in detecting the explosive secondly It is more difficult for a potential bomber to avoid, confuse or defeat the system.(b)Distributed System, Distributed Sensors. The architecture of such a system would consists of multiple array of different types of technologies. A set of spatially and geographically distributed array of orthogonal and /or partially orthogonal sensors provide the advantage of broad coverage and increased capability. Such a distributed sensor system would allow detection of explosives over a substantially larger area than a single fixed detector and would also provide spatial and temporal information about the explosive. Another advantage of distributed system is that it decreases the likelihood of successful avoidance of detection in relation to single location sensors. Integration of information from distributed orthogonal sensors would also allow real time conflict resolution and decision making with high system effectiveness.(c) Systems of Detection. Detection of explosive involves receiving a signal, processing the signal, assessing the results and ultimately deciding whether explosives are present or not. To be effective explosive detection must take into account more than one sensor indications because a system that relies on a single source of information is too likely to make decision with excessive false positives. Better and more accurate decisions can be extracted from a set of diverse sources of noisy data than from any individual source alone.

Systems of detection approach with use of multiple orthogonal sensors increases the sensitivity and specificity because the system finds not only more indications but also unique indications which reduces the probability of false indications. Robustness of a system is also greater since some sensor type will continue to function even if the system is presented with a single indignities. System approach allows for countering potential partial degradation of a sensor type which allows detection maybe at reduced performance , until all orthogonal detection means are effectively disabled. Another likely advantage is that novel threats may be recognized incidentally via intersection with the threat parameters currently considered by the system. 92. The present and likely improvements in the existing technology will improve the existing capability however keeping in mind the dynamic threat environment it is imperative that we graduate from a individual approach to a multi prong approach. There is no single perfect detection technology (trace/ bulk) for use in a variety of situations, a fusion of complementary or orthogonal detection methods can be relied upon to significantly increase the overall detection system capabilities. Developing effective integrated systems for explosives detection, which can address issues of the identification of appropriate combinations of technologies and development of suitable algorithms for rapid and accurate processing of multiple information sources in a systems that combine two or more detection technologies into a single system is required for detection of future threats.

PART VII – CONCLUSION

93. The field of explosives detection is certain to remain an active and wide-ranging area of research due to increased demand for homeland security in the face of perceived terrorist threats. Many methods of explosive detection have been employed historically ranging from canines, to analytical methods and more recently chemical techniques. The advantages and disadvantages vary and as such, one technique for the detection of all explosives is elusive. The future of explosive detection requires a technique that is sensitive to all varieties of explosive to be detected and one that is not dependant on the type of structure the explosive yields. It can be seen that almost all techniques addressed have undergone significant changes to improve one or more aspects of their working to include for example sensitivity, specificity, cost, ease of use and size. However further advancement are necessary to provide an ideal explosive identification technique. There appear to be many promising methods that are being developed as alternatives to the existing systems. Terahertz spectroscopy, once beleaguered with issues, has been realised as a technique that can identify explosives and other concealed objects beneath clothing and within luggage. 94. There are many techniques in development at this time, some are almost ready for field-testing while others are still years away. Future systems will most likely incorporate multiple sensors in a " suite" of technologies and techniques. Peering into the crystal ball, the future of detection will see not only the screening of persons, vehicles, baggage, mail and the like for explosives, but also the continuous monitoring of the environment where these systems are located. While new technologies will undoubtedly appear on the scene, there is

usually a several-year gap between the development of a new technology and its commercialization for widespread use in the meantime an accumulation of the aforementioned techniques should be employed to increase national security and defense against terrorist organizations. 95. Besides creating new capabilities and enhancing existing ones, the ultimate goal will remain to integrate relevant capabilities to provide a more cohesive and comprehensive approach to explosives detection. New technologies are likely to supplement rather than replace existing technologies. Miniaturized orthogonal sensors with increased sensitivity and selectivity and the ability to operate in a multimodal platform offer a potential paradigm for deploying a large number of sensors for detection. Protecting against explosive-based terrorism can thus only be accomplished by mass deployment of miniature sensors that are sufficiently sensitive and selective, inexpensive and amenable for mass production. A systems of detection approach involving distributed orthogonal sensor s is likely to be the complex solution to the very complex problem of detection of varied explosive available in varied matrix of time varying environment.